PROCEEDINGS / COMPTE RENDU

The Composting Council of Canada

Le Conseil canadien du compostage

2nd Annual Meeting
2e Congrès Annuel

"From Waste to Resource - Composting in a Sustainable Society"

«Des déchets aux ressources - Le compostage dans une société durable»

November 5 & 6, 1992

Les 5 et 6 novembre 1992

Hôtel Delta Ottawa Hotel,

Ottawa, Ontario

Co-sponsored by / Coparrainé par :

Environment Canada Environnement Canada

Proceedings

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TABLE DES MATIÈRES | TABLE OF CONTENTS

TABLE DES MATIÈRES — TABLE OF CONTENTS

page

TABLE DES MATIÈRES — TABLE OF CONTENTS

page

PANEL ON FISH WASTE / PANEL SUR LES DÉCHETS DE POISSON

PROSPECT AND RETROSPECT,
Don Cooke,
Outgoing Chairman,
The Composting Council of Canada

Good morning and welcome to our second Annual General Meeting.

It has been my privilege and honour to be the inaugural President and Chairman of the Board of Directors of our council. As I leave this position, I would like to review our first year and share some thoughts as we look forward to the future.

I look back on a year where we expanded our membership and the makeup of our Board of Directors to truly represent a wide range of interests, from mutinational corporations to cities, towns and villages; from leading academic institutions to interested individuals.

Geographically, we have organizations municipalities and individuals from Newfoundland to British Columbia.

I look back on the formation of our modest but effective national executive office in Ottawa.

I look back on a year where our fledging regional committees took their first steps and our founding Board of Directors searched for direction and focus.

This first year has been one of growth and expansion for our council.

We have been successful in finding and retaining an eminently qualified and energetic Executive Director in Dr. Peter Meyboom. Peter has been a pillar of strength to your executive board and to me personally this year. He deserves our thanks for a job well done in building the council and being a forceful advocate for us in Ottawa over the past year.

We held our first board meeting a year ago at the founding conference and elected a slate of officials. Our next meeting was held in Montreal in February where we were the guests of Johnson and Johnson. We added three board positions to balance representation of the non profit government membership group. In May, we were hosted by Edmonton and our August meeting was sponsored by the Hamilton Wentworth Region.

I believe we have been reasonably successful this year in establishing ourselves as a truly national organization. Regional committees in Quebec and Ontario under the capable leadership of Gilles Nadeau and John Olson, respectively, are set up and are well on the way to setting direction and plans for the ensuing years. Ron Westlake in Kelowna has made a start to get the ball rolling in the western region.

My only regret is that I have to report little or no progress in the Maritimes to date. This is largely because our regional director, Dr. Charles Bourque, has been in Europe for most of the year. I expect that we will see progress when Dr. Bourque returns and I would urge our eastern members to offer whatever help they can to enliven that region henceforth.

As we addressed the question of what the council could offer its members and what contribution we should make to the development of composting in Canada in the near term; we concluded that we should focus upon becoming a communications medium and a collection and clearing house for technical information.

To that end we have commissioned Michael Gibson, a post graduate student at the University of Guelph, under the direction of Dr. Lambert Otten, to build a data base on worldwide scientific papers and technical information as well as statistical data on composting plants and technical information as well as statistical data on composting plants in Canada. We expect this to be an on-going effort and expect to have an initial set of data available early in 1993. Dr. Otten will be able to provide you additional information when required.

So here we are at the beginning of our second year. We have a growing broadly representative membership, we have a strong executive, and we have made a good start at building strong local regional committees in most regions.

Where do we go from here? Let's take a brief look at the state of the composting business in Canada. Thanks to the leadership of regional organizations like the Recycling Council of Ontario and generous financial support from the provinces and some municipalities we have broad distribution of urban backyard composting programs across the country. We have a number of commercial and successful municipal low-tech leaf and yard waste composting facilities in operation and are developing a substantial knowledge and experience base in this area. Extensive recovery of organic material from animal and other agricultural wastes by composting is being carried out in a number of areas, notably in Quebec and British Columbia.

On the down side though, we have made little progress in the recovery of commercial industrial or urban wastes through composting. We have yet to build, commission and operate the first full scale state of the art composting plant in Canada. The continuing economic depression has diverted energy and funding, cooling the ardour and resolve of many municipalities. The political climate, the preoccupation with the recent constitutional event and the continuing inability of our elected officials and bureaucrats to take initiatives has stalled projects in a number of communities. The naysayers, Nimby Forces and the publicly- funded special interest groups that appear to flourish in our country these days continue to exert an influence that slows processes, blunts initiative and drains energy from the development of technology in composting as well as in other developmental areas.

So where do we go from here? I suggest that we should see this continuing period of low developmental activity in municipalities and regions as an opportunity. It is an opportunity for us as individuals and as an organization to build our knowledge base in the science and technology of composting. We should continue and exchange the development of our technical information data base. We should sponsor research that will have future application in our communities. Let's keep building a strong foundation. We should encourage and support our officials and political decision makers so that they will sponsor the construction of demonstration facilities.

We should help our members and others who are taking commercial risks to develop composting where that is possible. Let's help to drive out the fear of new methods and use our collective experience to ensure that when a community finally plucks up the courage to build a composting plant, we provide help so they avoid the mistakes that have been made in other similar north American ventures.

The next day and a half will give us chance to hear about a wide variety of topics, an opportunity to renew old acquaintances and to meet new associates. This is the purpose of this gathering. Our meeting can be a significant force in the development of a viable composting infrastructure in Canada.

As I leave the position of President and Chairman of your Board at the conclusion of our business meeting later toady, I want to wish you all the very best in your endeavours.

Good luck and have a good meeting.

EUROPEAN COMPOSTING TECHNIQUES

AN OVERVIEW

The slides I am going to show you of 11 composting plants in 6 European countries are based on the personal observations of the writer in trips to Europe from 1989 onwards. The purpose of these visits was not so much to gain detailed technical knowledge of the various processes involved, but rather to attempt to identify the "state-of-the-art" in centralized municipal composting operations in Europe with particular reference to evolving trends, both in the type of technology being used and also in the characteristics of the feed stock for the plants.

The locations reviewed are of course only a fraction of the total number of composting plants in Central Europe, but do represent a reasonable cross section of the various technologies being used and the trends that are evolving. The following overall conclusions may be drawn:

a) The plants visited appear to be operated in an environmentally acceptable manner with little or no evidence of external nuisance arising from dust, odours, etc. In many cases, upscale housing developments are located very close to the plant sites, but neighbourhood objections are apparently not an issue. The plants are for the most part operated by private companies on contract to local government and are usually not self-sufficient, i.e., the revenue from the sale of compost does not cover the entire operating cost and deficits are made up by a tipping fee as in North America. The plants are generally operated with a small staff of perhaps 2 to 4 persons.

b) The Europeans are carrying out experiments and trials in various locations in different types of waste collection systems, i.e., two-stream or three-stream, etc. and a considerable amount of research data is now accumulating in this area.

c) A greater emphasis is being placed on waste reduction and certain countries, notably Germany, have enacted very stringent legislation in this regard and there is every indication that such efforts will intensify.

d) It is obvious that increasing attention is being paid to keeping waste out of landfills, i.e., more and more recycling and especially composting. Both of the latter methods are clearly favored over incineration.

e) Finally, the most obvious trend by far in European composting philosophy is source separation with ever increasing emphasis on three-stream collection, i.e., recyclables (usually brought to a central depot by the public), organics (kitchen and yard waste) which are composted and the "rest waste" which is principally landfilled but may well be composted in the future except of course for bulky items, etc. It is noticeable that heavy metal content in compost is not a problem where full source separation is practiced but frequently is where it is not.

In general, Central Europe provides an excellent opportunity to observe developing trends in composting technology and practices. The more "low tech" techniques, i.e., open shed windrowing, etc. will continue to be used generally for smaller populations but there is an obvious trend towards more "high tech" methods for larger populations.

....
H. G. PAYNE, P. Eng.
City Administrator
Windsor, Ontario

HGP/jgb
November, 1992

EUROPEAN COMPOSTING TECHNIQUES

PLANTS REVIEWED

LOCATION	DESCRIPTION
1. Uzwil, Switzerland	Operated by Buhler Inc. of Uzwil as a small-scale pilot plant for various trials on composting methods. Presently receives 3,000 tonnes per year of organic kitchen and yard wastes and produces compost in windrows following a 12-week curing period. Compost bagged and sold for landscaping and horticultural use.
2. Darmstadt, Germany	"Green Bin" waste (kitchen and garden) is picked up every 2 weeks in waste collection trucks equipped with turning drums. The purpose of the latter is to commence the process of breaking down the organic waste in order to accelerate the overall process. The "Grey Bin" waste is picked up once a week and incinerated separately at another location. Recyclables are brought separately to community depots by householders. The plant receives 5,000 tonnes per year of organic waste which is collected from 35,000 people in the surrounding area. The organic waste is deposited in piles 3 meters wide and 1.8 meters high on a 20 centimeter thick base of wood chips which is intended to both prevent leachate runoff and the development of an anaerobic condition. The plant generally receives more kitchen waste in the

winter time and the waste has typically a higher moisture content in the winter. In the summer, it is necessary to add water from rain water holding tanks on the site every 2 weeks after the material has been 4 weeks in the windrow. (The plant is located in a very dry part of Germany).

Every 3 weeks (2 to 3 times totally), the windrows are turned in situ by means of a rotating screw mounted on a machine which straddles the windrow. This turning action not only further breaks down the compost but also moves outside material to the inside where the temperature of it will increase and furthermore, moves air into the windrow in order to accelerate aerobic bacterial decomposition. The waste remains for 6 to 8 weeks in the windrow.

The waste is then moved to larger piles in which it remains for 1 month.

Finally, the resultant compost is screened and sold for agricultural purposes for 25 dM per cubic/meter.

A total staff of 2 persons operate the plant and there are no reported problems with heavy metals in the compost (because of source separation). The plant operates at a cost of dM120 per tonne net of revenue. The cost for incineration in the same area is dM290 per tonne and the composting process therefore enjoys a considerable cost advantage.

3. Witzenhausen, Germany

This plant, which uses the open shed windrow process, draws from a population of 40,000 in Witzenhausen and surrounding small towns. It receives 6,500 tonnes per year of organic waste (kitchen and garden) which represent 50% of the total domestic waste produced in the area.

The finished compost is bagged and sold to farmers and gardeners for 6 dM per cubic/meter. The latter revenue is reported to be not critical to the success of the operation. Apparently, there is less than 1% loss in the entire process. No heavy metal problem is reported due once again to full source separation.

This location is regarded as "the cradle of German composting". Apparently, it was the forerunner of all of the composting plants in Germany.

4. Bad Kreuznach, Germany

Accepts 60,000 - 70,000 tonnes per year of municipal and industrial refuse from the Bad Kreuznach Region (which consists of the Town of Bad Kreuznach plus a rural area with a total population of 140,000) and converts the refuse into compost. It was originally intended to accept commercial refuse as well, but this did not happen. It was also intended to compost sewage sludge, but this also did not prove to be feasible and has not occurred. However, as of January, 1990, the Region will commence a separate

"Brown Bin" collection system, i.e., only organic refuse. which will be about 60% of the total waste stream will be composted. The volume of input will be lower, but the percentage output will be higher. The organic refuse entering the the plant will consist of kitchen and garden waste plus lower quality paper and cardboard which apparently will be necessary to avoid anaerobic decomposition of the kitchen waste in particular.

The plant produces approximately 18,000 tonnes of compost per year for sale to grape growers in the region. The price at the plant is 6 dM per cubic meter which is basically a nominal price since the compost cannot be given away free. This price is reduced by up to 35% for larger quantities.

The original compost produced was not saleable because of glass content. The plant was modified to overcome this problem and the end product is now acceptable to viniculturists.

5. Singen, Germany

The present basic process consists of production of compost from 70,000 tonnes of co-mingled household waste, together with 20,000 tonnes of sewage/sludge per year. The waste is put through a hammer mill and screen and sludge and water is added. The mixture is then made into briquettes which are cured aerobically.

The briquettes are then ground up to produce compost. Approximately 2% is ferric waste. Paper, plastic, cardboard, etc. - about 25% - are screened out and sent to landfill.

The above process will change in 1992 when use of sludge will be discontinued and the plant will use only organic waste (kitchen, plus yard) from full household source separation.

6. Medemblik, Netherlands

This plant which began production in the Fall of 1990 accepts house and garden organic waste from 70,000 households in the area. The incoming waste is first put through a Trimalin shredder and then goes into a closed hangar in which it is moved successively from the input end to the output end by means of a Wendelin Wheel. This process takes 11 weeks and air is forced up through the fermenting compost.

The resultant product is sold for agricultural use.

The plant has a total staff of 5.

Further details can be obtained from Mr. Erwin Notter of Buhler (Canada) Inc.

7. Schauffhausen, Switzerland

This plant has 2 processes as follows:

a) A biological waste composting plant which processes 5,000 tonnes per year of garden and kitchen waste (excluding recyclables) to produce high quality compost in a separate treatment line and composting area. The process time is about 12 weeks and the resultant product is sold for horticultural and vinicultural use.

b) A household and commercial waste plant processing 22,000 tonnes per year of household and commercial waste, 3,000 tonnes per year of bulky waste and 5,700 tonnes per year of sewage sludge to produce firstly a "black" compost for landfill cover and secondly, an RDF fraction as a fuel for a nearby incineration plant. The process time for the compost is approximately 4 weeks in a completely enclosed building.

Further details can be obtained from Mr. Erwin Notter of Buhler (Canada) Inc.

8. St. Agata, Bolognese, Italy

Produces compost (and in the future energy) from MSW, sludge, and industrial organic waste from supermarkets and produce stores, etc. A major feature is the Bionway System for intermediate treatment at source of waste in sealed containers. The latter are subsequently transported to the plant where the final process to produce compost takes place.

9. Ammerland, Germany

This plant utilizes an in-vessel composting technique to produce medium and fine grade compost for landscaping and horticultural use from source separated domestic bio-waste and yard waste. The waste is first crushed and homogenized and the metal fraction removed and it is then placed in closed containers into which air is forced for intermediate processing. Exhaust air from the containers is released through a bio-filter and leachate is drawn off to an underground drainage system. The entire process in the containers is computer-controlled. Following intermediate processing, the compost is screened and matured. The system treats 11,000 tonnes per year of domestic bio-waste plus 6,500 tonnes per year of yard waste. A total of 10 weeks processing time is involved.

Further details can be obtained from Mr. Gerald Tibbo of Stinnes Enerco Inc. of Oakville.

10. Helsingor, Denmark

This is an anaerobic plant which accepts organic domestic waste and yard waste and produces compost and biogas (for energy generation) in a closed process in container vessels. The plant will receive 20,000 tonnes a year of organic waste from 70,000 households in 6 surrounding area municipalities and will produce on a yearly basis, 3,000,000 cubic feet of biogas (which could heat 700 to 800 homes), 7,200 tonnes of compost and 4,800 tonnes of fertilizer.

Further details can be obtained from Mr. Kevin Matthews of Canada Composting Inc.

11. Madrid, Spain

The Madrid community has now commenced construction of an Integrated Solid Waste Recycling Plant with a capacity of 1,200 tonnes per day for the production of recycled materials, compost and RDF from MSW generated in the Community. It is expected that the plant will be in full operation in early 1994.

HGP/jgb
10-28-92

THE EUROPEAN EXPERIENCE - LESSONS TO BE LEARNED

by

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This paper provides an overview of the role of composting in Europe with an emphasis on its future European common market. Current issues and problems associated with composting in Europe are outlined. Areas of required European member state cooperation are presented such as approaches in developing Europe-wide compost guidelines. Comparisons of the European and Canadian situations are made. The goal is to present European issues that may also occur or are already occurring in Canada with the hope that past European experience will aid in the development of a successful long term role of composting in Canada.

With the approach of the European Common Market within the next few years, the European Community (EC) has already released legislation in the form of laws and ordinances which must be implemented by the member states. In this regard, a **Waste Management Hierarchy** was developed by the EC as outlined in Table 1.

TABLE 1: EUROPEAN COMMUNITY WASTE MANAGEMENT HIERARCHY

1. Waste reduction

2. Diversion from landfill including
   - Reuse
   - Recycling
   - Biological treatment
     - Composting
     - Anaerobic digestion
   - Incineration with heat recovery

3. Landfill

In order to create a more concrete form of this waste management hierarchy, the EC has set targets for the components in the hierarchy to be reached by the year 2000. These targets, also known as the **Ideal Waste Plan**, as well as the existing waste management situation (1992) in Europe are presented in Figure 1. Ontario's **Waste Diversion Targets** are also illustrated in Figure 1 for the purpose of comparison.

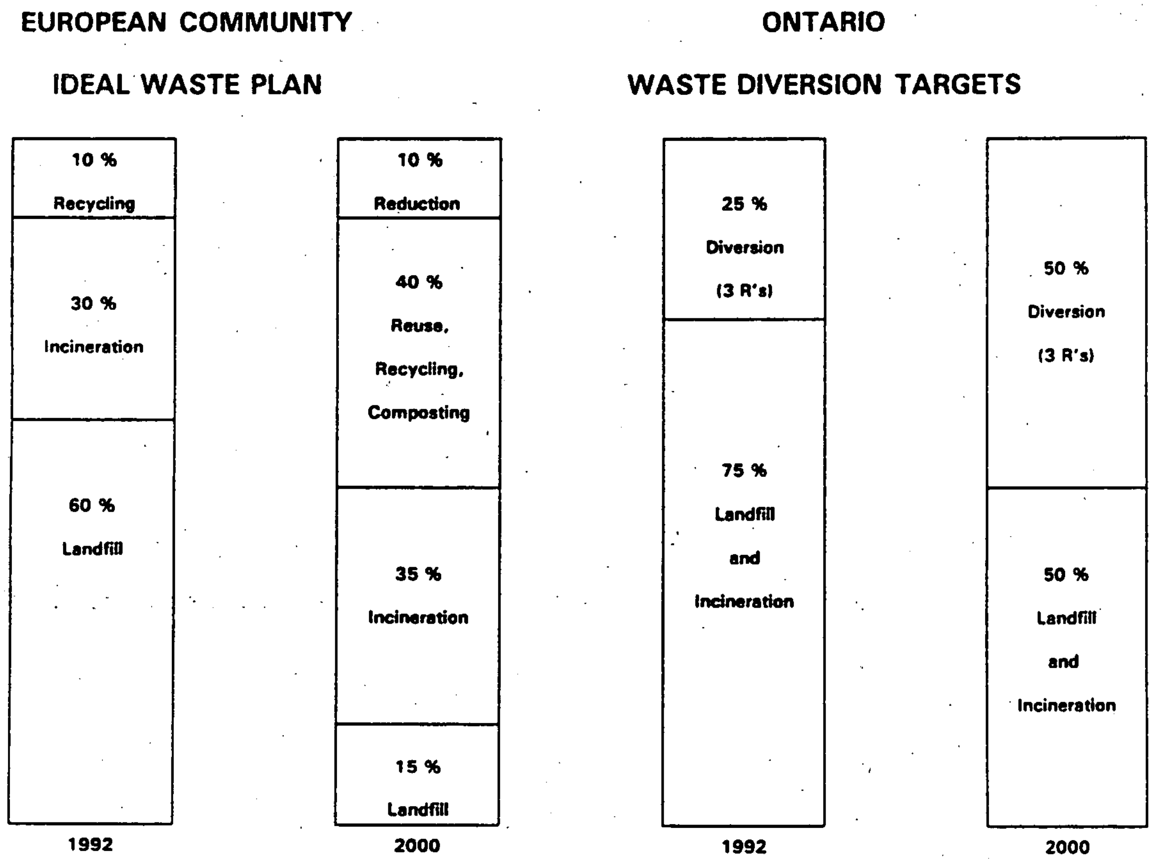


FIGURE 1: COMPARISON OF EUROPE'S AND ONTARIO'S WASTE MANAGEMENT STRATEGIES

As shown in Figure 1, 10 % of Europe's waste stream is to be recycled, 30 % is to be incinerated and 60 % is to be landfilled in 1992. According to the **Ideal Waste Plan**, by the year 2000, 10 % of the waste quantity is to be prevented (reduced) based on current waste generation data, 40 % is to be reused, recycled or composted, 35 % is to be incinerated and 15 % is to be landfilled. In comparing the **Ideal Waste Plan** with Ontario's **Waste Diversion Targets**, both strategies have set targets of 50 % diversion from landfill and incineration by 2000. The diversion targets are more detailed in the **Ideal Waste Plan** as diversion has been separated into reduction and reuse and recycling. In summary, Figure 1 shows that the diversion targets of Europe and Canada are essentially the same.

Although the diversion targets are comparable, this is not enough to be able to transpose European experiences to Canada. A comparison of the waste generation and composition data provides a more appropriate measure of compatibility. Table 2 provides a comparison of European and Southern Ontario waste generation and composition data.

TABLE 2: HOUSEHOLD WASTE COMPOSITION

	EUROPEAN COMMUNITY AVERAGE	SOUTHERN ONTARIO AVERAGE *
	350 kg/capita·a	410 kg/capita·a
MATERIAL	PERCENT COMPOSITION (by weight)	PERCENT COMPOSITION (by weight)
PAPER / CARDBOARD	25 - 35	30 - 37
PLASTICS	7 - 10	6 - 8
FERROUS METALS	3 - 5	3 - 5
NON-FERROUS METALS	0.5 - 2	1
GLASS	5 - 10	3 - 6
CERAMICS	1 - 2	-
ORGANICS (Food)	25 - 35	23 - 31
ORGANICS (Yard Waste)	10 - 15	10 - 15
HOUSEHOLD HAZARDOUS	1 - 2	0.3 - 1
MISCELLANEOUS	10	7 - 15

* ADAPTED FROM THE ONTARIO WASTE COMPOSITION STUDY, 1991 - 1992.

Table 2 shows that Europeans generate approximately 85 % of the household waste (350 kg/capita.a) that is generated per capita in Southern Ontario (410 kg/capita.a). In comparing the waste compositions however, it is clear that the relative quantities in each of the fractions are very similar. In comparing the putrescible waste fractions (food, yard waste and to some extent paper), the European fractions comprise 60 - 85 % of the total European household waste stream while these same fractions comprise 63 - 83 % of the total household waste stream in Southern Ontario. It is important to note that these quantities are generated quantities of organics and do not correspond to the organic quantities that are available for reclamation. Reclamation rates are generally much lower than waste generation rates. A realistic and technically feasible reclamation rate of 50 - 60 % of the waste generation rate is derived using an 80 % participation rate, a 90 % separation efficiency and 80 % reclamation efficiency.

It is also clear from the relatively large quantities of organics in Table 2 that the EC's and Ontario's waste diversion targets can be achieved only with the implementation of composting or anaerobic digestion. Therefore, based on the similarities in waste generation and composition data as well as the compatibility of the waste management targets, the transfer of experience from Europe to Canada seems reasonable.

Three phases can be identified in the history of composting in Europe. From the 1950's to early 1980's most compost facilities were composting municipal solid waste (MSW) and combinations of MSW and sewage sludge. This type of composting was undertaken mainly in France, the Netherlands, Austria, Switzerland and Germany. The resulting compost was marketed in vineyards, for landscaping purposes, and as landfill cover. Problems arose due to glass shards and other contaminants such as plastics in the compost. Discussions also arose regarding heavy metal contamination of soils as a result of the use of MSW compost. These problems spurred the separate collection and composting of organic residues in the Netherlands, Denmark and Germany during the 1980's.

With the current composting boom in Europe, the future of composting relies on environmentally sound biowaste collection programs and composting facilities as well as long term market opportunities for the compost product. Austria, Switzerland, the Netherlands, Denmark, Germany, Belgium and in some respects France and Great Britain have realized that compost from separately collected organics only have a long term future on the market. As a result of the problems related to mixed waste composting and market pressures, many compost facilities will only accept biowaste from separate collection programs. For example, the Singen compost facility has been converted from a mixed waste composting facility to a biowaste composting facility using the Brikollare composting process. Also, the composting facility in Bad Kreuznach co-composts biowaste and paper whereby the paper component of the input material is dominant.

Other dominant issues and problems that are currently being dealt with in composting facilities in Germany are related to odour control, and health and hygiene. Odour problems occur in a number of compost facilities in Europe. The Singen compost facility, the

Medemblick facility and the Bad Kreuznach facility (slides were shown of the facilities) for example, have odour problems. ITU is currently carrying out odour measurement and evaluation programs at various facilities (such as container systems - Stinnes, composting boxes - Herhof, rotating drum systems, Brikollare system, and windrow systems - Wendelin, Dynacomp) with the goal to optimize the composting process so that minimal odours occur. Odour problems are not necessarily manufacturer specific, as they are more specifically related to poor operating conditions in the facility.

The role of composting has been increasing in Europe, not only due to legislative incentives but also as a result of public perception that composting and recycling could eliminate the need for incineration. Unfortunately, reality does not correspond to the public's wishes in this case, as incineration continues to play a large role in European waste management strategies.

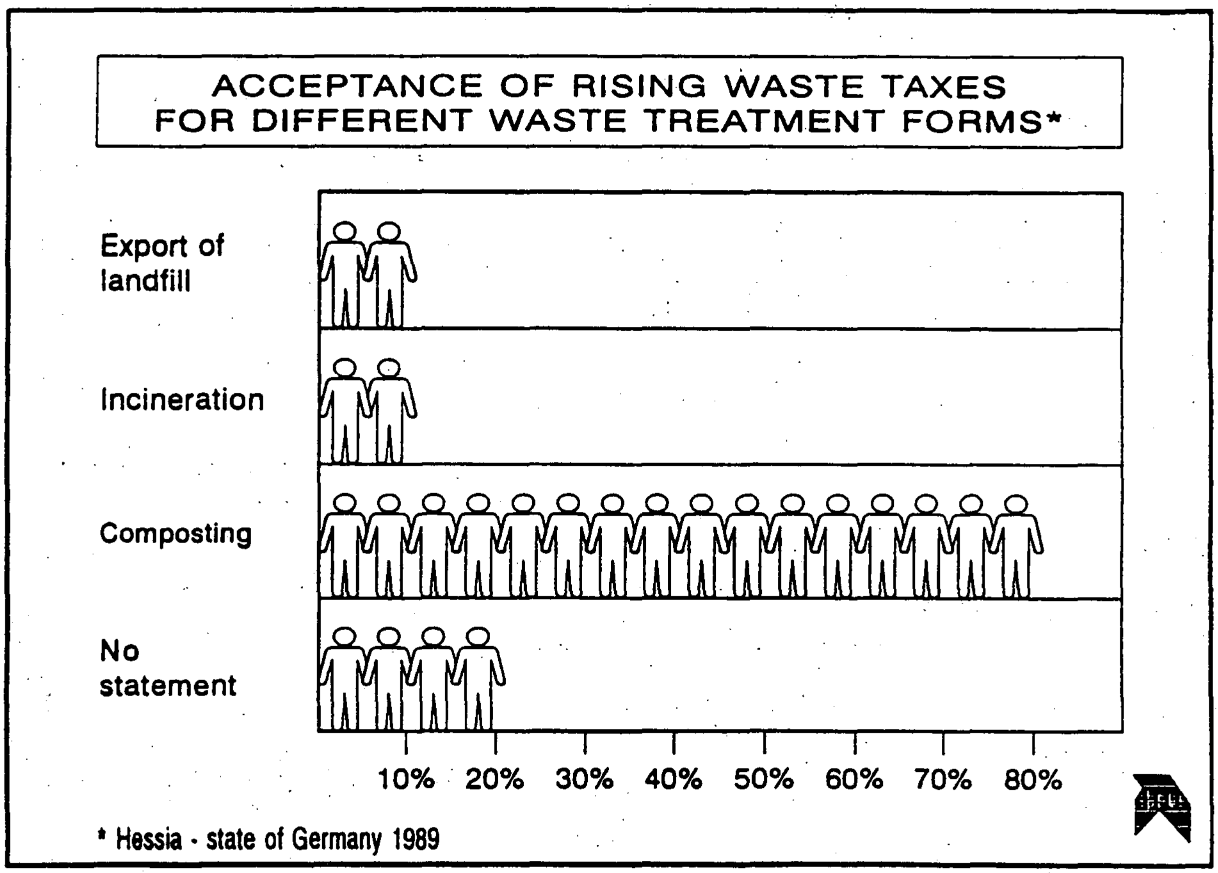


FIGURE 2: ACCEPTANCE OF RISING WASTE TAXES FOR DIFFERENT WASTE TREATMENTS

Using Germany as an example to illustrate the increasing importance of composting, Figure 2 illustrates the public acceptance of composting in relation to rising waste management taxes. The data shows that 80 % of the population would accept rising waste management taxes as long as they would be used to promote composting. The data was collected by means of a public opinion poll in the German state of Hessia in 1989.

Table 3 provides an overview of biowaste composting in Germany. By the year 2000 Germany has planned to serve 50 million people with separate biowaste collection programs. This corresponds to approximately 60 % of the country's population. The average per capita biowaste generation is 80 kg/a. This results in a total of 4 million tonnes of biowaste to be composted per year. With an average facility size of 15,000 t/a (which reflects two facility size classes - decentral facilities with inputs of up to 6,500 t/a and central facilities with inputs from 25,000 t/a to 50,000 t/a), 266 facilities would be required to treat the available biowaste. The current status shows that only 30 % of the required facilities have been constructed or even designed. These data provide an indication of the immense competition among the ten main German compost facility component manufacturers.

TABLE 3: OVERVIEW OF BIOWASTE COMPOSTING IN THE YEAR 2000

POPULATION SERVED (2000)	50 million
AVERAGE BIOWASTE GENERATION	80 kg/capita•a
QUANTITY TO BE COMPOSTED	4 million tonnes
AVERAGE FACILITY SIZE	15,000 t/a
NUMBER OF FACILITIES	266
EXISTING AND DESIGNED	20 - 30 %

However, as already mentioned compost quality is an essential component in compost marketing which is in effect the defining factor in the success of composting programs. The compost market is dependent on national compost standards which vary greatly throughout Europe.

The European Common Market will have to face a number of problems regarding the common compost market of the future. For example, without European-wide compost quality standards, unfair competition will arise among composting facilities in a country and among countries. The Organic Reclamation & Composting Association (ORCA) is a European organization with the mandate to promote composting in the EC. ORCA has defined the development of European-wide compost standards as one of their goals.

To develop meaningful guidelines for the EC, it is important to examine and compare the existing national guidelines of the member states. To do this, ORCA has developed a method to compare the existing guidelines. The following method has been developed to compare heavy metal limits.

A baseline weighting has been developed using the Dutch A List compost standards. These standards are the most stringent in the EC and therefore serve as the baseline for the comparisons. The Dutch A List as well as the weighting factors and weighted results are presented in Table 4.

TABLE 4: BASELINE FOR CALCULATING THE ORCA NUMBER IN THE COMPARISON OF HEAVY METAL LIMITS IN EUROPE

Baseline: Dutch A List			
METALS	LIMIT	FACTOR	WEIGHTED RESULT
COPPER	50	0.02	1
LEAD	50	0.02	1
CHROMIUM	100	0.01	1
NICKEL	50	0.02	1
CADMIUM	1	1	1
MERCURY	0.5	2	1
ZINC	200	0.005	1
ORCA NUMBER (sum of weighted results)			7

Using the compost standards of the Dutch A List, a factor was calculated so that the weighted result would be 1 for each heavy metal. Therefore, the Dutch A List has an ORCA number of 7.

As a further example, Table 5 shows the derivation of the ORCA number for the Belgian compost limits. Using the factors that were set using the Dutch A List, a weighted result was calculated for each of the heavy metals. These were then summed to produce an ORCA number of 56.5.

TABLE 5: EXAMPLE OF CALCULATING THE ORCA NUMBER FOR HEAVY METAL LIMITS IN BELGIUM

Example: Belgian Limits			
METALS	LIMIT	FACTOR	WEIGHTED RESULT
COPPER	500	0.02	10
LEAD	1000	0.02	20
CHROMIUM	200	0.01	2
NICKEL	100	0.02	2
CADMIUM	5	1	5
MERCURY	5	2	10
ZINC	1500	0.005	7.5
ORCA NUMBER (sum of weighted results)			56.5

A comparison of the heavy metal standards using the ORCA numbers for the European countries and for Ontario, Nova Scotia, North Carolina and New York is depicted in Figure 3. This figure shows that the Ontario Interim Compost Guidelines as well as Nova Scotia's guidelines for unrestricted compost are in the same range (for heavy metals) as the Austrian Biowaste compost guidelines and the German BGK compost guidelines. In comparison, both North Carolina's and New York's guidelines for heavy metals are substantially more lenient.

Based on this information, a parallel can be drawn between the European situation of varying compost standards and the need to develop a common set of guidelines and a foreseeable North American problem with the potential of a Canadian/US/Mexican free trading zone.

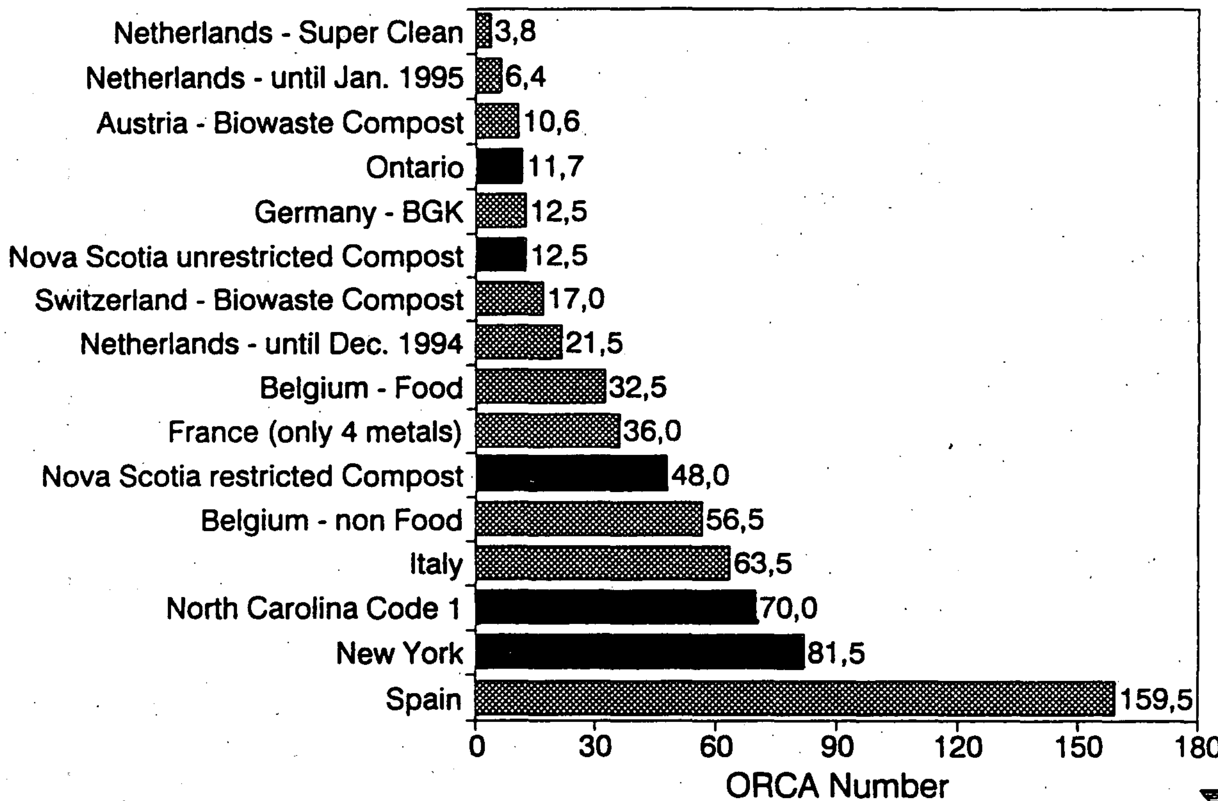


FIGURE 3: CALCULATED ORCA NUMBERS FOR A NUMBER OF EUROPEAN AND NORTH AMERICAN JURISDICTIONS

In conclusion, based on the compatibility of the European and Canadian waste generation and waste composition data, as well as the similar waste management targets, valuable lessons can be learned from European compost experience. For example, successful composting programs require good equipment, high quality input material and long term compost product markets. An important factor in obtaining and maintaining a long term market is a well developed set of compost standards that are consistent across a defined geographic area. In this respect, the Organic Reclamation & Composting Association (ORCA) in Europe aims to develop a set of compost standards for the EC. It may deem valuable to initiate a similar concept in North America since the possibility exists of a North American free market.

"The World is Our Classroom"

By: John Sherwin
Manager, Product Positioning
Novon Products Group
Warner-Lambert Company
Morris Plains, NJ

November 5, 1992

Good Morning. My name is John Sherwin. I represent Novon Products, a division of Warner-Lambert that is developing biodegradable materials to replace non-recyclable packaging and products. Because NOVON® specialty polymers are designed to be disposed of in biologically active environments, such as composting facilities, one of Novon Product's critical activities is to support the development of a sustainable composting infrastructure.

As a person whose background is primarily in marketing, I believe I bring a different and unique business perspective to the development of composting. What I see surprises and concerns me. You see we seem to be approaching the job of compost infrastructure development without looking at the product we are producing. This is like building a business from the bottom up, hiring personnel, renting a building, and creating an organization which operates efficiently, and then, not producing a product that anybody wants.

Sustainable Composting

=

Market Driven

+

Economically Justifiable
Collection & Processing

NOVON™

The same is true for composting. Regardless of the collection and separation techniques we choose, in order to make composting a sustainable activity, it must be market driven. This means that the humus must have value in the marketplace, and that the cost of collection and processing must be economically justifiable.

Environmentally and economically important decisions are being made over how to develop sustainable composting systems. In order to proceed there are many issues which are being looked at. I would like to discuss a few of them with you today. They include:

- Mixed vs. Source Separated Waste
- # of Collection Streams
- Aftermarket Development
- Collection/Disposal Cost

We have come together today in Ottawa to learn from each other, and I wish to share with you some lessons from around the globe. When it comes to the responsible growth of the composting infrastructure, the world is our classroom.

The growth of the composting infrastructure in Canada has been quite impressive, especially during a time of recession. Canadians have taken to backyard composting in record numbers. In Ontario, it has grown to the point where more than 20% of the population has a backyard composter. However, backyard composting cannot do the job of organic waste diversion alone.

To this end, more than 15 different centralized composting pilot projects have been initiated to collect and compost residential organic waste. They include the City of Guelph, Metro Toronto, Essex County, Mississauga, and Hastings County to name a few. The results have been impressive. Some pilots have reached diversion rates of over 80% of material going to landfill, and participation rates of close to 70%. When backyard and centralized composting of organics from residents and Industry, Commerce and Institutions (IC&I) work together, communities can exceed goals for municipal diversion. The question remains. With what processes, with what collection methods, and at what cost will we create a sustainable composting infrastructure?

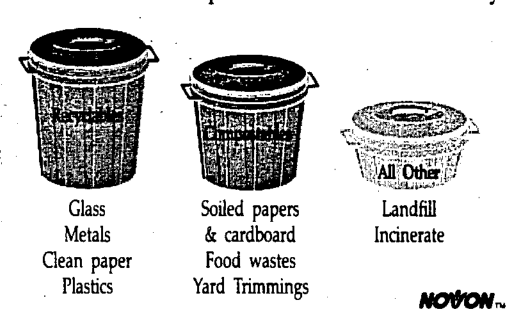
Let's see what lessons the world has to offer. While Novon Products has surveyed a number of countries in Europe on the state of composting, I will name only a few to illustrate a point. The experiences in these environmentally leading edge countries provide us with valuable lessons for what composting infrastructures work and why others have failed. Lessons that we can apply to the development of composting in Canada and the U.S.

In the German city of Saarbrucken, a plant run by SOTEC was opened in 1982 to compost one-stream, unsorted household waste for 200,000 people. But the plant has recently been closed by the local government. The problem was that the plant was trying to do sorting, composting, and recycling, all at the same time.

As a result, the quality of the recycled glass and plastics, and of the compost, suffered badly. The humus from this plant could not find a sustainable market. While you may argue that the technology for this system of waste management has improved since the SOTEC plant started up, it has given composting a black eye in this community.

As we look at the other countries in the European survey, it reveals much the same lesson. In Denmark, over the past three years, three plants have stopped producing mixed municipal waste compost. In Sweden, 10 plants have been shut down since the beginning of 1980, and in Belgium, mixed waste composting will be phased out by 1993.

Three-Bin Source Separation – Aachen, Germany



I won't pretend these examples represent all of Europe. Europe is a complex web of different countries with different environmental and political priorities. But, those who have had experience with failed mixed waste systems have opted to change their ways to collect and process three streams.

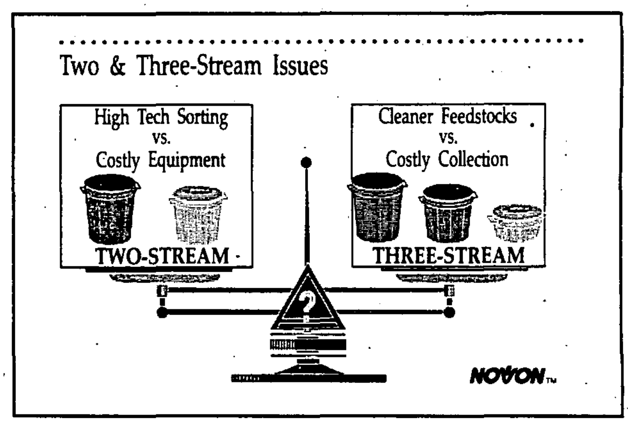
For instance, Aachen, Germany uses three-bin source separation for gathering clean organics. In the first bin are clean recyclables including glass metals, clean paper and plastics.

The second bin is for compostables such as soiled paper & cardboard, food waste and yard trimmings. The third bin is the remainder which is destined for incineration or landfill.

In Aachen, the clean organics are taken to a composting plant run by a company called GAB which is producing high quality humus with marketable value. Only with a valuable end-product were they able to close the loop to make composting a sustainable activity.

I am pleased to say after reviewing what happened in Europe that Canada took to source separation right from the start. But Canada, is at a crossroads. The discussion here is not about whether to source separate, but how to source separate. Each of the pilot project communities is trying to decide how many streams of separation will divert the most materials cost effectively.

Basically, there are two workable solutions: two or three stream source separation. In a three bin system, the compostable bin takes in only organic compostables, since there is an "All Other" bin to handle non-organic materials. In a two bin system, the recyclable bin takes only clean recyclables, and the second bin takes everything else.



Many of us are involved in evaluating the pro's and con's surrounding these methods. On the one hand, contaminants in a two bin system can be removed by high tech sorting equipment. On the other hand, the facility and equipment might be cost prohibitive. The same kind of hypotheses are developed for three bin systems. On the one hand, a three bin system probably generates cleaner feedstock. On the other hand, it could be more costly in collection.

Let's again look at what the world has to teach us. I offer you the results of two different studies on the costs of composting collection and disposal.

The first study tries to evaluate the cost differential paid by homeowners with two and three bin systems. The study took place in Minnesota and compares the two stream counties of Prairieland and East Central to the Three Stream Counties of Filmore and Swift. The cost of collection and disposal to households in the two stream communities range from $11.00 to $18.00. At the same time, the costs were comparable to the three stream communities who paid $13.00 to have their wastes collected and processed.

It is generally assumed that the addition of a third container will add substantially to collection costs. However, the haulers in these communities took steps to keep the cost of collection contained. Filmore County haulers have adapted their collection systems so that landfill destined materials are collected at the same time as recyclables by pulling a trailer behind the recycling truck.

In Swift County, by collecting the compostable and landfill portions of waste in the same vehicle, only one trip is required to each house each week. This can be accomplished by compartmentalizing the vehicle, or co-mingling different colored translucent bags, as is the case in Swift County.

The initial conclusion from the study suggests that the three-stream collection costs were comparable to the two-stream systems. Other information from this study will be published in the November issue of Biocycle magazine, and as the author points out, even more research is needed so that innovative collection systems and schedules can be evaluated to minimize the cost of three bin systems even further.

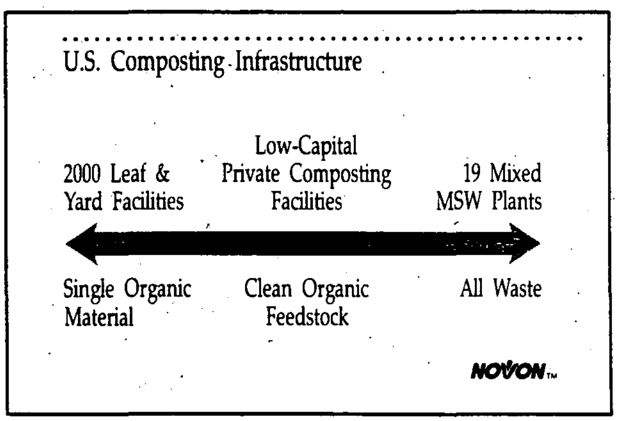
Another study comes from ORCA - The Organic Reclamation and Composting Association in Brussels, the European counterpart to the CCC. This study expands on the one done in Minnesota by including all costs from the start of collection to the final fate of the materials. However, the conclusion is quite the same.

Household costs are measured in European Currency Units (ECU's), and the study shows that the three stream method costs households 125 ECU's per year. However, households spend roughly the same for the two stream method of collection and disposal. In addition, the diversion of material only increased by 5% to a total of 60% when a two stream system was used.

Justifiably, two stream systems will divert a slightly greater percentage of the waste stream than in a system that has a convenient "garbage" can. However, there is also the need to sort out more contaminants. Maybe we can mechanically sort out these materials from the compost. But it will take costly sorting devises to do it.

This discussion surrounding costs of collection, separation, and equipment often causes us to overlook one of the most important factors: aftermarkets.

All over the world we are now evaluating how to set up systems which will capture as much of the waste stream as possible AND create a marketable end product. I would like to share with you examples of successful, sustainable composting companies and how they came to be that way.



In the U.S., the composting infrastructure started much the way Europe did, at the extremes. On one extreme we have 19 Mixed MSW plants, and on the other we have nearly 2000 leaf and yard compost sites.

Similar to the European experience, the U.S. has recently seen its mixed MSW compost facilities fail, including the Reidel facility in

Portland, Oregon, and Agripost in Miami Florida. But at the same time, we have seen private companies seize the opportunity to start low capital composting facilities to capture source separated organic municipal and IC&I waste.

Examples of these businesses in the northeastern U.S. include EarthGro, in Connecticut, American Soil, in New Jersey, Compost Connections in Maine, and Organic Recycling in Valley Cottage, New York.

While these operators accepted only the strictest of organic materials at the start, they are expanding their feedstock base into a broader range of compostable organic products that include food scraps, soiled paper, soiled corrugate, and more. Because they are not burdened with high overhead costs, such composters are achieving strong, multi-region growth. The key to their success has been starting facilities with:

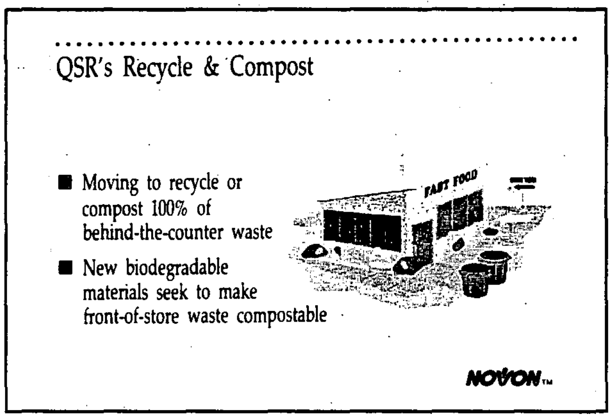
- lower capital investment.
- controlled-loop feedstocks.
- direct marketing of their end products at retail.

They incur lower capital costs because they are sized to take only part of the municipal waste stream. The feedstocks come from such sources as back-door food waste from Quick Service Restaurants (QSRs) and cafeterias, or from municipal leaf and yard collection. In addition, the end-product is of such high quality, they can sell it at retail. Earthgro for instance, is selling 20lb. bags of their highest quality humus for roughly $5 U.S. per bag.

Why is market development so critical to the success of composting? Just look at the lesson to be learned from recyclers. Across the continent they are stockpiling mixed glass, newspapers and plastics until there is a market for them. Mid-sized composters don't have this problem. In fact, now they are clamoring for feedstock. As they look for more organics they are expanding the types and sources of their inputs, while still maintaining high quality standards to ensure that their end-product has value at market. Communities and cities in Canada can also seize this opportunity to develop the composting infrastructure through partnerships with IC&I and municipalities.

The opportunity for diversion is ripe when you look at the organic IC&I generators. In Canada, the Ministry of the Environment published the Commercial Waste Composition Study in July last year which showed that 53 percent of large supermarket waste is organic, as is 58 percent of licensed restaurant waste. Even take-out restaurants where you would expect the waste to be "taken out" has 55% organic waste in the store.

In order for provincial waste diversion goals to be met by selected IC&I sectors, composting will have to be an integral part. In addition, the waste generators want to participate, not only to reduce waste management costs, but also to show their commitment to preserving our environment, particularly as it impacts an already overburdened disposal infrastructure in the very communities they are situated in.



Working in close cooperation with the Environmental Defense Fund, McDonald's Corp. has achieved international acclaim for its major leadership efforts to reduce, recycle and compost. Through simple source separation techniques, QSRs are demonstrating that it is possible to recycle or compost virtually 100 percent of behind-the-counter waste. By applying new materials technologies, the same becomes true of in-front-of-the-counter waste.

Biodegradable material technologies will, in the future, create major and exciting opportunities for designing broader and broader categories of products and packaging that are compostable. As this happens, the case for three-stream collection programs grows stronger because the widespread replacement of non-recyclables with organic compostables makes the achievement of high quality compost easier and easier.

My theme today was the world is our classroom. No doubt, the teacher is still in, and the lessons will continue, for there are many things we still don't know. But let's review what lessons the world offered us today. First, mixed MSW systems have real economic and public perception problems. Second, the jury is still out on two and three bin systems, but some of the support for two-bin systems has been refuted by the research and pilot studies we discussed. Third, the addition of a third bin doesn't necessarily increase costs. And finally, a positive sort on organics creates humus that is valuable and essential to closing the loop.

I raised these examples not just to draw these specific conclusions, but to raise our collective consciousness about what needs to be considered in developing sustainable systems for handling organic waste. Only systems which are market driven and economically justifiable have the best chance of creating a sustainable composting infrastructure.

EDUCATION PROGRAMS FROM A COMPOST DEMONSTRATION GARDEN

by

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Canada is one of the most wasteful nations in the world.

Dealing with our garbage is an urgent problem, as landfill sites close and population and waste quantities increase.

The Greater Vancouver Regional District is a partnership of eighteen (18) municipalities covering twenty-eight hundred (2800) square kilometres. It is responsible for providing essential region-wide services to half of the province's population, 1.6 million people.

Two (2) million metric tonnes of waste is produced each year. In our region, one of our landfills, Port Mann, serving the eastern section of the district is scheduled to close in the mid-1990's. The Regional incinerator and the Cache Creek landfill are reaching their capacity.

The population is expected to grow to 1.9 million by the year 2000. It is estimated that 2.6 million tonnes of waste will be produced, more than the existing system can handle. In GVRD's **Creating our future: steps to a more livable region** priority is given to the **3 Rs: Reduce, Reuse and Recycle**.

Reducing the quantity of waste at source is the most enduring and cost effective method available.

Composting reduces the waste that requires disposal by recycling organics into a soil amendment. It also reduces municipal disposal costs by eliminating the handling. Another R that composting contributes to is the reclaiming and renewal of depleted soils.

Composting that one-third of organic matter that makes up the waste stream makes good economic sense and is a wise conservation practice. To treat the earth with respect for the benefit of all generations is the stewardship that is required in a sustainable society.

A sustainable society must translate into individual action if there is to be any impact at all. Backyard composting is an individual action and is particularly relevant on the West Coast where the landscapes remain green all year round. Education is a key in achieving the 50% reduction in waste by the year 2000.

The goals of our education program is to: 1) build public understanding of the ways in which individuals can avoid or reduce the amount of waste they produce by composting, 2) educate about the proper procedures for composting.

The two main audiences are: a) home owners and b) school children.

Education consists of:

- one to one instruction
- school programs
- evening and weekend classes
- hosting a compost network group regularly
- ongoing support to compost practitioners
- acting as a municipal resource in training staff and volunteers, and developing new gardens
- participating in the GVRD in-house program
- funding a compost hotline
- acting as a resource for other regional districts.
- providing technical training to compost staff

The GVRD is the first government to have seen the wisdom in establishing an actively staffed Compost Demonstration Garden. Its purpose is to promote and educate about backyard composting as a means of reducing the residential waste stream. The garden is a cooperative effort by three levels of Government: the British Columbia Ministry of Environment, Lands and Parks, who provided one-third of the development costs, the City of Burnaby who provides the land, and the Greater Vancouver Regional District who is responsible for operational costs, as well as program development.

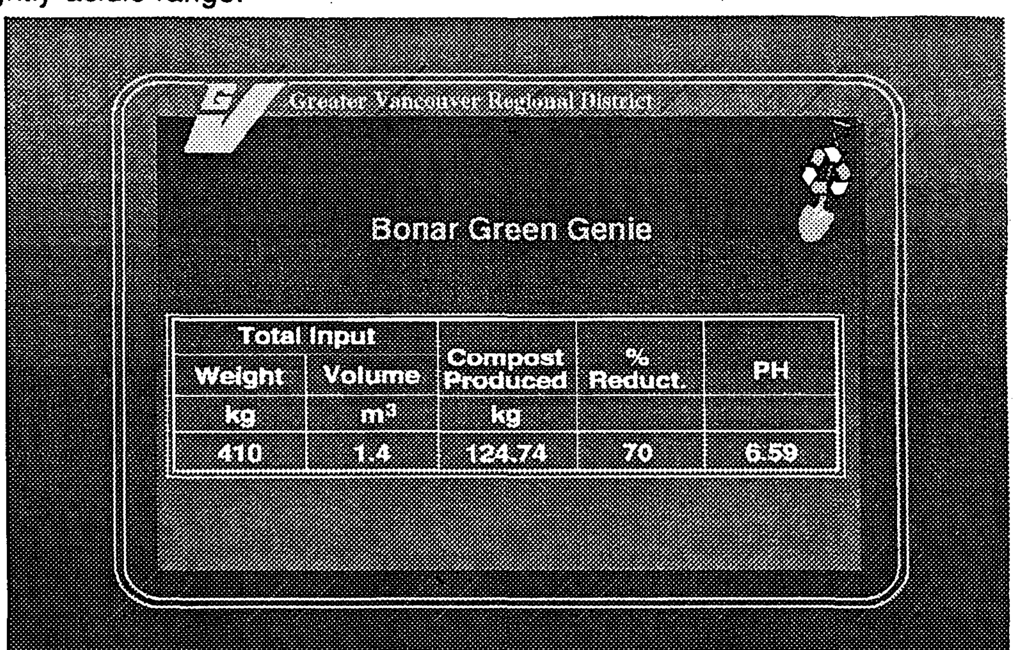
The garden is designed as a typical residential backyard. Promoting the advantages and possibilities of home composting the garden is staffed seven (7) days a week from March until the end of October.

Regional residents visit the garden to find out why, when and where to compost. They inquire on specific problems: "I'm putting all my grass clippings and food waste in my composter, why does it stink?". The garden is very much a "show and tell" facility where residents can also view the results of using compost. No chemical fertilizers or pesticides are used in the garden just compost, compost tea and then more compost.

Assistance is provided in helping the public make the most effective choice of available rodent resistant compost bins. Commonly asked questions are: How often do I add water or aerate material?, What size of a container do I need?, What is the capacity of this container?

In answering these questions the results from compost bin trials provide valuable information. The practical trials include procedures as: the weighing of nitrogen-rich and carbon-rich materials; temperature monitoring; the percentage of reduction; and the analysis of the compost produced.

Twelve (12) rodent resistant yard waste composters are on display and six (6) worm composting containers. A brief glimpse at the trial results indicate a reduction rate in feed stock material from 59% to 83%. The pH level from 6.1 to 6.8 is in the neutral to slightly acidic range.



Total Input		Compost Produced	% Reduct.	PH
Weight	Volume			
kg	m^3	kg		
410	1.4	124.74	70	6.59

FIGURE 1: BONAR GREEN GENIE

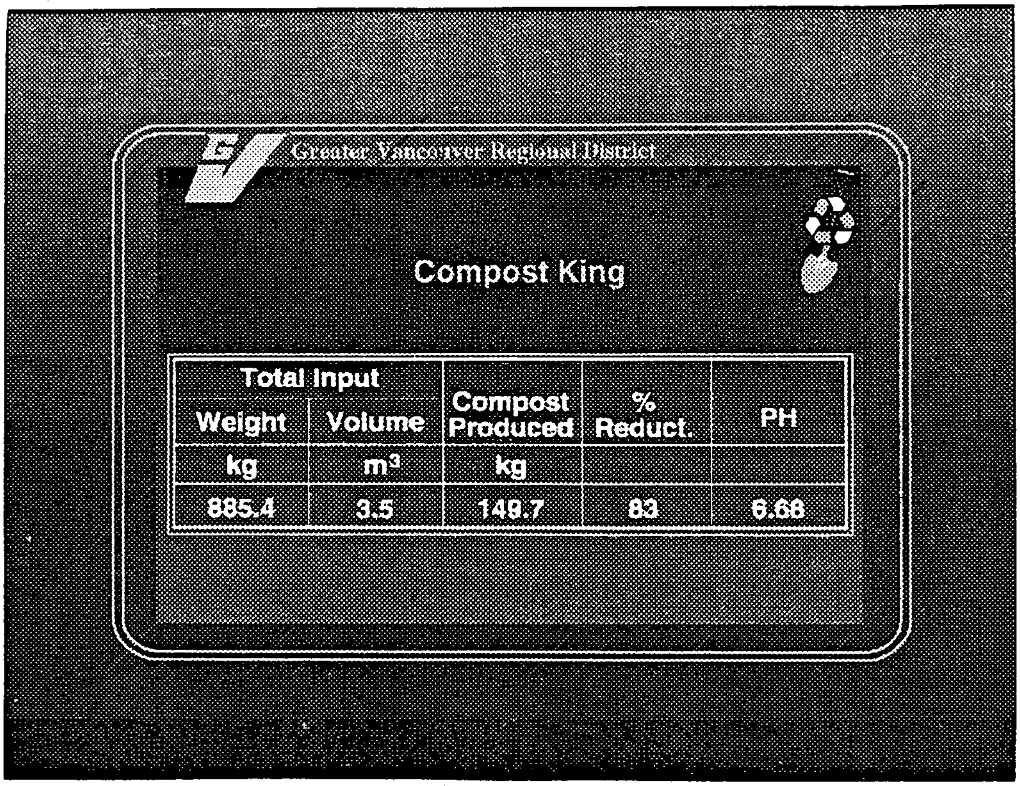


FIGURE 2: COMPOST KING

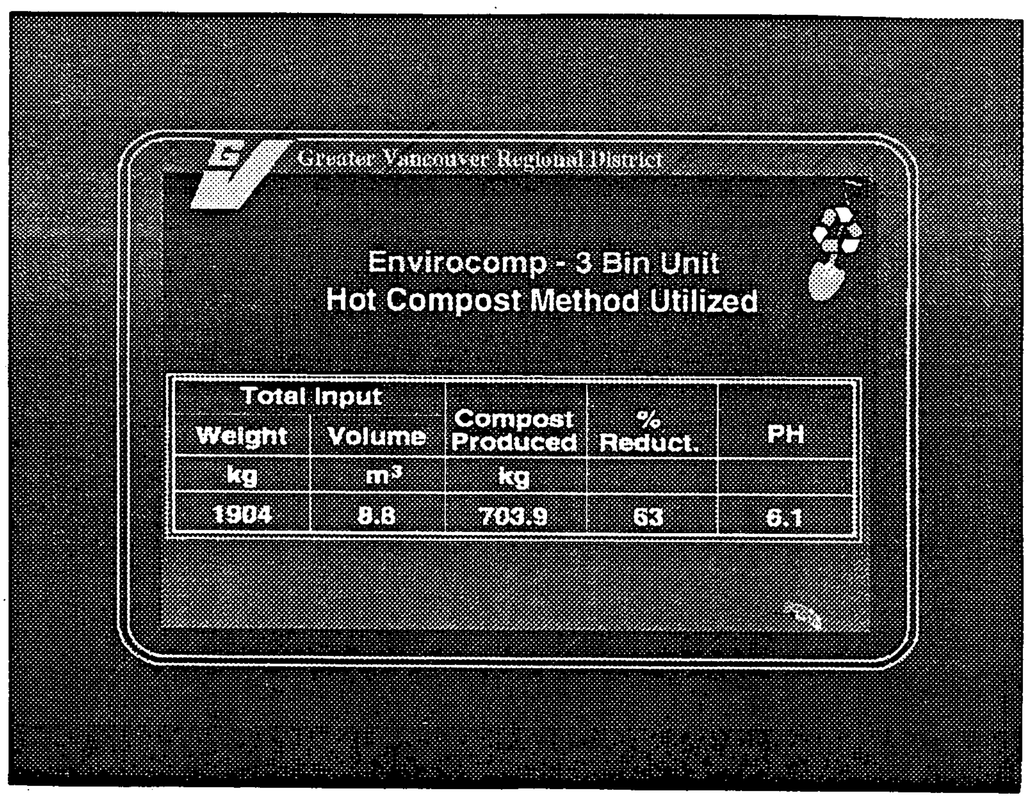
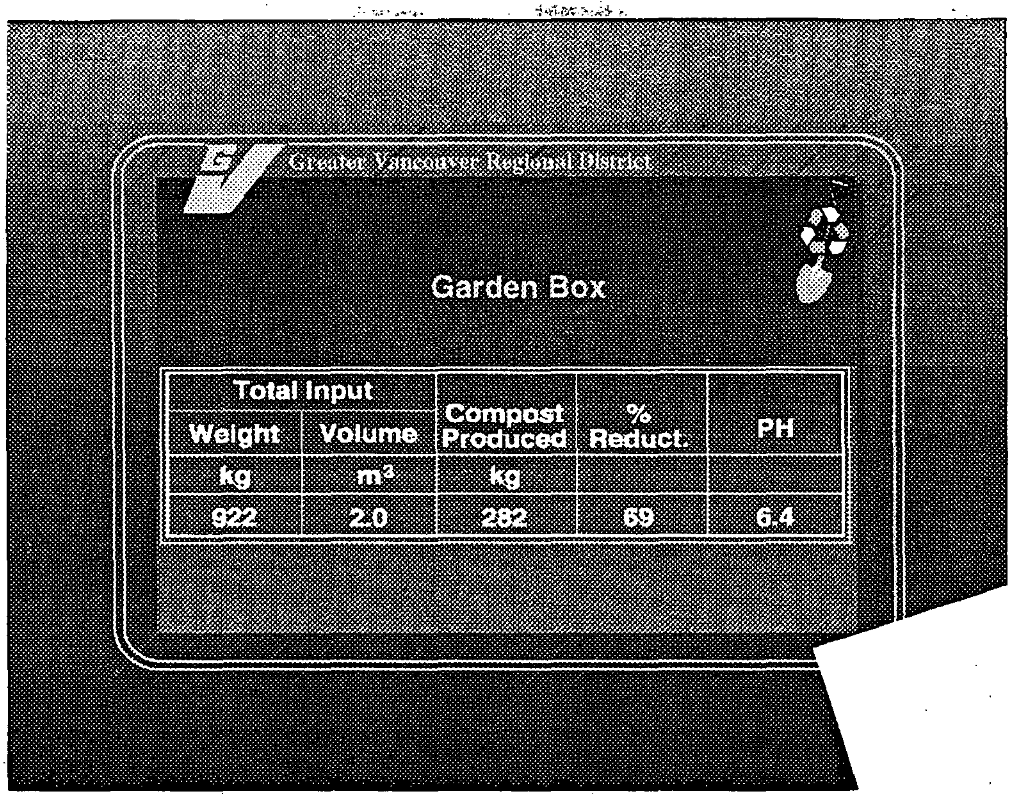
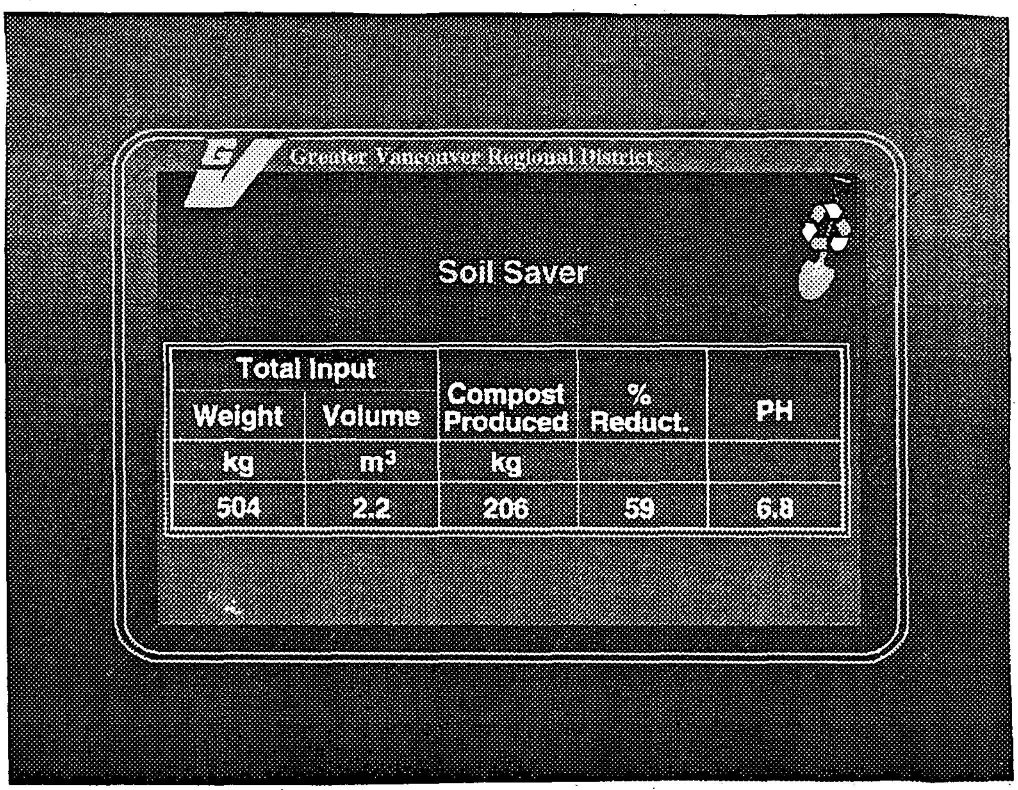


FIGURE 3: ENVIROCOMP



Total Input		Compost Produced	% Reduct.	PH
Weight	Volume			
kg	m³	kg		
922	2.0	282	69	6.4

FIGURE 4: GARDEN BOX



Total Input		Compost Produced	% Reduct.	PH
Weight	Volume			
kg	m³	kg		
504	2.2	206	59	6.8

FIGURE 5: SOIL SAVER

The compost produced is used in the garden. We also do trials where plants are grown in compost, then using the same plant stock but without compost a difference in size, health and colouration can be noted. The benefits of composting are promoted to residents through workshops that teach the basics of yard waste composting and worm composting. In 1991, thirteen (13) workshops reached 203 people and in 1992 twenty four (24) workshops were held for four hundred and twenty-seven (427) residents. Taxpayers are made aware of money saved through avoidance of not disposing of their organic waste. This is brought closer to their pocket books as more municipalities move towards charging user fees for generating more than two (2) containers. The value and uses of compost produced are discussed. The additional savings in not purchasing chemical fertilizers or amendments is also emphasized.

Community outreach events provide contact with thousands of people who have not yet considered composting as a means of waste reduction. We host tours for politicians. We lecture to horticultural students at community colleges. Presentations are given at provincial Home and Garden shows, as well as the botanical gardens.

Youth Groups

The GVRD has been presenting waste reduction information to schools since 1983. In 1990, the program was reaching ten thousand (10,000) students per month. Evaluation in 1991 resulted in a new revised education package entitled "No Time to Waste" which has just been released. Presentations to teachers in a train-the-trainer approach is emphasized. It contains an enlarged section on composting with many activities and learning situations which are designed to fit with the Provincial Education 2000 philosophy.

Compost education workshops that take place in the garden help school children discover what makes up the waste stream and how they can compost yard and food waste.

Here is a brief glimpse of the primary children's hands-on experience in creating a worm bin for their classroom.

Children bring along the luncheon waste they have collected at school to the garden. This we find enables them to find out the food waste that is appropriate for composting. We lay out the raw food waste on a tray. On another tray the finished product of worm castings are layed out. We ask "How do you think this change takes place?" Sometimes the answer is magic but most often "the worms" is found as the reason. We spend time introducing the children to the worms. That worms have five (5) hearts so they have a lot of feelings. Worms cannot possibly hurt you but you could hurt them. So please be gentle with them. Then we pass the worms and their cocoons around so children can observe, touch or hold these marvellous little creatures. We discuss the needs of worms and how we are creating a home for them. Each child has a little bucket in which they make the bedding. Newspapers are torn into strips approximately 2.54 cm wide. Leaves, straw, and sawdust are mixed and moistened. We do stress that leaves are the best source for bedding and add more at this time. The finished bedding is then placed in the worm bin which has aeration/drainage holes. Two (2) handfuls of soil is distributed throughout the bedding and discussion takes place on how the worms use the grit or soil to aid the gizzard in grinding the foodwaste. All this material is fluffed and mixed and is ready for the food to be buried. Next come the worms and the children watch them closely as they quickly disappear in the bedding.

Children have learned about the care and feeding of the worms and the results of making compost. The children prove to be bright, eager, enthusiastic and very knowledgeable regarding the part they play in the future of the environment. The worm bin is brought back to the classroom to recycle their food waste.

Using worm bins for food waste by people in apartments developed through the desire of individuals who wanted to participate in reducing their garbage. When the garden first opened, we had one worm bin made from a recycled plastic food drum. Over time, people with exclusive condos came looking for an alternative. A wheelchair accessible pine worm bin with flower planters on either side that can easily be brought into the kitchen for the winter is popular. As well as a pine bench which will process six (6) pounds of food waste per week.

Education materials developed by the GVRD for the composting education program consist of:

Video: "Here's the Dirt", a guide to backyard composting. It has been requested from across Canada and has been distributed locally to libraries, municipal coordinators and has been picked up by cable companies that give it good view time on television.

"Here's the Dirt" brochure which is distributed through the demonstration gardens, along with municipal bin distributions, and is now being used in the province by the Ministry.

We have the GVRD guide to worm composting, as well as an interactive, animated video on composting on permanent loan to Science World.

Fact sheets are available - "The World of Worms" is widely used by teachers and bibliographies of books for children and adults which can be borrowed from regional libraries.

Evaluation of Program

Over 12,000 Lower Mainland residents have recorded their signature in our guest book with positive feedback. Adult workshops are filled after one day of advertising and waiting lists established.

Municipal bin distributions are in popular demand with 23,000 Lower Mainland residents receiving a composting bin for minimal cost from 1991 to 1992.

In 1991, we hosted 12 workshops for 320 school age children. This year, school workshops went from one day a week to two in order to try and accommodate requests. In the 38 workshops given 1,016 school children discovered how to recycle food waste to compost. Our telephone information service handles around 400 calls per month.

Conclusion

The garden is just one of the initiatives that the GVRD has developed in education programs. Seeing is believing. Not only is the garden a delightful oasis, but seeing the process and the results motivates individual action, allays fears of odours and rodents and it also promotes regional waste reduction goals.

There are eight demonstration gardens operating in the region with four additional gardens being developed. All provide a valuable public education service. Crescent Beach is going to compost with eighty (80) Surrey schools this year. The City of Vancouver garden run by City Farmer's Mike Levenston makes an unique contribution to all.

Our common goal is composting. It provides an economical means of reducing the waste stream and produces a valuable resource. By returning organic material to the soil and begin part of the natural cycle of life, we contribute to a sustainable society.

"But Does It Stink?"

OR

How to Set Up a Backyard Composting Demonstration Garden

Prepared By

Geraldine King
Manager of Environmental Initiatives
City of St. John's, Nfld.

For The
Composting Council of Canada
2nd Annual Meeting
November 5 - November 6, 1992
Ottawa

Background:

In April 1991, the St. John's City Council directed staff with the Department of Engineering and Works to investigate the costs, benefits and procedures involved in becoming an affiliate of Keep America Beautiful, Inc. - an international non-profit, public education organization dedicated to improving waste handling practices. The formation of a new organization called St. John's Clean and Beautiful was the result. The organization was certified as a member of Keep America Beautiful, Inc. on October 3, 1992. While St. John's Clean and Beautiful operates as a separate, non-profit organization, it does receive financial support from the City of St. John's. At the organization's first Board of Directors meeting, eight subcommittees were set up, including a Solid Waste Management Committee. The Solid Waste Management Committee was initially made up of seven volunteer members. The City's Manager of Environmental Initiatives is also a member of the Committee.

Introduction:

Jan. 1992

The Committee examined a number of waste diversion and waste reduction programs, projects and technologies. Some of the options considered were too expensive, others were beyond the reach of a small group of volunteers. It should be noted that St. John's does not have a Blue Box Program or other curb side collection program. There is one private company in the City that operates a drop-off site for aluminum cans, plastic pop bottles, newspapers and bond paper. There is also a pilot recycling project in the West End of the City operated by a non-profit group with assistance from the Environmental Partners Fund, the City of St. John's and Mill Lane Enterprises, an outreach program of one of the City's hospitals. This is a drop-off program as well. The Committee decided to stay away from any type of collection/ recycling program and look at waste reduction ideas.

A Backyard Composting Demonstration Garden was decided upon as the ideal first step in dealing with waste reduction. The project appealed to the Committee since it would help educate residents about composting and waste reduction and would also introduce residents to the idea of sorting their waste at the source. It was hoped that this would create awareness of what is in everyday garbage. The Committee felt that this would not be too difficult a project to organize and decided upon June 3 as the date for the Grand Opening.

Getting Started:

Feb./March 1992 A proposal was prepared by one of the Committee members outlining the rationale for the project, the goals and objectives of the project, and an action plan. It also requested approval from City Council for use of a site in Bowring Park, one of the City's most beautiful, well known and well used parks. Bowring Park has a very high volume of visitors, is owned by the City, and has the necessary technical expertise and infrastructure required. It also has an aesthetically pleasing natural environment and is close to the Waterford Hospital, the intended source for the composting material.

Other Committee members began various tasks such as writing letters to manufacturers and suppliers of composters, requesting their participation in the project and asking if a free sample of their product could be provided. An application was forwarded to the Canada Employment and Immigration Centre for a Challenge '92 grant. This would enable the Committee to hire two students to staff the site.

The Waterford Hospital was contacted and asked to participate by saving "compostables" from the hospital kitchen for use in the garden. The hospital was also asked if residents from the hospital would be interested in participating in the project. This could involve delivering the material to be composted or working in the garden (planting, weeding, turning compost, etc.).

April 1992

The proposal for the Garden was on the Agenda for the Regular Meeting of City Council on April 7. During the discussion one of the Councillors had the following comment, "I have a question. Does that stink?" This comment notwithstanding, Council approved the request for the site for the project.

On April 17 the Committee made its first visit to the area that Park's staff had allocated for the project. It was a bit removed from the high traffic areas of the Park but the location would be very suitable for gardening and composting. There were a few problems noted at this first visit - there was no water supply or electricity near enough for use by the staff. This was also the day the Committee visited the Trouter's Special Worm Farm and made preliminary arrangements with the owner to put a worm bin at the project. The owner of the worm farm was very enthusiastic about the project and joined the Committee as a very welcome and much needed member.

Setting Up:

May

In early May the Committee spent a Sunday at the site. Branches were trimmed, stakes placed to show the boundary of the garden and rough trails were marked out. By this time, one Committee member had resigned. This was the person responsible for obtaining composters. Another member volunteered to fill this role. The Provincial Department of Health also entered the picture and advised that the Waterford Hospital could not participate until certain questions were answered and certain requirements met. Eventually health officials were satisfied with the planned operation of the project.

By mid May things were slowly getting put together. Two Committee members agreed to build a selection of "homemade" composters and one of these members also started work on a brochure and a handbook.

The application for CEIC funding was still somewhere in the federal process but CEIC officials could not tell the Committee whether the application would be approved.

June

By the first of June the Park's staff had the site tilled and had agreed to fence the area. The Committee also contacted CEIC again for information and was told that the application had been rejected. This would mean no funding for the two students needed to staff the project. However, the Committee maintained its spirit of optimism and kept working. The City's Recreation Division was approached for assistance with staffing.

By mid June the composters had started to arrive from various sponsors. Two "homemade" models were completed and the "worm" brochure was ready. The June 3 Grand Opening had obviously been forgotten about. The Committee members were almost ready to throw in the "trowel" when the Recreation Division agreed that two students could be hired. More phone calls were made and two really wonderful University students were found who were interested, willing to work and who were not afraid of the worms. They were hired for eight weeks. A local company agreed to donate a new shed for the project. Finding a storage shed had been a problem up to this point. The shed was delivered to the site in a small box and the "500,000" pieces in the box required that Park's staff (again to the rescue!) to spend two days putting it together.

The Committee members spent Sundays in early June at the site, raking, spreading topsoil and mulch, making walking paths and arranging composters. Another homemade composter was finished and the handbook covers were completed.

Grand Opening:

June 18, 1992

On Thursday, June 18, the official opening of Avalon Gardener, the City's first Backyard Composting Demonstration Garden took place.

Invitations had been sent to the media, government officials, business representatives, community groups, and interested members of the public. The local militia had agreed to set up two tents for the reception and the special worm signs made by the City's Traffic Division Sign Shop were in place to lead the way to the site. Everything was finally ready. At 1:15 p.m. CBC Radio Noon did a live interview with the Coordinator for St. John's Clean and Beautiful at the site - in the heaviest rain storm ever experienced in St. John's! The opening was cancelled. A few brave souls (the Committee and family members) met in the Park's main public building and enjoyed the luncheon. The daily City paper and the weekly paper did send representatives to the event. Both reporters stayed for coffee and took the specially decorated press kits back to their respective papers.

Late June & Early July, 1992

The weather continued to be cold, wet, damp and miserable. The students spent most of the time in the kitchen of the Park's maintenance shed. The worms went back to the Worm Farm until things improved. The Committee did manage to get in a late planting of vegetables and flowers.

Other problems were also surfacing. All the worms signs were stolen. The Waterford Hospital decided that "compostables" could be provided but residents would be unable to participate in the program because of limited staff to supervise those involved. Again, Park's staff agreed to help by picking up the bin, and delivering it to the site. A second bin was purchased so that the hospital always had a container in the kitchen.

Mid July, 1992

When the weather improved, the visitors to the site were very impressed with the concept. All the comments recorded in the visitor's book were enthusiastic and rewarding to read. However, most of the people who visited the site came upon it almost accidentally when walking on one of the paths through the Park in the area of the project.

The Committee soon realized that more promotion was needed, the planned workshops had not been scheduled by the students and new direction signs were required throughout the Park.

By this time, summer vacations, burnout, work committtments and family needs started to affect the Committee members' participation.

August, 1992 The students did finally hold one workshop for children. This event was very successful, but since it was held in August, another workshop was not possible. On August 19, the Mayor and a few of the Board members for St. John's Clean and Beautiful visited the project and then hosted an afternoon tea at the Park for the Committee and staff involved in the project. While they were very impressed with the work, it was noted that more publicity would have made a tremendous difference in the number of visitors. Bowring Park is regularly visited by at least 5000 people every day during the summer months. Only 700 of these visitors found their way to the site.

On August 24, three of the Committee members spent the evening removing the composters and storing them in the Park's compound until next Spring. The shed was moved into the compound by Park's staff. Unfortunately, it blew into a fence during a wind storm and was so badly damaged that it cannot be used again.

Conclusion/Recommendations:

The Committee spent an evening reviewing the project and made the following recommendations for next year.

- A project manager must be hired. This person should start work on April 1 and continue until November 30. This will ensure that the project can become a permanent fixture in the Park, rather than a seasonal one. A manager will also ensure that the summer staff carry out expected and required responsibilities. Funding for a salary for this position may be available through the Federal Government Section "25" Program. "Challenge" grants will still be required for summer students to staff the site.

- Advertising and promotion is a necessity and cannot be left to the discretion of summer staff. St. John's Clean and Beautiful has a Communications Committee that should take on this responsibility.

- Direction signs are required. Again, waiting for signs to be prepared by summer staff is not practical. In 1993, the Committee also hopes to have our unique "worm signs" made to sell at the site. This may reduce thefts of the Park's signs.

"Avalon Gardener" was well received by staff at all levels of the Park's Division. The Manager of the Division sees the project as an important segment of the City's proposed "Formal Garden" and "Garden of the Senses". These projects will eventually be established in an area near the compost project.

The City of St. John's is proposing a pilot Composter Program for 1993 and hopes to involve 500 homeowners. This program would provide composters and worm composters at reduced rates. The City is also developing a Composter By-Law. The Avalon Gardener project will complement both programs by providing residents with information on how to compost properly.

Other Findings:

The Black Earth Machine (manufactured by Norseman Plastics) and the Homemade Portable Wood and Wire Composting Bin were the most efficient units used. The rotating composter was very inefficient and would not be recommended for use.

And to answer Councillor Wyatt's question - "No, it doesn't stink".

Overall:

This project was considered a successful undertaking for the St. John's Clean and Beautiful Organization and for the City of St. John's.

The salaries for the students totalled approximately $7,000.00. St. John's Clean and Beautiful statistics show that $1,500.00 in volunteer time was donated to the project and donated goods and services totalled $3,075.00.

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Backyard Composting Demonstration Project

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March 18, 1992

The City of St. John's is examining various waste diversion and waste reduction options to extend the life of the Robin Hood Bay Sanitary Fill. Some of these options, such as Municipal Composting, would operate on a large scale. Backyard Composting would operate on a household scale. It would offer city residents an opportunity to participate in waste diversion and waste reduction at home. To help educate residents about composting, a Backyard Composting Demonstration Project is proposed for Bowring Park.

I. Introduction

1. Composting is a natural biochemical process of decay. Bacteria, fungi, worms and other small organisms in the soil and air break down organic material into a dark, nutrient-rich, earthy smelling soil conditioner known as humus, or compost.

2. Composting is an easy way to add or return organic matter to the soil. The composted humus conditions soil and improves plant growth. It's ideal for flower and vegetable gardens, trees, shrubs and bushes.

3. Composting also reduces the amount of organic material destined for landfill sites. Kitchen and yard wastes comprise 25 to 40 per cent of residential solid waste, depending on region and lifestyle.

4. The St. John's Backyard Composting Demonstration project is intended to introduce residents to the concept of backyard composting, inform them of the basic principles, and encourage them to establish their own backyard compost.

5. The goal of the Composting Project is to encourage backyard composting in St. John's thereby reducing the amount of waste entering the Robin Hood Bay landfill site. Residents who participate in composting will also be introduced to the concept of sorting household waste at source. This will have the long-term effect of heightening awareness of what constitutes household garbage. It will also permit people to feel they are contributing to a cleaner environment by taking part in waste reduction and diversion.

II. Proposal

The St. John's Clean and Beautiful Solid Waste Management Committee proposes that a Backyard Composting Demonstration Project be established. The project, situated in a highly visible location, would have a number of elements:

- The site would represent a backyard in size and shape. As such, it would be rectangular (50 x 100 feet), and enclosed by a residential-style fence.

- A variety of backyard composters would be set up on the site. Some of these would be commercially available from local retail outlets, while others would be hand-built.

- The composters would demonstrate the various composting techniques, such as slow composting, accelerated composting, and vermiculture (composting using worms).

- The various styles of composter would enable visitors to be site to see how the process works and determine the style best suited to their own needs.

- The project intends to hire qualified staff to work on site, conduct tours and explain the process to visitors.

- Brochures explaining composting will be developed and distributed on site.

- A public relations campaign will be conducted through the news media to develop a broad awareness of the project among city residents.

III. Site

The site proposed for the Backyard Composting Demonstration Project is Bowring Park. The park has a number of attributes that will enhance the project's success:

- It is well-known and has a high volume of visitors.

- It is owned by the city and has the necessary technical expertise and infrastructure.

· It projects an image of an aesthetically pleasing natural environment which complements the goals of the St. John's Clean and Beautiful Solid Waste Management Committee.

· It is close to Waterford Hospital kitchen, the intended source for the vegetable component of the composting project. This material would be collected at the hospital and transported across the road to the Backyard Composting Demonstration Project by hospital patients involved in a work activity therapy program.

IV. <u>Operation</u>

A wide variety of private companies and individuals will be approached to donate materials, including composters. Individuals who are already engaged in backyard composting have agreed to assist in the design and monitoring of the project. Professionals in public relations and desktop publishing have similarly volunteered their time and expertise to the public education component.

The compost generated would be incorporated into decorative flower beds at the site.

The staff hired for the project will be able to communicate effectively with the general public, and will conduct regular workshops and demonstrations. Staff will work afternoons and weekends when traffic volume in the park is highest. The project will be designed to accommodate self-guided tours, as well.

V. <u>Request</u>

The project will be managed by the St. John's Clean and Beautiful Solid Waste Management Committee. This committee formally seeks approval for this demonstration project, and further asks the City for the following:

· The advice of the Superintendent of Bowring Park on the most appropriate location for the project, keeping in mind the goal of public education, and the need for relatively flat ground with sun, shade, adequate drainage and some protection from prevailing winds.

· Access to a water supply.

· A source of electricity.

. A fence around the site which gives the appearance of a backyard while meeting the park's aesthetic standards.

. A review of the project after one season with a view to extending it for five years to permit growth in public awareness over time of the role individuals can play in keeping our city clean and beautiful.

VI. Schedule

. April-May, 1992: Project and site approval; staff hiring; site preparation.

. Official opening: June 1992.

. June-October: Site operation, public awareness campaign, brochure distribution.

. November: Close site for season.

. Winter-Spring: Conduct backyard composting survey in St. John's to gauge awareness of the project.

. Spring, 1993: Submit a written report to the City on the project; seek extension of the project for four more years.

PROMOUVOIR LE COMPOSTAGE DOMESTIQUE

par
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Introduction

Il y a quelques années encore, les mots compost et compostage étaient presque inconnus pour la plupart des Canadiens. Ou alors, ils évoquaient de mauvais souvenirs, comme des odeurs suspectes dégagées par un tas de compost mal géré ou une assez vague crainte de "vermine". Aujourd'hui, les problèmes engendrés par la gestion des déchets nous ont fait réfléchir à toutes sortes d'alternatives et le compostage est certainement l'une des meilleures. Le compostage municipal à grande échelle des déchets de cour, comme les feuilles et le gazon, est certes une partie de la solution. Mais c'est une opération coûteuse, qui exige de la machinerie et une assez bonne expertise.

Le compostage domestique est à la portée de toutes les communautés, car il élimine non seulement les frais d'enfouissement et de transport, mais aussi le coût de la cueillette. De plus le compostage domestique implique directement les citoyens et leur fait prendre conscience qu'ils peuvent jouer un rôle actif dans la réduction de leurs déchets et ainsi dans la protection de leur environnement.

Plusieurs villes encouragent donc les citoyens à se procurer un "composteur" en payant une partie de la note. Les composteurs commerciaux ont certainement leur place dans les foyers québécois, mais leur diffusion ne devrait jamais être envisagée sans une bonne campagne d'information sur le compost et le compostage.

Les moyens d'action:

Il y a plusieurs façons de sensibiliser les citoyens au compostage domestique. Si vous avez des doutes sur la popularité de cette méthode de réduction de déchets, commencez par essayer les idées les moins coûteuses et vous serez rapidement fixé sur la réponse de votre communauté. Nous résumons ici différentes approches:

Articles dans les journaux ou le bulletin municipal: Ceci est une première approche qui permet de lancer l'idée du compostage d'une façon progressive dans votre milieu. Laissez un numéro de téléphone en référence au bas de l'article, afin de savoir s'il y a un certain intérêt de la part de vos concitoyens.

Dépliant ou feuillet envoyé à toutes les portes: Voici une façon plus directe de rejoindre toute la population. Vous pouvez profiter de cet envoi pour annoncer une activité complémentaire (conférence, atelier ou autre).

Conférence avec diapositives ou vidéo: Un bon conférencier vous permettra de donner plus d'informations et de répondre à bien des craintes ou interrogations. Une présentation audio-visuelle est un atout.

Atelier: Un atelier pratique se passe à l'extérieur et permet de voir des tas de compost en activité, de toucher les matériaux et d'assister à différentes étapes de la fabrication du compost.

Concours du plus beau tas de compost: Ceci peut stimuler les adeptes du compostage, mais aussi faire réfléchir ceux qui croient que c'est une installation laide et malodorante. Il peut faire partie intégrante d'un concours d'embellissement "Maisons fleuries".

Exposition ou kiosque: Un kiosque peut être exposé lors d'un événement spécial ou simplement dans un endroit public achalandé. S'il est attrayant, il pourra accrocher l'intérêt de plusieurs personnes jusque-là indifférentes.

Site de démonstration: Un site permanent donnera l'occasion d'exposer plusieurs modèles de composteurs, que ce soient des modèles commerciaux ou de fabrication artisanale, et de faire un choix éclairé. Il permet aussi de suivre l'évolution du compost au cours de la saison et d'organiser facilement des ateliers.

Programme de parrainage ou "Maîtres composteurs": Ce programme connaît un succès grandissant dans l'Ouest du Canada. Il s'agit de former des "experts" bénévoles qui vont rayonner dans leur milieu. Cela permet de faire passer le message d'une façon très convaincante et économique. Les "Maîtres composteurs" peuvent animer des ateliers, des conférences, ou simplement répondre aux questions de leurs voisins et amis.

Vente ou distribution de composteurs: La distribution de composteurs à rabais est très populaire en Ontario et dans les parties du pays où les frais d'enfouissement ont atteint les 100.00 $ la tonne et plus et où le ministère de l'Environnement bénéficie de budgets importants pour supporter cette action. Si votre budget ne vous permet pas de faire une telle promotion, vous pouvez vendre des contenants au prix du manufacturier. Plusieurs villes l'ont fait avec succès. Toutes les compagnies qui vendent des composteurs seront enchantées de vous aider. La diffusion de plans pour fabriquer soi-même un composteur est très populaire également et des contenants peuvent même être fabriqués avec des matériaux usagés, par des organismes locaux qui peuvent en tirer des revenus

Ligne téléphonique d'information: Un tel service est très utile pour assurer un suivi auprès des gens qui ont acheté un composteur et pour évaluer l'efficacité du programme.

Réduction des déchets par la taxe proportionnelle

Notre expérience avec les campagnes de sensibilisation, nous ont permis de constater qu'une véritable réduction de déchets passe par un incitatif monétaire. Le citoyen qui fait du compost et participe à la cueillette sélective devrait payer moins de taxes que celui qui met tout à la poubelle. Pour ce faire, il faut modifier la façon traditionnelle de percevoir la taxe d'ordures.

Aux Etats Unis, plusieurs villes ont adopté la taxe proportionnelle. Au Minnesota, par exemple (Biocycle, septembre 1992), certaines villes percoivent la taxe par le biais de sacs d'ordures "officiels" vendus à 2 $ l'unité dans les supermarchés. En automne, un autre sac transparent est disponible, au coût de 1 $, pour la cueillette sélective des feuilles. Ailleurs, on procède au moyen d'étiquettes appliquées sur les sacs: les citoyens recoivent un nombre forfaitaire d'étiquettes avec leur reçu de taxes. S'ils en manquent, ils doivent aller en acheter à l'hôtel de ville. La seule vente de ces étiquettes supplémentaires a permis de payer pour le programme de cueillette sélective dans une municipalité. D'autres villes ont opté pour de vraies poubelles standardisées, pour éviter les sacs de plastiques. Les citoyens sont taxés annuellement en fonction du nombre de poubelles qu'ils ont acheté. Les résultats de ces différentes tactiques ont été immédiats: les programmes de recyclage ont connus un nouveau départ et, dans bien des cas, cela a permis d'augmenter les revenus pour la gestion des déchets. De plus, la taxe d'ordures est distribuée de façon beaucoup plus équitable. Les opposants au changement ont, bien sûr, soulevé plusieurs inconvénients, mais lorsque la volonté politique est présente tous les problèmes ont trouvé une solution. Les déchets sauvages n'ont pas augmenté de façon significative et des pénalités sévères ont été prévues. Les conteneurs commerciaux ont été verouillés. Certains éboueurs ont dû installer une pesée sur le camion et une limite de 25 lbs a dû être imposée pour éviter les sacs trop pesants (compacteurs à déchets domestiques).

Ce qui ressort de tout ceci est que tout changement passe par une bonne campagne de sensibilisation et l'implication des gens du milieu.

A REVIEW OF COMPOSTING CRITERIA

by

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SUMMARY AND CONCLUSIONS

WCI is involved with a number of composting projects and we have carried out an international survey of composting criteria from Canada, United States, Europe and Japan.

The significant factors that are motivating developments of composting criteria are:

- protection of workers and agricultural land from contamination
- increasing interest in composting because of commitment to achieve 50% reduction in solid waste by the year 2000
- in some cases, the disposal of sewage sludge and troublesome agricultural and food processing wastes.

At this time, there is very little motivation from compost users which is based on demand for compost as a valuable soil amendment. Hopefully, this will change with education and experience with the use of compost and changing attitudes as attempted by our conference theme "From Waste to Resource - Composting in a Sustainable Society".

In reviewing composting criteria in Canada, the United States, Europe and Japan, it is evident that composting criteria is going through rapid evolution. Many jurisdictions have issued non-enforceable composting guidelines and standards. Few jurisdictions have issued composting regulations enforced by law.

There is a wide variation in the allowable limits for heavy metals in compost. In Canada, the only existing regulation that applies to compost is the Fertilizers Act and Regulations administered by Agriculture Canada. Three provinces, British Columbia, Ontario and Nova Scotia have developed specific composting criteria and their approach taken to set heavy metal limits is the "no net degradation approach".

The composting criteria for heavy metals developed by the three provinces is up to seven times more restrictive than the heavy metal limits specified in the Canada Fertilizers Act and up to 17 times more restrictive than guidelines for sewage sludge utilization on agricultural lands. There is good evidence that compost is safer and more effective than sewage sludge in complexing heavy metals so that the metals are not available to plants. Some manures such as pig and turkey manures would most likely not meet the current composting criteria for heavy metals and

therefore, would not be able to be used in composting operations. Also, there are some agricultural soils in Ontario that would not meet the current composting criteria. The use of compost prepared to meet these proposed restrictive limits will most likely cause minor elemental deficiencies (Zn, Cu and Mn) in many soils.

These restrictive limits on heavy metals could lead to difficulties in implementing successful composting facilities in Canada because:

- The inconsistency between the developing provincial composting criteria and the Fertilizers Act and the requirements for utilization of sewage sludge on agricultural lands is confusing and will increase the difficulty in achieving acceptance of compost.
- To ensure that compost feedstock meets the criteria, there will be a tendency to try to compost mono-stream feedstock material when the demonstrated trend is to accept a wide range of organic matter.
- The tight limits for heavy metals will limit private investment in composting facilities. The criteria should be set significantly higher than what can be reasonably achieved on a day to day basis.

There seems to be an overemphasis on heavy metal criteria at the expense of organic criteria such as percent humus, biomaturity and pathogens.

Most jurisdictions that have composting criteria are upgrading or developing sampling procedures and analytical methods that are both practical and economical. Jurisdictions experienced in composting are also re-evaluating use criteria for composts.

For jurisdictions which adopt the "no net degradation approach" to establishing limits, care must be taken to satisfactorily define normal background levels.

Besides the wide range of composting criteria among jurisdictions, additional confusion results from unofficial compost criteria for labelling such as Environmental Choice in Canada and Green Dot in Europe. Also, associations such as the Agricultural Composting Association in the United States is developing composting criteria for agricultural based waste to differentiate agricultural compost from municipal waste compost. It is suggested that the Waste Task Group of the Canadian Council of Ministers of the Environment (CCME) rationalize composting criteria in Canada.

STANDARDIZATION

The principal aims of standardization as defined by the ISO are to promote:

- Overall economy in terms of human effort, materials, power etc. in the production and exchange of goods.
- The protection of consumer interest through adequate and consistent quality of goods and services.
- Safety, health and protection of life.
- Provision of a means of expression and of communication among all interested parties.

Standardization is a social as well as an economic activity and should be developed by a general consensus of all interested parties.

The challenge for standardization in composting is to define testing procedures which are practical and economical to carry out and which allow verification of the compost specifications by the supplier, the user and independent third parties.

COMPOSTING CRITERIA

Composting criteria refers to guidelines, standards and regulations.

- <u>Standards</u> are usually prepared on a consensus basis involving multi-stakeholders. Standards are voluntary and define minimum requirements for a product or service.
- <u>Guidelines</u> are very similar to standards and are generally less specific.
- <u>Regulations</u> are enforced by law and in most cases, they incorporate standards which then become mandatory.

The following scientific and philosophic approaches are used to develop criteria to regulate pollutants in air, water, or on land:

1) <u>Risk-Based or No Observed Adverse Effect Level Approach</u> - This approach is based on the biological, physical and chemical parameters of contaminants and information about the ecosystem which are used to set contaminant limits at levels that ensure no adverse effect on human health or the environment. This is the approach being used by United States EPA to develop new sewage sludge regulations.

2) No Net Degradation Approach - This approach requires that the use of the product not change the normal background levels of toxic compounds in the environment. It is assumed that "toxic", "normal" and "background" are rigid and precisely definable. This is the strictest standard.

3) Best Achievable Approach - This approach prescribes the use of the best available technology to produce the desired end product. The technology used should be based on the goals of the producers.

There is a wide variation in the allowable limits for heavy metals in compost (see Table 1). In Canada, the only existing regulation that applies to compost is the Fertilizers Act and Regulations administered by Agriculture Canada. Three provinces, British Columbia, Ontario and Nova Scotia have developed specific composting criteria and the approach taken to set heavy metal limits is the "no net degradation approach". Although the rationale was unclear, the approach taken to set heavy metal limits for compost criteria in Europe, especially northern Europe seems to be the "no net degradation approach" or a combination of the "no net degradation" and "best achievable" approaches. Whereas, in the United States, the "risk-based or No Observed Adverse Effect Level" (NOAEL) approach has generally been taken.

RATIONALE FOR THE RISK-BASED NOAEL APPROACH

The twelve elements that mostly comprise the mineral portion of soils are Si, Al, Fe, O_2, H, Mn, Ti, Ba, Ca, Mg, K, and Na in that general order. These most prevailing elements already include two (Al, Mn) that often injure or poison plants under moderately acidic conditions (pH below about 5.0), and one (Ba) that is highly toxic to animals.

Although there are wide variations in occurrence of the individual trace elements, and in combinations of the same, natural mechanisms within the soil and the plant keep these elements circulating only in appropriately low amounts, and in balance. These mechanisms have been naturally so efficient for Ba that it is not known to many that this element, a gram of which can kill a man and which man uses commonly to kill rats, is among the twelve elements most plentiful in soil. These mechanisms are necessary because many elements that are essential for life at low concentration are toxic at high concentration mainly because they can dislodge and replace other essential elements from their sites of vital activity, e.g. Cu replacing Fe in haemoglobin, or Cu replacing Mg in chlorophyll. The mechanisms that control the dynamics of these elements are therefore so vital to plant and animal life that when they fail they generally do so to cause deficiencies rather than toxicities so that it is possible under certain conditions for plants to be lacking in Fe even while growing in a soil containing millions of times the amount of Fe they need, because there is not sufficient iron available in the soil to the plants which can only absorb what is soluble in water.

In addition to the 'safety' mechanism in soils, plants exercise two kinds of control on most mineral ions, to prevent promiscuous uptake. One is the so called soil-plant barrier where the entry of certain ions is permitted only to a limited extent. The second mechanism prevents the mobility of certain ions within the plant.

It is also important to realize (a) that mineral nutrition of plants does not depend solely on absolute levels of the mineral elements in the plants, but more on their balance, and (b) that there is a considerable gap between sufficiency and toxicity levels.

Dr. R. Chaney with the Soil-Microbial Systems Laboratory of the USDA-Agricultural Research Service states that, "Research data from low metal sludges applied in the field over many years are the only real basis to make regulations for land application of sewage sludge". He also states that there is more and more support for the conclusion that low metal and organics are safe when applied to land. These statements would apply to compost as well.

The humus content of compost will moderate the availability and mobility of metals and therefore, metals standards should be related to the humus content of compost. It has been found that metals help retain humus and that the more metals in the humus, the less likely the humus is to decompose. Also, because humus provides buffering against acid rain, chances that metals will turn into inorganic salt are a non consideration. This has been well put by Dr. Chaney (Biocycle 31: Sept. 90, 54-59; 68-73) for metals in sewage sludges.

THE NO NET DEGRADATION OR UPPER LIMIT OF NORMAL APPROACH

Nutrient elements in a stable and equilibrated ecosystem are cycled continuously, and occur within a range optimal for its sustainability. As the range of trace elements may normally vary widely by one to three orders of magnitude, even among soils in similar ecosystems, there should be enough margins for increasing trace element concentrations within a range without adverse effects. Increasing the trace element contents beyond a certain range may indeed upset the ecological equilibrium. This approach therefore is reasonable provided one is dealing with stable ecosystems and has enough data to determine the normal ranges.

Forest and grassland ecosystems of Canada that have existed post glacially for a few thousand years only may still have been concentrating trace elements in the upper horizon through removal by deep roots from lower horizons and deposition of the organic matter on the surface. At the same time intermediate products of decomposition of the litter at the soil surface in humid areas may have been leaching metallic trace elements from the surface layer into the subsurface. Cultivation of the virgin lands removed the native vegetation and caused oxidation of the organic matter in the soil, causing some release and leaching of minor elements, where sufficient precipitation occurs. Trace elements may have been added to the surface soils where (a) the standing biomass was burnt and the ashes incorporated into the soil surface, (b) manuring was practised, and (c) certain fertilizers were added. Phosphate fertilizers, for example, contained cadmium. On the other hand, nitrogen fertilizers may have created acidity that helped leach the trace elements. Acid rain may have similar added effect.

Taken together, the above implies that the agroecosystems in Canada are still in a fairly dynamic state, rather than at a stable equilibrium. Nonetheless a range of trace element values do exist and represent a viable state. As the previous figure shows, these ranges can be discerned to be quite wide even for the limited number of samples in defined jurisdictions. Consequently, standards based on the objective of maintaining metal levels within the normal range need not restrict compost applications unreasonably, provided normal ranges for cultivated or managed soils are determined realistically. A good example of this approach is the one taken by Ontario.

Because of the wide variation in the concentration of elements in soil, it is critical that the appropriate background levels are used. Urban soils differ from rural soils and concentrations of elements will differ in the surface layer (0 - 5 cm) and the mixed "plough" layer (0 - 20 cm) where most herbaceous plant roots interact with soil. The surface layer of soil is subject to leaching of metals by acid precipitation, by any fertilizers applied in forests or on lawns, and by the organic acids released by the decomposition of the above-ground plant litter on the surface (rather than in the mixed plough layer).

There are other implications of the Ontario guidelines, particularly for Cu for which the limit has been set at 60 ppm. The muck soils in the Holland, Bradford and Keswick marshes are very similar to mature composts. They grow some of the world's best salad crops, and yield per ha perhaps the highest returns for Ontario farmers. A group of samples representing 29 fields in these three marshes was found to contain 190 ppm Cu, while some fields had up to 500 ppm Cu. Another group of 24 field samples from the Holland marsh alone contained an average (Mathur and Sanderson, 1980, Soil Sci. Soc. Amer. J. 44: 750-755) of 234.5 ppm Cu in 1980 (ibid). These soils probably have continued to receive the much-needed periodic Cu applications. Although they exceed the Ontario guidelines for Cu in composts, these soils do grow crops safely and profitably. This is a good example of metal complexing capability of humus.

It is also noteworthy that many P&K fertilizers contain more Cd than the 3 or 4 ppm allowed for composts in Ontario. Hovmand (1984)[1] has reported some phosphate fertilizers to contain 32 ppm of Cd, 32 ppm of Cu, 474 ppm of Zn and 44.2 ppm of Ni. For years, feed for finishing hogs in Western Europe safely contained 125 to 250 ppm of Cu.

Manures in North America from turkeys and broiler chicken were reported by Gilbertson et al (1979, Trans. Amer. Soc. Agr. Eng. 22: 602-611, 616) to contain 650 and 670 ppm of Zn both above the 500 ppm allowed in composts in Ontario. If such manures are composted the metal contents will be even higher in the compost.

Research at Agriculture Canada showed that metals in organic soils, so similar to composts, can be characterized by both individual and sequential extractions and correlated with plant uptake.

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1 Hovmand M.F., Department of Sanitary Engineering, Technical University of Denmark, Cycling of Ph, Cd, Zn and Ni in Danish Agriculture. Presented at CEC Seminar "Utilization of Sewage Sludge on Land: Rates of Application and Long-Term Effects of Metals, Uppsala, June 7-9, 1983.

Until such research is conducted on composts, the NOAEL established for sludge metals in the United States (see Table 1) will be the best available scientific basis. Andersson (1984)[2] had observed in a six year long field study in Sweden that metals in composts were generally less available to crops than those in sludge, The composts were applied at 2.5, 5.0, 10, and 20 tons/ha levels while the sludges were applied at 5 and 10 tons/ha levels.

IMPACT OF PROPOSED CRITERIA

If unscientific and stringent metal levels are set in some jurisdictions, they will discourage composting, except of leaf and yard wastes. It may also cast aspersions on the quality of crops produced on some soils and the use of agricultural waste for recycling nutrients on farm lands.

The use of composts prepared to meet some criteria may cause minor element deficiencies in many soils, leading to the use of soluble salts of Cu, Mn and Zn as fertilizers.

The risks associated with waste metal application to agricultural land are well recognized and criteria to limit loadings to soil, have been developed for several Canadian jurisdictions. There is variability between the limits. However, they generally correspond with the mid-range of values adopted by a large number of other countries. Canadian research on waste metal uptake by plants from sludge treated soils indicates that even the maximum suggested values are not likely to cause significant crop production or animal and human health problems.

Agricultural utilization of sludge according to the Ontario guidelines (see Table 1) has been practised for several years and has proven satisfactory for both the agricultural and wastewater treatment communities. The guidelines have prompted considerable reductions of waste metal concentrations in several sludges. These reductions were necessary to maintain sludge acceptability for agricultural utilization and in most cases were accomplished by improved management of industrial processing or pretreatment of industrial effluent. Only a few sludges have been declared unacceptable for agricultural utilization due to high metal concentrations.

COMPOSTING CRITERIA IN CANADA

The only existing regulation in Canada that applies to compost is the Fertilizers Act and Regulations administered by Agriculture Canada. A summary of the current status of the development of composting criteria in the various provinces/territories in Canada is presented

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2. Andersson A. Department of Soil Sciences, Swedish University of Agricultural Sciences. "Composted Municipal Refuse as Fertilizer and Soil Conditioner. Effects on the Contents of Heavy Metals in Soil and Plant as compared Sewage Sludge, Manure and Commercial Fertilizers". Presented at CEC Seminar "Utilization of Sewage Sludge on Land: Rates of Application and Long-Term Effects of Metals, Uppsala, June 7-9, 1983.

in Table 2. Only three provinces, British Columbia, Ontario and Nova Scotia have developed specific composting criteria.

The report of the Federal-Provincial Agricultural Committee on Environmental Sustainability, June, 1990, states that; "Overcoming soil deterioration is one of the greatest challenges that must be met if the future of the Canadian agriculture and food sector is to be assured."

Senator Sparrow, author of the report, "Soil At Risk - Canada's Eroding Future", written in 1984, has stated that Canada's agricultural soils are seriously deteriorated and warns that if dramatic and immediate changes are not made to improve the soil organic matter (humus), our lands will not support growth of crops in 30 to 40 years. Soil without humus is simply sand.

In addition to composting providing significant relief for our waste disposal problem, Agriculture Canada recognizes and promotes composting as a means of reversing soil degradation and restoring soil organic matter (humus).

Canada Fertilizers Act

Under the Fertilizers Act, the maximum acceptable metal concentrations in processed sewage, sewage-based products and other by-products with a total nitrogen content of five per cent (5%) or less represented for sale as fertilizers or supplements is shown in Table 1. Acceptable metal concentrations in these products increase proportionally with total nitrogen content above 5%.

The maximum acceptable metal concentrations in Table 1 are based on the assumption of a cumulative total application to soil of 200 tonnes per hectare of a 5% nitrogen product. These metal concentration criteria is adopted as a result of long-term effects of heavy metals in soils. Some metals are relatively phytotoxic; others toxic to animals or man. Some of the non-essential metals have long-term cumulative effects which are not fully understood.

Under the Fertilizers Act, the guaranteed analysis of a fertilizer or a supplement shall include in respect of manure, compost, humus or leaf mould, the minimum amount of organic matter expressed in per cent and the maximum amount of moisture expressed in per cent. Agriculture Canada is currently developing standards for pathogens.

Prior to approval for sale as fertilizers or supplements, processed sewage-sludge products derived following Process to Significantly Reduce Pathogens (PSRP) and Process to Further

Reduce Pathogens (PFRP) must be analyzed for compliance with standards for microorganisms in sludge. These standards are proposed to be:

Microorganism	Tolerance
Fecal coliform	5 x 10E4/100 g processed sludge
Fecal streptococci	5 x 10E5/100 g processed sludge
Salmonella sp.	<1/100 g processed sludge
Helminth ova	<1/100 g processed sludge

Pathogen reduction will be considered successful for products which meet these specifications; such products will be considered sanitary with regard to pathogenic microorganisms.

Alternative to end-product criteria, many composting criteria stipulate process parameters for determination of pathogen reduction as follows:

- Windrow method
  - a minimum of 5 turnings over 15 consecutive days, maintaining a temperature of not less than 55°C.
- Static pile method
  - pile insulated with 6" to 12" of insulative material (e.g. sawdust, cured compost, or wood chips); and
  - temperature at least 55°C maintained throughout mixture for 15 consecutive days.
- In-vessel (mechanically mixed and aerated) method
  - temperature at least 55°C maintained throughout mixture for 3 consecutive days.

COMPOSTING CRITERIA IN THE UNITED STATES AND EUROPE

It is recognized that there are several facets to composting and specialized groups are forming. For example, an Agricultural Composting Association (ACA) in the United States is being formed to establish and to protect a clear, distinct and positive identity of "agricultural" compost as distinct from "municipal" or "industrial" composts. ACA wants to develop national compost quality standards and labelling requirements.

The state of Minnesota is the most active jurisdiction in North America for implementing central municipal solid waste composting facilities. Currently, eight facilities are in operation six facilities compost mixed solid waste while two facilities compost source separated solid waste. Minnesota is carrying out a comprehensive evaluation program of its composting operations including testing procedures and compost utilization. Changes to the compost regulations may be made as a result of the evaluation.

Throughout the United States, there is a considerable amount of ongoing research on municipal solid waste compost quality, end use and measurement methodology. As data becomes more widely available, states could make changes to their solid waste composting criteria.

In Northern Europe, it appears that heavy metal limits are being set on the best achievable approach. To ensure compost that is very low in heavy metals, the current trend is to limit composting to the biowaste fraction of the household. Biowaste is not clearly defined but in many cases the definition is limited to the food and vegetable waste from the kitchen and the garden waste.

It is being reported (W. Verstracte, Laboratory of Microbial Ecology at the University of Ghent, Belgium) that some problems are being encountered with biowaste definition that is too restrictive. Due to the improper balance between carbon and nitrogen in biowaste, the end product is very often deficient in organic material.

Italy is one of Europe's largest municipal waste compost producers. A thorough evaluation of composting in Italy appears to have been conducted and new criteria for compost use and composition has been developed. Twenty-one composting plants recently exist in Italy. These plants can process a total of 3,300 tonnes/day of municipal solid waste. Recent analyses carried out on a number of samples from these plants[3] showed that many exceeded legislated limits for humification level (63% of samples did not comply) lead content (62.5% of samples exceeded limit), plastic and glass content (55% and 43% of samples exceeded limits), and total copper content (20% of samples surpassed limit).

[3] G. Zorzi & G. Urbini, "The Reality and Direction of Composting in Italy". Paper presented at the International Symposium "Production and Use of Compost", S. Michele all' Adige, 20-23 June 1989.

TABLE 1

MAXIMUM PERMISSIBLE LEVELS OF HEAVY METALS FOR HIGHEST QUALITY COMPOST (MG/KG DRY WEIGHT)

	Cd	Cu	Pb	Ni	Zn	Cr	Hg	As
CANADA FERTILIZERS ACT	20		500	180	1850		5	75
BRITISH COLUMBIA (Proposed)	2.6	100	150	50	315	210	0.83	13
NOVA SCOTIA (Guideline)	2.6	100	150	50	315	210	0.83	13
ONTARIO (Guideline)	3	60	150	60	500	50	0.15	10
ENVIRONMENTAL CHOICE (Guideline)	2.6	128	83	32	315	210	0.83	13
FLORIDA	15	450	500	50	900			
MAINE	10	1000	700	200	2000	1060	10	
MINNESOTA	10	500	500	100	1000	1000	5	
AUSTRIA	4	400	500	100	1000	150	4	
FRANCE	8		800	200			8	
GERMANY	1	75	100	50	300	100	1	
ITALY (Proposed)	3	200	200	50	400	150	2	5
NETHERLANDS	0.7	25	65	10	75	50	0.2	5
NOAEL SLUDGE	25	1200	300	500	2700	3000	20	
ONTARIO SLUDGE (Guideline)	34	1700	1100	420	4200	2800	11	170

TABLE 2 - SUMMARY OF COMPOSTING CRITERIA IN CANADA

Province/Territory	CURRENT STATUS OF CRITERIA
British Columbia	*Draft* Regulation For The Production And Use Of Compost From Municipal Solid Waste under the Waste Management Act includes: ● siting, design and operating criteria ● testing, recording and reporting requirements ● compost classification (seven types) ● criteria for compost use Undergoing revision. Some conditions do not apply to yard waste composting production of less than 20,000 m^3 per year.
Alberta	No specific regulations Discussions have been initiated to address composting.
Saskatchewan	No specific regulations Starting to collect standards from other jurisdictions
Manitoba	No specific regulations Plan to issue guideline late 1992
Ontario	Interim Guidelines For The Production and Use of Aerobic Compost In Ontario includes: ● permitting, siting, operating requirements ● compost quality ● monitoring, sampling, analysis, reporting On going review and update of Guidelines by multi-stakeholder group, Wet Waste Diversion Strategy Team. Sampling and analytical procedures being enhanced. Trading aspects of compost being considered. Existing Regulation 309 amended to enable the development of leaf and yard waste composting sites by permit by rule.
Quebec	No specific regulations General and preliminary siting and process requirements in Regulation respecting solid Waste under the Environment Quality Act. Revising Regulation to expand composting section but there is no immediate plan to incorporate standards. Le Bureau de normalisation du Québec is being funded by compost producers association to develop compost standards.
New Brunswick	No specific regulations Plan to issue draft within one year
Nova Scotia	Draft guidelines include: ● yard waste siting, design and operational requirements ● siting, facility design, operating criteria ● pathogen control guidelines ● monitoring, sampling, recording and reporting ● abandonment requirements Comments being received.
Prince Edward Island	No specific regulations
Newfoundland	No specific regulations
Yukon	No specific regulations
Northwest Territories	No specific regulations Developing guidelines for agricultural waste

Presentation of l'Association québécoise industrielle du compostage : Mission and Objectives,

(Présentation de l'Association québécoise industrielle du compostage : mission et objectifs)

Carl Genois, *Biomax Inc., Québec, Québec*

Texte non reçu au moment de mettre sous presse
Paper unavailable at time of printing

The First Year With Wet/Dry: A Report From the Field

Paul Taylor, President
Compost Management
Elora, Ontario

Compost Management operates 12 windrow composting facilities in Ontario, including both of the demonstration wet/dry composting facilities that have been contracted out. The firm has also done extensive research into backyard composting.

The City of Mississauga, together with The Mississauga Clean City Campaign, and the Region of Peel, embarked on research into wet/dry[1] residential waste collection systems in October of 1991. The project, as originally defined, was to last for one year, and was funded almost 100% by the Ontario Ministry of the Environment. The Province and the City have recently agreed to extend research on collection for a further nine months, until June of 1993.

Our role in the project was to design, supervise the construction, and then operate on a turnkey basis a composting facility to serve this project. We were selected by the City from among seven competitors who bid for the project in early 1991. We also operate the Region of Halton's wet/dry composting demonstration site. This article reports on what we, as the contractor, have learned about source-separated wet waste collection programs, after the first year of work in the field.

Compost Management is Canada's largest manager and operator of centralized composting facilities, currently with a dozen such facilities under our day-to-day control, on behalf of 15 municipal clients. We composted approximately 30,000 tonnes of various types of organic material last year. Our sister company, Organic Recycling Inc., is based in Clarkstown, NY, and is responsible for the day-to-day management of another 40 centralized composting facilities in that country.

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[1] 'Wet/Dry' refers to any type of program where the 'wet' components of the residential waste stream are source-separated in the home and collected separately from the 'dry' components. The chief variations include 2-stream (wet and dry) and 3-stream (clean wet, clean dry, and residue waste). Four demonstration-scale programs are now underway in Ontario to research the practicality of these collection systems, with a focus on the wet half of the equation.

Background

The existing program collects source-separated organic wastes from four existing garbage collection beats in the City of Mississauga; from a single, high-rise building also located in the City; and from the kitchens of the Mississauga General Hospital. These materials are collected regularly using a variety of different systems to contain or package it, and hauled to a demonstration composting facility constructed by the City for the duration of this project. The various streams of waste are composted on site, each in a separate windrow. In this way, the impacts that each of the different collection systems might have on subsequent composting operations and compost quality can be gauged.

The primary objective of the project is to test a variety of collection systems for source-separated organic wastes, and to try to identify which might strike the best balance of cost-effectiveness, convenience, and potential both for waste diversion and high compost quality.

A secondary objective of the project is to demonstrate the composting of this material using a very-low cost technology that has generally only been used to compost yard wastes, and to monitor the effectiveness and environmental impact of the use of this technology.

There can be little doubt that all participants in the project have learned a lot about the potential for these types of collection systems. Despite this, I have to conclude that no single collection approach has been identified amongst those tested that seems ideal, or suitable for recommendation for a City-wide roll-out. We have simultaneously been closely monitoring the parallel research that is being conducted in Guelph, Halton and Metro, and have visited each of these projects. And we do not yet see a clearly-successful collection approach emerging out of that work yet either, though new ideas continue to be tried.

We believe however, that all of the work that has been undertaken to date points the way toward a clear narrowing of the options. While we haven't yet found a workable system for collection of organics, we have developed some clear ideas about what appears to be unworkable, and would not be suitable for further pursuit.

What We've Learned

The discussion below summarizes some of our general findings that have come out of the work to date, and offers some implications for seeking a better approach.

Two vs. Three Streams

The City's demonstration project includes three 3-stream routes (one each in paper bags, plastic bags, and rigid containers) and a single 2-stream route.

Though the City of Guelph, in some of its earliest work,[2] was able to establish that their variation on the two-stream approach appeared able to capture a greater percentage of the organic waste steam than their 3-stream program did, the practicality of 'cleaning up' the organic material that is produced by the two-steam approach sufficient to produce a good, marketable compost remains unproven. While there are some obvious savings in collection on the two-stream side, the quality of the organic stream produced may be too poor.

We have recently sampled some of the compost from our two-stream windrow, and submitted it for laboratory analysis. It was able to meet the Ministry's stringent Guidelines for compost quality.[3] Nonetheless, this compost is very highly contaminated with inorganic contaminants, despite very intensive hand-sorting of the incoming feed materials, and we believe does not represent a sustainable approach to the production of a first quality grade of compost.

In particular, we have recovered significant quantities of household hazardous wastes (HHW) from the organic stream on this route, including sharps such as razor blades and hypodermic needles. One of the principle flaws in the two-steam approach is that it means that HHW must either be deposited in the wet stream or the dry stream--there is no 'waste' stream left. While we have recovered many of the sharps from the compost derived from

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[2] City of Guelph Wet/Dry Pilot Project: Preliminary Findings, City of Guelph, June 1990.

[3] Interim Guidelines for the Production and Use of Aerobic Compost in Ontario, Ontario Ministry of the Environment, November, 1991.

our two-stream route, we are not confident that even screening the material will recover all of them.

Some might propose that this problem will disappear once good quality HHW collection programs are in place. The fact remains however that even the best, most expensive programs seem to only be able to capture less than 10% of the available HHW--they just aren't working. So HHW is going to stay in one or the other of the two streams for some time yet to come.

The Compostability of Diapers

Two of the collection routes included diapers (and sanitary napkins) in the definition of 'organic'. Though there were some sanitary napkins routinely found in the loads from these routes, there were always substantial numbers of diapers included.[4] Most of our comments therefore relate to our experience with the diapers.

Most parents, after removing the diaper from the child, roll it up into a ball and then use the self-adhesive tapes provided with the diaper to tape the 'ball' closed, so that no leaks or odours may escape. Any parent that has done this a few times can testify to the effectiveness of this approach for sealing up the soiled diaper for extended periods of time.

The composting system that has been employed to serve our research project, by design, contains no up-front shredding of waste (other than shredding of separated brush). It is the our view that up-front shredding should not be included in any scale of system, since it would also shred and disperse the film plastic, the hypodermics, and the dry cell batteries that we have often encountered in the feedstock.

While our project employs a Scat windrow-turning machine, which uses teeth to lightly abrade and mix the material in the windrows, it does not pulverize in the conventional sense of MSW shredding equipment.

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[4] We once dug a single 3-cubic-yard bucket full of compost out of a windrow of otherwise finished material that had included diapers, and were able to count approximately 400 diapers in that single sample.

Consequently, the diapers in the windrow are almost entirely unaffected by the process. Despite repeated passes of the Scat machine, sufficient to compost the readily-accessible organics, the diapers remain largely unopened and inaccessible to degradation. The vast majority of them appear to be still unopened when the rest of the material is fully composted and stabilized.

The City discontinued diapers in one of the two routes in which they had originally been included, in May of 1992, and will remove them from the remaining route in January of 1993. We would not recommend sanitary napkins for inclusion either, since they are often rolled and packaged by the user in small, sealed plastic bags.

Should the diaper and napkin producers ultimately develop truly compostable backings on their products, allowing the whole product to be compostable, it may make sense to re-examine this question. It is our understanding that this research work is in fact taking place.

The Use of Plastic Collection Bags

Plastic bags were supplied to residents as the primary intended packaging system for their source-separated organics in both the 2-stream route and one of the three-steam routes. Both a small 'kitchen catcher' bag and a larger, clear yard waste bag were made available. Similar tests are being undertaken in Halton, Guelph and Metro.

The primary advantages inherent in the use of plastic bags are their cost and ready availability. One small disadvantage in the use of plastic bags (we believe) is that the use of plastic--as opposed to clearly degradable paper--may subtly encourage residents to include other non-compostable inorganics.

The largest disadvantage to using plastic bags is the issue of de-bagging. This is already a significant issue in the collection of yard waste across North America, and continues to be a major problem in these programs. De-bagging yard waste by hand is extremely time-consuming and demanding work. It should be noted that the predominant 'solution' to this problem for yard waste in Ontario has been to de-bag the yard waste right at the curb.

It is my understanding that in Ontario, only the Durham and York Region yard waste sites are still composting yard waste co-mingled with the shredded bags, and trying to screen the plastic out later. Most municipalities that we work with have moved to de-bagging yard waste at the curb.

While many systems have been created to de-bag mechanically, none of them appear to do so perfectly. We do not believe that sustainable composting programs can be built around the assumption that compost that contains even small but obvious shreds of residue plastic is marketable. We have a continuing interest in testing de-bagging systems, but do not consider mechanical de-bagging to be a proven approach at this time.

The work done in Mississauga has illustrated just how much more complex the de-bagging discussion can become. Some residents are placing bags of food waste within larger bags of yard waste, though they are supposed to be set out separately. There may be many such bags within bags within bags. In addition, all of this material is frozen in the winter, with some of the plastic bag actually folded and frozen into the organics in many cases. Under these circumstances, we do not believe that any type of de-bagging will ever be possible.

It has been suggested that the plastic shreds can merely be removed at the end of the process, by intensive screening. Such screening is relatively expensive, but perhaps more importantly, leaving the plastic shreds in the compost until the end means that all operations up to that point (including curing and product stockpiling) would ideally need to be enclosed to prevent the distribution of wind-blown plastic litter.

For these reasons, we would not recommend the use of small plastic bags for the collection of food wastes in future programs, but would still consider the use of plastic bags for pure yard wastes, only if the de-bagging of such material can be made reasonable. It should also be noted that we have spent a lot of time trying to involve the manufacturer of the bags in trying to help us find a solution to the de-bagging issue, and that that same company has been quite pro-active in developing 'blue bag' de-bagging technology for the dry side. We have had no meaningful help from them on de-bagging wet materials however, and they have discontinued discusssions with us.

The Use of Paper Collection Bags

One of the three-stream routes used conventional, wet-strength, kraft paper yard waste bags for yard waste, and a special, experimental paper bag for food wastes. At time of writing, we know of only one other program, in Brooklyn, NY, where the smaller bag is being used in a trial. That program is being managed by our U.S. sister firm--Organic Recycling Inc. The smaller bag is also made of wet-strength kraft paper, but is lined with cellophane to make it leak-resistant. The cellophane is intended to be compostable, since it is not a true plastic, but is derived from cellulose.

In fact, the bags have composted in the windrow, and have performed largely as expected.

The chief barrier to the broader use of paper bags lies in dealing with their bulk, when empty, in storage; the high cost of the bags; and finding effective methods to distribute them to residents.

We believe that the chief solution to all of these problems lies in moving to user-pay garbage collection. If residents have to pay something on the order of $1/bag to set out normal garbage, there is suddenly a strong incentive to purchase a specialized bag for organics collection. This has worked for yard waste programs in the U.S. Unfortunately, none of the current wet/dry pilots is being undertaken in a user-pay environment, so the effect that this might be expected to have can only be speculated on.

The Use of Rigid Collection Containers

The third 3-stream route uses rigid containers to package the organic wastes. This approach has also been used historically in Guelph. As in Guelph, it has been the City's experience that residents very commonly line the carts with plastic bags, to prevent the interior of the carts from being soiled. This of course largely defeats the purpose of the carts, which is to replace the bags with a re-useable system that doesn't involve de-bagging.

Carts of course are also expensive, though may not ultimately be expensive when compared to continual municipal provision of bags.

A recent article in Biocycle magazine[5] profiled approximately 80 wet/dry programs in the former West Germany, and reported that "The collection of biogenic waste material in bags did not prove itself, hence represents a collection system of minor importance." Of the 86 programs surveyed in the article, 3 used paper bags, 3 used plastic bags, and the remaining 80 used some sort of rigid container. While the article also clearly indicates that the carts in use in Germany, including special 'biobins', still need further design refinements, their apparent success there suggests that to dismiss them from further study in Ontario may be premature.

It may be that more effective promotional and educational programs could be successful in keeping plastic out of the organic containers. There is currently another wet/dry demonstration project operating in Lunenburg, Bridgeport and Mahone Bay, Nova Scotia. That program, which relies entirely on European-style carts and prohibits the use of bags, seems to be avoiding many of the contamination problems that we have experienced in Ontario.

The Implications of Co-mingling Brush With Other Organics

All four of the collection routes include brush in the definition of organic waste. This material is collected alongside the other organics, and co-mingled in the packer truck with them.

As described above, the composting system doesn't include a shredding stage of pre-processing, by design. Since the brush obviously has to be shredded or otherwise size-reduced to facilitate composting, it must then be separated from the other organics on site for separate processing. Separating the brush from the co-mingled load is quite difficult, and must be performed manually. Separating it in this way would not be recommended in a City-wide program.

The Metro Toronto wet/dry program has encountered the same problem, and has had to manually separate all the brush that has come in since the project started. This material has been landfilled, pending the shakedown of a recently-installed shredder. Even so, their

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[5] Source Separation of Biogenic Waste, H. Vogtmann and K. Fricke, June 1992 issue.

brush will still have to be pulled out of the co-mingled load manually. It's not easy, if you've ever tried it.

Thus the brush either needs to be collected separately from other organics, or the system has to be premised on up-front shredding of the entire feedstock, contaminants and all--which again we don't recommend.

Promotion and Education

The City used a high-profile promotional program, delivered to residents' homes, to outline how residents should separate their wastes and participate in the program. While subsequent promotional efforts have helped, we have a clear but general sense that the promotional efforts made by the City to date have been unable to produce good, consistent and widespread participation in the program. It should be noted that this is a problem shared by all of the wet/dry demonstration programs operating in Ontario.

Participation rates in Ontario's famous blue box recycling programs tend to be a consistent 75% +, under a variety of demographic conditions. These participation rates tend to be achieved in the first year of new programs, and are then sustained. By comparison, participation rates in the wet/dry demos tend to be at best about 50%, with the numbers falling off in the winter, when only food waste is set out. Some of the stated participation rates may also be inflated, by households that are co-incidentally setting out separately bagged leaves or bundled brush, without realizing that they are therefore 'participating in the program.

Subsequent work in this area will include more focused and intensive promotional and educational efforts, that will include a heavier emphasis on graphic, rather than textual communication.

The Definition of 'Organic'

All four of the routes included quite broad definitions of what constituted acceptable 'organic' wastes, largely in an attempt to maximize diversion. The spectrum of what was acceptable in one route or another included paper towels, facial tissues, animal droppings, kitty litter, diapers, ashes, vacuum cleaner bags, sanitary napkins, and non-recyclable paper products.

It is our belief that starting the program with such a broad definition of compostable did not lend itself to sending a clear message to participating residents, and that it might have been better to start at least with a more modest definition, (i.e. yard and food wastes only).

While the demographics in the study area were perhaps different there, the Halton program initiated collections with the full spectrum of yard wastes, and then added vegetative food wastes after the first three months. It is our sense that Halton has had much less difficulty with inorganic contaminants than any of the other wet/dry programs. In that case, inorganic contaminants have been well less than 1% of the incoming feedstock.

As an aside, we have discovered that to include tissue within the definition of organic has had the effect in this program of inviting contamination by all of the other things routinely found in bathroom waste baskets, including razor blades, makeup packaging and pharmaceuticals.

<u>The Key Role Played by Collection Staff, and by How the Collection Costs Are Structured</u>

Collection of the wastes in this project has been performed for the City by Laidlaw Waste Systems, the City's regular garbage collection contractor. Laidlaw has been very co-operative in allowing their staff on the truck to take the time to examine each bag of source-separated organic materials on the street, and to reject bags that are obviously grossly-contaminated.

The importance of the role played by Laidlaw staff has been underlined whenever the usual swamper on the truck is on sick leave, holidays, or temporarily transferred to other duties. Replacement staff have not always been able to maintain acceptable quality control. This is not a reflection on the contractor, but rather a reflection of the relatively straightforward nature of the work that is normally performed by waste collection staff. The Laidlaw employee that has been assigned to this duty for the duration of the program has been key to the success that has been achieved so far--we are painfully aware of when he is not on the truck.

Laidlaw's contract with the City is also structured such that they are paid by the tonne of material brought into the compost site. This, in hindsight, takes away the incentive for Laidlaw to want to take the time and collect only the cleanest material off the street.

In general, this highlights that collection systems should be structured such that contractors and employees are rewarded for hauling clean organics in the maximum amount to the site, but somehow penalized or discouraged from hauling in contaminants to whatever degree this is possible. Perhaps the same contractor should have to haul residue away from the compost site, and have to pay the City a per-tonne penalty for every tonne of residue.

The Role to be Played by Information Feedback to Residents

Most blue box programs achieve much of their quality control by undertaking some degree of curbside sort, and leaving behind incorrect materials in the box. This provides a very direct message to residents, specific to their own separation practices, and continually re-inforces what constitutes correct separation.

None of the organic collection programs in the Province offer any such type of direct feedback, and consequently collect whatever residents set out--contaminated or otherwise. This has understandably been done because of the nature of the material, yet may be in some ways a fatal design flaw that will always hinder any attempt to remove contaminants from the feedstock.

To date, the approach has been to collect contaminated material, and attempt to devise downstream systems at the compost facility to somehow cope with and remove that contamination. The chief flaw with this approach is that there is no inherent mechanism to ever correct the behavior of the specific waste generators that are the sources of contamination.

It can be readily imagined that if curbside staff could somehow complete at least a cursory sort of the material on the spot, and leave rejected inorganics behind for the resident to deal with, that significant improvements in feedstock quality could take place. Laidlaw has looked at the possibility of undertaking such a trial.

There are three opportunities for removing contamination in this type of program--in the home, at the curb, and at the compost facility. To the extent that sorting at the curb is possible, sorting at the home will also be improved, leading to more efficient programs.

Control of Sources of Nuisance at the Compost Site

As noted above, the secondary objective of this project has been to test a particular, low-cost method of composting the collected material. One of the potential risks in selecting this approach would be the concern that it offers insufficient control or protection against creating environmental nuisances, including problems with vectors, odours and groundwater contamination.

Generally, the results of the work to date have been positive. There have only been two sets of formal odour complaints received. The first was later dismissed as emanating not from the compost site but from an adjacent farm. The second group of complaints were the result of a period of a few weeks of restricted operations on the site, due to work being done to improve the pad surface. This led to insufficient turning of the material, and some anaerobic conditions. We do have some very sensitive neighbours however, including an exclusive private school that is within sight of our facility, and they are generally happy with and supportive of the project.

A study of the surface water runoff and groundwater under the site has been underway since operations began. An interim report on the findings to date has recently been submitted to the local Ministry District Office. In general, this study has so far identified nothing out of the ordinary.

The only vector that has been found on the site in significant numbers is our friend the gull. Measures have been taken to reduce the number that are attracted to the site, and again, we have made recommendations to the Ministry for further changes designed to largely end this problem. Chief among these is to construct a small, simple building to allow initial receipt and de-bagging of the material to take place indoors. It is expected that incoming material would spend no more than 24 hrs. inside of this building.

The Range of Seasonal Tonnage Fluctuation

During the winter, the average daily receipt of waste at the site has been as low as 2 tonnes. During the spring peak this year, the daily receipt of waste rose to as much as 15 tonnes. This is an extremely dramatic degree of fluctuation, and implies the creation of a system for collection and composting that is either operating vastly under capacity in the winter and/or vastly over its capacity in the spring and fall.

Recommendations for Change

All of the work that has been done on wet/dry research in Ontario to date shares the common assumption that the entire organic stream (be it within the context of two streams or three) needs to be somehow collected and dealt with as one mass of material. This assumption has been made in part at least because of the desire to minimize the number of separate streams and therefore the number of collection passes that would be made at a given location.

This assumption has brought with it significant costs however. It has meant that the normal degree of waste stream seasonality found in mixed garbage is dramatically magnified in separated organics, since that is where almost all of the seasonality originates. It has also presented significant problems around the handling of brush and woody wastes, which must in every case be subjected to size-reduction, even if the rest of the organics need not.

We want to go back and re-examine this basic assumption. We would start by dividing the organic waste stream up into its identifiable components, and then ask, "does it really make sense to co-mingle all of these materials:

- leaves
- brush, Xmas trees
- grass clippings
- weeds, sod, misc. yard wastes
- food wastes
- low-grade papers

We believe that if each of these streams are examined individually, that programs can be more effectively custom-tailored to best handle each, without incurring excessive costs.

From there, we would recommend in the Ontario context:

• further testing of 120-litre roll-out carts, 60-litre bins, and paper yard waste bags--ideally in a user-pay environment. We would complement these trials with the use of the small, cellophane-lined paper food waste bags.
• no further work be undertaken with plastic food waste bags, until the industry that produces them creates some type of realistic system to de-bag them under field conditions.
• that all forms of brush be removed from the core wet/dry program, and instead, be picked up by a separate collection once every second month, during a designated week. This is already a rasonably common practice in some municipalities. This change would be made since brush dramatically complicates the handling of mixed organics, since brush is stable and can be stored on residents' properties for weeks at a time, and since bringing it in to the compost site on isolated, specific occasions will improve the efficiency of that operation.
• that the promotional program include <u>specific</u> advice to residents to time their hedge and brush trimming activities to just before the regular bi-monthly collection, and include a calendar to facilitate this. All brush would still be hauled to the City demonstration composting facility, for size-reduction and incorporation into the windrows. Likewise, a separate collection would take place for Xmas trees.
• that residents be strongly discouraged from collecting their grass clippings at all. Promotional materials should clearly indicate that grass may be left on the lawn, backyard composted, or set out for separate collection up to the limit imposed by the collection container provided for all organics. The City would not collect grass clippings set out with the garbage on these routes. This overall component of the program should include elements of the Don't Bag It 'grasscycling' programs being tested in Waterloo and other municipalities.
• that leaves also be removed from the wet/dry program, and instead, be collected separately during the fall season as part of the existing City-wide leaf program. The City would employ vacuum and other equipment, and will also consider collecting leaves (only) in plastic bags if de-bagged at the curb. All leaves would still be hauled to the City composting facility.
• that low-grade papers not be included in the program until contamination levels with just food and yard wastes can be brought down to acceptable levels.

• that collection staff make an attempt to examine the contents of each roll-out container after dumping it into the hopper of the truck, as a trial. Any major and obvious contaminants will be removed on the spot and put back into the container. Collection staff would attach a specific but friendly violation notice to the cart, to provide feedback to residents.

YARD WASTE COMPOSTING: PRE-PROCESSING EQUIPMENT, COMPOSTING EQUIPMENT, AND ODOR CONTROL

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INTRODUCTION

Composting can be an environmentally sound and cost effective way to manage yard waste and divert it from incineration or landfilling. However, it is a complex and controlled biological process that requires more careful planning, design, and operations than many people realize.

To develop a yard waste composting program one must: determine quantity, quality, and variation in yard wastes; determine collection strategy; determine end users for the compost; identify an appropriate site; determine the appropriate level of technology; determine equipment needs; consider management and staffing requirements; design, permit, and construct facility; procure equipment; develop public education program; hire and train personnel; develop operations, maintenance, and monitoring programs; and market compost products.

E&A Environmental/EMCON, Inc. (E&A) is involved in the whole spectrum of composting: yard waste, wastewater sludge, septage, industrial wastes, municipal solid waste, food processing wastes, and agricultural wastes. In our work with composting facilities around North America we find two issues, among others, that are often poorly addressed in planning, development, and operations: specialized composting equipment and odor control.

This paper concentrates on selection and operation of specialized equipment and control of odors. Pre-processing and windrow turning equipment warrant special focus because they usually represent the largest capital equipment investments for many programs. They commonly also account for a large share of operating costs and day-to-day operations and maintenance nightmares. Odor problems are the bane of many inadequately designed and operated facilities. They are caused by poor siting, design, equipment selection, and/or operations. They can quickly become a regulatory problem and public nuisance that threaten a facility's existence. It is essential that the potential causes be addressed throughout design, development, and operations.

PRE-PROCESSING EQUIPMENT

Certain yard wastes delivered to compost sites need to be pre-processed to optimize decomposition, mitigate odor problems, and enhance final product quality. It can involve size reduction, contaminant removal, moisture addition, and/or mixing.

Selecting the appropriate preprocessing system is based on:

- Type and quantity of yard wastes to be composted
- Site capabilities and constraints
- End product quality desired

The ultimate objective is to cost effectively produce compostable material at specific throughputs to meet specific composting and end product quality parameters. Size reduction and mixing is generally not required at leaf-only facilities that receive source-separated leaves loose or in biodegradable bags. At these sites, moisture addition and direct formation into windrow is appropriate.

Options

Chippers, tubmill grinders, shear shredders, and horizontal feed grinders may be required for size reduction and blending. Chippers are appropriate when incoming yard waste composed primarily of leaves and grass separate from brush and wood waste. In this case, leaves and grass can be directly mixed, amended, and formed into compost piles and the brush chipped for mulch. In some cases site size constraints may necessitate leaf grinding to reduce bulk and accelerated decomposition. Any composting program that includes grass requires pre-processing to properly mix it with dry carbonaceous materials. Tubmill grinders, shear shredders, and horizontal grinders are generally selected for their ability to handle a wide variety of yard wastes including mixed leaves, grass, and brush and bagged yard waste.

Other equipment and accessories that round out and streamline pre-processing include dump trucks or trailers for moving material to composting, a feed hopper for shredders, feed and discharge conveyors, and trommel or disc screens for contaminant removal and material sizing. A front-end loader with large capacity or clam-type bucket is a necessity for loading and moving material. A grapple crane is needed if large quantities of bagged material and loose brush are handled in shear shredders or tubgrinders.

Equipment Performance and Costs

Once the pre-processing requirements are established, the equipment is selected based on specification, capital costs, and operating and maintenance costs (see Table 1). Thorough research into actual performance, maintenance and spare part requirements, and downtime is crucial. Owners and operators of equipment should be contacted as references so that actual operating performances and costs can be estimated. Purchasing contracts need to include specific performance guarantees.

Tubgrinders are generally consider for lower throughput demands (9 - 14 metric tons per hour actual) while shear shredders are appropriate for higher capacity (23 - 32 metric tons per hour actual). Life cycle cost analyses indicate that when actual throughput above about 18 tons per hour is required, shear shredders have significantly lower maintenance costs and downtime. This translates into lower overall operating costs that may offset the higher initial investment.

TABLE 1 - COMPARISON OF PRE-PROCESSING EQUIPMENT

	Shear Shredder	Tubmill Grinder	Horizontal Grinder
Approximate Cost (US $)	$450,000	$180,000	$200,000
Operating Thruput (mt/hr)	23 - 32	14 - 18	18 - 27
Pct. On-Line	90%	75%	85%
Weight Throughput (mt/hr)	20 - 29	10 - 14	15 - 23

The horizontal feed grinder is priced competitively with tub grinders and generally provides higher throughput and lower total operating costs. It has the added advantage of being easier to transport making it more appropriate for serving several sites in a regional program.

Debagging Options

Many programs collect yard waste in bags because of the many advantages offered over bulk collection methods including lower collection cost, higher collection efficiency, neater streets, ability to handle both leaves and grass, and use of standard refuse collection equipment.

Composting facilities must determine whether and how they will deal with the bags. Kraft paper bags are more expensive than plastic bags but they are truly compostable. A clear distinction needs to be made between decomposition of kraft bags and degradation of plastic bags. The degradable plastics typically do not simply disappear during the normal composting cycle. They typically must be screened out at some point during the process. Leaves collected in kraft bags do not require pre-processing although it is beneficial for controlling odors if grass is collected, assuring proper moisture content, and speeding initial decomposition.

Manual debagging is either performed at the curb when collected or at the composting site. The latter operation can generally handle 0.8 tons per hour per debagger. If debagging is to be performed it must be integrated into the pre-processing system. Mechanical debaggers have been designed. Grinders and shredders all do an adequate job of opening bags and liberating the yard waste. The challenge comes in separating plastics and yard waste due to their similar density and ballistic characteristics. Study of both screening and air classification systems has found that the maximum removal efficiency for full scale operations is 75 percent. Consequently, screening after composting is essential to remove remaining plastics.

WINDROW TURNING AND AERATING

Composting technologies generally fall into four categories:

- Minimal technology - leaf piles that are not turned require two years or longer to produce stable product.
- Low technology - leaf and chipped brush windrows that are monitored for temperature and turned with front-end loader to produce stable compost in 12 to 18 months.
- Medium technology - similar to low technology except that a specialize windrow turning machine is used to produce stable products within 4 to 6 months.
- High technology - involves the addition of forced aeration systems or enclosed vessels to further optimize composting and is appropriate only if other wastes like manures, food wastes, and sludges are

composted.

Minimal technology is not really considered composting because the decomposition process is not being controlled or managed. Low technology and medium technology composting are the most commonly practiced methods. The most appropriate composting technology is determined by many factors such as: types of materials, quantity of materials, seasonal fluctuations in quantity, method of collection, site capacity and constraints, type and cost of pre-processing, existing equipment, and potential markets. Figure 1 depicts the process steps for a generic yard waste composting operations.

Options Considered

Three general types of equipment are used for turning and aerating yard waste compost:

- Front-end loader
- Front-end loader/tractor with attached rotating flail drum or elevating face turner
- Self propelled rotating flail drum or elevating face turner

The equipment needed varies from one community to the next. Selection of the appropriate machinery is based on such factors as available equipment, throughput requirement, site size, type and condition of the composting pad type, the degree of chopping and mixing required in the windrows.

Performance and Costs

A standard front-end loader can provide sufficient aerating and turning capacity for most leaf composting sites. One may already be available on a part time basis to handle a small rural or suburban operation. For larger operations (e.g. greater than 19,000 cubic meters per year) and for faster decomposition, the specialized turning machines are appropriate. They accelerate composting by breaking up yard waste to expose more surface area and by providing more thorough mixing and aerating. For the mid-size programs (19,000 to 30,000 cubic meters per year), an attached turner may be joined with an existing loader or tractor to provide adequate throughput. Some of these units are easily transported making it possible to work several sites in a regional coordinated program. Larger programs generally require dedicated, self-propelled windrow turners so that yard waste is composted and moved off the active composting pad as quickly as possible.

Manufacturers' literature sometimes over estimates throughput. One manufacturer states that their self-propelled machine can turn windrows 5.5 m wide and 2.4 m tall. Under normal operating conditions, the machine really handles 4.8 m by 1.8 m piles for a throughput of 2675 m^3/hr. Another manufacturer states that their tow-behind units can process 2300 m^3/hr or 2000 metric tons/hr with windrows measuring 1.8 m high by 5.5

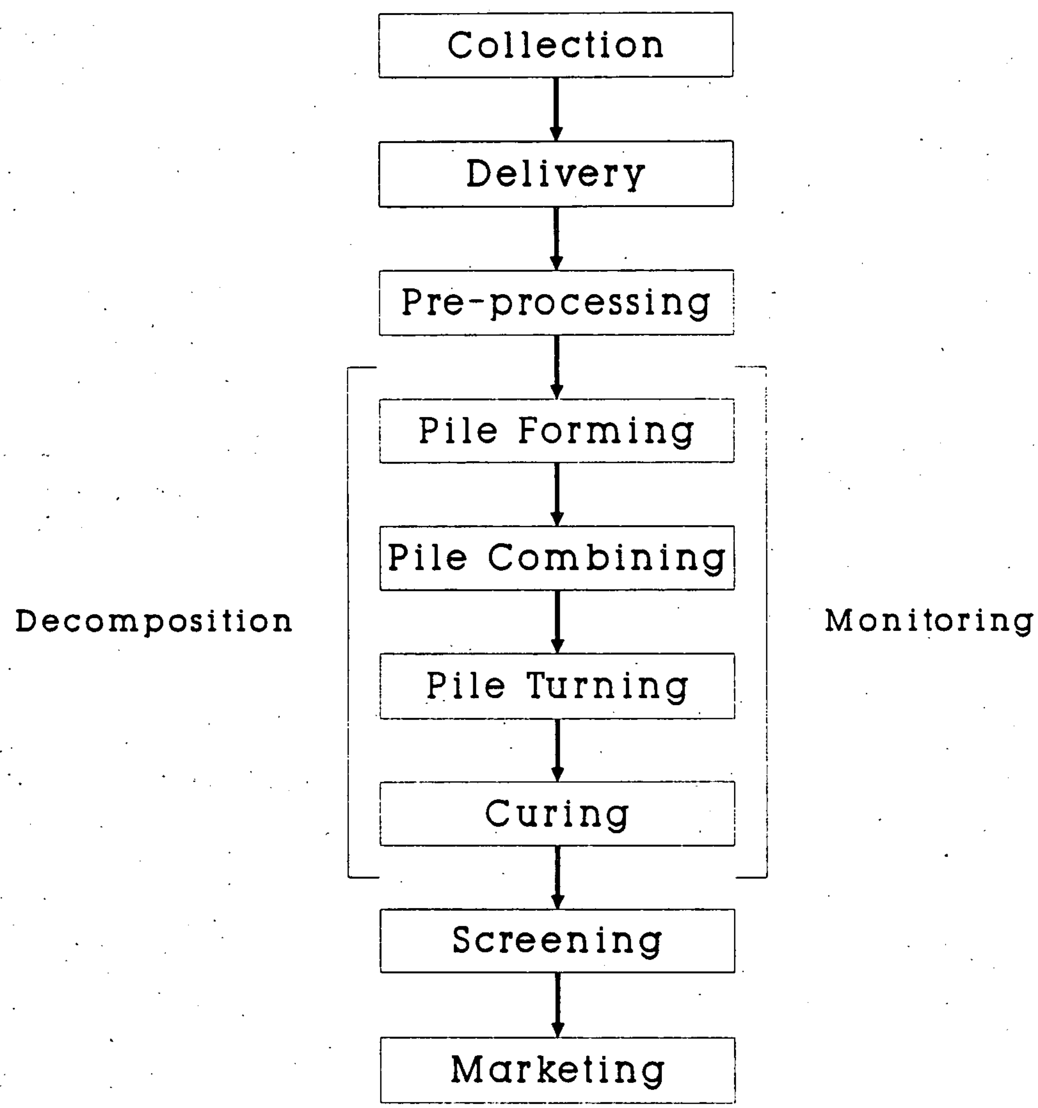

FIGURE 1 - PROCESS STEPS FOR YARD WASTE COMPOSTING

m wide. This implies that the machine can handle compost density of 870 kg/m^3. Field observation of this machine has found that its normal throughput averages 1900 m^3/hr and has difficulty with material more dense than 600 kg/m^3 without reducing the machine-windrow contact area contacted to 1.5 m high by 3.7 m wide.

Part of the narrowing down process is considering site specific constraints vis a vis the equipment. The size of the active composting pad and the quantity of yard waste to be handled must be considered. Although a specialized turning machine may not increase the amount of compost on the pad at any given time, the fact that compost can be produced more quickly means that the same size site can handle more than would be possible with a front loader alone.

The type and condition of the composting pad has a big impact on selecting the right equipment. A poorly built and maintained pad provides poor traction, potholes, and inconsistent grading. Self-propelled wheel-driven units will get stuck sooner or later on most unpaved sites. Self-propelled track-driven turners and tow-behind/front-mounted units are better suited to unpaved sites but require smaller windrows and thus more pad area to handle the same amount of yard waste. Potholes, large stones, and undulations can cause major damage to all types of specialized turning equipment. If the turning mechanism is lifted high enough to avoid a bad surface, the lower part of the pile is not turned and aerated which can lead to inconsistent decomposition and odor problems.

Once the potential options are narrowed down, final selection is based on detailed equipment specifications, capital costs, and operating costs (Table 2). Large-scale operations should have equipment demonstrated or leased for a period of time at their site to make certain that it is the right one. Purchase agreements should include specific performance and service guarantees. Too often, these details are overlooked in the haste to buy or trust in sales claims.

ODOR CONTROL

Landfill bans, streamlined regulations, and economic incentives for yard waste composting have led to rapid growth in the number of sites operating in the United States. Unfortunately this has all too often led to poorly designed and operated composting sites with odor problems. Yard waste composting sites are especially vulnerable to odor problems when grass or other organic wastes are included.

Malodors are caused by poorly controlled decomposition. They can be generated by anaerobic decomposition, excessive temperatures, and low C/N ratios. Care must always be taken to accurately identify the causes for such imbalances. It is also important to remember that the sense of smell is highly subjective. The odor produced by a well operated composting site may be offensive to one person and not to another.

Odor problems are caused by improper siting, design, equipment selection, and operations. Specific causes of odor problems include inadequate buffer zones, inaccurate waste characterization, inadequate surface water control, insufficient pre-processing capacity, poorly design collection systems, bad housekeeping, and inadequate pile turning and aeration.

TABLE 2 - COMPARISON OF WINDROW TURNING EQUIPMENT

	Loader	Side Mounted[1] Elevator	Side Mounted[1] Drum	Self-Propelled Elevator	Self-Propelled Drum
Approximate Cost[2] (US $)	$90,000	$180,000	$150,000	$190,000	$190,000
Operating Thruput ($m^{3/hr}$)	270	1910	1530	2675	2675
Windrow X-Section (height x width)	2,4 x 4,3	2 x 5,5	1,5 x 4,3	2,1 x 4,9	2,1 x 4,9
Compost Pad Capacity (m^3/ha)	7500 - 11,300	7500	4500	6800	6800

Notes:

1 Two passes are required to turn each windrow with side-mounted units.

2 Loader and Loader with turner options are both based on purchase of new loader, availability of existing equipment would eliminate or reduce capital costs.

Design Factors

Inadequate or incorrect data on the quantity and characteristics of yard waste lead to design errors and equipment and labor shortages. For example, under-estimating the amount of grass that will be received can result in a shortage of bulking material, excessive moisture, leachate problems, or inadequate space. The materials balance for composting and mulching activities need to be developed for each season based on the seasonal fluctuations in leaves, grass, and brush in terms of generation rates, moisture content, C/N ratio, and bulk density.

When siting a facility and designing buffer zones to protect surrounding land uses regulatory set-back requirements may not be adequate for preventing off-site odor impacts. Realistic assessment of odor potential may require larger set backs or specially designed buffers.

Site design and construction for odor control must provide:

- Adequate receiving and preprocessing areas
- Good drainage control for the entire site and especially for the pre-processing and composting areas
- Adequate buffer zones

Receiving and pre-processing can become a source of odor when more yard waste is delivered than can be handled or properly separated and stored. Run-off from up-slope needs to be diverted around the pre-processing and composting areas to prevent seepage into compost materials. Pre-processing, composting, and curing areas need to be gently and evenly sloped (2 - 3 degrees) to allow drainage of water away from waste and compost.

Operating Factors

Major operational causes of malodors are:

- Poor mix characteristics
- Materials handling
- Poor compost monitoring
- Staff training
- General housekeeping

The mixture of yard wastes for composting must provide adequate 40 to 60 percent moisture, a C/N ratio greater than 25:1, but preferably less than 40:1, adequate porosity to ensure aeration, and enough surface area to enhance decomposition. Green wastes such as grass, garden wastes, and food scraps are especially prone to causing odor problems. Grass has a tendency to cake up or form balls if not mixed properly, leading to anaerobic decomposition and malodors.

To avoid odors, green wastes like grass and garden residue should not be composted alone, nor stored for long periods of time before mixing with a bulking agent or incorporation into existing windrows. Grass needs to be pre-processed and placed in windrows immediately to minimize potential malodors. Green wastes arriving in degradable bags can be a major problem because odors can develop within the bag before it even reaches the site. Seasonal fluctuations need to be accommodated. For example, shredded brush, dry leaves, and/or compost need to be stockpiled for the spring so that grass and other fresh green wastes can be properly incorporated into composting mixes.

The composting process is primarily monitored through temperature. Additional information needs to be gathered and observed so that odor problems can be avoided or quickly remedied. These include field observation of moisture content, temperature over time, and in response to turning, precipitation, and ambient temperature.

Staff training is commonly insufficient at yard waste compost sites. Training sessions and O&M manuals need to go beyond equipment manuals or manufacturer's literature. They must include detailed procedures for proper materials handling, temperature monitoring, equipment operations and maintenance, composting process diagnosis, and troubleshooting.

Finally, general housekeeping practices contribute to comprehensive odor control. Pre-processing areas need to be cleaned frequently. All surfaces for pre-processing, composting, and storing need to be regularly maintained, filled, and regraded to avoid standing water and improper drainage, as well as, difficult equipment operating conditions.

SUMMARY

Yard waste composting programs commonly use the low or medium technology for windrow composting. Table 3 summarizes common pre-processing, composting, and post-processing configurations; equipment; and crew requirements. Total costs are highly dependent on the number of turnings and the type of equipment used. Average costs range from $10 to $35 per ton. Table 4 provides a generic cost summary for a low technology composting facility handling 10,000 metric tons per year of yard waste.

Composting this organic fraction of the waste stream can be quickly implemented by any community. Careful planning, design, construction, and operation can ensure that yard waste is economically composted with little, if any, environmental or public concerns. This paper focuses on only two of the many issues that go into making a successful program.

Yard waste composting is very amenable to integration with existing resource recovery and landfill facilities. In fact, it is only the first of many composting options that a community or business can institute to managed organic wastes. E&A has worked on many projects where yard waste is co-composted with other fractions of the waste stream including: pulp & paper mill sludge, wastewater sludge, septage, source-separated food waste, agricultural waste, industrial waste, and pharmaceutical waste. Additional information is available on these composting technologies and case studies are available by contacting E&A Environmental/EMCON, Inc.

TABLE 3 - SUMMARY OF LOW & MEDIUM YARD WASTE COMPOSTING TECHNOLOGY REQUIREMENTS

	Equipment	Personnel	Average Efficiency
Pre-processing:			
Grinding	1 grinder 1 front loader 2 dump trucks	1 operator 2 drivers	9 mt/hr
Shear shredding	1 shear shredder 1 front loader 2 dump trucks	1 operator 2 drivers	25 mt/hr
Manual De-bagging	1 front loader 2 dump trucks	1 operator many laborers	1 mt/person/hr
Composting:			
Turning	1 front loader	1 operator	50 mt/hr
Turning	1 windrow turner	1 operator	450 - 900 mt/hr
Monitoring	Thermometer	1 laborer	1350 mt/hr
Moving to Cure	1 front loader 2 dump trucks	1 operator 2 drivers	80 mt/hr
Post-processing:			
Screening	1 rotary screen 1 loader 1 dump truck	1 operator 1 driver	30 mt/hr

TABLE 4 - GENERIC YARD WASTE COMPOSTING COST -
4 HA SITE & 10,000 MT

Capital Cost	
Site Preparation	$235,000
Equipment	360,000
Annualized Capital Cost	89,000
Labor Cost	
Pre-processing	41,000
Composting	21,000
Monitoring	850
Post-processing	8,900
O&M Cost	
Pre-processing	18,400
Composting (front loader)	1,800
Post-processing	5,400
Total Annual Cost	186,350
Cost per Metric Ton	$18.64

YARD WASTE COMPOSTING: A SYNOPSIS

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R.G. Buggeln(3)

ABSTRACT

Compost has resource value as a soil conditioner for agriculture and horticulture. Composting constitutes a natural biological process for the recycling of organic matter. Yard waste includes a relatively benign grouping of organic residues dominated by leaves, grass clippings, and brush. Composting this waste fraction is a logical option for diversion from landfill sites. Proposed bans on the landfill disposal of yard waste will facilitate the establishment of composting operations. Yard waste composting can be undertaken using relatively simple windrow methods, and there appear to be few obstacles to the Permit by Rule approvals process proposed by the Ontario Ministry of the Environment.

The Association of Municipal Recycling Coordinators commissioned a comprehensive technical review on the state-of-the-art of yard waste composting, appropriate levels of technology, compost quality, operational manuals, and the identification of gaps for which research is needed. The purpose of this paper is to provide a synopsis of yard waste composting based on the AMRC project,and to address some of the pressing current needs.

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INTRODUCTION

In natural forest environments dead plant and animal matter forms an organic litter on soil, and is subsequently decomposed by consortia of heterotrophic microorganisms (Alexander, 1977). It is the purpose of these microbes to decompose and recycle organic matter for renewed growth. Composting basically works the same way except that the organic residues are concentrated in a pile or windrow and undergo accelerated decomposition aerobically and/or anaerobically. Historically composting has been a significant, albeit uncontrolled waste management method for millennia. Since the beginning of the 20th Century, interest in composting processes has stimulated scientific and technical studies on various issues especially process control or optimization. Regardless, the goal of composting has been and still is the decomposition of raw organic matter and the production of a humified soil amendment (Gotaas, 1956). Until the chemical industry was capable of producing various inorganic fertilizers, organic matter from manures, sewage and composts was the sole source of nutrients for crop growth Avnimelech (1986). Broadbent (1953) among others has emphasized that organic matter alone has a profound and beneficial effect on the physical, chemical and biological properties of field soils, and in turn crop productivity.

The historical prominence of composting as a waste management strategy along with the intrinsic values of compost, has catalyzed renewed interest in modern society. This arises from the economic and environmental costs associated with landfill disposal. Organic matter has been a substantial fraction of landfill waste, and given the intrinsic value of organic matter in soil, composting is a logical organic residue management or recycling option.

Yard waste, consisting of leaves, grass clippings, brush and woody matter represents a rather benign organic residual that can be readily diverted from landfill sites by composting. Such matter would surely decompose naturally if left on soil surfaces. Two recent proposals should encourage if not facilitate the implementation of yard waste composting, including bans on landfilling of yard waste, and Permit by Rule approvals by the Ontario Ministry of the Environment.

COMMUNITY	ANNUAL YARD WASTE PER HOUSEHOLD (kg/yr)
ONTARIO	
BARRIE	22
FORT ERIE	14
STRATFORD	4
OAKVILLE	34
GEORGIAN TRIANGLE	7
U.S.	
ANOKA, MINNESOTA	184
DAKOTA, MINNESOTA	99
WASHINGTON, MINNESOTA	44
OMAHA, NEBRASKA	207
COLONIE, NEW YORK	66

TABLE 1. Annual yard waste collected on a per household basis for selected locations in Ontario, and the United States. The data show a considerable variation in quantities generated between communities. Based on the susbtantial contrasts between the Ontario and U.S. it is very difficult to extrapolate from one community to another.

Ontario Population	Barrie	Etobicoke	Fort Erie	Oakville	Stratford
Yard Waste (tonnes)	530	13,000	160	1,116	42.78
Population Served	60,800	300,000	25,000	109,000	27,000
Type of Community (Established vs Young)	Both	Established	Established	Both	Established
% Participation	85%	90%			
Area of Communiy	72.7	127.1		140	21
Curb Miles (km)	352	821			50
# Households Served	23,700	48,000	11,400	33,000	10,000
% Households with Backyard Composters	25%		14-20%	25-30%	27%
Types of Materials Collected					
Leaves	X	X	X	X	X
Grass		X			
Brush		X		X	
Other		(1)			

(1) Cemetery soil and flowers; brush and Christmas Trees

TABLE 2: Geographic and demographic data profiles on yard waste collection for selected Ontario communities. As in Table 1 above, considerable scatter in the data prevent accurate extrapolations and predictions between communities.

(1) LEVEL OF SERVICE OFFERED

TO RESIDENT

TO ICI SECTOR PROPERTIES

TO PRIVATE AND MUNICIPAL LANDS (i.e. PARKS, CEMETERIES)

(2) LEVEL OF PARTICIPATION IN PROGRAM

FROM RESIDENTS

FROM ICI SECTOR

ALTERNATE MANAGEMENT TECHNIQUES AVAILABLE

- BACKYARD COMPOSTING, MULCHING
- COMMERCIAL LAWN CARE SERVICES
- ALTERNATE SITES FOR DISPOSAL OR COMPOSTING

(3) COMMUNITY CHARACTERISTICS

LOT SIZE

SINGLE VS MULTI FAMILY DWELLINGS

GREEN SPACE

(4) ENVIRONMENTAL CHARACTERISTICS

GROWING SEASON

PRECIPITATION, CLIMATE

TEMPERATURE PATTERNS

TABLE 3: Factors that can and will affect the quantities of yard waste collected within a community. It is apparent that some of the generators such as ICI sector and landscapers are not adequately surveyed.

I. FEASIBILITY STUDY AND CONCEPTUAL DESIGN

1. Estimate quantities and composition of wastes for municipal composting
2. Identify and investigate end uses of the final product, choose appropriate options
3. Evaluate existing collection system, identify required modifications
4. Identify and evaluate potential sites; select site
5. Evaluate potential environmental impacts
6. Identify permit requirements, obtain necessary permits
7. Site design
   - site requirements
   - structural requirements
   - general design and site layout
   - prepare detailed design of facility
   - equipment requirements
   - prepare equipment specifications
   - operating procedures
   - personnel requirements
8. Budget and contract negotiations
   - decide on operator (i.e. municipal or private)
   - capital costs
   - operating and maintenance costs
   - potential revenues
   - avoided costs
   - identify financing options
9. Develop promotional and educational campaign

II. CONSTRUCTION AND OPERATION

1. Procure equipment
2. Implement public education program
3. Make site improvements
4. Hire personnel
5. Begin operations
6. Maintain records
7. Evaluate the project regularly
8. Refine operational procedures

TABLE 4: Check list of planning and management tasks for composting activities. The itemized points facilitate site selection, planning, preparation and approvals. Initial waste inventory, as well as potential compost markets should be determined to scale the operations and to ensure that material has uses.

The Association of Municipal Recycling Coordinators (AMRC) commissioned a comprehensive technical review on yard waste composting (ORTECH, 1992). The goals were to define the state-of-the-art, technical aspects of the process; to document relevant case histories and experience; to assess appropriate levels of technology for composting; to assess the quality of compost; and to highlight any factors or issues that would preclude yard waste composting. An overview of current information gaps and needs for further research was also included. The purpose of this paper is to provide a synopsis of the aforementioned review. The discussion below includes an outline of the composting process, yard waste composition, compost quality, current and recommended processes.

YARD WASTE GENERATION

The generation of yard waste is controversial due to limited data bases, and the methods of collection and reporting. Estimates compiled from North American and European sources (ORTECH, 1992) indicate a wide range of generation rates from 9.5% to 45% of the waste streams, on an averaged annual basis. Data from U.S. sources suggest a per capita generation rate of about 680kg/yr. for each household. The national averages may be useful in general appraisals of waste management trends, however, they do not yield specific information for community level planning. For instance sample data provided in Table 1 indicates the per household output of yard waste. A national average as indicated above would be based on the total of all sources including commercial and industrial facilities. Table 2 provides a summary of yard waste collection estimates from selected Ontario programs. It is clear from the data available that the quantities of yard waste generated vary significantly between the communities.

Data are needed on a variety of factors and issues for planning and management purposes. For instance, surveys on household yard waste output should specify socioeconomic and demographic information, types of residences surveyed and serviced. Condominium complexes, including townhouses and apartments along with commercial and industrial sites may be important yard waste sources. Also, condominiums, many single family homes as well as commercial and industrial operations are serviced by landscape contractors. Unless the inventory of generated yard wastes includes the various potential sources, limited residential surveys could easily under- or over-estimate yard waste quantities. Data are needed to quantify all sources. Table 3 provides a summary of major socioeconomic and demographic factors that can and will affect the management of yard waste in a community.

Environmental factors associated with weather, and seasons, vegetation types and site management are important. Attempts to extrapolate between community profiles in different geographic regions can be erroneous due to the contrasting environmental conditions. This again will affect the generation rates. Such considerations hold true regionally as in Ontario. The quantities of yard waste generated as well as the composition of the materials will vary between southern Ontario and northern Ontario due to different plant species, growing seasons and management habits alone.

The foregoing underscores the need for accurate data on yard waste generation for planning purposes. The current information is limited in scope or depth, and does not fully address all factors and issues that would affect the collection programs, preprocessing, and composting processes. Moreover, the inadequacies in the data bases further hampers the ability to accurately predict the capital, operating and maintenance costs for composting programs. The latter has been abundantly clear from the scatter of cost data for various composting projects, and the uncertainty as to the basis for cost estimation. The planning process for composting organic matter, yard waste and separated wet-dry matter should proceed through a comprehensive checklist of tasks as indicated in Table 4.

COMPOSITION OF YARD WASTE AND COMPOST

Yard waste consists of plant matter including leaves, grass clippings, brush and woody debris other than cut or dressed lumber. Small quantities of top soil and subsoil materials may be incorporated in the collected yard waste fraction from clean-up and gardening activity. Depending on the collection methods other solid material may be included such as street sweepings from bulk waste collection at curbside.

Table 5 provides a summary of household organic wastes obtained from a pilot project in the Regional Municipality of Peel. The key points of interest from this data are the seasonal patterns of generated waste and quantities of yard waste relative to other materials. Yard waste content was lowest during the winter months, with brush and woody matter being the dominant fractions. From April until December of 1990, the sampled material yard waste amounted to 80% to 90% of the total organic waste stream, with grass clippings being significant during the summer and leaves during the fall periods. The data obtained from the wet-dry pilot project in Peel has indicated larger quantities of yard waste relative to other organic streams including kitchen waste. The implications are potentially significant assuming that similar organic waste composition trends are encountered for other communities. Yard waste may in fact represent the bulk of the organic matter generated.

COMPOSTING PROCESS

The decomposition of organic matter by consortia of microorganisms is the fundamental process in composting. Decomposition occurs under aerobic as well as anaerobic conditions. The two sets of conditions are different based on the availability of oxygen. Aerobic activity is dependent on oxygen respiration and bio-oxidation of carbon substrates to yield carbon dioxide, water and humic matter. The humified fraction consists of highly polymerized organic (aromatic) structures that form compost. In contrast anaerobic activity occurs in the absence of molecular oxygen, and results in the fermentation or reduction of organic and inorganic matter. By-products of anaerobic fermentation include various reduced organic and inorganic substances. Further, the by-products include a number of volatile compounds such as ammonia, methane, sulphides, mercaptans and fatty acids. The volatile fractions containing nitrogen and sulphur are typical sources of obnoxious odours from fermenting organic matter. Gotaas (1956) indicated that composting involves decomposition under aerobic and anaerobic conditions. Golueke (1991) defined composting as" a method of solid waste management whereby the organic component of the solid waste stream is biologically decomposed under controlled conditions to a state in which it can be handled, stored, and/or applied to the land without adversely affecting the environment." This recent definition does not distinguish between aerobic and anaerobic processes. A salient point is that the process of decomposition can involve aerobic or anaerobic conditions, and in many instances composting processes may progress through aerobic and anaerobic stages. Subsequent sections will present a low technology approach to composting yard waste. In large windrows with infrequent turning and in the absence of aeration, it is more than likely that a pile will proceed through intervals of anaerobic and aerobic decomposition.

Microbial Ecology, Growth and Composting

Composting media must be regarded as an aquatic environment. This is essential because microbial populations depend on aqueous conditions for growth and survival. The dependence on an aqueous medium underscores the importance of moisture content during the decomposition process, as described below, for the mass transfer of nutrients, oxygen and waste products between air, liquid and solid phases.

The adhesion and attachment of microbes to surfaces is fundamental to cell and tissue microbiology since cell division and population growth cannot occur otherwise (Pethica, 1980). In aquatic environments surfaces possess a net electrostatic charge which facilitates the deposition and

Table 5: Sample Household Organic Waste Composition

Percentages based on volume and weight collected in Regional Municipality of Peel Pilot Project

	Percentage	Total Yard Waste
January - April, 1990		
Fruit - whole, rinds, cores and peels	32	
Vegetables - tomatoes, potatoes, legumes, root	16	
Bread - sandwiches, whole loaves	12	
Dairy products - cheese, egg shells	4	
Paper products - tissues, paper towels, bond	8	
Miscellaneous - plant trimmings, bones, plastic	8	
Yard waste - leaves, woody material	20	**20%**
April - September Interval		
April - May, 1990		
Yard waste - Partially decomposed grass, leaves, sod	48	
Fresh grass clippings	16	
Woody matter - yard waste and scraps	16	
Kitchen waste - produce, dairy products, bread	20	**80%**
May - September, 1990		
Fresh grass clippings	70	
Soil and sod	10	
Leaves, evergreen needles	5	
Kitchen waste - produce	15	**85%**
September - December, 1990		
Grass clippings	15	
Leaves	75	
Kitchen	10	**90%**

adsorption of nutrients. In the case of organic matter, initial attachment would require the availability of nutrients as well as microbial species able to metabolize or degrade the organic substrate.

Initial attachment and colonization is followed by the formation of biofilms which expand until the surface is fully covered. The biofilm confers an ecological advantage for the capture of nutrients; provides an optimal living environment for the population; and provides a protective barrier against toxins or radical changes in the external environment (Wardell et al, 1980; Costerton et al, 1987).

Soils and composting media are colonized by consortia of microorganisms including bacteria, fungi, actinomycetes and protozoa (Alexander, 1977; Golueke, 1991). Consortia are important since no single species will possess the assimilative capacity nor the enzyme systems required to utilize all substrates (carbon), or to complete the decomposition process. A primary degrader, eg. a species of fungi or bacteria capable of degrading cellulose will exude waste by-products or metabolites which are broken down by other organisms adapted to these materials. Incomplete decomposition of a substrate as indicated by the presence of an intermediate metabolite indicates the absence of microbial species capable of assimilating that substance (Costerton, 1984). Further, the microbial consortia will include various species which will evolve and dominate depending on optimum environmental conditions associated with temperature, substrate availability, moisture content, nutrient availability, and oxygen supply.

Obligate aerobes, facultative anaerobes and obligate anaerobes will coexist within biofilms as has been illustrated by McCarty et al (1984). Persistence and survival of obligate aerobes will depend on the availability of oxygen. Respiration and various chemical and biochemical reactions will rapidly deplete available oxygen, the result being the development of anaerobic conditions. Obligate aerobes do not survive well under anaerobic conditions (Alexander, 1977). This could account for difficulties in reversing anaerobic conditions in composting material.

Having established that composting is a biological process it is absolutely essential that one recognizes the needs and limitations of the biological system. Finstein and co-workers (eg. Finstein et al, 1987a, b, c) noted that a fundamental problem with many composting operations has been human interference and an overemphasis on materials handling. Success is predicated on an understanding of the environmental needs of the microorganisms, and not human design.

The essential limiting factors affecting microbial ecology and hence composting processes include: moisture, temperature, pH, oxygen availability, carbon substrate and nutrient availability. In the last case nitrogen tends to be a critical limiting nutrient, while phosphorus, sulphur, potassium, calcium and so on tend to be present at acceptable levels for microbial activity. The significance of these limiting factors are outlined below.

Moisture Content

The moisture content of decomposing matter in a compost heap is a critical limiting factor for microbial life. Water is the essential support media for microorganisms, and at the same time plays a key role relative to aerobic versus anaerobic decomposition. As has been indicated by Haug (1979) the optimal moisture range for composting is 50-65%. Beyond this range, high moisture levels coupled with the putrefaction of succulent vegetable matter, and settling of solids in a pile will contribute to anaerobic conditions, and odours because air and oxygen transfer is blocked by water filled pores. Fresh grass clippings and legumes can yield moisture concentrations in excess of 80%. Wet grass clippings breakdown rapidly to form strong odours as well as leachate. Below a level of 50% moisture limits activity, and below 40% death and dormancy of the microbial populations will occur.

Moisture content may be one of the most critical limiting factors for yard waste composting. Fresh leaves can be too dry to process, and as recommended by Strom and Finstein (1989) material will have to be rewetted, preferably before construction of windrows. Irrigating windrows or static piles is ineffective because a substantial fraction of the applied water will be shed at outer slopes and surfaces, and rapid infiltration through large open pores without actually wetting the solids.

Grass clippings yield substantial odour problems when collected and bagged in a fresh state. Due to once per week collection frequency, bagged grass can rapidly putrefy before delivery and processing at the compost site. Leaving grass clippings on the lawn to dry out before raking and collection would be preferred to retard the putrefaction processes. Better still, grass clippings are beneficial sources of organic matter and nutrients for lawns, and should be left on the lawn. This would alleviate handling and odour problems associated with grass.

Temperature

Two temperature or thermal regimes are relevant to composting, especially in simple unconfined windrows. External temperatures especially in northern climates can affect biological activity. As temperature decreases towards $0^{o}C$ metabolic functions are suppressed. Gotaas (1956) indicated that the critical dimensions of a windrow are the width and height, to provide sufficient insulation of the pile interior. Pile length was accorded a minor status, although a minimum length is required to achieve the critical mass or volume for thermophilic composting. Gotaas (1956) further indicated that the maximum pile height should be about 1.8m to offset compaction and blockage of pore spaces as material settles. Strom and Finstein (1989) recommended width and height dimensions of 2.0m and 4.0m respectively for yard waste. The maximum height is dictated by the equipment used to turn piles or windrows. Excessive height will compress the lower portions and may promote anaerobic activity.

Assuming that a critical mass or volume has been achieved, thermal conditions within the compost heap will be determined by microbial activity, including respiration. Figure 1 provides an idealized thermal profile. The first or warming stage is mesophilic ($<40^{o}C$) and characterized by the decomposition of readily available substrates. The second thermophilic stage (40^{o} to $65^{o}C$) includes the proliferation of fungi (cellulolytic) up to $60^{o}C$. Above $60^{o}C$ fungi die off and spore forming bacteria prevail. The third phase marked by cooling includes the recommencement of mesophilic activity as T deceases below $40^{o}C$. This phase would correlate with increasing substrate recalcitrance or resistance to decomposition (eg. lignin). The fourth stage of maturation is noted by steady temperatures near ambient levels. Complex chemical processes and reactions including condensation and polymerization lead to the formation of humates (humic acid, and humin) during maturation. Temperature can be used as a relative index of compost maturity, as discussed subsequently. A pile that is self-heating when agitated or turned indicates that decomposable matter is present. A mature humified substrate should yield an isothermal profile.

Figure 2 presents actual thermal profiles from yard waste (exclusively leaves) in windrows at the Regional Municipality of York site. The early mesophilic stage has been truncated, probably because of the cold ($<0^{o}C$) ambient temperatures during debagging and windrow construction. The thermophilic stage lasted for a period of 2 to 4 months with twice weekly turning using a Scarab windrow turner. Achieving thermophilic temperatures ($>55^{o}C$) for three consecutive days is a minimum guideline requirement for pathogen and parasite kill in compost. Such conditions were achieved at the York Region site. Variability in the thermal profile could be expected with less frequent pile or windrow turning. The frequent turnings at the York Region site facilitated persistent high temperatures.

Temperature monitoring should be undertaken throughout a process in part to ensure thermophilic conditions are reached, for general process assessment, pathogen control and as a relative index for maturity. Personnel monitoring process temperatures must be cognizant of potential if not probable thermal stratification. Outer surfaces will be cooler than the centre. Due to settling and anaerobic activity the bottom and/or core of a pile may be cool. Considerable variability in the recorded data will result if the measurements are not taken from identical depths at each point along a windrow.

pH Values and Changes

Gotaas (1956) indicated that the pH of compostable matter is important. More recently, Golueke (1991) has noted that the pH in a compost heap will vary (eg. Figure 1) throughout the

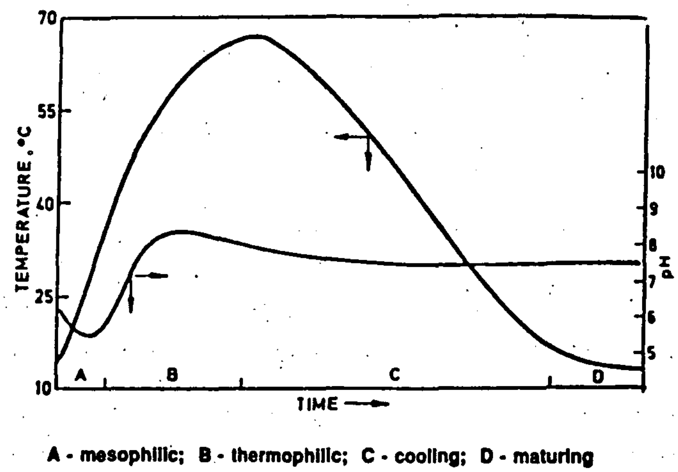

FIGURE 1: Ideal temperature and pH profile for composting organic matter with the identification of four phases of microbial activity.

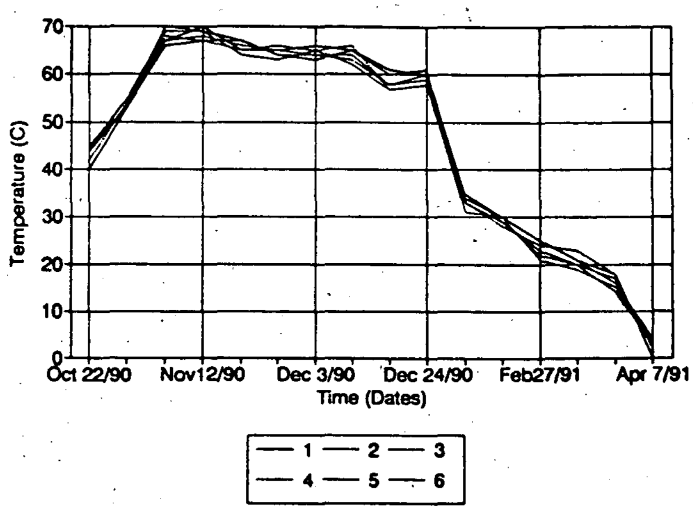

FIGURE 2: Actual temperature profile from 6 locations on the same windrow, each spaced at 15m intervals. The initial mesophilic phase has been truncated due to cold weather, as well as to the onset of decomposition within plastic bags before debagging.

process and should not be a major concern. During early mesophilic stages of decomposition, readily available carbon substrates (simple sugars, amino acids) will yield acidic pH values. During thermophilic conditions hydroxylation, and ammonia production will raise pH to alkaline levels (>8.0). Neutral to slightly alkaline pH should arise during the cooling and maturation stages.

Undue attention to pH could lead to unnecessary amendments of lime. An exception to this would be acidic conditions due to an abundance of conifer needles, bark and other tannin rich substrates. Problems of acidity due to natural tannins may be overcome with other more degradable matter. Extreme acidity (eg. pH <3.5) may require lime amendments. However, such problems are not anticipated for yard wastes.

Aeration, Oxygen Availability, and Gaseous Products

An adequate level of aeration is necessary during the composting process to provide oxygen required by aerobic microorganisms, and to remove metabolic waste products such as CO_2, ammonia, and H_2O. An inadequate air supply or poor air distribution within the pile will promote anaerobic conditions, since available O_2 will be rapidly depleted by respiration and chemical/biochemical reactions. As indicated previously anaerobic conditions will yield various malodorous compounds.

Aeration for oxygenation, waste removal and heat control has been practiced using the following methods, alone, or in combination: a. Passive aeration; b. Mechanical turning and agitation; and, c. Forced aeration under positive or negative pressure.

Passive Aeration:- The first form of aeration is exclusively dependent on the mass transfer of air from the external environment to the compost through interconnected pores. This occurs due to advection/convection, and molecular diffusion between air and aqueous phases. It has been suggested that heat within a pile or windrow will flow upwards, and in the process draw outside air in through the bottom. However, this is highly idealized, because pile settling and high moisture levels will limit pore volumes and air movement. Air cannot flow through wet or saturated porous media without physically displacing water. This is a fundamental concept in soil physics (Bear, 1979). Further, respiring microbial populations will rapidly deplete available oxygen, such that the demand for O_2 exceeds the supply, the consequence being anaerobiosis. Finally, oxygen solubility in water is temperature dependent and decreases as temperature increases. Under thermophilic conditions the expectation is that oxygen solubility will be minimal, and oxygen transfer between air and aqueous phases will be strictly limited.

Simple windrows employed for yard waste composting will be static systems between turning events. As such the internal environment will more than likely be anaerobic at least during early stages of decomposition (Strom and Finstein, 1989). Passive aeration has physical limitations and should not be emphasized as a source of oxygen in composting.

Mechanical Turning:- The physical turning of composting matter by a front end loader or dedicated compost machinery is simple and confers a number of advantages relative to aeration, waste dissipation, and particle size reduction. The efficacy of aeration by turning is dependent on the amount of exposure and homogenization achieved during the process. A single scoop of material is unlikely to allow full air penetration of the compost, while agitation and mixing at a location will improve homogeneity with respect to moisture, aeration, heat dissipation/temperature and decomposition. Aeration by turning is also dependent on the frequency of the process. Twice weekly or more frequent events can accelerate the process biologically and mechanically since the turning of material leads to the physical breakdown of particles (Strom and Finstein, 1989). Once a frequent turning program has been established it must be maintained. Infrequent turning, weekly, monthly or less, will have a transitory and very temporary effect on available oxygen due to consumption by the respiring microbial population.

Odour generation is a significant factor to consider with respect to mechanical pile turning. Assuming that a pile is essentially anaerobic at least during the early stages of decompostion, obnoxious odours will arise during the initial turning events. The proximity of the composting operation relative to other land uses, including residential areas, would be a determining factor in the frequency of turning, as well as the inclusion of odour causing matter such as grass clippings. Given the requirement that a windrow or static pile composting process achieves a temperature of at least $55^{O}C$ for at least 15 days (MOE, 1991, p.5), mechanical turning will be necessary. Further, the compost guidelines stipulate that windrows be turned at least five times during the process. Due to potential odour emissions, the turning events should be timed relative to prevailing weather and seasonal conditions to minimize discomfort, eg. windless days.

Forced Aeration:- The third major approach to aeration is to rely on positive or negative pressure, whereby air is pumped through the pore spaces of the composting matter. Forced aeration has been used extensively in the composting of sewage sludges, in windrows as well as in in-vessel systems. Strom and Finstein (1989) have noted that yard waste decomposition can be accelerated by forced aeration and frequent turning methods. In the case of yard waste, some field situations may require indoor processing and aeration especially in urban areas. In remote areas logistical and practical problems arise due to the need for electrical power, and trained personnel for operations and maintenance. Such approaches are more expensive than the simple windrow approach.

Overall, simple windrows with mechanical turning using a front end loader should be sufficient for most communities. The expense for dedicated machinery, eg. Scarab, for windrow turning would be justified for large scale operations.

Organic Matter and Nutrient Availability

Organic carbon (C) is the essential energy source for heterotrophic microorganisms in soil as well as compost (Alexander, 1977). Heterotrophic microorganisms will mineralize a significant fraction of the available C to CO_2. A major fraction is utilized to form new tissue and biomass, and residuals are synthesized and polymerized to form humates (Alexander, 1977; Paul and Clark, 1989). The utilization of organic C is dependent on the availability of various macro- and micronutrients. Macronutrients include nitrogen (N), phosphorus (P), sulphur (S), potassium (K), calcium (Ca), and magnesium (Mg). Micronutrients include various trace elements. The nutritive requirements for the decomposition of organic matter occurs within rather strict limits as expressed by the ratios of C:N:P:S:K and so on. With few exceptions nitrogen demand tends to be the highest, and the most significant limiting nutrient in soil and composting matter. For this reason nitrogen and C:N ratios have been highlighted as critical for composting (eg. Gotaas, 1956). However, it is prudent to stress that the ratio conveys minimal information about the available C and N which, in fact, is the limiting factor.

Soil scientists have used the C:N ratio to generally define the nutritive status of soil, and the competing biological processes of N mineralization versus immobilization (Jansson and Perrson, 1982; Young and Aldag, 1982). Jansson and Perrson noted that the C:N ratio of a soil can and will vary as a function of the types of carbon substrates present, and their relative availability to microbes. As such the ratio really defines a median value. Within this context the optimum C:N ratio for a field soil is in the range of 20-30:1 (Ensminger and Pearson, 1950; Stevenson, 1982). Beyond 30:1 microorganisms will immobilize available N for basic metabolic functions, at the expense of organic matter decomposition and organic N mineralization to ammonium (NH_4) and nitrate (NO_3). Within the optimum range net mineralization of N occurs. At less than 20:1, the excess nitrogen is converted to ammonia gas as a waste. The lowest possible C:N ratio is in the range of 10:1, corresponding to that of microbial tissue/cells (Alexander, 1977).

Available C and N are the critical parameters, as noted above, and both will vary as a function of the maturity and age of organic matter (plant tissue). Organic matter composition of plants can be divided into six general groups as follows:

a: Water soluble organic matter - simple sugars (glucose), amino acids and sugars
b: Cellulose - polysaccharide of glucose, carbohydrate.
c: Hemicellulose - broad category of carbohydrates associated with cellulose and lignin. Distinguished from cellulose based on solubility in alkali.
d: Lignin - highly polymerized aromatic (phenolic) structures, noncarbohydrate.
e: Various insoluble waxes, oils and lipids.
f: Inorganic - minerals or ash.

Young succulent vegetation including grasses and legumes contain higher relative proportions of water soluble organic matter and cellulose, while cellulose and lignin are the major constituents in mature woody matter. Simple water soluble sugars, amino acids and so on are readily available and will be consumed initially. Nitrogen availability is important, and a C:N ratio of 20:1 would probably be critical for decomposition of these materials. Cellulose and lignin are formed of polymerized matter, the molecules of which are not readily available. Initial enzymatic attack is required to render the molecules of cellulose available. Lignin is particularly resistant to decomposition. While nitrogen does improve the decomposition of cellulose and lignin, the N need is substantially less than for simple sugars because the organic C constituents are not biologically accessible nor available. A C:N ratio of 20:1 is probably meaningless for woody matter assuming that up to 30-40% of the organic matter is lignin which is resistant to decomposition. It is also prudent to recognize that in wood, lignin molecules may partially surround cellulose or hemicellulose, thereby reducing the accessibility and susceptibility of these materials to enzyme and microbial attack.

Pure substrates of cellulose and lignin will degrade slowly and decomposition is only partially enhanced by the addition of inorganic nitrogen (fertilizer). The effectiveness of inorganic nitrogen additions to decomposing matter is limited. As indicated by Alexander (1977), inorganic N (eg. ammonia, and nitrate) has no effect on the decomposition of cellulose beyond a C:N ratio of 35:1. Additional nitrogen would more than likely be converted to ammonia gas or nitrogen gas (nitrogen oxides or N_2 - denitrification) as wastes because the organic C is unavailable. The slow degradation of wood chips in piles can be due to excess carbon relative to nitrogen, as well as resistant organic substrates. The cellulosic materials will breakdown more rapidly when blended with other more available materials (Alexander, 1977). This has been attributed to the initial decomposition of the readily degradable matter, and an adaptation to cellulose and lignin as the remaining materials.

Yard waste composting operations have been in place for several years, and have successfully processed leaves, grass clippings, woody matter and brush, bark, and conifer needles. Table 6 provides a summary of C:N ratios for a variety of yard waste constituents. It is clear that no single or unique C:N ratio can be defined. A high C:N ratio may be due to excessive quantities of woody matter, and could be compensated for by adding a nitrogen rich material (grasses) or fresh leaves. Preference is given to the blending of organic matter rather than adding inorganic fertilizers. At this time insufficient information is available to prescribe a C:N ratio for yard waste.

COMPOST QUALITY

Physical, chemical and biological properties of compost define its quality and suitability for use as a soil conditioner. Physical attributes, including aesthetics will yield initial visual impressions and hence affect the marketability of the material. A poor visible quality could convey an impression that other invisible chemical attributes are unsuitable for use. Chemical quality includes the intrinsic properties associated with the organic matter, nutrients, salts, trace and heavy metals and organic contaminants. Biological quality would be associated with the persistence and survival of various pathogenic and parasitic organisms through the composting process. To a large degree the physical qualities can be controlled during collection, debagging/preprocessing, and final screening of finished compost. Chemical quality is less controllable, with possible exceptions being point of source (eg. household) elimination of metals, appropriate use of pesticides, and reduced disposal of soil materials that may be contaminated by petroleum products, pesticides, solvents, salts and various metals.

MATERIAL	N (%) (DRY WT.)	C/N RATIO (WET WT.)
GRASS CLIPPINGS (YOUNG)	4	12
GRASS CLIPPINGS (AVERAGE MIXED)	2.4	19
GRASS CLIPPINGS (NOT SPECIFIED)	2.15	20.1
GRASS CLIPPINGS/GARDEN WEEDS	2.03	19.3
LEAVES (FRESHLY FALLEN)	0.5 - 1.0	40 - 80
POTATO	1.5	25
LEAVES (DRY)		80
WOOD CHIPS		700

TABLE 6: Total nitrogen and C:N ratio data for selected yard waste components. Potato data is merely provided as a reference. Data compiled for household food wastes yields a C:N ratio in the range of 12-16:1.

Physical and Aesthetic Qualities

The significance of physical properties must not be underestimated, because of visual impact. High concentrations of shredded plastic or other nondegradable materials are undesirable and suggest a poor quality product. Few householders and farm operators will accept materials that are not attractive. Minimizing nondegradable matter is essential. This would include control over debagging processes either at curbside or at the compost site to ensure that plastic from bags is minimized. Manual debagging and sorting while labour intensive and expensive, will greatly assist in removing nondegradables. Mechanical debagging reduces labour, increases preprocessing rates, but will not eliminate all nondegradable materials especially plastic from bags. In the latter case a substantial fraction of the plastic will be removed, but small fragments will pass through the system to be incorporated into the yard waste components. Removal of these solid residuals depends on the use of screens at the end of the process, the screen size and the size of the particles. The compost guidelines specify that the maximum allowable plastic content passing through an 8 mesh screen (2.38mm) shall not exceed 1.0% on a dry weight basis. Other nondegradable matter shall not exceed 2.0%. Unless the nondegradable components are large enough to be trapped on screens, removal will be very difficult if not impossible. Minimizing initial concentrations at the points of generation, during collection and preprocessing would ensure a cleaner compost product.

Textural properties, odour, and colour are important compost attributes. Large clumps of soil or compost should be eliminated, through screening. The odour should be earthy and free of "sour" or vinegar-like odours that indicate active decomposition and the presence of organic acids. People expect compost to have a rich dark brown to black colour.

Chemical Quality

The current compost guidelines specify chemical qualities that effectively define the suitability and end product uses. The quality parameters include trace and heavy metals, salts, nutrients, organic carbon, pH, and PCB. The latter represents the only organic contaminant for which limits have been defined. Contamination arises due to deliberate or inadvertent additions of some chemical to air, soil, water, and compost, typically from anthropogenic sources. Point of generation conditions will vary relative to individual property management, including the use of fertilizers, pesticides, road deicing salts, and disposal of contaminated soil. Handling of the finished compost should also be considered. In this case finished compost could be blended with other materials such as soil, mineral soil/sand, peat moss, sawdust and so on. There is a possibility that soil additives may be derived from construction, industrial or other sites, and be contaminated by a variety of chemicals. To safeguard the quality of the distributed blend, and more importantly human health, these materials should be analysed before adding to compost. Table 7 provides a summary of selected yard waste compost data for discussion purposes.

Nutrients:- Compost is an organic soil additive. Nutrient value is secondary, and in fact should not be emphasized. This especially applies to the total N content, and C:N ratios. Decomposition and humification results in an organic matrix that is dominated (ideally) by humic acids, plus residual lignins. The carbon present in these materials is not readily available for further decomposition, and therefore places a minimal demand for nitrogen when added to soil (Hoitink and Kuter, 1986). As well, a substantial fraction of the nitrogen remaining in compost will be essentially tied-up, or otherwise combined with the humates and lignin components (Alexander, 1977). Thus the availability of nitrogen in finished compost is limited, and the fertilizer value of the material is limited. Hoitink and Kuter (1986) noted that compost possessing a C:N ratio of 70:1 does not necessarily imply a nutrient deficiency, or potential deficiency for plant growth, because neither the C nor the N are readily available. If nutrient content, especially nitrogen is deemed to be a value, one has to be able to specify the available N fraction. Based on current analytical capabilities, there is no reliable nor accessible method for defining the available N fraction in soil or compost (Keller, 1991).

TABLE 7: YARD WASTE COMPOSITION

All Concentrations as mg/kg except as noted

Source York Region

Parameter	Samp 1	Samp 2	Samp 3	Samp 4	Guideline
pH	7.29	7.58	7.65	7.18	
Vol.Sol.%	22.59	23.42	36.31	20.79	
Total Sol%	52.11	53.36	43.04	54.69	
TKN	4210	6490	7930	5180	
Ammonia	<0.2	<0.2	0.9	0.9	
Nitrate	0.52	0.36	1.02	1.48	
Potassium	1800	1800	2800	1700	
Tot. Phosphorus	750	820	840	710	
Tot. Calcium	150000	140000	193000	192000	
Sol. Calcium	1700	1300	2100	880	
Tot. Magnesium	8300	8400	18000	8800	
Sol. Magnesium	290	220	440	120	
Tot. Sodium	610	210	1100	10400	
Sol. Sodium	420	160	770	530	
Arsenic	2.8	2.29	2.4	2	10
Cadmium	0.27	0.24	0.37	0.57	3
Cobalt	3.6	3.6	4.2	4	50
Chromium	12	12	15	11	25
Copper	14	13	17	18	60
Mercury	0.075	0.069	0.648	0.101	0.15
Molybdenum	<0.04	<0.04	<0.04	<0.04	2
Nickel	7.9	7.7	7	8	60
Lead	9.4	7.7	18	15	150
Selenium	<0.2	<0.2	<0.2	<0.2	2
Zinc	54	52	110	64	500
SAR	2.48	1.1	4	4.4	5
CEC	14000	15000	19000	14000	
PCB Aroclor1254	0.01	0.04	0.03	0.05	0.5
DDT-DDD-DDE	<0.01	<0.01	<0.01	<0.01	
Aldrin	0.01	0.02	0.01	0.01	
Dieldrin	<0.01	<0.01	<0.01	<0.01	
Lindane	<0.01	<0.01	<0.01	<0.01	
Chlordane	0.22	<0.01	0.04	<0.01	

Guidelines: MOE (1991)

TABLE 7: Sample data on yard waste compost quality. The data were compiled from four different windrows. Each sample is a composite derived from grab samples at 15m intervals along each windrow.

Salts:- Inorganic salts especially those containing chloride and sulphate and various cations can yield problems at moderate to high concentrations. High loadings of deicing salts (sodium chloride) and potash (potassium chloride) fertilizer can result in excessive Na and K concentrations in soil. Sodium will deflocculate clay soils resulting in the loss of structure and permeability. High loadings of exchangeable Na has an adverse effect on root development. Potassium tends to react (cation exchange) with clay minerals to become immobilized either at mineral surfaces or within the lattice structure of clays. High loadings can induce deflocculation and reduced soil permeability as encountered for Na.

Complexation of various metal ions (cations) and anions such as Cl^-, and NO_3^- can increase the mobility and plant availability of metals as metal salts. This has been indicated from a number of research papers and reports reviewed by Black et al (1984) and Page et al (1987). Concentrations of salts as reflected by analysis for major cations (Ca^{2+}, Mg^{2+}, Na^+, K^+) and anions (Cl^-, SO_4^-) have indicated variability. It is expected that the highest loadings or concentrations would arise from contaminated soil materials.

Trace and Heavy Metals:- The inclusion of trace and heavy metals in compost is unavoidable because these constituents occur naturally in soil, are subject to plant uptake, and many are essential micronutrients for plant and animal growth. Guideline limits for trace and heavy metals have evolved from substantial research on the land application of sewage sludges, and phytotoxicity (eg. Black et al, 1984; Page et al, 1987). The maximum allowable limits for metals in Ontario soils have been indicated in the sewage sludge guidelines (OMAF, MOE, MOH, 1986), and are applicable for composting. For reference purposes these values are summarized in Table 8.

The eleven metals identified in the guidelines are all toxic at relatively low levels. Chromium (Cr), cobalt (Co), copper (Cu), molybdenum (Mo), and zinc (Zn) are essential micronutrients for plants and animals at low concentrations. The remaining six including arsenic (As), cadmium (Cd), mercury (Hg), nickel (Ni), lead (Pb), and selenium (Se) have no nutritive value and are toxic.

Recent discussions have pointed out the disparity between the sewage sludge and compost guidelines as shown in Table 9. The limits for sewage sludge are based on a cumulative 5 year loading of material and agricultural utilization that is derived from the nutrient content as well as the dry matter. For example, manure, sewage and paper sludges are applied at an annual rate of 12T/ha as dry matter. In contrast, domestic horticulture may use 100% compost as bedding or potting media for plants, ranging from ornamentals to fruit and vegetables. Intuitively if the quantities of compost used are substantially heavier than for sludge, then the allowable limit for the metals must be reduced to protect human and environmental health. The concern from the management perspective of composting is whether or not the finished material will meet these limits.

Data compiled in Table 7 are from the Regional Municipality of York site in Richmond Hill. By comparison with the compost guidelines, the metal levels have been within acceptable limits. Based on these results the chemical quality is acceptable and would not pose problems for handling or use.

Organic Contaminants:- The contamination of compost by organic chemicals may be due to various chemicals and especially pesticides used on lawns and gardens. Petroleum products (fuels, lubricants) solvents and so on may be present depending on the source. In the latter case contaminated soil would be a significant carrier of these materials.

By far the greatest concerns and emphasis have been focussed on persistent and toxic organochlorine insecticides such as DDT-DDD-DDE, lindane, aldrin/dieldrin, chlordane, methoxychlor and related compounds. Residues of these pesticides persist in soils, even though commercial availability has been limited since the early 1970's. None of these products are currently available. It is expected that contaminated sod and trimmings would be principal sources. Based on data compiled in Tables 7 and 10, concentrations of the above compounds and other pesticides are less than or at detectable limits, and should not pose problems. Polychlorinated biphenyl (PCB), a related compound used as a fire retardant, and coolant in electrical equipment, has shown a similar pattern with low to undetectable concentrations, in general below the allowable 0.5mg/Kg for compost and soil (MOE, 1991).

Table 8: Soil Quality Criteria

Maximum permissible metal content in soil mg/Kg

Metal	
Arsenic	14
Cadmium	1.6
Cobalt	20
Chromium	120
Copper	100
Mercury	0.5
Molybdenum	4
Nickel	32
Lead	60
Selenium	1.6
Zinc	220

OMAF, MOE, MOH (1986), Table 2, p. 20

Table 9: Sewage Sludge versus Compost Guidelines

Concentrations in mg/Kg dry weight

Metal	Sludge	Compost
Arsenic	170	10
Cadmium	34	3
Cobalt	340	50
Chromium	2800	25
Copper	1700	60
Mercury	11	0.15
Molybdenum	94	2
Nickel	420	60
Lead	1100	150
Selenium	34	2
Zinc	4200	500

OMAF, MOE, MOH, (1986) MOE (1991)

RESIDUE	CONCENTRATION IN SAMPLES (MG/KG) PORTLAND, OR (Range for 5 Samples)	CROTON POINT, NY (averages)	YORK REGION, ONT. (Range. for 4 samples)
2,4D	ND	0.0052	
2,4DB	ND		
2,4,5T	ND		
SILVEX	ND		
MCPA	ND		
MCPP	ND		
DICHLOROPROP	ND		
PENTACHLORO-PHENOL	0.001-0.53		
CHLORDANE	0.063-0.370	0.0932	< 0.01 - 0.22
DDE	0.005-0.019		< 0.01
DDT	ND		< 0.01
opDDT	0.004-0.006		< 0.01
ppDDT	0.002-0.035		
ALDRIN	0.007		0.01 - 0.22
ENDRIN	ND		
LINDANE	ND	0.1810	<0.01
MALATHION	ND		
PARATHION	ND		
DIAZINON	ND		
DURSBAN	0.039		
DIELDRIN	0.019		< 0.01
TRIFLURALIN	ND		
DALAPON	ND		
DINOSEB	0.129		
CAPTAN		0.0052	
DDD			< 0.01

TABLE 10: Pesticide residue concentrations for selected locations. The current data base is very limited. MOst attention has focussed on the organochlorine group or persistent insecticides. These compounds, DDT, aldrin dieldrin, lindane, and chlordane have not been available since the 1970's. Residue levels in soil and compost tend to be at or below detectable limits. Currently available pesticides are not persistent (eg. 2,4 D, parathion, diazinon etc.), hence the nondetected (ND) residues.

No guidelines, other than for PCB, have been established for organic contaminants in compost. This in large part is due to the lack of data on residue levels in compost; difficulties in tracking the fate of organics due to degradability (Page et al, 1987); and uncertainty as to the risks relative to exposure to compost.

Various pesticides are available to householders and commercial enterprises through nursery outlets and landscapers. The most commonly available ones are indicated in Table 10. Many of the newer products tend to be nonpersistent, so that tracking the fate of a compound that should degrade in 4 to 6 weeks would be extremely difficult. Problems could arise due to excessive or abusive application rates, or spills that yield excessively high concentrations in soil and on vegetation. The data base on organic contaminants in compost is presently limited. Based on current and ongoing research the guidelines could be amended with additional organic compounds.

Street Sweepings:- Street sweepings have been isolated as a specific contaminant source that could affect yard waste and compost quality. More specifically, bulk collection at curbside by sweepers, vacuum truck or loader will include street sweepings which can consist of non-degradable materials such as soil and dirt, oily matter, metal fragments, glass, paper, cardboard, plastic (food wrappers, cigarette packages), cigarettes and so on. Quantities of these materials may be small depending on sweeping frequency. However, as shown in Table 11 concentrations of selected trace and heavy metals can be quite high, in some cases exceeding the allowable limits in the MOE (1991) guidelines. Street sweepings can be a source of undesirable physical and chemical contaminants.

COMPOST MATURITY

The current compost guidelines for Ontario (MOE, 1991) have addressed quality as described above. As well these guidelines specify that the maturity of compost should be determined by one or more available methods, or the material must be stored/cured for an interval of 9 months prior to distribution. Physical and chemical compost quality determines the suitability of a compost for use, but conveys no relevant information on maturity. Compost maturity refers to the state of microbiological activity and the decomposition process.

Semantically, stability and maturity have been used synonymously. Stability implies a stable or static state in which no change in attributes will take place even if one or more independent or limiting variables are altered. Maturity on the other hand reflects a state of dynamic equilibrium (Chorley and Kennedy, 1971) in which change is an ongoing if not perpetual process. With regards to compost a stable state is never achieved because residuals of lignin and humates will continue to decompose even at infinitesimally small rates. Based on the above argument preference is given to the use of the term maturity when referring to compost.

The importance of compost maturity arises from the phytotoxicity of raw and partially decomposed organic matter (Hoitink and Kuter, 1986; Jimenez and Garcia, 1989; Inbar et al, 1991). Organic acids (acetic, propionic, butyric) produced during the early stages of decomposition, and as a result of anaerobiosis are phytotoxic. Secondly, actively decomposing matter when applied to soil will contribute to the rapid depletion of oxygen in plant root zones due to microbial respiration. Nitrogenous matter exhibiting a very low C:N ratio will contribute to an ammonia toxicity problem in rooting zones. This is due to the microbial conversion of excess N to NH_3 as a waste. Petruzzelli and Lubrano (1987) and Leita and De Nobili (1991) have shown that organic acids present in partially decomposed organic matter and immature composts increases the mobility and plant availability of trace and heavy metals including Cd, Cu, Ni, and Zn. Finally, Hoitink and Kuter (1986) and Chen and Hadar (1987) noted that the proliferation of plant pathogens occurs in soils amended with immature composts and other degradable organic matter, but not with mature compost. These phenomena are evidently due to the presence and availability of substrates that support various pathogens. In contrast mature compost does not yield the essential limiting substrates or nutrients for growth.

A fundamental problem at this time is that a plethora of maturity indices and methods have been described in the literature, (eg. Jimenez and Garcia, 1989 cite almost 200 references on the various maturity indices). Individual indices and methods are empirical and derived from experiments

Contaminant	Concentration (mg/kg)
OIL AND GREASE	11,300 - 26,500
TOTAL Cl	276 - 2,570
Cd	0.61 - 3.57
Cr	21 - 64
Cu	28 - 1,200
Fe	12,500 - 33,600
Pb	33 - 200
Zn	87 - 320
PCB	< 0.01 - 0.37

TABLE 11: Contaminant concentrations from roadside street sweepings, from a major metropolitan area.

COMPOST MATURITY INDICES

Type	Parameter	Measure	Method	Merits	Limitations	Utility
Aesthetic/Physical	Odour	Earthy odour due to actinomycetes activity	Sensory/qualitative Onsite	Simplicity	Relative and qualitative requires operator experience	Low
	Colour	Dark brown-black				
Process Related	Temperature	Temporal pattern with isothermal final state	In-situ, thermometer, thermocouple	Simple and simple, fast and inexpensive In-situ methods and limited sophistication	Relative stability for T pH yields inconsistencies These parameters define process conditions and should be monitored May yield symptoms of process problems Do not reflect the state of decomposition or degradable residues	Low to moderate for T
	pH	Near neutral finish	in-situ probe or laboratory			Low for pH
	Moisture	Minimum	in-situ moisture tension laboratory			Low for moisture

TABLE 12: Summary of major compost maturity indices, methods, merits, limitations and utility. Substantial research is required to standardize methods as well as protocols. Further, validation and QC/QA is required to define the most appropriate indices.

COMPOST MATURITY INDICES

Continued

Type	Parameter	Measure	Method	Merits	Limitations	Utility
Organic matter Composition and Properties	Organic matter properties	Humic matter FA/HA Himification indices Hydrolysable OM	Laboratory analysis of organic C, humic substances degradable C and residuals	Other than FA/HA good measures of humification and status of the compost product correlatative with other parameters eg., chemical properties	FA/HA inconsistent Methods of extraction vary and can include residual lignins Need for standardized methods	Overall humic matter analyses offer a good method
		Humic matter structure and composition based on spectra	Laboratory analysis of infrared and NMR spectra	IR-qualitative NMR-quantitative determinations of product properties	IR established NMR new with limited laboratory capabilities	Good to excellent but need to weigh against analytical costs

COMPOST MATURITY INDICES

Continued

Type	Parameter	Measure	Method	Merits	Limitations	Utility
Chemical/ Biochemical	C:N ratio	total C and total N solid phase	Laboratory available and total C Total N as TKN	Relatively simple laboratory methods	Relative index Can assess C cannot diferentiate between available and polymerized N fraction C and N dependent on initial substrate	Low to moderate Should be correlated with other indices
		soluble fraction	Laboratory methods water soluble extracts	Relatively simple	Few applications and a need for validation Need for standard methods	Moderate to High based on few published applications
	Nitrite/ Nitrate ratio		Laboratory analysis	Confirms aerobic transformation of N	Nitrite is an intermediate in the oxidation of ammonium to nitrate Based on laboratory study Traces of nitrite and nitrate from field samples May require special sampling and handling to preserve nitrite	Varies from low to moderate due to potential sampling and analytical error
	Cation exchange capacity-CEC	CEC capacity of solid phase	Laboratory methods	Increases with maturity Correlates with humic matter content	Inconsistencies due to interference from lignins if goal is to relate to humic matter	Moderate to high Utility depends on methods and protocols

COMPOST MATURITY INDICES

Continued

Type	Parameter	Measure	Method	Merits	Limitations	Utility
Chemical and biochemical	O2 respiration CO2	Oxygen tension CO2 content	In-situ O2 and CO2 and/or O2 tensions	Measures biological respiration - O2 CO2 evolution as indices of biological activity	Process dependent eg., optimal T, pH, moisture C:N ratio CO2 produced aerobically and anaerobically Direct DO measures do not reveal direct index of aerobic processes nor reflect O2 transfer for microbial use	Low to moderate In mature compost O2 should reflect ambient CO2 evolution should be minimal Utility limited by process dependence
	Respiration	Oxygen demand BOD/COD	BOD/COD laboratory	Independent of process and defined by the degradability of the organic substrate	BOD/COD developed for effluents and water not readily applied to solids	Direct BOD/COD methods are limited Respirometry has a high value with the comparison and validation of in-situ and ex-situ or laboratory determinations eliminates the need for detailed organic matter analysis
		Respirometry	In-situ or laboratory determination of O2 demand	Respirometry methods and instruments have been developed for in-situ and laboratory applications		
	Toxins	Organic acids acetic, butyric, and propionic	Laboratory methods HPLC or GC/MS	Definition of phytotoxic byproducts of decomposition Should be minimal in matured compost	Depndent on laboratory capabilities and instrumentation High costs if used for continuous monitoring	Moderate to high as these constituents indicate degradable matter. These constituents should be included as compost quality parameters

COMPOST MATURITY INDICES
Continued

Type	Parameter	Measure	Method	Merits	Limitations	Utility
Biological	Microbial evolution	Microbial species	Laboratory		Requires tracking of microbial populations and species throughout process Laborious task Requires experience	Low
	Plant assays	Germination of plant seeds growth and yield	Greenhouse container media field tests	general index of compost stability and quality Can be undertaken onsite Can be undertaken onsite	Non-specific index since the response could be limited by chemical quality, eg., salts heavy metals, nutrients Requires experience and assessment of chemical quality dependent on facilities and expertise	Moderate to high assuming quality of the compost is considered

Chen and Hadar (1987); De Nobili and Petrussi (1988); Jimenez and Garcia (1989); Haug and Ellesworth (1991); Inbar et al, (1991) Keller (1991)

	Technology			
	Minimal	Low	Intermediate	High
Land Required Total	1 acre/4000 cu yds leaves	1 acre/3000 cu yds leaves	Variable	Variable (potentially less than other methods)
Buffer Zone	1/4 mile			
Aeration (turning frequency)	1/year	3/during entire process	2/wk first few wks 1/wk, then 1/2 wks (determined through monitoring)	Controlled by temp. feedback system - automatic
Windrow Size	12' (h); 24' (w)	6' (h); 12-14' (w)	Depends on machinery selected	Depends on unit size
Aeration Equipment	Front end loader	Front end loader	Front end loader or turning machinery	Forced aeration equipment
Cost	Very low	Low	Low-Moderate	Moderate-high
Reported Problems	Odours (possibly during entire process)	Odour (during early stages)	Noise from machinery	--
Windrowing Time	3 years	10-11 months	6 mos	Less than 1 year
Curing Time	--	6-7 months	--	--
Monitoring	--	Temp., moisture, O_2	Temp., moisture, O_2	Temp.
Additions	--	Water	--	--

TABLE 13: Summary of yard waste composting technologies based on Strom and Finstein (1989). Low level technologies are cost-effective and practicial for most communities, and is recommended. Intermediate level technologies may be desirable for large communities, limited space, and large yard waste quantities.

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SCIENCE IN THE DESIGN OF CENTRALIZED COMPOSTING FACILITIES

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1.0 INTRODUCTION

Popularized myths in composting can unduly influence the selection and implementation of centralized composting facilities (CCFs). Some of these myths include:

- The bigger the fans the better the compost
- Composting is odour free
- Most expensive component of CCFs is processing technology
- They are ten years ahead in composting in Europe
- They are ten years behind in composting in the U.S.
- Composting is more art than science

The belief by some that composting is more "art than science" only further reaffirms the need to establish a scientific and engineering basis for the design of centralized composting facilities. While art may be more applicable in the operation of these facilities, science and engineering are key to the design.

With multi-million dollar compost facilities being proposed across Canada it is apparent that a scientific and engineering based framework is required. This framework will enable "potential buyers" to evaluate the many composting technologies available. Currently, most of these "composters" are available through venders who possess patents and rights to them. Therefore, obtaining answers to questions about the exact design of these various "composters" is sometimes difficult if not impossible. However, no matter what the details of the specific processes, three basic CCF components are required. These are:

- **Preprocessing component**
  - remove contaminants and prepare feedstock
- **Processing component**
  - maintain optimum environment for microbial degradation
- **Post-processing component**
  - prepare product for market requirements

Composting involves the microbial transformation of biodegradable organic waste into a stable, humic product referred to as compost. Thus, design and optimization of the composting process requires characterization of factors which affect microbial metabolism and growth. These factors, which influence the process design, include:

Biological Factors:

- nutrient balance
- moisture content
- composting temperature
- residence time/stability
- structure
- free air space
- aeration

Physical Factors:

- initial mass
- bed configuration (area, depth)
- agitation/mixing

In order for a biowaste CCF to produce high quality compost, be cost effective and be a good neighbour, the following steps must be kept in mind:

1. Biowaste must be collected in a way which minimizes the inclusion of contaminants, especially those which contain or are carriers of heavy metals.
2. The CCF feedstock (discussed below) must be processed to further remove contaminants (notwithstanding source separation) and to prepare the material for optimum microbial degradation.
3. The material must be processed in an environment which supports degradation until the material reaches a defined stabilization threshold.
4. The odours produced by the CCF must be managed to minimize any negative impacts on the surrounding environment.
5. The compost material must be post-processed to further remove any contaminants and prepare the material for the final use.

1.1 Purpose of This Paper

This paper will provide an overview of some of the critical scientific features on steps 2, 3 and 4 as outlined above. Its goal is to help the reader develop a cost-effective, consistent compost process that produces desirable results. This is, in part, achieved by definitions and the consistent application of the scientific and practical principles of compost design.

2.0 FEEDSTOCK DEFINITION

The selection of each component of the feedstock is key to the production of a good quality compost product i.e., "garbage in = garbage out". Consideration must always be given to the physical and chemical characteristics of each of the feedstock components as well as the mixture entering the compost process. Therefore, the feedstock should consist of the following components:

- Biowaste and Yard Waste
- Amendment
- Bulking Agent
- Water
- Other Additives

The following is a brief description of these five components.

Biowaste and Yard Waste - The Whole Reason for the CCF

Biowaste and yard waste are the compostable materials placed at the curbside for regular collection. Biowaste is usually collected on a weekly basis. Yard waste is generally collected separately from the biowaste during seasonal collection campaigns. Biowaste and yard waste are produced from residential, institutional, commercial and industrial sources. To date, this material is disposed of in landfills and is likely a significant component of the cause of odour, high strength leachate and the attraction of birds and animals.

Biowaste Includes:

- fruit and vegetable wastes
- meat waste
- egg and nut shells
- coffee and tea grinds
- spoiled foods
- kitty litter
- potted plants
- any yard materials not collected during the seasonal collection campaigns
- and the like

Yard Waste Includes:

- brush
- leaves
- grass clippings
- prunings
- weeds

- rotted wood (not pressure treated)

Associated with the collection of biowaste are two types of heavy metal contamination called geogenic (natural) and anthropogenic (man-made) contamination. Geogenic contamination refers to the background concentration of heavy metals in organic materials. Plant material and soil are examples of geogenic contaminants and may result in higher heavy metal concentrations in compost.

Anthropogenic contamination of compost is a result of the presence of specific heavy metal laden materials. It is a reflection of the materials specified as suitable feedstock for the compost process and on the care with which the program participants separate out the compostable materials for collection. Some organic materials such as pretreated wood, plastics and printed paper are high in heavy metals and thus should not be included as acceptable compostable materials. Inorganic materials such as batteries and metal can further degrade the quality of the compost and care must be taken to exclude them from the composting process. Other anthropogenic heavy metal sources include:

- batteries
- floor dust from sweepings and vacuum cleaner bags
- soot and ash from burnt garbage and treated or painted wood
- ferrous materials
- plated or treated metals components
- inked plastics
- pharmaceuticals

Amendments

An amendment refers to an organic material which is added to the feedstock to enhance the carbon balance of the incoming feed mixture. Amendments are high in carbon and are added to increase the amount of readily degradable organics in the mixture. Yard materials high in readily available carbon (e.g. leaves, brush, etc.) are typically used as amendments.

Bulking Agents

Bulking agents are material, usually organic, which are of sufficient size to provide structural support and free air space (FAS) within the incoming composting mass. If too little bulking agent is added, the individual bulking particles will not be in contact with each other and thus no increase in FAS will result. Conversely, the addition of bulking material beyond that required to assure adequate FAS will increase the quantity of material to be handled daily and this results in greater land and equipment requirements. Bulking agents are typically wood from pristine sources. Wood chips may also be used if they are produced from untreated wood materials.

Water

Water is required for microbial activities including transporting soluble nutrients and providing a medium for chemical reactions.

Other Additives

Other material which may be required for the process includes nutrients and/or recycled compost product.

Carbon, nitrogen, phosphorus, potassium and other elements are also required to maintain an ideal nutrient balance. Carbon and nitrogen are required for cell growth and maintenance. Phosphorus is a constituent of the microbial protoplasm and potassium is necessary for regulating the osmotic pressure relationship within the cell.

Recyclable compost product may be employed to enhance the FAS or to increase the carbon content of the composting mass, especially if amendment or bulking agent is not available.

3.0 OPTIONS FOR SYSTEM CONFIGURATION

Two options are available for the processing of biowaste and yard waste. These include:

1. Processing the biowaste, yard waste (including amendment), bulking agent and other additives together in one process (this is typically enclosed given the odiferous nature of food wastes), or
2. Processing the biowaste with required amendment (sourced from yard waste), bulking agent and other additives in an enclosed process with the remaining yard materials composted separately in an open air technology.

4.0 PREPROCESSING REQUIREMENTS

Following the delivery of the feedstock to the facility, several steps must take place prior to it entering the compost process. The individual components in the preprocessing stage are required to ensure the removal of contaminants (e.g. plastic bags, metals contaminants which may be removed through physical means) as well as prepare the feedstock so it possesses an optimum physical and chemical structure.

Preprocessing functions include:

- separation of wastes
- opening and removal of bags
- inspection for foreign material
- size reduction
- magnetic separation
- screening
- mixing or blending feedstock components

During the mixing stage, the components of the feedstock should be combined in order to ensure the optimum chemical characteristics (i.e. carbon to nitrogen (C:N) ratio = 25-30:1).

Nutrient Balance

While nutrient balance refers to all nutrients required by the microbial process (i.e. nitrogen, carbon, potassium, etc.) many of them are typically present in sufficient quantities in the incoming waste material. However, carbon and nitrogen content and their ratio to each other is critical to the composting process and often requires adjustment to the optimum range of 25-30:1.

If the C:N ratio is too low, excessive ammonia formation results. This increases the pH and correspondingly the rate of volatilization of ammonia. Conversely, if the C:N ratio is too high the process becomes nitrogen limited and detention times increase. In addition to affecting biomass growth, nitrogen limitation may lead to high organic acid production from the carbonaceous waste which tends to decrease the pH and inhibits microbial activity.

The carbon and nitrogen content of the individual feedstock components (e.g. biowaste, amendment, bulking agent) may be obtained through literature or by direct measurement. This information can then be used to determine the appropriate mix for the incoming feed materials.

A rule of thumb for amendment addition is about 20-25% of the incoming biowaste tonnages; however, this will strongly depend on the time of year. During the growing season, it is quite likely that the biowaste will contain sufficient high carbon materials (e.g. prunings (and other yard waste not collected during the regular seasonal collection), house plants, etc.) so that no amendment is required.

Moisture Content

Water is required for microbial activities including transporting soluble nutrients and providing a medium for chemical reactions. The optimum moisture content range is about 50 to 60%. Excessive moisture (i.e. greater than 70%) inhibits aerobic metabolism and promotes anaerobic metabolism as a result of oxygen diffusion limitations and a lack of moisture (i.e. less than 40%) impedes microbial growth. Also, free leaching water associated with a high moisture content may result in the removal of soluble constituents.

FAS, particle size and structure are physical characteristics of concern in producing a suitable feedstock for the composting process.

FAS, Particle Size And Structure

The porosity or FAS of the feedstock which enters the compost process and the ability of the feedstock to withstand compaction dictates the aeration rates required during the compost process. The FAS is a derived parameter based on moisture content, specific gravity and bulk density. An FAS of about 30-35% is required to obtain adequate aeration for a wide variety of materials.

Bulking agent is required to obtain the optimum free air space required. In the book "Compost Engineering - Principles and Practice", Haug presents a conceptual model for bulking agent addition to sewage sludge cake (Haug, 1980). The model was developed for two cases:

1. the quantity of moisture absorbed is limited by the bulking agent, or
2. the quantity of moisture absorbed is limited by the organics.

One key difference with this model developed by Haug for sewage sludge and the model which would be required for biowaste is that Haug's model assumes that the FAS of the initial composting mass is zero. However, the initial FAS for biowaste/amendment is greater than zero; therefore, prior to its use the model must be adjusted to account for initial FAS of the composting mass. It is of note that the required input data and complexity of this model do limit its use; however, understanding of the issues to be considered is key to evaluating the vendors claims on bulking agent requirements.

Generally, a rule-of-thumb for bulking agent addition is about 30-35% of the incoming biowaste tonnage. It is of note that the amount of bulking agent required during the growing season will be less than that required during the off-season months.

5.0 PROCESSING REQUIREMENTS

While the biological and physical/chemical treatment of liquid and slurry-type waste is well defined with facility designs based on established engineering and scientific principles, the treatment of solid waste is not so well understood. The design of treatment reactors for liquid and slurry-type wastes is much better understood because the assumptions which can be made for these materials (e.g. reactor is completely mixed, heat transfer is primarily via conduction) are well known and proven.

Therefore, the design of solid waste biological treatment reactors (i.e. composting processes) generally relies on years of experience and it is often refined after pilot scale testing where data can be obtained based on the actual operation of the process. For example, in the design of aeration systems, clogging of the piping used in the aeration bed has led many suppliers to innovative designs. Further, difficulty in predicting the exact air requirements for the microbial community and heat removal has led to process and season specific air flow rates and corresponding on/off fan times based purely on compost bed performance operating data.

Nevertheless, while these design and operating strategies may require empirical research, evaluation of each compost process is possible based on scientific and engineering principles. The basic processing functions to be carried out in aerobic composting are:

- prevent overheating
- supply oxygen
- maintain nutrient balance
- maintain adequate moisture content
- provide sufficient residence time

The following presents a rationale basis for evaluating various composting technologies including a discussion on temperature, aeration, agitation/mixing, residence time and stability.

Temperature

In order to control the growth and regrowth of pathogenic organisms a compost process designer must ensure:

1. the development of temperature sufficiently high to ensure pathogen reduction,
2. the exposure of all the compost materials to these high temperatures for a sufficient time, and
3. the prevention of development of conditions favourable to the regrowth of pathogens.

The Ministry of the Environment Interim Guidelines for the Production and Use of Aerobic Compost in Ontario (November, 1991) propose that to inactivate pathogens in a windrow or static pile, material throughout the pile must be maintained at a temperature of at least 55°C for at least 15 days during the composting process. Windrows must be turned at least 5 times during the composting period to subject all material to a minimum temperature of 55°C. This 15-day period is not necessarily consecutive but must be cumulative. Static piles which are not turned must be covered with an insulating layer such as cured compost or wood chips to ensure that all areas of the feed material are exposed to the required temperature. For in-vessel (mechanically mixed and aerated) composting, a minimum three-day retention time at a temperature of at least 55°C is required.

A drop in temperature during the composting process may be caused by low oxygen levels, low moisture content, die-off of microbial community and/or toxic effects of contaminants. Therefore, temperature drop in and of itself is not a measure of compost stability.

Aeration

Oxygen is required for high-rate aerobic decomposition. The rate at which oxygen is required will vary with the physical and chemical characteristics of the raw material and the temperature of the biomass. If too little air reaches the composting mass, the process becomes anaerobic, the rate of decomposition decreases and odours are released.

Several mechanisms, active and passive exist for aerating a composting system. These include mixing/agitation, forced pressure aeration, negative pressure aeration, molecular diffusion and natural ventilation. Of these, molecular diffusion and natural ventilation are the passive means of aerating a composting system.

Molecular diffusion combined with the movement of air in response to an energy gradient is one method of supplying oxygen to free air spaces within a static pile. Molecular diffusion results from constant and random collisions between molecules of a fluid. As a result of these collisions, there is a tendency for particles to move from an area of high concentration to an area of low concentration.

Another mechanism of aeration in a static pile is natural ventilation. This phenomena occurs due to a density difference between warm, moist air within the pile and drier ambient air. An upward buoyant force is produced which induces a natural ventilation upwards through the pile. The rate of ventilation is a function of the density difference, the FAS and particle size of the composting material.

Pressure aeration is generally a component of most aerobic composting processes. Two mains types of aeration systems exist: forced pressure and negative pressure.
Advantages of negative pressure over forced pressure aeration include:

- the elimination of the need for elaborate air collection systems above the composting process;
- the elimination of the need to provide corrosion protection for the inside of the composting enclosure.

Conversely, disadvantages of negative pressure over forced pressure aeration include:

- the less effective removal of heat from the pile resulting in a rise in temperature which may debilitate the microbial community;
- the tendency of aeration beds to clog as water and suspended solid are sucked downwards along with the air.

The majority of vendors to date supply forced aeration systems; however, some do offer negative pressure aeration, claiming to have overcome the disadvantages listed above.

Agitation/Mixing

Agitation of a compost bed implies that the compost has been disturbed or broken up in some manner during the composting cycle. This includes periodic turning, tumbling and mixing. Agitation of material during composting can accomplish a variety of tasks including:

- increasing the surface area of the pile contacting ambient air and thus maximizing oxygen transfer to and convective heat transfer from the pile;
- redistributing microbial communities and substrate to minimize mass transfer limitations;
- preventing air channels from forming and thus short-circuiting the air distribution system;
- assuring that all material has achieved the minimum temperature for pathogen and weed seed destruction.

Residence Time

The residence time required for the production of compost depends on various parameters including:

- physical and chemical characteristics of the composting material
- shape and size of the composting mass
- design and operating schedule of the aeration system
- design and operating schedule of the agitation system
- compost stability

Stability

The compost produced by a CCF should be stable such that it may be used and stored without deleterious effect. The measurement of stability is currently a subject of much debate. Several methods have been proposed as tests for stability. The methods include:

- reduction in organic matter (ROM)
- spontaneous heating test
- oxygen uptake rates (OUR)
- carbon to nitrogen ratio
- seed germination and plant growth tests
- redox potential
- ash content
- CO_2 respiration

The Interim Guidelines for the Production and Use of Aerobic Compost in Ontario (MOE, November 1991), specifies that the compost product must be tested for stability, otherwise, the compost must be left on site for a six-month curing period.

6.0 ODOUR CONTROL

Various literature references and handbooks provide information on odour threshold concentrations, minimum detectable odour concentrations, 100% odour recognition levels and an odour index which combines volatility with the odour threshold concentration.

Odour from composting of organic materials has been characterized as originating from ammonia, sulphur compounds (e.g. mercaptans and organic sulphides), and certain organic nitrogen compounds. A selection of classes of compounds is given in Table 1, with corresponding odour threshold and odour index values where available. The table reveals that the mercaptans and organic sulphides have significantly higher odour index values than other compounds on the list.

Table 1
ODOUR CHARACTERISTICS OF COMPOUNDS OF RELEVANCE TO COMPOST PROCESSES

Compound	Molecular Weight	TOC100* ppmv	TOC50** ppbv	Odour Index *** x 10^6
isopropyl mercaptan	76	0.0002	n/a	1052
ethyl mercaptan	62	0.002	0.19	289
n-propyl mercaptan	76	0.0007	0.075	263
methyl mercaptan	48	0.035	1.1	53.3
n-butyl mercaptan	90	0.0008	n/a	49.3
hydrogen sulphide	34	0.001	0.47	17.0
diethyl sulphide	90	0.004	n/a	14.4
acetaldehyde	44	0.3	4	4.3
dimethyl sulphide	62	0.1	1	2.76
ethyl amine	45	0.8	800	1.44
methyl amine	31	3	210	0.94
n-butyl amine	73	0.3	n/a	0.40
triethyl amine	101	0.3	80	0.24
ammonia	17	55	37	0.17

n/a not available
* threshold odour concentration in air which elicits a response 100% of the time
** threshold odour concentration in air which elicits a response 50% of the time
*** odour index = vapour pressure/TOC100
after Proctor & Redfern Limited (1992)

The control of odour may be carried out by physical/chemical and/or biological means in physical/chemical scrubbers, thermal oxidation systems or in biofilters.

The scrubber/reactor processes generally lead to contained air flow released through an elevated stack. Classical scrubbing may employ acid, alkali or an oxidant. Acid is appropriate for ammonia removal while an alkali scrubber removes hydrogen sulphide and volatile acids. Oxidants are generally combined with hypochloride and are used for the removal of sulphide and amines.

Some disadvantages of classical scrubbing include its variable performance on ammonia rich gas. Also, the residual produced typically has a pungent chemical smell. When using an oxidant in the chemical scrubbing process problems may occur as some odourants such as phenols and ammonia block oxidation of others. Also, oxidized products often smell worse than the original product (e.g. amines oxidized to chloramines, secondary alcohols oxidized to ketones, quinines and fatty acids).

Biofilter odour removal mechanisms include:

- adsorption to surface of biofilter particles
- absorption onto water film layer on surface of biofilter particle
- bio-oxidation of adsorbed/absorbed compounds thereby regenerating adsorptive sites

The media used for a biofilter should:

- be suitable for microorganisms
- be able to absorb water
- have a high adsorptive capacity
- have a high pore space
- be resistant to compaction over time
- have a high cation exchange capacity and/or pH buffering capacity
- have an appropriate particle size distribution

Primary components suitable for biofilter media include composts, sand, shredded bark, soil and peat. Polystyrene spheres, pelletized peat granules, lime and biological seed (e.g. activated sludge, nitrified sludge) are additives which may be added to the primary components. Polystyrene spheres and pelletized peat granules add porosity to media and tend to resist aging and shrinkage phenomena.

Advantages of biofilters include:

- low capital and operating cost
- simple operation
- can effectively treat a wide range of compounds (e.g. organic acids, methane, ammonia, aldehydes, ethylacetate, sulphur dioxide, volatile organics)

- minimal side stream requiring further treatment

Disadvantage of biofilters include:

- large land area required
- moisture and pH control is difficult
- media can become susceptible to aging phenomena (i.e. fissures/channels may develop resulting in short circuiting of air through the filter)
- system head losses can change over time

Some biofilter requirements are outlined as follows:

Parameter	**Value**
Moisture Content	40 - 70%
pH	7 - 8
Porosity	40 - 80%
Depth	1 metre
Surface Area	$1m^2/(80 - 100m^3/hr)$
Temperature	20 - 35°C
Media Replacement Frequency	12 - 24 months

7.0 SUMMARY

This paper presents a discussion on the following topics:

- feedstock definition
- options for system configuration
- preprocessing requirements
- processing requirements
- odour control

Above all, composting is a biological process and to optimize this process factors which affect the microbes must be considered.

It is the writers' hope that the above information will help "potential buyers" of CCFs to spend public and private money wisely. Canada is currently developing experts in the field of composting. Due to the complex nature of the process, these experts should be consulted prior to the implementation of a CCF. If they do, composting large tonnages of waste will more likely be a safe and effective reality.

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2. Odour Impact from Compost Operations and Feasibility of Odour Control by On-Line Monitoring at Source. Proctor & Redfern Limited. 1992.

A NEW COMPOST BIOMATURITY TEST

by

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Abstract

Biomaturity of compost is essential for its optimal use. Immature composts smell bad, their bags burst, piles catch fire, their landspreading pollutes water and air, and they hurt crop plants. To help meet the need for a good test to ensure that biomaturity has been achieved, four composts were studied. Temperature, % O_2, BOD_5, dissolved organic carbon, ammonia, nitrate, optical properties of extracts, and seed germinations were recorded. The results indicated that optical density of water extracts of composts at 665 nanometres promises to be the basis of a single, facile, reliable, and scientifically sound test for an inexpensive regulatory determination of compost biomaturity. The results were further validated scientifically by nuclear magnetic spectroscopy and pyrolysis-field ionization mass spectrometry that looked at atomic and molecular levels of the process.

This paper outlines a study by WCI (Mathur and Kennedy, 1992) supported by the Office of Waste Management, Environment Canada, and by the Centre for Land and Biological Resources Research of Agriculture Canada. Researchers who contributed to this study include J. Duggan, and M. Schnitzer of Agriculture Canada; H.R. Schulten of the University of Wiesbaden, Germany; and Joe Kennedy of WCI. Their vital roles are recognized in the three papers (Mathur et al 1992a, 1992b; Schnitzer et al 1992) which Agriculture Canada has sent out for publication of the detailed scientific results. Only the highlights are presented here.

Composting has multiple objectives:

- biostabilization
- humus formation
- nutrient conservation and cycling
- bulk reduction
- sanitization

For a waste to be fully and truly composted, all of the objectives have to be fulfilled collectively not singly. For example, organic wastes can be biostabilized by desiccation, and sanitized by gamma, beta or UV radiation, but neither will produce humus or conserve nutrients optimally. A number of complex tests are therefore used to determine compost biomaturity. The complexity due to multiplicity of objectives is further heightened by the fact that the desired properties are hard to define and measure. For example, biostable does not mean biologically inert. It is nearly impossible to define what level and type of microbial activity and population is acceptable in a biomature compost. Sanitary does not mean sterile but implies acceptable and non-threatening levels of pathogens (and weed seeds). Again, subjective evaluation is involved.

At the same time, one can not take a laissez-faire attitude towards compost biomaturity. WCI therefore was glad to provide scientific supervision of a project sponsored by Environment Canada and Agriculture Canada to (a) review the hazards of immature composts, (b) examine various tests that have been proposed or used, (c) suggest an experimental approach towards a single, facile and sound test for compost biomaturity, (d) help conduct the experiment, and (e) interpret its results. A full report of the project was submitted to Environment Canada.

The report discusses the following:

A. Adverse features of immature composts

- storage problems - malodours and fires
- marketing problems - smells, flies and spillage
- use problems - phytotoxicity (injury to crop plants) and pollution

B. Compost biomaturity tests

The report critically reviews 29 compost biomaturity tests. One of the criteria of analysis was that a compost biomaturity test applied as a regulation should not be easily amenable to subversion. The following is a summary of the discussions for a few of the groups of tests.

1. C/N Ratio

The C/N ratios of mature composts do vary with feedstocks, to some extent, because organic compounds vary in their biotransformability.

A test based on C/N ratio alone can be easily subverted by additions of nitrogen fertilizers or N-rich organic wastes to immature composts.

2. Organic C/Organic N in Compost Water Extract

This ratio may be narrow even in immature composts that contain water-soluble organic-N compounds, e.g. urine, blood.

3. NH_4-N/NO_3-N in Water Extracts

Although the very appearance of significant amounts of nitrate may be an indication of biomaturity, no particular level, or its ratio with ammonium, can be relied upon as an indicator of maturity. Also inclusion of fertilizer-NO_3 can easily subvert the test.

4. Circular Chromatography of Alkali Extract

The chromatographs are hard to interpret objectively. The mobility of humic substances will partly depend on presence of clay minerals and complexing metals that coagulate humus.

5. Other Indicators of Humification

- extraction rate
- humification index
- E_4/E_6 ratio
- Carbon in FA/Carbon in HA
- ^{13}C-NMR
- FTIR
- Multinuclear NMR

Some of these tests, e.g. Nuclear Magnetic Resonance (NMR) Spectroscopy, with or without Cross-Polarization Magic Angle Spinning (CPMAS), and Fournier Transform Infrared (FTIR) Spectroscopy, even if reliable and sound, are expensive and require hard to maintain special equipment.

Recent research has shown that the scientific premise of the E_4/E_6 ratio is questionable.

In any case, tests of this genre have the following problems.

- different feedstocks yield different proportions of humus.
- all that is extracted by alkali is not humus.
- extractability of the humus and apportionment into fulvic and humic acids is influenced by many factors, e.g. feedstocks, minerals and metals, not by biostability alone.

6. Proximate Analysis

These include:

- polysaccharide content
- decomposition degree
- starch index

The problems are that (a) plant and animal poly- saccharides decrease during composting, but microbial polysaccharides increase; (b) all that is not decomposed by H_2SO_4 is not mature humus, and (c) not all feedstocks are rich in starch.

7. Microbial Activity Tests

The report discusses about eight tests in this group. There is wide variability among feedstocks, and numerous factors influence microbial activity. These tests are generally for use by experts with access to special equipment. However, the percent oxygen in the gaseous phase of a compost mix is a good indicator of whether substantial level of bioxidation is occurring. The presence of transient or persistent bioinhibitors, however, can lead to misleading results based on microbial activity.

8. Cation Exchange Capacity

Humic substances have a high CEC, but all feedstocks do not yield the same amount of humus. Also the CEC of humic substances can be smothered by amorphous and crystalline mineral matter.

9. Water Extracts of Composts

Conceptually there is no doubt that a compost is immature as long as substantial amounts of readily bioavailable, that is water-soluble, carbon compounds, such as acetic and other aliphatic acids, are present. The water extract then has a high BOD. However, dissolved or soluble organic carbon compounds (DOC) in a compost vary widely in their bioxidizability. Nor are they all equally phytotoxic.

However, the water solubility of a compost mix can be the basis of a test if it can be simplified, validated and well calibrated, if necessary, for various feedstocks that vary in their contents of water soluble components.

10. The Reheating or Final Temperature Drop Test

This test can not be performed easily on small samples. The reheating is influenced by many factors, e.g. size of the heap, nature of the material, and climatic conditions. In large heaps with no constraining factors on biological activity, temperature is a good indicator of activity.

11. The Phytotoxicity or Germination Test

A seed germination test can be unreliable because plants vary in their susceptibility and adaptability to different phytotoxins. Also, some totally raw feedstocks will exhibit no phytotoxicity.

C. The new concept

The literature review in the report to Environment Canada therefore concluded that none of the 29 tests discussed is both (a) entirely free of conceptual deficiencies, and (b) easy to apply reliably for rapid testing of composts from all types of wastes at an ordinary composting facility at reasonable cost.

The literature review also led to the conclusion that it would be worthwhile to investigate whether the optical density of the water extract of a compost at a fixed wavelength can be the most appropriate test for compost biomaturity, with or without regard to the total organic content of the compost. The rationale for this conclusion was as follows:

1. Irrespective of the source(s) of a composting mass, and regardless of the presence or absence of transitory or permanent bioinhibiting factors, a substantial portion of the organic content occurs in a readily bioavailable, i.e. water-soluble form, as long as the compost is immature.

2. Aerobic decomposition of organic matter involves both mineralization and humification. Mineralization to CO_2 and H_2O can proceed to a limited extent even in the absence of free oxygen as some microbes can utilize fixed oxygen (e.g. in NO_3^-, SO_4^{--}, CO_3^{--} and PO_4^{---}). In contrast, true humification or formation of water-insoluble humus involves free oxygen radicals. A lack of formation of water-insoluble humus, or the presence of water-soluble humus, is therefore a characteristic of incomplete decomposition, as in peatlands.

3. Although the solution phase of an immature compost may contain various aliphatic acids, phenols, and ammonia, its intermediate stage will always contain water-soluble humic substances which can be measured photometrically in ultraviolet or near visible light regions without significant interference from iron compounds. Also, the presence of any readily autooxidizable free phenols will indicate lack of maturation of humus. Any water-soluble aliphatic acids, amino acids, proteins and polysaccharides present will compete with humus for the metal ions that complex and coagulate humus. And, any free ammonia present will help solvate humus as ammonium salts of humus are water-soluble. Similarly excess of Na^+ and K^+ ions in solution, due to salinity, will help peptize and solvate humus.

4. Measurement of the optical density of the water extract of a compost at a fixed wavelength, as in a glucometer, will be inexpensive and easy to perform at any ordinary composting facility, as a test for compost maturity.

WCI designed and supervised an experiment based on the above premises. The experiment was conducted at Agriculture Canada. Its results are summarized here.

D. **The Experiment**

Four types of mixtures containing various fresh animal manures and shredded waste paper were composted indoors during Jan. - March 1992, in drums with basal air intake pipes in accord with the Passively Aerated Windrow System created and developed at Agriculture Canada. The system was found to provide adequate aeration, without any forcing of air, and conserve the ammonia usually lost from some turned or forced-air composting systems.

Samples of the compost mixtures, replicated five times, were extracted with hot (60°C) water at six intervals. The filtered extracts were investigated to determine their BOD_5 (Biological Oxygen Demand for 5 days); dissolved organic carbon content (DOC), concentrations of ammonium and nitrate ions, effect on germination of cress seeds, and absorption (E) at 280 nm, 465 nm and 665 nm wavelengths of ultraviolet and visible light (UV, VL). Freeze-dried contents of the extracts were analysed by ^{13}C NMR spectroscopy to determine the distribution of carbon atoms in various types of chemical bonds, and by Pyrolysis - soft Field Ionization - Mass Spectrometry (PY-FIMS) to identify and inventory a plethora of individual organic compounds present in or resulting from pyrolysis of the extract contents.

The BOD_5 of the extracts increased as decomposition began and then declined as the composts matured because both the total carbon content and the biodegradability of the organic matter in the water extracts decreased after the thermophilic phase of the composting.

The DOC contents of the extracts correlated at more than 99.9% level of confidence with absorbances at all of the three, 280, 465, and 665 nm wavelengths of UV or visible light. Consequently the absorbances increased initially and then declined but they declined well below the values for zero time only for 665 nm. This was perhaps so because both a vast variety of individual organic compounds and humic substances absorb highly at 280 and 465 nm so that the presence of even benignly low amounts of individual organic compounds can exhibit strong absorbances at the lower wavelengths.

The temperature, % O_2, BOD_5, DOC, NH_4^+, NO_3^- and E665 data indicated that the composts matured between days 40 and 59 after initiation. This was confirmed by germination tests with seeds of cress.

The ^{13}C-NMR and PY-FIMS data lent highly scientific corroboration of the above, although these tests were expensive and PY-FIMS could be performed only in Germany. A large variety of organic compounds of plant, animal and microbial origins were identified in the extracts at initial stages and, as these disappeared, aromaticity, and the aromatic polymer-type humus, increased. High presence of acetic acid indicated that the decomposition process was under adequately aerobic conditions. Continued presence of acetamide suggested optimal proteolysis and humification.

One other question needs to be considered, unfortunately. Can the proposed colorimetric test be subverted easily, if it were used for regulation. For subversion of the test, one would have to (a) actually leach the entire compost mass with hot water and dry it immediately to forestall resumption of microbial activity, or (b) add metals of high complexation capacity such as Cu, Pb and Hg, to coagulate water-soluble fulvic acids that are not easy to saturate even with heavy or transitional metals (Schnitzer and Khan, 1972; Stevenson, 1982), and mix thoroughly in a wet state, without exceeding the metal concentration maxima allowed by regulations. Both alternatives would be prohibitively expensive and virtually unaccomplishable.

In summation, the composts were mature when the BOD_5 of a 10:1 water extract of 1 g of dry compost was < 5 mg; the BOD_5 of each gram of carbon extracted by water was < 300 mg; and the E665 of a 1/5 dilution of a 10:1 extract of a moist compost was < 0.008.

The conclusion of this study was that colorometric absorbance by water extracts of composts at 665 nm of visible light promises to be the basis of a single, facile, reliable, and scientifically sound test for determination of compost biomaturity, both during the process and after the fact. The intensity of the colour can be measured, as in a glucometer used by diabetics, or compared to a standard colour chart easily and rapidly. A glucometer is a simple, inexpensive, hand-held meter that accurately measures the intensity of a specific colour on a strip of paper carrying a sample. It is battery-powered. A similar instrument can be devised for measuring the colour of a compost extract at a specific set wavelength of light, for use by operators, regulators, retailers and bulk consumers.

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L'importance de l'étude des processus dans le compostage : une approche multivariée, le cas de l'azote organique

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Les fumiers de bovin, comme on le sait, constituent un résidu agricole important au Canada surtout par le volume produit (Émond, 1988). Leur mode de gestion sur la ferme, qui a tendance à évoluer ces dernières années vers le liquide, apporte de nombreux problèmes tant agronomiques qu'environnementaux (Cluis et Couture, 1987). C'est avec l'industrialisation de l'agriculture que l'on voit apparaître de véritables industries d'élevage où la taille des élevages augmente sans cesse jusqu'à aujourd'hui et, où la surface relative des sols diminue (GREPA, 1991). Il n'y a donc plus suffisamment de superficie de sols pour épandre les fumiers. En plus de ces facteurs, le phénomène de la concentration des industries d'élevage dans certaines régions contribue à l'augmentation du volume des fumiers.

Le compostage est une solution intéressante pour améliorer la gestion des fumiers et les valoriser. En général, les techniques de compostage sont diverses mais relativement bien connues et étudiées. Cependant, lorsqu'on parle de la réutilisation des composts sur les sols agricoles ou, également, des questions environnementales entourant le compostage, il faut approfondir la connaissance des cycles des éléments nutritifs à l'intérieur du processus de compostage. Certains cycles constituent encore de véritables boîtes noires et c'est le cas pour une grande partie du cycle de l'azote, en particulier de l'azote organique.

En général, dans la littérature, on interprète l'évolution du processus de compostage et les successions de micro-organismes responsables de la dégradation de la matière organique à l'aide de l'évolution des températures dans le temps (Crawford, 1983 ; Brakel, 1982 ; Gray et Biddlestone, 1981 ; Poincelot, 1974). La figure 1 représente une courbe idéalisée de l'évolution des températures sur l'échelle de temps de nos expériences au laboratoire. Cependant, la température est une mesure indirecte de la quantité de chaleur produite, qui est par ailleurs une notion thermodynamique (Mustin, 1987). En effet, la température est fonction de la chaleur massique des substrats en compostage, de l'humidité des substrats, et aussi de la manière dont on prend sa mesure. En conséquence, on a choisi d'interpréter la dynamique de l'azote en fonction des différentes phases du processus de compostage à l'aide d'une approche multivariée, plutôt que basée sur la température. Ceci constitue une nouvelle approche dans l'étude du processus de compostage.

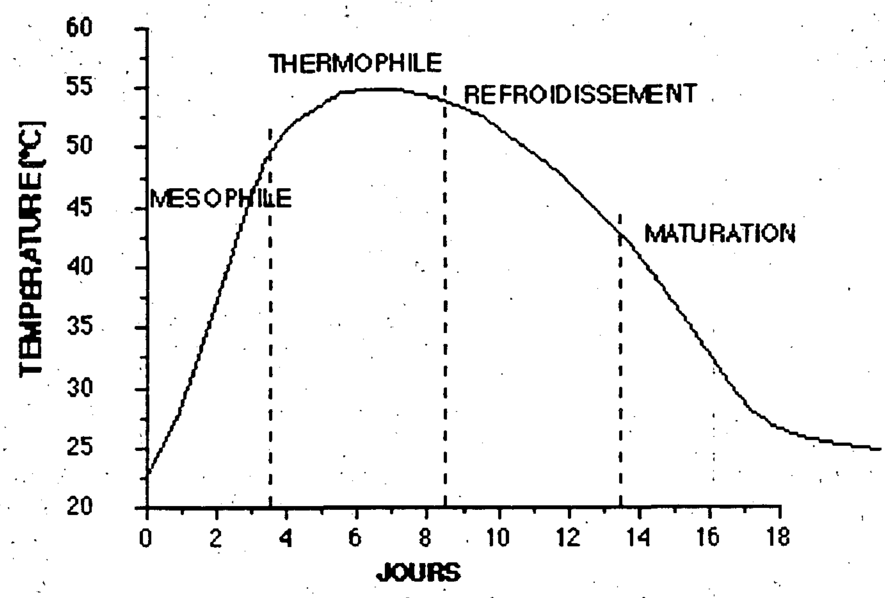

FIGURE 1 : COURBE IDÉALISÉE DE L'ÉVOLUTION DES TEMPÉRATURES ET PHASES CARACTÉRISTIQUES DU PROCESSUS DE COMPOSTAGE.

Le cycle de l'azote est en général très bien documenté. On retrouve dans la littérature plusieurs travaux traitant des aspects particuliers de la fixation de l'azote (Nommik et Vahtras, 1982), des pertes d'azote par lessivage (White, 1987 ; Kirchmann, 1985) et par volatilisation (Freney et Black, 1987 ; Freney et al., 1983 ; Adriano et al., 1974), de la nitrification (Flowers et O'Callaghan, 1983) et de la dénitrification (Parsons et al., 1991 ; Tiedje, 1988 ; Fillery, 1983 ; Focht et Verstraete, 1977), ainsi que de la minéralisation et de l'immobilisation de l'azote (Jansson et Persson, 1982) soit en écologie microbienne, ou encore dans l'étude de systèmes sol-plantes.

Cependant, le cycle de l'azote est beaucoup moins connu lors de la transformation d'un substrat organique par le processus du compostage; quelques ouvrages y font référence de manière générale. Outre une revue de littérature sur l'utilisation des boues d'épuration et des compost de boues en agriculture qui traite des pertes d'azote durant le compostage de différents substrats organiques (Witter et Lopez-Real, 1987), il est question des pertes d'azote lors du compostage de fumier de bovin sous différentes conditions d'aération (Ott, 1990), des pertes et des transformations de l'azote durant le compostage de boues d'épuration et de paille (Witter, 1986), et de la conservation de l'azote durant le compostage de fumier de bovin (Bishop et Godfrey, 1983 ; Willson et Hummel, 1975). L'importance de l'évolution des formes d'azote minérales pendant le compostage, pouvant servir d'indice de maturité, est soulignée par Godden (1986). Une étude récente rapporte avec plus de détails la distribution de l'azote dans différents types de composts (Mathur et al., 1990).

En résumé, la littérature rapporte que l'azote organique, qui constitue au départ plus de 90% de l'azote total, est minéralisé et que le peu d'azote minéral est rapidement transformé sous forme d'azote organique. Il s'agit d'un processus dynamique de minéralisation de l'azote au départ qui évolue vers une assimilation par la suite. On peut donc poser l'hypothèse que les formes d'azote organique assez facilement hydrolysables, présentes au début, vont être réorganisées sous des formes d'azote organique plus difficilement hydrolysables à la fin du compostage.

Matériel et méthodes

Les expériences de compostage ont été menées au laboratoire à l'aide de composteurs expérimentaux (van Bochove, 1993). On retrouve dans la littérature plusieurs auteurs qui ont utilisé de tels systèmes soit dans le but d'examiner les caractéristiques des produits obtenus suite au compostage de différents substrats organiques, ou encore dans le but d'optimiser le processus de compostage (Jeris et Regan, 1973 ; Clark et al., 1978 ; Mote et Griffis, 1979 ; Ashbolt et Line, 1982 ; Godden et al., 1983 ; Sikora et al., 1983 ; Hogan et al., 1989).

Le système utilisé dans cette étude est de type adiabatique (voir schéma à la figure 2). Le principe général des composteurs adiabatiques vise à permettre la succession caractéristique des micro-organismes responsables des processus de décomposition de la matière organique, en limitant les échanges de chaleur avec l'extérieur au minimum, et sans apport de source de chaleur externe au compost. Le montage est composé de trois sous-systèmes : la circulation de l'air, le contrôle des échanges de chaleur, et les composteurs eux-mêmes. Les quatre composteurs sont identiques et constitués d'un cylindre de CPV (chlorure de polyvinyle) de 21 cm de diamètre, et de 30,5 cm de hauteur (volume = 10,56 litres), soudé dans un cylindre extérieur de 29,5 cm de diamètre et de 26 cm de hauteur, aussi en CPV. Le cylindre intérieur est fermé par un couvercle amovible, en acrylique de 1,9 cm d'épaisseur, muni d'un joint d'étanchéité. Un trou percé dans le fond du cylindre intérieur permet l'entrée de l'air par un tube en verre, et deux trous dans le couvercle permettent le passage d'une part du thermistor et de la sonde d'humidité, et d'autre part d'un tube en verre de sortie des gaz. L'isolation thermique des composteurs est réalisée par un bain d'eau chaude circulant entre les deux cylindres de CPV. L'eau est chauffée et amenée à chaque composteur par une pompe chauffante immergée dans un récipient d'eau; l'eau revient ensuite à la pompe par gravité. Le contrôle de la résistance chauffante de la pompe permet d'ajuster manuellement la température de l'eau par facteur de 1°C en 30 secondes. Le volume initial de fumier placé dans le composteur est de huit litres et ne dépasse pas le niveau du bain d'eau à l'extérieur. Le compost est aéré par de l'air sous pression provenant d'un compresseur de laboratoire. L'air est d'abord réchauffé à la même température que l'eau en circulant dans un tuyau de cuivre hélicoïdal placé dans le bain d'eau chaude d'un des composteurs, et est ensuite humidifié à saturation par barbotage. Le réchauffement et l'humidification de l'air ont pour but de ne pas créer de chocs thermique ou hydrique à l'entrée, dans le compost. Finalement, avant d'être réparti entre les quatre composteurs, l'air est débarrassé de l'ammoniac présent, par barbotage dans une solution acide, et ensuite du CO_2 présent, par barbotage dans une solution alcaline. L'air est diffusé par une pierre poreuse, immédiatement à son entrée dans le composteur, ce qui assure une distribution homogène 2 cm en dessous de la surface du compost qui repose sur un grillage métallique galvanisé. L'air est acheminé aux composteurs à un taux d'aération pouvant varier de 0,5 à 2 l / min. / composteur. La température du bain d'eau chaude est demeurée, durant toute la durée de l'expérience, inférieure de 1° à 5° C à celle du compost, afin de maintenir les pertes de chaleur par conduction à un niveau minimal. Les ajustements de température se font manuellement. La température interne du compost est mesurée par quatre thermistors placés au centre du compost et reliés à un système d'acquisition de données.

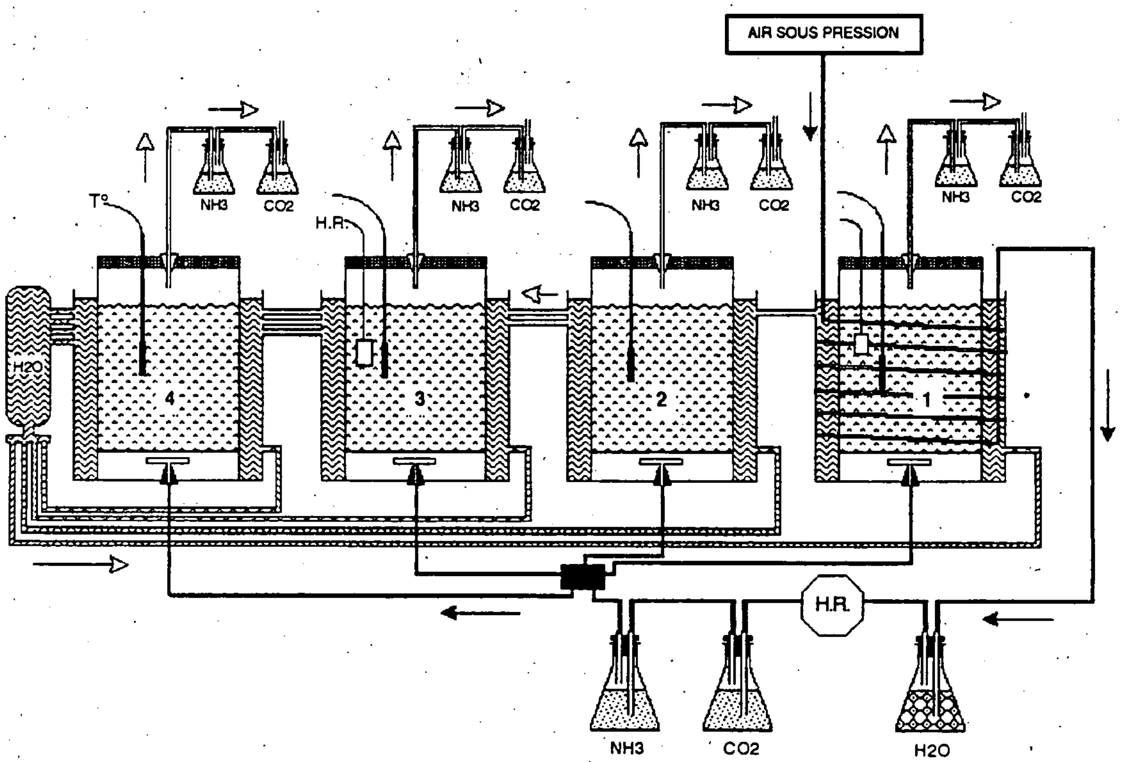

FIGURE 2 : SCHÉMA DES COMPOSTEURS DE LABORATOIRE

L'échantillonnage a été effectué dans deux des quatre composteurs tous les jours durant les expériences, et dans les deux autres composteurs aux jours initial et final. L'échantillon est composé de deux fractions. La première fraction, fraîche, de l'échantillon a permis de mesurer le pH, les pertes d'humidité, et surtout les pertes de solides secs durant l'expérience. Tous les résultats, présentés par la suite, ont été pondérés en fonction de ces pertes de solides secs. L'autre partie de l'échantillon a été congelée, lyophilisée et broyée pour le dosage du carbone total, de l'azote total, des formes d'azote minéral et des formes d'azote organique. L'azote organique a été fractionné par hydrolyse acide. Les méthodes de fractionnement de l'azote organique dans les fumiers et les composts ont également fait l'objet de recherches dans notre laboratoire, en effet ces méthodes ont été développées initialement pour les sols et il n'y a pas encore de consensus à ce sujet. Cependant, les résultats des méthodes d'hydrolyse dépassent le cadre de cette conférence, et nous présenterons seulement la méthode d'hydrolyse que nous avons adaptée (van Bochove, 1993). Il s'agit d'une méthode d'hydrolyse continue en deux étapes de quatre heures, à l'HCl 6N par ébullition à reflux. La première étape permet de doser les formes d'azote total hydrolysable, hexosamines, acides aminés, et hydrolysable inconnu (HUN). Cependant, une hydrolyse plus douce à l'HCl 1 N de 3 heures a été utilisée pour doser les formes d'azote NH_4 et amides. La deuxième étape d'hydrolyse de 4 heures a permis de doser les formes d'azote hexosamines supplémentaires.

La dynamique de réorganisation de l'azote a été interprétée en fonction de l'évolution du processus de compostage selon ses phases caractéristiques par une approche multivariée qui consiste, selon une approche écologique classique (Legendre et Legendre, 1982), à superposer une analyse en composantes principales (Hotteling, 1933) à un groupement à liens simples (Sneath, 1957).

Les deux analyses multivariées ont été effectuées sur 19 variables physico-chimiques, mesurées sur les échantillons prélevés dans deux composteurs, et sur 26 jours d'échantillonnage.

Résultats et discussion

On a observé au cours des 15 jours de compostage une diminution très rapide des formes d'azote minéral dans le temps avec une nouvelle augmentation après une dizaine de jours de compostage (figure 3). Cette augmentation est attribuable à la fin de la phase thermophile, lorsque la lyse des bactéries provoque la remise en circulation de l'azote qui était immobilisé dans les membranes cellulaires par une minéralisation rapide.

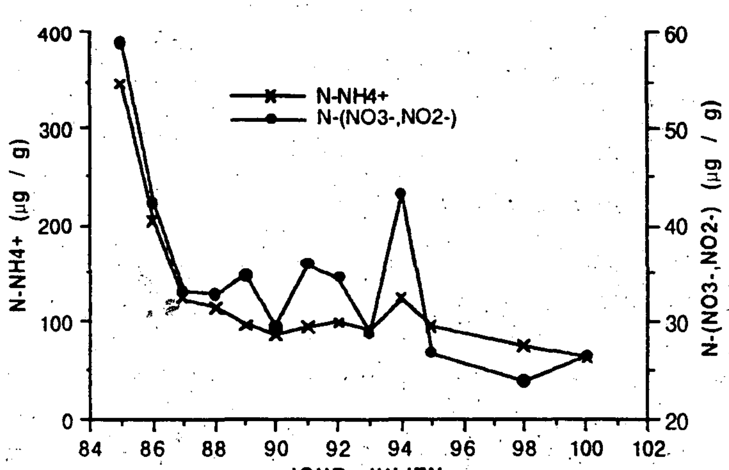

FIGURE 3 : ÉVOLUTION DES FORMES D'AZOTE MINÉRAL AU COURS DU COMPOSTAGE AU LABORATOIRE.

La synthèse des résultats des analyses multivariées est présentée aux figures 4 et 5. La figure 4 montre les résultats de l'analyse en composantes principales selon la première composante principale (axe x) et la deuxième composante principale (axe y). Les trois premières composantes principales représentent 72% de la variance totale. En médaillon, on illustre les gradients temporels de dégradation de la matière organique et d'une augmentation des formes d'azote organique plus difficilement hydrolysables. Ces gradients sont établis à partir de l'interprétation écologique que l'on donne aux corrélations fortes et significatives de certaines variables physico-chimiques avec les axes principaux. À droite sur la figure 4, on retrouve les jours d'échantillonnage disposés dans l'espace des deux premières composantes principales, et superposés à ces jours les résultats du groupement à liens simples. Le groupement montre clairement qu'après les deux jours initiaux de compostage, il y a formation de deux groupes distincts et disposés selon les gradients retrouvés. Le premier groupe de trois jours est interprété comme étant la phase thermophile et le deuxième groupe de six jours comme étant la phase de refroidissement. On peut poser l'hypothèse que si l'expérience avait été prolongée, il y aurait eu la formation d'un troisième groupe de jours correspondant à la phase de maturation.

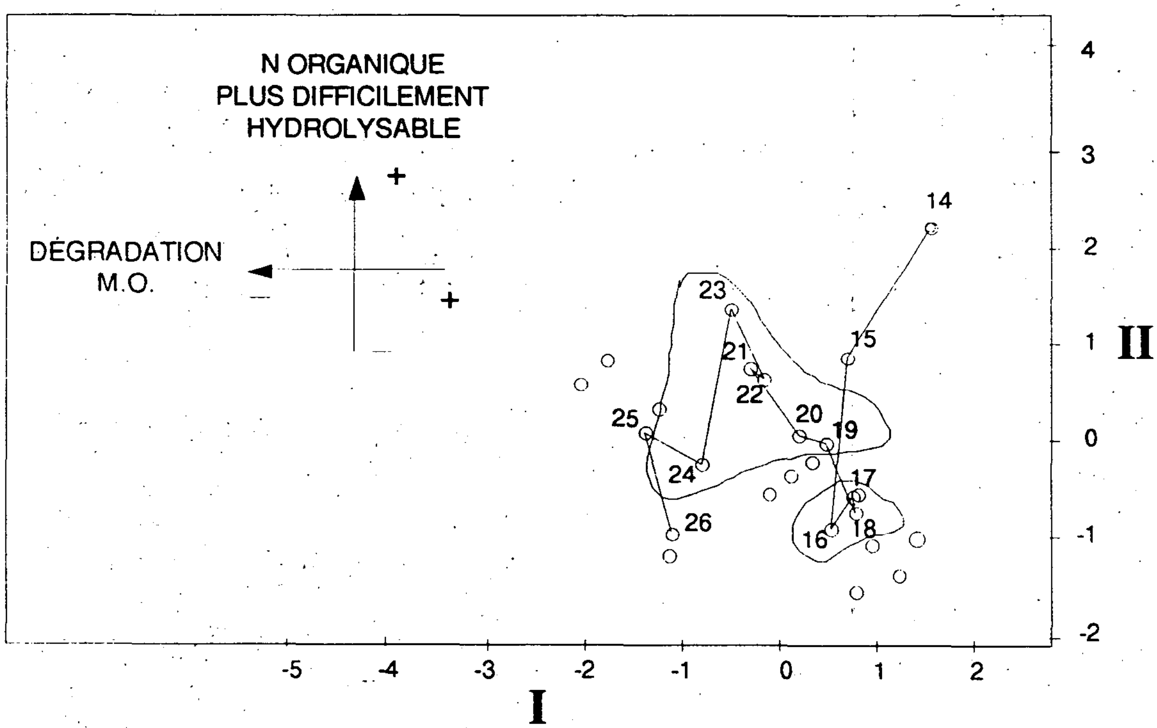

FIGURE 4 : SUPERPOSITION DE L'ANALYSE EN COMPOSANTE PRINCIPALE ET DU GROUPEMENT À LIENS SIMPLES, ESPACE DES DEUX PREMIÈRES COMPOSANTES PRINCIPALES (37,3% ET 18,8% DE LA VARIANCE TOTALE). M.O. = MATIÈRE ORGANIQUE.

La figure 5 représente la première composante principale (axe x) en fonction de la troisième composante principale (axe y). Suivant la troisième composante principale, on retrouve un autre gradient temporel qui est celui de l'augmentation de l'activité microbienne et de l'assimilation de l'azote sous forme acide aminé. Les groupes de jours représentés sont issus du même groupement à liens simples qu'à la figure 4, et sont orientés selon les différents gradients écologiques.

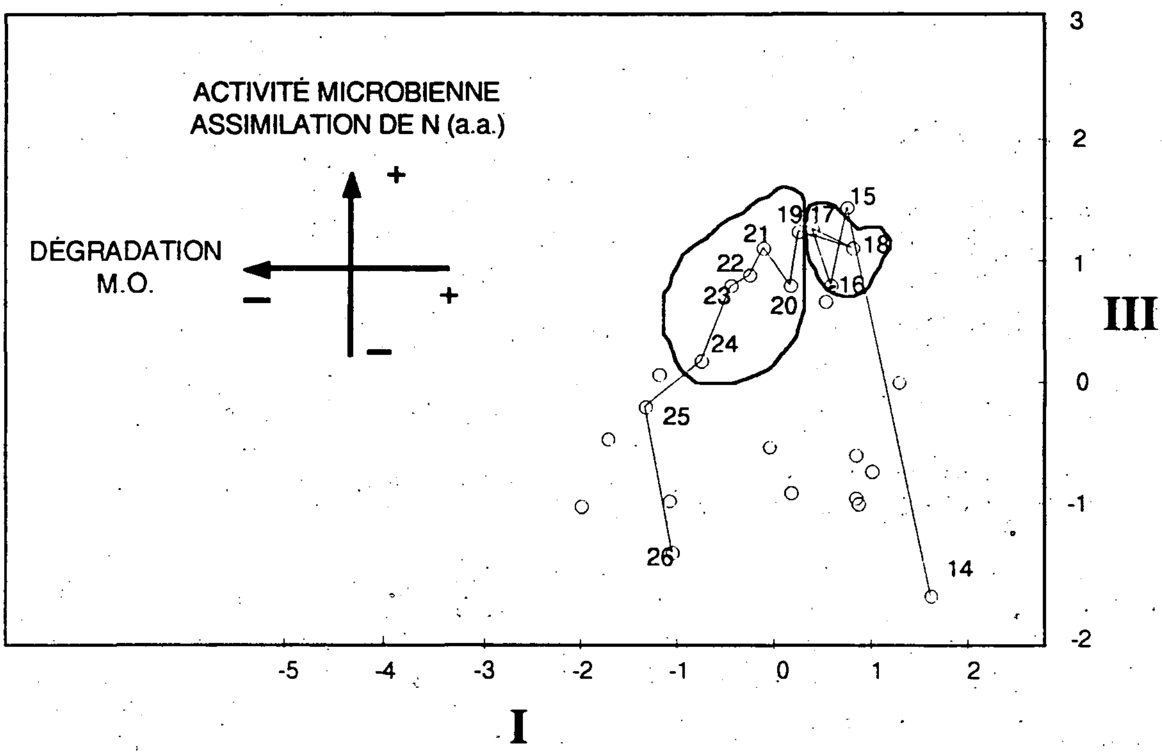

FIGURE 5 : SUPERPOSITION DE L'ANALYSE EN COMPOSANTE PRINCIPALE ET DU GROUPEMENT À LIENS SIMPLES, ESPACE DES PREMIÈRE ET TROISIÈME COMPOSANTES PRINCIPALES (37,3% ET 15% DE LA VARIANCE TOTALE). N (a.a.) = AZOTE ACIDE AMINÉ.

Les résultats de la dynamique de réorganisation de l'azote organique en fonction des différentes phases caractéristiques du compostage, issues de l'analyse multivariée, sont représentés à la figure 6. Lors de la première phase, la phase thermophile, on observe une augmentation importante de l'azote acide aminé. Il y a donc synthèse de protéines, i.e. de membranes cellulaires, par les bactéries. Durant la deuxième phase, la phase de refroidissement, on note une augmentation marquée de l'azote hexosamine. L'augmentation de cette forme d'azote montre qu'il y a synthèse de matériel pariétal des champignons, puisque ceux-ci colonisent le compost lors de la phase de refroidissement. Vers la fin du processus, au dernier jour de l'expérience, on note une augmentation des formes d'azote hydrolysable inconnues.

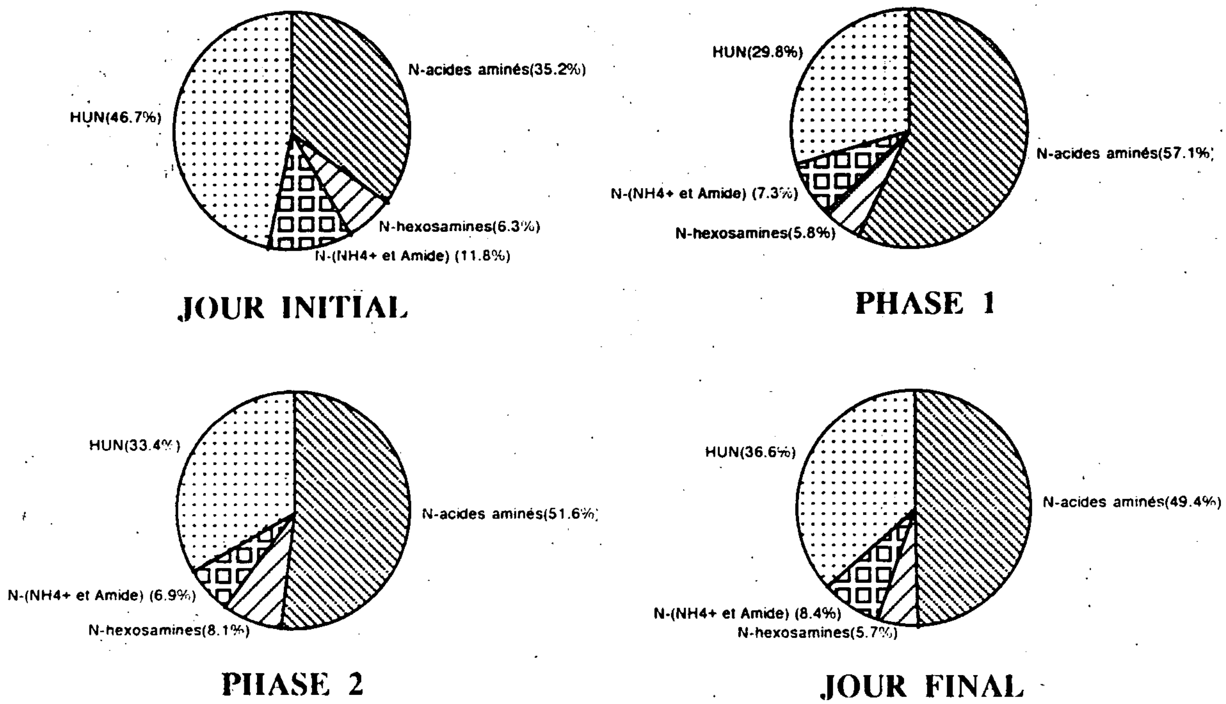

FIGURE 6 : FORMES D'AZOTE ORGANIQUES EN FONCTION DES PHASES CARACTÉRISTIQUES DU COMPOSTAGE (% N TOTAL HYDROLYSABLE).

Des analyses de spectrométrie de masse à champs ionisé (pyrolysis-field ionization mass spectrometry ou Py-FIMS), couplée à une pyrolyse (Schulten et al., 1987), ont été effectuées sur des échantillons de compost prélevés dans le temps, dans un composteur de laboratoire (van Bochove, 1993). Ces résultats, qui permettent d'identifier les principales composantes organiques, ont été interprétés (Schulten, 1987 ; Leinweber et al., 1992 ; Hempfling et al., 1988 ; Hempfling et Schulten, 1990 ; Hempfling et Schulten, 1991 ; Schulten et Schnitzer, 1990) et sont présentés aux tableaux 1 et 2.

TABLEAU 1

COMPOSANTES ORGANIQUES MAJEURES IDENTIFIÉES PAR LA TECHNIQUE Py-FIMS.

Composantes majeures	Composantes mineures
Hydrates de carbone avec radicaux pentose et hexose	Phénols
Monomères et dimères de lignine	Monoesters n-alkyle $n\text{-}C_{38}$ à $n\text{-}C_{51}$
Acides gras $n\text{-}C_{15}$ à $n\text{-}C_{34}$	Acide acétique
Stérols	Indole (composé N-hétérocyclique)

On identifie des stérols en grande quantité parmi les composantes organiques majeures. L'identification d'ions moléculaires de type stérol dans une matrice aussi complexe que le compost, grâce à cette récente technique de spectroscopie, constitue une information nouvelle et très intéressante. Jusqu'à ce jour, une seule autre étude rapporte des données similaires (Schnitzer et al., 1992). Les stérols sont des molécules de la classe des lipides et peuvent être d'origines animale et végétale. Puisqu'il s'agit dans cette étude de fumier de bovin, les stérols des deux origines sont présents (tableau 2).

TABLEAU 2

IONS MOLÉCULAIRES DE TYPE STÉROL IDENTIFIÉES PAR LA TECHNIQUE Py-FIMS.

m/z	identité
386	cholesterol
394	ethylcholestatriene
398	ethylcholestene
400	campesterol
410	ethylcholesterol
412	stigmasterol
414	β-sitosterol
416	dehydro-β-sitosterol
426	D : A-Friedooleanan-3-one
430	α-tocopherol

On peut poser l'hypothèse que les stérols présents dans les échantillons du début du processus de compostage vont être bio-dégradés, par les bactéries et les champignons entre autres, et vont donc se retrouver transformés au fur et à mesure de la maturation du processus.

Dans les composantes mineures (tableau 1), on retrouve également des molécules d'azote complexe hétérocyclique de type indole; ces molécules font, sans aucun doute, partie de l'azote inconnu (HUN) qui augmente en proportion vers la fin du processus de compostage et constitue plus de 36% de l'azote total hydrolysable (figure 6). On peut poser l'hypothèse que vers la fin du processus de compostage, dans nos expériences mais aussi en général avec la maturation d'un compost, on doit retrouver des formes d'azote organique de plus en plus complexes et plus stables. Les recherches d'identification des formes d'azote inconnu n'ont pas abouti depuis longtemps, probablement en raison de l'absence de techniques analytiques adéquates. Cependant, la technique de spectroscopie par Py-FIMS permet d'espérer une percée intéressante dans ce domaine.

Conclusions

En conclusion, on observe durant les expériences de compostage de fumier de bovin pailleux, en composteurs de laboratoire, qu'il y a une minéralisation très rapide de presque tout l'azote organique présent dans le fumier. Par la suite, il y a une assimilation nette d'azote sous forme organique, i.e. une réorganisation de l'azote sous des formes organiques plus complexes et plus stables dans le compost de fumier. L'identification de formes d'azote organique hétérocyclique (indole), grâce à une nouvelle technique spectroscopique (Py-FIMS), est un début prometteur vers une connaissance plus complète des formes d'azote inconnu. Ces connaissances permettront dans l'avenir de comprendre la contribution des composts à la restauration de la matière organique des sols agricoles, et d'étudier la dynamique de minéralisation de l'azote organique complexe.

L'identification de stérols en grande quantité est également un élément très intéressant, qui devrait retenir l'attention des chercheurs dans l'avenir.

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COMPOSTING POTENTIAL AND ACTIVITIES IN NEW BRUNSWICK

by

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COMPOSTING POTENTIAL AND ACTIVITIES IN NEW BRUNSWICK

Our serious involvement with composting began in 1990. Prior to this we had very little involvement with composting and little information on the subject. There were a number of reasons why we got involved. First, as soil management people we were aware of a number of soil problems related to low levels of organic matter. Secondly we have been promoting the utilization of manure as a soil amendment rather than a waste and there were a number of problems encountered which I will explain later. Another reason for becoming involved was the trend to sustainable agriculture which generated a lot of inquiries about composting. Last but not least, having been raised in the era of waste not, want not, there was the feeling we could turn a lot of waste into a resource.

Agriculture, forestry, fishing and aquaculture are major industries in New Brunswick which generate a lot of waste that can be useful as a soil amendment. Fishery activities in the Chaleur Bay, Northumberland Strait and Bay of Fundy produces a lot of fish waste, including shellfish waste. In the Northeast and to some extent in the Southeast there are a number of peat moss operations so that in this area we have all the ingredients for a high quality compost. Along the Bay of Fundy coast we have a number of aquaculture operations in addition to the regular fishery. While there are no commercial peat operations in this area, there are a few small deposits plus a number of forestry operations that generate chips and sawdust that can be used in composting operations.

Various agricultural operations occur throughout the province. With dairy and beef operations the land base is sufficient to spread the manure generated although the way manure is handled leaves a lot to be desired in terms of utilization and protecting the environment. Hog and poultry operations usually do not have a sufficient land base on which to utilize the manure and in some areas, the operations have become concentrated, such as the St. François area in Madawaska County. The resulting problems with swine operations in particular have been a major concern of environmentalists and a number of court cases has resulted. As a matter of fact, New Brunswick's Right to Farm Legislation was developed after a class action law suit against a hog farmer resulted in the farmer having to pay several thousand dollars to his neighbours as ordered by the court.

Horticultural operations are scattered throughout the province. Two areas of interest are the Maugerville-Sheffield-Grand Lake area and the Woodstock-Grand Falls area. In the first mentioned area market gardening is the major type of agriculture with little waste generated and mostly minor soil problems occurring. In the Woodstock-Grand Falls area our so called potato belt most farms produce potatoes and grain with very few having animals in their operations. There are two potato processing operations which generate a lot of waste plus there are many culls from each individual operation which are dumped. There are a number of major soil problems such as erosion, compaction and poor soil structure which could be improved a great deal with additions of organic matter.

Various forestry related industries are found throughout the province that produce by-products such as sawdust, chips and papermill sludge. So as for the potential for composting in New Brunswick, we have a good supply of the waste materials required for composting with the only drawback at the moment being markets for the compost products.

In 1990 we obtained funds under the Atlantic Livestock Feed Initiative Agreement for technical help to start an information file on composting and determine what was being done as far as composting was concerned in the province. We developed quite an extensive file of information mostly from literature sources. As far as composting activity we were pleasantly surprised. From an agricultural standpoint some efforts were being made although in many cases the end product could not be called good compost but was somewhere between well rotted manure and compost. One company was experimenting with windrowing feedlot manure and shavings. Some work was being done with liquid hog manure and peat moss. One peat moss company was composting fish waste and peat moss using windrows and had a very good product. Other people were composting waste from salmon farms and all in all, there was lot of interest and a fair amount of activity going on. Two people who had done considerable work in the province prior to 1990 on composting fish waste and peat moss were Dr. Sukhu Mathur and the then LRRI of Canada Agriculture and Dr. Jean Yves Daigle of the Peat Research Centre in Shippegan. It was quite evident during the first year, especially in the agricultural sector, that there was a lack of readily available information on composting and the various methodologies.

Early in 1991 we received funds from ALFI to purchase two compost turners and a bit later we again received funding for technical assistance. Our plans for 1991 were to demonstrate the windrow method on farms and produce a factsheet on on-farm composting. The turners were taken to different farms. We provided the transportation with the farmers making the windrows and supplying the tractor for the turners. Demonstrations were held on a number of farms and the results varied. After the first turning some farmers decided it would be too expensive or time-consuming or they could not work it into their schedule. Some farmers carried through to the end and were pleased with the product and planned to do composting in 1992. We gained a lot of first-hand experience in on-farm composting during the year. We had problems with mixes, moisture, temperature and others and had to do a lot of investigative work but we solved most problems. We also received a lot of inquiries regarding composting not only from farmers but from the public in general. Again we gained a lot of information in answering the inquiries. During the winter months we wrote a factsheet on "On-Farm Composting" and had it published. We also put together a draft video on the compost turners and distributed it to the Regional Offices. I must admit the video requires a lot of polishing yet plus we need it translated before it is released to the general public.

In the spring of this year (1992) we again received funding from ALFI for technical support but for a shorter period (7 months).

The number of requests for use of the turners were probably less than in 1991 but the people making the requests were more serious about composting and some were interested in the commercial aspects of composting. As a result, the turners were used much more in 1992 than in 1991. During 1992 we were involved with the composting of fish waste and sawdust or chips, poultry and liquid hog manure with sawdust and straw, potato culls, cattle manure and sawdust, cattle manure and chips & sawdust and poultry manure and straw, horse manure & shavings and other materials commonly found on farms. Requests for information on composting have remained constant but are more technical in nature.

Looking to the future, there are two areas related to composting that we need to get involved in. The first is field plot trials using various composts on different crops. There is a great lack of information in this regard in the province and we feel it is essential to have this information in order to encourage composting and develop markets for the compost. Marketing of compost in another area we must become involved with and again there is little information on the subject as it relates to New Brunswick. I expect in a year or two there will be at least two or three commercial composting operations in the province. What the potential market is, at the moment, we can only guess.

There is a lot of interest in New Brunswick in recycling and sustainable living. For instance, Dr. Bourque of the University of Moncton is in the process of establishing a centre of expertise in recycling and composting and overall, there is quite a movement towards a sustainable society. Those of us concerned with agriculture are doing all we can to promote the concept and encourage producers to convert their waste to a resource by composting. Thank you ladies and gentlemen.

REACHING CONSENSUS ON MANAGING ORGANIC WASTES IN ONTARIO

Background

I would like to speak to you today about a report produced by the Waste Reduction Advisory Committee (WRAC) regarding the organic wastes being produced by residential and IC&I (industrial, commercial, and institutional) sources in Ontario and the development of certain policy recommendations for dealing with these wastes. Formed in mid-1990, WRAC is a multi-stakeholder body, providing independent waste management advice to the Ontario Minister of the Environment on the reduction, reuse, recycling, and composting of residential, commercial, institutional, and industrial, non-hazardous solid waste and household hazardous waste in Ontario. The title of the report is: "Organic Waste Action Plan for Ontario". It has been submitted to the Minister of the Environment for her consideration.

WRAC's investigation of organic wastes was undertaken on its behalf by its Organic Waste Diversion Sub-Committee and the Sub-Committee's special support group the Advisory Forum. The Sub-Committee's membership was widely based, including not only WRAC representatives but also members from municipalities, universities, industry, and environmental and agricultural organizations. The Advisory Forum included additional individuals from these areas, as well as several from Ontario government agencies and consulting firms working in the waste management field.

Goals and Objectives of the Action Plan

One of Ontario's key environmental goals is to reduce waste generation by 50 per cent by the year 2000 as compared to 1988. With organic wastes making up approximately 20 per cent of the province's total waste stream, it is clear that significant steps can be taken to achieve this goal by reducing organic waste generation as much as possible.

WRAC's goal was to develop a general strategy, with supporting recommendations, by which Ontario could build on existing initiatives to decrease the disposal of organic wastes and to increase the reuse and recycling of such materials.

To achieve this goal, certain objectives were set:

- the development of guiding principles for organic waste management;

- the creation of a hierarchy of end uses for organic materials;

- the consideration of the roles and responsibilities of all stakeholders concerned with the planning, funding, and execution of organic waste management programs;

- the development of a general strategy for organic waste management in Ontario, including recommendations for funding and implementing the resulting program;

- the development of support recommendations for implementing the suggested waste management program.

The end result of WRAC's work in achieving these objectives has been a general strategy for managing wet organic wastes in Ontario.

Guiding Principles for Organic Waste Management

WRAC has concluded that an organic waste management system for Ontario should

1. **Maximize value of resources and integrity of environment.** The waste management system should preferentially promote environmentally superior end-uses for secondary materials, allowing for technical and economic constraints.

2. **Integrate the approach to organic waste management with the management of all other waste streams.** The system should be compatible or integrated with other 3Rs systems (e.g., Blue Box, wet-dry recovery, etc.), and should only resort to mandatory actions where voluntary approaches (including incentives) have failed.

3. **Be fair and equitable, and based on the concept of "stewardship of resources".** Stewardship of resources implies clear definitions of roles and responsibilities. These responsibilities should be distributed fairly between stakeholders. This means that

   - no one agent or sector, public or private, should carry all of the responsibility;

   - authority should be commensurate with responsibility.

4. **Promote personal awareness through involvement.** If people everywhere participate in the solutions to common waste problems, they will feel empowered. They will also become more aware of how their actions are either part of the problem or part of the solution. However, a system that is

too inconvenient will not be sustainable. Therefore, a balance must be struck between convenience for generators and their involvement in solutions.

5. **Promote constant re-evaluation and innovation.** Technical advancements will provide new options. Increased generator awareness will allow for systems development and growth. If the infrastructure has built-in flexibility and incentive for improvement, benefits such as waste diversion and resource/energy conservation will be maximized over time.

6. **Be practical, feasible, and sustainable.** The Province's goals cannot be achieved by a system that is so impractical or unwieldy that sustaining it requires constant effort by government. Once in place, the system should be cost-effective and should run by itself with minimal government intervention.

7. **Be operated under the precepts of true-cost accounting.** To be consistent with the guidelines for true-cost accounting being developed by the Ministry for application by municipalities in all of their waste management activities.

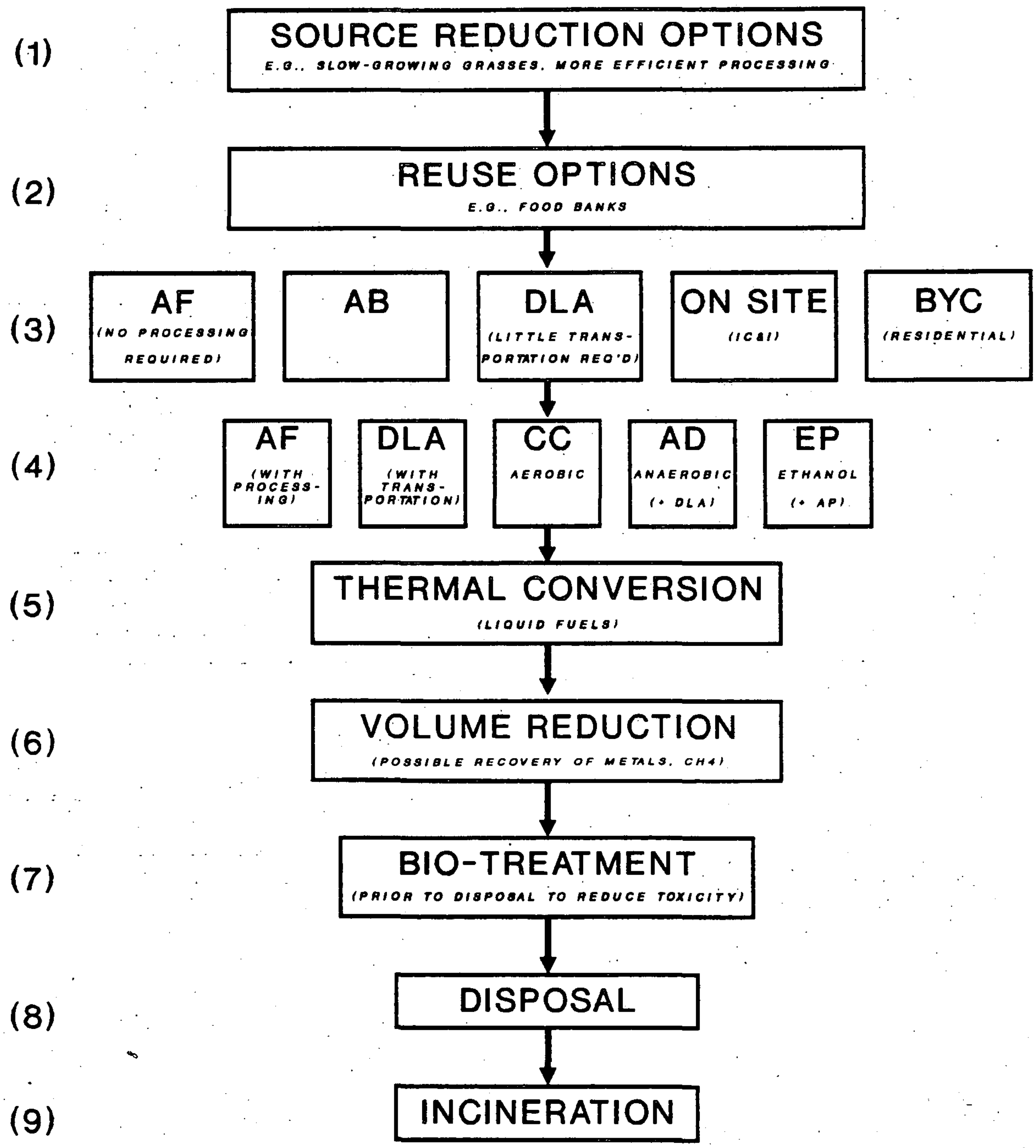
Organic Waste Management Hierarchy

The Organic Waste Management Hierarchy was developed as a "decision-making tree" for deciding on end-uses for organic wastes, based generally on degree of environmental impact and amount of processing required. The intent is to maximize the benefit of the value-added nature of organic waste streams. As indicated in the Figure, the Hierarchy embodies the 3Rs hierarchy of reduce, reuse, and recycle as the preferred options to consider before other approaches involving energy conversion, disposal, or incineration. WRAC considers the Hierarchy to be a general planning tool; it is meant to function as a preferred framework for considering end-uses based on the properties of given materials and prevailing circumstances, which may vary over time and from one locality to another. Key factors would be:

- applicability of an option to a given material
- proximity of available facilities for pursuing options
- transportation costs.

In this way, the Hierarchy could be used as a disciplined check-list for municipalities and others to consider during waste management planning, as a reminder to examine "higher" end uses before choosing "lower" end uses to ensure that sound social and environmental opportunities are not being missed. In other words, anyone proposing one of the options in the Hierarchy for a given portion of the waste stream should be able to demonstrate the reason for its selection over all of the options above it.

ORGANIC WASTE MANAGEMENT HIERARCHY



LEGEND

AD - "ANAEROBIC DIGESTION"
AF - "ANIMAL FEED"
BYC - "BACKYARD COMPOSTING"
AB - "ANIMAL BEDDING"
CC - "CENTRALIZED COMPOSTING"
DLA - "DIRECT LAND APPLICATION"
EP - "ETHANOL PRODUCTION"

The intention is to "push" resource stewardship "up the Hierarchy". The rejection of alternatives below the option selected need not be justified.

Roles and Responsibilities

Having established the guiding principles and hierarchy, the next objective involved developing a framework that would allow environmental goals to be met, with concerned, involved parties playing significant and responsible roles, all within a realistic timetable.

The general roles and responsibilities of concerned parties were summarized as follows:

- The Province should develop policies; regulate programs (set standards with clear, consistent rules); provide some measure of funding; approve facilities; police compliance; undertake educational programs.

- Municipalities should continue, as in the past, to fund, build, and operate facilities; to undertake educational programs.

- The private sector should also play a role to fund, build, and operate facilities; to undertake educational programs.

- Consumers should reduce, reuse, and recycle wastes, and, it was agreed, they should take part in public siting and approvals discussions.

In addition to the above, two additional agreements were reached:

- The federal government should fund research and development.

- Municipalities should be responsible for ensuring that wet wastes do not go into landfill, i.e., by implementing mandatory bans.

At the same time, two key issues had to be addressed:

- How should municipalities obtain capital funding for facilities required to handle and treat organic wastes?

- Should municipalities control the collection, transportation, and treatment of organic wastes from all sources (residential and IC&I) within their boundaries (flow control)?

With regard to funding, WRAC believes that the Province should not be involved in the funding of organic waste management development beyond providing seed money for demonstration composting facilities and pilot projects, although funding for backyard composters and their demonstration projects should continue. All other municipal funding demands, both capital and operating, should be met by the municipalities themselves, not from general revenues but through user levies of one sort or another.

Operating costs could be managed through an ongoing user-pay system.

Capital costs would be appropriated through the creation of reserve funds built up over time.

WRAC has recommended that the provincial government encourage municipalities to address the issue of meeting capital costs for composting facilities, not from general revenues, but by creating reserve funds. The revenues for these funds should come from pay-by-the-bag user fees, tipping fee surcharges, or other levies connected with the collection and disposal of wastes within their jurisdictions.

Municipalities would vary in their capability to raise money in such ways for reserve funds. Many northern communities, for example, do not levy tipping fees. In the north, centralized composting facilities will not generally be required because of the greater amount of land available for other uses of wet wastes (e.g., direct land application; mine tailings reclamation).

WRAC also addressed the question of flow control. It was decided that municipalities should continue to be responsible for the collection and treatment of residential organic wastes; however, it was agreed that municipalities should not be responsible for IC&I organic wastes. Responsibility for the receiving and processing of these wastes should be left with those who generate them. This would create incentive for private-sector investment in composting facilities.

An argument raised against this approach (i.e., private control of IC&I organic wastes) was the question of what would happen to such material should a private facility go out of business. With a landfill ban on organics in place and with its own treatment facilities operating at full capacity, a municipality would be unable to accept this material and would be under no obligation to do so. Such an eventuality, it was noted, would be handled by market forces: the material would be long-hauled to an outside facility until either the public or the private sector recognized the opportunities involved and put another facility into place locally, or increased the size of an existing facility. Private generators would be obliged to continue to pay for the disposition of their organic wastes.

General Strategy for Organic Waste Management

WRAC's general strategy for organic waste management in Ontario is based on the following major points of general consensus:

- the division of responsibility for various aspects of organic wastes between the public (residential) and private (IC&I generator) sectors;
- the elimination of provincial subsidies for municipal composting facilities;
- the adoption of user pay mechanisms to fund both capital and operating costs of municipal organic waste treatment facilities;
- the banning of organic wastes from landfill;
- the mandatory source separation of organics from other waste.

Taken together, these measures would provide Ontario with an effective program for managing organic wastes and helping achieve the provincial's waste reduction goal. Municipalities would be responsible for treating the organic wastes they collect now from residential and other sources. IC&I generators would be responsible for their own organic wastes; the provision of facilities for handling and processing those wastes would be left to market forces. Where appropriate, joint ventures could be organized between municipalities and private-sector proponents.

To effect this program, WRAC has recommended that the Provincial Government: recommend to municipalities that they start building reserve funds in 1993 for future capital requirements for wet waste management; phase out subsidies for municipal wet waste management programs by 1996 (excluding backyard composting); require municipalities to phase in user pay programs for wet waste by 1996; set a target date for a specified number of backyard composters to be in place in Ontario; legislate municipalities to provide households with backyard composters by a specified time; require municipalities in southern Ontario to undertake the separate collection of organic, or "wet", wastes from other wastes by 1996; require municipalities to ban organic materials from landfills in southern Ontario by 1998.

Program Support Measures

Aside from establishing the legislative framework that will require municipalities and industry generators to do other than simply dispose of organic wastes, the provincial government must also take steps to ensure that alternative measures can be implemented smoothly and consistently across the province. In this regard WRAC welcomes the Ministry of the Environment's intention to allow centralized composting facilities to be established by "permit-by-rule" procedures and its development of composting guidelines, which it should attempt to complete as soon as possible.

In addition, the Committee has offered recommendations in a number of related areas:

- administrative and approvals procedures
- education and communications
- funding and financial incentives
- technological development
- promotion and marketing

Time does not permit a full and detailed presentation of WRAC's program support recommendations. The following are a sample.

WRAC has recommended that the provincial government require by the end of 1992 that guidelines for handling and treating organic materials be incorporated in

(a) any programs requiring waste audits and waste reduction plans;

(b) relevant sections of building codes;

In the area of education WRAC has recommended that the provincial government undertake a public education program on organic waste management systems and procedures through school curricula.

In the area of financial incentives WRAC has recommended that the provincial government fund: the research and development of municipal, intermediate-scale, centralized composting demonstration projects; the research and development of institutional, on-site composting demonstration projects; research into the use of organics, including paper mill sludges, on agricultural lands.

In the area of technological development WRAC has recommended that the federal government be urged to fund: the development of alternative uses for wet wastes that cannot be used for agricultural purposes; research into the contamination of organic wastes destined to be used as animal feed; research of new and intermediate processing technologies; and research into the composition of paper fibre regarding its applicability as animal bedding and animal feed, with particular emphasis on potential toxic effects.

Finally, in the area of promotion and marketing WRAC has recommended that the provincial government: establish models for predicting material flows and quality of end product; establish an "end use" strategy for the finished product.

In Summary

Organic wastes represent a substantial proportion of total waste generation in Ontario. Their reduction, reuse, and recycling are vital to both Ontario's environmental well-being and economic development. The adjustments required by all concerned to reduce organic waste generation and to make better use of the resources remaining could result in radical changes in municipal and IC&I organic waste management practices and habits. The Blue Box experience has shown, however, that Ontario residents are, by and large, ready to commit themselves to change for the sake of environmental improvement. In addition, as the economics of improved organic waste management practice become more apparent to industrial, commercial, and institutional waste generators, the research and development required for the related benefits to be realized should begin to be quickly advanced and the environment correspondingly served.

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Composting: Part of the Waste Management Strategy for the Island of Montréal

by

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STOP is one of the oldest environmental groups active in Québec. Since 1970, STOP has promoted issues such as air and water quality, environmental impact studies, non-smokers rights, energy issues, sustainable development and waste management. The subject of todays talk is composting; part of the waste management strategy for the Island of Montréal.

The Island of Montréal is composed of 29 municipalities with a population of 1.7 million people in an area just under 500 km^2. The Island of Montréal has a population roughly equivalent to that of the provinces of Prince Edward Island, New Brunswick and Nova Scotia in an area equivalent to 0.3 percent of these three provinces. Or, put another way, the Island of Montréal represents over 25 percent of the population of Québec in 0.03 percent of its land area. This high density contributes to a particular waste management situation that is fairly unique in Canada. The Island's waste management activities are divided between two distinct and separate entities that manage the 1.85 million tonnes of municipal solid waste (MSW) that is generated each year on the Island.

The Ville de Montréal manages the 1.1 million tonnes of solid waste that is generated each year within the jurisdiction of the Ville de Montréal. The other 27 municipalities on the Island of Montréal are grouped under the jurisdiction of the Régie intermunicipale de gestion des déchets sur l'Île de Montréal (Régie) and annually generate 701,470 tonnes of solid waste. Montréal-Nord is expected to join the Régie at some future date. Waste management is under the control of these two distinct bodies. The Ville de Montréal and the Régie are both independently developing a waste management strategy that will affect the waste handling options of the 1.7 million people that live on the Island of Montréal for the next twenty years.

Currently, the Ville de Montréal owns and operates the Miron landfill (CTED) and the Rivière-des-Prairies landfill (RDP) and the des Carrières incinerator. The CTED landfill receives most of the solid waste from the Ville de Montréal and until recently, it received almost all of the solid waste from the Régie as well as waste from several outlying municipalities off the Island of Montréal. This was true until recently when the Ville de Montréal's tipping fees increased from $12.44/tonne in 1990, to $40.00/ tonne today. The Ville de Montréal also sends its waste to the RDP landfill as well as burning 300,000 tonnes/year at the incinerator. The RDP landfill is due to close this year, the CTED landfill was expected to close in 1994 (this may change) and the 23 year old des Carrières incinerator has recently been shown to emit significant quantities of toxic pollutants.

In tribute to the two waste management entities that are responsible for handling the close to two million tonnes of waste produced within the Island of Montréal each year, both entities have decided to approach solutions that have little or no need to export wastes from within their territories. This is not currently the case, but it is the goal.

The Régie was created in 1984 and was recognized by the Québec government in 1985. In 1988, the Regie awarding SNC a mandate to send 150 requests worldwide for the installation of waste treatment technologies that conform to the Régie's proposals'. From the 20 proposals received, seven companies were invited to submit more detailed proposals. An evaluation committee was organized and in November 1990, the Régie's executive committee and Board of Director's unanimously approved a proposal from Les Chaudières Foster Wheeler to build and operate the waste treatment infrastructure to treat the solid waste generated by the Régie municipalites over the next 20 years. This plan includes a separation centre to recuperate 116,000 tonnes and a mass burn incinerator with a capacity to burn 413,000 tonnes of the Régie's 700,000 tonnes of municipal solid waste. The Régie's plans also include a composting station to compost 59,000 tonnes of green waste (8 percent of MSW). These green wastes will include leaves, grass clippings and small branches. The centre will use the windrow composting method. The waste materials will be shredded, sprinkled with water if necessary to control dust and transported to the windrows. The windrows will be regularly turned to control the humidity, temperature and oxygen availability.

The technology chosen is of an intermediate level that will minimize the effects on the environment and assure a homogenous compost. The end product compost is expected to take six months. The end product is expected to be of the highest quality and will be used by member municipalities, and will be available to the general public.

The Régie has decided that the site for the composting centre must meet the following criteria:

-The site must be zoned agricultural or industrial.

-The site must meet certain hydrological, geological and other biophysical characteristics.

-The siting standards of the Solid Waste Regulations of Québec must apply.

-The site must be located less than 40 km from the waste transfer station which is to be located in Ville St. Laurent.

-The site must have reasonable access preferably by autoroutes.

The following potential impacts have been identified for the composting site:

-possibilty of contamination of surface water or the groundwater.

-the emission of odours.

-noise from the on site equipment and from the increased number of trucks.

-visual effects of the site.

-effects on the preservation of agricultural soils.

-socio-economic effects.

The site will be run in a manner to mitigate the impact on the water quality, the dispersion of odours, the noise and the aesthetics. Education programs will be put into place to reduce at source the quantity of green waste that will be collected. The compost produced will have a beneficial effect on the preservation of agricultural soils as it will replace topsoil used in landscape and horticultural practices. Les Chaudières Foster Wheeler has been chosen as the general contractor to build the composting facility. Based on the results of the BAPE hearings that are expected to be held soon, operation of this integrated waste management system including the composting centre, incinerator, and separation facility is still several years away if the proposed plan successfully passes the public hearing process.

It is anticipated that 28,000 tonnes of leaves will be received during the fall months of October and November. In the spring months of April and May, 7,000 tonnes of leaves and 3,000 tonnes of trimmings will be received, and during the main summer period from June to September, 18,000 tonnes of grass and 3,000 tonnes of trimmings will be received. The 59,000 tonnes of green waste are expected to generate 29,500 tonnes per year of high quality compost.

In 1992, the Ville de Montréal held public consultations in the first two months of 1992 to discuss current waste management practices within the Ville de Montréal, to discuss three possible waste management scenarios that have been broadly proposed by the Ville de Montréal's Service des travaux publics and to receive comments and input from the public on drafting a waste management strategy for the next twenty years. The B ureau de consultation de Montréal was given a mandate to conduct the public consultation process and to produce a report with recommendations to the Ville de Montréal. After 10 days of public meetings with the participation of 74 groups, companies, and individuals, which were carried live on cable TV, the BCM produced a set of recommendations which were submitted to Montréal's municipal council in August 1992. This consultation process is in sharp contrast to the closed process that the Régie had followed in developing its waste management strategy.

The Ville de Montréal has produced three different scenarios to manage the waste produced within its territory.
All scenarios include the following elements.

-The implementation of several types of collecte selective to the entire Montréal territory by 1994.
-The establishment of weekly curbside collections of green waste from April to November in community gardens and residential neighbourhoods where it is justified by sufficient mass by 1994.
-The gradual distribution of 30,500 composters over the next 10 years.
-The continuation of an annual Christmas tree collection program (these trees will then be turned into mulch).
-The development of six dechetteries to recuperate the recyclables and the bulky wastes of residents and small commerces by 1998.
-The development of three separation and recuperation centres to handle the recyclables from domestic, commercial and

industrial sectors. These facilities should be able to annually process 75,000 tonnes by 1997.

- The development of a separation and recycling centre for construction, demolition, and renovation waste in 1992.
- A regional separation and recycling centre for household hazardous waste (there is currently a mobile household hazardous waste pick-up program that is jointly run by the Régie and the city).
- A regional landfill for non-recyclable waste and waste from treatment processes.
- Setting a limit of six containers per regular collection of wastes from institutions in 1994.
- Prohibition of the landfilling of waste containing more than 30 percent recoverable materials beginning in 1995.

As well as the above components, the three waste management scenarios contain the following elements.

Scenario 1

The sequential development of three separation-composting plants each with an annual capacity of 200,000 tonnes of solid waste by 1996. (high quality compost is not expected to be produced from this process).

A 40,000 tonne per year composting centre for municipal and residential green waste in 1992.

This scenario will allow the Ville de Montréal to decrease the amount landfilled by 53 percent given the unlikely condition that all the compost could be sold.

Total cost:	237,000,000 $
Cost to the municipality:	120,000,000 $

Scenario 2

A 52,000 tonne per year separation and composting centre for solid wastes for the residents of Rivière-des-Praires and Pointe-aux-Trembles in 1997.

A 65,000 tonne per year composting pant for presorted residential, municipal, and industrial green waste by 1994.

This scenario will allow the Ville de Montréal to decrease the amount landfilled by 32 percent.

Total cost: 157,000,000 $
Cost to the municipality: 81,000,000 $

Scenario 3

A 52,000 tonne per year separation and composting centre for solid wastes for the residents of Rivière-des-Praires and Pointe-aux-Trembles in 1997.

A 65,000 tonne per year composting plant for residential, municipal, and industrial green waste by 1994.

The modernisation of the des Carrières incinerator without increasing its incineration capacity.

This scenario will allow the Ville de Montréal to decrease the amount landfilled by 57 percent.

Total cost: 222,000,000 $
Cost to the municipality: 138,000,000 $

In the fall of 1989, the Ville de Montréal started a composting program with 1,600 tonnes of leaves collected from parks and sidewalks. These leaves were composted at the separtion centre located at the main landfill site in regularly turned windrows. The leaf program was extended in 1990 and 2,300 tonnes were composted followed by 1,900 tonnes in 1991 and an estimated 2,400 tonnes this year. A pilot project was attempted this year in which residents were asked to place leaves in special paper bags. The heap is turned 8 times a year and high quality compost is available after 10 months. The costs of processing this green waste into compost is evaluated at $25-30/tonne. The compost was evaluated by the MENVIQ and was found to be of excellent quality with no restrictions as to use. In May 1990, 400 households participated in a residential composting program. At the same time, nine larger community composters were set up in cummunal gardens. This did not work too well and the gathered green waste was taken and mixed with the large compost pile at the separation centre. In 1991, 3,000 household composters were sold at a subsidized price by the city. Three quarters of these composters were sold within two weeks. This year, it took the entire season, until October to sell an additional 3,000 composters. Household composters are a favourable waste management tool of municipalities and environment groups as they contribute to the removal of biogas and leachate generating material from the waste stream and reduce collection, tipping and long term landfill remediation costs.

The Ville de Montréal estimates that there is slightly less than 200,000 tonnes per year of waste that is potentially compostable. This represents 17 percent of the MSW produced annually in the Ville de Montréal, and does not include the paper and cardboard fractions.

A study conducted for the Ville de Montréal has shown there is a potential market for 92,000 to 148,000 tonnes of compost per year in the Montréal region. Considering there is a 66 percent volume reduction and a 35 percent weight reduction in waste that has been composted, it may be possible to withdraw 255,000 tonnes of organic waste annually from the Island of Montréal and locate a market for the compost. The potential users of the high quality compost include the following;

Market sector	Tonnes
landscapers	29,500
municipal works	8,800
horticulturalists and nurseries	6,800
garden centres	6,500
turf and grass growers	39,400
golf clubs	1,000
Total	92,000

As our landfills reach capacity with an increasing quantity of waste produced by a consumption oriented society, municipalities and businesses are desperately searching to find and develop waste treatment sites. The mention of the word " waste "provokes a suspicious and offensive reaction to the locals and invariably, " NIMBY " or " pas dans mon cour " becomes part of the locals' vocabulary. Landfills have a bad reputation. They smell bad and attract vermin though modern landfills are better able to cope with these problems. For our purposes here, landfills are huge , poorly engineered, anaerobic MSW compost heaps sunk into the ground generating biogas consisting primarily of methane and CO^2 with an assorted mixture of other trace components including known and suspected carcinogens. Because methane is lighter than air and can be explosive at concentrations exceeding 5 percent, landfills now carry high post closure costs which are required to suck this biogas out and burn it in an manner that does not impair the health of the local population or the environment.

All landfills leak and depending on the composition of the waste contained in a landfill, the leachate is usually a toxic soup of rainwater and decomposing wastes that contains a wide variety of hazardous substances including organic chemicals and heavy metals that will usually reach the groundwater table. Landfills are a necessary component of any large waste treatment strategy. In Québec as in other North American jurisdictions, landfilling is by far, the most widely used waste management option. It is no wonder that people hear the word waste and immidiately develop a case of the NIMBYs.

Composting programs must be viewed as a waste management option. The term "composting" must be protected so that locals will welcome composting programs in their own region. It has been estimated that Québec farms that have used the classical rotation of hay-cereals over the past fifty years have lost 30 to 35 percent of the organic matter in the soil. The production of high quality compost from selected waste materials can help change this trend and lead to the rejuvination of these lands.

To most environmentalists, the term " compost " is a friendly term that refers to a soil amendment that nature has been making since the appearance of primitive life on this planet. Among other qualities, compost provides qualities to soil that enable the soil to retain nutrients, moisture, and air for the support of healthy plants. Simultaneously, composting illustrates an excellent example of a recycling strategy that serves an important need.

It is essential that the Composting Council of Canada and other implicated organizations associated with the composting process and the production of compost, protect the definition of the term compost. We must keep the standards of " compost " high and the term " compost " simple so that when citizens hears that a composting facility is planned for their community, they welcome the facility and not automatically fight it as is the case with so many other waste treatment processes.

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BILAN DU PROGRAMME DE COMPOSTAGE DOMESTIQUE DE LA COMMUNAUTÉ URBAINE DE L'OUTAOUAIS

RAPPORT SUR LE PROGRAMME DE SUIVI

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INTRODUCTION

La Communauté urbaine de l'Outaouais a amorcé son programme de compostage domestique en septembre 1991 en distribuant le samedi 14, 723 bacs à compost de type Soilsaver à des résidants des villes de Hull, d'Aylmer et de Masson-Angers qui en avaient préalablement fait la demande. L'expérience a été renouvelée au printemps 1992 alors que les villes de Buckingham et de Gatineau ont aussi adhéré au programme. Le samedi 30 mai 1992, 1 707 autres bacs à compost de type Soilsaver étaient distribués à des résidants des cinq villes qui avaient retourné le formulaire de demande avec leur chèque au montant de 27 $.

Rappelons que le bac à compost est utilisé par les citoyens pour valoriser les déchets d'origine organique à travers un processus biologique qui produit un excellent amendement pour le sol. Le compost domestique peut être fait sans inconvénient avec toute la partie végétale des déchets résidentiels.

Un suivi a été organisé de mai à juillet 1992 auprès des citoyens ayant reçu un composteur lors de la première distribution. Un étudiant en agronomie était chargé de communiquer avec les gens et de leur faire remplir un questionnaire portant sur différents points permettant de mesurer le succès de la phase I du programme. Les résultats de ce sondage sont présentés dans ce rapport.

COÛTS DU PROGRAMME

En 1991, les bacs à compost étaient offerts aux citoyens à un prix de 25 dollars soit 50% du coût réel, le reste étant défrayé par les villes participantes au programme. Voici le détail des coûts et la quote-part de chacun des partenaires :

723 bacs à compost (TPS fédérale et transport inclus) soit 44,57$ par unité	32 218,47 $
salaire employée temporaire (traitement des demandes)	1 090,91 $
Formulaires et publicité dans les journaux	1 169,98 $
TOTAL	*34 479,36 $*
Part de la Ville de Hull	9 000 $
Ville d'Aylmer	7 100 $
Ville de Masson-Angers	1 900 $
Citoyens	18 075 $
TOTAL	*36 075,00 $*

Le surplus de 1 595,64 $ sera reporté à la phase III du programme.

MÉTHODOLOGIE

L'étudiant en agronomie fut chargé de communiquer avec les citoyens participants et de leur faire remplir un questionnaire par téléphone, par la poste ou par une visite à domicile lorsque désirée. Certains participants avaient des problèmes ou désiraient simplement recevoir des conseils sur le compostage. Ces visites se sont avérées très productives car elles ont, non seulement permis de rassurer les gens sur l'état de leur compost, mais aussi de détecter certains problèmes qui n'auraient peut-être pas été mentionnés par un simple sondage postal.

Tous les citoyens ont été contactés par téléphone au moins une fois. Ceux qui ne pouvaient être rejoints, ont reçu une visite à domicile en soirée pour s'assurer qu'ils n'avaient pas de problème et pour leur remettre ou leur faire remplir le questionnaire.

Les citoyens de Hull ont été visités durant les mois de mai et juin, ceux de Masson-Angers durant la dernière semaine de juin et ceux d'Aylmer au mois de juillet.

Les gens visités étaient très heureux du suivi car il leur permettait de répondre à leurs interrogations et de les rassurer. L'accueil a été très chaleureux probablement en raison du sentiment de fierté qu'ont les gens à participer au projet de compostage à la maison; ils ont l'impression de faire un geste très significatif pour leur environnement.

723 composteurs ont été distribués en septembre 1991. De ce nombre, 52 personnes n'ont pas reçu le questionnaire et ce, entre autre, pour les raisons suivantes : déménagement (12), composteur non encore utilisé (7), mauvaises coordonnées (4), bac à compost volé (3). 8 personnes ont dit l'avoir donné à quelqu'un. Ce dernier phénomène, qui représente une perte de l'investissement de la CUO puisque le bac à compost est utilisé hors du territoire, ne semble pas avoir été très important sauf peut-être dans la ville de Masson-Angers. Il est à noter que quelques bacs à compost de la ville d'Ottawa ont été aperçus chez certains citoyens lors des visites.

A la fin de la période de compilation, le 28 août 1992, 543 des 670 questionnaires avaient été remplis et retournés soit un taux de réponse global de 81%. Ce taux représente 80,9% pour la ville de Hull, 75% pour la ville de Masson-Angers et 80,4% pour la ville d'Aylmer. 160 questionnaires ont été remplis lors de visites à domicile. Le reste, lors de conversations téléphoniques ou par retour du courrier.

Seulement sept répondants sur 543 ont dit avoir cessé de composter ce qui veut dire que 98,7% des gens continuent à utiliser leur bac à compost après un peu moins d'un an. Les raisons données variaient entre «*trop de trouble*» et «*plus de place dans le bac*» en passant par «*découragé par la famille*».

ANALYSE DU QUESTIONNAIRE

1. <u>SOURCE D'INFORMATION</u> (Question 12)

La plupart des gens (468) ont entendu parler du programme de compostage domestique de la C.U.O. via les journaux locaux. Ceci n'est guère surprenant puisqu'il s'agit du média le plus utilisé pour publiciser les programmes de la Communauté. D'autres (51) ont mentionné un ami, un parent ou «*le bouche-à-oreilles*» comme source d'information. Cette avenue serait très intéressante à explorer dans la mesure où des gens, ayant eu du succès avec le compost, en parlent à leurs voisins et les convainquent de se procurer un bac à compost. Cette tendance était déjà visible cette année puisque plusieurs personnes interviewées ont dit avoir des voisins qui se sont procurés un bac à compost lors de la phase II du programme.

La télévision ou la radio ont servi de source à 40 personnes. En raison de l'attrait médiatique que représente l'environnement actuellement, les émissions d'intérêt public, en particulier à la radio, parlent relativement souvent de compostage. Les villes d'Aylmer et de Masson-Angers, ont fait des efforts supplémentaires dans le but de publiciser le programme puisque 15 répondants ont dit avoir été informés du programme à travers un formulaire publié par leur corporation municipale. Des personnes travaillant pour la CUO ou l'une des villes impliquées ont dit avoir entendu parler du programme à leur lieu de travail. Un effort spécial pourrait être fait auprès des employés via un affichage supplémentaire dans les bureaux.

Tableau 1 : SOURCE D'INFORMATION SUR LE PROGRAMME

SOURCE	NOMBRE
Journaux	468
Amis, famille, collègues de travail	51
Radio ou télévision	40
autres	31

Le journal local reste un bon moyen d'information, mais n'atteint qu'une partie du public comme en font foi les nombreux appels pour obtenir un bac à compost après la date limite publiée dans les hebdomadaires. Il faudrait donc trouver un moyen pour rejoindre les gens qui ne lisent pas les nombreux journaux locaux publiés en Outaouais. Inciter les citoyens à parler à leurs voisins pour leur suggérer d'entreprendre le compostage, apparait être une bonne solution. Des formulaires de demande pourraient être postés à ceux possédant déjà un bac à compost pour qu'ils les distribuent à leurs voisins. Des cadeaux (livres, outils, etc.) pourraient être donnés à ceux qui amèneraient de nouveaux participants.

2. <u>RAISON DE LA PARTICIPATION</u> (Question 5)

Les questionnaires remplis lors des visites seront traités séparément pour l'analyse de cette question puisque la méthodologie n'est pas la même. Les gens visités donnaient une réponse spontanée alors que les autres avaient un choix de réponses et avaient tendance à en noter plusieurs, sinon toutes les raisons de la liste.

Les gens visités ont mentionné, le plus souvent, la production d'un amendement organique pour leur jardin (74), suivie de près par la préoccupation pour l'environnement (68) et la réduction des déchets (56) comme étant les raisons pour avoir participé au projet de compostage (voir graphique 1).

Par la poste et par téléphone, les raisons le plus souvent mentionnées étaient la préoccupation pour l'environnement (285), la réduction des déchets (273), la production d'un amendement (225) et le prix réduit (218) (voir graphique 2).

Vingt-six (26) personnes ont écrit qu'ils compostaient déjà depuis belle lurette et que le bac à compost servait surtout à améliorer l'apparence du compost. La curiosité a été la motivation pour 9 personnes. D'autres ont dit avoir été élevé sur une ferme ou avoir vu le procédé de compostage à l'étranger. 6 ont mentionné avoir été convaincus par leurs enfants et 3 voulaient donner de bonnes habitudes à leurs enfants.

Le pouvoir qu'ont les enfants à convaincre leurs parents est assez fantastique. Les enfants pourraient être sensibilisés au compostage directement à l'école. Les bacs à compost devraient donc être accessibles aux écoles primaires qui désirent commencer un projet de compostage comme il en existe un à l'Aylmer Elementary School sur l'avenue Frank-Robinson dans la ville d'Aylmer.

Il apparait donc que la préoccupation pour l'environnement est un incitatif majeur à commencer le compostage; les gens sont devenus en majorité très sensibilisés aux problèmes de gestion des déchets. L'obtention d'un produit fini reste très important dans le coeur des jardiniers. De plus, plusieurs personnes ont dit que le prix réduit des bacs à compost avait été un bon incitatif à commencer le projet de compostage auquel ils songeaient depuis longtemps.

3. <u>MATIÈRES COMPOSTÉES</u> (Questions 6 et 7)

La première source de déchets organiques se situe dans la cuisine puisque les différents résidus (coquilles d'oeufs, rognures de fruits et de légumes, résidus de thé et de café) sont compostés dans 85 à 97% des foyers.

Le compostage domestique semble se faire chez beaucoup de gens avec une majorité de matières riches en azote comme les déchets de cuisine ou le gazon. 87% des gens ont utilisé des feuilles mortes pour équilibrer ces matières. Malheureusement, 77% des répondants ont aussi ajouté du gazon coupé ce qui entraîne des problèmes qui seront vus plus en détail un peu plus loin.

Un peu plus de la moitié des gens interrogés ont dit composter les mauvaises herbes. Beaucoup avaient peur que leur compost serve de médium d'ensemencement pour celles-ci. Les brindilles ou le bran de scie sont compostés par 37% des répondants; les branches sont évitées par la plupart en raison de la lenteur de leur décomposition. Plusieurs personnes ne pensaient pas que la sciure de bois était compostable alors qu'il s'agit d'un excellent matériel pour réduire la densité apparente des déchets organiques si équilibré avec une bonne source d'azote.

La terre est utilisée dans trois composts sur quatre parfois même avec excès puisque certains, pour éviter les odeurs, remplissent leur bac à compost de terre en y enfouissant quelques déchets organiques. La terre n'est pas bonne à utiliser en grande quantité puisqu'elle ne se décompose pas; elle occupe vite une bonne partie de l'espace et rend le compost difficile à aérer en plus de servir d'isolant entre les couches de résidus organiques. Elle est à utiliser avec parcimonie seulement pour aider à réduire des problèmes d'insectes ou d'odeurs.

29% des gens ont dit composter les restes de table en faisant bien attention de ne pas mettre de matériel souillé par la viande ou par un corps gras. Les accélérateurs à compost commerciaux ont été utilisés par 30% des répondants ce qui est très élevé compte tenu du coût et surtout de l'efficacité limitée de ces produits dans un compost domestique ayant un rapport C:N (carbone/azote) relativement bas comme c'est la plupart du temps le cas. Certains ont ajouté des engrais ou du fumier dans leur compost. Ceux-ci peuvent aussi être considérés comme des accélérateurs. Le meilleur activeur disponible reste cependant quelques pelletées de compost fini provenant de la récolte précédente.

Les autres matières compostées sont : la mousse de tourbe, les samares, la paille, le crottin de lapin, le carton, les papiers mouchoirs, les poils d'animaux et les cheveux. Certaines matières moins recommandables observées incluent les aiguille de conifères (8 fois), la chaux et les excréments de chien.

Tableau 2 : MATIÈRES COMPOSTÉES

JARDIN		CUISINE		AUTRES	
gazon	419 (77%)	coquilles d'oeufs	491 (90%)	cendres	168 (31%)
feuilles	470 (87%)	fruits	521 (96%)	viande	2 (<1%)
légumes	422 (78%)	légumes	525 (97%)	activeur	163 (30%)
fruits	253 (47%)	café,thé	462 (85%)	engrais	23 (4%)
fleurs	416 (77%)	nourriture	157 (29%)	fumier	34 (6%)
bois	203 (37%)			terre	407 (75%)
mauvaises herbes	282 (52%)			autres	27 (5%)

4. <u>PROBLÈMES RENCONTRÉS</u> (Question 3)

Les problèmes susceptibles d'être remarqués par les citoyens sont les problèmes d'odeurs, d'insectes, d'animaux ou de capacité insuffisante. D'autres problèmes comme l'humidité inadéquate ou un déséquilibre dans le rapport carbone/azote ont été mieux remarqués lors de visites à domicile.

34% des répondants ont décelé des odeurs se dégageant de leur compost dont seulement 11 (2%) étaient qualifiées de graves. Ces odeurs étaient quelquefois le résultat d'un manque d'aération, c'est-à-dire que le tas n'était pas piqué ou remué assez souvent. En d'autres occasions, il s'agissait plutôt d'un excès d'humidité. Un citoyen ayant un compost très malodorant disait : «*J'ai beau le mouiller, l'odeur ne s'en va pas*». Malgré tout, la raison la plus fréquente expliquant les problèmes d'odeurs est la quantité excessive de gazon présente dans le bac à compost. Plusieurs personnes ont tendance à remplir leur bac à compost de feuilles à l'automne et à mettre tout leur gazon par dessus durant l'été. Une épaisseur trop grande de gazon empêche la pénétration de l'air à mesure que le gazon se tasse entraînant des odeurs et retardant la décomposition.

Le problème le plus fréquent mentionné par les gens (40%) était celui des insectes. Les drosophiles ou mouches à fruits représentent la majorité des cas et ne sont que peu problématiques; elles ne sont pas dérangeantes lorsque le couvercle du bac à compost est fermé. Ce phénomène peut être évité en ajoutant une couche de terre ou en enterrant les matières fraîches au centre du tas dans les déchets partiellement décomposés. Le compost constitue un bon endroit pour l'installation d'un nid de perce-oreilles. La majorité des 23 personnes ayant des problèmes graves d'insectes étaient au prise avec ces insectes particulièrement dégoûtants qui ont été retrouvés en abondance durant l'été 1992 en raison de la température particulièrement fraîche et humide. Le compost est un lieu parmi d'autres pouvant servir au développement des perce-oreilles, mais il n'est pas responsable de leur présence; ceux-ci peuvent tout aussi bien se retrouver dans les terrains où il n'y a pas de composteur.

9% des répondants ont eu des problèmes d'animaux attirés par le bac à compost, surtout aux abords du Parc de la Gatineau. Les écureuils, les mouffettes et surtout les ratons laveurs ont causé des problèmes. Plusieurs ont considéré le système de fermeture du bac à compost comme n'étant pas résistant à l'habileté de ces derniers. Le plastique de quelques bacs à compost avaient même été rongé par des animaux affamés. Une seule personne a parlé de rat ayant élu domicile dans son compost. Les problèmes de rongeurs peuvent la plupart du temps être évités en enterrant les matières fraîches au centre du tas dans les déchets partiellement décomposés.

Tableau 3 : **PROBLÈMES AVEC LE COMPOSTAGE**

	aucun	mineur	grave
odeurs	358 (66%)	172 (32%)	11 (2%)
insectes	319 (59%)	197 (36%)	23 (4%)
animaux	491 (90%)	39 (7%)	9 (2%)
capacité	356 (66%)	120 (22%)	61 (11%)

Le bac Soilsaver a une capacité de 12 pieds^3 ce qui est suffisant pour composter les déchets de cuisine (équilibrés avec des feuilles) d'une famille de quatre personnes. Cependant, ce n'est pas suffisant pour les déchets de jardin d'un terrain d'un acre. Les terrains étant en général relativement grands en Outaouais, les feuilles, les résidus de potager et le gazon peuvent remplir très vite les composteurs. Même si le gazon n'était pas mis dans le composteur, mais plutôt laissé sur le terrain après la tonte comme il le devrait, plusieurs personnes auraient suffisamment de matériel pour remplir plus d'un bac à compost. De plus, il est toujours mieux de laisser mûrir le compost et d'ajouter le matériel frais dans un deuxième composteur pour obtenir un bon produit fini. C'est pourquoi, il serait bon de permettre aux gens qui le désirent, en particulier ceux avec un grand terrain, de se procurer un deuxième bac à compost selon un système donnant la priorité aux gens n'ayant pas de bac et ce, jusqu'à une certaine date, et aux autres par la suite.

35% des répondants ont dit ne pas composter ni entreposer en hiver surtout en raison de la neige ou parce que le bac à compost était trop rempli. Le processus de compostage s'arrête durant les périodes froides, mais il est toujours possible d'accumuler les déchets organiques dans le bac à compost ou dans une vieille poubelle près de la maison. La décomposition sera très rapide au printemps. Il faudrait faire savoir aux gens que l'accumulation des matières organiques est possible en hiver.

Tableau 4 : AUTRES PROBLÈMES

plaintes des voisins	**3 (<1%)**
apparence du bac	**32 (6%)**
compostage en hiver	**190 (35%)**
pas d'élévation de température	**240 (44%)**
trop sec	**50 (9%)**
trop mouillé	**75 (14%)**

Durant les visites à domicile, 62% des composts ne présentaient aucune élévation de température. La décomposition se fait donc «à froid», ce qui signifie qu'elle est beaucoup plus lente. Ce phénomène est dû au volume insuffisant du bac à compost, à la petite quantité de déchets organiques dans le bac ou au manque d'aération. Lorsqu'une élévation de température était détectée, elle était le plus souvent de l'ordre de 3°à 6°C. L'humidité est probablement le paramètre qui rend les gens incertains. On ne sait pas si le compost est trop sec, trop humide ou si l'humidité est adéquate. Ceci entraîne des situations où le compost est trop mouillé (23% des visites) ou trop sec (14% des visites). Dans le premier cas, il y a production d'odeurs désagréables et dans le deuxième, la décomposition s'arrête. L'excès d'humidité est quelquefois causé par un ajout d'eau excessif dans le bac à compost ou le plus souvent par l'addition de matériel organique humide comme les déchets de cuisine et le gazon. Il est donc important d'équilibrer les matières humides avec des matières sèches comme des feuilles mortes ou de la mousse de tourbe ou de faire sécher le gazon avant de l'ajouter. Les composts trop secs se retrouvent principalement en terrain ouvert où ils sont exposés au soleil toute la journée ou lorsqu'une grande quantité de matières sèches est compostée. Dans le premier cas, le pourtour du tas tend à s'assécher car celui-ci entre en contact avec les côtés du bac à compost qui deviennent très chauds durant le jour. L'ajout d'eau dans le compost est donc, de façon générale à éviter sauf sur les côtés du tas.

Plusieurs personnes ont dit trouver le processus de compostage très lent souvent en raison du manque d'équilibre et d'aération ou du peu de volume de déchets dans le bac à compost.

Pour avoir du succès avec le compostage, il est nécessaire de maintenir un bon équilibre, les excès d'une seule sorte de matériel sont toujours à éviter. 9% des gens visités avaient trop de matières azotées dans leur composteur ce qui peut amener des problèmes d'odeurs ou d'insectes. Des excès de carbone et de terre ont été notés lors de 4,5 et 5% des visites, respectivement, entraînant un ralentissement considérable du compostage. Un phénomène souvent observé chez des gens commençant à composter, est un bac à compost à moitié rempli de feuilles au-dessous et à moitié rempli de gazon au-dessus. Cette méthode n'est pas efficace pour produire du compost. Il est ESSENTIEL pour bien composter d'avoir une réserve de matériels riches en carbone, préférablement des feuilles mortes, pour les utiliser durant l'été alors qu'une grande quantité de déchets azotés est disponible.

5. <u>FRACTION REMPLIE DU BAC</u> (Question 11)

Il est nécessaire d'avoir une certaine quantité de matière organique dans le bac à compost pour obtenir une activité biologique suffisante, mais cette quantité ne doit pas être trop grande, car elle rend l'aération du tas de compost ardue.

Le bac à compost était rempli à moitié et aux trois quarts pour 174 (32%) et 161 (30%) personnes, respectivement. Ces personnes devraient avoir les résultats optimaux possibles avec un bac commercial comme le Soilsaver. 96 répondants (18%) avait un bac rempli au quart ou moins. Ces gens ont tendance à composter presque exclusivement des résidus de cuisine qui ne permettent pas une grande accumulation, à cause du rythme lent de production et de composition (pourcentage élevé d'eau) de ces déchets. Le bac à compost était plein à ras bords chez 108 citoyens (20%); ce fait rend l'aération difficile avec les outils conventionnels (pic ou fourche) et nécessite l'utilisation d'un outil spécialisé assez dispendieux. Ce chiffre est moins élevé que celui donné par les gens qui trouvent que la capacité du bac à compost est insuffisante (33%); plusieurs se sentent à l'étroit même si le bac à compost n'est rempli qu'à 75%. Le graphique 3 permet de visualiser ces chiffres.

6. <u>À PROPOS DU COMPOSTEUR SOILSAVER</u> (Questions 8, 9 et 10)

L'assemblage du bac à compost est très simple et très rapide car il n'y a qu'une douzaine de vis à poser. Les gens ont d'ailleurs trouvé le bac facile à assembler dans une proportion de 99%. La fonctionnalité du bac à compost était moins appréciée; 23%

se sont plaints de trouver ledit bac difficile à utiliser, en particulier pour les fermetures du couvercle. 94% des répondants ont trouvé le bac à compost suffisamment solide même si quelques-uns ont mentionné que ledit bac avait tendance à se tordre, en particulier durant l'hiver. Le Soilsaver semble donc assez intéressant même si des modifications importantes pourraient être apportées au niveau du couvercle. Des citoyens ont suggéré que le couvercle soit muni d'une penture qui rendrait sa manipulation plus facile.

Tableau 5 : **BAC SOILSAVER**

ASSEMBLAGE FACILE		UTILISATION FACILE		STABILITÉ ET RIGIDITÉ	
oui	non	oui	non	suffisante	insuffisante
530 (99%)	8 (1%)	415 (77%)	122 (23%)	503 (94%)	33 (6%)

Le problème majeur rencontré avec le fournisseur Barclay Recycling Inc. est le nombre de bacs à compost auxquels il manquait des pièces. La poignée et les vis sont le plus souvent mentionnés; il arrive aussi que ce soit les fermetures ou la lame du pic.

Le Soilsaver ne présente que peu de pertes d'humidité et peut causer des problèmes dont nous avons discuté précédemment, s'il n'est pas placé au soleil. De plus, les sols argileux qui existent en Outaouais n'aident pas au drainage. Plusieurs personnes se sont plaints de fermetures se brisant durant l'hiver. Leur solidité pourrait donc être améliorée. La petite dimension du bac à compost nuit à la manoeuvre pour l'aération dès qu'il est rempli à plus des trois quarts. La seule façon d'avoir un bac à compost aux dimensions plus appropriées (un m^3 ou plus) serait d'encourager la fabrication d'un bac à compost par le citoyen car aucun bac commercial ne semble avoir une capacité suffisante.

32 personnes (6%) ont dit ne pas aimer l'apparence du bac Soilsaver dont trois ont suggéré l'utilisation de plastique de couleur vert foncé. 3 répondants ont trouvé le dépliant d'explication très clair. Le haut dudit bac devrait être renforcé pour permettre le retournement avec une fourche; le bac à compost est porté à se tordre. Les autres commentaires des citoyens sont : pas assez de trous d'aération; portes trop petites; un panneau devrait être complètement amovible; il devrait y avoir un crochet ou un support sur le côté du bac à compost pour permettre d'y accrocher le pic.

Plusieurs citoyens ont aussi demandé d'avoir un choix de modèles de composteurs. Le cône vert et le modèle circulaire, plus sophistiqué mais pas aussi efficace, ont été mentionnés. Il serait bon d'offrir plus d'un modèle de composteur à la population en gardant la subvention au même niveau pour chaque modèle (exemple : 27 $ par unité). Ceux dont le coût de revient à l'unité serait plus élevé, seraient vendus à un prix plus élevé.

7. **RENSEIGNEMENTS SUR LES GENS QUI COMPOSTENT** (Questions 13, 14 et 15)

Un peu plus du tiers des répondants (37%) avaient déjà composté soit dans un bac artisanal ou commercial, soit en tas ou en enterrant directement des déchets organiques dans la terre (voir graphique 4). Ceux-ci ont acheté un bac Soilsaver pour des raisons d'esthétique ou croyaient qu'il serait plus efficace. Le taux des gens qui débutent le compostage devrait augmenter dans les futures phases du programme (en ne comptant pas les gens qui font la demande d'un deuxième bac à compost).

78% des gens qui compostent ont un jardin potager et la plupart des autres ont des plates-bandes de fleurs; l'importance de la production d'un amendement pour le sol confirme l'influence de la décision des gens à commencer à composter. Le compost peut aussi être utilisé sur le gazon ou dans les plantes d'intérieur, mais ces options sont très peu utilisées. Le programme de compostage domestique doit donc viser en priorité les jardiniers amateurs.

Les gens qui compostent ont été divisés en quatre groupes d'âge (voir graphique 5). Les 30-44 ans étaient les mieux représentés avec 47,2% de la population adulte suivis par les 45-65 ans avec 30,9%. Ces chiffres sont plus élevés que ceux de la proportion réelle de ces deux groupes dans la population en général et sont dûs au nombre peu élevé de gens qui compostent âgés dans la vingtaine. Ces derniers étant surtout locataires, ils n'ont pas souvent la possibilité de participer au compostage. Les 20-29 ans mentionnés ici vivent en grande majorité chez leurs parents. Les personnes âgées de 65 ans et plus sont aussi un peu moins nombreuses comparativement à la population en général. Parmi les deux groupes bien représentés, le rapport 30-44 sur 45-65 est plus élevé chez les gens qui compostent que dans la population en général, ce qui signifie que le premier groupe est plus intéressé au compostage.

Le tableau 6 détaille ces résultats; les trois premières colonnes font allusion aux gens faisant du compostage alors que la dernière se rapporte à la population en général.

Tableau 6 : **POPULATION ADULTE PAR GROUPES D'ÂGE**

groupes d'âge	hommes	femmes	total	total
	COMPOSTEURS			POPULATION[1]
20-29	70 (12,1%)	64 (11%)	134 (11,5%)	20 250 (30,2%)
30-44	266 (45,9%)	283 (48,5%)	549 (47,2%)	22 590 (33,7%)
45-65	185 (31,9%)	175 (30%)	360 (30,9%)	16 875 (25,2%)

Tableau 6 : **POPULATION ADULTE PAR GROUPES D'ÂGE**

groupes d'âge	hommes	femmes	total	total
	COMPOSTEURS			POPULATION[1]
plus de 65	59 (10,2%)	62 (10,6%)	121 (10,4%)	7 300 (10,9%)

1. Total pour Hull, Aylmer et Masson-Angers d'après Communauté régionale de l'Outaouais, Service de la planfication, «Cahier statistique de la Communauté et de ses composantes», mars 1990, 2ᵉ édition p. 64

Les ménages ayant reçu un bac à compost en 1991 comptent en moyenne 3,12 personnes. Selon le recensement 1991 de Statistique Canada cité dans le Trait-d'union du 15 juin 1991, les ménages des villes de Hull, d'Aylmer et de Masson-Angers comptaient en moyenne seulement 2,54 personnes. Le graphique 6 détaille le taille et le nombre de ménages.

La grande différence dans la taille des ménages est due à la sous-représentation, chez les gens qui compostent, des ménages comportant une personne et le grand nombre de ménages de 4 et 5 personnes. Les ménages les plus nombreux sont ceux de 4 et 5 personnes (39,4%) suivis de près par ceux de deux personnes (30,8%). Les familles plus nombreuses sont, d'ordre général, plus susceptibles de vouloir un bac à compost que les couples sans enfant.

Ces faits rejoignent ceux mentionnés dans la section «raisons de la participation» où des parents disaient vouloir donner un bon exemple à leurs enfants ou avaient été influencés par ceux-ci.

Tableau 7 : **TAILLE DES MÉNAGES**

NOMBRE DE PERSONNES	COMPOSTEURS	POPULATION[1]
1	32 (6%)	8 020 (22,9%)
2	164 (30,8%)	11 115 (31,8%)
3	112 (21%)	6 960 (20%)
4-5	210 (39,4%)	8 100 (23,2%)
6 et plus	15 (2,8%)	775 (2,2%)

1. Total pour Hull, Aylmer et Masson-Angers d'après Communauté régionale de l'Outaouais, Service de la planification, «Cahier statistique de la Communauté et de ses composantes», mars 1990, 2ᵉ édition, p.48

En regardant tous ces chiffres, il serait possible de dresser le portrait type des gens qui compostent sans pour autant vouloir exclure les autres groupes de gens. Le ménage type comporterait un couple dans la trentaine ou la quarantaine ayant aucun ou deux enfants. Ce ménage aurait un assez grand terrain (de type banlieue) où serait cultivé un potager. Il serait préoccupé par son environnement et participerait à la collecte sélective. Cette préoccupation altruiste le pousserait à tenter sa première expérience en compostage, mais la production d'engrais pour le jardin serait aussi importante dans sa décision. Enfin, il sera très satisfait de son compost et fier de ce qu'il fait pour l'environnement.

8. COMMENTAIRES DES RÉPONDANTS

Les commentaires qui ont été écrits le plus souvent sont présentés dans le tableau suivant :

Tableau 8 : **COMMENTAIRES**

	NOMBRE
Bonne initiative ou excellent programme.	109
J'aime le programme de suivi à domicile.	40
J'aimerais suivre d'autres cours sur le compostage sur un horaire plus flexible.	37
J'ai aimé le cours sur le compostage.	11
J'aimerais avoir un plus grand bac ou un deuxième.	50
J'ai remarqué une grosse diminution des déchets en conjonction avec le bac vert.	30
J'aimerais voir plus de publicité et de sensibilisation sur le compostage	29
Il devrait y avoir une collecte municipale des matières compostables.	15
Il devrait n'y avoir qu'une collecte des déchets solides.	6
Je manque d'informations sur le compostage	6
J'aimerais un bac circulaire rotatif	6

Voici d'autres commentaires sur le compostage donnés par les citoyens qui n'ont pas été mentionnés précédemment dans le texte : je suis étonné de la quantité mise dans le bac; la CUO devrait subventionner l'achat de déchiqueteuse; il ne devrait pas y avoir de restriction quant au programme de compostage à domicile (maisons unifamiliales); je voudrais avoir un bac plus petit. À propos des moyens d'informations que plusieurs trouvent déficients, les suggestions abondent: vidéos sur le compostage à la bibliothèque; réseau de personnes intéressées au compostage et cours offerts en anglais. Certains voudraient des notes de rappel périodiques alors que d'autres parlent de chronique dans les journaux régionaux. Enfin un citoyen demande que les résultats du sondage soient publiés dans les journaux régionaux.

Des suggestions ont aussi été recueillies sur d'autres sujets : cloches de recyclage pour desservir les immeubles à appartements; collecte ou dépôt central pour les branches et le bois; plus de collectes de DDD (déchets domestiques dangereux); interdiction de mettre le gazon et les feuilles aux déchets; plus de réduction des déchets à la source.

CONCLUSION

La première phase du programme de compostage à la maison de la Communauté urbaine de l'Outaouais a, sans aucun doute, été un franc succès en raison de la participation des citoyens, de la satisfaction qu'ont ceux-ci relativement à cette technologie de compostage et de la réduction drastique du volume de déchets produits par les ménages possédant un composteur.

Les taux de pénétration de la phase I ont été de 3,78% des ménages à Masson-Angers, 2,69% des ménages à Aylmer et 1,34% des ménages à Hull.[1] En comparaison, le taux a été de 2,54% pour la ville de Gatineau dans la phase II. Un taux moins élevé pour la ville de Hull est probablement dû au plus grand nombre d'habitations en hauteur dans cette ville. Ces taux, tous genres d'habitations confondus, dénotent un intérêt relativement élevé considérant qu'il s'agissait de la première expérience du genre dans la région de l'Outaouais québécois. Les citoyens disaient être très satisfaits du programme de compostage à la maison; d'ailleurs près de 99% des répondants se servaient de leur bac à compost. Ils approuvent et remercient la CUO pour le programme. Le compostage est un moyen de sensibilisation et d'éveil aux réalités environnementales pour les gens qui sont, par la suite, fiers de leur action. Cette préoccupation pour l'environnement et l'attrait de la production d'un amendement pour le jardin sont les raisons majeures qui poussent les gens à commencer le compostage. Peu de problèmes graves ont été rencontrés à l'exception de la capacité du bac à compost pour 11% des répondants. Les insectes ont incommodé 40% des gens sans vraiment être un problème sauf pour quelques uns.

Le bac Soilsaver est apprécié par la majorité même si plusieurs suggèrent des améliorations pour rendre la manipulation des fermetures plus facile; de plus, plusieurs bacs à compost avaient des pièces manquantes. Les adultes entre 30 et 44 ans ainsi que

[1] Le Trait-d'union, CUO, no 6, 15 juin 1992, p. 9

les ménages de deux et quatre personnes sont les plus susceptibles de s'adonner au compostage.

Le manque d'informations sur les moyens à utiliser pour obtenir un bon compost est quelque peu problématique. Il est nécessaire que ces informations parviennent aux citoyens car les gens ne réussissant pas sont plus susceptibles de se décourager et d'abandonner le compostage. Un effort spécial devrait donc être fait sur les moyens d'informations (voir recommandations 8 à 10).

La plupart des répondants compostaient la grande majorité des déchets organiques d'origine végétale. Le volume des déchets domestiques se trouve donc grandement réduit, ce qui a incité les gens à réclamer une seule collecte hebdomadaire d'ordures ménagères au lieu de deux.

Que ce soit au niveau de l'intérêt, de la satisfaction ou de la réduction du volume des déchets, le programme a été jusqu'à maintenant une grande réussite.

ANNEXE 1

Mai 1992

OBJET : Sondage sur le compostage domestique

Madame,
Monsieur,

Vous avez acheté et reçu l'an dernier un bac à compost dans le cadre du programme de compostage à la maison de la Communauté urbaine de l'Outaouais. Le compost est un excellent moyen de mise en valeur des déchets organiques et votre participation au programme contribue directement à la réduction de la quantité de déchets solides qui sont enfouis en plus de vous fournir un excellent amendement pour votre sol.

Cette année, nous amorçons la phase du suivi auprès des citoyens qui ont reçu un bac. Nous aimerions que vous preniez quelques minutes de votre temps pour remplir le sondage qui suit en répondant aux questions et en nous faisant part de vos commentaires et suggestions pour améliorer le programme. L'objet de ce sondage est de déterminer le succès du programme de compostage à la maison de la Communauté urbaine de l'Outaouais et d'assurer le succès des phases ultérieures.

Veuillez retourner le questionnaire rempli dans l'enveloppe pré-adressée et pré-affranchie ci-incluse.

Si vous avez des questions, n'hésitez pas à communiquer avec ***M. Jean-Philippe Linteau*** *au* ***770-1380.***

Nous vous prions d'agréer, Madame, Monsieur, l'expression de nos sentiments les meilleurs.

Bernard Beauregard, ing., M.Sc.A.
Directeur adjoint
Service de l'environnement

BB/JPL/pm

p.j.

COMMUNAUTÉ URBAINE DE L'OUTAOUAIS

SERVICE DE L'ENVIRONNEMENT

SONDAGE DE LA COMMUNAUTÉ URBAINE DE L'OUTAOUAIS

PROGRAMME DE COMPOSTAGE À LA MAISON

Le type de bac à compost qui a été remis aux citoyens qui en ont fait la demande est le composteur Soil-saver de Barclay Recycling Inc. La distribution des 720 bacs à compost a été effectuée le samedi 14 septembre 1991.

PARTIE UN

1. *Participez-vous toujours au projet de compostage à la maison ou utilisez-vous toujours votre bac à compost pour produire un terreau à l'aide de certains de vos déchets domestiques ?*

☐ *OUI* ☐ *NON*

2. *Avez-vous lu la brochure sur le compostage fournie avec votre bac à compost ?*

☐ *OUI* ☐ *NON*

3. *Avez-vous rencontré l'un des problèmes suivants, quel en était la gravité et comment avez-vous réglé les difficultés rencontrées ?*

	AUCUN PROBLÈME	*PROBLÈME MINEUR*	*PROBLÈME GRAVE*	*FAÇON DE LE RÉGLER, LE CAS ÉCHÉANT*
ODEURS				
INSECTES ET MOUCHES				
ANIMAUX				

	AUCUN PROBLÈME	*PROBLÈME MINEUR*	*PROBLÈME GRAVE*	*FAÇON DE LE RÉGLER, LE CAS ÉCHÉANT*
PLAINTES DES VOISINS				
APPARENCE DU BAC À COMPOST				
CAPACITÉ DU BAC À COMPOST INSUFFISANTE				
COMPOSTAGE OU ENTREPOSAGE EN HIVER				
AUCUNE ÉLÉVATION DE TEMPÉRATURE DU TAS DE DÉCHETS ORGANIQUES DANS LE BAC À COMPOST				
DÉCHETS ORGANIQUES DANS LE BAC À COMPOST TROP MOUILLÉS				
AUTRES PROBLÈMES (précisez)				

4. *L'une de ces difficultés a-t-elle été suffisamment grave pour que vous cessiez de composter ?*

☐ *OUI* ☐ *NON*

Veuillez dresser la liste des difficultés qui vous ont fait abandonner le compostage à la maison :

___

___

___

5. *Qu'est-ce qui vous a poussé au projet de compostage à la maison ?*

Préoccupation à l'égard de l'environnement ______________

Réduction de la quantité des ordures ménagères ______________

Disponibilité d'achat d'un bac à compost pour un prix moindre ______________

Valorisation de la partie compostable des déchets domestiques ______________

Convaincu par la famille, des voisins ou des amis ______________

Programme de la Communauté urbaine de l'Outaouais ______________

Production d'un amendement organique pour ses propres besoins ______________

Autres raisons (précisez) ______________________________

____

6. *Quelles sont les matières que vous déposez dans votre bac à compost ?*

DÉCHETS DE JARDINS

Herbe coupée ou gazon ______________

Feuilles mortes ______________

Résidus de plants de légumes ______________

Résidus de fruits de votre jardin ______________

Résidus de fleurs ______________

Branches, brindilles et sciure de bois ______________

Mauvaises herbes ______________

DÉCHETS DE CUISINE

Coquilles d'oeuf ______________

Rognures de fruits ______________

Rognures de légumes ______________

Résidus de café et sachets de thé ______________

Cendres de foyer ou de poêle ______________

7. *Vous arrive-t-il d'ajouter des matières autres que les précédentes et lesquelles ?*

Déchets de table ______________

Viande, os et produits laitiers ______________

Activeur commercial ______________

Engrais et fertilisants ______________

Fumier ______________

Terre ______________

PARTIE DEUX

8. *Le bac à compost qui vous a été distribué était-il facile à assembler ?*

☐ *OUI* ☐ *NON*

9. *Le bac à compost qui vous a été distribué est-il facile à utiliser (manipulation du couvercle et manipulation des deux portes) ?*

☐ *OUI* ☐ *NON*

10. *Le bac à compost qui vous a été distribué est-il assez robuste (stabilité et rigidité) ?*

☐ *OUI* ☐ *NON*

11. *Veuillez indiquer quelle fraction approximative du volume du bac à compost est remplie :*

1/4 ______________

1/2 ______________

3/4 ______________

Plein ______________

12. *Comment avez-vous été informés du programme de compostage à la maison de la Communauté urbaine de l'Outaouais ?*

Radio ______________

Télévision ______________

Article d'un journal ______________

Formulaire de demande dans un journal ______________

Bouche à oreille ______________

Ami ______________

Autre ______________

13. *Vous adonniez-vous au compostage à la résidence où vous habitez actuellement avant d'acheter un bac à compost du programme de compostage à la maison de la Communauté urbaine de l'Outaouais ?*

☐ *OUI* ☐ *NON*

PARTIE TROIS

14. *Quelle est la dimension approximative de votre jardin (potager) ?*

_____ *pieds sur* _____ *pieds ou*

_____ *mètres sur* _____ *mètres*

15. *Veuillez indiquer le nombre de personnes dans votre ménage qui correspond à chacune des catégories de sexe et d'âge suivantes :*

HOMMES

( ) *moins de 10 ans*
( ) *10 - 19 ans*
( ) *20 - 29 ans*
( ) *30 - 44 ans*
( ) *45 - 65 ans*
( ) *65 ans et plus*

FEMMES

( ) *moins de 10 ans*
( ) *10 - 19 ans*
( ) *20 - 29 ans*
( ) *30 - 44 ans*
( ) *45 - 65 ans*
( ) *65 ans et plus*

16. Commentaires et suggestions

ANNEXE 2

RECOMMANDATIONS

1. **INCITER LES CITOYENS À CONVAINCRE LEURS VOISINS**

Des formulaires pourraient être postés aux citoyens possédant déjà un bac à compost pour qu'ils les fassent remplir par leurs voisins. Des cadeaux (livres, instruments aratoires, etc.) pourraient être remis à ceux qui trouveraient un certain nombre de personnes nouvellement intéressées par le compostage.

2. **RENDRE LES BACS ACCESSIBLES AUX ÉCOLES PRIMAIRES**

Les écoles voulant mettre sur pied un programme où les élèves seraient invités à participer au compostage (comme à l'Aylmer Elementary School), devraient avoir l'opportunité de pouvoir acheter un bac à compost de la CUO. De cette manière, plusieurs parents seraient rejoints à travers leurs enfants. De plus, de tels programmes aideront à sensibiliser la jeune génération à la gestion des déchets.

3. **AUGMENTER LA PUBLICITÉ DANS LES LOCAUX DE LA CUO**

Les employés de la CUO pourraient être rejoints en plus grand nombre par le programme de compostage à domicile à travers un affichage accru dans les bureaux et usines de la Communauté, les enveloppes de paie ou le Trait-d'union.

4. **VISER EN PRIORITÉ LES JARDINIERS AMATEURS ET LES GENS AYANT DES ENFANTS**

Ces deux groupes sont, d'après le sondage, les plus susceptibles de s'intéresser au programme de compostage. La publicité du programme pourrait donc faire ressortir des points susceptibles d'intéresser ces deux groupes.

5. **PERMETTRE L'ACHAT D'UN DEUXIÈME BAC**

Les citoyens devraient pouvoir procéder à l'achat d'un deuxième bac à compost. Un seul bac est souvent insuffisant pour tous les déchets de jardin produits sur une propriété. Les gens qui dépensent 25 $ pour un bac à compost devraient logiquement s'en servir pour composter plus de matériel ou pour rendre le processus plus efficace en alternant les bacs utilisés. Les bacs à compost devraient néanmoins être d'abord disponibles pour ceux qui n'ont pas de composteur et selon un système de priorité où les gens désirant un deuxième bac ne pourraient le faire qu'après une certaine date.

6. **OFFRIR PLUS D'UN CHOIX DE BAC**

Plusieurs modèles différents de composteurs pourraient être offerts aux gens. Ces modèles seraient tous subventionnés de la même manière, le citoyen payant la différence entre le prix de gros et la subvention. Parmi les modèles offerts, il pourrait y avoir un digesteur, un composteur en bois de cèdre et le Soilsaver. Le modèle rotatif désiré par plusieurs apparait avoir trop d'inconvénients (odeurs, insectes), même si la décomposition y est plus rapide, pour être considéré.

7. **INSTAURER UN PROJET DE COMPOSTAGE MUNICIPAL**

L'intérêt des gens est probablement suffisant pour procéder à l'instauration d'un projet pilote de collectes de matières compostables surtout durant l'été et au début de l'automne. Un citoyen d'Aylmer serait prêt à accepter ces matières sur son terrain.

8. METTRE SUR PIED UN JARDIN DE DÉMONSTRATION

Le problème du manque d'informations pour les gens à propos du compostage serait réglé avec l'instauration d'un jardin de démonstration comme il en existe un dans plusieurs autres villes (Ottawa, Montréal, Vancouver). Différents modèles de composteurs et de techniques seraient exposés et des sessions d'informations seraient offertes directement sur le site. Un tel site pourrait également se charger de la distribution des bacs à compost qui seraient disponibles sur une plus grande période de temps pour accommoder les citoyens. Des instruments pour le compostage et des engrais naturels seraient en vente. Des conseils agronomiques pourraient aussi être dispensés. Un tel projet pourrait être peu dispendieux s'il était installé sur un terrain appartenant à la CUO qui comporterait déjà un lieu de rangement pour le matériel. Si un tel jardin ne voyait pas le jour, il serait nécessaire d'offrir des subventions à un organisme pour que des cours sur le compostage soient offerts.

9. INFORMER LES GENS À TRAVERS LES JOURNAUX RÉGIONAUX

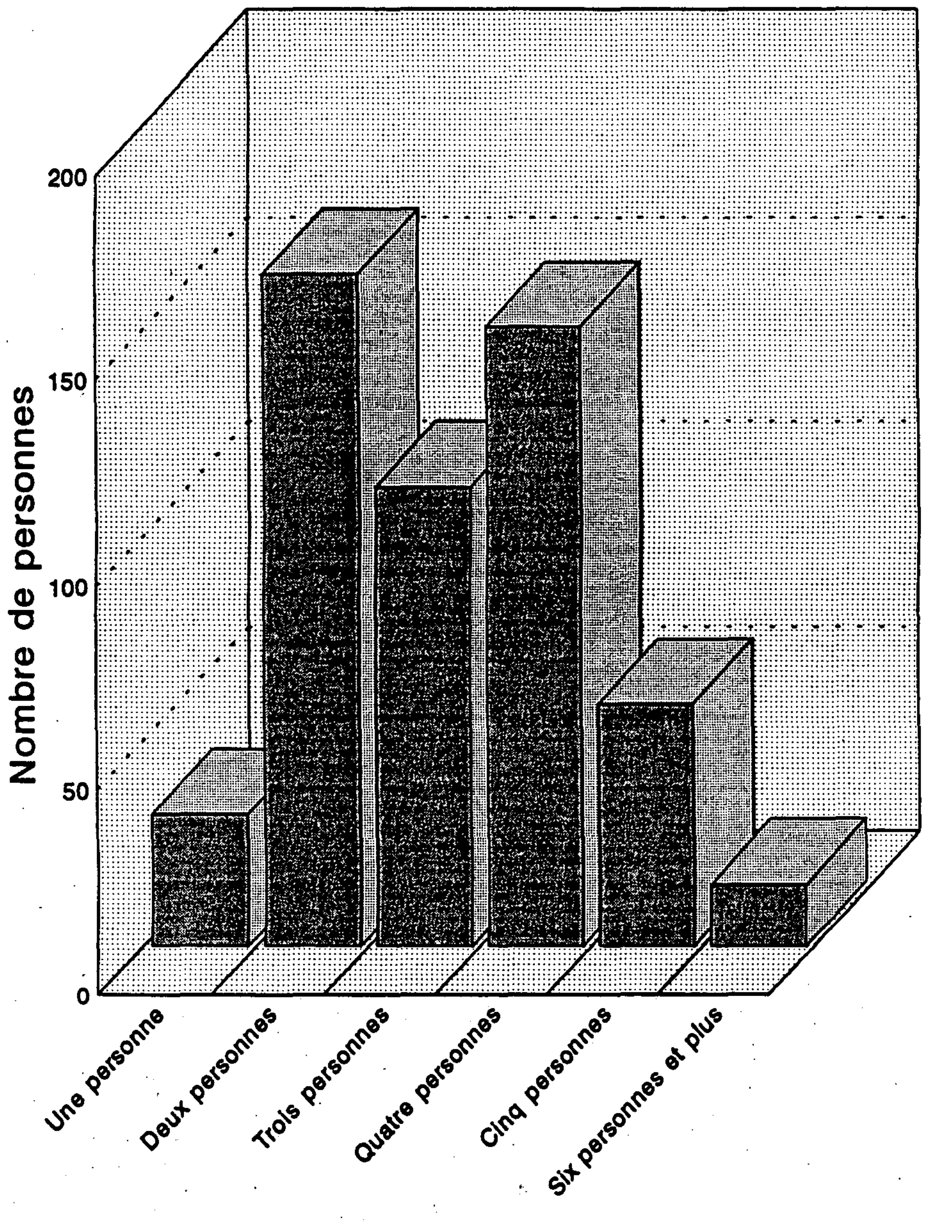
Des notes de rappel sur les feuilles mortes à l'automne, le gazon à l'été, l'entreposage en hiver et d'autres principes importants pourraient être publiés périodiquement dans les journaux régionaux.

10. AVOIR DES INFORMATIONS DISPONIBLES DANS LES BIBLIOTHÈQUES

Les bibliothèques des différentes municipalités pourraient augmenter la documentation disponible relativement au compostage sous forme de livres, pamphlets ou cassettes vidéos.

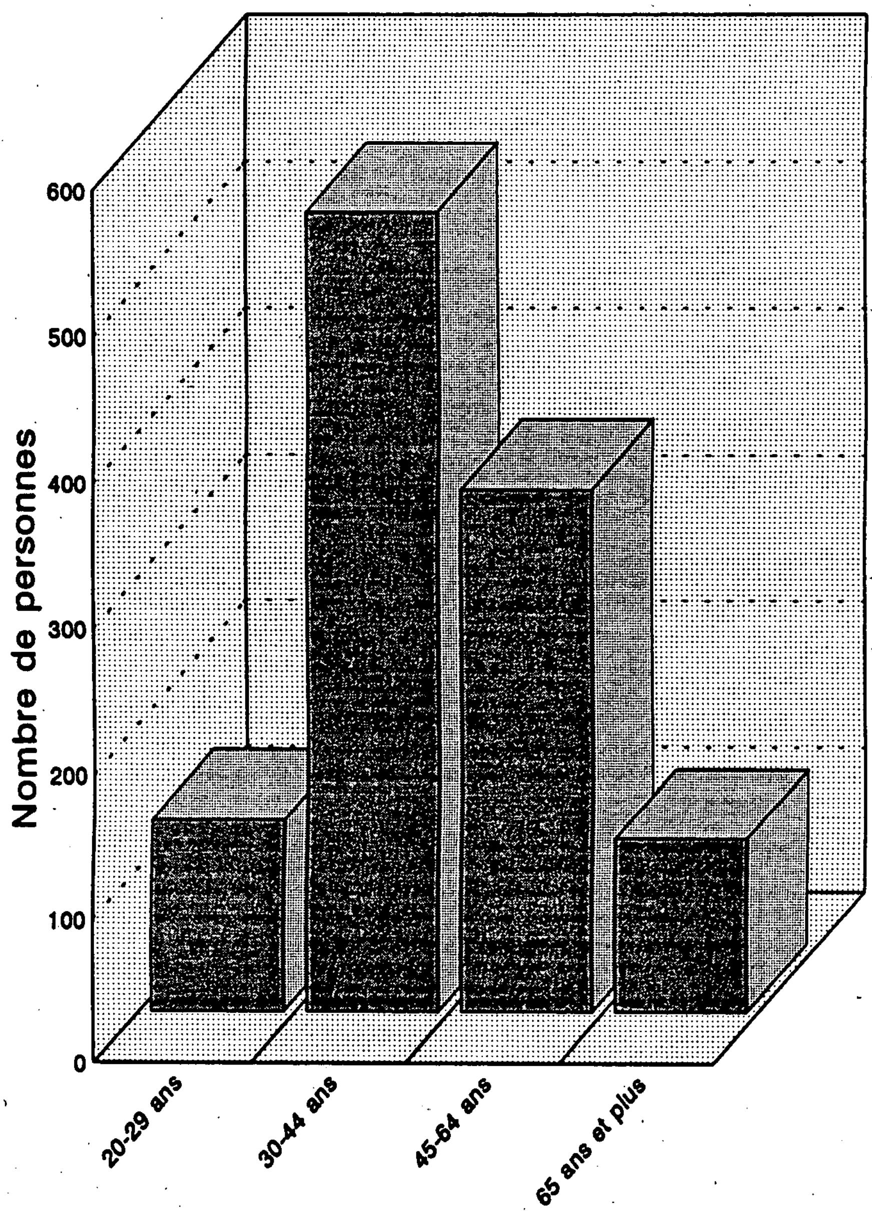
ANNEXE 3

Graphique 6
Taille des ménages faisant du compostage



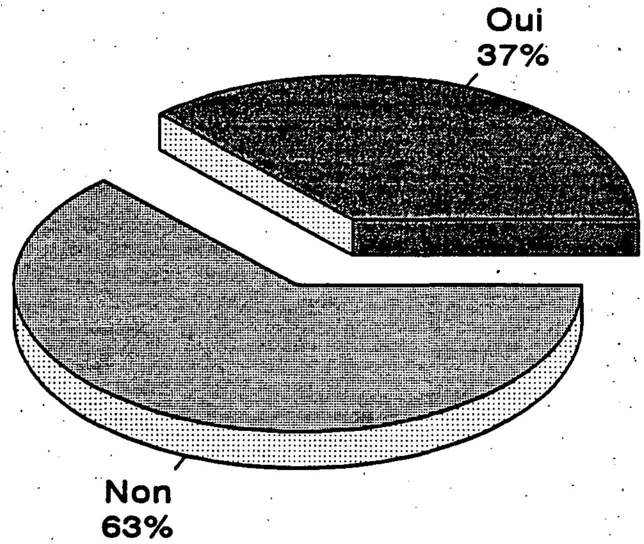
(C.U.O. octobre 92)

Graphique 5
Groupes d'âge des adultes faisant du compostage



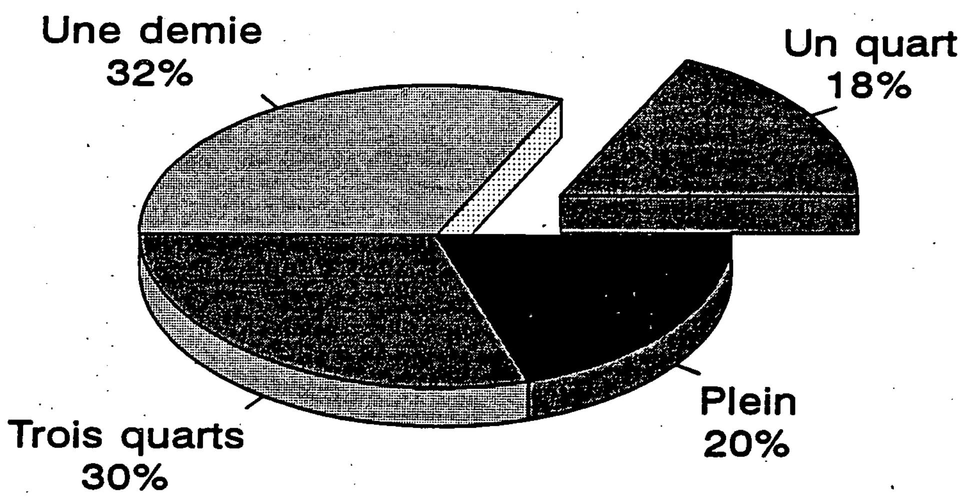
(C.U.O. octobre 92)

Graphique 4
Citoyens ayant de l'expérience dans le compostage



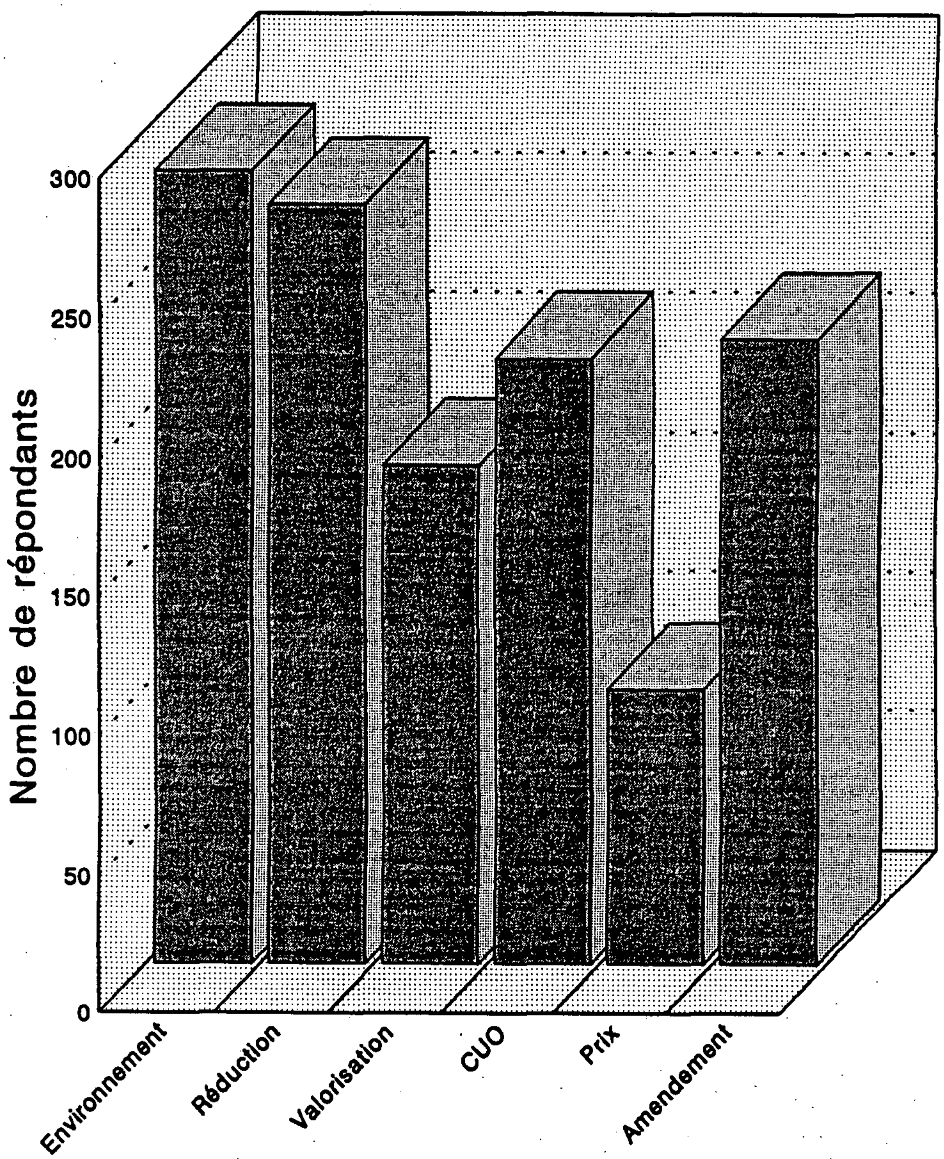
(C.U.O. octobre 92)

Graphique 3
Fraction remplie du composteur



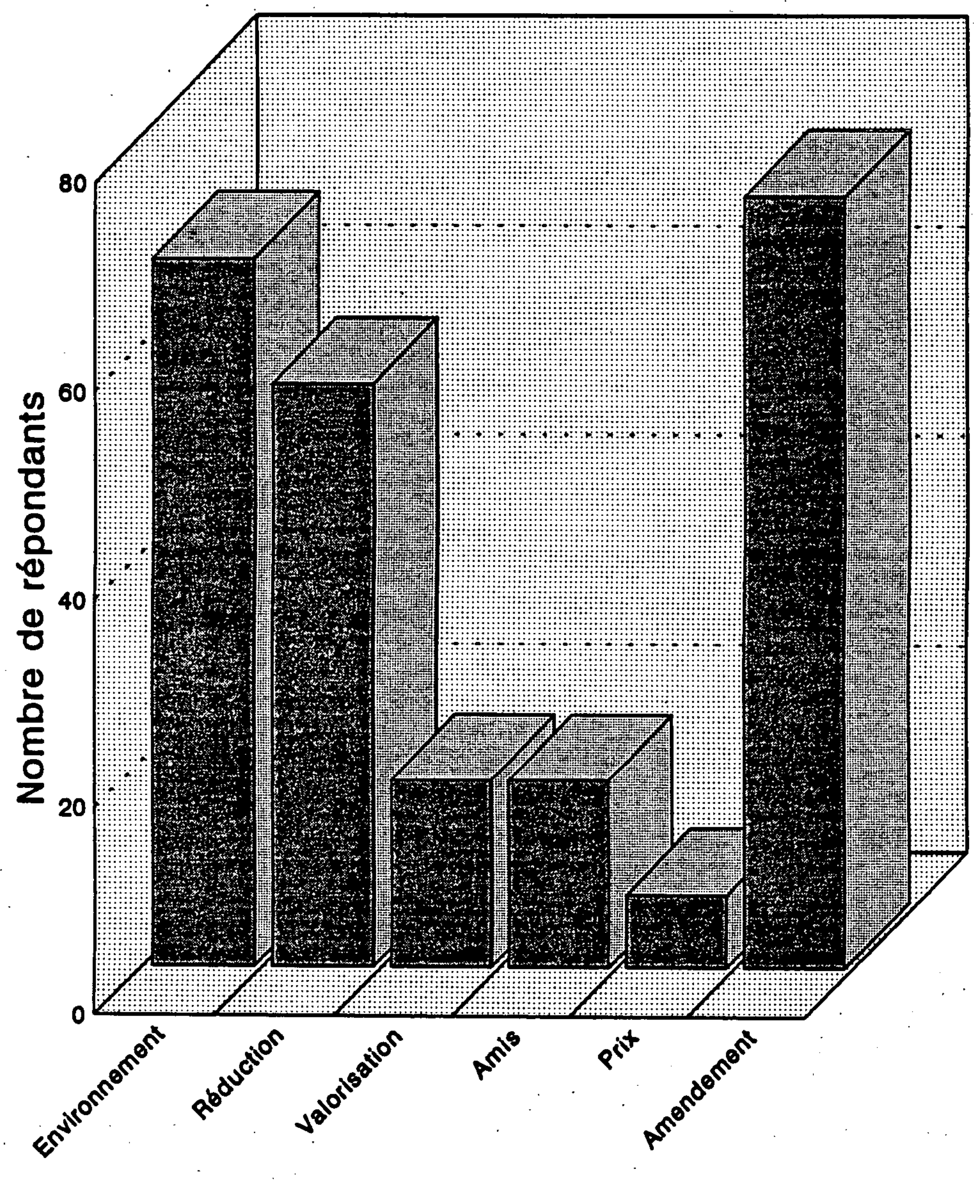
(C.U.O. octobre 92)

Graphique 2
Incitation au compostage
(Questionnaires remplis par la poste et par téléphone)



(C.U.O. octobre 92)

Graphique 1
Incitation au compostage
(citoyens visités)



(C.U.O. octobre 92)

ANNEXE 4

COMMENT BIEN RÉUSSIR VOTRE COMPOST

3 PRINCIPES DE BASE

ÉQUILIBRE: Il faut varier les matières compostées et avoir un bon rapport entre les matières riches en carbone ou matières brunes (ex. feuilles mortes, bran de scie, gazon séché) et les matières riches en azote ou matières vertes (gazon, pelure de légumes...).

AÉRATION: Il est important de percer des trous dans le tas de compost à toutes les semaines ou toutes les deux semaines. L'aération doit être plus fréquente si le compost dégage des odeurs.

HUMIDITÉ: Le compost ne doit pas être ni mouillé, ni sec. Il doit être simplement gardé humide et l'eau contenue dans les déchets de cuisine est habituellement suffisante. Pour déterminer si l'humidité est adéquate, il ne faut pas regarder qu'en surface, mais creuser un peu dans le tas. Si le compost a l'air mouillé, il peut être asséché en laissant le bac ouvert ou en intégrant des matières sèches (feuilles mortes, peat moss...). S'il apparait être trop sec parce qu'il est en plein soleil, le tas peut être arrosé sur les bords qui seront toujours les premiers à s'assécher.

Attention: un excès d'humidité entraînera des odeurs désagréables.

À PROPOS DE ...

LES FEUILLES MORTES: Elles sont très importantes pour assurer l'équilibre dans le compost. Il faut conserver des feuilles mortes à l'automne pour les ajouter graduellement durant l'été quand les matières vertes sont en abondance.

LE GAZON: Pour le composter, vous devez absolument l'équilibrer avec des matériaux riches en carbone comme les feuilles mortes et le disposer en couches d'au plus 10 à 15 cm (4 à 6 pouces). Il est préférable de laisser sécher le gazon quelques jours avant de le mettre dans le bac. N'oubliez pas que trop de gazon à la fois sans matières brunes occasionnera des odeurs.

LES DÉCHETS DE CUISINE: Pour éviter l'apparition de petites mouches, ne les laissez pas en surface, enterrez les plutôt dans le tas de matières partiellement décomposées.

L'HIVER: Vous pouvez continuer à ajouter des déchets durant la saison froide même si le compostage s'arrête. Le processus reprendra de plus belle avec le retour des beaux jours. Vous pouvez aussi entreposer les résidus dans une vieille poubelle près de la maison que vous viderez dans le composteur au printemps.

ANNEXE 5

FORMULAIRE DE DEMANDE D'UN BAC À COMPOST

Veuillez écrire en lettres moulées

Nom : ....

Adresse : ....

Code postal : ....

Téléphone (résidence) : .... *Téléphone (bureau) :* ....

Avez-vous un jardin potager? _______ *oui* _______ *non*

des plates-bandes de fleurs? _______ *oui* _______ *non*

ou une rocaille sur votre propriété privée? _______ *oui* _______ *non*

Coût : 25 $ _______ *chèque* _______ *mandat-poste*
Payable à l'ordre de la «Communauté urbaine de l'Outaouais»

À L'USAGE EXCLUSIF DU SERVICE DE L'ENVIRONNEMENT

Numéro : ....

Date de réception : ....

Paiement : ....

Poster votre demande à l'adresse suivante :

Communauté urbaine de l'Outaouais
Service de l'environnement
25, rue Laurier, bureau 500
Hull (Québec)
J8X 4C8

Pour de plus amples renseignements, composez le 770-1380.

GEORGIA DEVELOPS USA'S FIRST STATEWIDE COMPOSTING AT HOME PROGRAM

CLARK GREGORY, PH.D.

COMPOST SOUTH

(404) 876-2943

While 21 states have banned the continued landfilling of leaves, brush, and yard trimmings and launched hundreds of large-scale municipal composting projects, they may have gotten the cart before the horse. Since it costs from $50 to $150 per ton to pick up, transport, and process yard trimmings at central sites, would it not be better to encourage the ordinary citizen to take responsibility for dealing with this material at home? Believing that "composting begins at home", the Georgia Department of Community Affairs is developing the nation's first statewide composting at home program. A U.S. EPA grant provided seed money. The theme of the project is "Why make your leaves leave home? Compost makes them work for you. A little ol' bin is all you need". We are helping Georgians overcome the invisible barriers preventing them from starting to compost at home. Ten regional home composting orientation workshops to "train the trainer", are activating a friends helping neighbors grassroots network, Georgia's Composting Army, to spread the word that home composting is OK. Georgia Governor Zell Miller provides a good example by composting at home at the governor's mansion in Atlanta. The program includes assisting local government set up regional home composting demonstration sites around the state consisting of 12 bins (half homemade, half purchased), a set of attractive signs, and a landscaping plan that emphasizes use of compost. Mini-sites consisting of 3 bins and 3 signs echo the message at hundreds of public buildings, schools, and churches. Volunteers use the sites as outdoor classrooms to teach composting to local residents during frequent one-hour workshops on weekends and evenings. Volunteers distribute the basic bin, a $3.00 one cubic yard wire hoop, at these workshops. Next, we will establish several "zero discharge of yard trimmings" communities through an intensive door-to-door effort to put bins in residents' hands. We expect to divert 1000 pounds per family per year into the bin instead of the landfill, thus putting a large dent in the waste stream.

Static Pile Composting with Passive Aeration

by

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presented
to

THE SECOND ANNUAL MEETING
OF
THE COMPOSTING COUNCIL OF CANADA

(November 1992, Ottawa, Ontario)

ABSTRACT

Static pile passive aeration composting method (SPPAC) treating animal manure slurries was studied at the pilot scale level. This method can reduce capital costs and labour input associated with forced aeration and over-turing required in conventional composting operations. The SPPAC system would be suitable to farms equipped with slurry manure handling systems. Compost material for this study was made of poultry manure slurry mixed with peat, the bulking agent. Two treatments of high initial moisture content of 73% and 80% were examined in three replicate piles, each with a volume of 3.35 m^3. Open-ended perforated pipes, laid at bottom of each pile, were used to support passive aeration of the compost mass. Temperature monitoring results indicated that air was available to the material to sustain the treatment process. Thermophilic temperature was attained confirming that biological activity was effectively taking place. Pile temperature distribution demonstrated that the peat created the porous structure for air to diffuse into the high moisture compost material. Performance similarity among the replicates of both treatments was displayed by the temperature progression profiles. High quality compost with dark brown color, earthy smell, loose structure, and rich nutrient content was produced.

INTRODUCTION

Farm animal manure mismanagement often causes environmental pollution. Because of high costs involved in transportation and treatment, large amount of manure are often spread onto the lands closest to the operations. High rate of manure land application results in water pollution, phytotoxicity, nutrient imbalance and soil compaction, (Robinson and Draper, 1978; NRC, 1983; Gonzalez *et al.*, 1989; Barnett, 1991). Among the problem solving technologies, composting has received increasing attention. Products from composting treatment of form animal manure are biologically stable, rich in nutrients, easy and safe to handle, and can be applied to land as soil conditioner or fertilizer.

Animal manure slurries often contain over 90% water. Composting is impossible to be initiated with such materials because of difficulties in piling and providing aeration (Lau and Wu, 1987; Schuchardt, 1987). Bulking agents are needed to adjust the moisture content to about 50 to 60% as commonly recommended (Poincelot, 1974). However, use of considerable amount of bulking agents will raise treatment costs. Although less consumption of bulking agents would certainly reduce costs, a side effect would be a high initial moisture content, which if not properly controlled, could reduce aeration effectiveness (Haug, 1980).

Maintaining aerobic system conditions is critical for the success of the composting process. Pile turning (windrow system) and forced aeration in a static pile system are the two conventional aeration methods. But they are labour intensive and costly operations. These costs, however, can be minimized by using a non-forced or passive aeration method. Naturally heated air in the composting mass would rise, driven by buoyant forces, and release from the system while ambient air is drawn into the mass to fill up the vacancy that is left behind. Limited work has been done in studying the effect of passive aeration during composting. Mathur *et al.* (1990) applied passive aeration method to treat manure slurries in static piles using perforated pipes laid at bottom of composting piles. Ishii *et al.* (1991) studied static pile composting of sewage sludge composting using natural ventilation.

For manure slurry composting, minimum use of bulking agents and application of passive aeration would be attractive because of the operational simplicity and low cost. However, basic knowledge of thermophilic temperature development and distribution under such conditions is still limited and inadequate. The need for such information is directly related to estimation of the effectiveness of passive aeration mechanism. A pilot scale study on poultry manure slurry composting was initiated in cooperation with the Centre for Food and Animal Research and the Research Program Service of Agriculture Canada in Ottawa, Ontario. The objective of this study was to evaluate process effectiveness of static pile passive aeration composting method, SPPAC, under high initial moisture condition by monitoring temperature and changes in physical and chemical parameters of the compost.

MATERIALS AND METHODS

Poultry manure slurry containing 89% moisture was mixed with peat to obtain two levels of moisture content, 73% and 80%, denoted as Compost-I and Compost-II. Table 1 shows the physical and chemical characteristics of the poultry manure slurry, peat, and initial compost mixture under the two treatments.

Weighed amount of peat and poultry manure slurry were down loaded into a farm-scale feed mixer equipped with augers, and thoroughly mixed for about 30 minutes. A peat base about 10 cm thick was prepared on level ground, and two 10 cm diameter perforated pipes were laid on it. Trapezoidal shaped compost piles were set up using a front end loader. Fig.1 shows the configuration of the 3.35 m^3 volume piles. Three replicate piles were set up for both Compost-I and Compost-II treatments, a total of six piles. A wooden frame was used to have a uniform initial the shape and size of the replicate compost piles according to the designed pile specifications. To reduce odours, ammonia loss and flies, the piles were covered with a layer of peat about 5 cm thick.

Temperatures at several locations in the compost piles were monitored with thermocouples installed at the bottom, middle and top parts of each pile (Fig.1). Multi-Channel

Automatic Data Logging Systems were used to log the temperature data. Temperature monitoring was carried out over a period of four months. Compost samples were collected 13 times and analyzed for moisture content (MC), volatile solids (VS), ash, pH, and phosphorous (P) according to the methods described by McKeague (1978). Total carbon and total nitrogen (C and N) were determined using a LECO CHN-600 Analyzer.

RESULT AND DISCUSSION

Temperature Distribution

With readily accessible food (organic matter), water and air (oxygen) indigenous aerobic microorganisms are able to carry out exothermic reactions involving metabolism and synthesis of biodegradable organic matter. In the process heat is released, thus raising system temperature as well as changing composition of the composting material. Temperature started rising on day 1 (day 0 being the day the piles were assembled). Fig.2 shows the temperature distribution at day 5. The highest temperature, up to 65°C, was located at the pile periphery, while lower temperatures were found to be in the pile interior. Five days later, on day 10, the high temperature region moved to pile inner part, whereas pile exterior became low temperature region as shown in Fig.3. And this temperature distribution was retained until the whole pile cooled down.

Figs. 4A, 4B, 4C and 5A, 5B, 5C display some typical temperature profiles recorded at different thermocouple positions shown in the inserted diagram at the upper right corner of the figures. It can be seen that these profiles are different with respect to the two treatments and the individual recording locations. All the figures show that the peak temperature was reached later at the inner recording locations in comparison to outer locations. This is constant with the results shown in Figs. 2 and 3. Since the material was thoroughly mixed before being piled up, air availability became the key factor affecting the initiation of composting reaction and the temperature increase in the material. The fact that the high temperature prevailed in the pile exterior area first and in the interior afterwards, demonstrated with the above temperature results, suggested that the necessary amount of air was first available at exterior locations followed by the interior locations. It appeared that diffusion of ambient air into the material through the pile surfaces rather than air flow through the perforated pipes was the driving forces for the temperature development pattern.

Aeration via the perforated pipes was probably important locally in the composting piles. Locations 5 and 11 in Figs. 4A and 5A were comparable for they were both in bottom part of the piles and about 0.5 m inward from the exterior perimeter. But location 11 was right above one of the two perforated pipes, while location 5 was 0.4 m from both pipes. Temperature profiles from these two locations indicated that more air was available from the perforated pipe to location 11 than to location 5. In general, higher peak temperature, faster temperature rise rate, and shorter duration of peak temperature were observed at location 11 than at location 5.

In Figs. 4A, B and C the temperature profiles are generally similar in peak levels, around 60 to 65°C, and a common crest type configuration, with the exception of some time delay in reaching the peaks at the inner locations and higher peak temperature at location 11 as it was influenced by a perforated pipe. The time lag in reaching peaks at the inner locations implied the natural tendency that the surrounding air would be first available to the outer looser material before it reached to the inner more compacted mass. In contrast, the profiles in Figs.5A and B are different in peak temperature levels and configurations. For example, at location 2, temperature rose to a peak value of 56°C at day 8, followed by a relatively fast drop to 30°C at around day 30. In comparison, temperature at location 7 rose to a peak value of 44°C at about day 15, and it maintained around this level for more than 60 days before starting to drop gradually to 30°C at about day 100, a plateau type of profile configuration was formed. These results indicate that available air was more uniformly distributed in Compost-I piles of the lower initial moisture content than in Compost-II piles of the higher moisture content. It is, therefore, possible to improve the passive aeration status in Compost-II piles to provide more and evenly distributed aeration through modifying the perforated pipe system.

Profiles of average temperature in the piles are shown in Fig.6. In both treatments, thermophilic temperatures were reached within 3 to 5 days. This confirmed that biodegradation was well supported under the initial conditions. The temperature profile similarity among the three replicates indicated the stable performance of the SPPAC process. The temperature profiles (Fig.6) show that the process lasted much longer in Compost-II piles which took about 85 days for temperature to drop to the ambient level, compared to about 30 days in the Compost-I piles. The basic reason for this would be the substantially greater amount of poultry manure slurry that were used in Compost-II piles than in Compost-I piles. The ratio of poultry manure slurry to peat in Compost-II was about 3 times higher than that in Compost-I on a dry matter basis. Most likely, higher air availability occurred in Compost-I material because of its lower bulk density, 325 kg/m^3, which would naturally induce higher number of pores per unit volume of material. The bulk density of Compost-II material was 530 kg/m^3, which would associate with less pores per unit volume material and consequent higher diffusion resistance than Compost-I. This would lead to a lower air diffusion rate, which was actually reflected by the recorded temperature profiles. It is, therefore, understandable that Compost-II took longer time than Compost-I for temperature to drop back to the ambient level.

The above results indicated that pores in the compost mass consisting of poultry manure slurry and peat supported passive aeration as they provided effective channels for air to diffuse through the material. The effectiveness of passive aeration may be increased, especially for high initial moisture content mixtures, by increasing the number of the perforated aeration pipes at various positions. In this way a shorter composting time could be attained.

Compost Composition

Table 1 shows the initial and final values for the physical properties and chemical composition of the compost mixtures and the percent change in these values. The total nitrogen and C/N ratio changes in Compost-I material were small, compared to Compost-II material. Change in volatile solids was small for both treatments presumably because of the high volatile solids content in peat, which was a biologically stabilized material. Decrease of moisture content occurred because of the evaporation of water under high temperature. Steam rising from the piles was observed during the early days of the treatment. Fig.7 shows that the moisture content in the samples decreased steadily with a total reduction of 9% in Compost-I samples and 8% in Compost-II samples (Table 1). These changes are low, and possibly associated with the high moisture holding capacity of the peat. This high water holding capacity in the compost matrix would certainly favour microbial metabolism, and yield high quality product.

Quick start of the composting process, as demonstrated by the temperature profiles discussed above, indicated that the initial C/N ratios for the two treatments were within the proper range. It is shown in Fig.8 that during the composting process C/N ratio went up and down. A significant positive correlation was found to exist between C/N ratio and temperature changes. This could be explained that because both the C/N ratio and temperature change were directly related to the intensity of microbial activity. Decrease of carbon was due to conversion of organic matters into the released carbon dioxide (CO_2). Increase of dry matter nitrogen in Compost-II material probably indicated a lower loss of nitrogen, as NH_3, per unit mass of water evaporated compared to that in Compost-I piles.

The initial pH values in the two treatments ranged from 5.5 to 8.0, which was within the range that microorganisms generally grow well. During the composting process, as shown in Fig.9, pH increased sharply to alkaline range between 8.5 and 8.8 due most likely to decomposition of amino acids, production of NH_3/NH_4^+, and release of CO_2 (Golueke and McGauhey, 1953). The final pH of the compost product was near neutral, which would be in harmony with most soils if applied to land. The increase in dry matter phosphorous concentration occurred because of dry matter decrease. Mineralization of organic compounds would mostly contribute to ash gain. The significant positive correlation between ash and phosphorous indicated that there might be some conversion of phosphorous from organic to inorganic form.

Results in Table 1 indicated that the compost produced from the two treatments possessed good nutrient and fertilizer value. The product had dark brownish colour, earthy smell, and loose structure, which are common characteristics of good quality compost. Volume reduction of the composing piles was measured to be 26% for Compost-I treatment and 35% for Compost-II treatment.

CONCLUSION

Mixtures of poultry manure slurry and peat with high initial moisture content were successfully composted with the static pile passive aeration composting method (SPPAC) to yield good quality compost. Stable performance was indicated by temperature profiles among the replicates of each treatment. During the first few days, higher temperatures were observed closer to the surface of the piles, but later the interior of the piles, presumably because of air diffusion through the surface of the composting piles into the composting materials. Air supply via the perforated aeration pipes appeared to be effective locally. Higher initial moisture content of compost mixture required a longer time for the composting process to be completed compared to piles with lower initial moisture content. This requirement of longer time could possibly be reduced by increasing the number of aeration pipes. The results of this study show that it is possible to successfully compost mixtures of poultry manure slurries and peat at substantially higher initial moisture content than the commonly accepted values of 50 to 60%.

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Table 1 CHARACTERISTICS OF POULTRY MANURE SLURRY, PEAT AND THE COMPOSTS AND CHANGE (%) OF THE COMPOST

Property	SLURRY	PEAT	COMPOST-I	%change	COMPOST-II	%change
Moisture Content (MC)	89	52	I 73 F 66	-9.1	I 80 F 73	-7.9
Volatile Solids % (VS) (dry matter)	66	97	I 87 F 86	-1.5	I 81 F 79	-1.7
pH of water extract	7.3	3.8	I 6.2 F 7.6	22.0	I 7.2 F 7.3	0.5
Total Carbon % (C) (dry matter)	40	48	I 46 F 43	-5.1	I 42 F 39	-7.9
Total Nitrogen % (N) (dry matter)	4.7	1.9	I 2.9 F 2.8	-2.3	I 3.3 F 4.0	19.0
C/N Ratio	8.5	25	I 15.9 F 15.5	-2.9	I 12.6 F 9.7	-22.6
Phosphorous % (P) (dry matter)	4.02	0.01	I 0.9 F 1.2	25.0	I 1.6 F 1.9	21.3
Ash % (dry matter)	33	3	I 12 F 13	11.4	I 18 F 20	15.1
Bulk Density kg/cubic meter			I 325 F ND		I 530 F ND	

I: initial value
F: final value

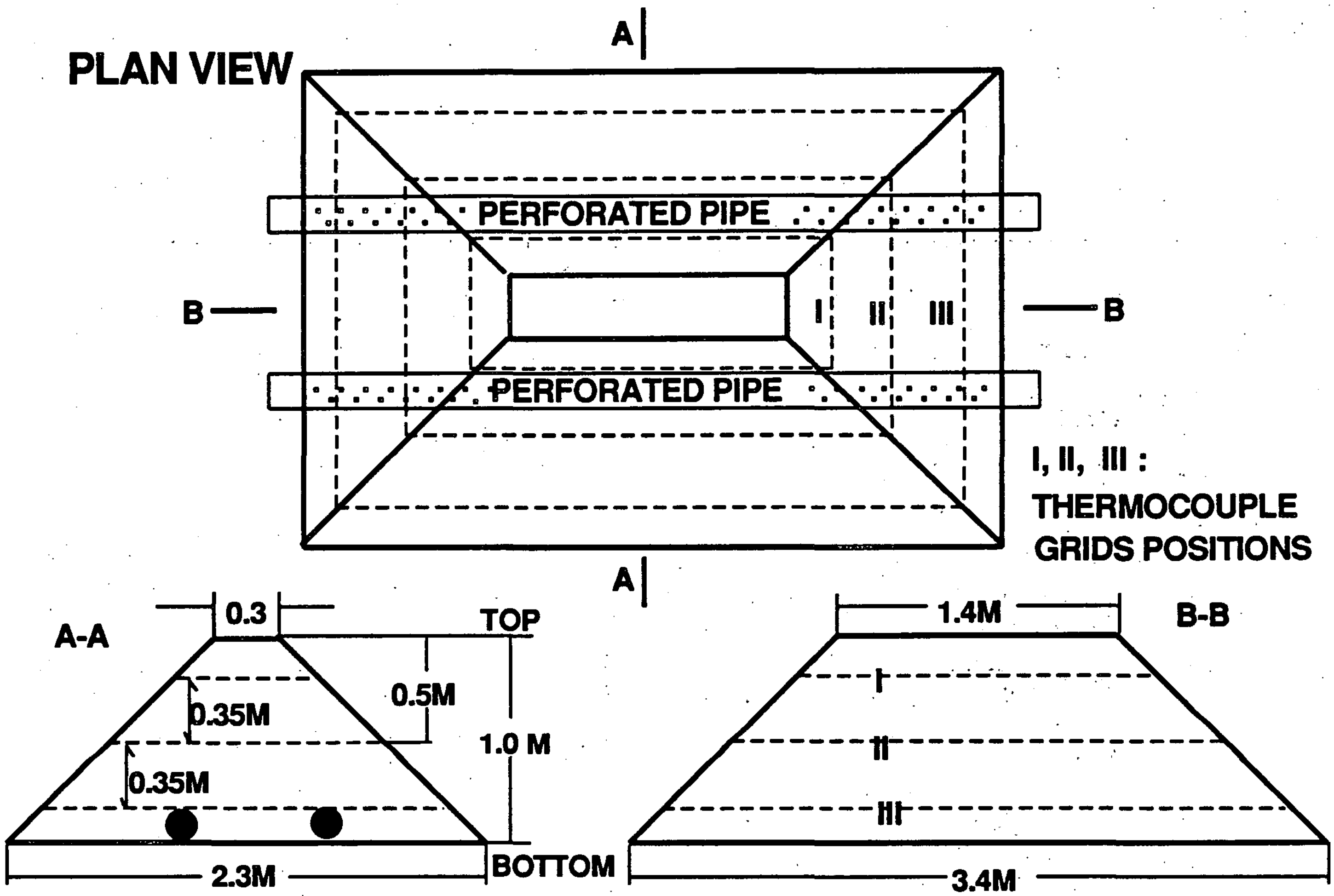
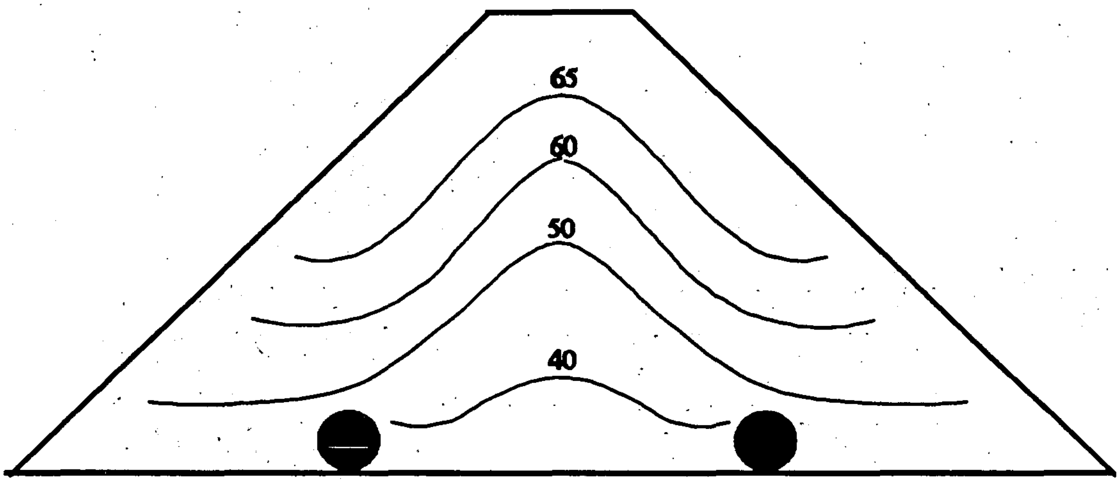
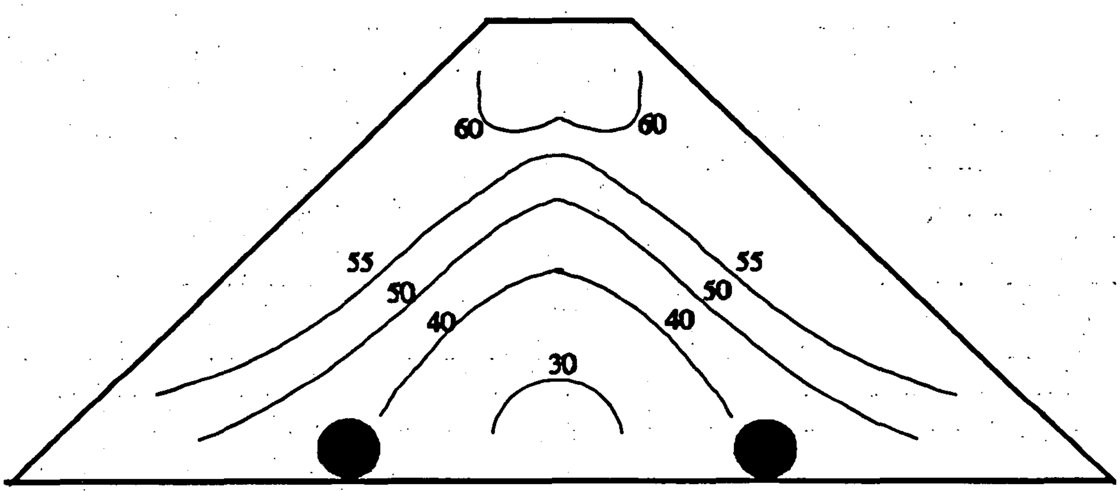


Fig.1 COMPOST PILE CONFIGURATION

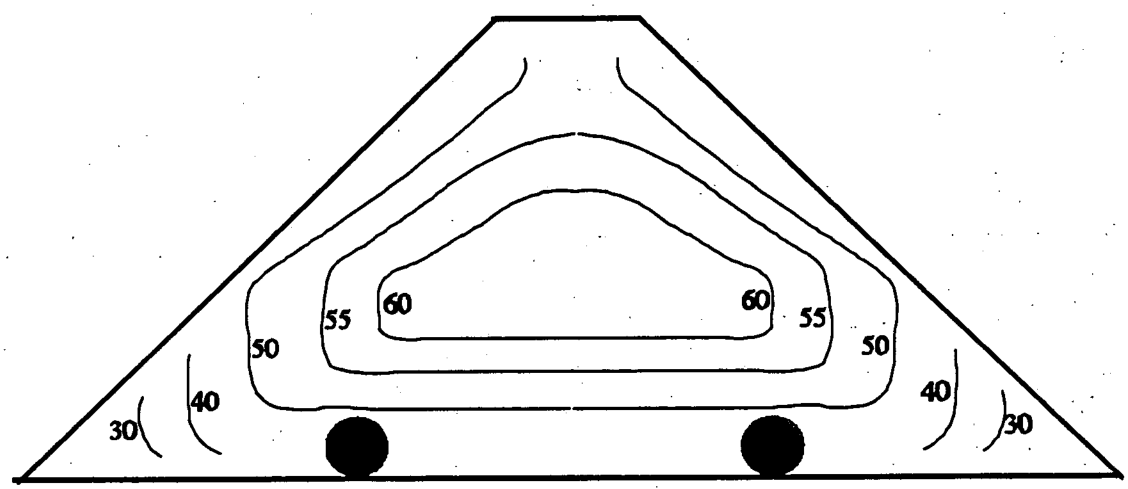


COMPOST-I, DAY5

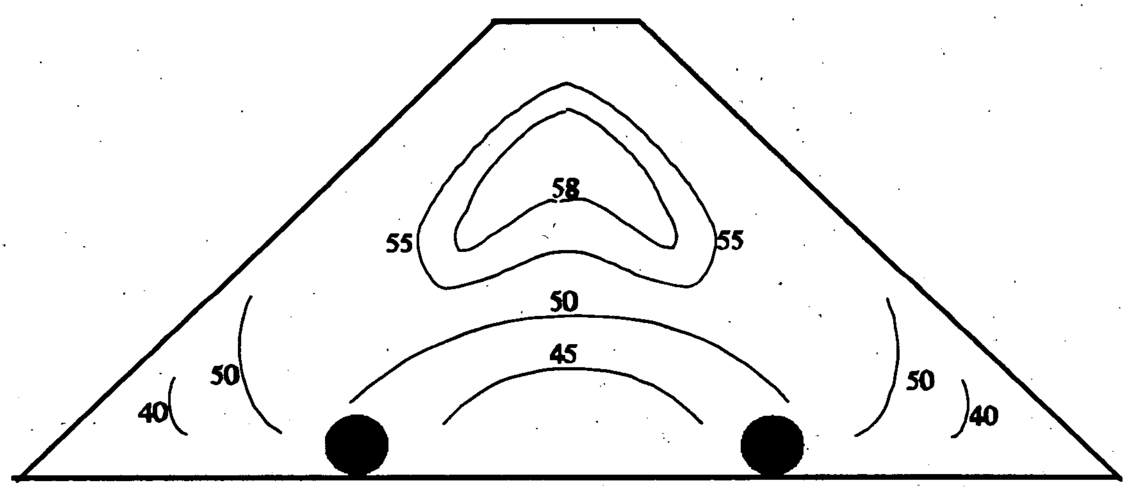


COMPOST-II, DAY 5

Fig.2 TEMPERATURE DISTRIBUTION, DAY 5



COMPOST-I, DAY 10



COMPOST-II, DAY 10

Fig.3 TEMPERATURE DISTRIBUTION, DAY 10

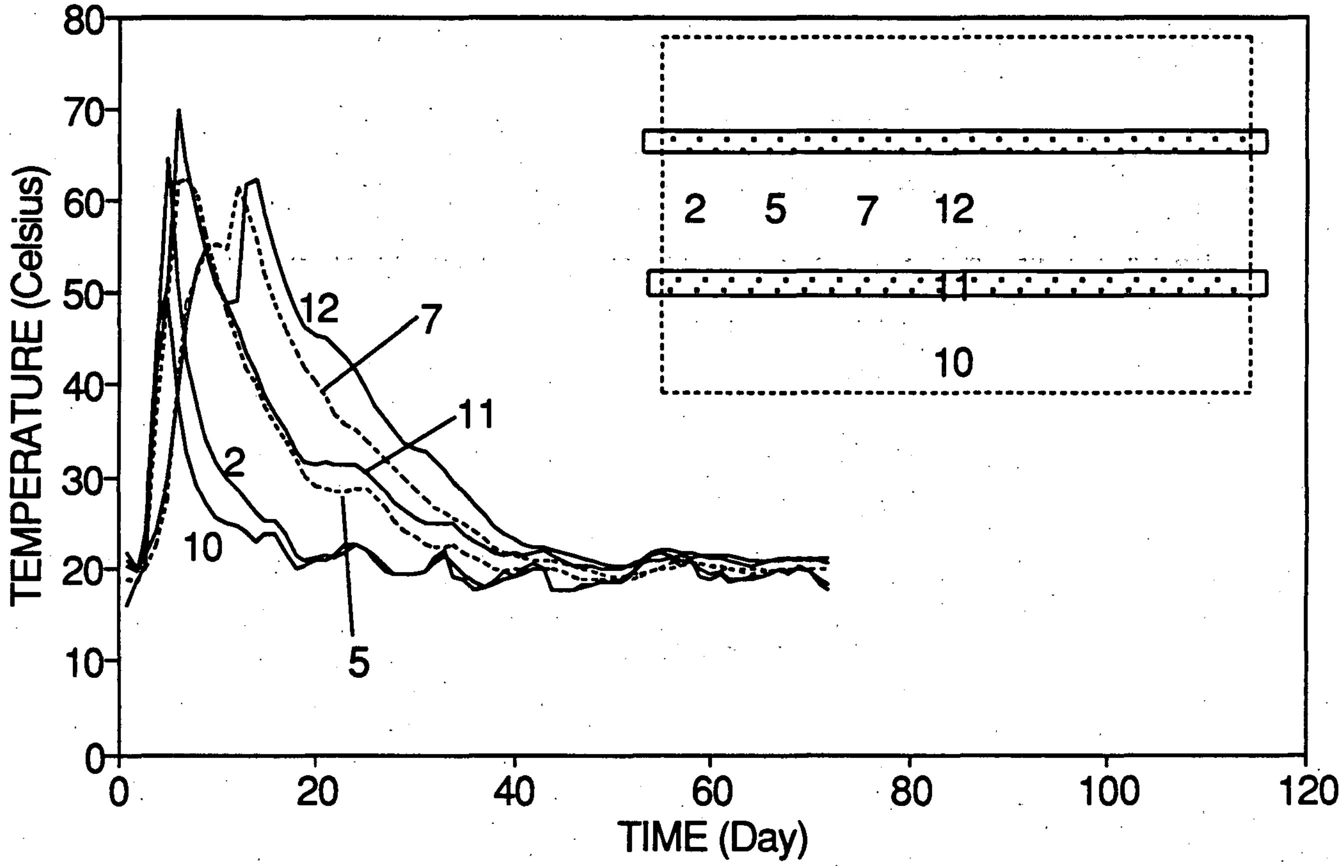


Fig. 4A TEMPERATURE IN COMPOST-I PILE BOTTOM LOCATIONS 2,5,7,10,11,12

(POSITION III IN Fig. 1)

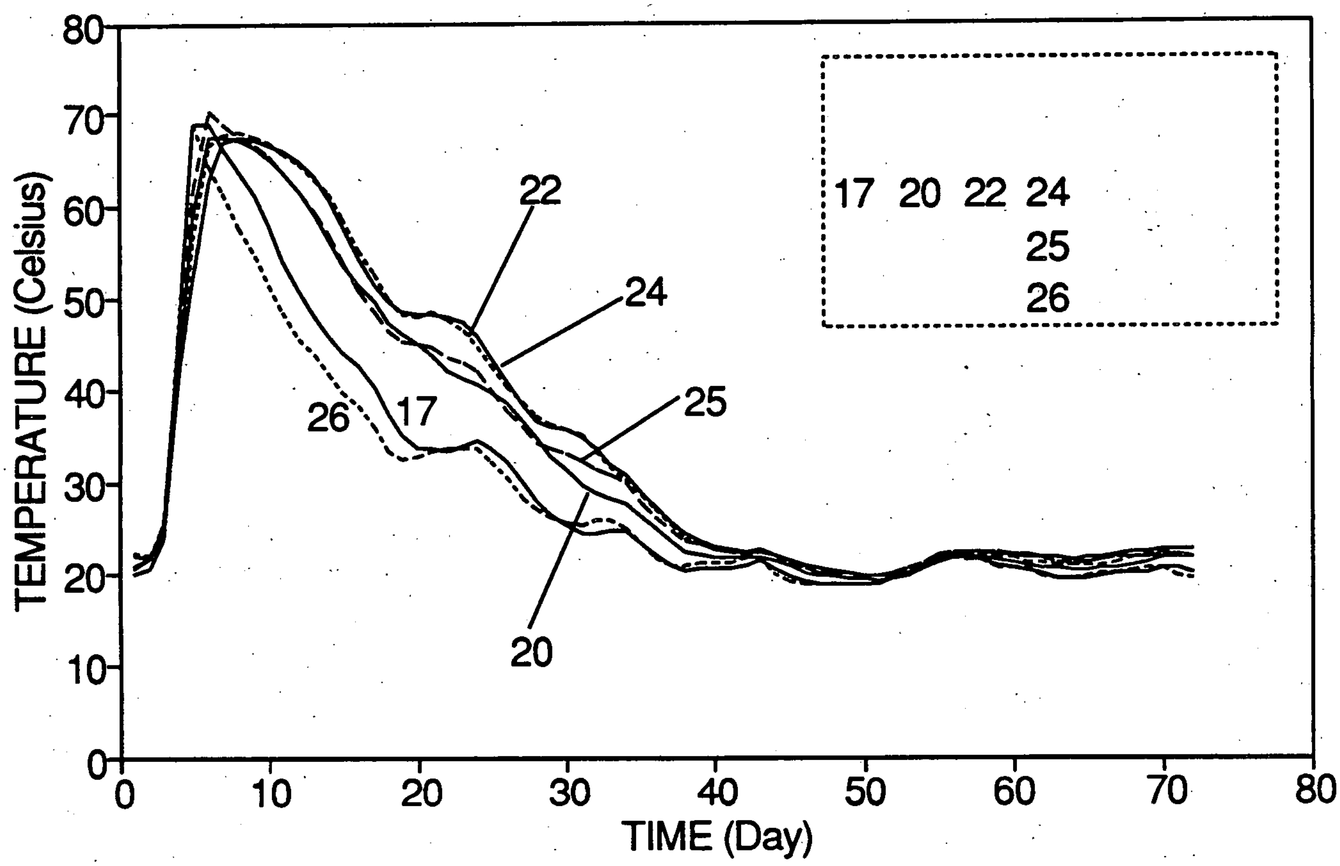


Fig.4B TEMPERATURE IN COMPOST-I PILES MIDDLE LOCATIONS 17,20,22,24,25,26 (POSITION II IN Fig.1)

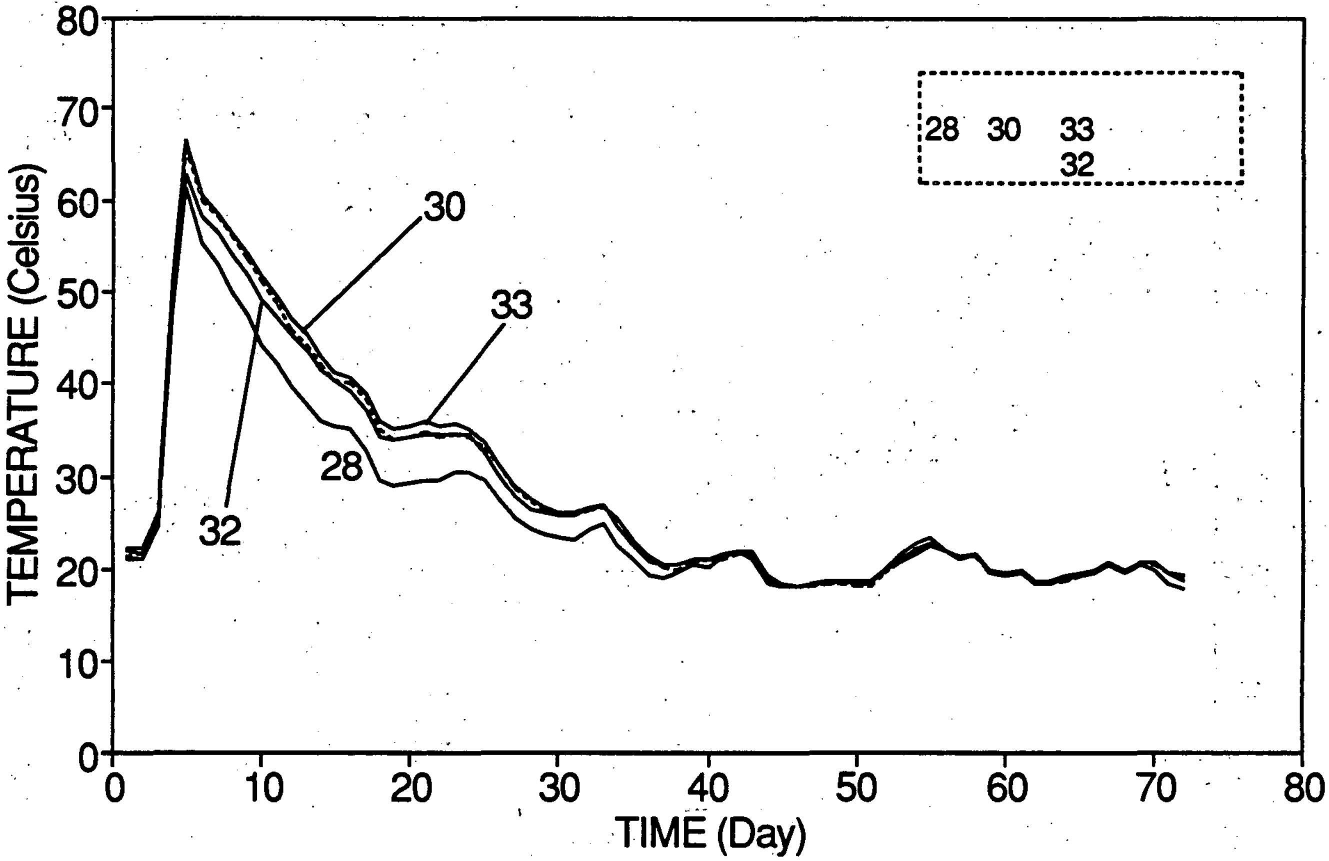


Fig.4C TEMPERATURE IN COMPOST-I PILES TOP LOCATIONS 28,30,32,33
(POSITION I IN Fig. 1)

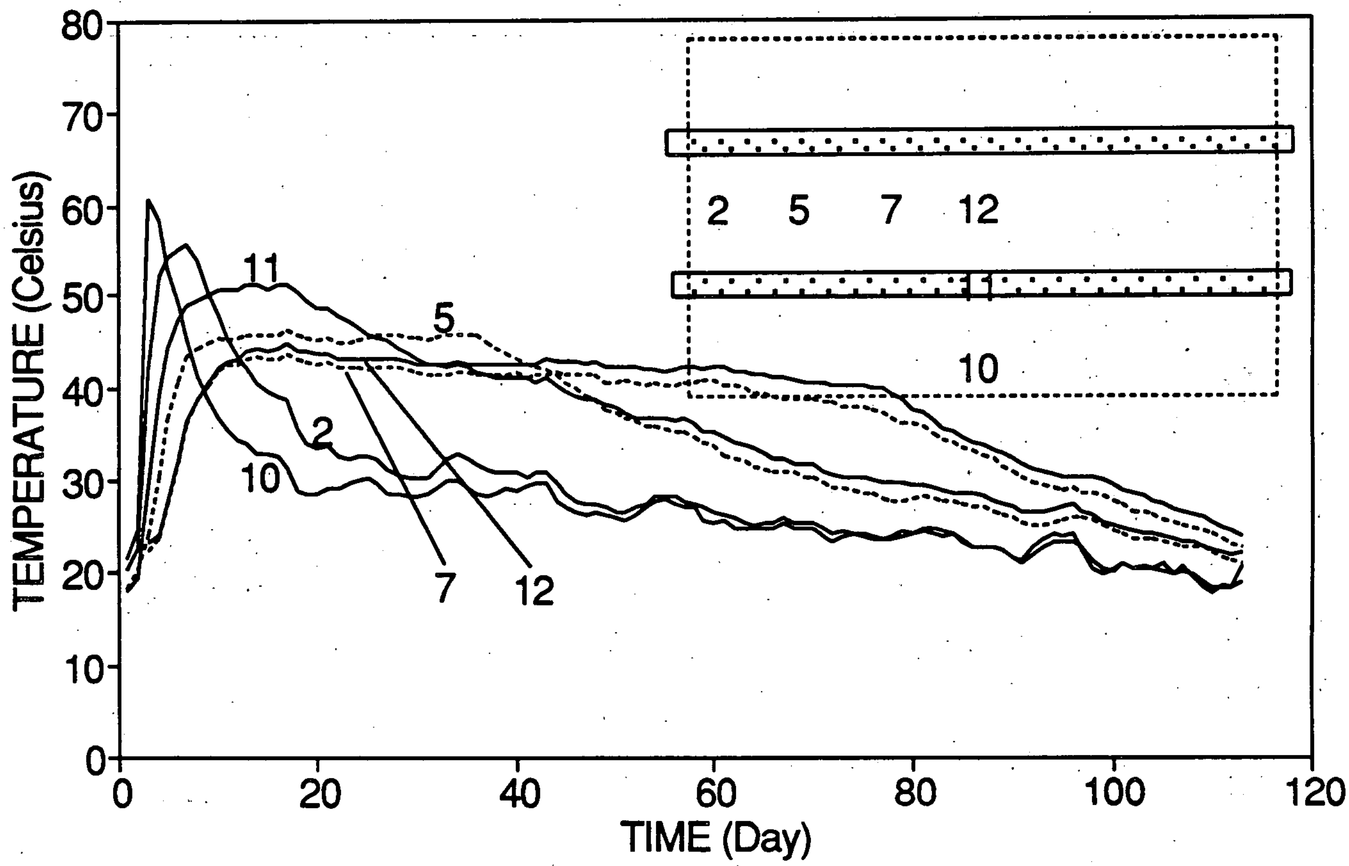


Fig.5A TEMPERATURE IN COMPOST-II PILES BOTTOM LOCATIONS 2,5,7,10,11,12

(POSITION III IN Fig. 1)

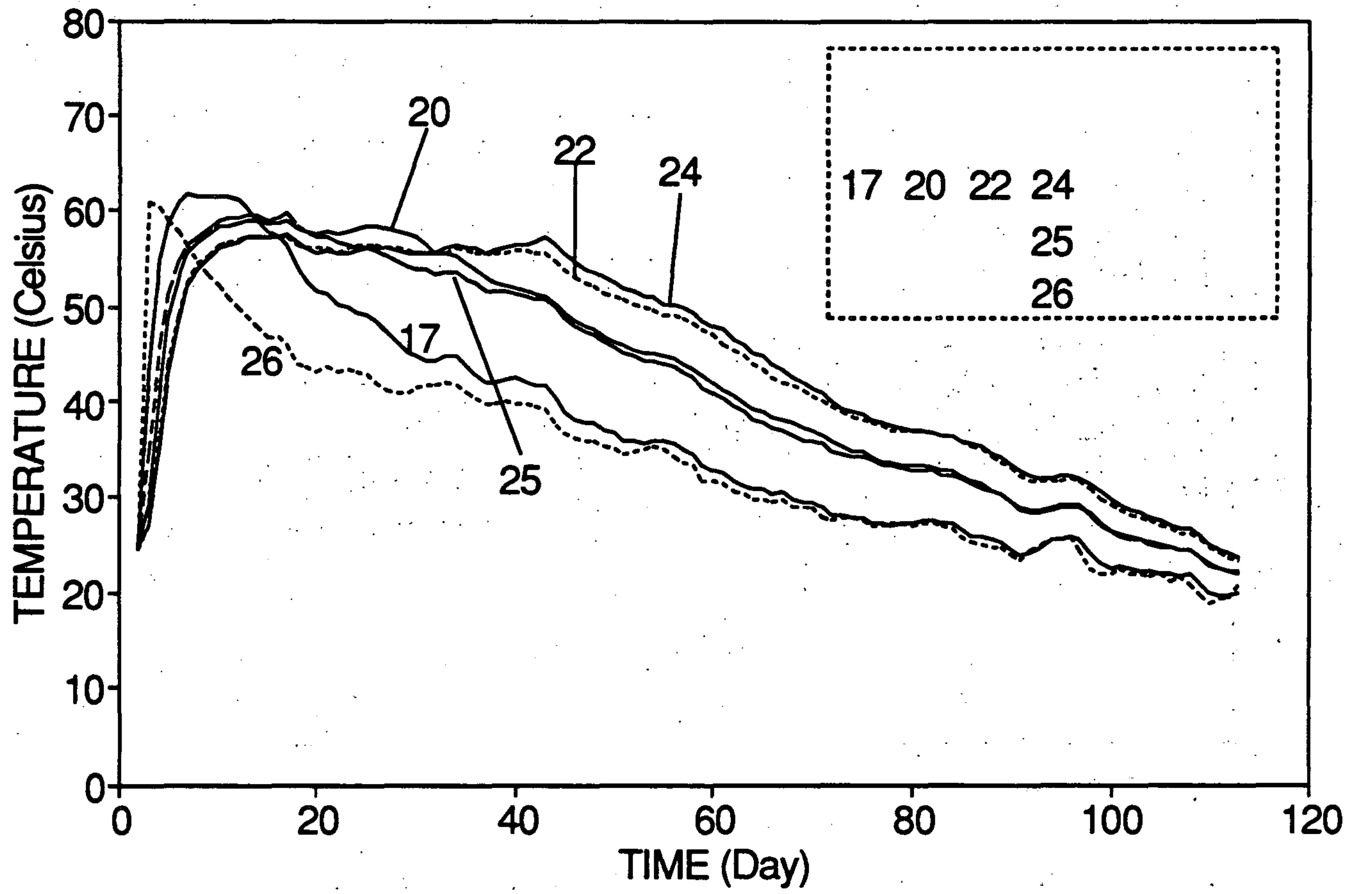


Fig.5B TEMPERATURE IN COMPOST-II PILES MIDDLE LOCATIONS 17,20,22,24,25,26 (POSITION II IN Fig. 1)

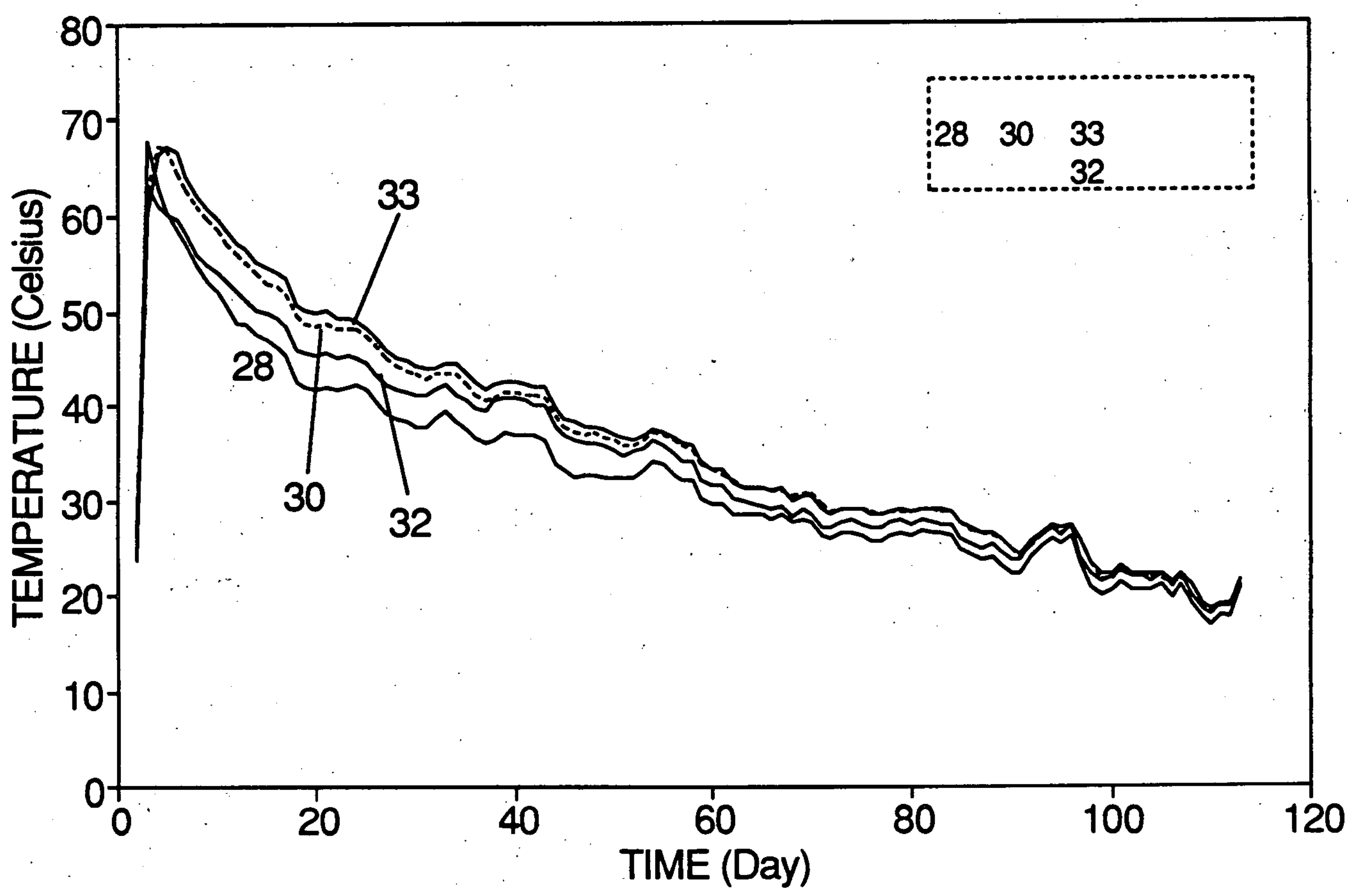


Fig.5C TEMPERATURE IN COMPOST-II PILES TOP LOCATIONS 28,30,32,33 (POSITION I IN Fig. 1)

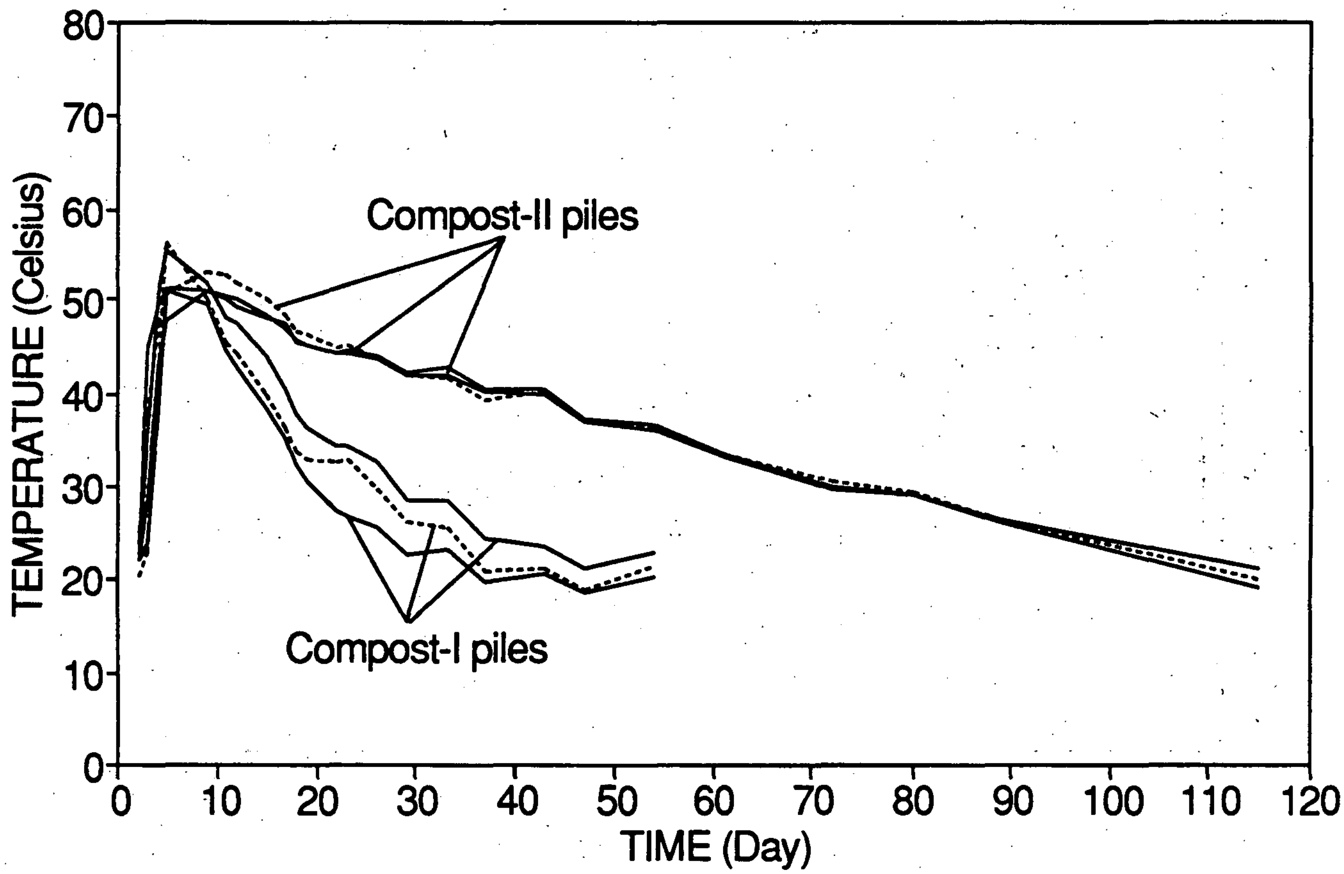


Fig.6 AVERAGE TEMPAERATURE IN COMPOST-I AND COMPOST-II PILES

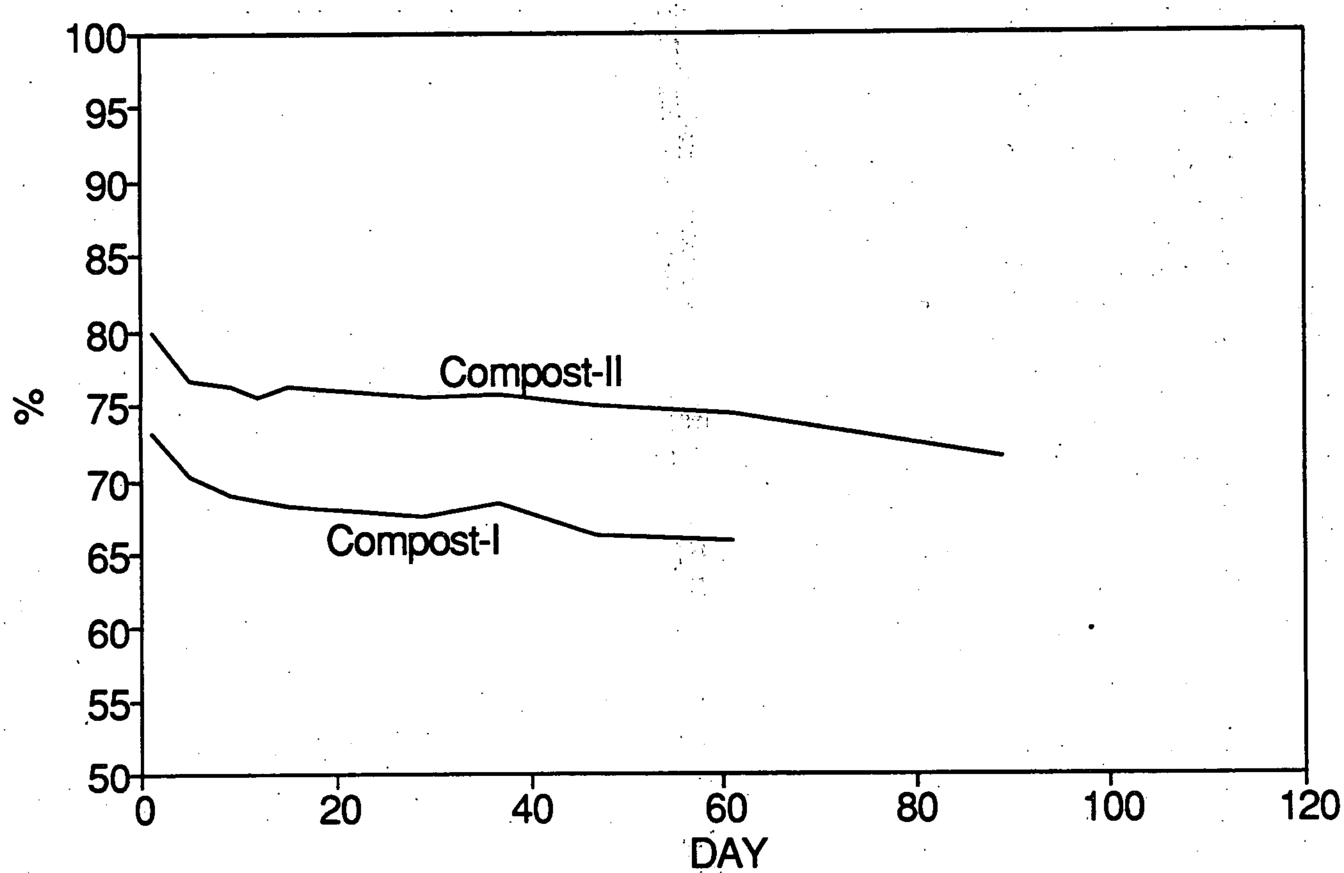


Fig.7 MOISTURE CONTENT CHANGE IN COMPOST-I AND COMPOST-II PILES

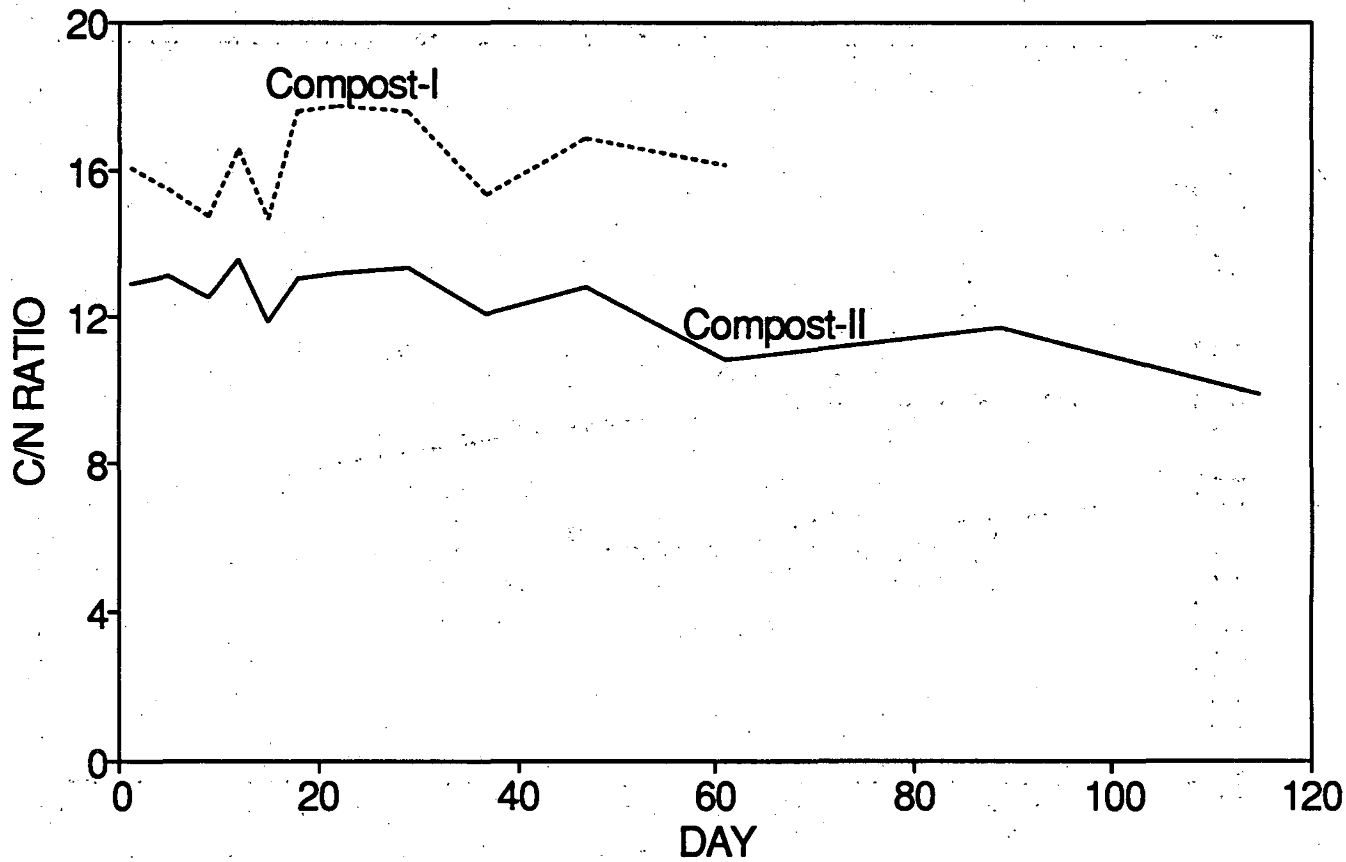


Fig.8 C/N RATIO FOR COMPOST-I AND COMPOST-II

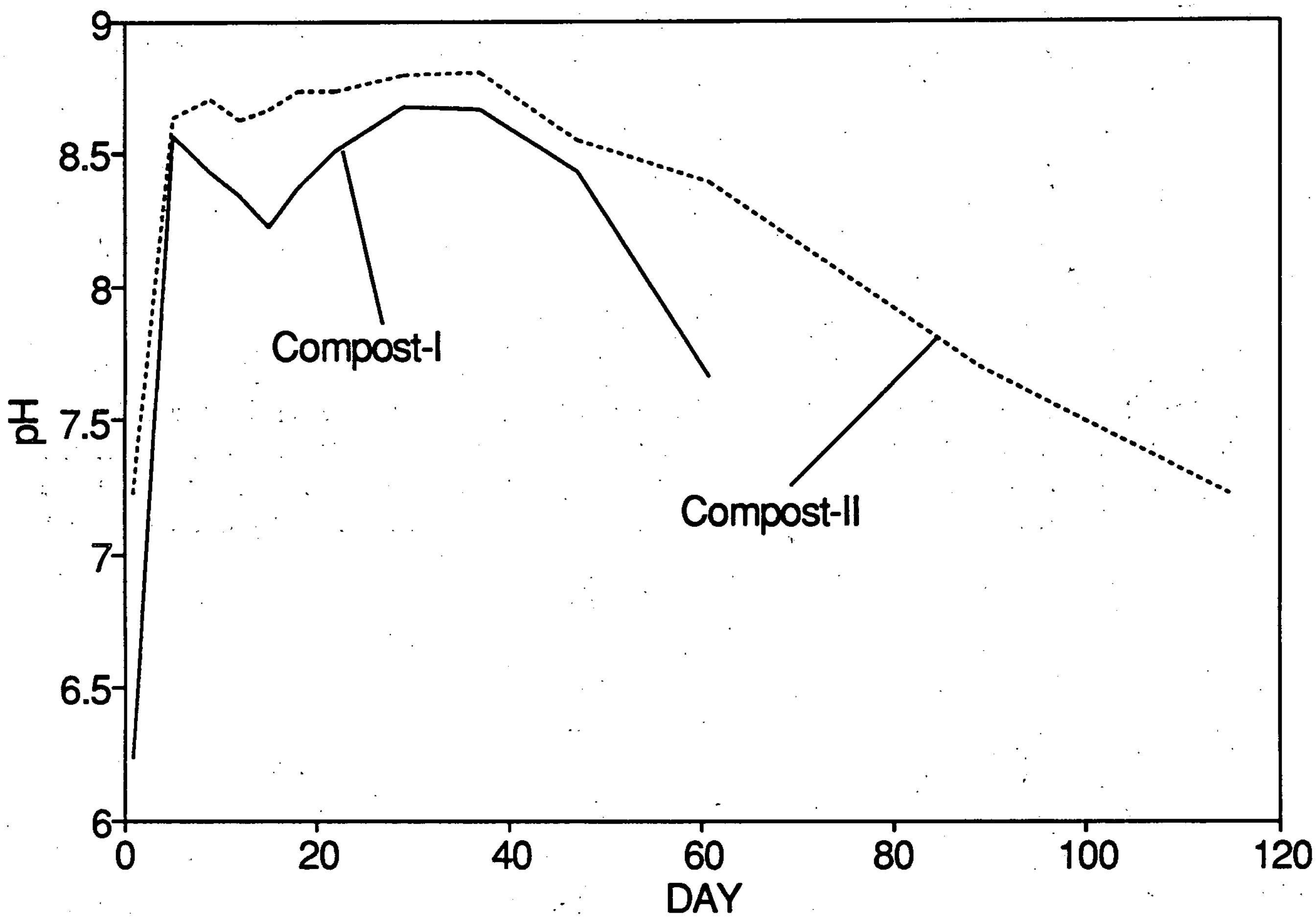


Fig.9 pH FOR COMPOST-I AND COMPOST-II

Le compostage des fumiers de bovin laitier sous aération forcée

par

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2^{e} congrès annuel du
Conseil canadien du compostage

RÉSUMÉ

Un premier système de compostage par aération forcée, développé à l'I.T.A. de La Pocatière, fonctionne suivant le principe d'une circulation horizontale de l'air entre deux conduits (pression et vacuum). Il permet de recycler l'air vicié ainsi que la récupération d'énergie. Ses deux ventilateurs de 7,5 kW permettent de composter 135 m^3 de fumier de bovin, en 18 jours, au coût de 5,07 $\$/m^3$ et qui pourrait descendre à 2,26 $ avec la récupération d'énergie.

Un deuxième système, aussi par aération forcée, fonctionne suivant une circulation verticale de l'air. Il est amené par 6 conduits dans un lit de copeaux de bois sous la masse de fumier. Ses 6 ventilateurs de 0,25 kW permettent de composter 72 m^3 de fumier, en 30 jours, au coût de 5,62 $\$/m^3$.

Un troisième système constitué d'andains, aéré deux fois en quatre mois (à l'aide d'un épandeur), servait de comparaison. Il a permis de composter 80 m^3 de fumier, en 120 jours, au coût de 8,29 $\$/m^3$.

Chez un agriculteur, dans une gestion globale des fumiers les coûts de production pourraient être de 0 à 2 $\$/m^3$ avec les gros ventilateurs, de 1,50 $\$/m^3$ avec les petits ventilateurs et de 5 $ avec les andains.

Le procédé avec les gros ventilateurs est préférable aux deux autres principalement au niveau:

- du rendement;
- du coût de production;
- de la protection de l'environnement;
- des éléments fertilisants.

INTRODUCTION

Le stade embryonnaire des installations d'entreposage et de traitement des quelque 20 millions de tonnes de fumier de bovin au Québec, les coûts de leur gestion, leur potentiel agronomique ainsi que la pollution diffuse qui en résulte nous ont incité à rechercher de nouvelles avenues pour leur gestion.

Le premier pas

La première fosse d'entreposage et de compostage, sol et géotextile (Texel 7618), a été édifiée en 1987 (3 000 m^3 de solide et 1 200 m^3 de liquide), tel qu'illustré à la figure 1. Elle a permis des économies de 50 % par rapport aux fosses conventionnelles en béton.

Le deuxième pas

Un projet de compostage rapide des fumiers en fosse par aération forcée a été développé; il constituera d'ailleurs la majeure partie de cette présentation.

Le troisième et dernier pas

L'ensemble de ces travaux devrait permettre le développement d'un système de traitement des fumiers (compostage et entreposage) chez l'agriculteur. Ce procédé s'effectuerait en continu, sans manutention supplémentaire et son coût se situerait dans les limites des installations actuelles d'entreposage. Le produit obtenu serait plus stable, d'une efficacité agronomique supérieure et avec moins d'impacts environnementaux négatifs.

OBJECTIFS

Les objectifs de la présente étude sont:

1) Concevoir et mettre au point un procédé de compostage rapide par aération forcée des fumiers solides.

2) Comparer et évaluer la performance de trois méthodes d'aération pour le compostage des fumiers de bovin (temps, qualité, coût).

3) Évaluer le potentiel de récupération d'énergie associé à l'aération forcée.

REVUE DE LITTÉRATURE

G.B. Wilson (1980) met au point le procédé "Beltsville" pour le compostage des boues de station d'épuration en andain avec aspiration d'air à travers la masse. M. Finstein et al (1982 à 1987) élaborent le procédé d'aération par pression d'air sous les andains de façon à créer un refroidissement des masses, favorisant ainsi le développement des bactéries. En Europe, L. Berthelsen et al (1984), mettent au point un procédé de compostage en chambre par aération forcée incluant un système de récupération d'énergie. O. Tjernshaugen (1982) élabore un procédé de compostage des fumiers liquides de vache avec récupération d'énergie.

MATÉRIEL ET MÉTHODES

Deux méthodes par aération forcée et une par aération mécanique constituaient l'ensemble de l'étude (figures 2 et 3).

Équipement.

Les deux méthodes d'aération privilégiées étaient constituées:

1) D'un premier système à deux gros ventilateurs Dayton de 7,5 kW débitant 1,4 m^3/s d'air (à une pression statique de 1,5 cm de mercure) dans deux conduits triangulaires permanents (1,4 m H x 0,9 m L x 8,0 m L) espacés de 4 m. Un ventilateur fonctionne en pression positive pendant que l'autre est en pression négative (vacuum), interchangée à toutes les 4 ou 6 heures, permettait la récupération de l'énergie dégagée par le processus de biodégradation et de la stocker sous terre (figure 4).

2) D'un deuxième système à six petits ventilateurs Dayton de 0,25 kW débitant chacun 0,06 m^3/s d'air (à une pression statique de 1,0 cm de mercure) dans six conduits temporaires en polyéthylène (diam. 100 mm), de 5,0 m L, séparés de 1,0 m (figure 5).

La méthode par aération mécanique (andain) ne nécessitait pas d'équipement installé en permanence sur le site.

Un système de prise de données et de contrôle informatisé combiné à 45 capteurs (ADC-590) assurait le bon déroulement des opérations.

Type de fumier

Les fumiers de bovin ayant deux taux de litière différents (4 kg/a.j. et 2 kg/a.j.) principalement à base de paille ont été soumis à l'expérimentation.

Période

Les deux expériences vont de novembre 1989 à mars 1990.

RÉSULTATS ET DISCUSSION

Fumiers de bovins à 2 kg/a.j.

En raison d'un ensemble de circonstances (temps d'entreposage trop long, conditions climatiques très rigoureuses...) et du fait que la marge de manoeuvre est très étroite avec ce taux de litière, aucune des trois méthodes a donné de résultats satisfaisants (à reprendre en modifiant la méthodologie).

Fumiers de bovin à 4 kg/a.j.
Biodégradabilité

Les valeurs moyennes relatives en pourcentage des principaux paramètres physico-chimiques apparaissent au tableau 1 ainsi que leur évolution lors du processus de compostage (regroupe l'ensemble des fumiers dans les trois techniques).

En général, les paramètres physico-chimiques de ces fumiers favorisent un bon développement bactérien. Par contre, la biodégradation optimale (vitesse de compostage) ne sera obtenue qu'en fonction d'une aération refroidissante suffisante (bien dispersée grâce à une bonne porosité), évaluée à 0,08 m^3/s par tonne de matière sèche (0,02 m^3/s par tonne de fumier humide). À ce taux, l'oxygénation est excédentaire aux besoins. Les gros ventilateurs respectaient ces débits tandis que les petits ventilateurs ne satisfaisaient qu'à demi les besoins de refroidissement, mais avec une bonne oxygénation. Les andains ne sont absolument pas satisfaits (refroidissement et oxygène), soumettant des parties de la masse à des conditions anaérobies.

Les trois techniques expérimentées ont donné de bons résultats permettant d'obtenir un compost jeune, d'aspect physique semblable et s'ouvrant à une utilisation générale à la ferme confirmée par l'absence d'inhibition et phytotoxicité à la germination et à la croissance lors d'essais en serre. Par contre, la vitesse de compostage est très différente: 18 jours pour les gros ventilateurs, 30 jours pour les petits et 120 jours pour les andains.

Évolution des températures

L'évolution du processus peut être interprétée à partir de l'évolution des températures si leurs mesures s'effectuent sous un flux de chaleur dynamique évacué important, garantissant une bonne activité microbienne.

La figure 6 comporte 3 courbes des températures moyennes de chacune des masses en compostage, superposées à la courbe idéalisée de l'évolution des températures moyennes d'une masse de fumier en biodégradation optimale. Cette dernière a été conçue à partir des données, observations et conclusions des procédés expérimentés.

Pour obtenir une bonne hygiénisation, une biodégradation optimale et un minimum de perte des éléments N et K, la courbe des moyennes des températures devrait non seulement s'approcher et suivre le profil de la courbe idéalisée mais témoigner du fait que les températures dans les différentes parties de la masse ne soient pas disproportionnées.

Évolution des principaux paramètres chimiques

L'évolution des résultats d'analyse chimique a permis de tracer des profils de concentration des principaux éléments (N, P, K, Mg).

Les figures 7 et 8 montrent les variations dans les profils. On remarque une augmentation (gains) des concentrations de 25 à 35 % durant le premier mois correspondant à une diminution approximative de 30 % de la matière sèche; les bactéries atteignent leur développement maximal, immobilisant une bonne partie des éléments. C'est ici que nous avons le potentiel fertilisant maximum correspondant à un compost jeune, accompagné d'une perte de volume d'environ 40%. Au cours des 2e et 3e mois, des pertes importantes pour N et K (très différentes d'une technique à l'autre) et qui se stabiliseront par la suite, résultant possiblement de la baisse et stabilisation de l'activité microbienne, du retournement et du développement de conditions anaérobiques dans certaines parties des andains en particulier. Alors s'exercent particulièrement, durant cette période, le lessivage, la volatilisation et la dénitrification.

Pertes et gains absolus des principaux éléments

Le tableau 2 fixe les pertes et gains absolus des principaux éléments et établit un parallèle entre les trois procédés. Les calculs ont été faits à partir des résultats d'analyse en tenant compte d'une perte de matière sèche évaluée à 30 % à la fin de la phase thermophile et d'une perte de 40 % après 5 mois de maturation. Les valeurs obtenues ont été confirmées par une 2e méthode utilisant le magnésium (élément stable et sans perte sensible dans le processus) dans l'établissement des rapports C/Mg, N/Mg et K/Mg et dans l'évolution de leurs variations.

Cet aspect est très important pour l'agriculture, car il fixe la valeur fertilisante du produit. Il est aussi très important pour l'environnement, car il modifie la qualité du milieu. Quelques suggestions peuvent en être tirées:

- compostage en continu,
- manutention minimale
- aération suffisante,
- phase thermophile la plus courte possible,
- récupération de l'air vicié,
- récupération des liquides de suintement,
- utilisation du compost jeune,
- recouvrement des masses.

Rendement

La différence entre les trois techniques est très marquée sur le plan du rendement (ratio) c'est-à-dire le volume de fumier traité annuellement par unité de surface utilisée. Le volume traité à chaque séquence ainsi que le temps de séjour sont les facteurs dominants. Le tableau 3 montre les performances de chacun des systèmes à ce niveau. Le système des gros ventilateurs permet de traiter sur une même surface 22 fois plus de fumiers qu'avec les andains et 3 fois plus qu'avec les petits ventilateurs. Cela veut dire que l'unité de compostage par gros ventilateurs occuperait une surface très petite (environ 25 à 30 m^2) chez un agriculteur moyen (environ 60 U.A.)

Récupération énergétique

Seul le système par gros ventilateurs permettait cette récupération. Une évaluation sommaire (à partir des données de 1989-1990, des données préliminaires d'expériences subséquentes ainsi que sur des déductions et estimations) permet d'envisager trois scénarios différents :

1) Le système original du projet, c'est-à-dire totalement ouvert aux intempéries.

2) Le système de base, mais partiellement fermé.

3) Le système de base, mais hermétique et isolé.

Le tableau 4 fait la synthèse des valeurs moyennes calculées et retenues pour chacun des scénarios. Elles sont valables pour 7 des 12 mois (octobre à mai).

Il y a sûrement un intérêt à récupérer l'énergie pouvant servir principalement à réchauffer les bâtiments d'élevage.

Coût de production

Les coûts d'investissement et autres ont été évalués comme si les systèmes avaient été mis en place chez un agriculteur. Les coûts fixés comprennent les achats d'instruments, les constructions, la main-d'oeuvre, un amortissement différentiel sur 5 ou 10 ans. Les coûts variables comprennent le matériel périssable, l'entretien-réparation, la manutention et la consommation énergéti que.

Les coûts reliés à la recherche (équipement particulier, expertise à développer, etc.) ont été écartés.

Le tableau 5 résume les principaux paramètres de cette étude économique.

Dans un processus global de gestion des fumiers d'un agriculteur (de l'étable aux champs), contrairement à l'évaluation pour cette expérimentation qui ne tient compte que du procédé de compostage avec travail à forfait, si l'on suppose que la diminution de manutention à l'épandage des composts (environ 30 à 40 %) par rapport aux fumiers verts équivaut à la manutention supplémentaire durant le procédé de compostage, les coûts d'opération pour les trois techniques diminueraient d'au moins 50 %. L'agriculteur pourrait s'attendre à des coûts de production de 0 à 2 $ par mètre cube de fumier à traiter avec les gros ventilateurs, à 1,50 $ avec les petits ventilateurs et à 5 $ avec les andains.

CONCLUSION

À la lumière des travaux effectués lors de cette étude, plusieurs conclusions s'imposent. Elles sont :

1) Outre les paramètres physico-chimiques déjà mentionnés, la porosité influencée par le type et taux de litière et le temps d'entreposage a beaucoup d'influence sur la circulation d'air.

2) Un débit d'air de 0.02 m^3/s. ton. de fumier humide sous une pression statique de 1 à 2 cm de mercure semble suffisant.

3) En aération naturelle (mécanique), le nombre de revirements pour arriver à un compostage rapide serait trop grand rendant le processus non rentable et avec une forte perte de N et K.

4) Les courbes d'évolution des températures sont une mesure de la biodégradation si elles s'accompagnent d'un transfert intense du flux de chaleur.

5) Un profil souhaitable de ces températures, ayant une biodégradation optimale montrerait :
   - une élévation rapide des températures (moins de 48 heures),
   - un sommet situé vers les 60°C à 65°C,
   - une baisse progressive sur une quinzaine de jours pour atteindre 45°C,
   - une stabilisation entre 40°C à 45°C pour un certain temps de maturation.

6) Le dimensionnement choisi semble adéquat sauf pour les petits ventilateurs où la puissance devrait atteindre 0,75 kW.

7) Les pertes minimales enregistrées avec le système des gros ventilateurs (6 % N et 19 % K) après la phase thermophile courte résultent d'une bonne aération refroidissante alimentant un fort développement bactérien.

8) La fin de la phase thermophile est un moment crucial (pour ce compost jeune) pour les raisons suivantes:
   - potentiel fertilisant à son maximum,
   - perte de volume importante,
   - populations bactériennes stabilisées mais encore très actives disposant encore d'une bonne quantité de carbone,
   - sans inhibition ou phytotoxicité pour les grandes cultures, il profiterait d'une interaction sol-plante pour compléter son humification.

9) L'évaluation sommaire du potentiel énergétique laisse entrevoir une récupération nette de l'ordre de 30 % à 50 % du coût de compostage; ce qui pourrait permettre de descendre le coût d'opération de 5,07 \$/m^3, le plus faible avec le système des gros ventilateurs, jusqu'à 2,26 \$/m^3.

10) Le concept du compostage par air forcé est supérieur aux andains parce qu'il permet:
    - de composter en toute saison,
    - d'optimiser le processus (temps de biodégradation),
    - de réduire la surface primaire de compostage,
    - de diminuer considérablement les infrastructures d'entreposage actuelles,

- d'éliminer les pertes d'éléments nutritifs dans l'environnement,
- de s'adapter à n'importe quelle grosseur de ferme.

11) Pour établir une projection des coûts à la ferme on doit tenir compte que:
- l'unité de compostage serait petite (25 à 30 m² pour 60 U.A.);
- la surface d'entreposage serait entre 35 à 60 % plus petite qu'actuellement (pour ceux qui utilisent déjà 4 kg/a.j. de litière);
- la diminution de la manutention à l'épandage serait d'environ 35 %.

À partir des deux hypothèses suivantes:
- le coût d'installation de l'unité de compostage et sa plate-forme d'entreposage serait équivalent au coût actuel de la seule plate-forme;
- la manutention supplémentaire pour le compostage équivaudrait à la diminution de cette dernière à l'épandage.

On a établi les principaux paramètres technico-économiques du compostage à la ferme par aération forcée au tableau 6. Les coûts seraient alors d'environ 2 \$/m³ de fumier traité par les gros ventilateurs si l'on ne tient pas compte de la récupération énergétique et 1,50 \$ par les petits ventilateurs.

12) D'autres travaux devront être entrepris pour développer tout le potentiel du système d'aération forcée par gros ventilateurs (pression-vacuum) et d'évaluer les impacts économiques pour l'ensemble des fermes laitières.

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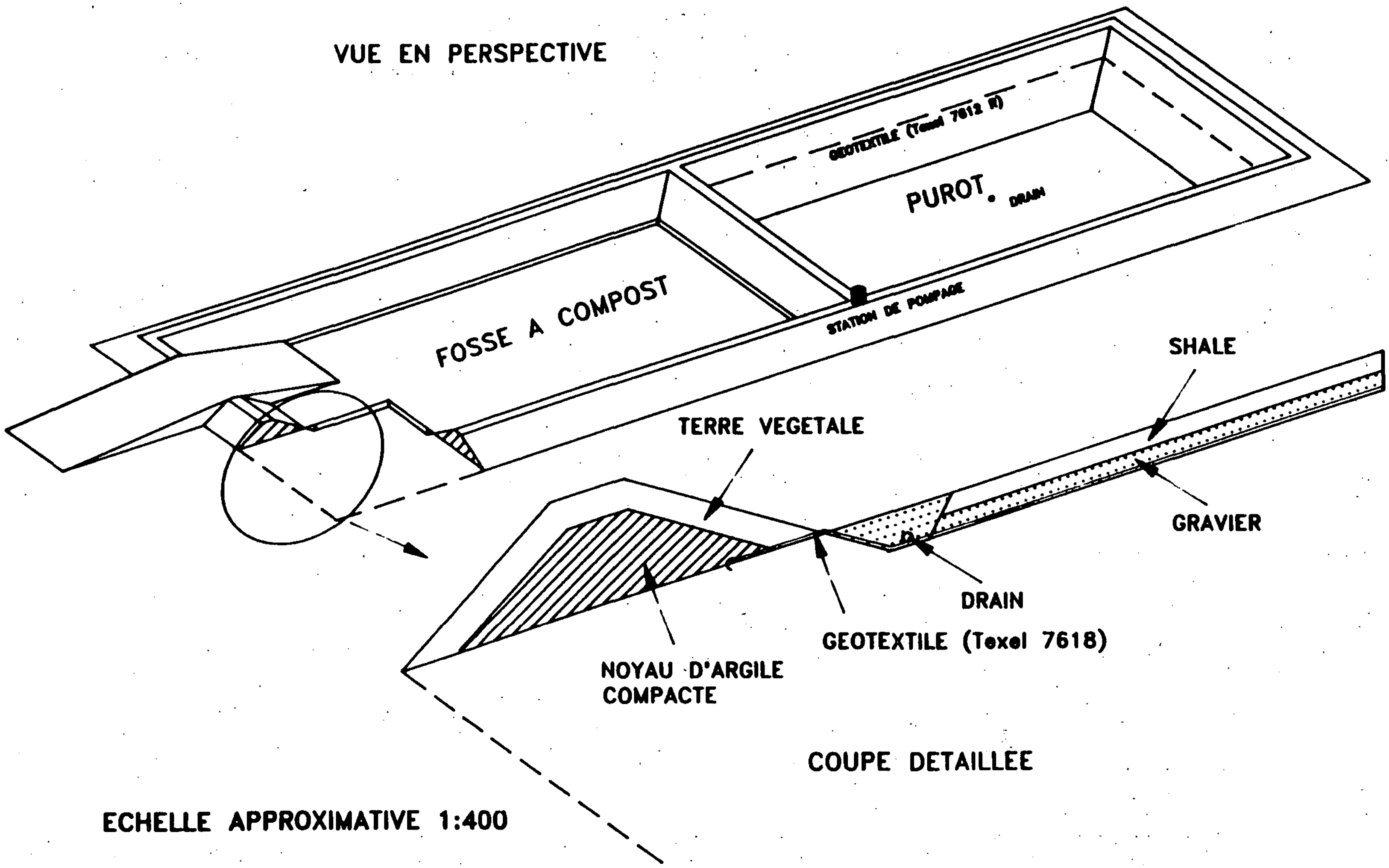


FIGURE–1 COMPLEXE EN TERRE DE L'I.T.A. POUR L'ENTREPOSAGE ET LE COMPOSTAGE DES FUMIERS

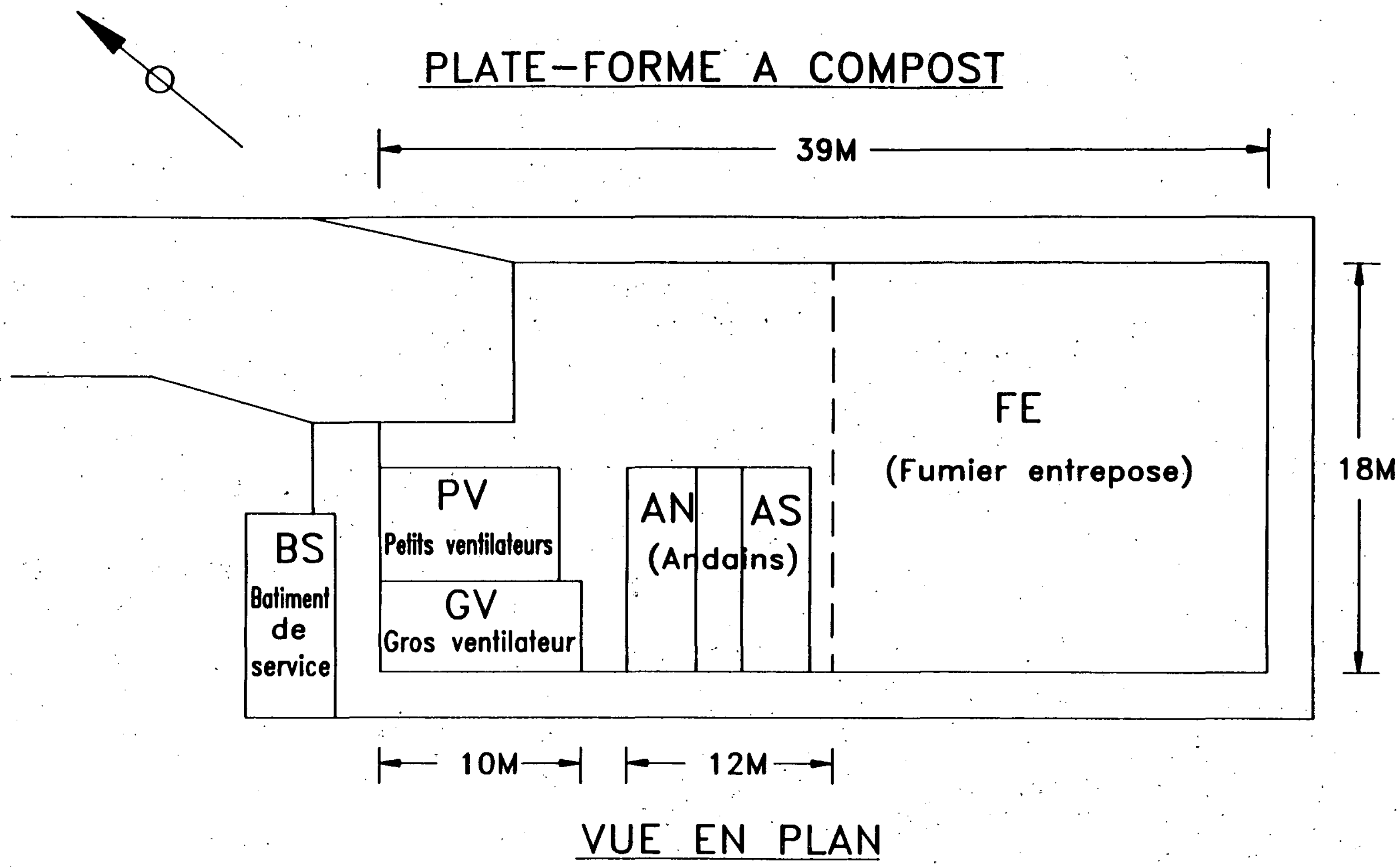
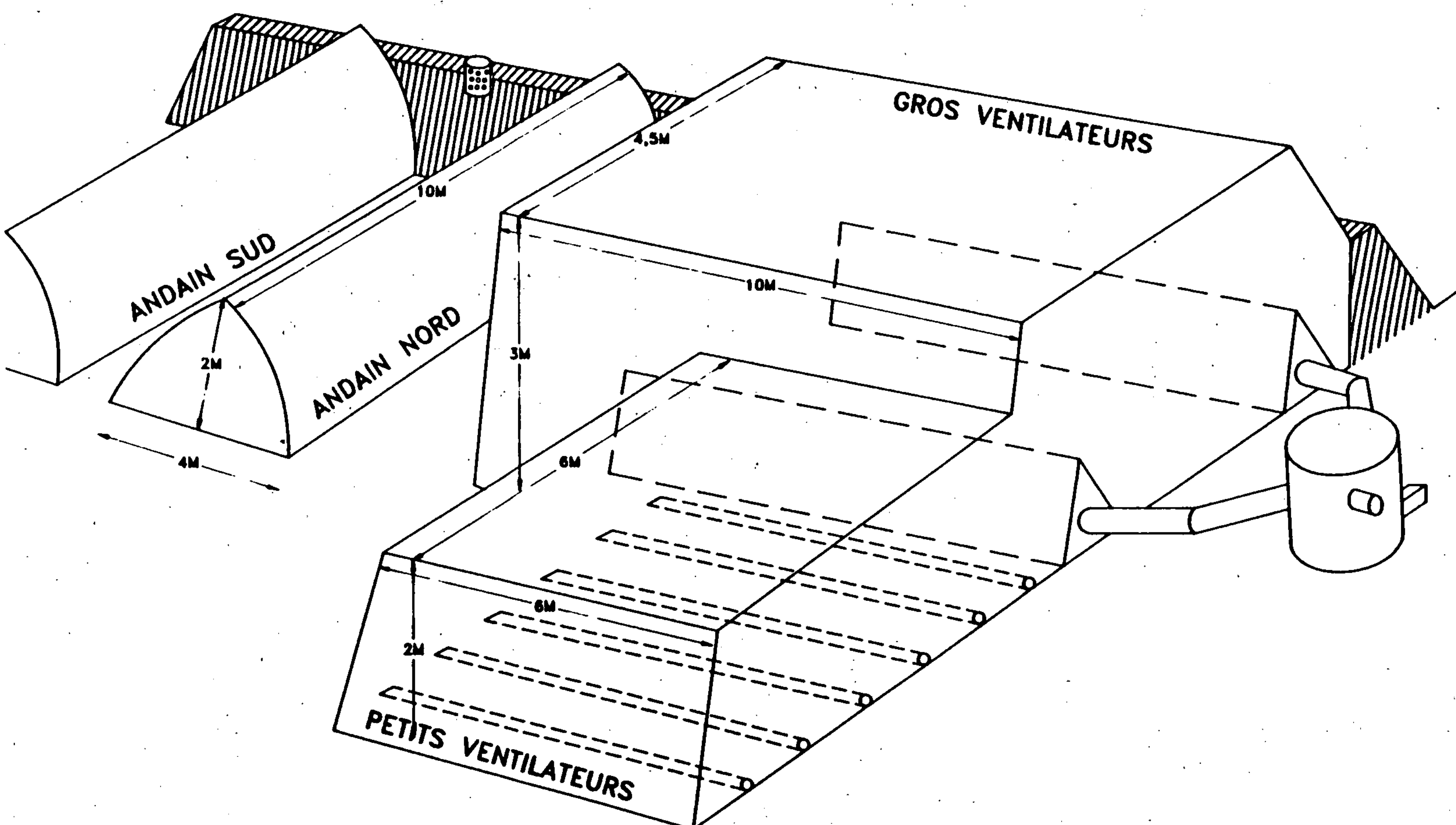


FIGURE-2 LOCALISATION DES ZONES D'EXPERIMENTATION
(ECH.: 1:250)



ECHELLE APPROXIMATIVE 1:100

FIGURE-3 DIMENSIONNEMENT DES TROIS PROCEDES EXPERIMENTES

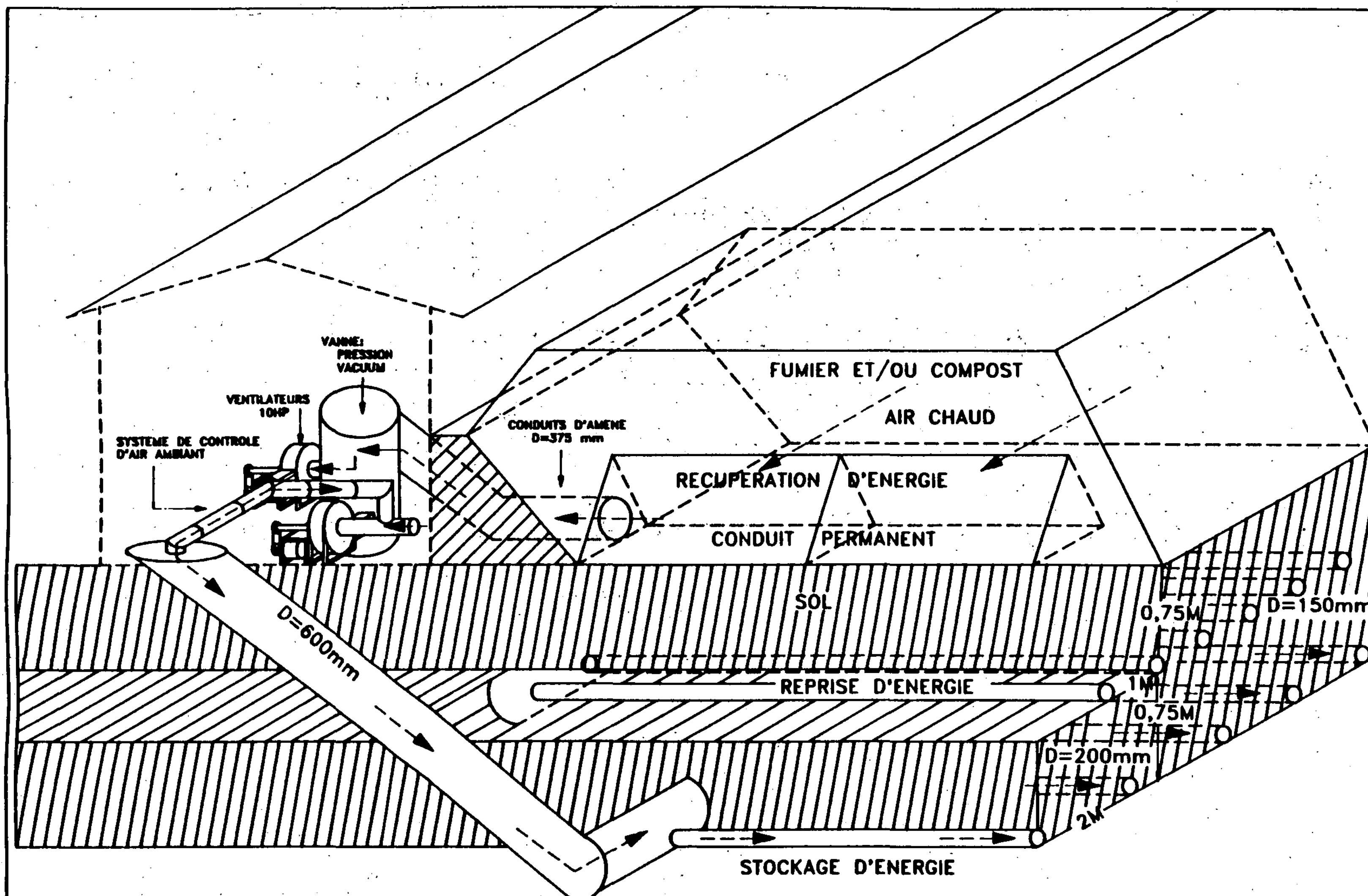


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FIGURE-4 SYSTEMES DE RECUPERATION, REPRISE ET STOCKAGE D'ENERGIE

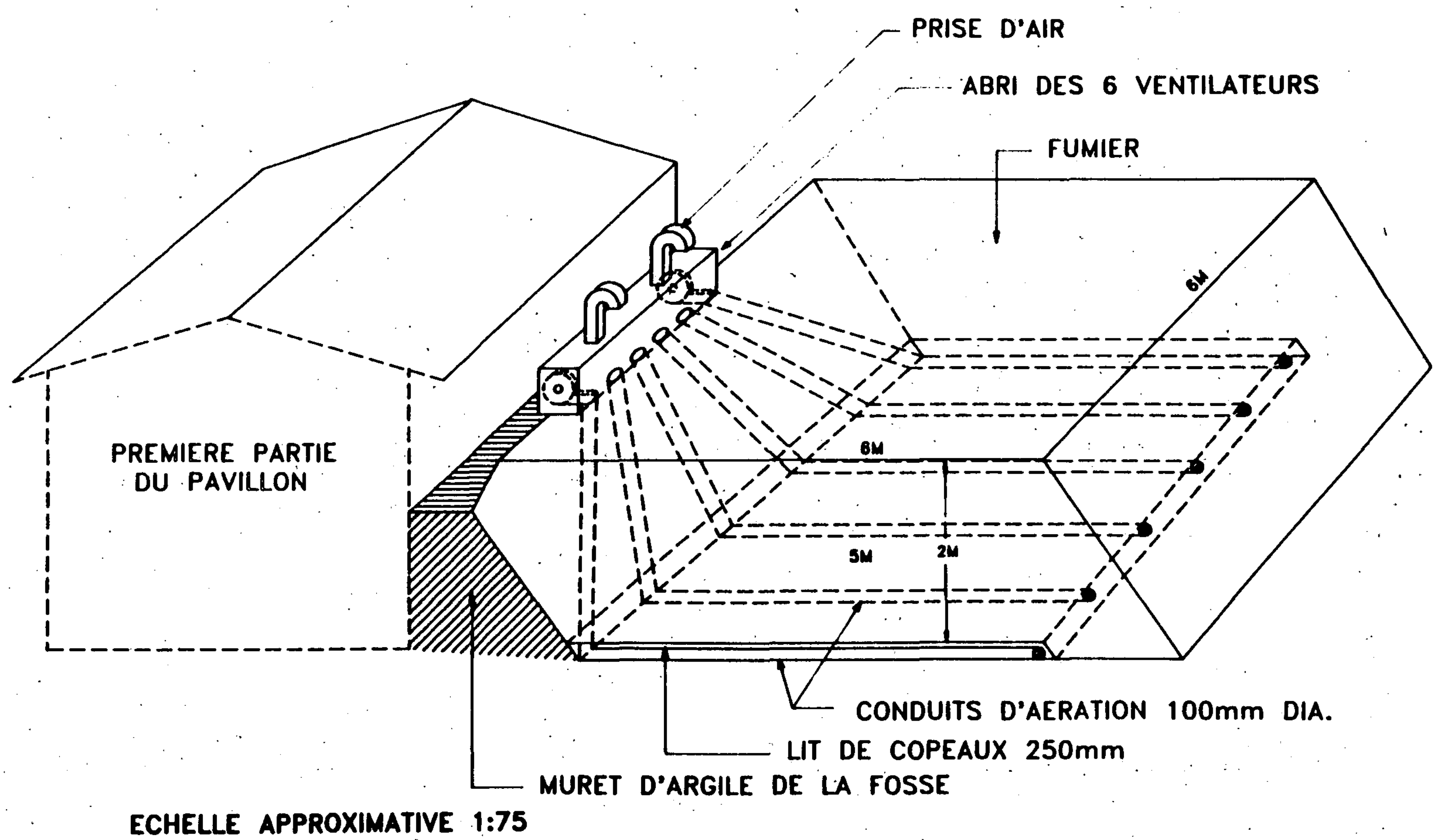
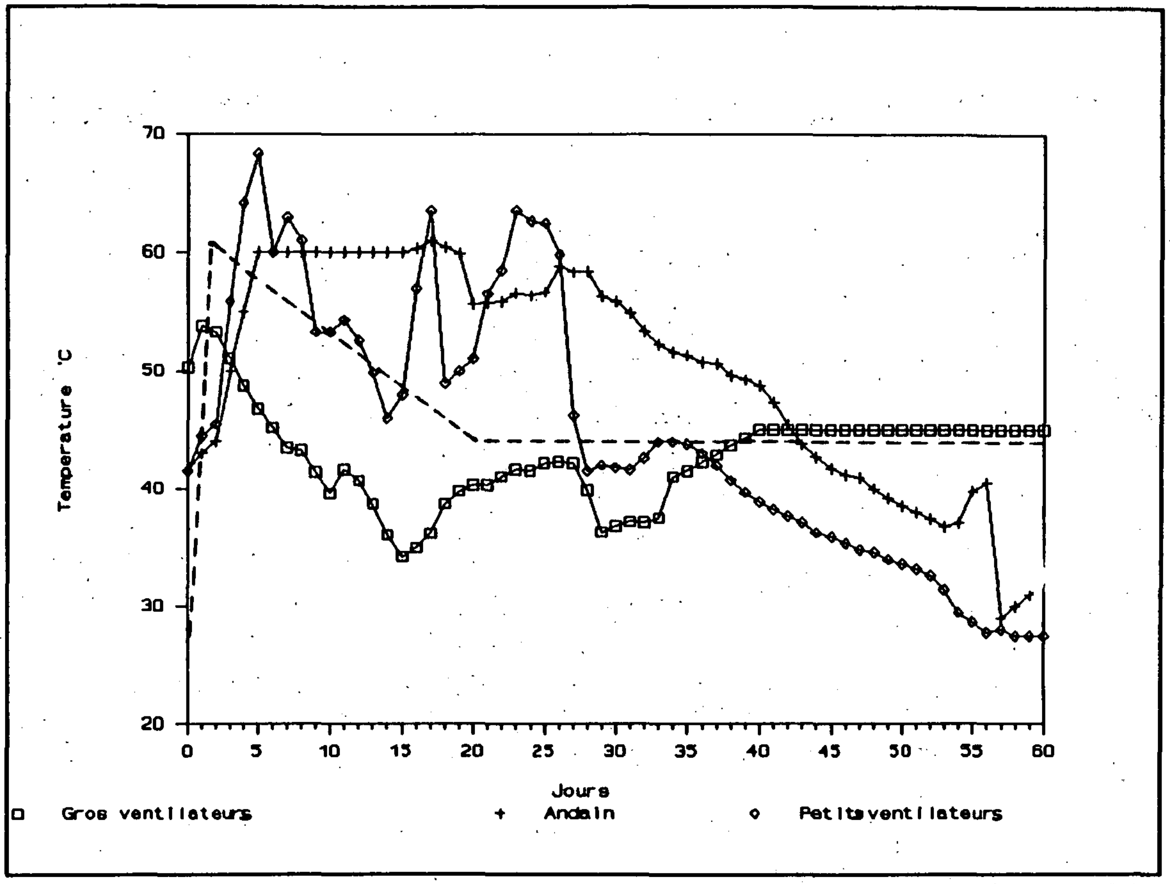
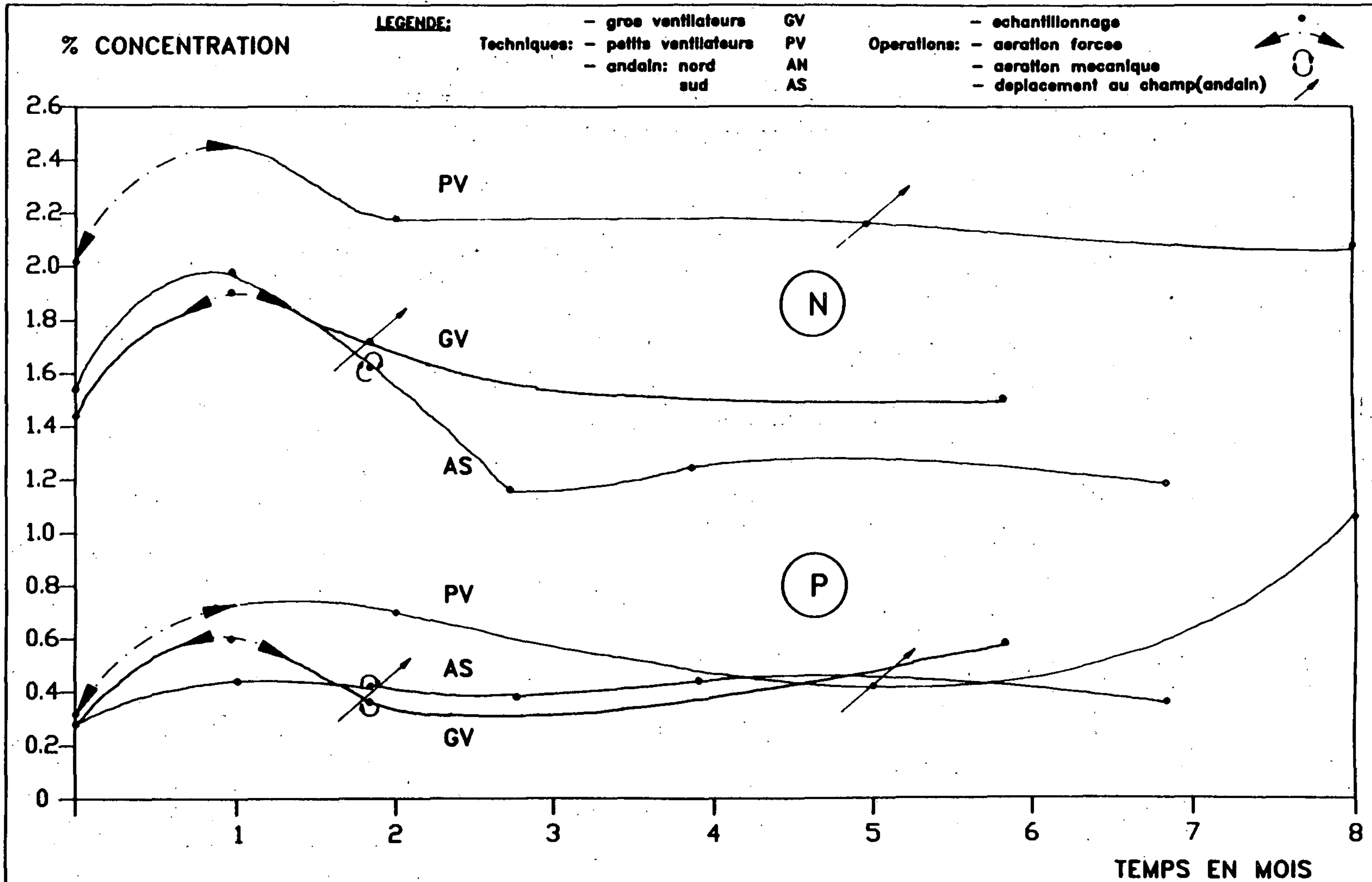


FIGURE-5 SYSTEME DE COMPOSTAGE PAR PETITS VENTILATEURS ET CONDUITS TEMPORAIRES

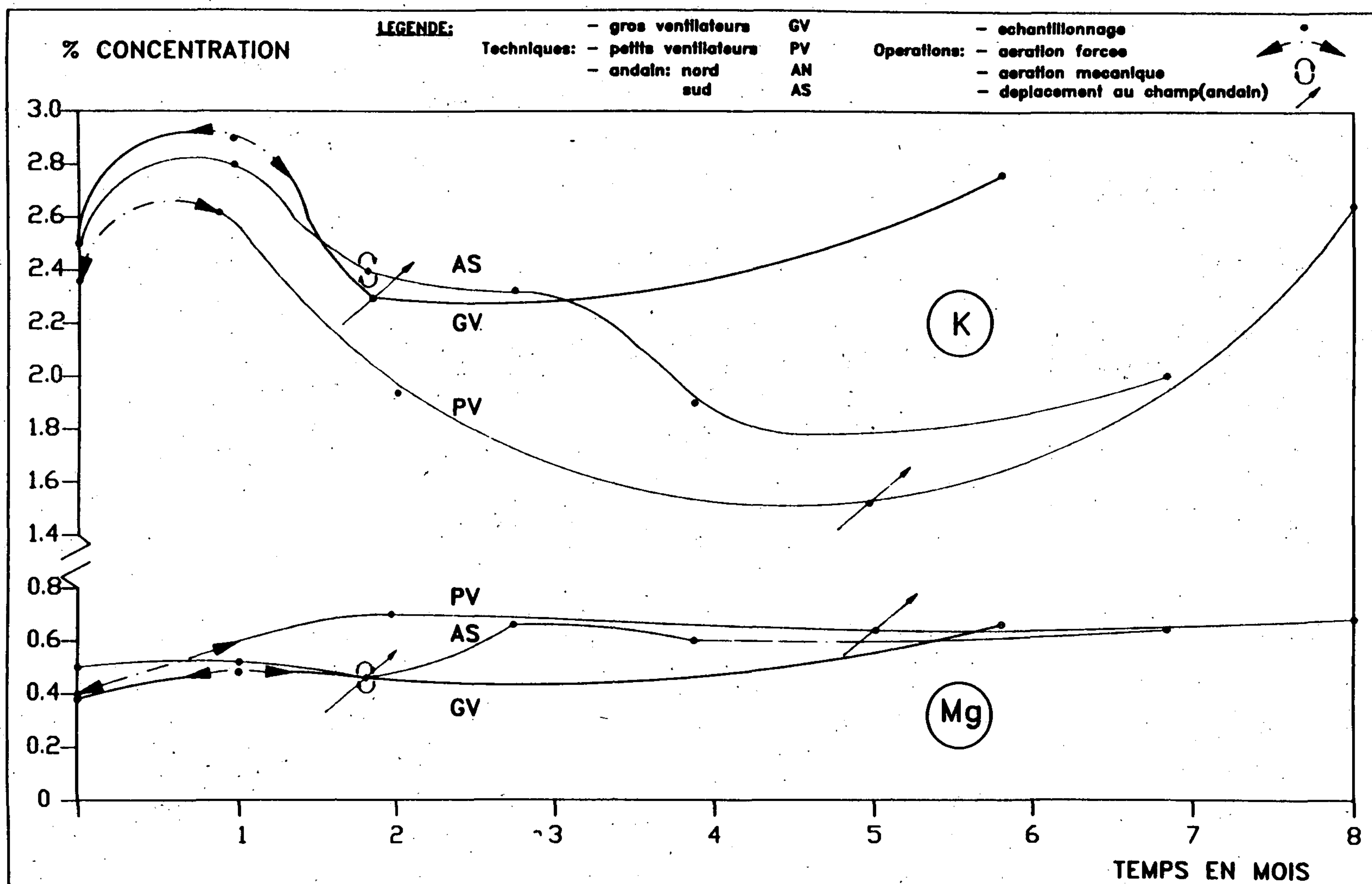


------ Courbe idéalisée

FIGURE 6 - Courbes des températures moyennes de chacune des masses en compostage, pour les trois procédés, superposée à une courbe idéalisée de l'évolution des températures moyennes pour une masse en biodégradation optimale.



Figure–7 Variations des profils de la concentration en azote et en phosphore lors du compostage des fumiers de bovin ayant 4kg/a.j. de litiere



Figure–8 Variations des profils de la concentration en potassium et en magnesium lors du compostage des fumiers de bovin ayant 4kg/a.j. de litiere

TABLEAU 1 - **Valeurs moyennes relatives en pourcentage des principaux paramètres physico-chimiques pour trois phases différentes du processus (fumiers de vache à 4 kg/a.j.).**

ÉLÉMENTS	DÉPART	THERMOPHILE (fin)	MATURATION (5 mois)
COT	44	40	38
MS	28	25	23
N	1.7	2.1	1.6
P	0.30	0.58	0.48
K	2.5	2.6	2.4
pH	8.8	8.9	8.4
C/N	27	22	23

TABLEAU 2 - Pertes et gains des principaux éléments.

APRÈS LA PHASE	ÉLÉMENT	% DES PERTES (GAINS) ABSOLUS		
		GROS VENTILATEURS	PETITS VENTILATEURS	ANDAIN
Thermophile	N P* K	6 (48) 19	14 (58) 23	36 (3) 29
Maturation	N P* K	36 (21) 34	37 (15) 52	52 14 54

*** La dispersion non uniforme du phosphate étable en granule a probablement influencé les valeurs du phosphore.**

TABLEAU 3 - **Performances des trois techniques en termes de capacité de traitement.**

TECHNIQUE	SURFACE OCCUPÉE (m^2)	TEMPS DE SÉJOUR (j) (PHASE THERMO-PHILE)	VOLUME DE FUMIER TRAITÉ (m^3)		RATIO ANNUEL m^3/m^2
			SÉQUENCE	ANNUEL-LEMENT	
Gros ventilateurs	50	18	135	2700	54
Petits ventilateurs	48	30	72	864	18
Andain	100	120	80	240	2.4

TABLEAU 4 - **Quantité nette d'air et d'énergie récupérée et sa valeur pécuniaire.**

SCÉNARIO	VOLUME D'AIR CHAUD RÉCUPÉRÉ (%)	QUANTITÉ NETTE D'ÉNERGIE RÉCUPÉRÉE DU FUMIER (kW.h/m^3)	VALEUR PÉCUNIAIRE (1) (\$/m^3 fumier)
1. Système original ouvert (projet 1989-1990)	33	34,1	1,76
2. Système de base partiellement fermé (donnée préliminaire 1990-1991)	66	68,2	3,52
3. Système hermétique et isolé (non expérimenté)	100	102,3	5,28

(1) Coût moyen de base de l'électricité à 0,516 \$/kW.h

TABLEAU 5 - **Coût d'investissement et volume traité annuellement pour chacune des techniques sur une surface de 50 m² ainsi que le coût d'opération et de production.**

TECHNIQUE	INVESTISSEMENT ($)	VOLUME ANNUEL TRAITÉ (m^3)	(1) COÛT D'OPÉRATION ($/$m^3$ fumier)	(2) COÛT DE PRODUCTION ($/$m^3$ fumier)
Gros ventilateurs	16 300	2700	5,07	Scén. 1 4,04 Scén. 2 3,01 Scén. 3 2,26
Petits ventilateurs	3 350	900	5,62	5,62
Andain	200	120	8,29	8,28
Andain (3)	—	120	10,00	10,00

(1) Coût opération = coûts fixes + coûts variables.
(2) Coût production = coût d'opération - valeur pécuniaire de l'énergie récupérée.
(3) Coût comparatif d'un chercheur américain Robert Rynk (1989).

TABLEAU 6 - **Projection des coûts de compostage à la ferme**

TECHNIQUE	VOLUME (m^3)	COÛT D'OPÉRATION ANNUEL	COÛT D'OPÉRATION PAR m^3 DE FUMIER	COÛT (GAIN) DE PRODUCTION PAR m^3 DE FUMIER
Gros ventilateurs	2 700	5 120 $	1,90 $	Scénario 1 0,87 $ Scénario 2 0,16 $ Scénario 3 1,19 $
Petits ventilateurs	900	1 316 $	1,46 $	1,46 $

SWINE WASTE COMPOSTING IN VERTICAL REACTORS

by

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INTRODUCTION

Many of the existing high density swine farms in British Columbia have a limited land base. The land application of animal manure can therefore contribute to a soil nitrogen content that greatly exceeds crop requirements, resulting in environmental contamination. Implementation of a cost-effective animal waste treatment and utilization system such as composting would reduce the environmental impact and also allow a cash return to the farmers through the sale of a usable, recycled product.

The aerated static pile is a useful system of on-farm composting[1,2]. Given the limited land bases of so many swine operations, a configuration of the aerated pile which maximized the vertical dimension of the pile would be advantageous to farmers. The aim of this study was to evaluate the performance of different heights of vertical reactors or modified static piles in the composting of separated solid swine wastes.

The effectiveness of the composting process is tied to many physical conditions under which a wide variety of microorganisms (actinomycetes, bacteria and fungi) decompose the organic matter. Temperature, oxygen availability, pH level, moisture content, carbon-to-nitrogen ratio, total nitrogen, and particle size and degree of compaction all influence the process. An extension of the height of the composting pile could affect all these factors. One important factor it would affect is compaction.

Finstein and Miller outlined the principles of composting leading to maximization of decomposition rate, odor control and cost effectiveness[3]. They defined an approximate critical height of 2.0 m as the point in the vertical dimension at which the 60°C operational ceiling became established for raw sludge/woodchips composting, noting that the critical height depends on numerous factors specific to the waste such as its moisture content, porosity, compaction, and heat generation characteristics.

One of these factors, moisture content, was also selected for study as an important variable in the composting process. Two different initial moisture contents of compost mix were therefore tested in correlation with the variation in height of the compost piles. Any or all of these factors can also be monitored as parameters of the effectiveness of the process. The criteria used to determine composting effectiveness in this study were the physical parameters of temperature, moisture content, particle size, shrinkage and compaction.

Temperature: Temperature has traditionally been used as a key parameter to evaluate the performance of the composting process. The temperature profile of the composting pile is directly related to the activities of microorganisms. Since composting is an aerobic process, adequate oxygen must be provided if the process is to transpire effectively; an adequate oxygen level in the void space of 5 to 18% is recommended for an aerated static pile system[4]. With too great an increase in the height of the compost pile, the airspaces within the compost could be reduced due to compaction and the process inhibited. Monitoring the temperature profiles of the compost piles is therefore an important means of establishing the efficiency of the experimental process. In monitoring temperature, certain criteria are usually employed if the process is to satisfy the regulatory requirements for composting to be classified as a PFRP (Process to Further Reduce Pathogens), as stipulated by the U.S. Environmental Protection Agency[5]. For rapid composting, the compost pile should reach a high temperature in the thermophilic zone within a week, after which it must be maintained at 55°C or above for a minimum of three days.

Moisture Content: The moisture content or degree of drying is indicative of the decomposition rate and the tendency to stabilize, since the heat generation that accompanies decomposition drives vaporization. The change in moisture content over time is therefore considered useful for monitoring the progress of the composting process[6]. Factors that contribute to moisture loss include evaporation, leachate and aeration in the form of natural or forced air injection.

Particle Size: Decomposition is an essential indicator of the composting process effectiveness. It is associated with the breakdown of larger particles to smaller particles, a process which results in an alteration over time of the particle size distribution within the compost. Small particle size is beneficial for degradation because of the greater surface area available for microbial activities. Nevertheless, when particle size becomes too small, void space is reduced and the rate of gas diffusion slows down, especially during the thermophilic stage of composting when oxygen demand is greatest. Measurement of particle size distribution therefore indicates the degree of biodegradation.

Shrinkage: Volumetric shrinkage results from two factors: the loss of moisture and biodegradable organic matter, and compaction due to the overlying weight (pressure) of compost materials. Moisture content and height of the compost pile are both significant for the rate of shrinkage. A wet porous medium is less readily compressed and therefore less compaction occurs. As composting proceeds, the loss of moisture can contribute to higher compressibility. However, the loss of moisture also results in reduction of overlying weight for a medium of low bulk density, and consequently counteracts the compaction effect to some extent. The degree of compaction is measured in terms of dry density of the porous medium.

MATERIALS AND METHODS

Reactors Design

The configuration of the experimental setup may be treated as a modified static pile. Three uninsulated wood-frame vertical reactors were used in the experiments. To test the effect of the height of the compost pile on the process, Reactor A had dimensions of 0.9 m x 0.9 m x 1.2 m (length x width x height), Reactor B had dimensions of 0.9 m x 0.9 m x 1.8 m, and reactor C had dimensions of 0.9 m x 0.9 cm x 2.5 m. The reactors were equipped with perforated plastic pipes which served as air ducts supplying oxygen to the compost pile. A fine screen mesh was installed about 0.25 m above the bottom to segregate the compost pile and the aeration pipes. It also enabled leachate to be collected underneath the compost. Based on a previous study by the authors on aeration rates in laboratory-scale swine waste composting[7], the reactors were set up to receive continuous aeration at a flow rate of 0.1 L/min kg volatile matter.

Compost Mixes

The separated fibrous solid swine waste was mixed thoroughly with sawdust as the bulking agent. Two sets of compost mix with different moisture contents were tested. In Set I, the compost mix was formed from five parts of swine manure and one part of sawdust (5:1 manure-to-sawdust ratio on weight basis, initial moisture content = 69%, C:N=38.6). In Set II, the manure-to-sawdust ratio was raised to 5:2 (initial moisture content= 59%, C:N=48.4). On a volumetric basis, the mixing ratios for Sets I and II were then 1:3.5 and 1:2, respectively. The loadings for the three reactors were (320 kg, 540 kg, 780 kg) in Set I runs, and (240 kg, 410 kg, 550 kg) in Set II runs. Each set of experiments lasted for nine weeks.

Process Monitoring

Solid state temperature sensors were inserted in the compost material. Reactors A, B and C had 3, 5 and 7 sensors, respectively, uniformly spaced in the vertical direction. For the experiments of Set I, temperature data were recorded every six hours on a data-logger (Model Soltec AD5312). For Set II experiments, the data-logger was replaced by a microcomputer data acquisition system (PC/AT computer with Advantech data acquisition /multiplexer boards). This allowed data to be recorded on an hourly basis and stored on disk. Physical characteristics of the compost were measured at regular intervals during the nine-week composting period. The compost was sampled at the temperature sensor locations using a core sampler. Bulk density was first determined from the weight and the volume of the sample material, after which the measurements for moisture content and particle size distribution were taken. Moisture content was determined from samples that had been oven-dried for 24 h at 105°C. Particle size distribution was determined by sieving for 6 particle size ranges as follows: Range a:<0.295 mm, b:0.295-0.589 mm, c:0.589-1.000 mm, d:1.000-2.000 mm, e:2.000-4.750 mm, and f:> 4.750 mm. The dry density of the material was calculated on the basis of bulk density and moisture content. The volumetric shrinkage of the compost pile was deduced from measurements of displacement of the surface.

RESULTS AND DISCUSSION

Temperature Profiles

Set I

The temperature profiles of the upper, middle and lower levels of the three reactors are shown in Fig. 1.

(i) **Reactor A:** All three levels of tower reactor A show temperature profiles typical for high-rate composting (Fig. 1a). Uniform temperature distribution can be observed in this reactor. The entire compost pile managed to achieve a temperature in excess of 75°C within 5 days without adverse effects on process efficiency. In addition, a steady cooling rate of 0.6°C/d over the composting period for all three temperature profiles indicates proper stabilization.

(ii) **Reactor B:** This reactor exhibited temperature stratification among the three levels. The upper level of tower reactor B reached a temperature of 73°C within a few days. A stabilizing trend with a gradual decrease in temperature over time can also be readily seen from Fig. 1b. However, the temperature profiles of the middle and lower levels were different from the upper level; they remained around 50 to 60°C for a prolonged period of time, slowly approaching stabilization towards the end of the composting period.

(iii) **Reactor C:** Temperature stratification is even more evident in Reactor C, the tallest tower (Fig. 1c). While its upper level attained a temperature of 70°C after 10 days, the temperature profiles reveal that the majority of the compost pile remained in the mesophilic regime (temperature below 45°C) throughout the composting period due to inadequate oxygen uptake by the microorganisms.

Set II

The temperature profiles for the three tower composters in the Set II tests are depicted in Fig.2.

(i) **Reactor A:** Fig. 2a reveals that tower reactor A had multiple peaks in all its temperature profiles, though the maximum attained temperature of 70°C was lower than those observed in the Set I experiments.

(ii) **Reactor B:** In this Set, Reactor B had more distinct temperature climbing and declining stages than the reactor of the same height in Set I. Stabilization was generally attained after nine weeks of composting, as seen in Fig. 2b.

(iii) **Reactor C:** This reactor also contrasted with its counterpart in Set I, in that the entire compost mass achieved thermophilic conditions. The highest temperature in the pile occurred in the lower level of the reactor (Fig. 2c). The temperature profile of the upper level resembled its Set I testing counterpart.

These results are attributed to the lower moisture content of the compost mass in this set. It allowed the forced aeration to be more effective in the lower part of the reactor where the compost was most subject to compaction effects. These observations seem to imply that the upper part of the pile can compost successfully in response to a measure of natural aeration even when the lower levels of the tower do not receive sufficient oxygen. It is interesting to note that the middle level showed a gradual increase in temperature over time with no indication of stabilization. In fact, after day 50 its temperature even surpassed that of the other two levels. This temperature regime may be explained by sustained microbial activities due to a moisture content that was maintained above 45%.

The difference between our observations and others[8-11] suggests that the optimum temperature for composting is not only material (waste and bulking agent) specific. It also depends on oxygen availability as affected by physical characteristics such as the initial moisture content and the degree of compaction. A comparison between the two runs shows that except in the shortest of the reactors (Reactor A), a 5:2 mix was superior to a 5:1 compost mix, particularly at the lower level of the reactor where the effects of compaction were greatest.

Moisture Content

Set I

The variation of moisture content over time at various levels for reactors A, B and C in the Set I experimental runs is shown in Fig. 3.

(i) **Reactor A:** Fig. 3a reveals that the upper levels of Reactor A had a much lower moisture content than the lower levels at the end of the experimental period. In 63 days, the moisture content of the upper level was reduced to 30% compared to 50% for the lower level. (Due to data handling problems, the moisture content data for the middle level of this reactor is missing.)

(ii) **Reactor B:** In Reactor B, the upper level also had the largest decrease in moisture content over time. This was largely due to evaporation. The lower level was somewhat drier than the middle level, although their respective temperature profiles exhibited the opposite trend. It is evident that forced aeration caused moisture migration from the lower level to the middle level. In both the upper and the lower levels, the moisture content was successfully reduced to below 50% after 63 days of composting as the temperature gradually dropped.

(iii) **Reactor C:** Reactor C maintained the trend towards greater loss of moisture from the upper level, with evaporation again providing the dominant driving force. In this reactor, however, there was only negligible change in the moisture content from the onset of the experiments in the lower and middle levels. The final moisture content remained at around 70% for these two levels. No significant difference was found between the moisture content of the middle level and that of the lower level. The unfavorable temperatures achieved at both levels (Fig. 1c) probably accounts for this phenomenon.

Set II

The corresponding moisture content profiles for the same reactors in the Set II experiments are illustrated in Fig. 4. Here all three levels registered a significant decrease in moisture content from the initial value of 60%. The final moisture contents were 21%, 46% and 31% for the upper, middle and lower levels, respectively, compared to 38%, 70%, and 69% in Set I. For the lower levels of Reactor C in the Set II runs (Fig. 4c), the moisture content reduction was therefore much better than in Set I. As the temperature of the lower level is much higher in Set II (Fig. 2c), the larger reduction in moisture content relative to the Set I test results is not unexpected.

A combination of the overall moisture content profiles with the temperature profiles suggests that shortest tower (Reactor A) was the most efficient in decomposition, followed by tower Reactor B. Both reactors met the PFRP requirements. Reactor C, which had a high moisture content throughout the composting process, made the least effective configuration. It should be noted that the compost pile height of Reactor C was 2.3 m, which exceeds the critical height of 2.0 m.

There was, however, an improvement when a 5:2 mix was used for composting. All three towers in the Set II runs obtained larger moisture content reductions than were achieved in the Set I experiments. The 5:2 manure-to-sawdust mix (at a lower initial moisture content of 60%) was found to be more conducive to aeration, which in turn made for more effective composting. In this way, the results reconfirm the recommended starting moisture content of 50 to 70% for composting of agricultural wastes[9]. The results also highlight the importance of adjusting the aeration rate during the composting process in reference to the moisture status of the compost pile.

Particle Size Distribution

The particle size profiles of both Sets I and II experiments (Figures 5 and 6) reveal a trend for the percentage of the smaller particle size ranges 'a, b, and c' to increase over time, while the percentage of size ranges 'd, e, and f' decrease over time. This indicates the breakdown of larger particles to smaller particles (i.e. decomposition) in all three towers.

Set I

In the Set I experiments, the smaller particle size ranges comprised a maximum of 15% in the compost pile in the thermophilic stage of composting. Upon isolating the combined 'a and b' size ranges for comparison purposes, towers A, B, and C had 66%, 56%, and 27% distribution respectively. Reactors A and B therefore had similar particle size distributions after nine weeks of composting. This distribution of particle sizes is further evidence of more effective composting in Reactors A and B than in Reactor C.

Set II

In the Set II runs, the rate of decomposition was slower than in the Set I. Only the smallest size range 'a' showed a larger increase in percent distribution (7% - 12%) during the thermophilic stage. Ranges 'b' and 'c' had a negligible change in their distribution. This could be explained by the initial high sawdust content in the Set II runs. Sawdust is a fibrous wood material that is not as readily decomposed as swine manure.

The particle size distribution profiles again point to more effective composting in Reactors A and B than in Reactor C. Reactor C did, however, improve its capacity to decompose the material in the Set II runs with a lower moisture content compost mix.

Shrinkage and Compaction

Figures 7 and 8 illustrate the total shrinkage of Reactors A, B,and C in Set I and Set II runs, respectively.

Set I

Figure 7 shows clearly that Reactor A had the largest shrinkage (27%) after 40 days of composting. This is partly due to the relatively high moisture loss. In addition, the increased particle breakdown (previously illustrated in Fig. 5) resulted in a more efficient arrangement of particles. The latter phenomenon is supported by dry density results from this reactor; it had the greatest increase from an initial average value of 125 kg/m^3 to 170 kg/m^3. In contrast, the shrinkage in Reactor C was only 10% in the Set I tests.

Set II

In the Set II experiments, the volumetric shrinkage of 33% for Reactor A also surpassed the other two reactors. In contrast, the volume of compost in Reactor C was reduced by only 14% in this set, although this was an improvement over the Set I results. The small shrinkage in Reactor C in both sets is likely due to a combination of a small moisture loss, the lower compaction associated with fibrous materials with a high moisture content, and to insufficient decomposition.

Among the three tower reactors, compaction was greatest in the tallest reactor, although this was not as pronounced as had been anticipated. Its dry density of 165 kg/m^3 was the highest among the three towers; moreover, the lower level was 21% denser than the middle level, compared to a 15% difference between the two levels for Reactor B and a 6% difference for reactor A.

While least compaction is anticipated for the shortest tower (reactor A), the increase in its dry density with time demonstrates the relatively more significant influence of biodegradation (particle breakdowns), rather than compaction, on shrinkage.

ENGINEERING SIGNIFICANCE

The results indicate that the effectiveness of the composting process is affected by the initial moisture content and the height of the composting pile. A compost pile up to 1.6 m gave a good result. However, for any given lateral dimensions of a compost reactor, a larger quantity of waste could be composted in a deeper pile. The results do suggest that a tower reactor with a pile height of 2.3 m could be operated effectively given a proper initial moisture content and an effective aeration strategy. It is therefore recommended that engineering designs for on-farm composting facilities be based on an optimum combination of initial moisture content, aeration rate and waste:bulking agent mixing ratio. Moreover, as the composting process proceeds, adjustment to maintain process performance can be made via feedback control based on *in situ* monitoring of temperature, moisture content and oxygen availability. Frequent assessment of particle size distribution during the stage where the temperature is ascending is also recommended.

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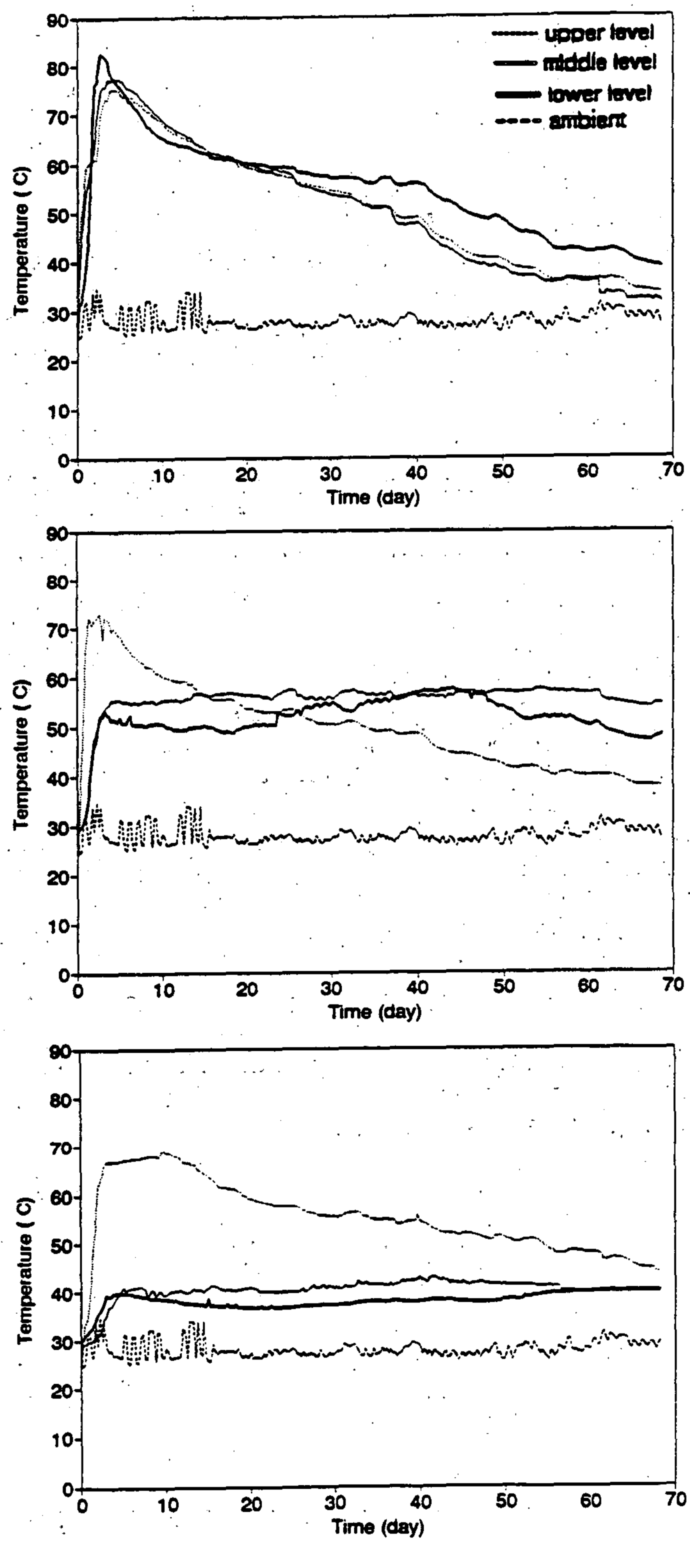


Fig. 1. Temperature Profiles - Set I Experiments
(manure-to-sawdust ratio = 5:1)

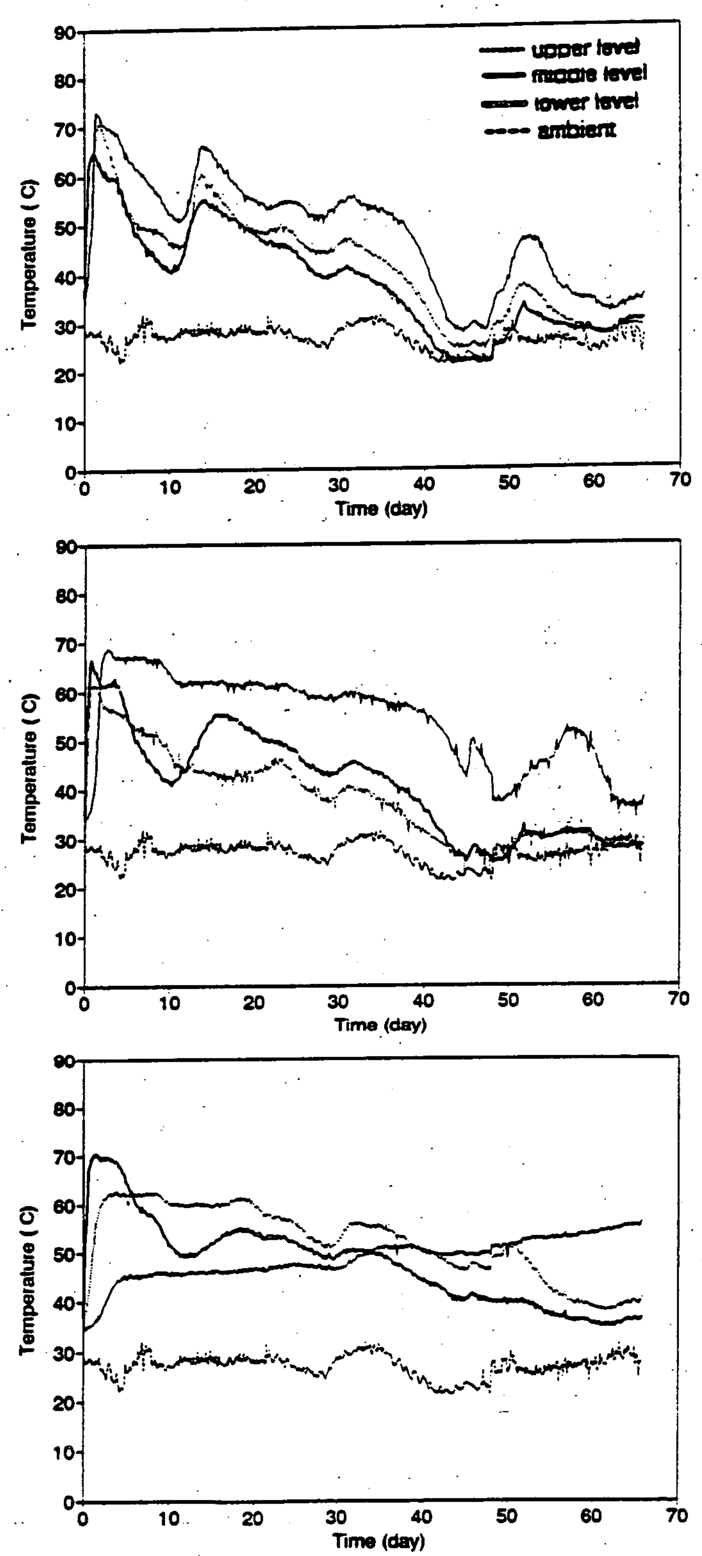


Fig. 2. Temperature Profiles - Set II Experiments
(manure-to-sawdust ratio = 5:2)

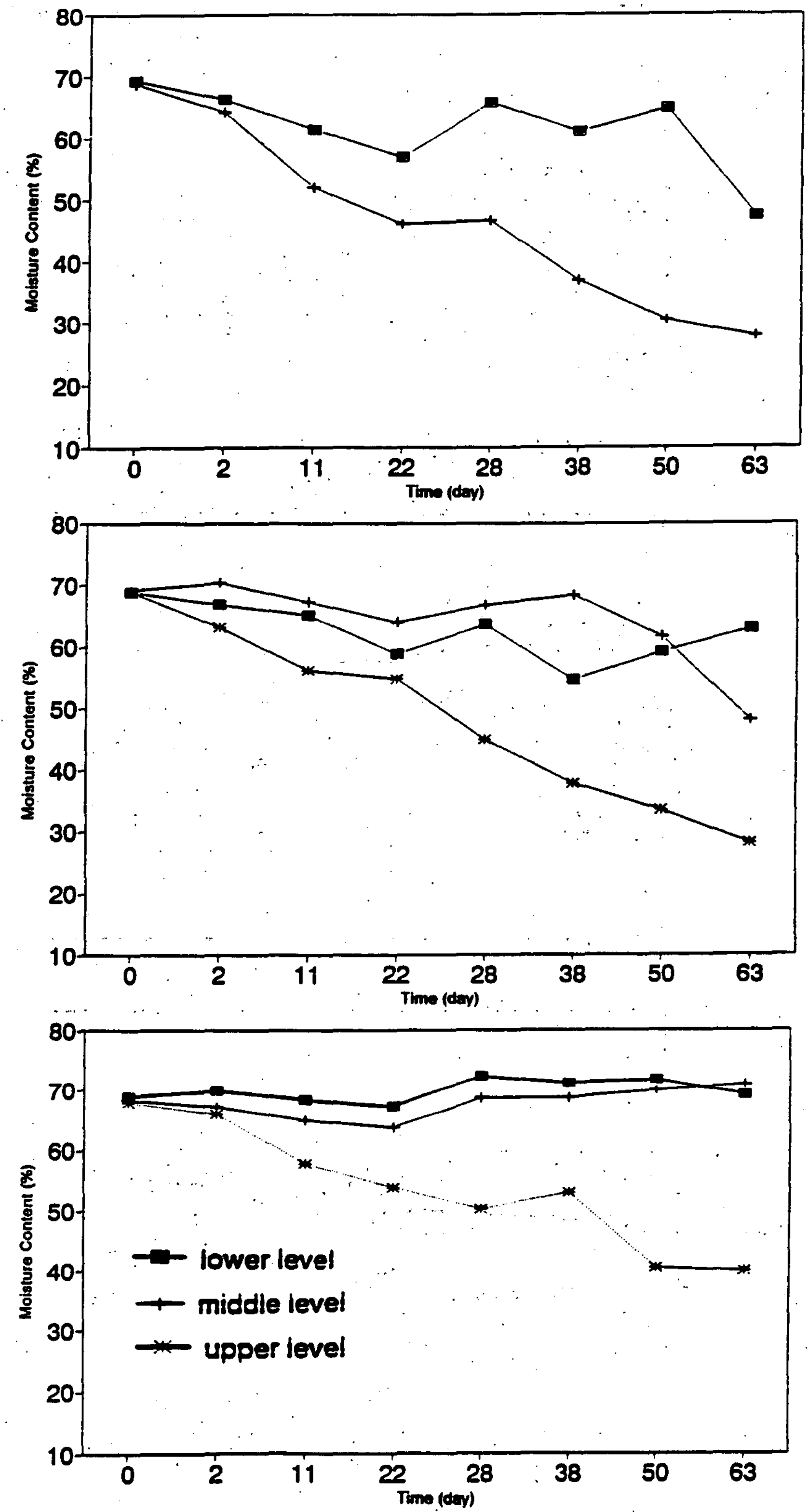


Fig. 3. Moisture Content - Set I Experiments

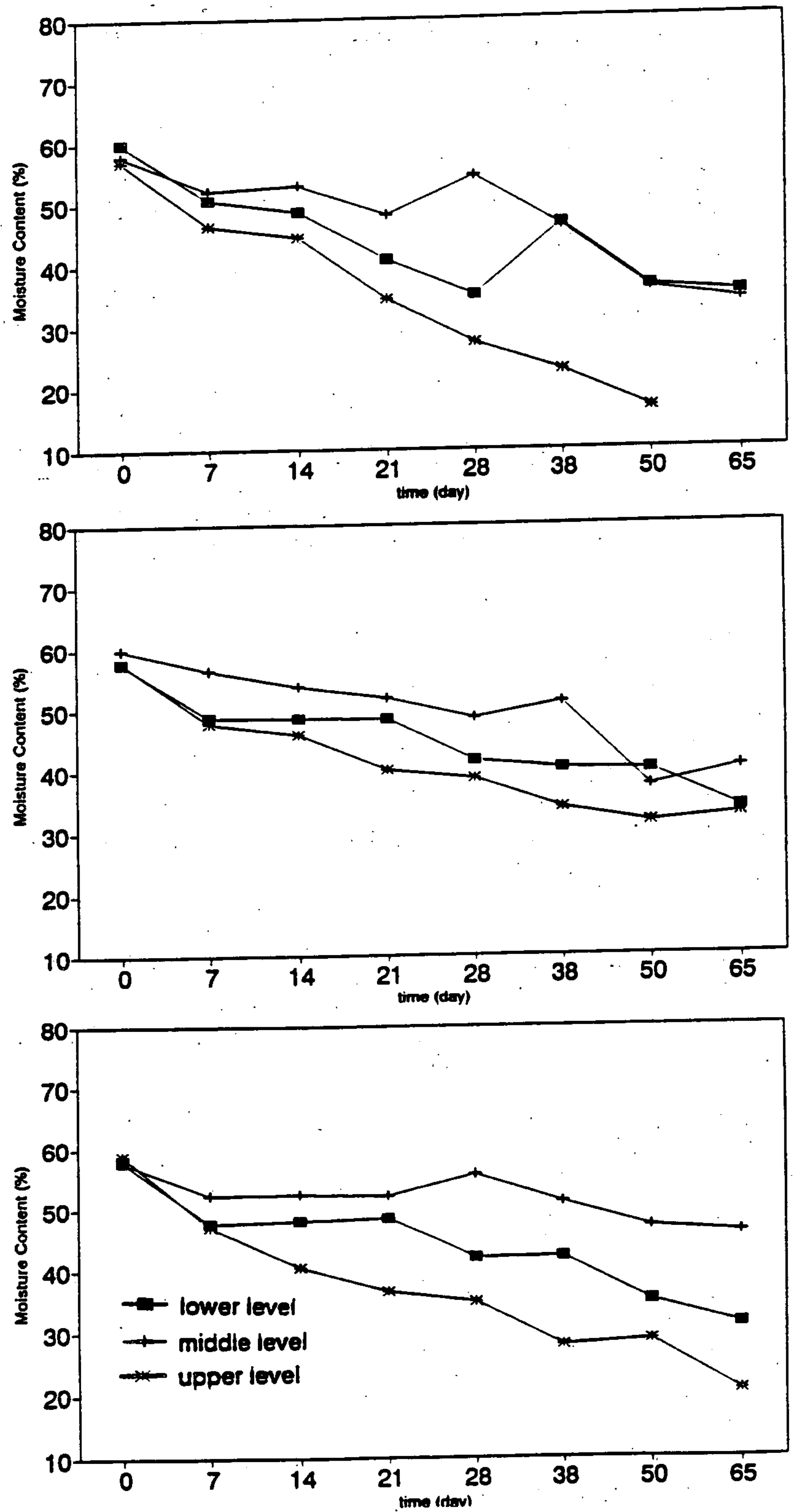


Fig. 4. Moisture Conten: - Set II Experiments

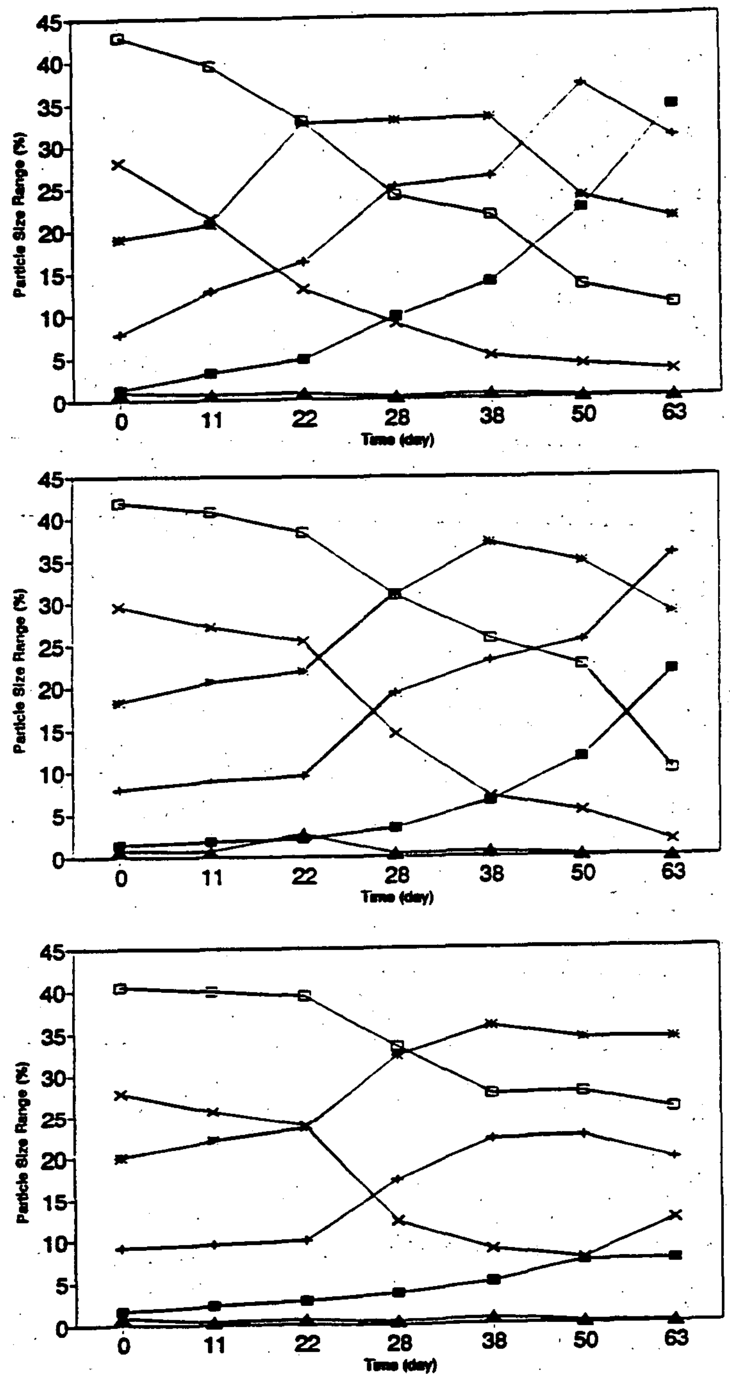


Fig. 5. Particle Size Distribution - Set I Experiments

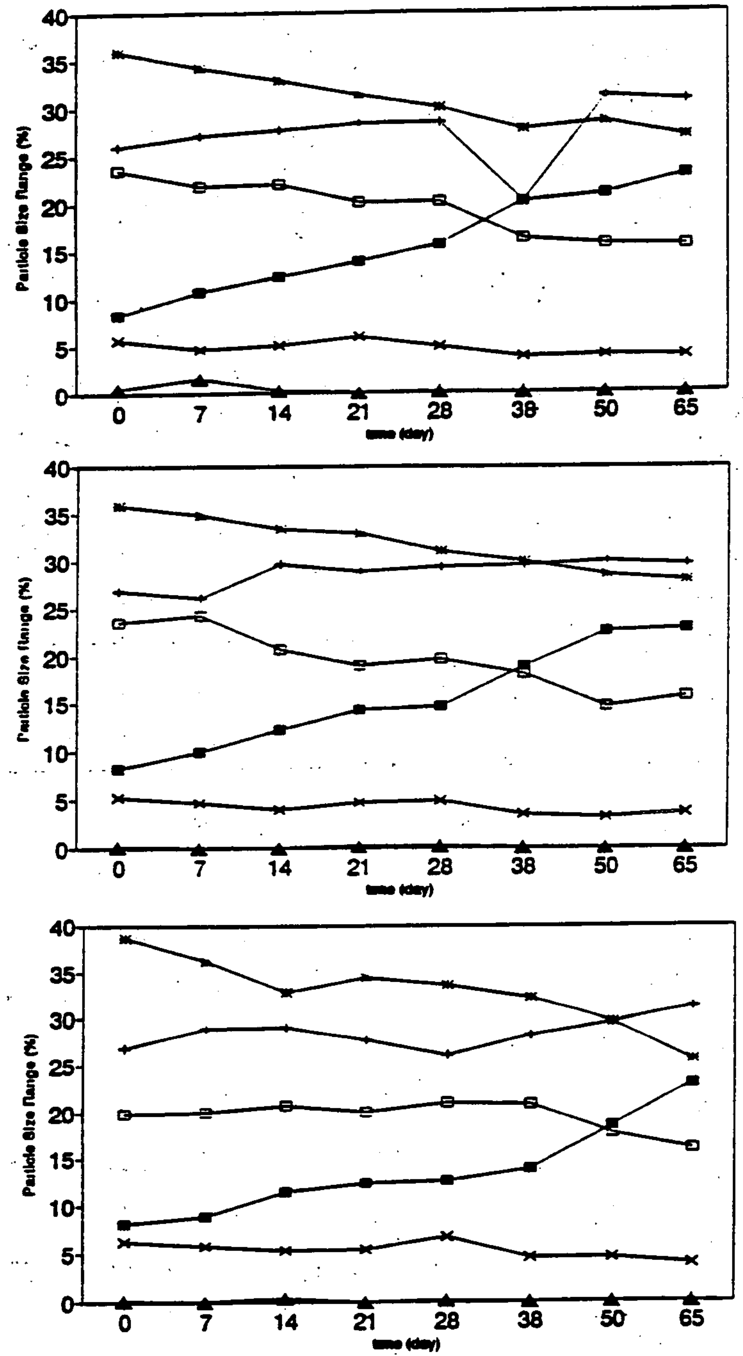
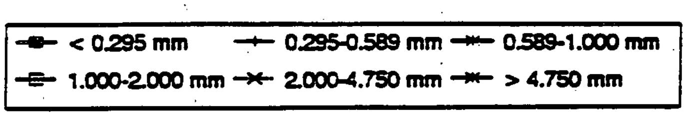


Fig. 6. Particle Size Distribution - Set II Experiments



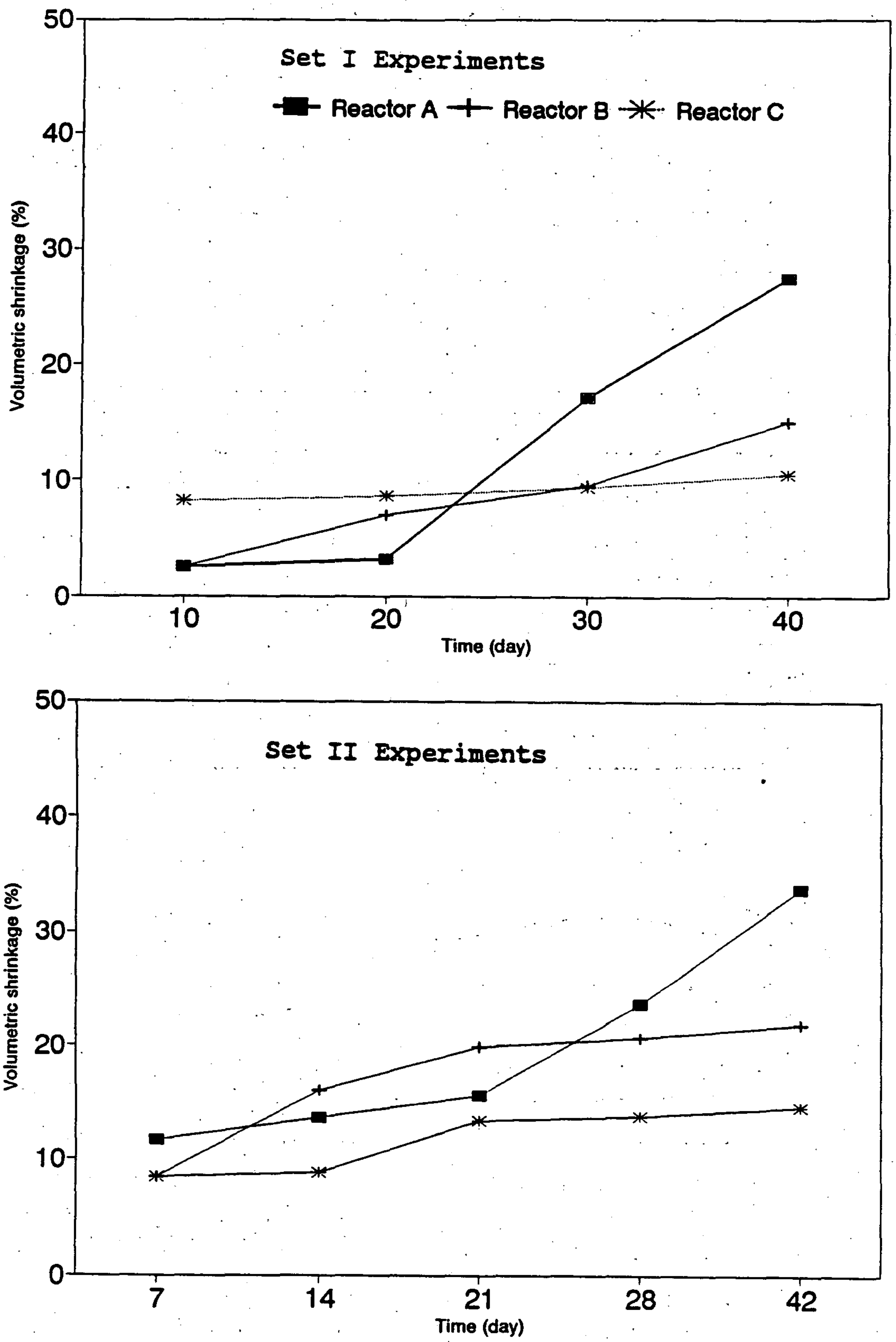


Fig. 7. Volumetric Shrinkage

ON-FARM COMPOSTING IN MASSACHUSETTS - POLICY, REGULATORY ISSUES, AND SUMMARY OF ACTIVITIES

BY Maarten van de Kamp, PhD, Compost Program, Massachusetts Department of Food and Agriculture, Boston, MA, USA

Composting has its historical origins in agriculture and is well suited to farming operations. Composting and related practices that manage organic matter for return to agricultural soils are logical and practical means of utilizing organic residuals in agriculture. Compost product values are realized in their roles of supplying organic matter and nutrients in farm soils. Various agricultural enterprises have been practicing composting in Massachusetts for several decades. It has been the purpose of the Massachusetts Department of Food and Agriculture(DFA) to guide and encourage the legitimate agricultural nature of farm-based composting during a period of tremendous enthusiasm for composting by solid waste management planners.

The pioneering on-farm compost operations in Massachusetts had been receiving source-separated leaves, manures, food processing residues, and limited amounts of other diverse materials for many years before state agencies developed policies and regulations to address these facilities. Farmers practicing composting have usually been the primary end-users of their compost products and therefore have been selective about receiving materials from off-farm sources. These composters have perceived their operations to be farming activities utilizing organic residues as resources to yield a farm product for use in soil management practices or for off-farm markets. Composting farm operators do not wish to be characterized as waste managers nor do they wish to be inhibited by cumbersome solid waste regulatory procedures.

The Massachusetts DFA has taken the position that on-farm composting is a valid management practice for handling a wide variety of organic residues generated by farm activities as well as uncontaminated or "clean", source-separated degradable materials from off-farm generators. The very nature of composting brings together materials of diverse origins to establish a mixture of input ingredients that optimizes the composting recipe and also greatly influences the qualities of composts produced. For these reasons, the DFA and various private farming groups have strongly advocated for recognition of composting and compost use as legitimate agricultural practices that should be largely exempted from permitting or site assignment by solid waste management authorities, even where appropriate materials are derived from sources other than the farm itself.

The Massachusetts DFA has been providing encouragement and technical support to on-farm composters since 1985. In 1987 the

DFA was authorized by legislation to work cooperatively with the Department of Environmental Protection(DEP) to establish an agricultural composting program as a modest component of a comprehensive solid waste management act. DFA and DEP have undertaken joint responsibility for on-farm composting and oversight since 1988. This effort has resulted in a regulatory framework that provides for adequate environmental protection without unduly inhibiting farming activities.

On-farm composting operations are conditionally exempted from regulatory control in the following circumstances: (1) handling only agriculturally generated materials, when located at an agricultural unit; and (2) handling selected source-separated compostable materials from off-farm sources, provided that such operations are registered with and comply with policies of the DFA. DFA has established a registration process supported with technical assistance and site inspections for these farm-based composting operations. This process has assured DEP regulatory staff that agricultural composters are being overseen and are providing responsible management for on-farm composting operations.

The DEP regulations specify materials that may be exempted from requirements for solid waste site assignment procedures and also allow for a review of regulatory issues for the inevitable unforeseen exceptions to the rules. Many individual materials that are not specified in the language of the regulation may be entirely suitable for on-farm composting but must be evaluated one at a time for a determination of need for permitting or for a beneficial use designation. By these means a wide variety of uncontaminated or "clean" organic materials are now being composted at on-farm facilities. Sludges from municipal wastewater treatment facilities and mixed waste materials are already regulated by the DEP and are not handled at farm-based composting operations thus precluding the need for specific regulations to compost such materials at farms.

The agricultural composting program of the Massachusetts DFA is the first in the United States to focus on the unique position of farm-based composting to play a modest yet significant role in solid waste management strategies. On-farm composting must be workable from the perspectives of both agricultural interests and environmental regulatory groups. Toward these ends it has been essential that agricultural interests have been active participants in the development of policies and regulatory procedures that affect farm-based operations. Farmers do not want their farms designated as or perceived to be solid waste facilities, and solid waste regulatory authorities would rather not be involved in regulatory procedures that overlap or interfere with agricultural production activities. Environmental planners in other states as well as in Canada are advised to include agricultural perspectives in discussions concerning the establishment and regulation of farm- based composting operations.

The well established on-farm composting operations with many years of experience have served as valuable demonstration facilities for other farmers considering composting and for officials of state agencies involved in articulating policies or developing guidelines and regulations for composting operations. During the past five years more than two dozen additional farms have integrated composting activities into their operations. These farmers are motivated to undertake composting for a variety of reasons. These include:

1) Composting is a management practice of choice for manures and/or other organic matter generated within the farm.

2) Compost products may be needed for on-farm soil and fertility management. On-farm composting may reduce input costs while permitting control of compost qualities.

3) Composting may generate revenues from fees for receiving organic residuals from off-farm sources and from the sale of compost products. These revenues may offset handling costs or actually increase profitability of the farm.

The following summary tabulates the extent of composting activity for those farms that have registered with DFA and/or DEP.

<u>SUMMARY OF ON-FARM COMPOSTING ACTIVITY REGISTERED WITH DFA/DEP</u>

NUMBER OF FARMS WITH REGISTERED COMPOSTING OPERATIONS	32
Receiving 90%+ materials from off-farm sources	23
Accepting materials from landscapers	11
Receiving leaves and/or other materials from towns	12
Handling food processing/other specialized material	7
Receiving fees for off-farm materials	10
Using some or all of product on the farm	27
Selling compost or soil mixes	10
SCALE OF OPERATION	
250-1000 cubic yds/yr	16
1000-5000 " " "	13
15,000+ " " "	1
30,000+ " " "	2

Approximately two dozen other farms are receiving some quantities of materials although they have not yet registered with DFA. It is estimated that these operations may account for another 15,000+ cubic yds/yr.

QUANTITIES OF MATERIALS COMPOSTED

Total volumes annually (as cubic yards)	150,000
Total weight annually (as tons)	70,000
SPECIFIC MATERIALS BY TYPE (cubic yards)	
Leaves and other landscape materials	40,000
Horse manure with bedding	25,000
Poultry manure	10,000
Dairy manures	5,000
Fruit/vegetative processing residue	25,000
Newspaper and other paper	10,000
Other miscellaneous materials	10,000

SITING AND TECHNOLOGIES

Most farm-based composting operations are located directly on the soil surface with attention to drainage conditions, distances from surface waters, wetlands and wells, as well as neighbors. Area needs for materials handling, vehicular access and buffering from adjacent land uses are also considered carefully. Several facilities utilize constructed pads and/or bunker structures for receiving and mixing materials. Agricultural composters generally employ windrow methods managed with existing farm equipment. The larger operators use turning machines and screening equipment. Site development and equipment are updated where needed as many operations have expanded their capacity during the past two years.

END-USES AND MARKETS

Most Massachusetts agricultural composters use their own compost products in farming operations. On-farm uses of compost include field application for regeneration of depleted soils and as a soil amendment for cropping of vegetables, nursery stock, corn and forage, as well as tree production. Nursery growers routinely employ compost products in blended potting mixes. Off-farm markets range from small-scale home gardeners to landscapers and garden centers purchasing bulk quantities. Custom spreading of compost topdressings for golf courses, athletic fields, and wetlands restoration projects accounts for some bulk sales. One producer is mixing compost with wood chips to formulate a customized product for use in a biofilter system for odor control at a sludge handling facility. At this time compost products are not regulated in the marketplace and each producer sells by reputation rather than by specific claims for nutrient and/or performance criteria. As compost production and marketing continue to expand it is anticipated that compost products may be subject to quality guidelines and labeling criteria established for marketing of farm products through the DFA.

CONCLUSIONS

The Agricultural Composting Program of the Massachusetts DFA has effectively worked with solid waste management staff of the DEP to establish exemptions from solid waste facility designations for on-farm composting operations handling a wide variety of materials from off-farm sources. This cooperation has demonstrated the importance of agricultural interests being involved in the development of policies and regulations for composting facilities.

As our society faces increasingly complex and costly decisions for disposal options or alternatives to disposal for diverse organic materials, agricultural operations have great potential to serve these needs. Simultaneously, agricultural composters may produce soil amendments that may reduce needs for soluble fertilizers and pesticide applications. This unique opportunity for agriculture should be encouraged from the perspectives of both solid waste planners and the interests of soil and water resource protection for agriculture.

REFERENCES FOR FURTHER INFORMATION CONCERNING AGRICULTURAL COMPOSTING ISSUES.

Agricultural Composting Association, P.O. Box 608, Belchertown, MA, 01060, USA. A recently organized professional association to work with agricultural compost producers, users, and related interests.

ON-FARM COMPOSTING HANDBOOK, Northeast Regional Agricultural Engineering Service(NRAES), July 1992, 152 Riley Robb Hall, Cooperative Extension, Cornell University, Ithaca, NY, 14853-5701, USA. A comprehensive technical guide to a broad range of composting issues for farm-based operations. This publication aims to serve composters, agricultural professionals, educators, regulators, local officials, and generators of organic materials concerning planning and operations at composting facilities.

DFA COMPOSTING PROGRAM, Bureau of Education and Outreach, Draper Hall, University of Massachusetts, Amherst, MA, 01003, USA. ATT'N: Maarten van de Kamp.

COMPOSTING AT THIRTEEN FEDERAL INSTITUTIONS

ENVIRONMENTAL LEADERSHIP BY CORRECTIONAL SERVICE OF CANADA IN THE KINGSTON AREA

by

Philip S. Kerrigan, B.Sc. (Eng.)
WCI Waste Conversion Inc.
Ottawa, Ontario

INTRODUCTION

I am pleased to have the opportunity to talk to you today about a very interesting composting trial that has been running in Kingston, Ontario for a little more than a year now.

Correctional Service of Canada, the federal department responsible for our prisons, has ten separate facilities in the Kingston area, giving this lovely community the unenviable distinction of the highest per capita inmate population in our country.

However, it has also provided a tremendous opportunity for CSC, which, to their credit, they have seized with the support WCI Waste Conversion Inc., to type trial a composting program that promises to divert a full 50% of the waste going to landfill - that's composting alone!

In conjunction with the Department of National Defence, which also has a sizeable commitment in Kingston by way of three facilities, the two government departments effectively represent, from a population, waste generation and infrastructure point of view, a small community in the order of 15,000 to 20,000 people.

And with ...

- tipping fees in the area in excess of $150/tonne
- landfill problems with no solutions in sight
- prison operating budgets under pressure
- federal green plan objectives stressing diversion and environmental responsibility
- and a natural "market" for the final compost product on their farming institutions to improve soils ...

Both opportunity and incentive were present along with the potential for financial reward.

At this time a successful type trial has been completed, and recommendations have been developed by WCI for a permanent composting facility and infrastructure.

In 20 minutes, I can't possibly cover much detail, but I will attempt to provide an overview of what we consider to be a fine WORKING example of environmental leadership.

PROGRAM OBJECTIVES

- Achieve Federal Green Plan Goal of 50% reduction in landfilled waste by 2000
- Save waste disposal costs
- Save fertilizer costs and improve soils
- Reduce detrimental environmental impact of applying manures and sewage sludges to land
- Develop potential opportunity for training and employing inmates/parolees

PROGRAM PHASES

I	Waste characterization
II	Plans for prototype collection and composting
III	Prototype operations
IV	Development of recommendations for permanent composting operation
V	CSC business planning - resourcing, budgeting, etc
VI	Facility design and implementation

OVERVIEW OF CSC FACILITIES AND WASTE MANAGEMENT SITUATION

- facilities
  - 10 institutions
  - includes 2 minimum security farming operations
  - more than 3,200 inmates
  - wide variety of organic feedstocks

- reference attached pie chart for waste distribution
  - food waste 40 %
  - paper waste 33 %
  - wood waste 8 %

  total organic content of landfilled waste is 81%

- organic waste streams (readily collectible)

animal manures	3900 tonnes/year
food waste*	525 "
sawdust	230 "
agriwaste	124 "
yard waste	26 "
TOTAL	4805 tonnes/year

* represents 23% of annual landfill (2300 tonnes)

OVERVIEW OF DND FACILITIES

- facilities
  - 3 institutions
  - in excess of 10,000 people on sites

- organic waste streams (readily collectible)

food waste	386 tonnes/year
yard waste	7 "
TOTAL	393 tonnes/year

PROTOTYPE WASTE COLLECTION LOGISTICS

The CHALLENGE was food waste source separation and collection. WCI designed processes for a comprehensive prototype collection infrastructure including:

- source separation of food waste at ...
  - food preparation
  - tray return areas
  - cell blocks

- food waste collection using primary units only
  - 5 gallon plastic pails
  - 45 gallon plastic drum
  - currently type trialing other unit types

- food waste transportation
  - 1/2 ton pick-up truck

- food waste collection issues
  - separating non-compostables
  - use of garburators
  - security & collection logistics
  - vehicle inadequacies
  - waste pail cleaning

PROTOTYPE COMPOSTING OPERATIONS

WCI developed operating procedures for the composting site addressing the following:

- technology
    - PAWS (passively aerated windrow system)
    - turned windrow with front-end loader
    - passive box system
- management requirements and resources
    - site supervisor
    - 2-3 inmates
- operations and equipment
    - comprehensive operations plan
    - jersey barrier mixing pit for food waste and manure
    - farm tractor with front bucket
    - manure spreader for downsizing/mixing
    - PAWS windrow building
- operator monitoring - daily recording
    - windrow temperatures, waste volumes, precipitation, ambient temperature, odours, etc
- technical monitoring - every 2nd week by WCI
    - WCI developed protocol - windrow temperatures, oxygen levels, pH, electrovalent potential, ammonia, and hydrogen sulphide

PROTOTYPE RESULTS AND CONCLUSIONS

- Food waste source separation and collection logistics are complex, yet fundamental to program success:
    - required the most development time
    - involved the most people and coordination
    - presented the most logistical challenges - eg. functionality of primary and secondary collection units, intermediate storage logistics, wet/dry vehicle requirements, vehicle systems to interface with waste collection units, winter operations, washing of collection units, etc
    - human factors - staff & inmate co-operation
    - prison security implications
    - process redesign - eg. garburators, space limitations, etc
    - innovative process designs for source separation processes, collection containers, collection vehicles, etc

- Food waste composts optimally with 20% manure and bedding:
  - manure and straw bedding improve structure, moisture, CN ratio

- Composting of food waste requires enclosed environment to control key composting parameters and nuisance factors:
  - climatic conditions too severe to allow effective outdoor composting during the Canadian winter (temperature, winds, rain, snow, sun)
  - vermin, primarily birds, were an active nuisance
  - general lack of control over key process parameters inevitably would lead to problems such as odours, leachate, quality problems
  - not suitable for highly putrescible wastes like food

- PAWS technology proved effective, but land intensive and in the format utilized, unsuitable for large scale operations
  - particularly good for composting N rich wastes where high ammonia loss and leaching might result from active turning
  - thorough pre-mixing of wastes is important

- Turned windrow technology produced good results and is more suitable for larger scale operations:
  - available farm equipment allowed for better use of land, a shorter period to compost maturity, and produce a more homogeneous result than PAWS

FUTURE PLANS

WCI has presented CSC with recommendations for a comprehensive full scale composting operation. Details of a source separation & collection infrastructure, and plans for composting waste at two sites have been provided. A high rate aerobic channel composting facility is the feature of these plans.

SOURCE SEPARATION AND COLLECTION RECOMMENDATIONS

- Increase capture rate of food waste through:
  - establishing "empowered" team in each institution
  - eliminating poor handling practices (eg. garburators)
  - improving process design (eg. tray return areas)
  - conducting awareness/education programs

- Include other organic waste materials in composting operations:
  - yard waste
  - paper waste

sawdust
sewage sludge
slaughter house waste

- Implement detailed plans for food waste collection logistics:
  primary collection units
  secondary collection units
  washing of collection units
  waste transportation logistics inside institutions
  waste storage depots
  security requirements
  collection vehicle interface systems

- Procure specialized waste collection vehicle:
  wet/dry
  two bins
  flexible dumping systems to interface with variety of primary and secondary waste collection units

- Include DND food waste in collection and composting operations.

COMPOSTING RECOMMENDATIONS

- PAWS technology should be utilized in a relatively small application for composting poultry manure to minimize N loss in this highly nutrient rich waste stream

- Turned windrow with specialized equipment should be employed for composting cattle manure, yard waste, paper waste, and sawdust on pads with leachate collection.
  least capital cost technology

- An enclosed high rate aerobic channel should be utilized for the highly putrescible wastes such as food and slaughter house wastes. Other waste streams (yard, paper, wood, etc) should be added to ensure appropriate C/N ratio, moisture content, structure, etc.
  ensure control over key composting parameters
  protection from vermin
  minimizes site size
  best technology for expanding into handling other municipal/ICI sector wastes

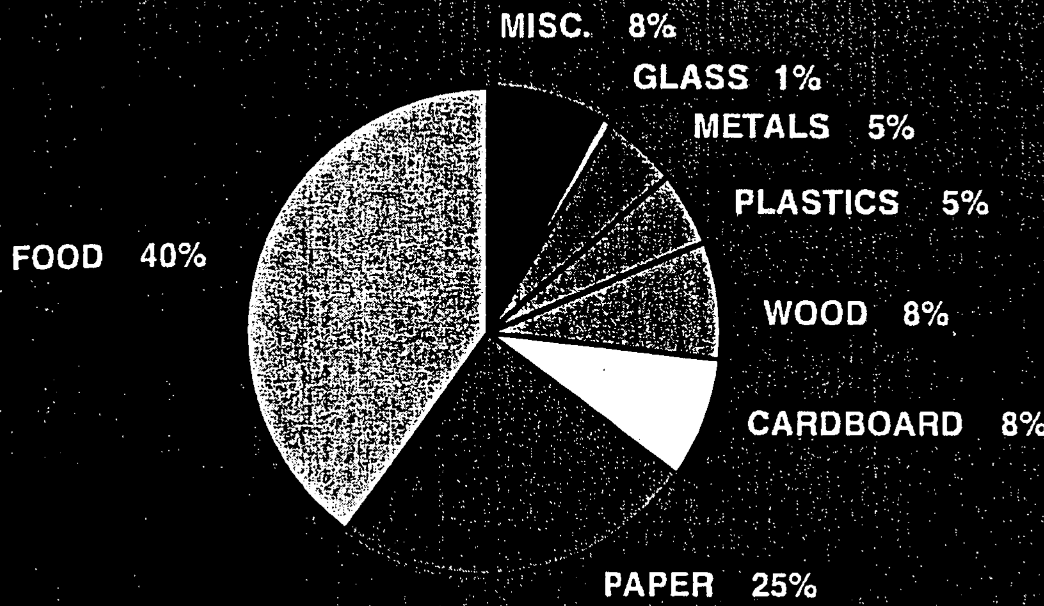
The implementation of these plans will result in the diversion of 50% of current landfilled CSC wastes.

CLOSING COMMENTS

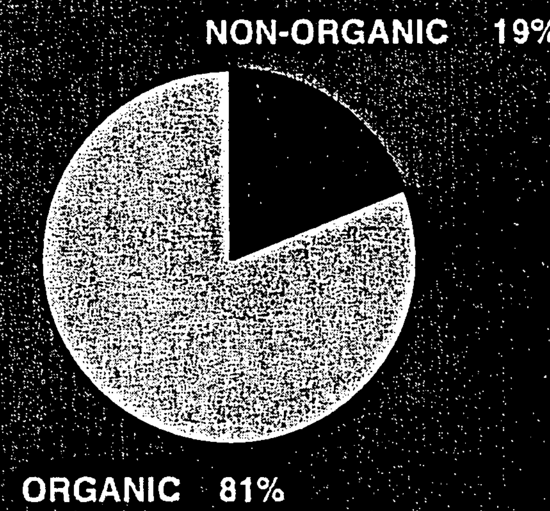
I am pleased to be able to report that based on these recommendations, CSC has made a decision to proceed with the implementation of a full scale composting facility in Kingston, and in fact hope to be able to strike agreements with the local municipalities to provide a composting solution for their bio-waste - an exciting possibility indeed !

In closing, I believe this CSC initiative has demonstrated how composting, when integrated into a system that encompasses the full spectrum of waste activities from point of waste generation to product end-use, can contribute significantly to achieving truly sustainable solutions to our waste management problems.

TYPICAL CSC INSTITUTION WASTE STREAM COMPOSITION BY WEIGHT



WASTE COMPONENTS



ORGANIC vs. NON-ORGANIC

WCI

DEGRADABLE BAGS FOR THE COLLECTION OF MATERIAL FOR COMPOSTING

Dr. G. M. Chapman
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181 Cooper Avenue
Tonawanda, NY 14150
USA

Presented to the 2nd Annual Meeting of The Composting Council of Canada. "From Waste to Resource - Composting in a Sustainable Society".

A. Introduction

As composting is growing as an important component of the economic and environmentally - responsible handling of solid waste, there is increasing attention on technical standards for all aspects of the operation. Although there are only about 20 Municipal solid waste composting facilities operating in the USA, there are over 1400 yard waste composting facilities and collection of the waste is an important issue.

There are three principal ways of collecting yard waste:

- simple vacuuming from swept piles
- emptying of bins
- bags

Vacuuming from swept piles presents difficulties, particularly with domestic yard waste. Bins can be filled simply and sometimes emptied easily; problems arise from cost and odours necessitating frequent cleaning of the bins which causes it's own environmental nuisance. Bags offer the best general solution both for yard waste and compostable domestic refuse and are an economic solution to the collection problem.

B. Bag Selection

The choices of bag type are illustrated in Figure 1.

Type	Advantages	Disadvantages
Paper	Good degradability	Poor wet strength Cost
Coated Paper		Non-degradable coating Cost
Plastic	Low Cost	Have to be emptied-not practical
Degradable Plastic	Relatively low cost	-------

Figure 1. Advantages of Degradable Plastic Compost Bags

Paper bags, whilst they can be readily degradable have two major problems. Wet strength is obviously one. Without going into all the arguments for plastic bags compared with paper bags it is worth summarizing the main points.

- production of plastic bags require 20-40% less total energy than production of paper bags.

- for equivalent strength you need about 10% of the weight of paper bags, resulting in much lower transport costs as well as materials usage.

- the environmental impact, particularly air and waste water emissions are much less for plastic compared with paper bags.

One effect of this is to make the cost of paper bags very much higher than the cost of the equivalent strength and capacity of a polyethylene bag.

To overcome the problem of wet strength a barrier layer can be inserted. However, this needs to be compostable and adds to the cost. Furthermore, the inherent environmental disadvantages of paper are not overcome.

Normal non-degradable plastic bags are the cheapest, but there is an additional cost from emptying the bags. Another problem is that the efficiency of separation of the bags from their contents is not perfect and contamination by undegraded plastic always occurs.

Degradable plastic bags are the most cost-effective solution. They can easily be colour-coded to simplify source separation; they can either be sold through retailers or by municipalities. Different size bags can be provided to meet specific needs and are hygienic. However, it is necessary for them to meet certain criteria concerning degradation rate and possible contamination.

C. Composting with Degradable Plastic Bags

In order for degradable plastic bags to be suitable for collection of compostable materials they need to degrade at least sufficiently so that, by the time the compost is ready for sale, no plastic pieces should be visible. Composting times and conditions vary, but the shredded bags should at least be broken down under average composting conditions.

In the past, because insufficient research had been carried out, performance of "degradable" plastic bags was variable. Now, much more is known and predictability of performance can be achieved. It is also important that no toxic materials are leached into the water stream.

D. Effect of Degradable Compost Bags on Soil, etc.

In each of three grades of compost, e.g. compost as made (e.g. for landfill cover), refined compost (e.g. for silviculture, agriculture and commercial landscaping) and mature compost (e.g. for retail) it is important that there are no persistent or toxic residues. Although the polyethylene bag may be fragmented to "plastic dust" it is necessary for this to breakdown further or "mineralize" to carbon dioxide, water and biomass, and for there to be no long term accumulation through persistent use of the compost.

Standards for potential contaminants such as metals and PCB's must also be met so that no adverse effects from the use of the compost will be found.

E. Production of Compost Bags containing Ecostarplus

Degradable compost bags containing Ecostarplus can be made on existing plastic bag making machinery with no change to the running conditions. The effect on some typical film properties with different addition levels of Ecostarplus masterbatch are shown in Figure 2. It is stressed that these results were obtained from one set of running conditions.

ECOSTARplus masterbatch addition level (%)		0.0	7.0	14.0	21.0
Gauge (microns)		53	56	53	55
Elmendorf Tear	MD	100	109	110	138
	TD	100	94	95	95
Tensile at yield	MD	100	103	102	103
	TD	100	98	97	102
Tensile at break	MD	100	96	97	75
	TD	100	80	78	69
Elongation	MD	100	89	91	83
	TD	100	87	86	79
Dart Impact		100	83	91	61

Figure 2. Effect of different ECOSTARplus additions on film properties. All figures related to zero addition level of 100%.

F. Degradation with ECOSTARplus

There has been much debate about the mechanism of degradation and its measurement. However, over recent years research has provided a much better understanding of the process.

There are three distinct but related mechanisms that take place during environmental degradation of plastic articles containing ECOSTARplus (Figure 3).

1. Digestion of the starch out of the plastic article.
2. Thermal oxidative breakdown or photodegradation of the polymer.
3. Digestion of the polymer fragments.

Figure 3. Mechanism of Degradation of Plastic Articles Containing ECOSTARplus.

In the laboratory these mechanisms can be studied independently, but in natural environments they will take place contemporarily and there is synergy between all three.

G. Digestion of Starch from Plastic Articles

The ability of microorganisms to digest particulate starch from plastic articles has been shown by numerous investigators and it was examined quantitatively using FTIR by Ianotti and coworkers. His results are illustrated in Figure 4.

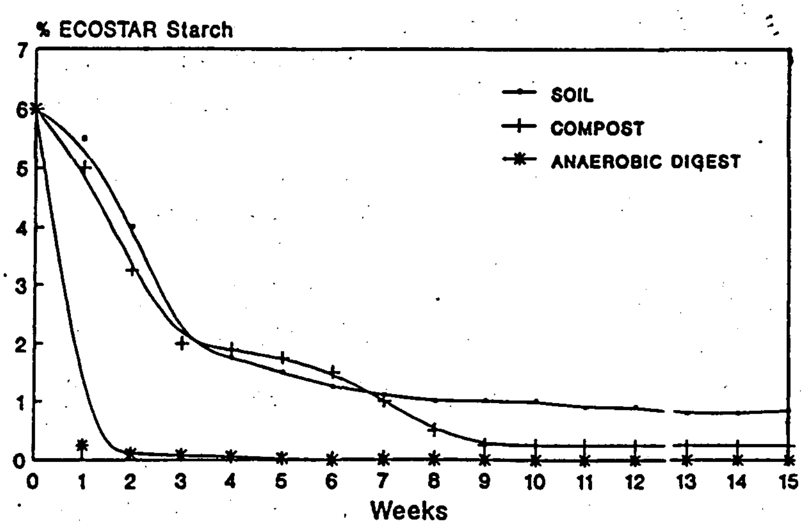

Figure 4. Removal of Starch Granules from PE Film in Various Environments.

H. Thermal oxidative breakdown and photodegradation of the polymer.

ECOSTARplus contains a sophisticated additive package to accelerate the oxidative breakdown of the polymer. This can be followed by measuring one or more of several parameters (Figure 5).

Loss of elongation

Carbonyl group formation

Loss of weight

Reduction of molecular weight

Figure 5. Parameters used to measure thermal oxidation breakdown or photodegradation.

This breakdown is well known in the plastic industry, but is accelerated with the ECOSTARplus system.

One factor that has been found to be very important in ensuring good performance for degradable compost bags has been the polymer used.

Use of different polymers can have a dramatic effect on the rate of this degradation as is shown in Figure 6. It is not just the polymer that effects this rate but also the additives, particularly the antioxidants in the polymers that can modify the rate of breakdown as shown in Figure 7.

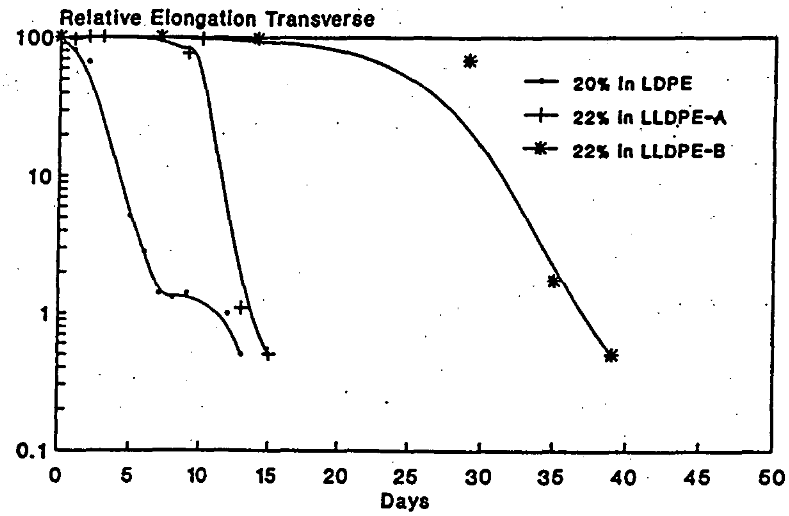

Figure 6. Loss of elongation of various polymer films at 80°C

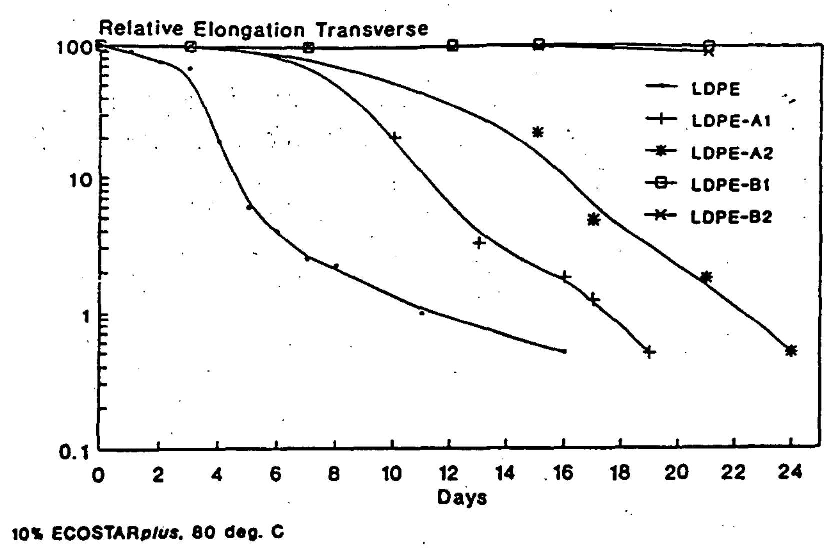

Figure 7. Loss of elongation of various film containing ECOSTARplus with different antioxidants at 80°C.

Reduction of the polymer molecular weight is important to convert the high molecular polymer, such as polyethylene with an average molecular weight of 100,000 which cannot be directly attacked by microorganisms, to low molecular weight fragments which can be eaten. The change in molecular weight distribution is shown in Figure 8, showing, under abiotic conditions, accumulation of low molecular weight fragments below the "digestible" level of about 1,000.

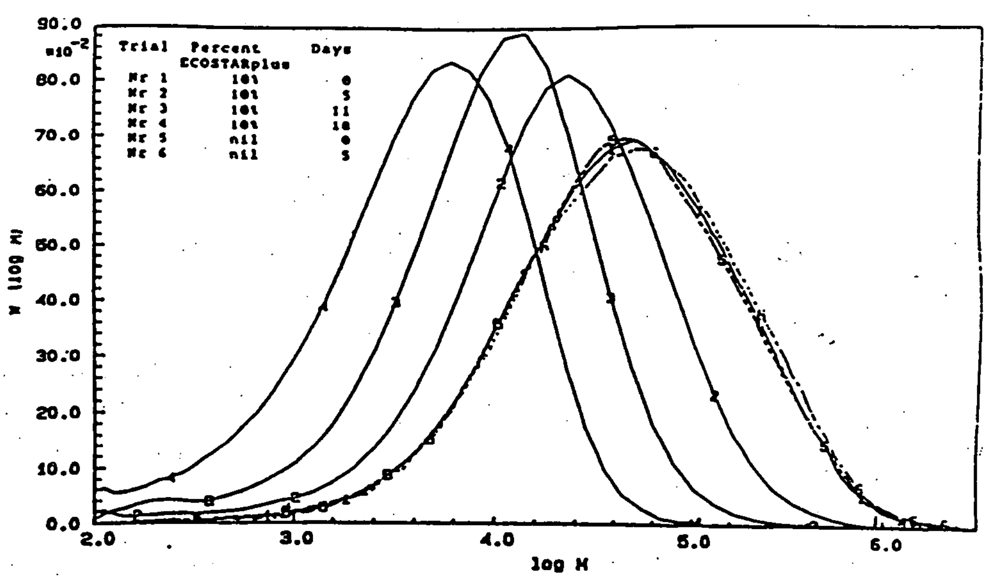

Figure 8. Change in molecular weight distribution of LDPE films containing ECOSTARplus.

Instead of achieving the polymer degradation by thermal oxidation, it can also occur with UV light as is shown in Figure 9.

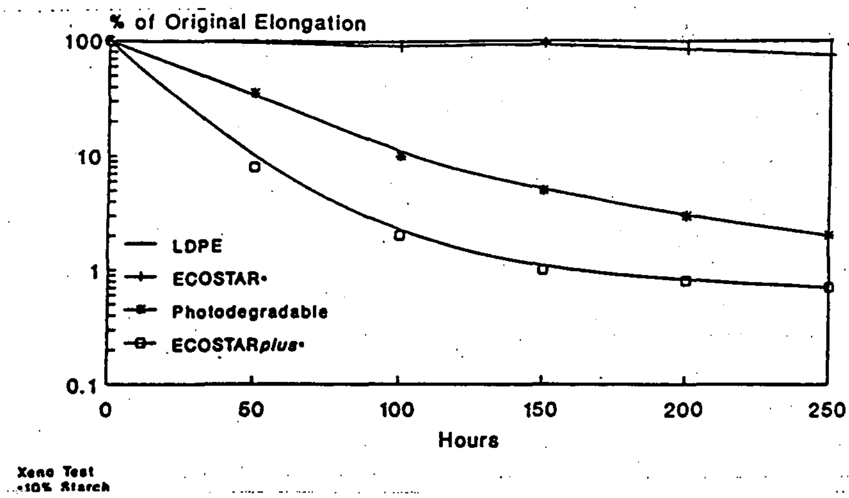

Figure 9. Effect of Ultraviolet Exposure of the Elongation of Various Degradable Formulations.

I. <u>Digestion of the Polymer Fragments</u>

Professor Albertsson at the Royal Institute of Technology in Stockholm, Sweden, has shown the very slow evolution of carbon dioxide from LDPE during soil burial. The mechanism was assumed to involve first a chemical breakdown as above followed by microbiological attack on the polymer fragments.

Potts showed that low molecular weight fragments from polyethylene could support fungal growth. While it is an oversimplification to state a simple molecular weight as the upper limit on microbiological digestion since it will depend on:

- chain branching
- presence of polar groups
- hydrophobicity of the surface.

However, it is generally accepted that low molecular weight hydrocarbon fragments can be digested by microorganisms.

A modified Stürm test was carried out using thermally oxidized high density polyethylene containing ECOSTARplus. By measuring the carbon dioxide evolved it was proven that, in the relatively short time of the test, that some of the polyethylene was metabolized (Figure 10).

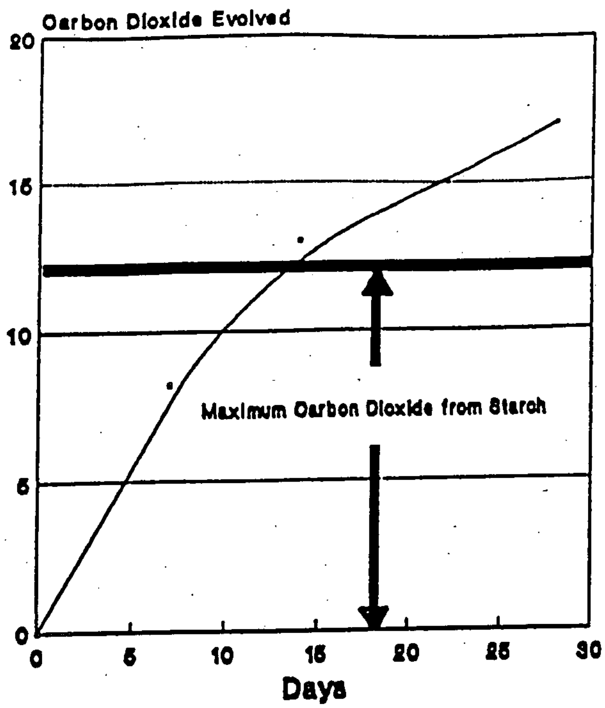

Figure 10. Carbon dioxide evolution from thermally oxidized HDPE film containing ECOSTARplus

Further work on ECOSTARplus containing ^{14}C - labelled polyethylene to elaborate our understanding of this mechanism is being carried out at the State University of New York at Buffalo.

J. Degradation in Various Natural Environments

The practical test of these mechanisms is the degradation performance in various natural environments. For low density polyethylene during soil burial this is shown in Figure 11.

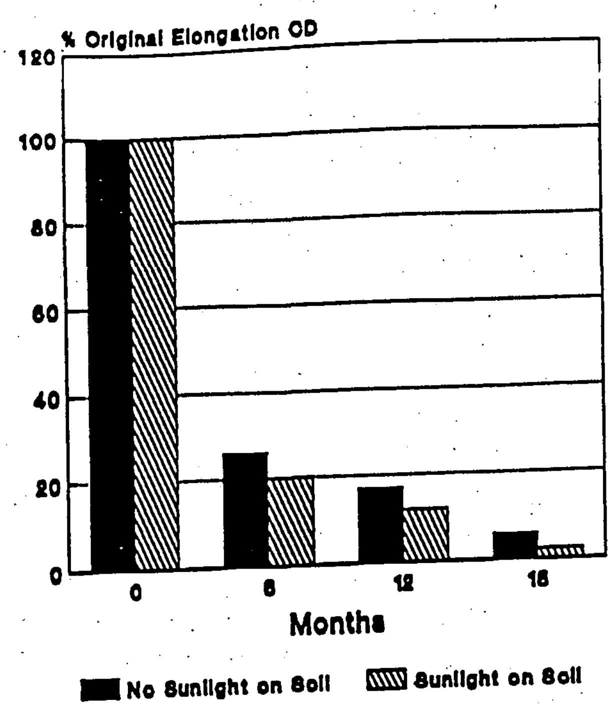

Figure 11. Effect of soil burial on LDPE films containing ECOSTARplus.

Composting trials were carried out in Switzerland with the results as shown in Figure 12.

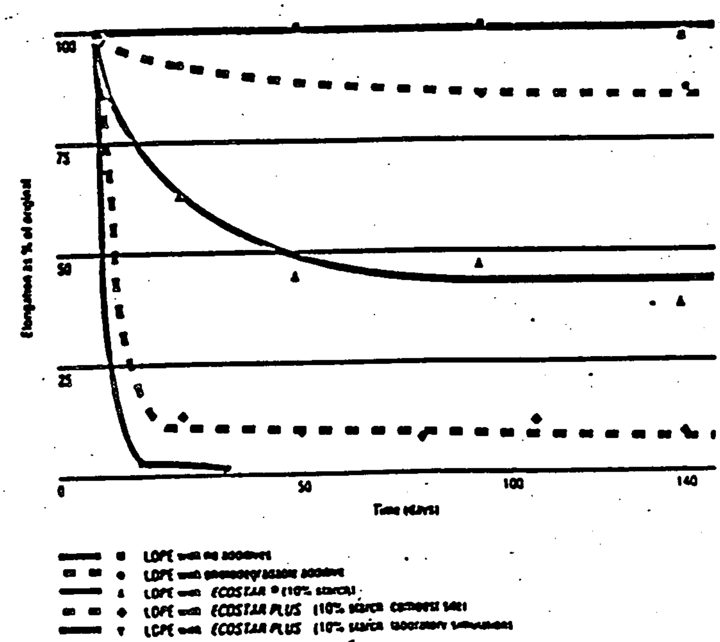

Figure 12. Changes in Elongation of various film samples in compost.

K. Contaminants from Degradation of Bags Containing Ecostarplus

No toxic residues have been found from degrading and degraded bags containing Ecostarplus and there have been no significant effect on the metal content of soil.

L. Conclusion

Economically-variable compost bags with good performance in use during collection and suitable degradation during composting and subsequent use can now be achieved. They are already being used successfully in Germany and the USA.

PREVENTION AND CONTROL OF ACID MINE DRAINAGE FROM TAILINGS WITH MUNICIPAL COMPOST: POLICIES, PROGRAMS AND VIABILITY.

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ABSTRACT The feasibility of using composted municipal organic waste (food and yard waste) to aid in the reclamation of acid mine tailings was investigated. Tailing reclamation represents a potentially unlimited market for municipal compost and may assist municipalities in meeting provincial waste diversion targets. This study reviews the composition and distribution of organic waste in Ontario, organic waste collection methods, government waste management and tailings reclamation policies, compost quality, markets for municipal compost, feasibility of using sewage sludge, transportation, cost analysis and tailings reclamation programs and methods.

When sulfide-bearing mine tailings are exposed to air and water, adjacent surface waters may become contaminated with high levels of acidity and metals. Since biological communities are greatly affected by highly acidic, metal contaminated water there is a compelling need to seek and apply corrective measures. The seriousness and extent of the acid mine drainage (AMD) problem (15,000 ha in Canada) has prompted the mining industry along with the federal and several provincial governments to cooperate in investigations of innovative methods for long-term, environmentally effective management of tailings which reduce or prevent the formation of AMD and minimize long-term active management of tailings sites after mine closure.

Two tailings reclamation methods appear promising. Flooding of mine tailings to create artificial wetlands has been proposed by Rio Algom Limited because it offers an effective means of preventing and attenuating AMD by reducing the exposure of tailings to oxygen. A second method utilizes a layer of fine-grained material above coarser material. The fine cover material is designed such that it is maintained in a moisture-saturated state regardless of the depth to the water table (i.e. drainage is limited) and therefore minimize exposure of underlying tailings to oxygen. In either case, erosion of tailings material is reduced.

The effectiveness of flooding and engineered covers in limiting oxygen supply and reducing erosion would be greatly enhanced by application of organic material which would increase productivity and biological diversity; however, there is a shortage of organic material near many mines situated on the Precambrian Shield in northern Canada.

A partial solution to the shortage of organic material may lie with composting municipal organic waste which comprises about 24% of the total non-hazardous municipal solid waste stream. At the present time, composting diverts a very minor amount of waste from landfill in most Canadian municipalities.

Urban communities are finding it increasingly difficult to dispose of growing amounts of municipal solid waste using the traditional method of landfilling. They are under increasing government and public pressure to divert waste from landfill by reduction, recycling and reuse. Given that much of the waste stream is compostable, many municipalities may find large scale composting attractive if long-term markets can be secured.

1. INTRODUCTION

Many ore bodies and surrounding waste rock consist of metal sulfides, particularly iron sulfides, pyrite and pyrrhotite. During a mining operation 90% of an ore is typically discarded as tailings after separation by milling and flotation to prepare a concentrate for further processing (Moore and Luoma 1990). The tailings frequently contain a significant amount of sulfides and heavy metals.

When sulfide-bearing mine tailings are exposured to air and water, adjacent surface waters may become contaminated with high levels of acidity and metals. Specifically, formation of acid mine drainage (AMD) is caused by chemical and bacterial oxidation of readily oxidizable iron sulfides with the concomitant formation of sulfuric acid, which in turn leaches heavy metals. In general, metals are readily leached at low pH.

There are approximately 15,000 hectares of acid generating mine wastes in Canada. Since biological communities are greatly affected by AMD there is a compelling need to seek and apply corrective measures. The seriousness and extent of the problem has prompted the mining industry along with the federal and several provincial governments to cooperate in investigations of innovative methods for enduring, environmentally effective management of tailings that would allow mine operators to walk away after mine closure without subsequent long-term active management of the tailings.

This report is a preliminary examination of the feasibility of using the organic waste portion of the non-hazardous municipal solid waste stream suitably processed as compost to help address the AMD problem. As urban communities find traditional waste disposal methods such as landfill increasingly difficult, they may be persuaded to engage in appropriate collection and large scale composting activities if ensured of securing suitable markets.

Ever increasing amounts of waste have placed a premium on wise land use and environmental planning. The Ontario Ministry of the Environment has decreed that municipalities must divert 50% of their waste from landfill and incineration by means of reduction, recycling and reuse by the year 2000. For the Municipality of Metropolitan Toronto and the Regions of York and Durham, approximately 2 million tonnes of waste must be diverted each year. Many municipalities will have difficulty meeting this target unless creative solutions are found.

This report examines the viability of the concept of compost application to mine tailings from technical, economic and policy perspectives. Although AMD and municipal solid waste problems are national in scope, Ontario data and policies are emphasized. Ontario's proposed provincial waste management policies may soon lead to large scale composting and the mining industry has initiated several relevant research and reclamation projects in Ontario.

1.1 Prevention and Control of Acid Mine Drainage AMD often exceeds regulatory standards for metal concentrations and pH (low pH is associated with high acidity). The Ontario Provincial Water Quality Objectives (PWQO) for pH, alkalinity, metals and radionuclides are published by the Ontario Ministry of the Environment (Water Management, 1984, Table 1). The acceptable pH range in surface waters is 6.5-8.5 and alkalinity should not be decreased by more then 25% of the natural concentrations for protection of aquatic life. The federal guidelines are similar (Canadian Council of Resource and Environment Ministers 1987). The PWQO are currently under review.

Mitigation of AMD can take the form of treating acidic discharge from tailings impoundments by means of natural attenuation processes in wetlands or by controlled or semi-controlled dosing with neutralizing agents such as calcite, slaked lime or quicklime (Zurbuch 1984, Fraser et al. 1985, Sverdrup et al. 1985).

Dosing is used by Rio Algom Ltd. at its Elliot Lake tailings sites as well as many other mining companies (Al Vivyurka, personal communication). It is also very common in Scandinavia where sophisticated doser technology has been developed for the treatment of remote streams which are atmospherically acidified. Controlled dosing must be employed as long as exposed tailings continue to generate AMD, which may last centuries beyond the life of the mine, and may produce large volumes of sludge.

AMD can also be controlled and perhaps eliminated by reducing the rate of oxygen supply to sulfide-bearing tailings by means of some type of cover to prevent acid generation although relationships between field conditions and long-term effectiveness have yet to be firmly established. Two tailings reclamation methods appear promising.

Flooding of tailings (i.e. raising the groundwater level and maintaining the surface in a permanently saturated state) where hydrologically feasible may be an effective means of preventing oxygen penetration because the molecular diffusion rate of oxygen in quiescent water is quite low. Hence, flooding is receiving increased attention (Environment Canada 1987; Balins et al 1991). The rate of oxygen diffusion to tailings beneath a wetland could be further lowered by the introduction of an oxygen consuming barrier, such as microbially active organic material, placed between the tailings and sources of oxygen such as aquatic plants and the atmosphere. In natural aquatic systems, thick organic-rich bottom sediments are an effective oxygen consuming barrier.

A second reclamation method utilizes a layer of fine-grained material above coarser material (Nicholson et al. 1991; Yanful 1991). The fine cover material is designed such that it is maintained in a moisture-saturated state regardless of the depth to the water table (i.e. drainage is limited) and therefore minimize exposure of underlying tailings to oxygen. As with flooded tailings, the effectiveness of engineered covers in reducing AMD as well as erosion would be greatly enhanced by the presence of organic material.

The central scientific premise of this report is that the rate of AMD formation in an artificial wetland or from tailings with engineered covers will likely be lower when substantial organic sediments are present than in a system lacking substantial organic sediments.

1.2 Creating an Enhanced, Self-Perpetuating Oxygen Barrier The oxidized zone (zone with oxygen present) of bottom sediments in natural aquatic systems typically does not extend more than 2-4 cm below the sediment/water interface. Sediments below 4 cm are virtually oxygen free. This is because the rate of oxygen consumption by heterotrophic bacteria in surface sediments exceeds the rate of oxygen diffusion into the sediment from surface sources. (Heterotrophic bacteria obtain energy and carbon from the breakdown of organic detritus and are very numerous in sediments.) The rate of oxygen consumption in sediments is a function of new organic material derived annually from the activity of the pond's biological communities, which are, in turn, partially dependent on sediments as well as new inputs of nutrients from external sources each year. Sediments play an important oxygen consuming role in viable, self-sustaining aquatic ecosystems.

In newly flooded tailings (or tailings with moisture-saturated covers) there will be little organic material. Therefore, the rate of oxygen supply to the tailings will be limited primarily by the molecular diffusion rate of oxygen through water. Organic sediments will accumulate at a very low rate, even if tolerant vegetation such as the common cattail, Typha latifolia, are planted. Also, the rate of successional changes following planting due to invasion by native flora from adjacent wetlands will be slow, although in time a mature, self-sustaining, productive aquatic community would develop (e.g. Brooks 1990).

A thick layer of organic-rich material added to newly flooded tailings or engineered covers would likely promote aquatic plant productivity and facilitate the creation of a more effective oxygen-consuming sediment barrier. The organic-rich material would provide suitable substrate for bacterial activity and plant growth in addition to being a temporary source of essential plant nutrients such as phosphorus, nitrogen, potassium, calcium and magnesium. Organic material would also reduce drying during droughts because organic material has a high moisture retention capacity.

Unfortunately, many tailings impoundments in Canada are situated on the Precambrian Shield which is characterized in general by extremely low amounts of suitable cover material. The overall scarcity of large volumes of natural organic material might be offset by using other materials such municipal compost, provided that transportation costs to the mining industry were reasonable.

1.3 Municipal Compost as a Source of Organic-Rich Material Composting is the biological decomposition of organic material under varying degrees of control which produces a relatively stable organic end product used as a soil enhancer.

It is estimated that up to 30% of non-hazardous municipal solid waste (MSW) is readily compostable and is therefore a potential source of organic material for reclamation. The compostable fraction is primarily organic waste, such as food and yard wastes, although paper products are compostable and are sometimes included in the compostable fraction. Large quantities of sewage sludge are also available for composting across Ontario.

The provincial government and municipalities are showing increasing interest in large scale composting. Scenarios proposed by the Municipality of Metropolitan Toronto in its master plan for solid waste management (to take effect in 1996) include gradual implementation of large scale composting options ranging from 500,000 to over 1.25 million tonnes of organic waste (250,000 to 600,000 tonnes of compost) per annum. Production of this magnitude exceeds current demand and new uses must be sought.

Assuming that 1 tonne of organic waste generates 0.5 tonnes of compost, then 1 million tonnes of organic waste would produce enough compost to cover 100 hectares to a depth of 1 m assuming a bulk density of 0.5 tonnes of compost per m^3. This is a very small fraction of the extensive tailings area in need of reclamation in Canada and it is likely that compost derived from MSW could be applied to tailings for many years.

The advantages of using municipal waste to help solve the mining industry's waste problem are compelling and should be looked upon favourably by the general public and regulatory bodies. Not only would there be improvements in the quality of tailings discharge but urban communities would reduce their dependence on landfill. Large scale composting could go a long way to meeting the provincial government's target of diversion of 50% of municipal waste from landfill and incineration. The situation is timely for both the mining industry and municipalities to consider the mutually beneficial application of compost from MSW to rehabilitate tailings sites.

2. SOLID WASTE COMPOSITION AND DISTRIBUTION IN ONTARIO

2.1 MSW Composition Effective waste management planning requires information on the amounts and types of solid wastes generated. Several waste composition studies have recently been conducted in Ontario - the Metro Toronto Solid Waste Composition Study and the Ontario Waste Composition Study. The results for the residential sector were similar but different methodologies for the ICI (industrial, commercial and institutional) sector preclude comparison of the ICI results from the two studies.

<u>Metro Toronto Solid Waste Composition Study</u>: The organic waste fraction (yard plus kitchen waste) in post-blue box residential waste was 31%. This may decrease somewhat as participation increases in the home composting program. The average organic waste fraction in the post-recycling ICI sector was 18%. The average post-blue box organic waste fraction of MSW currently going to landfill is 23% in Metro Toronto assuming a mix of 60% ICI and 40% residential. The average organic waste fraction will likely be slightly higher in Ontario communities with a smaller ICI sector.

<u>Ontario Waste Composition Study</u>: Estimates of kitchen waste ranged from 26 to 29% in the residential sector of three Ontario communities (East York, Fergus and North Bay) in 1989-1990. Yard waste was not included. Food waste in the ICI sector in the Regional Municipality of Waterloo ranged from 0.55% in the retail furniture, appliance, floor covering and furnishings sector to 57% in the take-out food sector. An average value for the ICI sector was not calculated.

<u>Other Studies</u>: Organic waste fractions in several American surveys ranged from 16 to 33% (summarized in Denison and Ruston 1990).

The fraction of organic waste in a small community obviously depends upon the proportions of residences and businesses as well as the type of dwelling and business. However, across larger regions it is assumed that these proportions will approach the average value for Ontario. Furthermore, it is reasonable to assume that not all organic waste will be captured.

The Metropolitan Toronto Solid Waste Management Master Plan (1991) combined several studies and assumed for planning purposes that the average organic waste fractions were 36% (residential) and 13% (ICI) for an average organic waste fraction of 22%.

The 'operationally obtainable' organic waste fraction is assumed here to be 17% of the total waste stream in Ontario. This is the organic waste which will be collected if high participation rates occur across all sectors. This percentage is derived by assuming a organic waste fraction of 24%, a participation rate of 90% and a capture efficiency of 80% across Ontario.

2.2 Distribution of Waste in Ontario Data were collected for those municipal governments responsible for waste disposal. Under current legislation in Ontario, waste collection is the responsibility of area municipalities (cities) while waste disposal is the responsibility of the regional government in regional municipalities and area municipalities in counties and districts. MSW generation rates in Ontario were estimated from 1986 census data for regions and cities with populations greater than 40,000 (Table 1) representing over 80% of the population.

Smaller municipalities were ignored in this report. However, the trend in waste management is towards increasing coordination and planning, particularly among area municipalities in counties, which will undoubtedly increase the quantity of waste.

MSW generation rates were estimated by assuming an annual per capita generation rate of 1 tonne from the residential and ICI sectors from areas outside the Greater Toronto Area (GTA) and 1.1 tonnes within the GTA. The higher per capita rate in the GTA is attributed to higher industrial, commercial and institutional activity.

Landfill data obtained from municipal works departments are also presented in Table 1. Landfill data were not always in agreement with estimates derived from population data either because landfills were accepting waste from other municipalities or were exporting to other regions. Outside of the Greater Toronto Area, population derived estimates are considered in this report to be a more reliable estimate of MSW generation rates than measurements of landfill tonnages.

Table 2 presents operationally obtainable organic waste fractions for major urban areas in Ontario. These data were derived from MSW data in Table 1 assuming an operationally obtainable organic waste fraction of 17% of the total MSW stream. About 1.4 million tonnes of operationally obtainable organic waste are generated each year in Ontario of which about 53% originates in the Greater Toronto Area and 29% originates in southwestern Ontario. Approximately 87,200 tonnes (6%) are generated each year in northern Ontario. Over 680,000 tonnes of compost could potentially be produced in Ontario annually, assuming a 50% reduction in weight during composting. All of Ontario's annual compost production would cover 136 hectares per year to a depth of 1 m assuming a bulk density of 0.5 tonnes/m^3. Given that approximately 15,000 hectares of tailings are in need of reclamation, unlimited composting application could occur for many decades.

TABLE 1. MSW GENERATION RATES DERIVED FROM 1986 CENSUS DATA AND 1990 MSW LANDFILL DATA (TONNES PER YEAR UNLESS SPECIFIED) FOR MAJOR URBAN AREAS IN ONTARIO. MSW GENERATION RATES WERE ESTIMATED FROM POPULATION DATA BY ASSUMING AN AVERAGE PER CAPITA GENERATION RATE OF 1 TONNE PER YEAR FROM RESIDENTIAL, INSTITUTIONAL, INDUSTRIAL AND COMMERCIAL SECTORS FOR NON-GTA MUNICIPALITIES AND 1.1 TONNES FOR GTA. LANDFILL DATA WERE OBTAINED FROM MUNICIPAL WORKS DEPARTMENTS AND OFTEN INCLUDE SEWAGE SLUDGE.

	TONNES MSW/YEAR	
	POPULATION	LANDFILLED
Central		
Barrie	48,286	83,000
Peterborough	87,080	55,000
subtotal	135,400	138,000
South West		
Brantford	76,920	120,000
Cambridge	79,920	363,300
Chatham	42,210	4,360 m^3
Guelph	85,962	**
Haldimand-Norfolk Region	90,000	**
Hamilton-Wentworth Region	557,029	300,000
London	342,302	265,000
Niagara Region	370,000	**
Sarnia	85,700	32,650 m^3
Windsor	253,988	189,000
Waterloo Region	311,195	**
Woodstock	26,385	504,600 m^3
subtotal	2,321,600	**
South East		
Belleville	40,000	163,000
Cornwall	46,425	45,830
Kingston	122,350	100,000
Ottawa-Carleton Region	606,639	250,000
subtotal	815,400	558,800
North West		
Kenora	52,834	7,700 m^3
Thunder Bay	122,217	178,000
subtotal	175,000	185,700
North East		
North Bay	57,422	50,000
Sault Ste. Marie	84,617	70,700
Sudbury Region	148,877	25,000
Timmins	46,657	100,000 m^3
subtotal	337,600	245,700

..... Table 1 continued.

TABLE 1. CONTINUED.

	TONNES MSW/YEAR	
	POPULATION	LANDFILLED
Greater Toronto[1]		
Durham Region	373,000	400,000
Halton Region	314,000	200,000
Metro Toronto Region	2,500,000	2,500,000
Peel Region	666,000	700,000
York Region	385,000	500,000
subtotal	4,238,000	4,300,000
TOTAL	8,023,000	

1. MSW data from MOE Backgrounder No. 2, November, 1990.

TABLE 2. OPERATIONALLY OBTAINABLE ORGANIC WASTE (TONNES/YEAR) GENERATED BY MAJOR URBAN AREAS IN ONTARIO. THE OPERATIONALLY OBTAINABLE FRACTION IS ASSUMED TO BE 17% OF MSW. THE FINAL COMPOST TONNAGE ASSUMES A REDUCTION OF 50% IN WEIGHT DURING COMPOSTING. MSW GENERATION RATES ARE LISTED IN TABLE 1.

	ORGANIC WASTE	COMPOST
Central		
Barrie	8,200	4,100
Peterborough	14,800	7,400
subtotal	23,000	11,500
South West		
Brantford	13,100	6,550
Cambridge	13,600	6,800
Chatham	7,200	3,600
Guelph	14,600	7,300
Haldimand-Norfolk Region	15,300	7,650
Hamilton-Wentworth Region	94,700	47,350
London	58,200	29,100
Niagara Region	62,900	31,450
Sarnia	14,600	7,300
Windsor	43,200	21,600
Waterloo Region	52,900	26,450
Woodstock	4,500	2,250
subtotal	394,700	197,350
South East		
Belleville	6,800	3,400
Cornwall	7,900	3,950
Kingston	20,800	10,400
Ottawa-Carleton Region	103,100	51,550
subtotal	138,600	69,300
North West		
Kenora	9,000	4,500
Thunder Bay	20,800	10,400
subtotal	29,800	14,900
North East		
North Bay	9,800	4,900
Sault Ste. Marie	14,400	7,200
Sudbury Region	25,300	12,650
Timmins	7,900	3,950
subtotal	57,400	28,700

..... Table 2 continued.

TABLE 2. CONTINUED.

	ORGANIC WASTE	COMPOST
Greater Toronto[1]		
Durham Region	63,400	31,700
Halton Region	53,400	26,700
Metro Toronto Region	425,000	212,500
Peel Region	113,200	56,000
York Region	65,500	32,750
subtotal	720,500	360,250
TOTAL	1,364,000	682,000

1. Organic waste derived from measured landfill tonnage.

3. ORGANIC WASTE COLLECTION AND COMPOSTING METHODS

3.1 Collection Organic waste can be separated 'at source' by the waste generator or it can be isolated from mixed waste at a centralized waste sorting facility. In general, compost quality is expected to be higher (less contamination with debris and chemical pollutants) when waste is separated at source into appropriate streams and carefully handled. For example, the recent Ontario Ministry of the Environment Downsview Resource Recovery Project in Toronto mechanically separated mixed residential waste into several streams and found an unacceptably high degree of physical contamination of compost with plastic and other inert material. Coloured plastic debris is highly visible today in soils around the plant amended with compost. If similar compost were applied to flooded tailings, plastic debris would inevitably become free and litter areas downstream.

Several curbside mixed waste collection methods extract recyclable goods to varying degrees (see SWEAP Discussion Paper 3.2 for a more detailed review). Examples of curbside collection methods are (1) no separation, (2) the currently popular residential blue box + residual waste system, (3) the wet/dry system and (4) the three stream approach of dry recyclables, organic waste and residual waste.

Method 1 is the conventional method used by virtually all North American municipalities until recently. Waste was treated as unusable and landfilled or incinerated.

In the blue box method, recyclable dry goods such as cans, glass bottles, plastic containers and newspapers are placed in a separate container by the waste generator (i.e. separation at source) leaving organic waste and unusable waste mixed together in another fraction.

In the wet/dry method, waste generators separate waste into two fractions both of which contain recyclables and non-recyclables - a 'clean and dry' fraction and a 'wet and dirty' fraction. The 'wet and dirty' fraction contains the compostable fraction. The wet/dry method produces two low quality waste streams because of the presence of undesirable wastes and is inconsistent with the notion that efficient separation is necessary to produce high quality material to meet market requirements. Consequently this method may limit diversion rates from landfill.

Additional sorting of the 'wet and dirty' stream via a mechanized central sorting facility prior to composting or post-production cleaning of the compost may produce an acceptable final product. This cost can be avoided by the municipality if the burden of separation is placed on the waste generator (i.e. the three stream method) although collection logistics may be somewhat more complicated.

The three stream approach will produce the highest quality materials and therefore will likely divert more waste than the two stream approach particularly when markets are soft and markets for low grade commodities shrink. The three stream collection method was recommended for implementation by 1994 in Metro Toronto (Metropolitan Toronto Solid Waste Management Master Plan, 1991).

The provincial government in Ontario will require source separation by all sectors once enabling legislation has been passed (see Section 5.1). Therefore, it is expected that all municipalities and businesses in Ontario will use the three stream collection method.

The residual waste stream may be compostable although it will undoubtedly produce a very low quality product with a high percentage of inert material and possibly some contamination with metals and organic chemicals. Physical processing of the compost to remove inert material would likely be required before shipment.

3.2 Composting Composting is the biological, primarily microbial, decomposition of organic material under varying degrees of control which produces a relatively stable organic end product used as a soil enhancer (Diaz et al. 1982). Technology is used to optimize critical environmental variables such as oxygen, particle size, moisture and temperature and promote microbial growth rates. The technologies briefly described below pertain directly to centralized facilities rather than backyard composting. Composting is described in more detail in the Ontario Ministry of the Environment compost guidelines (1991).

Composting technology is divided into two general types, windrow (open) and mechanized (closed or in-vessel) (Diaz et al. 1982). The windrow is a low technology method in which piles of waste are left exposed. Aeration is accomplished by periodic turning with heavy equipment or by forced aeration. Turning also promotes decomposition of surface material by moving it inside the windrow. As the length of exposure depends on climatic conditions, long periods of time are required for decomposition to reach a suitable state, particularly during Canadian winters. Open systems may produce objectionable odours and attract birds and other scavengers.

In mechanized systems, closed reactors are used to exert more control over environmental variables and accelerate the first stages of decomposition. In a typical plug flow system waste moves through a composting vessel and exits after a residence time of approximately 3 days. The compost requires further decomposition and is stacked in windrows allowing it to mature for approximately 6 weeks. Although the residence time in-vessel is short, it greatly speeds up the decomposition of labile organic material, hence, subsequent outdoor maturing is not objectionable.

4. GOVERNMENT COMPOSTING POLICY IN ONTARIO

4.1 Provincial Policy The general intent of the provincial government is to spawn greatly increased 3R's activity with composting playing an important role. The provincial government released 'Regulatory Measures to Achieve Ontario's Waste Reduction Targets' in October of 1991 and has tabled enabling legislation with amendments to the Environmental Assessment Act, Environmental Protection Act and Municipal Act. The government intends to make waste audits and workplans, source separation in the ICI and municipal sectors and composting of leaf and yard waste mandatory. Collection and composting of kitchen waste is expected to follow.

There is some concern that compost derived from municipal waste may be contaminated and that uncontrolled use of contaminated compost poses an environmental risk. In response to these concerns, the Ontario Ministry of the Environment issued 'Guideline for the Production and Use of Aerobic Compost in Ontario' in 1991. The Guideline outlines required approvals and permits, facility siting criteria, operating conditions and compost quality specifications.

Compost meeting all of the guidelines and criteria would be permitted unrestricted use. Compost not meeting guidelines will be considered a processed organic waste under Regulation 309 and "In this case, the MOE will require Waste Disposal Site approvals for locations where compost is applied, and Waste Management Systems approval for handling it." Although the provincial government does not have a policy specifically governing application of contaminated compost to mine tailings at this time, land reclamation projects are suggested as potential sites for low quality compost ('Guideline for the Production and Use of Aerobic Compost in Ontario', page 8, Section 7.1).

The derivation of compost quality specifications on pages 8 - 11 of the 'Guidelines for the Production and Use of Aerobic Compost in Ontario' is explained on pages 14 and 15. Metals criteria were derived from Ontario guidelines for rural soils ("Upper Limit of Normal" Contaminant Guidelines for Phytotoxicity Samples, MOE) and total salts and sodium absorption ratio limits were taken from 'Guidelines for the Decommissioning and Cleanup of Sites in Ontario' (MOE 1990). Compost particle size was based on past MOE experience (presumably the Fairfield Digester at Downsview). Composting literature was reviewed, including Florida Department of Environmental Regulation, Rule 17-709, "Criteria for the Production and Use of Compost Made from Solid Waste", but there is no indication of the importance of given documents to criteria development other than those cited above.

4.2 Metro Toronto Policy Metro Toronto appears committed to both large-scale and back yard composting activity. Back yard composting does not require formal approval and reduces the need for large investments in time and money for land acquisition and equipment. However, backyard composting will not divert a majority of organic wastes because it cannot serve the ICI sector and apartment dwellings. To illustrate, if we assume 90% participation of single family dwellings in backyard composting in a community in which 50% of the residences are apartments and 50% of the organic waste is generated by the ICI sector, then backyard composting will divert approximately 15-20% of the total operationally obtainable organic waste stream. Hence, large scale composting is necessary.

Metro Toronto recommended that a prototype facility be built before 1995 capable of composting up to 500 tonnes/day of source separated organic waste (Metropolitan Toronto Solid Waste Management Master Plan, 1991; see Appendix A this report), which is about 25% of Metro Toronto's operationally obtainable organic waste, and has inititiated a site selection process for centralized composting facilities. The prototype facility is 'intended to demonstrate the feasibility of large scale composting, provide a basis for determining the characteristics of the finished product and establish marketability' (page 8.5 of the Master Plan). The plant would produce about 75,000 tonnes of compost annually.

Two to three more facilities of comparable size are expected by the year 2000 (page 8.6 of the Master Plan) each costing approximately $35 million exclusive of land costs. Hence, within 9 years Metro Toronto is expected to separate up to 410,000 tonnes of organic waste and produce approximately 300,000 tonnes of compost. In comparison, this report estimates that Metro Toronto can separate 425,000 tonnes of organic waste and produce 212,000 tonnes of compost (Table 2). Apparently, the Master Plan assumes a much smaller weight loss during composting, only 27%, compared to the assumption in this report of 50%. An official for Metro Toronto Works Department suggested that the weight loss would be 40%. The actual loss will depend upon feedstock composition - for example, yard waste may differ greatly from kitchen waste.

Metro Toronto initiated a composting pilot project in late 1991 involving 13,000 homes in Etobicoke, North York and Toronto. Source separated organic waste is collected and delivered to the recently retrofitted 50 tonne per day Fairfield Digester located at the Dufferin Transfer Station in North York.

The composting policies of other municipalities have not been reviewed but are likely to be similar to Metro Toronto policies given the provincial objective of implementing 3R's programs uniformly around the province. Guelph is currently operating a pilot project comparing compost from two stream and three stream collection methods.

5. COMPOST QUALITY AND MARKETABILITY

Municipalities will seek to produce high quality compost that meets Ontario Ministry of the Environment specifications for unrestricted use in spite of the cost because it will expand their opportunities for diversion from landfill. The most desirable markets for municipal compost will be those nearest to composting facilities because proximity of market reduces transportation costs. In southern Ontario, the most promising markets are horticulture and agriculture. Furthermore, compost meeting Ministry specifications could be shipped to anywhere in the province without fear of adverse public reaction because the waste will have been transformed into a high quality commodity and will no longer be considered waste.

However, some compost may not meet MOE specifications for unrestricted use in spite of proficient collection and composting methods. Knowing the proportion of compost not meeting MOE specifications will be important because the cost of disposing of rejected batches could be a significant operating cost. However, few data relating organic waste source, collection method and compost quality exist. It is generally assumed that yard and kitchen wastes will produce uncontaminated compost provided they are properly separated at source. Flindall and Haight (1991) compared some compost quality data for household separated waste in the Netherlands and mechanically separated mixed waste in Toronto. Concentrations of metals (cadmium, chromium, copper, lead and zinc) in the Netherlands study were below the draft Ontario guidelines for unrestricted use (Ontario Ministry of the Environment, 1991a) while concentrations of eight of 11 metals in the Toronto study exceeded the guidelines.

In practice, compost batches utilizing source separated organic waste will occasionally be contaminated with inert debris and high priority organic and inorganic chemical contaminants. The level and frequency of contamination will probably be a function of the proportion of non-kitchen and non-yard wastes finding their way to the composting facility.

Additional data is expected to be forthcoming from the current Guelph pilot project. The objectives of the Guelph project are to compare organic waste capture efficiencies and compost qualities using the two stream and three stream collection methods. Compost products from both collection methods are similar and may meet MOE guidelines (City of Guelph Wet/Dry Pilot Project Summary of Preliminary Findings, 1991); however, the amount of waste collected is small enough to permit efficient hand sorting and this may account for the similar qualities (Mike Gibson, City of Guelph, personal communication).

If municipalities throughout Ontario are to be persuaded to engage in large scale composting activity to meet provincial diversion targets they must be assured that there will be markets for all compost produced. In northern Ontario, horticulture and agriculture markets are small and may be too small even for the limited amounts of compost northern Ontario could produce. There must also be a ready market for contaminated compost so it need not end up in landfill. Tailings reclamation is proposed here as a suitable alternative/addition to agricultural and horticultural markets.

The use of contaminated compost bears consideration by the province and the mining industry. If compost metal levels are quite low relative to tailings, use of contaminated compost could be acceptable where overall environmental improvements can be shown to occur. However, in examining this issue, the presence of organic contaminants may be a cause for concern and should be adressed in additon to metals. Conditions could be defined under which rejected batches are deemed acceptable as tailings cover.

6. EXTRAORDINARY SOURCES

Sewage Treatment Sludge Municipal wastewater treatment plants produce a sludge byproduct during treatment of sewage. Sludge is a material of high organic content which is readily compostable but which, unfortunately, is frequently contaminated with a large number of high priority organic and inorganic contaminants. Sludge disposal is a problem for municipalities partly because of contamination. Conversations with several municipal works departments revealed a range of sludge disposal options including landfill, incineration, and spreading on agricultural lands.

Sludge is often thickened, stabilized and dewatered before disposal. Thickening and dewatering serves to increase solids content from about 2% to about 25%. Stabilization serves to reduce pathogens, volatile organic solids (and therefore odour), volume and weight. Common stabilization methods include anaerobic and aerobic digestion, composting and lime addition (Water Pollution Control Federation 1985). Raw or digested sludge are compostable. A solids content of 50% is considered optimum for composting, hence, bulking agents are usually added to improve aeration.

Composted sludge appears to be a more desirable end-product than other forms of digested sludge because it is less objectionable and cheaper to transport; however, composting is more expensive than other stabilization methods (Water Pollution Control Federation 1985).

No reports were located on composted sludge application to artificial wetlands on tailings. However, Seaker and Sopper (1988a, 1988b) reported the results of applying a mixture of composted and anaerobically digested, dewatered sludge to terrestrial minespoils. They concluded that 'sludge amendments enhance soil formation and site stabilization in minespoil at a more rapid rate than does chemical fertilizer.' Growth of tall fescue improved on acid mine soils when soils were amended with a mixture of composted garbage and sewage sludge (Stout et al. 1982). Beneficial uses of municipal sludge is briefly reviewed in 'Water Pollution Control Federation, Manual of Practice FD-15 (1989)'.

Metro Toronto's Main Treatment Plant at Ashbridges Bay serves about 1.25 million people and produces an average of 120 to 130 tonnes per day of dewatered, anaerobically digested sludge which is incinerated. The plant could produce 10,000 tons of compost per year assuming an average solids content of 25%. It appears reasonable, therefore, to assume that at least 30,000 tonnes of composted sludge could be produced in Ontario.

The Ontario Ministry of the Environment requires that sewage sludge be stabilized by aerobic digestion or other approved methods before being spread on land. Application is restricted near surface and ground waters and sludge cannot be applied to soils with pH less than 6 because nitrification (the bacterial production of nitrate from ammonium) can lower soil pH. State and provincial regulatory requirements are summarized in Water Pollution Control Federation, Manual of Practice FD-15 (1989).

Sludge from sewage treatment plants in Ontario is typically contaminated with a suite of metals and high priority organic contaminants (Ontario Ministry of the Environment 1988). Although metal levels may be very low relative to levels present in tailings, organic contaminants may be cause for concern. Government and the mining industry should review whether composted sludge application to tailings is environmentally desirable. Provincial approval for application of digested or composted sludge to flooded tailings will probably be necessary.

Other Sources Other potential sources to be investigated include food processing plants, pulp and paper, sawmill and paper recycling plants.

7. COST ANALYSIS

7.1 Composting The cost of composting is related to the composting method and likely the scale of the operation. Commercially available composting methods have been reviewed by Diaz and Savage (1982). Composting sludge is also considerably more expensive than composting organic waste according to a review by BioCycle (1991).

In the United States, estimated operating costs ranged from US$9 per ton for a 300 ton/day solid waste windrow operation to US$85 per ton for a 90 ton/day windrow operation (BioCycle 1991, page 45) (CAN$10 - $89 per tonne). Of the 15 facilitites for which cost data were cited, operating costs for 11 ranged from CAN$26 to $52 per tonne. (Although not stated, the costs are probably expressed per ton of compost rather than per ton of organic waste.) Most sludge composting costs in the U.S. ranged between US$125 and $175 per dry ton (CAN$131 - $183 per dry tonne).

The estimated capital cost for each Metro Toronto composting facility with an annual production capacity of 75,000 tonnes of compost is $35 million exclusive of land costs. For comparison purposes I have made the simplistic assumption that Metro Toronto will debt finance the entire capital cost at 10% over a ten year period. On this basis, the annual capital payment is $74 per tonne. Assuming the operating costs will be $26 to $52 per tonne, the total annual cost will be $100 - $126 per tonne in constant dollars.

7.2 Transportation Transportation of compost in bulk is the preferred method in terms of logistics and cost. Bagging imposes extra costs on both ends (bagging and emptying) and typically produces an unecessary waste problem - disposal of bags.

Due to its relatively high moisture content, compost will freeze during winter shipment. Hence, bulk transportation would most likely be seasonal. Compost would have to be stored at or near composting facilities during the winter months.

Since transportation costs and method depend upon origin, destination and quantity, a general cost analysis was not prepared for all of Ontario. I chose instead to examine one possible scenario - shipping 150,000 tonnes of compost each year from the Greater Toronto Area to Elliot Lake via rail, truck or water. The cost estimates provided are probably on the high end since they were obtained without the benefit of serious negotiations.

CP Rail: The probable location of the composting facilities and tailing sites are relatively close to CP lines. An approximate estimate was provided by Earl Kornack, a marketing representative with CP Rail Special Projects in Toronto (telephone: (416) 863 8313). The estimate was based on the assumption that open gondola cars with a cubic capacity of 1746 cubic feet (50 m^3) would be filled to their maximum capacity of 98 tons (89 tonnes) for an assumed density of 1.8 tonnes/m^3. Gondola capacity can be increased on dedicated cars by welding walls onto the cars.

Cost:
1. Loading gondola cars in west Toronto - $2 per tonne.
2. Rail transfer from west Toronto to Spragge - $20 per tonne.
3. Unloading, transfer and trucking from Spragge to Elliot Lake - $8 per tonne.

Adding $5 per tonne to load and truck compost to CP Rail's west Toronto yard yields a total cost of approximately $35 per tonne plus GST based on a density of 1.8 tonnes/m^3. The cost of rail transfer from west Toronto to Spragge using a more realistic density of 1.1 tonnes/m^3 is $30 per tonne with a total cost of $45 plus GST.

Compost density is an important factor in transportation cost but it is difficult to estimate. Bulk density for spent mushroom compost has been reported at 0.65 tonnes/m^3 although density during transportation might be increased with an appropriate loading technique. Truck and rail loading techniques should be reviewed for their effect on density.

Trucking: An estimate of $42.35 per tonne for trucking 150,000 tonnes from Toronto to Elliot Lake based on a density of 0.5 tonnes/m^3 was provided by LCI Environmental Inc. (contact John Fowler, telephone: (416) 615 0935). Loading and unloading charges would bring the total cost to approximately $46 plus GST, about the same as rail transport.

Trucking may be the only alternative when composting facilities and tailing sites are not near rail lines or for short hauls.

Water: Shipment by water may be a cost-effective alternative when tailing sites and composting facilities are located near Great Lakes ports. ULS (contact Wayne Hennessy, telephone: (416) 920 7610) provided an estimate of $6.00 - $6.25 per tonne for shipping 150,000 tonnes from Hamilton to Spragge (northern Georgian Bay) based on a density of 0.5 tonnes/m^3. This estimate includes all charges against the vessel (but not the cargo), lockage and harbour charges but excludes trucking, Seaway charges against the cargo, wharfage and stevedoring. It assumes that the ship is a full sized lakes self unloader (40,000 m^3 or 20,000 tonne capacity) and a 'fast as can' cargo discharge (unloading) rate of 5 to 8 hours. Eight monthly consignments of 20,000 tonnes each are required. As bulk cargoes are not readily handled at the Toronto Harbour facilities, I was directed to Seaway Terminals in Hamilton, a private wharf owner/operator (contact Ken Gange, telephone: (416) 528 8741). Loading is expected to take 4 to 5 days. The Spragge wharfage and stevedoring costs were provided by Reiss Lime Ltd. in Blind River which owns the harbour facility (contact Al Lucas, (705) 849 2201).

Total charges:
1. Loading and trucking to Hamilton Harbour $5/tonne,
2. Shipping from Hamilton Harbour to Spragge $6.00 to 6.25/tonne,
3. Welland Canal cargo toll of $0.52/tonne,
4. Wharfage fee in Hamilton: no charge for storage of 20,000 tonnes for 30 days, $0.50 per tonne thereafter,
5. Scale-in and loading at Seaways Terminal in Hamilton Harbour $2.50/tonne,
6. Stevedoring cost in Hamilton of $7.50/tonne,
7. Hamilton Harbour cargo charge of $0.4405/tonne,
8. Stevedoring (throughput) cost in Spragge of $2.50 per tonne,
9. Trucking from Spragge to Elliot Lake $5/tonne.

The estimated total shipping charge is $30 per tonne plus plus GST which is significantly less than rail or trucking.

How many trucks are required at each end? Approximately 670 truckloads with a capacity of 30 tonnes per truck are needed to move 20,000 tonnes each month or an average of 30 truckloads per 7.5 hour work day. If a round trip between wharf to facility takes 2 hours, then a minimum of 8 dedicated trucks will be required at each end. If it takes 15 minutes to load 30 tonnes into a truck, then 30 trucks can be loaded each day assuming a 7.5 hour day and one set of loading equipment.

The above analysis was intended to serve only as a guide. The choice of transportation method will depend in the end upon the locations of producers and end users and quantity.

7.3 Solid Waste Management Policy Implications The cost of landfilling is probably less than $50 per tonne in most municipalities whereas estimated composting costs are $100-$126. In Metro Toronto private haulers pay a landfill tipping fee of approximately $150 per tonne while area municipalities pay much less. In effect, residential waste disposal is significantly subsidized by the private sector. Although private sector tipping fees will subsidize centralized composting to some degree, there appears to be little or no financial incentive for municipalities to divert waste from landfill and engage in centralized composting without provincial incentives or 'encouragement' to meet diversion targets.

We can expect that municipally owned composting facilities, even if they do not pay the full tipping fee, will choose to ship excess or contaminated compost to a tailings site rather than landfill it because of these same incentives. The incentive for privately owned composting facilities will be financial - it is cost-effective to ship compost to a potential tailings site and avoid high landfilling fees.

These arguments are predicated upon the assumption that the mining industry will not pay for compost but would be a willing recipient.

8. TAILINGS RECLAMATION PROGRAMS AND METHODS

8.1 Reclamation Programs The seriousness and extent of AMD in Canada has prompted the mining industry and the federal and several provincial governments to cooperate in investigations of innovative methods for long-term, environmentally effective management of tailings that would allow mine operators to walk away from a site after closure with minimum subsequent long-term active management. According to the federal government, "Over 15,000 hectares of acid-generating mine wastes have been identified at operating mine sites in Canada. Site rehabilitation would cost more than $3 billion during the next 15 years, a cost unacceptably high to the mining industry if it is to remain competitive. Some [abandoned] sites are the responsibility of the Crown and solutions to AMD are, therefore, of significant interest to the public through provincial and federal governments" (CANMET fact sheet). In Ontario, 2000 abandoned mine sites have been identified and at least 20 sites covering 830 hectares pose an AMD problem (Feasby et al. 1991). Responsibility for reclamation of abandoned tailings rests with the Ontario Ministry of Northern Development and Mines.

In response, the Canada Centre for Mineral and Energy Technology (CANMET) of Energy, Mines and Resources Canada, initiated the Mine Environment Neutral Drainage (MEND) program with representation from federal, provincial and industrial interests. "MEND is a co-operative research organization sponsored, financed and administered by the Canadian mining industry, the Federal government and the provinces of British Columbia, Manitoba, Ontario, Quebec and New Brunswick" (MEND Annual Report, 1991).

Some 34 MEND sponsored research programs have been initiated since 1988 with a budget of $4.8 million and 21 projects were completed by the end of 1990. Research and development have been undertaken in 5 main areas: AMD prediction, prevention and control, treatment, monitoring and technology transfer. Prevention and control has received the largest budget. "Some of the most promising results have been obtained during the studies into the prevention and control of acidic drainage using barriers and solid covers" (MEND Annual Report, 1991).

Choice of reclamation method is site-specific, for example, flooding may not be appropriate at all sites. Nevertheless, revegetation should be a goal in all reclamation projects for reasons of aesthetics and erosion control.

After a series of studies and a review of reclamation approaches, Rio Algom Limited has recommended the wet tailings approach for the decommissioning and reclamation of its Quirke Mine tailings (Balins et al. 1991). The objective is to raise the water table, maintain ponded water and promote vegetative growth. Flooding of one of the five engineered cells at the Quirke site, Cell 14 with a ponded surface area of 64 hectares, began in the fall of 1991 and should be completed by the summer of 1992. The remaining cells should be flooded by 1993 for a total ponded surface area of 192 hectares. The common cattail, Typha latifolia, will be planted in the shallow flooded areas (Al Vivyurka, personal communication). The cattail is a good candidate to initiate colonization because it is present in local wetlands, it is tolerant of metal-laden, very acid conditions (Kalin and van Everdingen 1987) and because it reproduces vegetatively via rhizomes (horizontal underground stems which produce emergent plants at intervals).

Rio Algom has also initiated a small field study of the effects of cover on AMD generation (Al Vivyurka, personal communication). The study design utilizes twelve 8 m by 11 m plots (six treatments in duplicate: no flooding, shallow flooded, deep flooded, compost cover, organic cover with cattails, cattails without cover). The water table in the non-flooded plots will be maintained about 1 m below the surface; all other plots will be flooded.

Falconbridge has recently completed a small field study of the effects of organic matter application on AMD production rates in irrigated test plots and is about to embark on further studies involving literature reviews and lab and field testing under the auspices of the MEND program (Mark Wiseman, Falconbridge, personal communication).

Development of policy and planning and successful implementation of tailings reclamation projects with municipal compost will require the cooperation of many interested parties in Canada. For example, the federal government through Energy, Mines and Resources is a co-sponsor of MEND research program. Environment Canada would also be an interested party. Provincial governments are responsible for setting and administering environmental policy. In Ontario, several Branches of the Ministry of the Environment are involved (Water Resources Branch, Waste Management Branch and Waste Reduction Office set policy while Approvals Branch and regions administer policy). The Ontario Ministry of Northern Development and Mines (MNDM) is involved in tailing operations and rehabilitation and both Ministries participate in the MEND program. Municipal governments are charged with responsibility for developing municipal solid waste master plans and for soild waste diversion and disposal under the direction of provincial governments. The mining industry, of course, is responsible for managing tailings at operating sites (government is responsible for abandoned sites, specifically MNDM in Ontario) and the solid waste management industry may be asked to provide composting technology and services.

Over 400 wetlands have been constructed on mined lands in the bituminous coal region of the eastern U.S. for acid water treatment in climates which are considerably warmer than northern Ontario (Kleinmann et al. 1991). The U.S. Bureau of Mines is conducting a long-term evaluative study of many of these sites (Kleinmann and Girts 1987). Preliminary results from 20 wetlands surveyed by 1987 indicate that wetlands dominated by emergent plant species out-performed Sphagnum-dominated (moss) wetlands and that much of the water treatment was accomplished by diverse communities - bacteria, algae and plants - and by amendments such as mulch. The authors noted that survival of cattails was high in mine water with a pH of 3 or greater, with little replanting necessary and considerable spreading during the second growing season. The effectiveness of the constructed wetlands in meeting regulatory compliance was not evaluated.

The Tennessee Valley Authority (TVA) is in the process of planning and/or operating fifteen constructed wetlands for treating coal-related AMD. "TVA's experience suggests that constructed wetlands alone may be appropriate and very effective for treating weak to moderately polluted acid drainage on a long-term basis" (Brodie 1990). The wetlands are designed to promote biological diversity and appear to be fertilized with phosphorus and potassium in the first year of operation. The studies apparently did not include unfertilized controls to examine the effectiveness of fertilizer applications in attenuating AMD.

The U.S. wetlands have been constructed primarily to treat acidic effluent rather than prevent AMD formation because the AMD originates from undergound seepages, hence, the studies have focussed on attenuation processes (reduction of metal concentrations and neutralization of acidity). The design of Rio Algom's Quirke tailings reclamation project differs somewhat in that their wetland system is built entirely on tailings in order to minimize AMD formation.

In general, retention of metals other than iron was very site specific and was apparently a function of biological structure (Dollhopf et al. 1988; Dave and Lim 1989; von Michaels 1987) and hydrology (Knight 1987; Dierberg et al. 1987).

8.2 Wetland Reclamation Methods Ecologically, differences between flooded tailings and engineered sites will depend on the degree of moisture saturation maintained. This report assumes that both methods maintain a high degree of saturation and therefore discussion of wetland ecology is pertinent to both.

The central hypothesis proposed here is that the rate of AMD formation in flooded tailings or from sites with engineered covers will be lower and the rate of AMD attenuation will be higher in a biologically productive system with stable, mature, diverse wetland flora and substantial organic sediments than in an unproductive system with sparse flora and no organic sediment. The rationale for this is (i) heterotrophic microbial oxygen consumption in aquatic sediments is a function of annual wetland productivity, hence, increased productivity which is a function of diversity will ensure an effective oxygen barrier in organic sediments above the tailings, (ii) a stable, mature, diverse floral community is supported nutritionally and physically by sediments and the floral community in turn maintains a constant input of new organic detrital material to the bottom sediments with each annual growth/dieback cycle, (iii) AMD attenuation is a function of many biological processes (Dave and Lim 1989; von Michaels 1987) which implies that biological productivity and diversity should be promoted, (iv) biological cover reduces transport of suspended tailings material downstream and (v) organic substrate has a relatively high ability to retain moisture which helps wetland communities withstand drought conditions.

One example of a desirable biological process is sulfate reduction by bacteria which proceeds under highly anoxic and organic carbon-rich conditions. Reduction of sulfate to sulfide results in the formation of certain insoluble metal sulfides, particularly iron sulfide, and production of alkalinity (Stumm and Morgan 1981; Rudd et al. 1986; McIntyre et al. 1990). Hence, bacterial sulfate reduction is the antithesis of the oxidation of sulfide minerals which produces sulfuric acid in tailngs.

Oxidation of sulfide minerals could take place even under continuously saturated conditions if the rate of water movement through tailings is sufficient to supply oxygen (Kalin and van Everdingen 1987). It is possible, therefore, that AMD formation may occur at some locations in the Quirke Mine tailings although the overall rate is expected to be very low. Elevated metal levels would then be expected in these locations. The rate of AMD formation is probably related to the hydraulic residence time (Knight 1987; Dierberg et al. 1987; Dillon and Rigler 1974; Dillon and Molot 1990).

The oxidized zone (zone with oxygen present) in the bottom sediments of natural lakes, ponds and wetlands typically does not extend more than 2-4 cm below the sediment/water interface. In very productive (eutrophic) systems, surficial sediments are anoxic even when the overlying water column is oxygenated although a high annual nutrient loading rate is required to maintain a eutrophic state.

Undisturbed sediments exhibit a vertical redox potential gradient. The gradient is associated with a vertical sequence of microbially-mediated redox reactions beginning with reduction of O_2 (e.g., aerobic decomposition of oragnic matter) at the sediment surface when O_2 is present and followed in descending order by denitrification, nitrate reduction, fermentation, sulfate reduction, methane fermentation, and hydrogen gas formation (Stumm and Morgan 1981). Denitrification and sulfate reduction have been shown to important alkalinity producing reactions in atmospherically acidified systems (Rudd et al. 1986). Maintenance of vertical redox gradients in sediments, i.e. maintaining undisturbed sediments, will be vital to maintaining the effectiveness of artificial wetlands. Emergent vegetation are essential to maintenance of undisturbed sediments in large, shallow ponds because they reduce wind shear at the water surface.

It is hypothesized that a single addition of compost is sufficient to 'jump-start' an artifical wetland and accelerate the formation of a mature floral community. Nutrient loading from natural sources such as direct atmospheric deposition, weathering, etc. should then be sufficient to nurture and maintain a productive community. **The compost application rate should be such that reducing conditions capable of supporting sulfate reduction are well within the organic layer.**

Although the nutrient content of compost is insufficient to be technically classified as a fertilizer, several studies have shown that compost promotes plant growth, presumably because of its nutrient content and physical properties. The application of a mixture of composted and anaerobically digested, dewatered sludge to terrestrial minespoils resulted in enhanced soil formation and site stabilization compared to application of chemical fertilizer (Seaker and Sopper 1988a, 1988b). Growth of tall fescue improved on acid mine soils when soils were amended with a mixture of composted garbage and sewage sludge (Stout et al. 1982).

The mean total phosphorus concentration of compost from the Guelph pilot project was 0.32% and the nitrogen/phosphorus ratio was 4.8. For comparison, typical surficial sediment phosphorus concentrations in unproductive Ontario Lakes ranged from 0.05 to 0.3% with nitrogen/phosphorus ratios of 8 (Dillon et al. 1990). Although phosphorus levels are probably sufficient to support plant growth, nitrate amendments might increase productivity and raise the pH. (Biological consumption of ammonium produces acidity, hence, ammonium should never be added to acidic systems.) The wetlands could also be amended with other nutrients, minerals and finely ground calcite upon construction.

Wetlands used for AMD treatment and prevention may result in exposure to and accumulation of high levels of metals by wetland flora and fauna with potentially toxic results (Dollhopf et al. 1988). Body burden analyses and bioassays (e.g. rainbow trout toxicity tests) should be an essential element of monitoring programs.

9. CONCLUSIONS AND RECOMMENDATIONS

1. Construction of artificial wetlands is, in general, a viable technique for AMD prevention and attenuation. The technique has been successfully applied in the U.S. to treat acidic effluent rather than prevent AMD formation. Retention of metals other than iron is very site specific and is apparently a function of biological structure. The effectiveness of engineered covers is unproven.

2. The effectiveness of artificial wetlands or engineered covers is enhanced when organic material is added. However, sufficient quantities are in short supply near many tailing sites. Composted municipal organic waste may be a suitable source of organic material for tailings reclamation projects.

3. Solid waste management policies are rapidly developing in Ontario to the point where large scale composting is being seriously considered by provincial and municipal governments in order to meet provincial waste diversion targets. If municipalities throughout Ontario are to be persuaded to engage in large scale composting activity to meet provincial targets they must be assured that non-landfill uses are available. Tailings reclamation is proposed as a suitable alternative/addition to agricultural and horticultural markets. Furthermore, tailings reclamation may be an acceptable non-landfill use for contaminated compost.

4. The 'operationally obtainable' organic waste fraction is assumed to be 17% of the total waste stream in Ontario. This percentage is derived by assuming an organic waste fraction of 24%, a participation rate of 90% and a capture efficiency of 80% across all sectors in Ontario. The 'operationally obtainable' organic waste fraction could produce approximately 680,000 tonnes per year of compost assuming a 50% weight loss during composting. All of Ontario's annual compost production would cover 136 hectares to a depth of 1 m assuming a bulk density of 0.5 tonnes/m^3. Given that approximately 15,000 hectares of tailings are in need of reclamation, unlimited composting application could occur for many decades. About 30,000 tonnes of composted sewage sludge could also be produced annually.

5. The three stream waste collection method will most likely be implemented in Ontario. The method should minimize contamination levels and produce compost which meets the Ministry of the Environment's guidelines for unrestricted use. Nevertheless, some compost batches will likely not meet the guidelines for unrestricted use.

6. The legal and environmental ramifications of contaminated compost application to tailings must be addressed.

7. The rate of compost application to flooded tailings should be such that reducing conditions capable of supporting sulfate reduction are well within the organic layer. This operational criterion is best translated into tonnes/m^2 empirically.

8. Coordination of composting and tailings reclamation policies is essential for success. A policy planning group should be formed consisting of representatives from the mining industry, composting industry, municipalities (perhaps from an umbrella organization of municipalities), the Ontario Ministry of the Environment (Water Resources Branch, Waste Management Branch, Waste Reduction Office and possibly Northeast and Northwest Region offices), the Ontario Ministry of Northern Development and Mines, Environment Canada and Energy, Mines, Resources Canada (CANMET).

9. Criteria should be developed governing conditions under which contaminated compost is deemed acceptable as tailings cover. Liability concerns should also be addressed.

10. Test plots and pilot field projects are needed to evaluate the effectiveness of compost application.

10. ACKNOWLEDGEMENT

This work was funded by Laidlaw Technologies Inc.

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MIXED MSW COMPOSTING OBSTACLE OR OPPORTUNITY?

by

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November, 1992

1. SYNOPSIS

The objective of an advanced waste management program is to achieve the maximum diversion of waste from landfill in the most economical and environmentally sound manner possible.

While the majority of MSW (municipal solid waste) consists of compostable components such as yard and wood waste, paper, and food waste, it is estimated that approximately 42% of MSW is potentially available for composting after reasonable (or currently achievable) reuse and recycling have taken place. The amount of MSW that can actually be diverted from disposal through composting depends upon collection methods and compost technology employed.

This presentation examines the factors and criteria related to engineering a composting system which incorporates proven components while meeting prevailing and developing standards.

The concept of MSW processing as a means of achieving efficient diversion through composting, while ensuring that the product quality conforms with required standards, is one that has met with resistance from some established and traditional schools of thought. The principal argument presented in opposition to any form of MSW composting is the concern over product contamination.

This paper examines the respective roles, including advantages and disadvantages of principal composting concepts. These are generally comprised of wet/dry collection, streamed collection, and mixed MSW selected collection processing. The effectiveness of yard composting at individual properties is also reviewed briefly in this overall context.

The concept of mixed MSW composting merits serious consideration as a vehicle which can achieve significantly increased waste diversion in an effective and economical manner. While there may be reservations with respect to compost quality and reduced recovery and recycling of some potential recyclables, these concerns are likely less significant than initially perceived.

Restricting composting to source–separated feedstock only may possibly permit the recovery and recycling of greater quantities of paper products. However, in many waste streams, a significant portion of the paper waste (corrugated cardboard, newsprint, packaging, boxboard) is soiled or contaminated by other components of the waste stream, or by the materials originally contained by the paper product. Furthermore, markets for recovered paper products are not yet expected to be able to absorb the quantities which would be available through almost full-scale recovery efforts. Because of these factors, the processing of mixed MSW, which also contains soiled or non-recoverable paper products, provides an effective and practical means of recycling these materials.

With respect to the issue of compost quality, many communities are pursuing programs to discourage the disposal of toxic or hazardous materials (batteries, chemicals, paints, cleaning products, etc.) in the regular garbage stream. Additional efforts include the establishment of household hazardous waste programs to provide a safe alternative for the disposal of these materials. By selecting and blending appropriate feedstock streams from residential and commercial sources, monitored by suitable quality control procedures, mixed MSW composting can be used to generate a high-quality compost product while maximizing waste diversion at an economical cost.

2. INTRODUCTION

Any effective large-scale composting operation, whether for mixed MSW or separated feedstock, should incorporate proven components designed to meet the following goals:

- establish necessary facilities and infrastructure (i.e. central composting plant) with assured flexibility to be able to evolve with developing collection practices and public requirements.
- develop a system to direct a broad range of acceptable compostable material to a central composting operation.
- provide a high level of process control to minimize environmental impact of the facility and to produce a quality compost
- assess capability and suitability of source separation and plant separation techniques, building on existing practices and minimizing inefficient changes or costs at the generator/collection level
- if required, incrementally adjust either separation techniques or generator/collection system to obtain quality compost in an economically effective manner.

Generally, feedstocks for a central composting facility could be obtained from:

- selected streamed organic materials (i.e. yard and food waste) from designated municipal, horticultural, and commercial sources.
- source-segregated organic waste obtained from trial residential curbside collection programs.
- mixed MSW from residential and other appropriately selected sources. Note that Blue Box materials and bulky refuse would normally be collected separately from the MSW stream.

If mixed MSW operations are successful in producing compost of acceptable quality, the need for expensive separation, collection and transportation of organic materials will be eliminated. Under the worst quality conditions, composting mixed MSW may still provide the following significant benefits:

- materials recovery potential and up to 70% volume reduction.
- landfill surface restoration.
- organics are stabilized to eliminate leachate (ground water pollution) and to eliminate the production of methane gas (air pollution).

An essential element for the success of a progressive waste management program is the removal, collection and treatment of hazardous waste including: paints, solvents, pesticides, batteries, motor oil, and pharmaceuticals. In order to increase the separate recovery of hazardous waste, several options may be considered. These are:

- a mobile facility at strategic locations
- permanent satellite facilities
- home pick-up or "Toxics Taxi"
- curbside collection.

The current best practices for composting are constantly being advanced. Performance and compost quality criteria are still being developed by the Ontario Ministry of Environment and federal regulatory agencies.

Many of the current development projects in MSW composting are focusing on wet/dry collection methods, which involve the separate collection and processing of household and commercial organic waste streams. A further level of development can include central processing of mixed MSW to extract and compost acceptable organics. This aspect has the potential to complement the efficient and continuing use of established Blue Box systems.

Also, the relative financial viability of mixed MSW collection and processing, versus segregated wet/dry options, is an important factor to be examined in evaluating the overall feasibility rating of various system options.

As with all waste conversion and recycling operations, the major challenges are first to divert materials from disposal by producing a desirable product that can be marketed and sold, and second to develop markets. Output products can be distributed to progressively developed market outlets. Initially, these would include uses which do not generate revenue, such as municipal horticultural applications and landfill site restorations. In planned stages, income producing outlets would be developed, as the compost product demonstrates a desirable commercial profile in terms of consistently high quality and practical usefulness.

3. COMPOSTING PROCESS AND BENEFITS

Composting is a natural process that breaks down or biotransforms organic material, such as household garbage and yard waste, into a soil-like product rich in humus and microbial life, known as compost. It involves controlled mixing of organic materials with moisture and air to encourage a natural decay process. Characteristically, compost is dark coloured, relatively odourless (slightly sweet musty smell), unattractive to flies, and free of viable weed seeds and harmful pathogens.

The recent report of the Federal-Provincial Agricultural Committee on Environmental Sustainability states that; "Overcoming soil deterioration is one of the greatest challenges that must be met if the future of the Canadian agricultural and food sector is to be assured."

Agriculture Canada recognizes and promotes composting as a means of reversing soil degradation and restoring soil organic matter (humus). Also, large-scale composting can assist in reversing the worldwide depletion of natural peat bogs.

Compost promotes good tilth (physical texture) of the soil, while adding conditioning elements and nourishing vegetation. It moderates the effects on soil caused by physical and chemical stresses such as compaction, erosion, and acid rain. In turn, aeration, moisture content, and thermal conditions of the soil are improved measurably.

Compost or humus is known to provide excellent protection against heavy metal absorption in plants, as it converts the metals into a form which cannot be assimilated readily by vegetation.

It is a recognized and accepted fact that organic waste can be reduced in volume and weight by as much as 40% - 60% by composting. Also, organics are stabilized through composting to eliminate leachate (ground water pollution) and to eliminate the production of methane gas and odours (air pollution).

Depending on the extent of existing recycling and source separation programs, between 30% and 75% of the MSW stream consists of organic materials that are compostable. This material includes food waste, yard waste (grass, leaves and branches), paper, and miscellaneous organic waste such as textiles, leather, and wood products. Composting also provides an excellent option for reclamation of soiled paper waste which is not suitable for conventional recycling.

In the composting process, putrescible organic matter is transformed biologically to simpler compounds and biomass with the accompanying release of heat, water vapour, carbon dioxide, and trace ammonia. This transformation is performed by naturally occurring microorganisms and bacteria.

The objective of composting is to recover and recycle acceptable biodegradable materials from agricultural, commercial, and municipal organic wastes in an environmentally acceptable and cost efficient manner, and to produce a marketable end product. The attendant benefits include:

- conversion of a reusable waste resource to a stable and useful product as a soil amendment and mulch medium.

- reduction of pollution potential of organic waste (odour and methane in air, and leachate in ground waster).
- reduction in organic waste volume and weight (approximately 50%), thereby permitting more economical handling and utilization. The mixed MSW component stream will be reduced approximately 70% by volume (up to 55% by weight) because of the removal of non–compostable items such as plastic, metals and glass.
- destruction of various stages of nuisance insect pest activity, including breeding and propagation of flies.
- elimination of most pathogenic organisms, rendering a sanitary compost product.
- elimination of viable seeds, particularly weed seeds.

In summation, composting reduces the bulk of organic material, concentrates and conserves nutrients, and sanitizes the waste to produce a humus–rich additive that conditions soils and nourishes crops.

4. REVIEW OF COLLECTION METHODS AND COMPOSTING TECHNOLOGIES

4.1 Background

Many communities are attempting to pursue responsible and resourceful planning in introducing suitable and progressive solid waste programs which provide convenient and environmentally sound disposal services for the residential and business sectors.

A typical simplified regional waste management model may include any or all of the following landfill waste diversion measures:

- Transfer Station waste separation and disposal restrictions:
  20% diversion
- Corrugated and Wood Recovery Systems:
  8% diversion
- Municipal Composting Program:
  25% diversion
- Extended Blue Box Collection System:
  12% diversion
- Materials Recovery Process Centre and RDF (Refuse Derived Fuel) Plant:
  35% diversion.

Other specific measures can include:

- restrictions on waste accepted at municipal facilities, coupled with increased disposal fees, to encourage generators and haulers to pursue other viable waste recovery and diversion options for the purpose of:
  - encouraging reduction in waste generation,
  - conserving valuable landfill space.
- improved waste control and Household Hazardous Waste programs, to reduce undesirable contamination in the waste stream.
- landfill mining and resource recovery.
- implementation of a waste processing operation to produce quality compost to serve as a soil amendment.

The execution of all combined strategies can be projected to achieve a 75% total reduction/diversion of landfill quantities.

Routine management measures often consist of "hard" strategies which involve the establishment and operation of physical infrastructures, such as processing plants, landfill sites, transfer stations, collection systems, Blue Box programs, and backyard composting. Improved approaches recognize that effective waste management requires a balanced combination of "hard" and "soft" strategies. The latter measures consist of activities such as 4R's promotion and education, comprehensive short–term and long–term planning, appropriate regulatory policies, and research and development. Also, tipping fee incentives are combined with waste restriction policies in conjunction with co–operative guidance for refuse generators, to further reduce landfilling and incineration. These measures can make it possible to achieve significant diversions at relatively low costs, prior to addressing the balance of the waste stream which requires more expensive measures.

Multiple co–ordinated measures are necessary to achieve and maintain effective reduction and diversion objectives; a restricted program limited to only one or a few measures cannot be relied upon to meet current and long–term waste management goals.

4.2 Alternative Composting/Collection Methods

The success of recycling depends to a great extent on the waste collection method. In order to maximize recycling, and optimize the use of facilities, the following factors are important operational elements for consideration:

- hazardous waste control.
- source separation of waste stream components.
- uniform collection strategies.
- control of the movement of collected wastes and recoverables to the appropriate designated facility.

As waste collection methods mature, improved source separation of waste stream components will result, and recycling will increase. Within several years, it is anticipated that most single-unit residences and large-volume commercial generators of "wet" organic wastes will perform source-separation of these materials. Nevertheless, it is recognized that collections from multi-residential complexes may continue to require processing of a mixed MSW stream.

For these reasons it is prudent to establish mixed MSW composting in parallel with streamed and source-segregated feedstock processing.

Three of the available basic composting process concepts include "Selected Streaming", "Wet/Dry", and mixed MSW methods, for use in conjunction with a compost processing technology which converts the organic fraction into finished compost. A description and summary of a general assessment related to these three methods is presented in the following commentary.

i) Selected Streaming

Streaming involves collection of selected wastes which are generated in a relatively pure condition with few or no contaminants present. Numerous commercial and municipal activities generate relatively large quantities of narrow-stream unadulterated vegetation and food matter. This can be introduced directly into the composting process with little or no preparation.

ii) Wet/Dry

Some communities in Ontario are experimenting with this relatively new concept, Wet/Dry Collection. This method, used in conjunction with municipal composting operations, normally requires separate collection and processing of compostable (wet) and recyclable (dry) fractions of the waste stream. Two variations of the Wet/Dry concept are currently envisioned.

a) The "Two Stream" method requires households to deposit compostables into a "wet" materials receptacle. The remainder of the waste stream, consisting of both recyclable and non-recyclable material, is placed into a "dry" materials receptacle. Both fractions are collected separately at curbside and processed in a separate operation.

Advantages:

- good feedstock and final product quality for the wet stream process. Because manual source segregation depends on voluntary effort, contaminants will be present though minimal. These can be removed by screening, magnetic separation and density separation. Contaminants were evident in the "wet" stream being composted in the City of Guelph pilot program.
- not subject to "Blue-Box" market fluctuations if markets diminish or collapse.

Disadvantages:

- larger volume collection requirements.

  The "Dry" stream mix collection requirements would be three to four times greater than the current Blue Box stream because it includes bulky dry wastes which are normally collected in compactor trucks. Such a mixed garbage stream is expected to necessitate significant processing and manual separation to recover recyclables. Because of its increased combined volume, and the need for voluntary segregation, extensive contamination of the "dry" stream is expected. For example, residents are expected to encounter difficulties in determining whether to deposit certain materials in the "dry" stream or "wet" stream. Typical wastes of this nature which are prevalent in MSW include soiled paper products (i.e. pizza boxes, disposable diapers) and animal faeces.

- loss of Blue-Box program and the associated individual participation, and revisions to existing collection and processing methods.

  Management of a "dry" stream mix will require an entirely different collection and processing system than used for the Blue Box program. The several years of development for the Blue Box program would be lost and the established systems would become largely obsolete.

  One important area of concern relates to the elimination of the Blue Box and the collection of "Wet/Dry" materials. At present, there is no successfully demonstrated collection vehicle which can collect both streams simultaneously and efficiently. A unique difficulty is presented with respect to the significant seasonal variations which occur in the wet waste/dry waste ratio, and its implications for the sizing of wet and dry compartments in single-stop collection vehicle bodies. If double collection activities are required, this represents a reduced level of efficiency in comparison to the current double collection system for Blue Box and waste materials. In conventional Blue Box and MSW collections, waste is usually compacted for efficient collection and transportation. Because the recoverable Blue Box components are usually collected separately from the waste stream, compaction of the refuse stream does not impede materials reclamation operations. However, in a "Wet/Dry" system, the "dry" stream must be collected and transported in a relatively uncompacted state for recyclables to be of any value.

  If the collection and transport of the "dry" stream is to be conducted in an uncompacted condition, it will be necessary to replace existing collection fleets with loose-loading large-bodied vehicles. As the "dry" fraction constitutes the greatest volume of materials in the waste stream, on an annual average, the significantly expanded demand of handling this component in this manner is not considered to be a desirable or efficient course of action.

While it may be possible to moderate the additional expense of separate collections by resorting to alternate week pick–ups, the departure from standard weekly collections may be difficult to implement, and may create unsanitary conditions.

- extensive hand sorting of the dry stream is expected in order to maintain cross–contamination within acceptable limits; operational scale "mixed dry stream" material recovery facilities are not proven.

b) The "Three Stream" system requires that the "dry" fraction be further separated, into recoverable components, and waste for discard. Each of these three fractions is collected separately at curbside, with the "wet" and "dry" (Blue Box) recoverables being directed to recovery centres for processing, and the waste being delivered to landfill.

This method is beneficial in improving the quality of the recoverable stream, without disrupting existing Blue Box programs, and it permits effective compaction truck collection of unusable wastes. However, overall efficiency is compromised by the need for three separate collections. The most certain method of ensuring that recoverables streams contain minimal contaminants is to provide multiple collections. Ideally, all waste components would be segregated into several discreet categories, such as:

- Blue Box recoverables
- Organics
- Garbage
- Hazardous Waste
- Bulky Trash
- Christmas Trees
- White Goods

In practical terms, the monetary and energy investments required for extensive multiple collections, and the time needed to develop and apply the necessary infrastructure and community orientation may be onerous at this time. Therefore, the use of the existing methods of collection together with a structured plan for progressive future requirements and changes, may be selected as an appropriate approach.

Advantages:
- retains Blue Box program
- good feedstock and final product quality for the dry and wet recovery stream
- good contaminants control
- permits effective compaction truck collection of unusable wastes
- personal empowerment of individuals to contribute to environmental solutions
- improved community awareness.

Disadvantages:

- resistance to participation because of perceived inconvenience of conducting 3 sorts and maintaining 3 containers
- increased collection costs.

Equipment development is being pursued to produce a multi-compartmented collection vehicle, so that more economical single-pass collection can be practised.

iii) Mixed MSW Composting

This concept relies upon established two-stream collection methods which are in place under existing Blue-Box programs. Blue-Box materials continue to be separated and handled in the existing manner, and the remaining mixed municipal solid waste is delivered to the composting process facility. In this operation, the mixed waste passes through separation and screening stages to isolate clean compostables from non-compostables.

This system builds upon the successful established Blue Box program by supplementing it with a process, consisting of proven components, which efficiently separates compostable organics from the remaining discards.

The Blue Box programs in most communities function well and produce high quality recycled products. It is projected that existing operations can be expanded to divert up to 30% of the curbside municipal waste stream, however a relatively high cost is associated with all Blue Box programs. It is recognized that a minor, but measurable quantity of household recoverables is still deposited into the waste stream for disposal, rather than into the Blue Box program. However, current indications suggest that this practice is gradually declining. Consequently, cancellation of Blue Box activities would be a regressive measure; in comparison, processing of the remaining waste stream to produce compost becomes an increasingly viable option. Because most of the dry recyclable materials are diverted to Blue Boxes, the MSW compost process stream can be collected and delivered efficiently in conventional compactor trucks. Preparation of compost from this stream can be done in a relatively straightforward and dependable manner.

The concept of mixed MSW composting has not been previously considered in as much detail as wet/dry systems, for Ontario. With this system, the potential level of contamination of the compost stream may be somewhat greater than with a discreet "Wet/Dry" collection system. However, the current and proposed measures emerging for waste control can be instrumental in reducing contamination to nominal or insignificant concentrations.

These measures include:

- active public promotion and education of the 4R's and acceptable disposal practices.
- development of a progressive Hazardous Waste disposal program.

Furthermore, the specific design applied to separation, screening, and operation of a mixed MSW composting process, will effectively separate and remove most or all undesirable contaminants from the product stream compost. Functional assessments suggest that the large-scale separation of compostable organics from a mixed MSW stream may be performed more efficiently and successfully than can the separation and processing of multiple recoverable streams from a mixed "dry" MSW stream.

Cross-contamination of any significance that occurs in a mixed MSW composting process usually involves adherence of small quantities of the organic fraction to the discard residue fraction. This contamination is inconsequential because the residues will be discarded. If the residues are directed to a useful application in the future, they can be washed and screened to remove organic soiling.

Measures for waste stream management and control are expected to progress gradually to become more finely attuned to the needs of the 4R's programs. This is currently reflected in the increasing awareness and active participation being demonstrated by many community sectors. With these developments, it will be possible to direct progressively increasing quantities of source-segregated and selected organic streams to the composting facility. The mixed MSW stream will also contain diminishing quantities of contaminants, thereby facilitating more efficient plant processing, and yielding an improved product.

Advantages:
- builds on Blue Box program
- broad community acceptance and participation
- greater landfill diversion potential than "Wet/Dry" system
- little or no impact on existing waste collection systems.

Disadvantages:
- greater potential level of contamination of the compost stream than "Wet/Dry" system.

One perspective expressed about mixed MSW composting is concern that the provision of a system which automatically segregates and recycles the wet organic fraction, without the conscious effort and participation of individuals, serves to perpetuate the "status quo" of irresponsible and excessive waste generation and disposal habits. It is true that more detailed "hands-on" involvement by individuals, in the separation and handling of their own waste, will promote greater environmental awareness. Possibly, each individual could be required to segregate each discrete component of their waste stream into separate containers or segments, and then deliver their own waste personally for disposal or recycling, and be further required to pay a representative user fee for their personal waste disposal.

While this option would provide significant incentives for individuals to revise wasteful habits, it is unlikely that it would be applied or accepted successfully across the broad community. Therefore, it appears reasonable to build upon currently established successful systems. The mixed MSW composting concept does not diminish the current profile and awareness of the 4R's. Because Blue Box activities are retained without disruption, citizen participation is at least as involved as the two-stream Wet/Dry method. While the three-stream Wet/Dry method adds a further level of awareness and involvement, this gain must be weighed against the additional container and collection costs of the three-stream system, and anticipated resistance to participation. By combining a mixed MSW composting operation with the present Blue Box System, with added education and publicity related to composting activities, it is believed that citizen awareness and involvement will increase noticeably from present levels.

It is necessary to also test and compare the overall feasibility of Wet/Dry options, selected streaming and mixed MSW processes, at a suitable automated scale to assist in the development of more extensive information about their strengths and weaknesses. Data about the quality of compost obtained from Wet/Dry collection indicates favourable results; however, the broad effectiveness and feasibility of this method needs to be substantiated, and warrants evaluation under controlled conditions. There is also a particular lack of data concerning the quality of "dry" recoverables obtained through Wet/Dry collection programs. At present, even the relative advantages of both 3 stream and 2 stream wet/dry programs are still unresolved, as are the collection aspects of these systems. Preliminary pilot-scale results noting good quality of recoverables, and minimal contamination, are based upon extensive hand-sorting of materials. Alternately, there is a significant lack of sound recent data respecting the quality of compost derived from mixed MSW utilizing modern technology. One important consideration is to assess the quality of compost derived from mixed MSW, to determine if prevailing standards can be met. If trials are successful, the economic benefits, in comparison to wet/dry collection systems, will be substantial. If the trials establish that compost produced from mixed MSW is not of acceptable quality, production and investigation activities can focus on source-segregated and selected streamed feedstocks, and associated operations. If necessary, incremental changes to collection of the mixed MSW stream may be carried out to improve the feedstock directed to the compost facility. It is important to emphasize that central municipal composting is intended to process only those organic wastes which cannot be managed by individual backyard composting operations. Residents should be encouraged to compost their own materials in an efficient manner, on their own properties, wherever and whenever possible.

It is projected that the residential waste stream can be reduced by up to 25% in households having sufficient space to accommodate yard composters. Considering realistic participation rates and the availability of suitable backyard areas, an overall residential waste reduction factor of 15% is considered feasible. This would normally represent about 7.5% of the total solid waste managed by a typical urban municipal operation.

4.3 Comparison Of Options For Alternative Compost/Diversion Systems

Two principal compost/diversion systems and their processing sub-systems are subjected to a relative assessment. These are:

A. Blue Box Recycling and Mixed MSW Composting
B. Wet/Dry Recycling:
   1. Two-Stream
   2. Three-Stream

This assessment is contained in Appendix I and presents comparative factors related to the operability, cost, and overall feasibility of the noted systems.

It is emphasized that this comparative assessment model is substantially qualitative in its scope. It was developed specifically for the evaluation of the noted options in an objective manner. Although this model, or a similar one, has never been used in any previous applications, it is considered to be reasonably accurate, representative, and impartial, based upon the best information and professional opinions available.

The majority of MSW consists of compostable components. Many of these components, like paper, may be recycled at a higher economic value than conversion into compost. However, a certain amount of paper is soiled and/or mixed with other compostables and is most readily diverted from disposal by composting. The projected amount of MSW available for composting after reasonable (or currently achievable) reuse and recycling measures are applied is indicated in the following table:

MSW PROFILE

Compostable Component	MSW Average % Composition	% Reusable/ Recoverable	% Available For Composting
Yard & Wood Waste	23	3	20
Corrugated Paper	12	8	4
Newsprint	8	6	2
Other Paper	20	12	8
Food Waste	9	1	8
Total	72	30	42

Selected Streaming

For composting, the objective is to obtain a feedstock which is as uncontaminated as possible. The first priority is to ensure that the large amount of easily streamed compostable waste is diverted from landfill to composting. Streaming involves the identification and delivery of selected wastes which are generated in a relatively pure condition with few or no unwanted contaminants present. Numerous commercial and municipal activities generate relatively large quantities of narrow-stream unadulterated vegetation and food matter which can be introduced directly into the composting process with little or no preparation. Proposed streamed feedstock materials can include:

- food processing plant wastes
- horticultural wastes from private and municipal agencies (grass, tree, and shrub trimmings, and leaves)
- autumn leaf collections
- institutional and cafeteria food wastes
- farmers' market and supermarket food wastes
- designated bagged residential grass clippings
- sawdust and fine wood chips from carpentry firms
- Christmas trees.

By streaming these materials, significant additional quantities of organic matter can be diverted from disposal, with minimal additional collection, processing, and associated costs. It is recognized that a portion of these wastes may be processed by private sector firms and may not be available to a municipal operation.

Wood and yard waste can represent about 23% of the annual MSW stream and can exceed 50% in seasonal peaks.

Wet/Dry Collections

- Two Stream

This method processes source-segregated "wet waste", which is collected separately from a mixed "dry stream". The dry stream includes a mix of dry refuse, commingled with "Blue Box" class recoverables.

- Three Stream

This method processes residential source-segregated "wet waste", "Blue Box" recyclables, and a "garbage" stream.

Mixed Municipal Solid Waste Collection

This method processes residential curbside collections which are delivered by municipal packer trucks. The neighbourhoods served by these vehicles practise source separation of "Blue Box" materials, which are collected and processed for recycling separately. Also, a comprehensive and effective hazardous waste program must be developed adequately, in conjunction with the diversion of mixed MSW to the composting facility.

The mixed MSW can be processed to produce compost and separate recoverables, with residual discards being directed to landfill or future recycling.

FIGURE 1

COMPOST PLANT TRIAL FEED STREAMS

Evaluation Criteria

1. Quality and quantity of compost product.
2. Quality and quantity of recyclable materials.
3. Cost of collections.
4. Cost of processing.

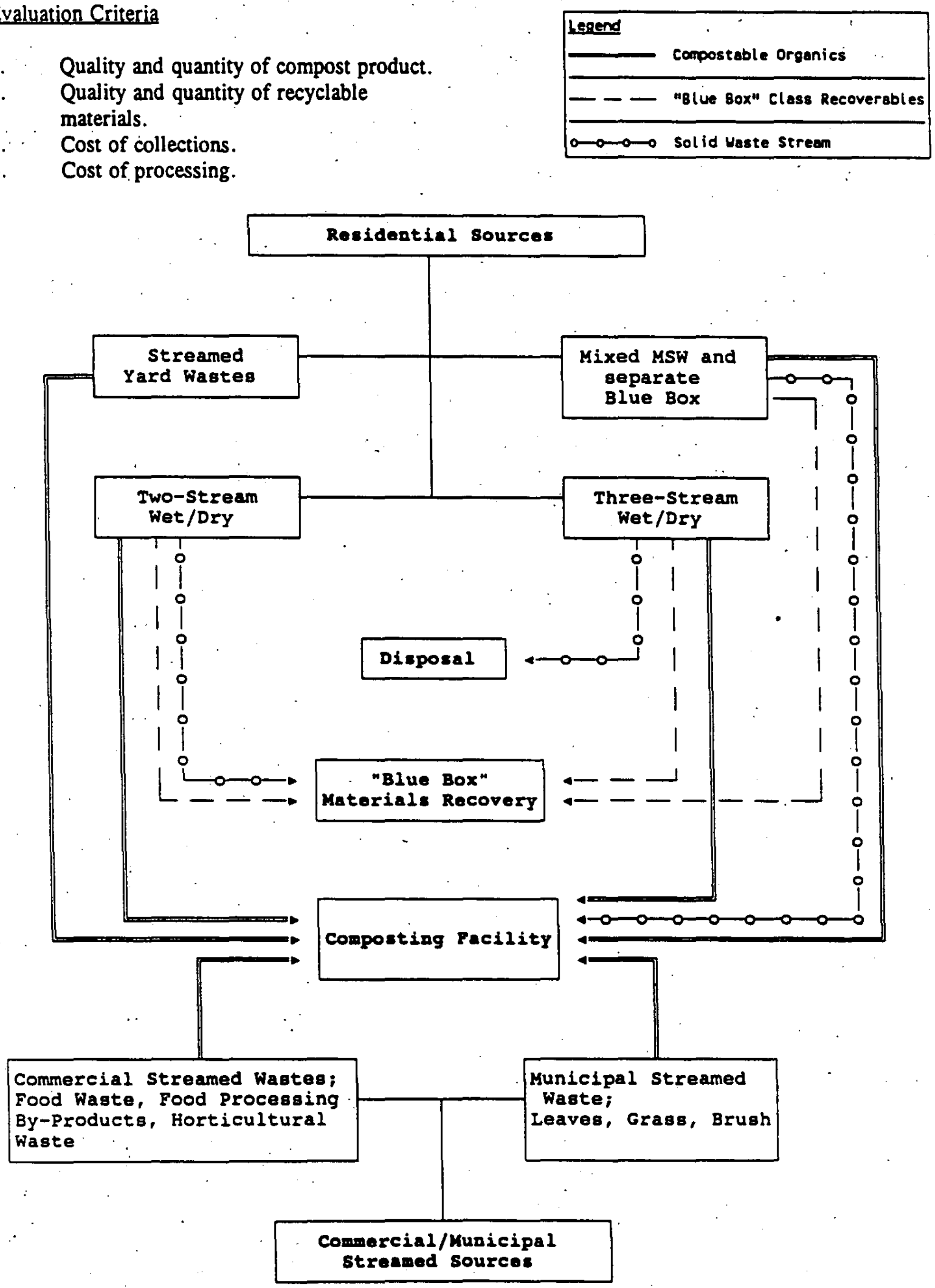


FIGURE 2

COMPOST FEEDSTOCK

Feedstock	**Source**
1. Streamed A. Commercial/Institutional Cafeteria Waste Food Processing By-Products Horticultural Waste - brush, grass, leaves, tree trimmings Processed Wood Waste	Municipal Public Works Departments, Hospitals Hotels Supermarkets Manufacturers
B. Residential Kitchen Waste Yard Waste - brush, grass, leaves, tree trimmings	Municipal collections
2. Mixed MSW	Municipal and commercial collections
Sewage Sludge	Sewage Treatment Plant
Organic/Nitrogen Sources	Agricultural Waste poultry waste manures

5. COMPOST QUALITY

As with most organic materials, compost feedstocks derived from source–segregated and mixed MSW and sewage sludge contain essential and non–essential trace metals. The issue of potential heavy metal contamination is particularly important in dealing with mixed MSW and sewage sludge streams. Some of these metals, when present at excessive levels, can imbalance plant nutrition or cause toxicity. The Ontario Ministry of Environment has developed guidelines for the disposal of sewage sludge on agricultural lands, which includes parameters for eleven heavy metals and their effect on soil chemistry. Draft guidelines have now been developed for compost. The draft standards for compost are more restrictive than for sludge with respect to heavy metals, to reflect the higher rates of application generally used with compost. However, it should be taken into account that compost is known to be the best shield against heavy metals for plants as it locks the metals in non–bioavailable forms to a great extent. Approved regulatory limits for metal content in compost should correspond to the metal–complexation capacity of the compost i.e. the humus in the compost that captures metals. The higher the humus content of the compost, the more metals will be complexed into forms not available to plants.

As the Ministry of Environment proceeds with its MISA program to reduce pollution at source, the metal content of most municipal sewage sludge is expected to decrease so that it can be more readily used for composting.

Compost draft standards from the Ontario Ministry of Environment include the following criteria:

Exposure in the process environment for mechanical composting	minimum 3 days between 55°C and 60°C
Minimum organic content, % dry weight	30.0
Minimum inorganic content:	
Plastics, % dry weight	1.0
Glass, % dry weight	2.0
pH (range)	5.5–8.5
Soluble salts content (milliSiemens/cm)	<3.5
Maximum water content	30% to 55%

Maximum content of the following potentially toxic metals	Concentration (mg/Kg drywt)
Arsenic (As)	10
Cadmium (Cd)	3
Cobalt (Co)	25
Chromium (Cr)	50
Copper (Cu)	60
Mercury (Hg)	0.15
Molybdenum (Mo)	2
Nickel (Ni)	60
Lead (Pb)	150
Selenium (Se)	2
Zinc (Zn)	500

Figure 3 illustrates the proposed draft standards and guidelines for compost quality criteria for metals concentrations in Canada and Ontario compared to standards of other government agencies. As shown, compost standards for metal concentrations vary significantly in different jurisdictions. It should be noted that standards for metal concentrations for land application of waste by-products published by the Food Production and Inspection Branch of Agriculture Canada are about six times less stringent that Ecologo standards and the draft Ontario guideline. In assessing the significance of the various standards, prevailing background levels of contaminants in the soil, the use of the compost, and its humus content, should be considered. The humus content of compost will moderate the availability and mobility of metals and therefore, metals standards should be related to the humus content of compost. It has been found that humus helps to retain metals and that, the more metals in the humus, the less likely the humus is to decompose. Also, because humus provides buffering against acid rain, chances that metals will turn into inorganic salt are not a concern.

It is interesting to note that the soils in the Holland, Bradford and Keswick marshes are very similar to mature composts and on average these soils contain from 190 ppm to 500 ppm of copper compared to 60 ppm allowed in the draft Ontario guidelines for compost. Because of the metal complexation capacity of the marshes, periodic copper applications are still required to maintain good crop production.

Examples of analyses of composts for green waste, wet bin waste and mixed MSW are also presented for comparison.

An effective mixed MSW process concept is capable of meeting the anticipated strict compost standards, by assuring the production of high quality compost in the following manner:

- controlling the quality and sources of waste received at the facility. Household hazardous waste including batteries should not be permissible in the waste stream delivered to the compost plant. While this objective is progressing, certain hazardous components may

FIGURE 3

QUALITY CRITERIA FOR COMPOSTS - LIMITS OF HEAVY METALS CONTENT

	Government Standards and Guidelines (ppm)							Analyses of Composts (ppm)					
	ECOLOGO Canada Draft	Ontario Draft	Minnesota	Austria	Netherlands as of 1993	France	Maine	A	B	C	D	E	F
Cadmium	2.6	3	10	1-6	1.5	8	10	1	.4	3.5	6	4	5.5
Chromium	210	50	1000	50-100	100		1000	30	28	139	200	57	71
Copper	128	60	500	100-1000	50		1000	40	65	175	310	452	274
Lead	83	275	500	200-900	150	800	700	160	84	193	730	328	513
Mercury	.83	.15	5	1-4	1.5	8	10	.5	.3	n.d.	n.d.	3.8	2.4
Nickel	32	60	100	30-200	50	200	200	10	20	97	140	44	45
Zinc	315	500	1000	300-1500	250		2000	240	250	980	1300	730	1070

A De Bilt, Netherlands, green waste compost, average (ref. 10)

B Lustenau, Austria, green waste compost, average (ref. 10)

C Neunkirchen, Germany, Wet Bin Compost, average (ref. 10)

D Baienfurt, Bavaria, Wet Bin Compost, maximum (ref. 10)

E St. Cloud, Minnesota, MSW Compost using drum digester and windrows, maximum (ref. 15)
Note that there is no Blue Box source separation nor hazardous waste programs

F Germany, MSW/Sludge compost works - average of 207 samples 1976-81 (ref. 10)
Note that most of the compost works included severe shredding of the MSW

still be present in the refuse delivered to the composting plant. To address this concern, the operation's physical processes and analytical procedures should be structured to identify and remove isolated toxic materials, or contaminated feedstock, without compromising the quality of general production.

- avoiding harsh treatment (shredding) of the feedstock to avoid dispersion of battery materials in mixed MSW and to minimize the distribution of heavy metals and other contraries throughout the compost product. The waste should be gently handled throughout the process and most ferrous metal removed by screening and magnetic separation after initial and partial composting in rotary digesters. Operating experience with rotary drum digesters indicates that oxidation of lead solder and ferrous material does not occur, within three days to any significant extent.
- controlling essential process parameters
- refining cured compost to remove foreign matter. A refining process involving magnetic separation, density separation and screening can be employed.

There is a specific and on–going concern about the presence of potentially toxic metals and polychlorinated biphenyls (PCBs) in solid waste/sludge compost. Fortunately, most of the concerns can be addressed with reliable information; as can most of the potential problems be resolved by good management practices.

As an overview, various factors must be considered when dealing with the potential for environmental/human/plant/animal exposure to toxic metals.

1. The metals are already part of solid waste/sludge, and their presence in an available and potentially toxic form is the result of human activity in the environment. They were originally a relatively benign part of our surroundings and must now be removed from, or returned responsibly to, the environment in the safest possible fashion.

2. Metal toxicity is related to exposure. The less exposure to, or interface with, metals, by plants/animals/humans, the less chance of toxic effects. Another factor is the manner of exposure, with (generally) inhalation being more critical than ingestion, and ingestion more critical than physical handling.

3. Some assimilation of trace levels of metals, which are toxic at higher concentrations, is often beneficial. Dietary requirements for zinc, chromium, selenium, copper, and nickel are well established. However, while trace dietary amounts of these metals are essential, health concerns related to over exposure require close control of these elements.

4. The potential for toxic metal ingestion is influenced by uptake exposure. This exposure is influenced by a number of interdependent factors, such as:

   - soil pH
   - soil cation exchange capacity
   - soil structure and composition
   - specific crop grown
   - part of the crop ingested
   - food–chain accumulations resulting from animals eating the crop
   - amount of crop ingested
   - specific metal of concern
   - timing between application of metal to the soil, and subsequent crop planting and growth
   - method used to apply compost to land
   - climate and precipitation.

This list of factors is provided for reference, and is not exhaustive. While comments related to toxic metal exposure cannot be presented in a simple statement, it is important to emphasize that the process, feedstock, and analytical controls used in a facility must ensure that the finished product is free of contaminants which can pose a danger to the general environment and human health.

The soil pH is probably the single most important factor to be considered when dealing with the toxic potential of soil metals. For a metal to be available to a plant it must be in solution. To be in solution a metal has to be at the proper pH which is, in most cases for toxic metals, acidic.

Most agricultural soils are maintained at or around neutral (pH 6–7). Acidic soils can be limed to raise their pH. Most of the toxic metals (except for the anions; and including molybdenum/selenium/antimony) are almost totally unavailable in solution(s) at a pH greater than 6.0.

Also, pH is not measured on an arithmetic scale but a logarithmic one. This means that a pH of 6 is not a single acidic unit greater than a neutral pH of 7, but that it is a logarithmic single unit, or 10 times greater. Thus a pH of 6 is actually 10 times more acidic than a pH of 7, a pH of 5 is 100 times more acidic than a pH of 7, a pH of 4 is 1000 times more acidic than a pH of 7, and so on up and down the scale. This exponential increase/decrease offers a significant degree of safety when considering the stability of soil pH and metals availability.

Another important soil factor is the Cation Exchange Capacity (CEC), or its ability to buffer chemical change. CEC is the ability of soils to remove and exchange charged basic ions from solution. Metals in solution will have a charge, either positive (cations) or negative (anions). Soils with high CEC's (>15 meq/100 g) tend to contain more clay and humus that binds metal into forms which are not readily absorbed by plants. Soils with low CEC's (<5 meq/100 g) lack this capability. Low CEC soils tend to be sandy and arid.

Polychlorinated biphenyls (PCBs) are a class of man-made compounds that have gained significant environmental notoriety within the last three decades. The chemical characteristics that originally made PCBs so desirable to industry have also contributed to their environmental persistence. While manufacture in the United States was discontinued in 1979, PCBs are still produced and used in other countries. PCBs are also present in pre-1979 electrical and hydraulic components, and are found in landfills, and in the general environment.

The bioaccumulation of PCBs is much more dramatic in animals than in plants, especially in fish and birds. Terrestrial plants may accumulate some PCBs, but do not biomagnify them as occurs in animals. The available evidence suggests that PCBs at less than 5 ppm do not influence either crop yield or quality. At levels above 5 ppm some plants may suffer from decreased growth and reproduction. Under flooded or anaerobic conditions plants develop an enhanced susceptibility to damage by, and biomagnification of, PCBs.

Another important factor which can create an unacceptable compost batch is toxic contamination. This may result from the disposal of unacceptable materials in MSW (batteries, containers of solvent, etc.). While the compost operation should be designed to remove these unwanted items, they may be received in a damaged condition and their contents dispersed throughout the input stream.

Incoming vegetation may also contain high levels of unacceptable contaminants, if received from a source where excessive soil pollution was present, or if the vegetation was recently treated with pesticides.

An appropriate plant sampling and analysis protocol can permit the detection and removal of contaminated material at the front-end, before it is processed and dispersed through a larger portion of the compost process stream. If the contamination is not detected initially, it can be identified in the finished product during the final quality control tests.

If warranted by the type and level of contamination found, the input material or finished compost may be directed to landfill. Contaminated feedstock material can usually be landfilled directly with the general refuse stream, unless it contains hazardous wastes which must be directed to a special disposal facility. Contaminated finished compost may be deposited into a disposal cell at landfill, or it may be used to supplement the intermediate cover at the site, depending upon the nature of contamination.

It is expected that use as an essential landfill site cover supplement and the restoration of finished cells will be a major outlet for compost product during initial commissioning, demonstration, and market development periods.

6. DISPOSABLE PAPER PRODUCTS/SOILED PAPER WASTE

While aggressive 4R's initiatives are encouraging a reduction in the use of disposable products, soiled paper waste, and soiled cardboard, it is expected that they will continue to form a measurable part of MSW for the foreseeable future. Also, low-grade paper products such as boxboard are difficult to recycle effectively because they already contain a high percentage of recovered short-fibre paper content. For these materials, composting represents a promising method of waste diversion, and this is reflected in the boxboard industry's current assessments. One of the attractive features of a multi-facet municipal composting plant relates to its ability to accept whole disposables, remove the non-compostable fractions, and bioprocess the cellulose fibres into the finished compost product. This capability is not provided as effectively, or at all, in the more limited compost processes which accommodate only "Wet/Dry" recycling systems, because they are designed to perform less extensive separation of contraries.

7. PUBLIC HEALTH AND SAFETY

With respect to exposure to the compost product, a number of possible public concerns have been identified. These include specific matters related to:

- general hygiene
- physical contaminants such as glass slivers and metal shards
- toxic or hazardous chemical elements; heavy metals, toxic organics and inorganics, etc.
- exposure to bacteria, viruses, cysts, pathogens, etc.

The issues of health and safety are always concerns in any activity involving the handling or processing of wastes, particularly those from human sources. The overall process and management measures provided for composting facility should be designed to minimize or eliminate potential hazards. Important considerations in this regard include:

- restrictions, monitoring and analysis for incoming waste streams
- close control and recording of the composting process to ensure the elimination of infectious agents
- multi-stage process removal of undesirable or potentially injurious physical agents
- monitoring and testing of finished product for quality assurance.

Although some infectious agents may be present in the delivered materials, these will not pose any greater health threat than that presented by the normal household garbage stream. This stream is handled routinely by individual residents and waste collection and processing personnel. After composting, the remaining viable pathogens are virtually nonexistent. In order to contract disease from infectious agents, five primary conditions are essential:

- exposure to a high population of pathogens
- adequate length of exposure
- suitable environmental conditions (temperature and moisture)
- entry into the body
- specific susceptibility

The presence of all these conditions with respect to the compost product is considered to be extremely unlikely, so that danger to public health is not considered to be a cause for concern.

8. QUALITY ASSURANCE PROCEDURES

To ensure that a reliable high-quality compost is produced and distributed to the appropriate users, a comprehensive quality assurance program is essential with respect to the following:

- waste inputs
- process parameters
- health and safety
- compost quality
- applications of compost
- leaching tests.

9. OTHER COMPOSTING FACILITIES

Downsview Composting Facility

Ontario's only experience with MSW composting is with the Fairfield digester installed by the Ontario Ministry of Environment at the Ontario Centre for Resource Recovery in Downsview in the late 1970's. This research facility was originally built to experiment with the production of Refuse-Derived-Fuel for incineration. It was later converted to a composting trial facility. The Fairfield digester is like a large tank and consists of a number of augers, mounted on a bridge which slowly rotates above the tank. The augers turn down through the biomass for mixing and aeration. The compost was removed from the digester, screened and stored in non-aerated piles before being distributed.

At the Downsview facility the total MSW stream was shredded in a large hammermill, and compostables as well as non compostables were reduced to small particles. The shredded MSW flowed through an air classifier which attempted to separate the light fraction (refuse derived fuel) from the heavy fraction (wet compostables). The heavy or compostable fraction of the MSW was screened and separated magnetically to remove contraries. As it was impossible to remove the small contaminating particles which were dispersed throughout the mixture, compost quality was poor. Also, mixing and aeration in the Fairfield system are rather poor, producing a compost of inconsistent quality.

Although a significant marketing effort for the compost product was carried out, no reliable long-term markets could be developed.

Future mixed MSW operations can rectify the problems that were experienced at the Downsview Facility by:

- receiving a selected feedstock stream
- receiving a wide range of supplementary organic waste for composting
- not shredding or exposing MSW to harsh treatment
- screening out non-compostable material such as plastic and metals while they are whole and not size reduced and finely dispersed throughout the compost mass
- improving aeration and mixing
- effective market development for compost product.

A number of European communities have developed extensive experience in simple windrow composting over the past 20–30 years. Most of these operations were based upon processing of mixed MSW. However, the development of new regulations for compost quality standards in Germany, Netherlands and Switzerland is expected to result in the termination or modification/upgrading of most current operations within these countries. One of the principal factors, contributing to poor compost quality in Europe is the presence of heavy metals. While this might at first suggest that mixed MSW composting in Ontario will be prone to similar difficulties, it is necessary to examine the source of contamination, and the differences in the European waste stream directed to composting.

The feedstock for European compost plants was typically derived from the entire blended solid waste stream generated by a broad range of residential, commercial, and industrial sources. Modern mixed MSW compost operations should obtain feedstock only from curbside residential collections, and selected "clean organic" sources.

Inadequate data is available to ascertain the level of household hazardous waste segregation from MSW in European projects. However, it is apparent that progressive measures are necessary to eliminate a significant quantity of hazardous wastes from the MSW stream.

In most European operations, street sweepings are included with the compost feedstock, because this material contains sand, soil, leaves, and other compostable components. Unfortunately, the street sweepings also contain high levels of lead, which is deposited by vehicle exhaust gases, and crankcase oil drippings. This contamination is also augmented by the disposal of residential vacuum cleaner bags, which have been found to contain high levels of dust and dirt–borne lead, carried into homes from city streets. Additional metals contamination is introduced by means of coal ash residues (from residential heating systems), which are prevalent in many European waste streams.

Mixed MSW composting processes should not use street sweepings in their composting stream. Also, the elimination of lead compounds in North American automotive fuels reduces the exposure and uptake of this toxic contaminant by vegetation which will be composted. While residual levels of lead will persist in the immediate environment for years, its presence will gradually diminish.

10. MARKET DEVELOPMENT

During the operational development of any large-scale composting plant, emphasis must be placed upon the following necessary preliminary activities:

- characterizing compostable organics and trends (quantity and quality) delivered in mixed and streamed residential MSW
- characterizing compostable organics, and "Blue Box" recoverables obtained from Wet/Dry collections, including trends in quality and quantity of all input components
- ascertaining and evaluating quantity and quality and process performance of mixed and streamed non-residential MSW and acceptable plant process residues
- developing appropriate formulations and blending stocks for various compost products
- proving quality control and output quantity consistencies for compost product
- analyzing finished compost to ascertain suitability and environmental compatibility for designated applications
- refining plant operations and product formulations
- field testing of compost product to demonstrate its suitability and safety to potential market users.

Initially, it is necessary to fine-tune process operations and formulations in order to develop a product with consistent nutrient value and acceptable quality control. During this stage of work, the compost can be used in base-value applications, such as:

- landfill cover enrichment
- reclamation of mined out pits and quarries
- highway area plantings
- parks and recreation areas
- mulch and nutrient supply for regeneration of forest reserves.

These uses will proceed only in conjunction with quality assurance testing which verifies that the product characteristics are consistent with established standards pertaining to public health and environmental protection.

A particularly successful compost operation has been established in Gainsville, Florida. Compost produced from MSW and sewage sludge, applied to nearby woodlands over a period of 16 years, has increased forest growth by 70% compared to woodlands without compost.

The noted early applications of compost are not expected to generate product revenue, although transportation costs are intended to be paid by the end-user. However, this development period is required to demonstrate, in highly visible conditions, that the compost product is useful, safe, aesthetically acceptable, and has inherent value. Also, a lateral objective of composting is to recover materials and divert them to a productive application, rather than directing them to landfill or incineration. By diverting compostable organics to a useful activity, a principal goal is met. The reduced level of putrescible landfill wastes and the attendant increase in landfill site life, are significant direct benefits which can result from a composting project. Subsequently, when the proven product attracts revenues to offset the costs of operation, this will constitute an added benefit.

As the compost product proves to be successful in various non–revenue–generating applications, marketing approaches should be directed to both large–volume and small–volume users. Using the initial demonstration applications and associated documentation as models for potential users, the product may be offered for sale using a stepped escalating price structure. At first, prices should be held at levels to encourage purchase by interested parties. Once the product performance is recognized, it will establish a firm niche in the open market. When this occurs, the price structure can be extended to a level which is representative of the net cost of production. As a means of encouraging greater public awareness of environmental issues, composting and the broad 4R's, municipalities may consider providing small quantities of finished compost to local residents, for private residential use.

In the overall scheme, the compost produced by a municipal facility can be made available in bulk to home–owners, gardeners, crop farmers, commercial landscape planners, land reclamation specialists, mushroom growers, sod farmers, conservationists, and government agencies for park and recreation areas.

In comparison to the massive quantities of manufactured commercial fertilizers used in agricultural applications, the impact of full–scale compost operations in all municipalities would be relatively small. Furthermore, compost does not provide all of the nutrients needed in agricultural applications, therefore the requirements for commercial products will be affected only marginally. However, compost is an essential ingredient in large–scale agricultural uses, as well as in applications extending down to individual household gardens and lawns. With its organic conditioning properties, compost improves soil structure and tilth to achieve more efficient use of manufactured nutrient additives, while also diminishing run–off. The net effect of this feature includes:

- reduced costs to farmers and other users
- more efficient crop production
- reduced contamination of surface and groundwater by fertilizer run–off and leaching
- reduced residue ("salting") in surface soil

Compost produced from organics in MSW will probably not immediately become a notable contender for the established fertilizer mass market, but it will provide a useful and beneficial supplement for a broad range of users.

11. CONCLUSIONS

Investigations and research to date have illustrated that source segregated organics, including streamed waste, can be used to produce a compost product which contains lower levels of trace metals than is now possible with mixed MSW composting.

Some European central composting systems, which have operated for a period of up to 30 years, are now moving away from mixed MSW feedstock to source–segregated organics.

It is important to note that these findings and changes are the result of new metal concentration limits which are based upon the expected levels achievable through source-segregation activities. However, there is no consensus among the metal standards established or proposed in various North American jurisdiction comprising federal, provincial, and state authorities.

In many cases, the emerging more stringent standards do not consider the specific requirements of different compost applications, nor do they consider the background levels of metals in the receiving soil. Furthermore, when the definition of acceptable feedstock components creates limits which prevent the introduction of high carbon materials and bulking agents (i.e. non–recyclable paper–based materials), the overall compost collection and processing operations may become more difficult and less efficient.

In particular, a move to multiple collection routes and vehicles (garbage, Blue Box, compostables) can be unacceptably expensive and can escalate environmental degradation through the increased consumption of fossil fuels.

While source–segregated organics achieve a lower metal content compost than MSW compost, even the segregated "green stream" contains measurable amounts of metals. If the concept that "less is best" were carried to its logical conclusion, even source–segregated compost should not be produced or used, because it contributes additional metal loadings to the general environment.

Clearly, a major initiative should be pursued in encouraging residential yard composting wherever possible. However, for multi–residential complexes and institutional/commercial complexes, a more realistic off–site alternative is essential.

Major waste stream reduction through large–scale composting will not be achieved in urban areas unless commercial–scale technologies are employed. This technology must be appropriate, and flexible enough, to accommodate full processing of mixed MSW, as well as source–segregated and streamed "green waste" from food processing and horticultural operations. This approach will also ensure that the constituents of compost feedstock are broad enough to supply most or all of the components required for a high quality end product and that the process is achieved at reasonable cost.

APPENDIX I

COMPARISON OF METAL CONCENTRATIONS

METAL	MIXED WASTE	EAST HAMPTON PILOT STUDY mg/Kg dry weight	GUELPH PILOT STUDY	NEW YORK STATE 6 NYCRR PART 360 CLASS I
Zinc	453	73.6	135.6	2500
Lead	150	21.0	37.5	250
Copper	92	25.9	22.8	1000
Chromium	74	3.1	8.2	1000
Nickel	30	3.1	6.9	200
Cadmium	1.5	<1.0	0.6	10
Mercury	--	<1.0	not reported	10

Metal	MOE Guideline for Compost	Canada's Fertilizers Act	Ontario Guidelines for Sewage Sludge
	(mg/Kg, dry weight)		
Arsenic	10	75	170
Cadmium	3	20	34
Chromium	50	--	2800
Cobalt	25	150	340
Copper	60	--	1700
Lead	150	500	1100
Mercury	0.15	5	11
Molybdenum	2	20	94
Nickel	60	180	420
Selenium	2	14	34
Zinc	500	1850	4200

COMPARISON OF SHORT-LIST OPTIONS
FOR
ALTERNATIVE COMPOST/DIVERSION SYSTEMS

COMPARISON OF SHORT-LIST OPTIONS FOR ALTERNATIVE COMPOST/DIVERSION SYSTEMS

Two principal compost/diversion systems are evaluated, along with their collection and processing sub-systems.

A. Blue Box Recycling and Mixed MSW Composting:

- i) Curbside Blue Box recoverables
- ii) Mixed MSW with recoverable compostables

B. Wet/Dry Recycling:

1. Two-Stream

   - i) Mixed dry waste with recoverables
   - ii) Wet compostables

2. Three-Stream

   - i) Curbside Blue Box Recoverables
   - ii) Wet compostables
   - iii) Mixed MSW discards

<u>Operability</u>

Each sub-system within the principal systems is assessed on a scale of 1 to 5 for the following four operability factors.

- degree of overall difficulty and participation; i.e.:
  - difficulty of personal separation decisions
  - difficulty of collection
  - difficulty of processing and separation at central facility
  - degree of personal convenience
- degree of effectiveness; i.e.:
  - how well is the overall system expected to function
- demonstrated success

- projected product damage and contamination

A ranking of 1 to 5 is used because this provides the lowest common factor with a defined neutral rating (3), while enlisting an adequate span in the lower numerical range (1 and 2) and in the upper numerical range (4 and 5), to reflect the relative degree of confidence available, based upon available information, experience and judgement. The 1 to 5 scale can be factored to more detailed ranges (i.e. 1 to 10 or 1 to 100, etc.), but the information available for this assessment is not considered suitable for a model of greater sensitivity. The operability assessment interpretation is based upon a lower score representing a more desirable rating projection in the selection review.

Cost

The factor of collection and processing cost is initially assessed separately from operability. While the overall project feasibility is based upon a combined factoring of costs and operability, it is important to segregate these two components so that the selection decision can include an overview of both areas of interest. For the purposes of this assessment, a ranking of 1 to 4 is applied to costs. This range is used because the cost factor is examined in terms of escalation once it exceeds the base score of 1. This component is rated against a score of 1 for basic existing garbage collection operations and simple disposal. It is recognized that many other important cost factors, both direct and indirect, are related to various methods of waste management. However, this ranking is not intended to examine the broad range of comprehensive waste management options. Its scope considers only the comparison of the two principal systems under review at this time.

Because the desirability of specific collection and processing operations decreases with an increasing cost score, a neutral mid-range number is not used, as it would conflict with the base level ranking of 1.

In accordance with the sensitivity span applied to the operability assessment, it is not considered meaningful to factor up the 1 to 4 range used for costs.

Also, a single cost ranking was provided for the combined collection processing streams (sub-systems) under each principal system. This reflects the interdependency of costs as a function of the combined system elements, while avoiding the unnecessary redundancy of attempting to assign separate cost scores to each sub-system as independent entities.

Feasibility Calculation

Feasibility is defined as "the quality of being feasible; i.e. the possibility of being able to do or achieve" an activity or objective. In practice, and for purposes of this assessment, a feasibility assessment must consider both operability and costs equally. These are considered to be equally important and discreet components.

In order to assign each of the three systems a common base for assessment, all scores for operability and cost are normalized to a base of 5. To achieve this, the Cost Factor (maximum rating = 4) is multiplied by 1.25 to render it consistent with the Operability Factor, also a potential maximum rating of 5. The Cost and Operability Factors are then added and divided by 2, to render an average Feasibility Factor within a range of 1 to 5.

It is emphasized that this comparative assessment model is substantially qualitative in its scope. It was developed specifically for the preliminary evaluation of the noted options in an objective manner, based upon the expertise and capabilities of the project team. Although this model, or a similar one, has never been used in any previous applications, it is considered to be reasonably accurate, representative, and impartial, based upon the best information and professional opinions available at this time.

While this model provides a general assessment of the noted systems, the same ranking factors will be established in a more quantitative manner during the conduct of the proposed composting project.

COMPARISON OF SHORT-LIST OPTIONS FOR ALTERNATIVE COMPOST/DIVERSION SYSTEMS

	A. Blue Box Recycling and Mixed MSW Composting		B. Wet/Dry Recycling				
			1. Two-stream		2. Three-stream		
Source Components	i) Curbside Blue Box recoverables	ii) Mixed MSW with recoverable compostables	i) Mixed dry wastes with recoverables	ii) Wet compostables	i) Curbside Blue Box Recoverables	ii) Wet compostables	iii) Mixed MSW discards
Source Separation Requirements	Glass, metals, newsprint, PET. Options for: OCC, film plastics, rigid plastics, fine paper.	Household Hazardous wastes.	Household hazardous wastes	Kitchen & yard wastes	Glass, metals, newsprint, PET, Options for: OCC, film plastics, rigid plastics. fine paper	Kitchen & yard wastes	Household hazardous wastes
Collection Method	Existing & supplementary automated & manually loaded non-compaction vehicles.	Existing compaction vehicles	New automated & manually loaded non-compaction vehicles	New compaction or non-compaction manually or automated loading vehicles	Existing & supplementary automated & manually loaded non-compaction vehicles	New compaction or non-compaction manually or automated loading vehicles	Existing compaction vehicles
Potential Recovered Product	Steel - Aluminium - Glass - PET - HDPE - LDPE - Newsprint - OCC - Fine Paper	Compost	Steel, Aluminium, Glass, PET, HDPE, LDPE, Newsprint, OCC	Compost	Steel, Aluminium, Glass, PET, HDPE, LDPE, Newsprint, OCC, Fine Paper	Compost	NIL
ASSESSMENT RANKINGS							
Operability **Assessed Degree of Difficulty & Participation** **1= Low difficulty/High participation** **5= High difficulty/ Low participation**	1	2	3	3	1	2	1
Assessed Degree of Effectiveness **1= High Effectiveness** **5= Low Effectiveness**	1	2	2	2	1	2	1
Demonstrated Success **1= Fully Demonstrated** **5= Not Demonstrated**	1	2	4	3	1	3	1
Projected Product Damage and Contamination **1= Low Contamination** **5= High Contamination**	1	2	3	2	1	2	1
	4	8	12	10	4	9	4
Operability Factor	$\frac{4 + 8}{8 \text{ modules}} = \frac{12}{8} = 1.50$		$\frac{10 + 12}{8 \text{ modules}} = \frac{22}{8} = 2.75$		$\frac{4 + 9 + 4}{12 \text{ modules}} = \frac{17}{12} = 1.42$		
Cost Factor 1= Low Cost 4= High Cost	2		3		4		
Feasibility Factor 1= High Feasibility 5= Low Feasibility	$\frac{1.50 + (2 \times 1.25)}{2}$ $= \frac{1.50 + (2.50)}{2}$ $= 2$		$\frac{2.75 + (3 \times 1.25)}{2}$ $= \frac{2.75 + (3.75)}{2}$ $= 3.25$		$\frac{1.42 + (4 \times 1.25)}{2}$ $= \frac{1.42 + (5)}{2}$ $= 3.21$		

CANADA'S FIRST COMMERCIAL IN-VESSEL COMPOSTING PLANT

by

RICK CHASE
President
Biowaste Management Ltd.

We own and operate Canada's first commercial in-vessel composting facility. It's located in Matsqui, B.C., about 60 minutes east of downtown Vancouver. We have been successfully composting a broad variety of organic materials for over one year and during that time, we've proven the technology, learned a lot in the process and we've expanded both our site and our operating scope. We are now prepared to develop and build other plants in North America. I'd like to tell you our story.

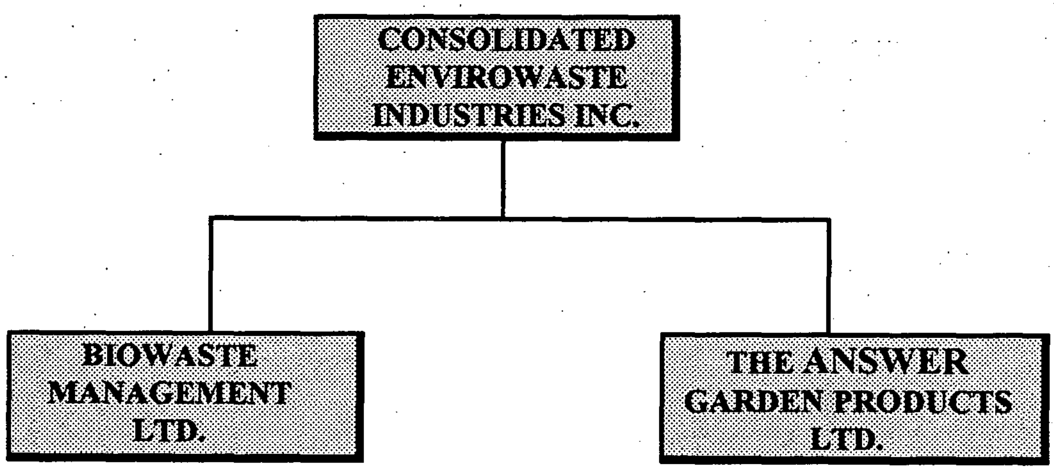
WHERE DID WE COME FROM:

Our company was actually incorporated in 1983 and became publicly-traded in 1986 to finance a composting project. We initially intended to compost only poultry manure and spent mushroom compost to produce potting mixes and organic fertilizers. Since then:

- world awareness of problems created by abuse of the environment
- economic considerations
- technical innovations and
- many other factors

shaped our company to its current structure and status. We started our financing efforts in 1987 to raise about $2,000,000. Our financing wasn't complete until mid-1991. All funds came from private placement with some bank debt. For various reasons, no government funding was provided. We spent $4,200,000 to build our plant - of which about $2,500,000 was needed for the composting part of our operation.

WHO ARE WE:



(Plant Developer) **(Our First Plant)**

Consolidated Envirowaste Industries Inc. of Vancouver, B.C., is a Canadian public company that is directing its growing resource base to the achievement of organic waste reduction goals in North America.

Biowaste Management Ltd., a wholly-owned subsidiary, finances, develops, builds and operates organic waste processing facilities that:

- divert material from landfill or other undesirable disposal methods
- reduce organic waste handling and disposal costs

- assist the community achieve its environmental goals
- produce a nutritious natural organic horticultural soil product line to enhance the earth's productivity.

These objectives may appear to be flowery embellishments of the day-to-day composting grind but we think they are solid principles and we are realizing their achievement.

We employ both in-vessel and windrow composting technology appropriate to the specific situation and waste needs. The first plant we have developed and built is The Answer Garden Products Ltd. facility in B.C.'s lower mainland. Let me give you some pertinent facts about this operation.

1. The on-site composting, pelletizing and bagging operations make the plant unique and a first in North America.
2. In-Vessel composting capacity is 13,000 tonnes.
3. Windrow composting current volume level is 7,000 tonnes which means we are currently accepting about 20,000 tonnes per year in total at this stage.
4. Our 30 acre site capacity is over 100,000 tonnes.
5. The in-vessel system, developed by International Process Systems Inc. ("IPS"), allows very accurate temperature control (within 1°C) to produce an optimum compost in about 3 weeks.
6. The system is modular so expansion is easy; different waste streams to produce different custom composts can be handled at the same time.
7. Our product is marketed in bags to the mass markets in B.C., Alberta, Washington & Oregon.
8. We started composting in October, 1991.

THE WASTE STREAM PROCESSED

It's very broad in scope and has expanded significantly over this past year. All organic material that is biodegradable and clean generally describes the stream parameters. Source separated material only is a fundamental operating principle. The waste materials processed include:

- supermarket, grocery, restaurant and curbside pick-up household kitchen (This segment presents a real challenge to obtain clean waste: it requires patience and working with the waste producers so they understand the consequence of their actions and buy into the whole process.)
- food processing and produce (Sources include grocery distributors, citrus fruits, sugar beet processors, coffee bean processors, etc.)
- yard, garden, tree, shrub, leaf (this green waste comes from municipalities, clearing contracts, householders, etc.)
- agricultural manures and product processing (including hatchery waste, bird mortalities, poultry eviscerates, etc.)
- selected paper and sludge, cardboards
- fish (sea urchins, salmon, etc.)

HOW DOES THE PROCESS WORK?

Author's note: About 10 photographic slides of the plant in operation, shown during the presentation, are excluded here.

All material is analyzed for physical and chemical properties prior to acceptance for site receipt. Prior to acceptance the waste site is usually visited, the potential for contaminants is evaluated, inorganic content is noted and other liability potential is reviewed. Once accepted, the material delivery is scheduled (for optimum biomass blending/mixing and operating purposes), weighed at the gate and directed to the respective receiving locations.

Green waste is deposited in the windrow composting area. It is size reduced at least once and composted in windrows up to 15 feet high. Moisture and temperature are monitored on a regular and continuous basis to ensure optimum composting management, maintenance of an aerobic condition and leachate minimization.

The other waste is directed to the receiving building where it is deposited, size reduced if necessary, blended and mixed immediately to produce an optimum composting biomass. We especially control biomass pH, moisture, density, nutrient level and sort out any inorganic contaminants (plastic, bottles, plates, etc.). The building is small so we are forced to maintain a "just-in-time" discipline and move the prepared mix into the composting building immediately.

The enclosed in-vessel composting building employs technology developed by IPS which we adapted to suit our needs. This modular system employs forced air to control temperature and moisture and maintains an aerobic composting state.

The building is about 50 feet by 250 feet and has six concrete open-end channels running the length of the building. A skid-steer tractor loads the front end of these bays every day. An agitating machine, which can be programmed to agitate all 6 bays automatically, travels from the back end of each bay to the front, fluffing and adding air to the material and moving the biomass 12 feet toward the back of the bay with each agitating pass. In this way, the biomass introduced at the front end of the bay arrives at the back of the bay about three weeks later. Temperature and moisture are controlled by forced aeration fans which blow air up through the biomass. These fans operate according to temperature and/or time cycle instructions received from a microprocessor which obtains temperature data from temperature sensors located in the concrete channel walls.

In this way, an effective pathogen kill is achieved but the valuable bacteria, enzymes and microbiological elements desired for horticultural purposes are retained. The produced compost

- exceeds all local, provincial, federal and EPA regulations
- consistently provides a 3-3-2.5 or above N-P-K value
- has a balanced pH
- has non-detectable levels of pathogen (salmonella, fecal, chloroform, etc.)
- has an aerobic plate count that exceeds all other competitive products found in our market area.

A biofilter was installed in September to eliminate ammonia odour escaping to the atmosphere. It is very effective. Final air movement balancing is targeted for completion before year-end.

The compost is automatically moved from the end of the composting building by conveyors to the compost storage building where it is stored and turned for about 3 weeks or until curing is complete and the degree of stability desired is achieved.

The compost is then screened and blended with other organic materials to produce over 30 different varieties of:

- potting/planting mixes
- soil conditioners
- pelletized organic fertilizers (8-2-4, 5-5-5, 3-3-3).

The pellet mill is sized to process product in excess of plant capacity and the bagging line can produce over 8,000 bags per shift.

In the interest of time, I have left out a lot of detail so I will be pleased to have further discussion at our exhibit after this session.

We have built our first plant. We wish to employ our experience, skills and ability to do the same for you. We are capitalized to provide a composting facility for you at no capital cost to you if finance is your constraint.

Accordingly, please know we are prepared to

- develop and construct
- finance
- own (100%, joint-venture)
- operate

other organic waste processing facilities to meet your situation and requirements.

Thank you for your interest.

AGRICULTURE CANADA'S PASSIVELY AERATED WINDROW SYSTEM OF COMPOSTING FARM, FOOD AND INDUSTRIAL WASTES

by

Sukhu P. Mathur

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Abstract

In this system, the composting mass is enveloped in mature compost or peat, and the heat generated by decomposition utilized to draw air through strategically-placed air-intake pipes, without expending any external energy for aeration. The cooler and cleaner envelope deters nuisance insects, moderates heat changes, curtails odour dissemination, and prevents ammonia loss. Originally designed for fisheries residues, the system has been extended and upscaled to compost food scraps, farm manures, pulp and paper mill residues, abattoir byproducts and urban wood waste, through the collaboration of various federal agencies, industry and universities.

Composting is gainful for the pocket and the planet, but is not free of hassles and pitfalls. Benefits for the planet include mitigation of pollution, enhancement of environmental sustainability of agriculture, and reduction of greenhouse gas emissions through sequestration of carbon in soils and curtailing of methane and nitrous oxide biogeneration. Conversely, the main drawbacks of composting are perceived to be: odour; potential loss of nitrogen, capital and operating costs; and the expense of manual and mechanical energy. These were exactly the worries of Agriculture Canada scientists when they were asked to create a system for composting fertilizer-rich but highly malodourous seafood wastes. In response, they created and developed the Passively Aerated Windrow System (PAWS), and transferred the technology to practical use. The PAWS has two essential features: one, the active composting process occurs within a shell of biomature compost or peat; and two, the heat generated by composting energizes air movement through pipes or plena open to the atmosphere at the base of the compost. Agriculture Canada, a federal department, is continuing to help extend this technology to various other wastes with the help of Environment Canada and Correctional Service Canada even after the research program was concluded officially due to voluntary retirement of the scientist involved, now a private consultant and an honorary associate of the department. The technology transfer and extension activities are described here broadly.

1. <u>The Passively Aerated Windrow System: The Practice</u>

The PAWS composts are built by laying down a 6" to 9" (15 to 23 cm) layer of finished compost or peat as a 10 ft (3 m) wide base of any desired length. On the basal layer one places at 12 to 18" (30 to 45 cm) intervals, across the width, 10-ft-long plastic pipes of 4" (10 cm) diameter, with two rows of perforations facing upwards just off the top side. The perforations are 1/2" in diameter, 4" apart. These pipes widely sold to be used for spreading fluids from septic tanks into soil treatment beds, and generally available for $3 to $8 each 10 ft length. They are reusable.

A mixture of material to be composted is placed on the pipes and base to a height of 3 to 4 feet from base in a shape that is trapezoidal in cross section, leaving about 6 to 9" of the base at the margins uncovered at this stage. The uncovered base border is then used to place an envelope of mature compost over the whole windrow. It is preferable to build this from the base to the top.

PAWS composts of seafood wastes must be protected from rain, as seafood waste is particularly malodourous when water-logged. Sheltering of other PAWS composts from rain has been found to be not necessary as the envelope acts as a good buffer. PAWS composts must never be covered in a way that smothers air movement. Clear plastic tents over the windrows tend to dry out the composting mass, particularly if it contains loose materials, e.g. crab wastes or uncut straw. Clear plastic tenting, however, does help PAWS composting in winter.

PAWS composts are designed not to need turning or force-aeration. The active composting process is completed in 6 to 12 weeks, when the core and the envelope attain similar temperatures. At this stage the material over the aeration pipes can be removed and the pipes retrieved for reuse, or in some cases with lighter materials, the pipes can be pulled straight out without bending. Removing the pipes is easier when they are first loosened by rotation and jiggling.

The compost can be now set up in larger piles, preferably underlined with pipes, for further maturation, or subjected to additional physical breakdown and screening.

In the absence of both a mature compost and peat, one can use well-rotted farm manures, straw, wood shavings or chips, for the

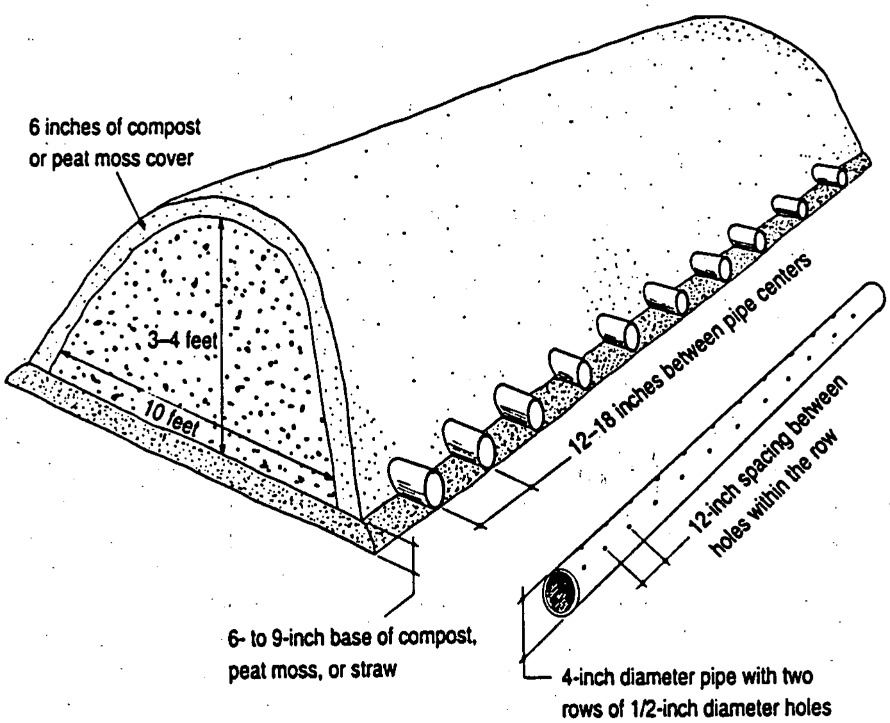

Figure
Passively aerated windrow method for composting manure.

first PAWS batch. The raw enveloping materials can be mixed into the next batch for composting but not into the mature compost they covered.

Figure 1 illustrates a PAWS pile. It is reproduced here from the "On-Farm Composting Handbook" (Rynk, 1992), recently published by the Northeast Regional Agricultural Engineering Service, a consortium of thirteen Land Grant Universities and USDA (Cooperative Extension Service) which favours composting in full view of all the benefits and demerits, and describes various composting techniques, including PAWS.

2. The Passively Aerated Windrow System (PAWS): The Theory

The PAWS technique of composting is partly based on the windrow with frame channel for passive aeration from interior described by Gotaas (1956), and on the Chinese perforated compost pile (Polprasert, 1989). The PAWS differs from the first in using several pipes across the width rather than a single tunnel at the base along the length of the windrow; and from the Chinese method in not using vertical pipes that achieve cooling. The PAWS differs from the Chinese method also in not employing a clay plaster or straw as cover as the two have a much lower capacity for retaining ammonia and other malodours, compared to peat or mature compost.

In effect, the PAWS lets the heat generated by aerobic decomposition energize air movement through open-ended perforated pipes at the windrow base, because of the natural chimney effect. Hot air rises, and nature abhors vacuum so that fresh oxygen-rich air replaces the oxygen-poor hot air that escapes. Once the mass heats up, the rate of air flow is actually controlled by the microbial activity itself. The higher the activity, the greater is the heat generated, causing a larger air intake. Thus, in the PAWS, the time and money expended on active aeration by turning or forcing air is saved. PAWS avoids the problems of odours, steaming, allergen dispersion and ammonia loss caused by excessive aeration. When no heat is generated no air is pulled through actively.

In a sense, the PAWS is an in-vessel system where the 'floor', 'ceiling' and 'walls' that envelope the composting mass are made of peat or mature (finished) compost. The envelope acts as a thermal insulator, an ammonia trap, a chemical buffer, a biofilter for odours, and as a physical screen against nuisance vermins and vectors.

The biomature (finished) compost or peat envelope does not decompose significantly during the process, and is closer to the atmosphere than the decomposing mass. Consequently the envelope is cooler than the actively composting mass in the core. The water vapour containing ammonia, ammonium acetate and other odours emanating from the decomposing core condenses in the cooler envelope. Any finished compost or peat holds water and has a considerable capacity for adsorbing and retaining both positively and negatively charged ions such as NH_4^+, HS^- and volatile fatty acids like acetic acid that occur commonly in active composts. The envelope curtails the evaporative loss of water that often necessitates remoistening of turned windrows.

Normally, as long as an aerobic composting mass is hot and active the mineral nitrogen in it occurs and remains predominantly in the ammoniacal form because during this phase the organisms that achieve the next step in nitrogen transformation are at a triple disadvantage. The bacteria that oxidize volatile ammonia to nonvolatile and odourless nitrites and nitrates, called nitrifiers, are mesophilic chemoautotrophs. Therefore the three handicaps encountered by nitrifiers in hot composts are: (i) they cannot tolerate high heat, ii) the bacteria that convert nitrite to nitrate cannot tolerate high ammonia levels; and (iii) they cannot compete very successfully for the oxygen that is being voraciously consumed by the organisms that oxidize carbon compounds of which the supply is lot more abundant than of the ammonia that acts as fuel for the nitrifiers. At least the third disadvantage also applies to the micro-organisms that oxidize malodourous sulphides to inodourous sulphate ions.

It is therefore understandable that exposure of the hot composting mass to ambient air during turning or excessive aeration expels and spreads any malodours present, and causes loss of some ammonia, volatile acids, and esters. Such loss of ammonia may of course be much less than the loss during storage and land application of uncomposted solid or liquid manures (Brogan, 1981; Leger _et al_, 1991; Rynk, 1992; Mathur, 1991). The loss of ammonia from composts lowers humus production and delays biomaturation. That is so because for every unit of nitrogen only about 10 units of carbon can be ideally retained in humus, the rest is eventually respired away by the microbes in compost or soil.

The PAWS thus curtails two other important 'demerits' of composting - potential loss of nitrogen, and output of malodours. The nuisance insect problem is also controlled to a large extent although seafood materials already containing fly maggots or eggs have been known to yield maggots that crawl into the pipes or on to the surface if the heating within the core is not rapid enough to kill them. The maggot problem occurs particularly when milled peat rather than rough peat or mature compost or wood shavings are used as the envelope. In any case, the maggots do not survive to become flies that lay eggs because there is no food for them in the compost envelope. In a properly set up compost, the build up of heat is fast enough to destroy the maggots within the composting mass.

3. What can be Composted by PAWS?

(a) Seafood Wastes

Many research papers (Mathur et al, 1985, 1986, 1988a; 1990b; Preston et al, 1986; Mathur and Johnson, 1987) have been published by several scientists on small and commercial scale composting of shell and finfish wastes: wastes from lobster, shrimp, crab, cod, sole, flounder, capelin, herring, mackerel, redfish, dogfish, salmon and white fish, have been composted on a small or commercial scale.

As indicated in the September 1988 issue of Biocycle the PAWS can use piles with heights of up to 7 feet with a second layer of pipes placed a foot and a half or so above the first layer. Subsequent experiences have shown that one layer of pipes is sufficient, and that better results are obtained, and leachates avoided, by mixing the seafood wastes with the bulking agent, rather than by layering within the core, particularly when the waste is uneviscerated ("round") finfish.

Although peat is the preferred bulking and enveloping material for seafood wastes, PAWS has also been found to be effective in composting seafood wastes mixed with wood shavings and sawdust, enveloped in mature peat or wood-based compost, in a project supported by Environment Canada's DRECT program (Shigawake Organics, 1992). Wood-based seafood waste composts, however, are not as rich in N as the peat-based composts, nor do they look and feel as attractive. Peat-based seafood composts are being marketed successfully.

The University of Minnesota (Profs. Levar and Malterer) and others have duplicated and expanded the success achieved with seafood wastes and PAWS by the Agriculture Canada staff.

(b) Manure Slurries

Peat has been employed as the bulking agent for PAWS composting of manure slurries from hogs, poultry, dairy cattle and sheep (Mathur et al, 1988b; 1989; 1990a; 1990b). As peat can absorb water up to 20 times its dry weight, air dry peat with 50% dry matter can be mixed with manure slurries 10 times its weight in a feed mixer or a rotating drum. The mature compost produced may be reusable at least once as a bulking agent for a fresh batch of a manure slurry, or as bedding for farm animals.

Screened fine peat can be spread, such as by a snowblower, on a manure lagoon. The peat floats, traps odours, captures ammonia, and deters flies. It then also helps to compost the slurry, bulked with more peat. This approach has been tested satisfactorily on manure slurries from poultry, hogs and dairy cows. These tests were funded by PERD (Panel on Energy Research and Development), an energy-conservation program of the federal department of Energy, Mines and Resources Canada.

Peat-based composts are similar to limed and fertilized peat that commands a high price in horticulture.

(c) Solid Farm Manures

Several studies in Ottawa, Kapuskasing and Kingston in Ontario by Agriculture Canada, Waste Conversion Inc., of Brampton, Ontario, and University of Ottawa have demonstrated that PAWS is effective in composting solid manures, mixed with bedding of straw or wood shavings and sawdust (Mathur and Brown, 1990; Mathur and Duggan, 1991; Mathur et al, 1992a, 1992b; WCI, 1992; Mathur and Kennedy, 1992). The sources of the manures tested were dairy cows, beef cattle, hogs, layers, and sheep. The manures were compostable by PAWS separately as well as in combinations.

Mature and finished composts were used as base and cover to envelope the excreta mixed with bedding materials.

The parameters monitored during composting included O_2, CH_4, CO_2, NH_3, H_2S, pH, Eh (electrovalent potential) and temperature at all depths and aspects. It was found that both the base and cover of mature composts provide thermal insulation. The data on percent free oxygen in the composting mass showed that aerobic conditions prevailed except for a few days before heat built up sufficiently to exert the chimney effect. No CH_4 or H_2S were detected in the compost piles. They were present in manure piles.

In addition to the tissue culture testing (Mathur and Johnson, 1987), multi-element Nuclear Magnetic Resonance (NMR) spectroscopy (Preston et al, 1986), reheating test, germination index, the maturity of PAWS composts, and the process itself, have been recently examined by other methods in a study sponsored by the Office of Waste Management of Environment Canada, Agriculture Canada, and WCI Waste Conversion Inc. (Mathur and Kennedy, 1992). Ultraviolet and visible light spectroscopy, BOD_5 tests, NH_4^+/NO_3^- ratio, dissolved organic carbon content, and Pyrolysis-Field Ionization-Mass Spectrometry that identified numerous individual compounds and determined their overall biodynamics, were employed. The data gathered are under editorial consideration for publication in scientific journals.

(d) Pulp and Paper Mill Wastes

In a study supported by Agriculture Canada, and funded by Quebec Ministry of Agriculture and Food, PAWS was tested for these wastes with only partial success (CRS, 1992). Some paper mill sludges fortified with urea composted well, others did not. Nor did sawdust itself compost well. However, when bark, sawdust, and any paper mill sludge were combined with about 10% dairy manure and urea, the PAWS was effective, even though, unadvisedly, narrower pipes were placed in many layers in the piles which were built to 10 to 12 feet heights.

(e) Food Wastes

WCI Waste Conversion Inc., and Correctional Service Canada (vide T.K. Crawford), aided by Agriculture Canada, have tested PAWS for composting food wastes from the kitchens and cafeteria of five penitentiaries and Department of National Defence facilities around Kingston, Ont. (WCI, 1992), and at CSC Beaver Creek, Ont. The PAWS technology was effective when the food wastes were mixed in 1:1 or 4:1 ratios with dairy manure that included straw bedding. The food wastes composted contained meat, bones, and dairy products.

(f) Slaughterhouse Wastes

The National Research Council of Canada, through its Industrial Research Assistance Program (IRAP), supported WCI Waste Conversion Inc., for an application of PAWS technology to composting waste from a chicken abattoir, and a duck farm, in view of earlier results of a study at Agriculture Canada at Kapuskasing with blood and rock phosphate (Mathur et al, 1987). Both peat and chips of urban wood wastes have been used successfully last summer as bulking agents for composting these wastes (WCI, 1992a).

(g) Paper Waste

Shredded office paper was composted effectively when mixed with manures at Agriculture Canada in a trial where the PAWS principles were applied to composting on a small scale in 45 gallon drums with 3"-diameter perforated air-intake pipes (Mathur and Kennedy, 1992).

4. Can PAWS work in boxes and barrels?

Initial results indicate that the PAWS principle does operate in barrels and boxes of up to 10 feet height, width and length. This is being further examined in efforts to curtail the relatively large land area required for composting by the PAWS technology, with the help of a NRC of Canada's IRAP program at WCI Waste Conversion Inc. Similarly, 50 feet long, 8 feet wide and 5 feet high channels with sectioned lids are being tested in the Trinity Bay area of Newfoundland for mixed wastes from fisheries, farming and a rural municipality (Seabright, 1991), with the support of the Environmental Partners Program, and with the help of Procter and Gamble Inc.

5. Can PAWS Work in Canadian Winters?

A trial by CRS (1992) showed that PAWS compost piles within clear plastic tunnels that resembled Quonset huts or greenhouses remained in the 45° to 60°C (113 to 140°F) range through January and February 1990 while outside temperatures were as low as -20°C (-4°F). Similar positive results were also obtained at Kingston, Ontario, with a Quonset hut.

6. Can PAWS Work at Larger Scales?

In a recent study two aeration pipes were joined to provide 19 1/2 foot lengths. These were used to build a PAWS pile 50 feet long, 10 feet high and 19 feet wide. The aeration pipes were spaced 15" apart. The feedstock was a combination of manures from dairy, beef, sheep and hogs with beddings of straw and wood shavings (Mathur and Kennedy 1992). The percent oxygen and temperature data showed that the PAWS pile was as effective as a comparable pile that was turned with a front end loader whenever the % O_2 in the air within the pile was less than 7%. The PAWS pile generally maintained the more than minimum required % O_2 (7%) except for 2 or 3 days during the initial period. This trial is in progress at the Plant Research Centre (vide Trevor Cole), Central Experimental Farm, Agriculture Canada, Ottawa.

7. Conclusion

The passively aerated windrow system (PAWS) of composting overcomes or constrains many perceived demerits of composting. It curtails odours, ammonia loss and the time and expense needed for composting. The PAWS has proven itself for seafood wastes, solid manures mixed with bedding, liquid manures mixed with peat, food wastes mixed with manures, and has given encouraging results for wood wastes, waste paper and abattoir refuse. It remains to be tested for leaf and yard wastes.

One does not have to use peat to utilize PAWS, although peat yields the best results with seafood wastes. For all others, finished compost is equally effective as envelope, in the PAWS method. Efforts are underway to reduce the land area required for PAWS, by testing contained systems in which the chimney effect is utilized for aeration and, at least initially, a cover of mature compost helps retain ammonia, other odours and moisture while it prevents exposure of the composing mass to flies.

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SOGEA Technology - Adaptation to Canada and North America

(La technologie SOGEA - Adaptation au Canada et à l'Amerique du Nord)

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Texte non reçu au moment de mettre sous presse
Paper unavailable at time of printing

DEVELOPPEMENT D'UN SYSTEME DE COMPOSTAGE A PETITE ET MOYENNE ECHELLE POUR LES RESIDUS ORGANIQUES FORTEMENT PUTRESCIBLES

Par :

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Biomax inc.
Québec 1992

Biomax inc. s'est impliquée dans l'industrie du compostage depuis 1987. Notre entreprise a réalisé des projets pilotes de petite envergure dans plusieurs régions du Québec. Nous avons ainsi exploré les techniques d'andainage avec retournements et de piles statiques avec aération forcée pour le compostage de résidus verts et de boues résiduaires d'épuration des eaux usées.

A très petite échelle, la maîtrise du procédé de compostage de déchets organiques, même fortement putrescibles, nous a paru facile.

Nous avons donc implanté un projet à grande échelle de compostage de résidus verts, de 10 000 tonnes de capacité annuelle. Du jour au lendemain, nous avons dû faire face à des arrivages hebdomadaires de plus de 450 tonnes de sacs remplis d'herbe de tonte compactée à souhait. L'andainage ayant ses limites, nous découvrions tout le potentiel de l'anaérobiose avec ses odeurs pestilentielles. L'offense atteignant son paroxysme au moment où le rayon de nuisance atteignait, au dire des principaux médias de la région, plus de cinq kilomètres.

L'impact du compostage sur le milieu humain environnant est très important. Les problèmes d'un mauvais contrôle du procédé peuvent surpasser les avantages de la récupération et de la valorisation des déchets qui sont détournés de la filière normale d'élimination.

Ainsi, en aire ouverte, les odeurs plus ou moins importantes ainsi que la grande quantité de lixiviat produit en milieu de précipitations abondantes sont des menaces omniprésentes à la survie d'un tel projet.

Il est fini le temps où l'on pouvait faire croire aux gens que LE COMPOSTAGE NE GENERE PAS D'ODEURS. C'est faux. Le compostage dégage une odeur qui, lorsque le procédé est bien contrôlé, peut être acceptable à une majorité de citoyens avoisinants. Néanmoins, un seul mécontant suffit souvent à semer la bisbille. Et que dire de ces quelques occasions où, le lendemain d'une précipitation diluvienne, avec de faibles vents laminaires à dominance inverse, les odeurs offensantes semblent ressurgir comme une magie noire. Ces occasions, très rares me direz-vous, en sont de trop.

L'andainage, en aire ouverte, à proximité de quartiers habités (2 ou 3 kilomètres), ne peut remplir ses promesses que pour quelques résidus organiques tels les feuilles d'arbres, les copeaux d'élagage et une modeste quantité d'herbe de tonte.

Lorsque vous envisagez transformer des résidus fortement putrescibles, tels l'herbe de tonte, les boues d'épuration des eaux, les restes de nourritures et de poisson, etc. Il vaut mieux vous prémunir contre les conditions atmosphériques extérieures. Le procédé de compostage n'étant justement pas un procédé aléatoire.

Ainsi, vous devrez assurer des conditions physico-chimiques stables dès le début, que vous contrôlerez en vase clos jusqu'à la fin de la phase de stabilisation. Les conditions de porosité, d'humidité, d'oxygénation et de température interne sont primordiales et doivent en tout temps être maîtrisées.

Notre entreprise a donc orienté son développement dans la conception d'une unité de compostage sous abri. Celle-ci offrait la possibilité d'isoler le procédé de l'extérieur afin de minimiser les émissions atmosphériques gazeuses, d'éliminer complètement la lixiviation et de maintenir une porosité optimale en agitant régulièrement le mélange. L'ajout d'air forcé au travers du mélange garantissait des conditions aérobies strictes ainsi que l'évacuation de la chaleur produite en excès.

Un minimum d'automatisation permettait d'éliminer les tâches fastidieuses et de régulariser le procédé. Le plus grand défi demeurait dans la réalisation d'une telle unité à haute performance avec un budget le plus faible possible et capable de compétionner avec les vrais rivaux du compostage : l'enfouissement et l'incinération.

Biomax est fière de vous présenter son nouveau système de compostage modulaire automatisé : TRIPLE-A. Les trois A indissociables et indispensables au contrôle adéquat du procédé de compostage :
ATMOSPHERE CONTROLEE - AGITATION MULTIPLE - AERATION FORCEE.

L'atmosphère contrôlée est implicite à un concept sous abri. Elle minimise les émissions atmosphériques. Elle élimine, de plus, la production de lixiviation due aux précipitations et permet de produire en toute saison.

L'agitation multiple grâce à l'équipement de conception unique permet l'homogénéisation du mélange tout en réduisant progressivement la taille des particules. Les chemins préférentiels d'aération sont constamment défaits, assurant une oxygénation mieux répartie dans le mélange. L'opération de l'agitateur permet une progression en continu du mélange au travers du système ou bien en lot.

L'aération forcée maintient des conditions aérobies strictes. Elle permet de régulariser la température du procédé afin d'éviter les seuils trop élevés qui ralentissent la croissance des microorganismes. La période de stabilisation est réduite : 14 à 21 jours seulement, en fonction du mélange choisi.

Certes, cette description de notre concept traduit bien la clarté et la confiance que nous avons dans ce nouveau produit.

Il est aussi plus facile de convaincre la population et les élus quand l'exposé est clair et que rien n'est laissé au hasard. De plus, le fait que ce système soit de dimensions restreintes n'attire pas de réaction "PAS DANS MA COUR" des citoyens, mais plutôt une certaine assurance qu'ils auront le contrôle de qualité des intrants et du produit composté.

En fait, de petites unités installées localement et dont le contrôle demeure dans les mains des citoyens, ont sans doute de meilleures chances de succès et de durabilité. Les composts produits localement seront consommés localement aussi, puisque la qualité du produit aura été établie par les utilisateurs.

LA REGIONALISATION DE LA TRANSFORMATION ET DE L'UTILISATION DES COMPOSTS ISSUS DE RESIDUS ORGANIQUES TRIES A LA SOURCE SONT DES GAGES DE DEVELOPPEMENT DURABLE DE L'INDUSTRIE DU COMPOSTAGE.

Il n'est pas nécessaire de créer des méga-usines bétonnées pour assurer des bases solides pour l'avenir de la valorisation de nos résidus putrescibles.

SYSTÈME INTÉGRÉ DE TRAITEMENT ET DE VALORISATION DES BOUES DE FOSSES SEPTIQUES

par

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Dans le cadre du 2[ième]
Congrès annuel du
Conseil canadien du Compostage

5 - 6 novembre 1992

1.0 INTRODUCTION

Selon le Guide sur la gestion des boues de fosses septiques (BFS) du ministère de l'Environnement du Québec, quelques options de traitement sont possibles; la déshydratation, le lagunage, les dépôts en tranchées, le compostage, la stabilisation chimique, l'addition aux stations d'épuration et les stations mécanisées dédiées aux boues de fosses septiques.

Dans plusieurs cas, les alternatives de gestion sont limitées par les conditions spécifiques régionales. Face au besoin grandissant dans ce domaine, la firmer Serrener Consultation inc. a procédé en 1989 à une étude exhaustive des différentes technologies disponibles dans le monde pour la gestion des boues de fosses septiques.

L'option retenue consiste en un système intégré de gestion incluant la déshydratation suivie d'un traitement du filtrat (rejet liquide) et des boues solides (20 % M.S.). Les boues déshydratées peuvent ensuite être traitées et valorisées.

2.0 PROBLÉMATIQUE ET CONTEXTE

Le ministère de l'Environnement du Québec déposait en 1988 sa politique en matière de gestion des boues de fosses septiques, qui indique, qu'avant tout, la gestion de ces résidus d'origine résidentielle demeure une responsabilité municipale. Ainsi, selon cette politique chaque municipalité régionale de comté devra être desservie par au moins un lieu de traitement et d'élimination de ces boues sur son territoire. Cette politique venait renforcir le cadre règlementaire actuel en matière de gestion des eaux usées des résidences isolées de la Loi sur la qualité de l'environnement.

En 1985 au Québec, on estimait à plus de 65 millions de gallons de boues de fosses septiques à vidanger chaque année sur un potentiel de 300 millions de gallons. Avant 1988, un très faible volume de boues était géré de façon adéquate. Quelques entreprises spécialisées dans la vidange et le transport des boues utilisaient le lagunage et/ou l'épandage agricole ou sylvicole comme méthode de disposition. Cependant, ces méthodes demeurent dans certaines circonstances peu appropriées.

Les boues de fosses septiques provenant des résidences isolées se présentent sous forme liquide avec une teneur en solides de seulement 2 à 4%. Elles sont principalement générées au cours de la période qui s'étend d'avril à novembre. De source résidentielle, les boues de fosses septiques contiennent des contaminants grossiers mais en revanche une faible quantité de métaux lourds comparativement à la moyenne des boues de stations d'épuration des eaux usées municipales en raison de l'absence de rejets industriels. Les boues de fosses septiques constituent donc une ressource valorisable qui peut être gérée sous forme liquide ou alors déshydratée de manière à faciliter par la suite la gestion de la fraction solide concentrée, et une fraction liquide dont la charge organique est de beaucoup diminuée. Une campagne de caractérisation réalisée par Serrener Consultation inc. dans plusieurs régions du Québec a démontré le potentiel de valorisation des boues.

Lorsque les boues de fosses septiques brutes sont introduites dans une station d'épuration municipale des eaux usées, elles perturbent le traitement par l'apport d'une charge polluante importante. De plus, la station est alors soumise à des variations de production saisonnières et des périodes de pointes de production, caractéristiques de la génération des boues de fosses septiques. Ces variations de production nécessitent des aménagements spécifiques et coûteux.

La déshydratation des boues en un lieu centralisé de traitement réduit les coûts de transport et facilite le traitement ultérieur des fractions liquides et solides obtenues. Plusieurs options de traitement sont disponibles pour la séparation des solides. Le lagunage est une technique utilisée depuis longtemps par certains entrepreneurs québecois qui permet la décantation des boues dans des bassins et l'infiltration du liquide dans le sol. Des conditions hydrogéologiques particulières sont requises de sorte que la méthode est resteinte à certains type de terrains récepteurs. Elle comporte de plus des contraintes techniques telles la difficulté d'évacuer les boues décantées, le colmattage potentiel du sol servant à l'infiltration et les grandes superficies de terrain nécessaires. Il faut ajouter à cela les risques de contamination des eaux souterraines et le potentiel d'émission d'odeurs, qui soulèvent de plus en plus de craintes parmi les milieux avoisinants.

Il semble que les technologies de déshydration des boues utilisées dans le domaine de l'épuration des eaux usées municipales demeurent peu appropriées en raison de leurs coûts trop élevés par rapport aux volumes de boues de fosses septiques produites dans une collectivité typique du Québec.

3.0 DESCRIPTION DU SYSTÈME INTÉGRÉ

Le procédé proposé regroupe plusieurs étapes; la réception des boues, la déshydratation, le traitement et le rejet de la fraction liquide et, le traitement et la valorisation de la fraction solide.

Le système a été sélectionné suite à l'évaluation de diverses alternatives sur la base des critères suivants:

- Choix d'un site;
- Coûts de construction et d'opération;
- Flexibilité, fiabilité;
- Impacts environnementaux.

La figure 1 présente un schéma d'écoulement typique du système intégré. Le premier centre québécois de traitement et de valorisation des boues de fosses septiques qui réunit à la fois la technologie DAB_{MC} et un système de compostage fut implanté en 1991 à Cowansville. L'usine, financée et opérée par la firme Valoraction inc., fonctionne depuis une année et constitue une solution novatrice à un besoin urgent de gestion appropriée des boues de fosses septiques. L'ensemble de l'usine permet de traiter 3.6 millions de boues par année, ou 80 m^3/jour.

3.1 Le système de déshydration DAB_{MC}

Dans un concept de gestion intégrée, Serrener Consultation inc. a retenu le système de déshydratation DAB_{MC} pour l'atteinte d'une siccité de plus de 20 % lors du pré-traitement des boues.

L'unité DAB_{MC} consiste en un mécanisme passif de filtration et de décantation sur membranes qui comprend l'ajout de floculants destinés à faciliter la déshydratation des boues. Pour les boues de fosses septiques le système inclut un dégrilleur, un réservoir de stockage, une unité de dosage du floculant, et l'unité de déshydratation DAB_{MC}.

Ce système en cuvée, qui fonctionne sur une base quotidienne, permet d'augmenter la siccité des boues, initiallement d'environ 2%, à plus de 20% en tout temps. De plus, il réduit d'au moins 90% la charge organique des boues dans le filtrat, et de 99% les matières solides. Le filtrat peut par la suite être acheminé vers une station d'épuration des eaux usées municipales ou vers une unité de traitement spécialement conçue et intégrée à l'usine du DAB_{MC}.

Le tableau 1 présente la caractérisation des boues brutes et du filtrat rejeté par le DAB_{MC}. Le pourcentage d'enlèvement est présenté à la dernière colonne du tableau. Nous constatons que l'enlèvement est supérieur à 90 % pour la majorité des paramètres. Les résultats les plus faibles sont obtenus pour NH_3 (22 %) et le phénol (35 %). Les plus forts pourcentages d'enlèvement sont observés pour les huiles et les graisses (H & G), les matières en suspensions (MES) et les bactéries coliformes, soit 99 % et plus. Les métaux, à l'exception du bore, sont très fortement enlevés (88 à 99 %). La DBO_5 est réduite de 92%.

Le rendement d'enlèvement est relié au fait que les contaminants sont sous forme

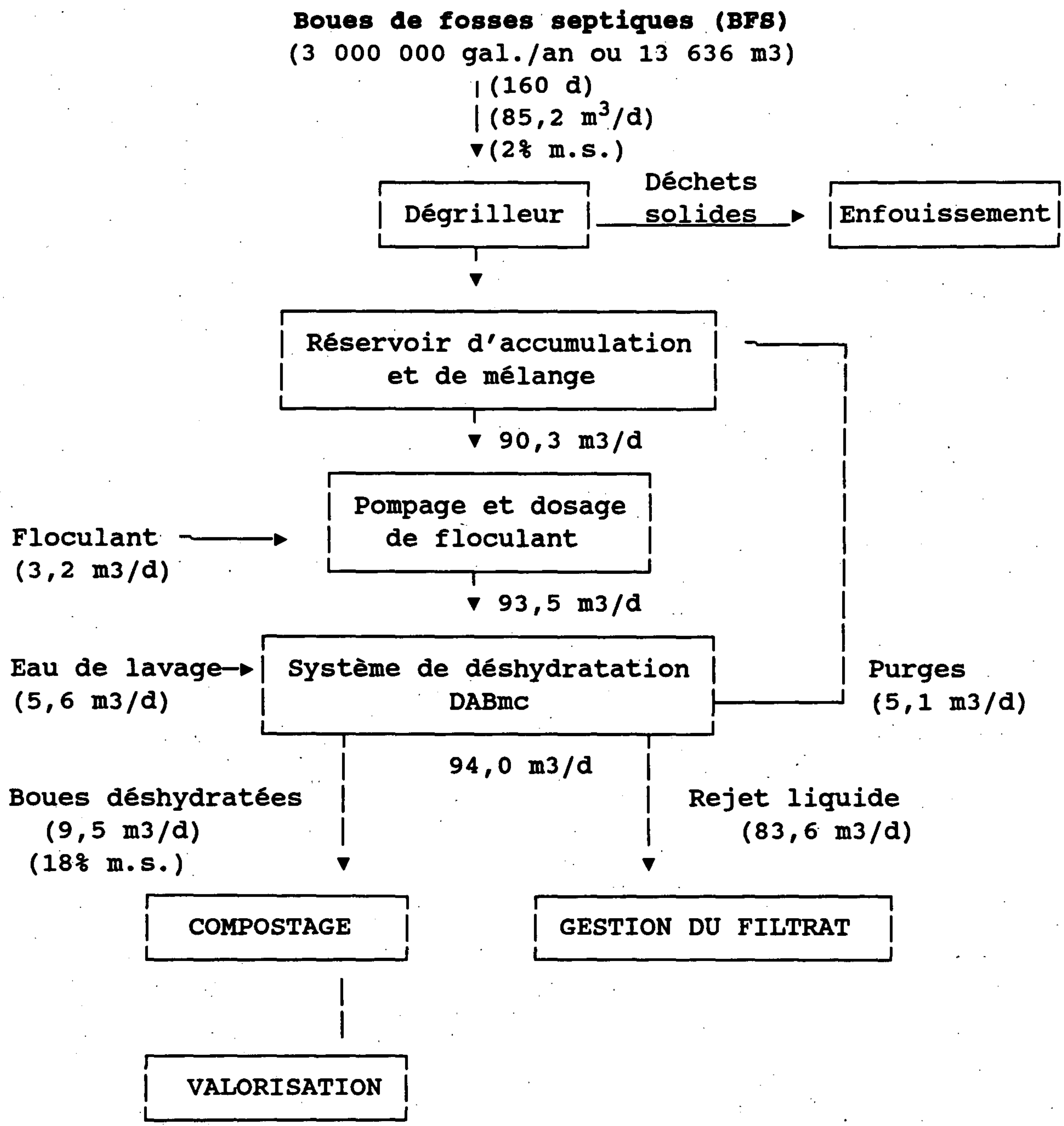

FIGURE 1 Schéma d'écoulement du procédé de traitement et de valorisation des boues de fosses septiques

TABLEAU 1
Résultats d'analyse de boues brutes et rendement d'épuration du système DAB enregistrés à Cowansville en 1990

Paramètres	Unités	Boues brutes (entrée du DAB_{mc})*	Nb. échant.	Rejet liquide du DAB_{mc}*	Nb. échant.	Rendement (% enlèv.)
pH		5,9	17	6,8	17	--
DBO_5	(mg/l)	6 979	6	506	6	92,75
DCO	"	19 537	17	1 250	17	93,60
Huiles et graisses	"	7 200,0	3	2,6	3	99,96
M.E.S.	"	17 311	17	81	17	99,53
Phénol	"	1,20	9	0,78	9	35,00
Sulfures	"	54,8	15	1,3	17	97,4
Azote total (NTK)	"	596	16	156	17	73,8
Azote ammoniacale (NH_3)	"	169	3	132	3	22,1
Phosphore total	"	100,79	16	18,06	14	82,04
Chrome	"	0,72	17	< 0,05	17	> 93,06
Cuivre	"	7,80	17	0,04	17	99,49
Cadmium	"	0,06	17	< 0,02	17	> 66,66
Fer	"	220,04	17	5,19	17	97,64
Nickel	"	0,68	17	0,07	17	89,71
Plomb	"	2,63	17	0,08	17	96,96
Zinc	"	8,67	17	0,12	17	98,62
Arsenic	(ug/l)	71,1	4	2,9	4	95,95
Sélénium	"	16,6	4	1,7	3	89,89
Bore	(mg/l)	2,03	4	0,68	4	66,50
Mercure	(ug/l)	11,6	4	1,3	2	88,81
Coliformes totaux	(ufc/100 ml)	109 000 000	17	708 000	17	99,35
Coliformes fécaux	"	11 550 000	17	120 000	17	98,96

* Moyennes des résultats obtenus en attribuant la limite de détection pour les paramètres non-détectés (sous la limite de détection).

particulaire ou reliés à la phase solide.

Le tableau 2 compare les teneurs en métaux obtenues pour les boues déshydratées et les critères de valorisation des boues en vigueur Québec. En regardant l'écart-type des résultats en fonction de la moyenne, nous constatons que les paramètres les plus variables sont le bore, le mercure, le sélénium, les bactéries coliformes et le zinc. Les résultats les plus stables sont obtenus pour le % de matière organique, le pH, la siccité, l'azote, le phosphore, le cadmium et le nickel.

Nous constatons que les normes pour tous les paramètres sont respectées. A l'exception du molybdène, tous les paramètres ont une concentration à moins de 1/3 de la norme. C'est donc dire qu'à première vue, les boues de fosses septiques déshydratées sont admissibles pour valorisation agricole subséquente.

3.2 Traitement du filtrat; le filtre Médiaflex$_{MC}$

On peut avantageusement incorporer le filtrat avec les eaux usées municipales à l'usine d'épuration sans modification de cette dernière dans la mesure où la capacité d'épuration de la station le permet. De plus, il est toujours possible de réaliser un pré-traitement du filtrat avant rejet à l'usine d'épuration ou encore de construire une usine d'épuration autonome avec rejet au réseau hydrographique de surface. Le système intégré proposé par Serrener Consultation inc. inclut le traitement du filtrat à l'aide d'un biofiltre développé par l'entreprise.

Le système de filtration repose sur l'utilisation de couches filtrantes multiples. L'épaisseur des milieux filtrants varie en fonction de la qualité du lixiviat. La mousse de sphaigne est un des matériaux employée pour la construction des couches du filtre; la capacité épuratoire de cette matière végétale morte et partiellement décomposée est reconnue depuis longtemps. Sa structure cellulaire, sa grande surface spécifique, sa porosité et sa capacité d'échange cationique confèrent à la tourbe quatre (4) mécanismes d'enlèvement; l'échange ionique, la complexation des métaux, l'absorption et la filtration des matériaux particulaires. Le second milieu filtrant est du charbon de bois activé et permet des mécanismes d'épuration tels l'absorption chimique, la précipitation chimique, et la filtration des matières particulaires.

3.3 Traitement des boues déshydratées par compostage

La boue déshydratée est recueillie à la base du DAB$_{MC}$ et peut alors être intégrée à

TABLEAU 2

Comparaison des caractéristiques[1] des boues déshydratées pour le système DAB avec les normes québécoises de valorisation agricole des boues

Paramètres	Unités	Nb. échant.	Moyenne	Valeur maximale admissible pour valorisation agric.[2]
Siccité	% solide	12	18,3	-
Matière org.	%	10	74,6	-
pH	-	9	5,7	-
Azote total	(mg/kg M.S)	11	23 440	-
Phosphore tot.	"	11	1 170	-
Bore	"	4	14,55	200
Mercure	"	4	0,914	10
Arsénic	"	4	1,7	30
Sélénium	"	4	1,4	25
Cadmium	"	12	4,2	15
Chrome	"	12	22	1 000
Cuivre	"	12	330	1 000
Nickel	"	12	20	180
Plomb	"	12	114	500
Zinc	"	12	120	2 500
Calcium	"	12	17 426	-
Cobalt	"	12	< 10	100
Magnésium	"	12	1 905	-
Manganèse	"	12	176	3 000
Molybdène	"	11	23	25
Sodium	"	12	2 196	-
Potassium	"	12	873	-
Colif. tot.	ufc/gr	9	15×10^6	-
Colif. féc.	"	9	$3,1 \times 10^6$	-

1 D'après les résultats lors de la phase expérimentale de l'automne 1990 à Cowansville.

2 Référence: Valorisation agricole des boues de station d'épuration, MENVIQ ET MAPAQ, 1991.

la filière de traitement des boues de l'usine ou encore suivre une filière de traitement indépendante.

Avec le système intégré, les boues déshydratées sont stabilisées par une méthode éprouvée, soit le compostage. Cette méthode, comparativement à la stabilisation chimique, présente de nombreux avantages soit:

- la stabilisation biologique efficace des boues, conformément aux critères de valorisation en vigueur;
- la réduction du volume de boues généré d'environ 40%;
- la production d'un amendement organique hygiénisé ayant des caractéristiques agronomiques appréciables et exempt d'odeur.

Le système de compostage sélectionné pour cette filière de traitement est la méthode de compostage sous aération forcée basée sur le procédé Rutgers pour la ventilation induite. Le procédé de compostage utilisé à l'usine de Cowansville a été sélectionné en raison des superficies de terrain limitées, d'une priorité attribuée au contrôle des odeurs, de facteurs économiques et puisque la méthode sous aération forcée est toute indiquée pour traiter des boues produites sur une base régulière.

Le système comprend une plate-forme de réception et d'entreposage des agents structurants, une aire abritée de compostage sous aération forcée et une aire de maturation du compost (voir figure 2). La plate-forme de béton servant au compostage est divisée en quatre sections indépendantes dont la capacité permet de traiter annuellement 1 400 m^3 de boues déshydratées. La plate-forme abritée de compostage d'une superficie de 105 m^2 est aménagée en annexe au bâtiment principal abritant l'unité de déshydratation.

A la sortie du DAB_{MC}, les boues sont reprises à l'aide d'une chargeuse avant pour être mélangées avec des matières carbonées structurantes sur une aire assignée à cette fin, dans une proportion de une partie de boue pour chaque partie d'agent structurant. Plusieurs types de matières ont été utilisées à titre expérimental comme agents structurants soit: de la sciure de bois copeaux d'émondage des arbres, et du compost de boues. Un mélange rapide des boues et de l'agent, et une mise en andain immédiate sont nécessaires afin d'éviter toute production d'odeur. Compte tenu des volumes annuels relativement faibles de boues à traiter, un mélangeur mécanique n'est pas rentable dans une première phase d'implantation du centre mais doit être envisagée à plus long terme.

Le mélange est par la suite acheminé vers la plate-forme abritée, où il est déposé

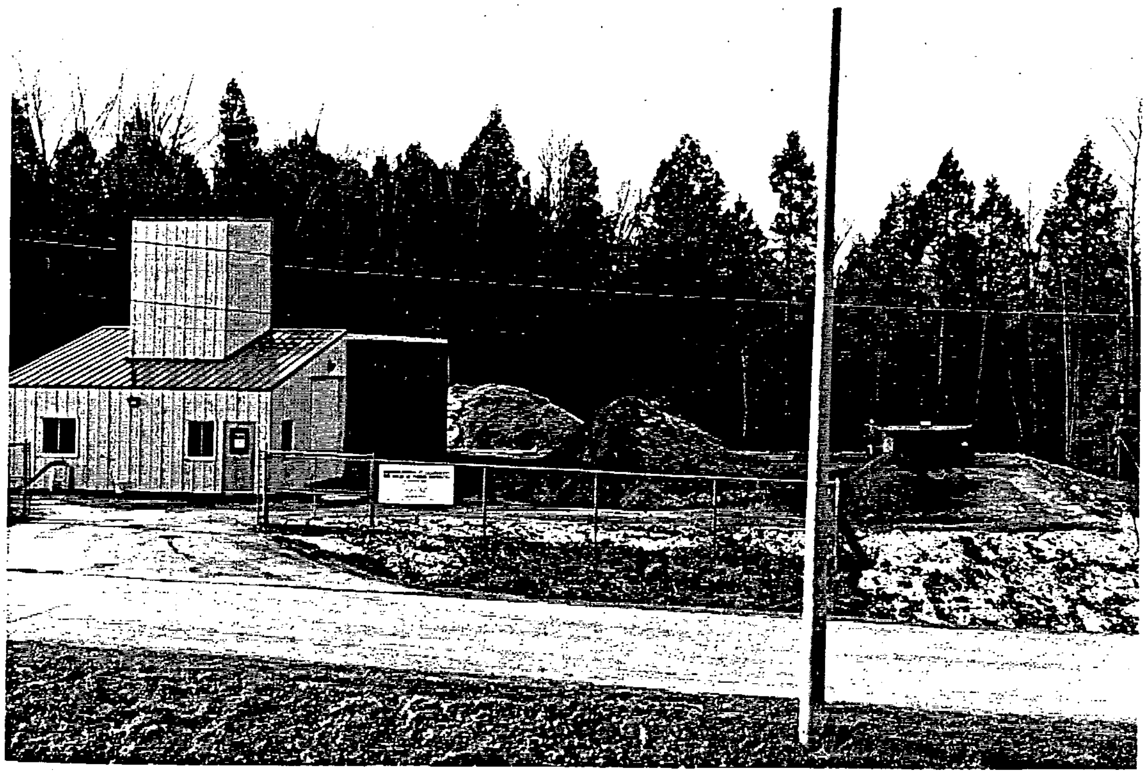

FIGURE 2 CENTRE DE TRAITEMENT ET DE VALORISATION DES BOUES DE FOSSES SEPTIQUES DE VALORACTION INC. À COWANSVILLE

sous forme andains au-dessus d'une couche de 20 cm de copeaux de bois recouvrant deux tuyaux perforés, distants de un mètre, constituant le réseau de distribution de l'air forcé sous pression positive. Le réseau est alimenté par des ventilateurs fournissant un débit maximal d'environ 20 m^3/heure pour chaque m^3 de mélange à composter. Le système fonctionne dans un premier temps sur une séquence de ventilation fixe, laquelle est ensuite ajustée selon les températures observées dans la pile statique en décomposition. Le cycle de ventilation est varié de façon à maintenir les températures autour de 60^0C. Les matières séjournent sur la plate-forme abritée, fermée sur trois cotés, durant une période de quatorze jours, après laquelle une phase de maturation d'au mois 30 jours est réalisée.

Le compost produit, et dont l'humidité n'excède pas 45%, est en partie recirculé dans le procédé à titre d'agent structurant. La recirculation du compost diminue les coûts d'approvisionnement en agent structurant et nécessairement la quantité de compost à mettre en marché. Graduellement, la demande et le prix du compost sur le marché s'accroissent et la recirculation devient moins importante.

Le centre de traitement et de valorisation des boues de Valoraction inc. à Cowansville opère depuis un an. Près de 2 millions de boues ont été traités et plus de 500 m^3 de compost ont été distribués gratuitement en 1992 pour la production de terreaux destinés à être utilisés pour l'aménagement paysager. A l'automne 1992, une deuxième phase d'implantation vient compléter et optimiser le système de traitement des boues déshydratées. En effet, la superficie du centre a été accrue afin d'accueillir une aire de préparation des matières avant compostage. Cette étape permettra d'optimiser la décomposition sous aération forcée, en homogénéisant le mélange de boues et d'agent structurants et en démarrant le processus d'échauffement avant l'acheminement des matières sous aération forcée. L'étape préparatoire consiste à mélanger les matières à l'aide d'un retourneur d'andains, à plusieurs reprises sur une période d'environ sept jours, une plate-forme imperméable étant aménagée à cette fin. Le mélange homogène permettra d'améliorer l'efficacité du système sous aération forcée par une répartition plus uniforme de l'air induit. Le tamisage du compost permettra en 1993 d'accéder à de nouveaux marchés locaux et de mieux rentabiliser le traitement avec un revenu de vente du compost.

D'autres méthodes de compostage peuvent par ailleurs être utilisées pour le traitement des boues déshydratées. En effet, les boues peuvent être compostées en réacteur (enceinte) ou selon la méthode des andains retournés. Serrener Consultation inc., pour le compte d'une entreprise de traitement des boues de fosses septiques de la région de Lachute, a vérifié l'efficacité de la méthode des andains retournés pour la stabilisation de boues décantées ayant une siccité d'environ 15 %. Lors de ces essais, les boues ont été mélangées avec de la sciure de bois et des écorces, dans une proportion de 1 partie de boue pour 1.7 parties de sciure et d'écorces. Les retournements ont été effectués à l'aide d'un retourneur d'andains SITTLER (figure 3). Au total douze retournements ont été effectués et ont permit de maintenir la température interne des andains supérieure à 50 °C durant une période de 40 jours consécutifs. Réalisé en collaboration avec le Conseil national de la recherche du Canada (CNRC), ce projet a permis de valoriser 2 000 m^3 de compost de boues de fosses septiques issu de cette entreprise. Le compost a été utilisé avec grand intérêt par les entreprises d'aménagement paysager locales.

4.0 CONCLUSION

Le résultat obtenu et le concept proposé de traitement et de valorisation des boues permettent maintenant d'offrir une solution intégrée à la problématique existante. Plusieurs avantages sont notables dont la superficie utilisée, l'acceptation sociale du concept, le contrôle adéquat des arrivages et des nuisances, la valorisation des boues et les faibles coûts d'implantation et d'opération du système.

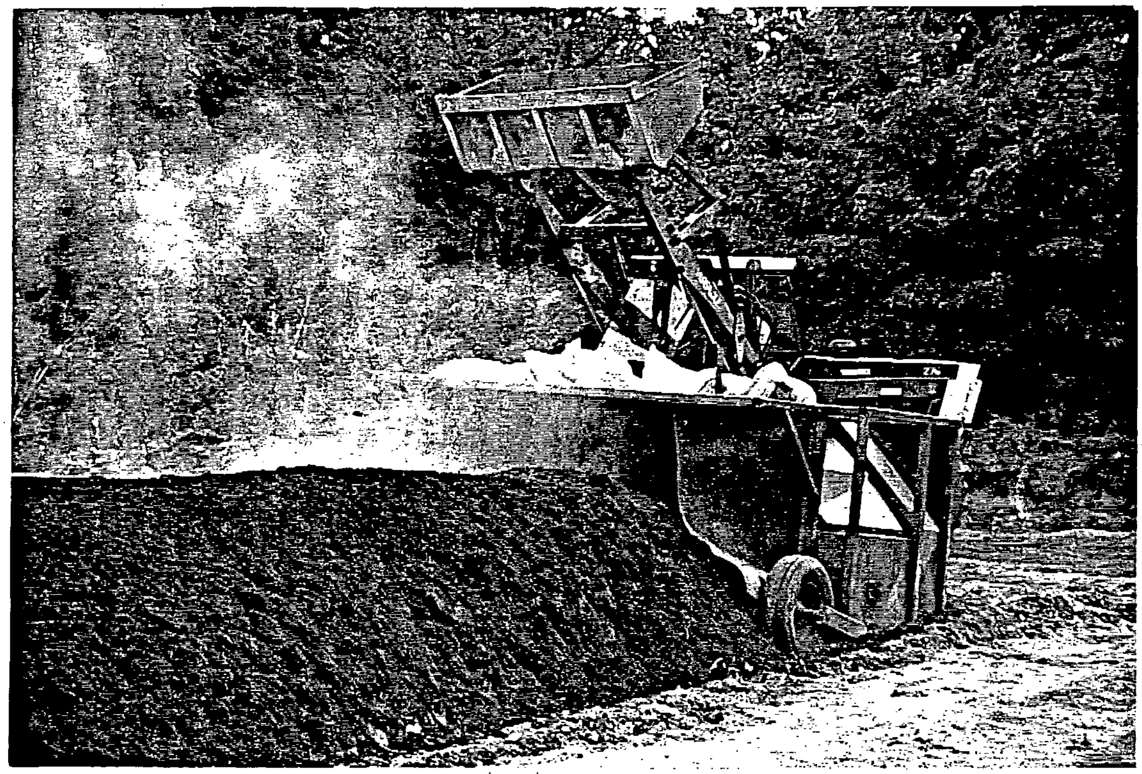

FIGURE 3 COMPOSTAGE EN ANDAINS RETOURNÉS DE BOUES DE FOSSES SEPTIQUES (ST-PHILIPPE-D'ARGENTEUIL, QUÉBEC)

Les coûts d'investissement du système présenté varient de 250 000$ à 400 000$ selon les scénarios envisagés. Avec ces niveaux d'investissement, il est possible d'offrir l'ensemble du service à un coût compris entre 18$ et 30$/m^3. Les coûts d'opération sont variables en fonction des volumes reçus. Jusqu'à présent, six centres de traitement des boues de fosses septiques utilisant ce système sont en opération au Québec et environ une dizaine sont à l'état de projet.

Serrener Consultation inc., pour le compte d'entrepreneurs et de municipalités a facilité la mise au point et l'implantation de méthodes de gestion efficaces des boues de fosses septiques au Québec. Le système DAB$_{MC}$ s'est montré des plus appropriés à la problématique nord-américaine dans ce domaine, en facilitant la valorisation des boues sous une forme solide. D'autres modes de déshydratation pourraient s'avérer performants dans un objectif de valorisation des boues. Cette approche de gestion intégrée constitue une solution efficace et rentable pour les municipalités ou les entreprises privées désireuses de gérer adéquatement ce résidu domestique en le transformant en une ressource valorisable et sécuritaire pour l'environnement, le compost.

TEXTE DE CONFÉRENCE

ETUDE DE FAISABILITE TECHNICO-ECONOMIQUE SUR LE TRI-COMPOSTAGE DES DÉCHETS DOMESTIQUES

par
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Urgel Delisle et Associés

1. INTRODUCTION

Le consensus des intervenants en matière de traitement des déchets domestiques (soit le sac vert) favorise lorsque possible, le recyclage et le compostage avant tout autre procédé drastique, comme par exemple l'incinération ou la mise en décharge. Actuellement, le Québec en est à ses tous premiers pas dans le développement de centres automatisés de tri-compostage, visant la récupération et la commercialisation d'une partie ou de la totalité des déchets domestiques. Cependant, dans le monde, plusieurs unités de tri-compostage ont été construites, notamment en Europe, où certaines sont en opération depuis plus d'une décennie.

C'est le cas notamment d'un organisme para-publique belge, IDÉLUX (Intercommunale de Développement Économique du Luxembourg), qui a procédé aux premières études sur le tri-compostage à la fin des années '70 et qui a, au début des années '80, construit deux unités de tri-compostage basées sur divers principes préconisés par la compagnie Buhler-Miag. Ce qui caractérise d'abord cet organisme, c'est sa grande similitude avec plusieurs régions du Québec. En effet, il s'agit d'un territoire à caractère essentiellement rural. Le Luxembourg couvre une superficie de 4 400 km^2, où se retrouvent 223 000 habitants dans 44 municipalités. La principale ville de la région, Arlon, comprend une population de 25 000 habitants.

Dans le but de solutionner rapidement le problème des déchets, IDÉLUX a d'abord mis en place les divers équipements nécessaires pour traiter le pire des cas, soit celui du sac vert dans son ensemble. Le procédé est toutefois particulièrement simple. Il comporte d'abord une étape de réception et de broyage, suivie de la séparation de la ferraille, puis de la séparation des papiers-plastiques-chiffons dans leur ensemble. Ce qui reste, soit la partie biodégradable, est envoyé sur une plate-forme de compostage couverte. Enfin, une étape d'affinage du compost finalise le concept de base IDÉLUX.

Le procédé est basé sur des composantes modulaires relativement adaptables aux évolutions prévisibles du marché. En effet, diverses composantes peuvent être ajustées ou modifiées, sans nécessairement impliquer trop d'impacts sur les autres composantes. Certaines étapes, notamment la section reliée aux papiers - plastiques - chiffons, pourraient être davantage sophistiquées pour permettre une meilleure séparation des composantes.

La firme Compo-Sortium inc. de Saint-Hubert, une filiale du Groupe Désourdy impliquée dans les matières premières et recyclables, s'est donnée comme mission de proposer aux municipalités des solutions adéquates et éprouvées pour la gestion des déchets domestiques. A cause des caractéristiques mentionnées précédemment, Compo-Sortium a retenu le procédé de tri-compostage mis en place par IDÉLUX et, a signé avec le gouvernement belge, une entente d'échanges technologiques, rendant ainsi accessibles toutes les études passées et futures d'IDÉLUX.

Ce qui a apporté un poids indéniable dans le choix de ce procédé, c'est la longue expérience de l'équipe d'IDÉLUX et le savoir-faire que les responsables ont acquis au cours des douze dernières années. En effet, avec la mise en opération des deux usines de tri-compostage en 1980, IDÉLUX a acquis une expérience inestimable tant au point de vue de la connaissance des limites des équipements, que de la préparation du matériel initial et des marchés s'appliquant à chacun des produits ainsi récupérés. De plus, le procédé IDÉLUX apparaissait très compatible avec la collecte sélective, telle qu'on l'applique présentement au Québec. Enfin, la littérature internationale indiquait que le compost belge faisant bonne figure en comparaison avec d'autres composts produits par des procédés similaires.

Toutefois, une technologie ne doit pas se transférer d'une façon aveugle. D'une part, il y a bien sûr l'adaptation au climat et au territoire. D'autre part, compte tenu de la conscientisation populaire face aux déchets, on peut supposer que l'avenir sera caractérisé par une évolution rapide des habitudes de consommation, du contenu du sac vert, des modes de collecte sélectives, des politiques gouvernementales ou des normes applicables aux différents sous-produits. Il faut aussi se demander si, une usine de traitement des ordures ménagères doit être conçue pour traiter le maximum de déchets possibles, ou si elle doit être conçue pour obtenir un compost de la plus grande qualité qui soit. C'est ainsi que, quel que soit le procédé retenu, à cause des investissements importants qui sont impliqués, il est important de se demander si une infrastructure mise en place aujourd'hui sera encore appropriée dans un proche avenir. et déterminer ce qui doit être prévu pour qu'il en soit ainsi.

Favorisant un esprit de concertation et de partenariat des secteurs publics et privés, Compo-Sortium voulait aussi d'abord répondre à plusieurs interrogations soulevées par divers représentants du Ministère de l'Environnement du Québec et d'élus municipaux.

C'est dans ce contexte que Compo-Sortium a décidé de procéder d'abord à une étude technico-économique sur le tri-compostage des ordures ménagères, afin de parfaire l'adaptation du procédé dans le contexte du Québec, mais aussi dans le but d'anticiper et de solutionner les contraintes futures envisageables dans le domaine des déchets domestiques, le tout dans le cadre d'un territoire spécifique,type du Québec.

C'est ainsi qu'un projet a été présenté au Gouvernement du Québec et n'a été accepté que tout récemment. En conséquence, je ne pourrai que vous présenter les grandes lignes de l'étude, puisque les résultats ne seront connus qu'en avril 1993. Le projet est financé conjointement par le Ministère de l'Environnement du Québec, Compo-Sortium inc. et la M.R.C. du Haut-Richelieu qui sert de cas type pour la présente étude.

2. CADRE DE L'ÉTUDE

De façon globale, la présente étude vise donc à déterminer la faisabilité technique et économique d'implanter au Québec le procédé de tri-compostage basé sur le procédé IDÉLUX amélioré et adapté aux conditions climatologiques et sociales du Québec, établir la flexibilité de ce procédé en fonction des changements prévisibles et/ou hypothétiques à survenir dans le domaine des déchets ménagers, procéder à diverses comparaisons en tenant compte du contexte d'une région spécifique (soit une MRC) et enfin établir les cadres de la recherche et du développement qu'il sera nécessaire de réaliser en situation réelle. Pour atteindre ces objectifs et pour répondre aux exigences et recommandations du MENVIQ, nous avons proposé un plan de travail par étapes spécifiques, en commençant par l'adaptation du procédé de base d'IDÉLUX.

Amélioration du procédé IDÉLUX

L'évolution du type de déchets ménagers en Belgique, l'introduction de la collecte sélective, l'établissement du concept de parc à containeurs et l'introduction de nouveaux équipements sur le marché font en sorte que le procédé actuel devra être amélioré tant en Belgique que pour le Québec. L'expertise acquise depuis 12 ans par les responsables d'IDÉLUX jouera un rôle important dans la définition du concept «IDÉLUX amélioré».

Description du cas type (MRC)

Afin d'étudier l'applicabilité des résultats de l'étude dans un contexte précis québécois, la MRC du Haut-Richelieu a accepté de s'impliquer dans le projet. Le plan de travail prévoit donc la prise de données précises sur ce territoire. Afin de s'assurer de la plus grande exactitude possible quant aux données de ce territoire, chacune des municipalités composant la MRC a été rencontrée de même que tous les intervenants majeurs de la région (les entrepreneurs en services sanitaires, les responsables de projets spéciaux, les producteurs importants de déchets putrescibles, etc.).

Variante de population

Afin d'évaluer l'impact de la population à desservir et tenter d'optimiser la capacité de l'usine la plus appropriée en tenant compte des caractéristiques d'un territoire particulier, une première comparaison sera effectuée en tenant compte de capacité d'usine pouvant desservir des populations de 40 000, 80 000, 120 000 et 160 000 habitants. Cette première comparaison technique et économique est uniquement basée, à ce stade-ci, sur le procédé IDÉLUX amélioré.

Comparaison de deux systèmes extrêmes

Compte tenu des tendances observées en Europe, il est potentiellement envisageable de prévoir qu'une usine pourrait recevoir l'ensemble des déchets ménagers (collecte traditionnelle), ou qu'elle pourrait recevoir uniquement la partie putrescible dans le cas d'une collecte sec/humide. A partir de la dimension d'usine la plus applicable à la MRC participante, l'étude procédera donc à l'élaboration et à la comparaison de deux approches adaptées à chacun de ces types extrêmes de collecte sélective.

La première approche consiste en une collecte de déchets ménagers traditionnelle, donc avec ou sans collecte sélective multi-matières (papier, carton, verre, plastique) et la construction d'une usine de tri-compostage basée sur le principe du procédé IDÉLUX amélioré.

La deuxième approche extrême consiste en une collecte sélective de type «sec/humide/DDD/autres» impliquant la construction d'une usine de compostage de déchets putrescibles uniquement triés à la source.

Dans le contexte de la MRC servant de cas type, ces deux approches seront comparées sur la base des avantages et des inconvénients de même que sur les bases techniques et économiques.

Cependant, il est évident que les coûts de construction et d'exploitation d'une usine qui n'aurait à traiter que la partie putrescible des déchets, seront moins élevés que pour une usine qui traitera la totalité de ceux-ci. D'autre part, si le produit à traiter est très prêt de la qualité ou de l'état qui en est recherché, il est tout aussi évident que les équipements nécessaires à sa préparation seront limités au strict minimum.

Cependant, il faut comprendre que l'étude de faisabilité telle que présentée par le promoteur et acceptée par le MENVIQ, vise à étudier l'ensemble des opérations reliées aux déchets et ainsi de pouvoir comparer les deux approches sur une même base. Il sera donc essentiel dans le deuxième scénario de tenir compte de toutes les composantes, soit la collecte, le transport, une usine de compostage, un ou des centres de tri, requis pour la partie sèche, le tout en relation avec la qualité des sous-produits obtenus.

Implication des variantes dans la collecte

A mi-chemin des deux scénarios extrêmes décrits précédemment, diverses variantes dans le type de collecte pouvant être effectué seront étudiées en fonction de leur faisabilité technique et économique, mais surtout en fonction des impacts que ces diverses variantes pourraient avoir sur la qualité du compost et des autres sous-produits. Sans s'y limiter, le projet mise sur les résultats d'une importante étude présentement en voie de réalisation par IDÉLUX qui vise à déterminer l'impact de l'enlèvement de divers produits sur la qualité du compost subséquent.

L'intégration de déchets connexes

Puisque le projet mise d'abord et avant tout sur les déchets dits domestiques, une attention particulière sera apportée à l'incorporation de divers produits organiques sur la conception et la qualité potentielle du compost produit. C'est ainsi que l'étude tentera d'évaluer tous les autres produits putrescibles, autres qu'agricoles, ainsi que les avantages et inconvénients reliés à leur intégration à l'intérieur d'une usine de tri-compostage. On peut penser, entre autres, aux déchets organiques d'épiceries, d'usines agro-alimentaires, d'hotelleries, d'entretien paysager, de menuiserie, de même que les boues d'épuration ou de fosses septiques.

Marché potentiel versus qualité

Il est indéniable que le succès d'une telle entreprise est relié à la capacité des marchés à absorber les sous-produits dans la forme produite. Puisque la mise en marché et la qualité des produits récupérés sont intimement liées, l'étude de faisabilité tentera de déterminer plus précisément cette interrelation de façon à émettre des recommandations pertinentes sur les modèles à préconiser et les variantes à utiliser, mais aussi sur certaines orientations que les organismes de réglementation devraient favoriser.

Mode de gestion et forme juridique

Compo-Sortium inc. n'a jamais caché sa volonté de former une entreprise conjointe associant, en partenariat, les pouvoirs publics et l'entreprise privée.

Dans ce contexte, et en vue d'orienter les différents intervenants, et plus spécifiquement la MRC participante, le projet portera une attention particulière sur les différents modes de financement, de participation et de gestion d'un tel centre, de même que les formes juridiques les plus appropriées rencontrant les critères spécifiques de la MRC. Sur la base des limitations actuellement applicables pour ces organismes publics, des recommandations particulières seront alors formulées de façon à orienter les organismes réglementant ce domaine d'activité.

Éléments de R & D

Enfin, au terme de l'étude et suite à la qualité de l'information qui peut être obtenue à chaque étape, l'étude vise à soumettre une série de recommandations pertinentes en termes de Recherche & Développement ou d'essais à échelle réelle de certaines variantes possibles, dans le but d'améliorer le procédé ou de l'adapter à la réalité québécoise.

Conclusions

Pour conclure, l'intérêt du Ministère de l'Environnement de supporter ce projet de recherche et développement réside principalement dans le fait de comparer différentes approches et que certaines favorisent l'implantation combinée d'un mode de collecte et de compostage des déchets municipaux qui soit viable au Québec.

Pour la M.R.C. du Haut-Richelieu, en plus d'attendre des informations techniques et économiques basées sur son territoire particulier, cette occasion lui permet d'assumer de façon optimale sa mission de disposer des déchets municipaux avec les meilleures performances environnementales possibles.

Pour ce qui est de Compo-Sortium, le promoteur du projet, il aurait très bien pu concevoir et implanter immédiatement un tel projet, basé sur l'expertise et le savoir-faire de son partenaire IDÉLUX. Cependant, dans la mesure où un partenariat à long terme est recherché, avec les pouvoirs publics, il a jugé important de s'assurer d'abord de certaines réponses techniques et économiques précises, afin de pouvoir anticiper le mieux possible les contraintes potentielles de ce domaine d'activités et de s'y ajuster dès maintenant dans la mesure du possible.

16 décembre 1992.

GETTING AHEAD OF THE 'NIMBY' SYNDROME - A CASE IN POINT

by

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Presented at the 2nd Annual Meeting of The
Composting Council of Canada
Nov 5 - 6, 1992
Ottawa, Ontario

Introduction

What is possibly the most sophisticated composting facility in British Columbia is now sitting almost idle, and may never operate, largely because of roadblocks imposed by the British Columbia Ministry of the Environment, the very Ministry which helped fund the project. These restrictions and regulatory requirements are unrelated to any real threats to the environment and have been put in place simply to appease the 'not in my back yard' or NIMBY critics.

In these days of increasing environmental awareness you would expect that a composting facility, located in a sparsely populated rural community, would receive a warm welcome from the community and the B.C. Ministry of the Environment. What could be better than being located in the middle of a fifteen hundred acre portion of a University Research farm, almost a kilometre from the closest residence and supported by two levels of government, industry and the university? It is hard to imagine a better setting and yet our facility is being treated by a few members of the community, and the B.C. Ministry of the Environment, like a negative, rather than a positive, development.

In the two years since its inception, the Pacific Bio-Waste Recovery Society (PacBio) has been a model citizen in trying to develop a community minded production and research facility. As a willing partner in trying to reach consensus in the community, PacBio has been maligned and taken-advantage-of at nearly every opportunity. The result is a facility so highly regulated that it will have probably the highest operating costs in Canada and may never even open.

The blame for the spiralling network of restrictions and operating requirements lies largely with the B.C. Ministry of the Environment. When the project began in 1990, PacBio voluntarily agreed to jump through regulatory hoops rather than contest their necessity. This is because it was perceived by the Board of Directors as being 'the right thing to do'. We naturally assumed that the B.C. Ministry of the Environment would act as a responsible referee and would ensure that we were treated fairly. It seemed logical to assume that the regulations imposed on us would be based on real environmental threats and would be the same as for other facilities. We could not have been more wrong.

Background

I would like to provide some background to our case. With luck, our experience can save others a great deal of wasted time, money and grief. Please note that any references made to the 'Ministry of the Environment' or 'MOE' refer to the Provincial Ministry in British Columbia.

In the late eighties, the salmon farming industry grew rapidly in British Columbia. However, its growth was opposed by the salmon fishermen's union who generated as much negative propaganda as they could. As a result of imaginative claims made by opponents to fish farming, farm wastes were elevated from being just dead fish, to being somehow contaminated and much more dangerous to the environment than other fisheries wastes.

The attention given to farm wastes then forced the Federal Fisheries Department and the Ministry of the Environment to do something about them. In order to appear pro-active, the government began insisting that farmed fish wastes be given special treatment. No longer could they just be land filled near the farms, or thrown back into the water like some wild fishery wastes. Instead, they had to be transported to urban centres, at considerable cost, and dumped in land fill sites there. This was somehow perceived as being more responsible although these actions soon led to new disposal problems.

The scrutiny of wastes from fish farms naturally raised the question of what was being done with processing plant wastes. This attention inadvertently brought wild fishery practices into question. Very suddenly the traditional practice of pushing the wastes off the end of the dock was no longer acceptable. Between the farms and the processing plants, almost overnight there developed a serious disposal crisis. After all the hype about farmed fish wastes being 'contaminated', the municipal land fill sites and rendering plants didn't want the fish wastes either.

In the tradition of all government initiatives, interim solutions were found and a study was undertaken. This study involved a review of disposal and utilization options, which included everything from ocean dumping to feed production. The conclusion was that composting offered the only cost effective, quick fix solution to the fish waste problem.

Once composting had been elected as the long term solution, funds were offered by government as an incentive for private enterprise to develop composting services. Among the organizations which submitted a proposal was UBC, through its research farm at Oyster River just south of Campbell River on Vancouver Island.

UBC's proposal was eventually accepted. The Pacific Bio-Waste Recovery Society was then formed as an independent, non-profit organization designed to encourage industry participation.

Noble Beginnings

In the Fall of 1990 a total of $955,000 was in place and the Society poised to build a state of the art, in-vessel facility which would serve as both a production facility and a research centre for organic waste recycling. Tipping fees from fish wastes were to form the backbone of the revenues which would make the facility financially self sufficient.

As a collection of community minded individuals and institutional representatives, the Society felt it would be best to go through all the regulatory hurdles, even though they may not have been necessary. This was seen as being a show of good faith after having received nearly $750,000 in government funding.

It is worth noting that, in compliance with legislation, the facility could have been built on the research farm lands, without any approvals, if the compost was to be used entirely on the farm. However, since the Society's plans were to sell product far and wide, an application was made to have five acres, of a 1500 acre block of research farm land, rezoned for 'commercial' composting use.

That was our first mistake. The rezoning application opened up a can of worms that took nearly a year to sort out. Once the application was underway we could not back up and start over, we were forced to win approval in a public relations contest that quickly lost sight of the facts. Local critics used the application as evidence that the Society's real goal was to change the research farm into an industrial park. The Ministry of the Environment distanced themselves from the process, rather than taking a stand one way or the other, which heightened the concerns of residents.

A few months after the rezoning application was filed, we also applied for a waste management permit at the suggestion of MOE officials. Although such a permit was not necessarily a requirement these officials indicated that it would be in our best interests to apply. Like lambs being led to the slaughter, PacBio succumbed. It was our biggest mistake and may have been fatal.

No Champions

If we had been planning a chicken farm, or hog facility, there would have been regulations defending us from the NIMBY syndrome. As a composting facility, we were neither agriculture nor industry and had neither champions in government, nor specific regulations to defend our rights. The Society was on its own in a public relations battle which caught it completely by surprise. There was no public body that could be turned to for moral or legal support.

PacBio found itself combating a small, tenacious group of opponents who were convinced that the composting facility was a cover up for the equivalent of a nuclear waste dump site in their backyards. (Of course I am being facetious but that is the kind of argument that was used to arouse fear and suspicion in the community). This core of critics fanned the flames of conflict and exaggerated the issue into a regional crisis. Everyone involved with the project became tainted by the bad publicity. Government officials became increasingly wary of being seen to cooperate with us and as a result every conceivable permit and application had to be filled out in triplicate.

Criticisms

There were four basic arguments used by critics to oppose the facility. First and foremost was the fear of odours. This was particularly well entrenched because of an open air, sewage sludge composting facility in a nearby community which was a source of considerable complaints. That facility was eventually forced to close because of odour problems.

The other criticisms were couched in pseudo-environmental terms as a way of camouflaging NIMBY motives. They included claims that leachate would reach a 'nearby' river, (over a kilometres away), and transfer devastating farmed fish diseases. It was also argued that increased traffic on the small service road would result in the deaths of children waiting for school buses. Another recurring theme was wildlife attraction. People became convinced that the facility would attract wildlife, such as bears, that would make the neighbourhood uninhabitable.

In order to fully understand the absurdity of the situation it is important to realize what was going on in other parts of the province at the same time. While PacBio was seeking approval from MOE to compost fish wastes, the same office of the MOE was approving the spraying of the very same, ensiled fish wastes, untreated, onto forest as a 'natural fertilizer'. It seemed that the only threat to fish streams came if the liquids leached out of our facility.

Also at the same time, a septic waste composting facility in our own community, was given permission to compost fish wastes without any environmental controls. This facility used windrows, operated completely outdoors and had neighbours closer than do we. No permit was required of them and no regulations imposed.

While all this was going on, two other fish composting operations were approved in other coastal communities and a large in-vessel facility was permitted to start-up in the Vancouver area without any permits at all.

Patience

Unaware of just how unfairly we were being treated by the MOE, PacBio persevered. After a gruelling six months of letters to editors, open houses, public meetings and two public hearings, the rezoning was finally approved by the Regional District.

However, we had won the battle but not the war. Our problems did not end with the rezoning approval, they merely moved from the public forum into the courts. A challenge to the rezoning was immediately launched and was followed shortly afterwards by an appeal of an already onerous waste management permit.

Arbitrary Treatment

Simply put, the MOE was being completely arbitrary in the management of composting operations. If you were foolish enough to apply for a permit, the MOE took the opportunity to display how diligently public input was considered by them.

In formulating the waste management permit, the MOE forced PacBio to address every criticism, real or imagined. Rather than act as a responsible referee, protecting the environment and treating PacBio fairly, the Ministry of the Environment formulated the requirements based on public pressure. Instead of regulating us as they had other facilities, as logic would suggest, the MOE issued a waste management permit more onerous than for a nuclear test station.

According to the original permit, not only were we required to collect all leachate, we could only operate and store materials indoors. At the same time we were required to have both a packed bed scrubber and biofilter for odour control, we could only process fish wastes and are required to do a wide range of tests including air quality. The real tragedy is that this permit was drafted by MOE at the same time as a similar, but larger in-vessel facility was being established in the lower mainland without any restrictions what so ever.

Never Enough

The tremendous cost of the permit requirements threatened to suffocate PacBio with financial problems before construction was even complete. To make things more ridiculous, and expensive, immediately after issuing the permit, the MOE accepted an appeal of our waste management permit.

This appeal used arguments made credible by the participation of 'an expert witness' from the Composting Council of Canada, and resulted in the imposition of even more severe restrictions. This is despite the fact that other composting operations were being left unregulated and we had yet to receive our first delivery of wastes.

Believe it or not, as it now stands, we are only permitted to receive fresh, or preserved fish and sawdust. Nothing else! The most sophisticated facility in Canada, with the most elaborate environmental controls, and we can only process fresh fish. It is ludicrous.

The critics have now launched yet another appeal of our waste management permit. Not content to let us die a slow financial death from over regulation, the NIMBY critics are using the appeal process to beat us to death.

In the latest appeal, the critics are demanding such things as the installation of a back-up generator and fire fighting equipment. They also want the definition of fresh fish to be strictly defined. Want they really want is to use the regulatory process to put us out of business, and the MOE is cooperating.

Current Status

To recap, the situation as it stands is that, considering the nature of the waste stream, PacBio has probably the strictest waste management permit in the world. Our one million dollar construction budget was originally meant for a covered, open air, in-vessel facility. These funds have not turned out to be adequate to fulfil the arbitrary regulatory requirements demanded by the MOE. As a result, the PacBio facility may never open. The waste disposal problem that got us going in the first place would then remain unresolved because of small 'p' politics within the MOE.

Faced with yet another appeal of the waste management permit, and with nothing to lose, PacBio has decided to fight back. It has taken a long time to sink in, but we now realize that the Ministry of the Environment is our worst enemy, not the NIMBY critics. The fact that our operation will be good for the environment has not insulated us from NIMBY critics in the eyes of MOE. We were foolish to be cooperative, to have expected fair treatment from regulating authorities, but we now plan to demand equity.

Options

Three options remain open to us. The first is to continue as we have been, hoping that someone in government will ultimately acknowledge the injustices of our situation. Of course this approach would involve preparing an expensive defense for the upcoming appeal of our waste management permit and does nothing to address the financial shortage. It is also the least likely to succeed.

If everything went very well at the hearing, there may not be any more regulations or restrictions imposed on us and a few may even be lifted. Of course, we might also find that even more restrictions and expenses were imposed. Any more restrictions and capital costs would certainly be the end of PacBio.

The second option is to mothball the facility and hope that a million dollar white elephant is enough to embarrass someone into taking remedial action. What would be needed to revive the facility is a contribution of the necessary funds and a relaxation in the terms of the waste management permit.

The third option is to simply return the waste management permit to the MOE. This would create quite a stir but would not necessarily solve the financial crisis that the permit requirements have introduced. It would, however, make us feel better!

What we really want is compensation (approx. $300,000) from the Ministry of the Environment and an apology for all the grief their inconsistency and lack of backbone has caused us.

Regulatory Proposals

In summary it is fair to conclude that some changes are needed in the way composting is regulated, at least in B.C.. Our experience has suggested that the establishment of regulatory standards would go a long way towards promoting composting. First and foremost, we need consistency in regulation. Anyone considering an investment in composting should know what to expect and have precedents on which they can depend. Mid-level bureaucrats should not be free to formulate regulations on an ad hoc basis according to public pressure. As an aspect of consistency, I would suggest that concerns about leachate be addressed by regulations requiring that reasonable precautions be taken to avoid excessive runoff. These regulations should allow for flexibility in meeting the requirements and should not involve detailed standards or substantial capital costs. This kind of approach would be based on the premise that composting is a positive activity which should be encouraged and recognizes that the leachates from most composting operations are generally harmless.

Regarding zoning, I would propose that agricultural lands be permitted to be used for commercial composting as if composting were the same as any other agricultural activity. The nuisance factor and the odours are comparable to other forms of agriculture. Such a regulation would promote composting in areas of low population density, where the soils would be in demand. There should be no waste management permits required unless the materials being composted are proven to be hazardous to the environment. In rural areas odours should be dealt with in the same way as they are for other agricultural activities. Odour control should be imposed only if there are consistent smells that are not in keeping with the nature of the surrounding area. What is considered an unacceptable odour in an urban setting might be allowable in a rural setting where agricultural odours are common.

Conclusion

There are three lessons we have learned and that I would like to pass on to others considering the treacherous game of composting.

1. Do not trust the Ministry of the Environment to behave either responsibly or consistently. It does not appear to be the environment that they are protecting.
2. Do not assume that because you are doing something good for the environment that others in the community will support you. Start a public relations campaign early, even though you do not expect to need one.
3. For the short run at least, do not apply for any permits if you plan to operate in British Columbia.

If there is a moral to our tragedy, it is this;

"It is easier to ask for forgiveness than to seek permission."

OVERCOMING THE RESIDENTIAL MISCONCEPTION: COMPOSTING AT HOME

by

Dave Douglas
Program Co-ordinator - Waste Management
Town of Markham
101 Town Centre Blvd.
Markham, Ontario L3R 9W3
(416) 477-7000, Ext. 356

I refuse to compost - It stinks!
I don't have time to compost!
I hate rats, so I'm not putting a bin in my yard!
Composting - What the hell is that?

These are all very common concerns that I hear over and over again from residents. The very same people who continue to place three, four, or five bags of waste material at the curbside for weekly collection. The majority of these people (approximately 60%) could likely be convinced through proper education, to participate in home composting.

Markham's population is approximately 146,000 ppl. with 41,000 single family residences. We have been offering composters to residents since late 1990. To date, six thousand composters have been sold through the Town. Approximately 17% of household compost. (The actual figure is higher, but we do not have any record of those who bought a unit elsewhere or built their own.)

In June, 1992, we implemented a fairly aggressive campaign to promote backyard composting. We began by increasing the number of types of units that were available to residents to entice additional individuals to participate on the basis of aesthetics. We increased the selection from two to nine types.

As advertising is very important, we ran ads in local papers informing residents that the Town was promoting a Home Composting Program, and residents could expect to see our staff at their door during the summer. Residents were also encouraged to visit our Works Office to view the composters on display and pick up a unit.

One resident of Markham submitted a letter to the local paper, encouraging others to protest the proposed dumpsites (M3 and M6) by purchasing a composter to reduce waste at home (Appendix "A").

With funding provided from the province, as well as the suppliers of composters under Markham's program, the Waste Management Department hired nine summer students to assist with the implementation of our program. These staff members designed "Home Composting Guides" as well as other pieces of information for residents. Flyers were prepared and dropped off at every household in Markham (Appendix "B" - "C").

Information was also prepared in Chinese as a high proportion of Markham consists of Chinese immigrants (Appendix "D").

Sales steadily increased during the summer months. In our peak period, we were averaging fifty sales per day. Traditionally, municipalities have found that sales are low during summer months. However, our program enabled us to maximize sales during summer months (Appendix "E").

Our recycling/composting hotline is used quite regularly, as we receive approximately six hundred calls per month. Our demonstration booths at Markham festivals and fairs also enable us to meet with a large proportion of the community.

Another method used to reach the public was to set up a display a local mall, in an area provided to the department at no charge, staff remained on hand to discuss composting issues with store patrons. During Waste Reduction Week, the mail also purchased composters from the Town for the first fifty Markham shoppers who purchased over $50.00 retail. A coupon was provided to those customers and they submitted it at our office when they picked up a composter. The response was overwhelming as the coupons were all handed out in one day (Appendix "F").

We recently held a composter distribution day whereby residents were provided the opportunity to meet with Town staff, master composters, and composter companies to learn about composting. In four hours, we were able to distribute 125 units (Appendix "G").

One important aspect of our program is that we have prepared a data base of all sales. We will now be beginning a follow up program to see how many people continue to use their composters on a regular basis. We will also be targetting those residents who don't compost to find out why, and determine what we have to do to make them start.

Consider the benefits of garbage in our own backyards - compost

Editor's Mail

Dear Editor,

Almost everyone has heard the favorite camp song round "Don't Throw Your Junk in my Backyard."

Clearly that is the cry of those affected by the proposed M3 and M6 sites. The announcement on June 4th by the province of Ontario's Interim Waste Authority has ignited a raging fire of indignation and disgust.

There is no doubt that M3 and M6 are most inappropriate sites as the research and work of the dedicated citizens of the Town and the Mayor's Citizen Task Force Against the Markham Dumps have pointed out.

At this very moment our major concern is keeping the garbage out of our backyard. Maybe we do need garbage in our backyard.

Our own personal backyards can be effective landfill sites and command our attention in dealing with the greater picture.

We have made a magnificent effort in using the 'blue box'. This lifestyle change is evident every garbage day. Clearly evident on every garbage day are the multiple green and clear garbage bags that find their way to the curbside smothering the righteous 'blue box'.

A composter in every backyard would reduce the curbside load tremendously.

The Crombie Report, Regeneration, released in June, reports that in order to achieve an environmentally sustainable economy 17% of the respondents were willing to use the blue box as a lifestyle change and only 3% would compost.

Markham has hired staff to distribute an information letter and easy order form to all residents. For every thousand letters delivered, about 10 per cent have responded with a purchase. Ten per cent sure beats three per cent.

Do we give ourselves a pat on the back or a kick in the pants?

The blue box has become, for most people in Markham and Unionville, a way of life. Now it's time for the composter. Unionville Library's Nancy Black, who's an active composter, outlined the following concerns shared with her by individuals who were researching the possibility of backyard composting:

Don't they stink?
I'm afraid of animals invading it.
Does it look awful in your yard?
Where do I put it?
What can I put into it?

She said "People don't understand composting. We need to inform people more.

They don't see the benefits to themselves or the environment and they don't understand how simple it is."

The Township information letter clearly points out the 30% of the garbage we put at the curb every garbage day is compostable. Instead of putting kitchen scraps and grass cuttings at the end of the driveway they could be making rich humus for the gardens right in your own backyard and finding out how a composter works is simple.

When you buy your composter there is an easy to follow user's guide included.

Visiting the local library and borrowing such books as The Environmental Gardener by Laurence Sombke, The Rodale Book of Composting, or How to make your Garden Fertile by Pauline Pears is a great first step to knowledge acquisition. David Suzuki, has a great book for kids called Looking at the Environment.

If you're interested in and educational experience for the family, take a quick trip to the Town of Markham Waste Management Department, located at 555 Miller Avenue which is about 2km south of Hwy #7 off Woodbine Ave.

The Town has set up a display of the six types of composters available for purchase through the Town and there is always someone available to explain how they work. The kids will learn too.

Next spring you won't have to buy potting soil. Your vegetable garden will be healthier than it's ever been before. You'll be taking less garbage to the curb or incinerator and you will be proud to have been part of the solution to the Waste management crisis. If everyone used a composter the impact would be incredible.

We would reduce our personal garbage by a minimum of 30%. It's possible to reduce our garbage by as much as 50% by making composting part of our lifestyle.

Landfill hysteria is all about the fight to keep garbage out of our backyard.

While we fight the M3 and M6 battle lets also fight the battle to save our planet. We can't turn our backs on the fact that North Americans produce more garbage per capita than any other place in the world and almost 50% of that is recyclable and could be stopped tomorrow through a personal commitment to make a lifestyle change to compost.

Jacqui Byers
Unionville

Come buy your composter

PHOTO SJOERD WITTEVEEN

Composters for sale at the town's waste management department on 555 Miller Ave. have been seeing some action. From the left, program co-ordinator Dave Douglas, Karen Rose, Ken Stewart, Anand Ghanekar, Leonard Eng and Sharon Ho, all of the Environmental Youth Corps are ready to answer the public's questions and help them select the best type for their needs.

APPENDIX "A"

MARKHAM

Dear Markham Resident:

As you are probably aware, the Town of Markham has been actively involved with the implementation of measures to reduce the amount of waste being sent to landfills. **CONGRATULATIONS!** With the help of the Towns Recycling and Composting Programs, your efforts have **PAID OFF!!**

In 1991, the Town achieved a 29% decrease in the amount of municipally-collected waste that goes to landfill. As a result the Recycling Council of Ontario and The Ministry of the Environment, have recently awarded Markham with the "1991 Waste Minimization Award-For A Municipality With Over 100,000 People".

The Waste Management Department is now embarking on a very aggressive "Home Composting Program". By encouraging residents to compost their food and yard waste on site, a further 30% of material can be diverted from the waste stream. This will further assist to alleviate the incredible pressures in finding a landfill site, as well as reducing the high costs associated with the collection and disposal of waste material. Furthermore, the benefits to the environment by using natural compost material are definitely greater than using chemical fertilizers.

To encourage residents to participate in this waste minimization practice, the Waste Management Department is presently providing composters to residents at a reduced price. The Ontario Ministry of the Environment has provided the Town with a subsidy on the purchase of all units. Therefore, we are able to provide you with a unit for $20.00 and $25.00 for the larger units (including tax). We will even deliver the unit to your door, once the order form and full payment has been returned to our office.

Please review the attached information. If you are interested in purchasing a unit, you may complete and return the ORDER FORM (along with the applicable amount), and a composter will be delivered to you. If you wish to see the units on display, you may do so by going to 555 Miller Avenue (1 mile south of #7 and Woodbine Avenue), Monday-Friday, 8:30am to 4:30pm. Composters can also be picked up at that location.

Please direct any questions to Mr. Dave Douglas, Program Coordinator, at 477-7000, Ext. 356.

Sincerely,

Markham Waste Management Department

The Corporation of The Town of Markham 101 Town Centre Boulevard, Markham, Ontario, Canada L3R 9W3

APPENDIX "B"

TOWN OF MARKHAM

1992/93 HOME COMPOSTING PROGRAM

COMPOSTER MAIL ORDER FORM

PLEASE PRINT

NAME (Surname, Initial) ______________ DATE ORDERED (day/month/year) ______________

ADDRESS ______________ APT. # ______ NEAREST MAJOR INTERSECTION ______________

CITY ______________ POSTAL CODE ______ HOME PHONE ______ BUSINESS PHONE ______

DELIVERY INSTRUCTIONS:
- ☐ front porch
- ☐ backyard
- ☐ inside garage
- ☐ other (specify) ______________

UNIT ORDERED:
- ☐ Soil Saver ($20.00)
- ☐ Garden Gourmet ($20.00)
- ☐ Eco Balance ($20.00)
- ☐ Earth Machine-black ($20.00)
- ☐ Earth Machine-green ($20.00)
- ☐ Cedar Bin-10 cubic feet ($20.00)
- ☐ Cedar Bin-20 cubic feet ($25.00)
- ☐ Vermi-Bin/small ($25.00)
- ☐ Vermi-Bin/medium ($25.00)
- ☐ Vermi-Bin/large ($25.00)

ALL PRICES INCLUDE TAX AND DELIVERIES

DUE TO THE LIMITED NUMBER OF UNITS AVAILABLE, RESIDENTS ARE REQUESTED TO ORDER ONE UNIT ONLY

ALL DELIVERIES MUST BE PREPAID. PLEASE ALLOW TEN BUSINESS DAYS FOR DELIVERY

SAMPLE UNITS HAVE BEEN SET UP AT 555 MILLER AVENUE (1 mile south of #7 and Woodbine Ave.) OPEN FROM 8:30am-4:30pm, Monday to Friday.

UNITS CAN BE PURCHASED FROM 555 MILLER AVENUE OR RETURN MAIL ORDER FORM WITH THE CORRECT AMOUNT TO:

Town of Markham
Waste Management Department
101 Town Centre Boulevard
Markham, Ontario
L3R 9W3 Attention: Dave Douglas

AMOUNT ENCLOSED: $__________ (Cash or Cheque Only)

PLEASE MAKE CHEQUES PAYABLE TO THE TOWN OF MARKHAM

OFFICE USE ONLY

DATE OF DELIVERY ______________
(day/month/year)

APPENDIX "C"

MARKHAM

致：
麦鎮市居民：

為减少廢物，淨化環境污染
請用"堆肥催化器"(COMPOSTER)

自一九九一年開始，麦鎮市参予"再造及堆肥催化"計劃後，廢物收集比以往减少百分之廿九，為此得到安省環境保護署嘉許頒獎。
麦鎮市廢物處理部再接再勵推行"堆肥催化器"(COMPOSTER)計劃鼓勵市民，每家每户用"堆肥催化器"去處理菜皮菜屑等，因此百分之卅(30%)拋棄廢物可以再造催化变成肥料，用来種菜及種花，减少用化學肥，淨化環境污染，一舉二得，全民受益。
市政府為鼓勵市民参予此計劃，特低推出"堆肥催化器"給市民使用，每個20元及25元兩種，免费送到户上，如有興趣購買請填妥夹附之申請表並附下支票，市政府廢物處理部當会派人送到或親自到555 MILLER AVE.(七号公路以南一英哩夫活拜大道)亦可。
办公時间星期一至星期五早上八時半至下午四時。
如用疑问請用英語电 477-7000 EXT 356 MR. DAVE DOUGLAS

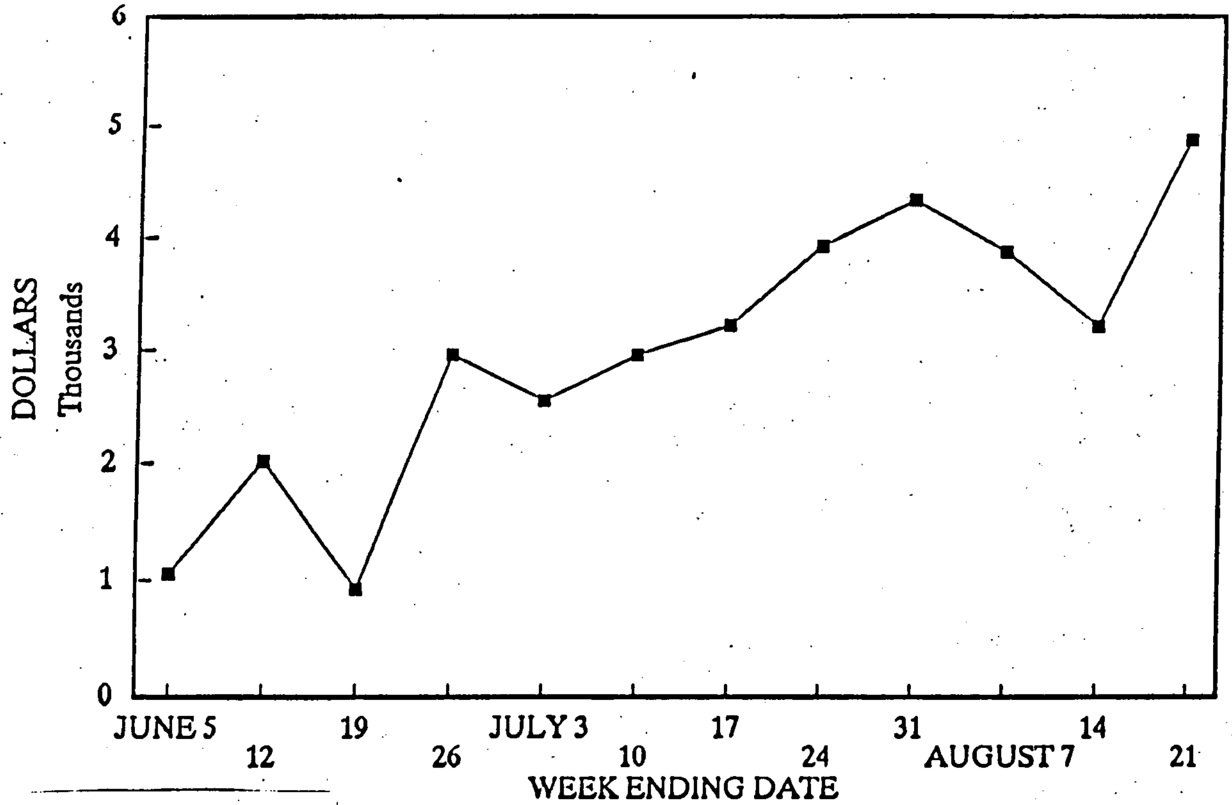
麦鎮市廢物處理部

The Corporation of The Town of Markham 101 Town Centre Boulevard, Markham, Ontario, Canada L3R 9W3
(416) 477-7000 Fax (416) 940-1550

APPENDIX "D"

COMPOSTER SALES

SUMMER 1992



APPENDIX "E"

First Name: ______________

Last Name: ______________

Address: ______________

____

____

Postal Code: ______________

Phone #: ______________

Waste Reduction Week October 1 – October 3

In conjuctions with the Town of Markham

FREE COMPOSTER

This ocupon is valid until **October 31, 1992** with proof of purchase of **$50.00** or more at Thornhill Square.

You are entitle to **1 FREE COMPOSTER** per household.

This offer is availabe to resident in the Town of Markham only.

This coupon may be redeemed at: ***55 Miller Avenue, Markham, Ontario***
Mon. – Fri. 8:30 a.m. to 4:30 p.m.

THORNHILL SQUARE

Reduce · Reuse · Recycle

Printed on Recycled Paper

APPENDIX "F"

COMPOSTER SALE

for residents of Markham
Pick up your composter
for the very low price of

$20.00 - $25.00

(approx. value $80.00 - $100.00)

THORNHILL
SQUARE
SHOPPING CENTRE

Sat. Oct. 31
10:00 - 2:00 p.m.
North East Parking Lot
Thornhill Square
300 John St.
(East of Bayview)

Fall is the perfect time to start composting.
Did you know that you could eliminate 30% of the material you put out for collection just by composting at home?

MARKHAM

APPENDIX "G"

April 1, 1992

Social Change Workshop Interim Report:

APPLYING SOCIAL PSYCHOLOGY THEORY

IN AN EVALUATION OF WATERLOO REGION'S

BACKYARD COMPOSTING PARTICIPATION STUDY

By Steve Gombos
Composting Coordinator
Regional Municipality of Waterloo

1.0 INTRODUCTION

This report summarizes the trial intervention used to encourage backyard composting participation amongst a selected group of Kitchener, Ontario residents who were given units free. The report also evaluates the intervention from the points of view of G. N. Jones and other persuasion researchers.

The Jones evaluation is based on a framework outlined in his book entitled, "Planned Organizational Change: A Study in Change Dynamics." A point-form application of the Jones method to the case study is attached as Appendix A.

2.0 CASE STUDY SUMMARY

2.1 Selection of Study Area

This section highlights methods used for the backyard composting participation study and presents significant results.

The Region of Waterloo began selling cedar backyard composters and plastic backyard digestors at a subsidized cost of $20 each in 1991 through six waste transfer stations and four local garden centres. To date, approximately 7,100 units have been sold. This represents an allocation of units to about 9% of single family dwellings in the Region. An important point is that over 50% of the units were sold during the first two weeks of the program (June 1991), then sales dropped sharply.

In order to determine the potential home owner participation if composters and digestors were delivered to households at no cost, a new distribution methodology was established and tested in three study neighbourhoods. Using information provided by the Regional Planning Department, 100 households were selected in each of three income delineated neighbourhoods: lower-middle, middle and upper-middle. Researchers followed up on the Planning Department information by driving around the potential neighbourhoods to confirm target homes and lots were the same size and general value, and were in close proximity to one another. Each of the three study populations were clearly definable "neighbourhoods," as opposed to an intermittent scattering of homes along streets.

The three study neighbourhoods were chosen from within the City of Kitchener on the basis of results from a 1991 survey, which indicated that, generally, residents in Kitchener had an average awareness of environmental and waste management issues relative to other parts of the Region. Another reason for selecting neighbourhoods in Kitchener was their convenient proximity to Regional headquarters.

2.2 Overview of Methods and Results

Each study household received a door hanger on September 27, stating that the household had been selected to receive a free composter and digestor (see Appendix B). If home owners did not want to receive the units, they were instructed to check the appropriate box on the self-addressed, stamped card and drop it in the mail. The instructions also offered the home owner the alternative of calling the Region directly to cancel delivery. The deadline for negative responses was October 11. The critical factor here is that home owners who did not respond, by mail or phone, were assumed to be participating.

Of the 300 households receiving door hangers, 84% received at least one unit during the week of October 15. Each unit was delivered with comprehensive instructions on how to backyard compost/digest (see Appendix C). A covering letter urged residents to phone the Region if they needed assistance with assembling the units, and announced two evening workshops on composting at two nearby schools.

The education workshops were conducted on the evenings of October 21 and 24. Twelve people attended the first workshop, while none showed up for the second workshop.

One month following the delivery of composters and digestors, a survey was mailed to study households that received units. The most important finding was that, in the short term, 77%, or 231 of the original 300 target homes, were using the units. In June of 1992 (nine months after delivery), another survey will be conducted to determine what the longer-term participation rates are.

Another short-term finding was that the middle-income neighbourhood responded best to the program, and had the highest participation. The lower and upper income neighbourhoods were equal in participation rate and previous composting experience.

3.0 ANALYSIS OF RESULTS

The composter/digestor participation study was designed and initiated prior to the Region's closer look at the socio-psychological aspects of affecting change in the community. Therefore, the interpretations of some of our observations and results are tentative.

The Social Change workshop members felt that the Jones framework is difficult to apply to some aspects of the study, therefore, other literature was referred to for additional support. Two sources found to be especially applicable to the case study were excerpts from "Influence," by Robert Cialdini; and "Applied Social Psychology," by Stuart Oskamp.

The message on the door hanger instructed residents to contact the Region ONLY IF THEY DID NOT WANT TO PARTICIPATE. This approach was a unique departure from other tactics used in composter distribution. The short term study results indicate that this approach was successful.

In a similar "free composter" study in Durham Region, Ontario, a team of backyard composting specialists used a hard sell approach in composter distribution. For several months, the specialists went door-to-door to approximately 1,100 homes. They explained the composting process and encouraged residents to take composters for their back yards. The result was that 75% of the target population accepted the units, which is 10% lower than the Waterloo acceptance rate. The participation rate after one year is approximately 59% of the target population.

Cialdini's suggestion is that a foot-in-the-door, soft-sell approach to motivating individuals to change behaviours may be more successful than a hard sell tactic. In the Kitchener study, it is suggested that the home owner would hesitate to step forward and be counted as someone that does not want to receive a composter/digestor, i.e., by mailing or phoning the Region. In time, the individual was confronted with the units and accompanying information on the benefits of composting, methodology, etc. As the apparent "persuasive" influence from outside sources was minimal, i.e. simply the door hanger, the individual would believe her motivation to participate was more consciously self-initiated. She would then adopt a script of values that supported this new composting activity. The individual would think that, since she has accepted the units, she must believe the positive attributes of composting: that it is good for the environment and saves taxpayers' money.

Cialdini suggests that people align their personal values with their actions. The reason a person begins composting, for example, may not be the reason he gives others when explaining why he does it. Cialdini also gives a good example of how the soft sell or "low-balling" tactic can work to make individuals believe their actions are based on internal motivations instead of external pressure. A car salesman initially low-balls a price quote to secure a deal with a person. Once the person has been convinced that he or she likes a specific car and all its features, the "mistake" in pricing will be revealed. Instead of dropping the deal, the buyer will invent reasons to spend the extra money, because he believes he wants the car.

Nancy Stockert, a Social Psychologist with the University of Hawaii at the Manoa campus, provided written comments on our study evaluation on March 24, 1992. She liked the Cialdini explanation. She said that changing self perceptions to align with behaviour is explained by the "self-perception theory." The theory is that people who begin doing something for no apparent external reason will continue to do it because they will assume they like to do it.

"According to self-perception theory, if you aren't very sure how you feel about something and you find yourself behaving in a certain way in regard to that something, then you take your attitudes from your behaviour (rather than the more normal route of attitude leading to behaviour). According to the theory, we sometimes infer our own attitudes the same way we infer attitudes of others - from behaviours," wrote Ms. Stockert.

Another revelation regarding the Region's study distribution approach is that, so far, the participants have not received significant rewards for their new behaviour. Cialdini says that rewards should not be too large, because they represent external pressure.

He says that, "Social scientists have determined that we accept inner responsibility for a behaviour when we think we have chosen to perform it in the absence of strong outside pressures. A large reward is one such external pressure."

Ms. Stockert confirmed that home owners followed the path of least resistance by doing nothing (thus receiving the units), and not publicly highlighting the fact they may not be sensitive to environmental issues (self perception begins working). Then, if instructions were clear, they would try using the units (minimal effort, and self perception is reinforced).

Finally, if individuals talk to neighbours and confirm they are using the units, the commitment has then become public. If neighbours do communicate, then the neighbourhood-by-neighbourhood approach to distribution would be successful. By determining basic sociological characteristics of target neighbourhoods, e.g., cohesiveness, predominant languages, etc., specific strategies and tactics could be employed. Cohesive neighbourhoods predominantly composed of Portuguese-speaking families, for example, could receive information in Portuguese. Also, if it is determined that people in upper-income neighbourhoods do not routinely communicate with each other, their efforts to compost could be "made public" (or initiated) through service clubs (e.g. Chambers of Commerce).

Instead of presenting awards, the Social Change Workshop members believe that Stuart Oskamp's suggestion to provide feedback to the participants is a positive way to reinforce desired behaviours. It is recommended that feedback be given to the local media in the form of a press release that announces the successful nature of the program in the pilot area.

Oskamp identifies a self-motivated feedback method that may reinforce long-term behaviour in a cost-effective way. In his example, householders were trained to record their own metered energy consumption in order to save on bills. The method was found to be very successful. In reviewing the composting participation study, a similar self-motivated feedback may have been present with the Region's request to complete the compost user survey. Home owners were asked to record the amount of waste they felt they had diverted to composters. They were also asked to comment on the appearance and practicality of the units. Several respondents stated that it was too early to give this information, but that it would be provided in their next survey. These comments suggest that people may be internalizing their commitment through feedback.

If the workshop members conclude that feedback is an essential component in reinforcing continued, long-term behavioural change, then all Regional waste reduction programs will need this component built into them. In the case of the Backyard Composting Participation Study, the survey may have "inadvertently" provided this feedback. It may be beneficial to include follow-up surveys as a reinforcement tactic in a Region-wide composter distribution program.

Ms. Stockert felt that the deadline for responses to the initial card was good, because it allowed enough time for a response, but not enough time for them to forget about it. She also felt that the one month follow-up survey was timed well, because it would provide reinforcement at the right time for those who started using the units for a couple of weeks and then ceased to use them or forgot.

4.0 CONCLUSION

As change agents, or "social interventionists," perhaps we should empower the community to change through education, the proper legal/political framework, and successful tactics like the low pressure approach employed in Kitchener.

5.0 POINTS TO CONSIDER FOR NEXT STUDY SURVEY

Some of the questions which should be asked on the follow-up participation study survey to be conducted in June, 1992, include:

5.1 What kind of communication, if any, is going on between neighbours?

5.2 How consistent were participants in putting organic waste into the units (especially in winter)?

5.3 Questioning people about why they are not composting must be posed in a non-judgmental tone. This may open the possibility of getting them started on composting later.

APPENDIX A

APPENDIX A - SOCIAL CHANGE WORKSHOP

REVIEW OF 1991/92 BACKYARD COMPOSTING PARTICIPATION STUDY

USING G.N. JONES EVALUATION METHOD

1. Perceiver

   - Steve Gombos

2. Sociocultural Environment

   - it is a modern societal environment that is industrialized, technological, urbanized and has a high standard of living
   - Jones says, in modern societies, "change is somewhat readily accepted"
   - it is a competitive setting, characteristic of modern political democracies

3. Change Catalyst

   - None Evident

4. Agent of Change

   - Steve Gombos - Region of Waterloo
   - indigene
   - commonwealth organization
   - government
   - organizational unit

5. Client System

   - 3 distinct neighbourhoods, divided by income in Kitchener
   - community organization
   - urban
   - urban
   - group (2.11112) - not sufficient data to determine how common values are shared

6. Change Agent Goals

   A. Order Goal - Stop Behaviour
   - marginally present (rated 2) because we want them to stop putting organic waste out to the curb

   B. Economic Goal - Save on Collection and Tipping Costs
   - quite important (rated 4) to Change Aent

   C. Sociocultural Goals - Adopt New Value-Based Behaviours
   - of Paramount Importance (rated 5)

7. Client System Goals

A. Order Goal - present (rated 3)

B. Economic Goal - assume present (rated 2)

C. Sociocultural Goal - paramount importance (rated 5)

8. Net Goals (mean of Client System and Change Agent goals)

A. Order Goal - 2.5, marginally to fully present

B. Economic Goal - 3, indicates was present

C. Sociocultural Goal - 5, of paramount importance

9. Goal Setting Process

- mutually set by the agent of change and client system; both parties freely and openly established their own goals, with no coercion

10. Strategies and Tactics

- strategies were strictly normative

- tactics included:

A. Participation Tactic
- people were free and spontaneous in actions
B. Education/Training Tactic
- people taught to compost through literature, seminars

11. Structuring of Change

- participation by Change Agent, 75-100%
- participation by Client system, 0-24%
- participation by Change Catalyst, 0-24%

12. Structure of Cessation

- participation by Change Agent, 0-24%
- participation by Client System, 75-100%
- participation by Change Catalyst, 0-24%

13. Evaluation of Goal Achievement

- were net goals achieved? - YES (more than partially)

14. Results of Change - Functional or Dysfunctional?

- Functional - they are doing what we want them to

15. Change Agent Performance

    - Excellent (the top rating)

16. Magnitude of Change Alternation

    Slight-Moderate-Extensive?

    - overall, rated as "moderate" because 56% of participants had tried composting before, therefore only a drastic change in behaviour in 25% of study group

17. Client System Receptivity

    - very receptive

18. Adaptability - Effectiveness of Change
    (the system's ability to adapt to future change)

    - speculate that it is slightly to greatly increased
    - insufficient data

19. Reality - Orientation Effectiveness

    - insufficient information to rate where in range from "Greatly Decreased" to "Greatly Increased" the group falls

20. Role Identity Effectiveness
    (are their roles in the community organization more clear?)

    - unchanged

APPENDIX B

Canada Post Corporation • Société canadienne des postes
910145

From:
Address:

Composting Coordinator
Engineering Department-Waste Reduction Section
Region of Waterloo
Marsland Centre, 5th Floor
Waterloo, Ontario
N2J 4G7

Attention: Steve Gombos

☐ Do not send a composter and digestor to the address noted above

CONGRATULATIONS!

You have been chosen to receive a

FREE BACKYARD COMPOSTER & DIGESTOR

from the Region of Waterloo!

Your neighborhood will receive free backyard composters and digestors during the week of October 15 as part of a waste reduction study being conducted by the Region. The objective of the study is to find out how many people are willing to begin digesting kitchen scraps and composting yard wastes in their own backyards. How-to instructions will be delivered with composters and digestors.

There is no obligation. If you do not want the Region to deliver a composter and digestor to your home, please let us know by filling out the reverse side of this card and mailing it to us, or by calling **747-5010** as soon as possible. If we do not hear from you by **Friday, October 11**, we will deliver the composter and digestor units to your door.

HAPPY COMPOSTING/ DIGESTING!

The Regional Municipality of Waterloo

Funded in part by the Ministry of the Environment.

Door Hanger Delivered to residents (2-sided card)

APPENDIX C

The
REGIONAL
MUNICIPALITY
of WATERLOO

ENGINEERING DEPARTMENT
Commissioner of Engineering

Marsland Centre, Waterloo, Ontario N2J 4G7
Recycling Office Telephone: (519) 747-5010
FAX: 747-4944

October 15, 1991

Dear resident:

As announced in the flier delivered to your door recently, the residents in your area have been selected to receive a composter and digestor at no cost. This is part of a pilot study on waste diversion being conducted this fall by the Region of Waterloo.

The objective of this study is to determine the willingness of residents to try backyard composting. Your participation will help us learn more about how much waste can be diverted through home composting. This information will be used to plan future programs.

In response to your willingness to participate in this study, you will find a plastic digestor, and a partially-assembled cedar composter beside your front or side door. Inside the envelope, or attached directly to the composter unit, you will find instructions on assembly and usage.

If you are physically unable to assemble the composter, please call Christine Adam, of the Region's Waste Reduction Office, at telephone number 747-5010, and she will arrange to have someone from the Region come and assist you.

The enclosed booklet entitled, Composting, The Natural Choice, will provide you with in-depth information on all aspects of composting, including troubleshooting tips. The fact sheet, Home Guide to Using a Digestor, provides information about the difference between a composter and digestor, and how the two can be used at the same time.

Please note that there is no obligation for you to use both the composter and digestor. You are free to use one unit if it will better suit your needs. If you would like us to take either of the units back, please call Christine at 747-5010 to arrange pick up.

To complement the literature provided, the Region will be conducting two composting information seminars in your area. The first seminar will be held on Monday, October 21, beginning 7:30 p.m., at Westmount Public School, 329 Glasgow St., Kitchener; and the second seminar will be held on Thursday, October 24, beginning at 7:30 p.m., at Resurrection Catholic School, 455 University Avenue West, Waterloo.

Our staff will be contacting you to ask a few questions about the program in November. Your answers to these questions will help us develop future composting programs in the Region of Waterloo.

Thank you for taking the time to consider composting in your backyard.

Yours truly,

Steve Gombos

Steve Gombos
Compost Coordinator
Waste Reduction Office

FACT SHEET

HOME GUIDE TO USING A DIGESTOR

The major difference between home composters and home digestors is how they are used. Composting is a process that requires air for microbes that feed on the organic materials present. To provide the air, most people use a shovel or pitch fork to turn the pile about once per week. Aerobic (meaning with air) composting produces a finished product within three to six months that can be worked into the garden to help soil quality.

Digesting, on the other hand, is a slower process that does not require air to break down the organic materials. Anaerobic (meaning without oxygen) digestion requires less work, because the organic materials do not have to be turned. Normally, the digested material is left in the ground and covered over with soil.

To use your digestor, simply dig a two foot deep hole, place the unit over top, and bury its edge about three inches into the soil. Deposit food wastes from your kitchen into the digestor and close the lid. Manufacturers of digestors suggest that meat and dairy products can also be put into the digestor, along with small amounts of yard wastes. When the hole is full (approximately 1 year), remove the digestor, cover the compost with dirt, and begin digesting in a new area.

Do not plant flowers or vegetables in the previous digestor location for at least one year. The buried materials will continue to degrade, and this will temporarily demand nutrients from the soil that would normally be available to plants.

Since the largest volume of organics generated around the home comes from the yard and garden, a good practice would be to compost this material in the wood composter. The kitchen scraps, along with yard wastes that will not fit into the composter, can be put into the digester.

Another option is to use your digestor more like a composter. By moving the digestor and turning the materials deposited in the hole occasionally, you will degrade the material aerobically. The result will be a humus-like material that can be added to your garden. By composting mixtures of kitchen and yard wastes in both the wood and plastic units, you will be able to maximize the compost production. Due to the potential for attracting animals, it is not recommended that you add meat, fish, oils and bones to the composter.

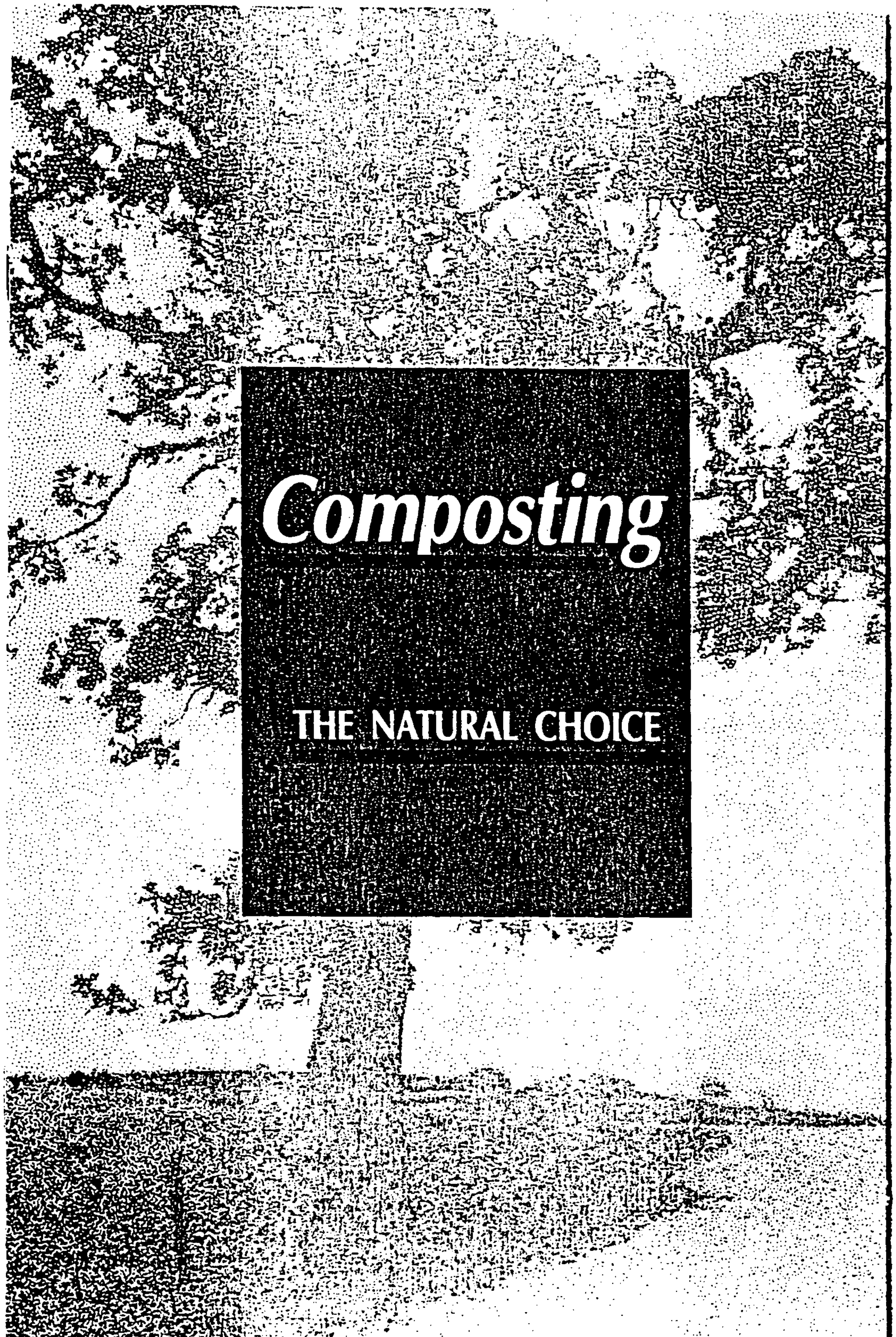
SUMMARY OF FACTS, COMPOSTING AND DIGESTING
(assuming digestor will be used anearobically - no turning)

COMPOSTER	**DIGESTOR**
o Above ground container	o Container partially buried
o Aerobic decomposition	o Anaerobic decomposition
o For garden wastes mainly	o For food wastes mainly
o Food wastes OK	o Some garden wastes OK
o No meat, fish, oils, bones	o Most food scraps acceptable
o End product in garden OK	o Leave product in ground

No matter how you use your composter and digestor, bear in mind that nature will eventually take its course. The materials you feed your composter or digestor will eventually break down and become a valuable part of the environment.

The main difference between one composting recipe and another, is how fast the organics will break down. By adding the occasional shovel full of finished compost or soil to your composting organic material, you will provide extra microbes and nutrients to enhance decomposition, while helping to prevent odour and insect problems. **There is no need to purchase commercial fertilizers, activators or starters in order to compost effectively.**

'How To' Compost Handbook developed by Region



FISHERIES WASTE TO FISHERIES BY-PRODUCT, A COMPOSTING SYSTEM DEVELOPED FOR BRITISH COLUMBIA'S FISHERIES SECTOR

by

Niels Holbek
University of British Columbia Research Farm,
Campbell River, B.C.

and

Brian Egan
Pacific Bio-Waste Recovery Society,
Campbell River, B.C.

for presentation to the 2nd Annual Meeting of

The Composting Council of Canada

Ottawa, Ontario,

November 5-6, 1992

Introduction

Serious disposal problems for fisheries waste from remote fish processing plants and fish farms on Vancouver Island led to a collaborative effort by the University of British Columbia, The B.C. Ministry of Agriculture, Fisheries and Food, the Mount Washington Community Futures Committee (Employment and Immigration, Canada) and the fish processing and farming industry to establish a state of the art functional and research composting facility at the University of British Columbia's Research Farm at Oyster River on the central east coast of Vancouver Island. The inter-agency cooperation to resolve this regional problem represents a positive strategy for progressive approaches to economic development within a sustainable context.

Composting was recognized as a low end use option for the highly proteinaceous fish wastes but was also recognized as a common solution for a variety of qualities of fish wastes. The Pacific Bio-Waste Recovery Society's goals include developing higher and better uses for fish by-products. The Society is optimistic that volumes of fish by-products composted will ultimately decrease as other uses are identified, permitting the facility to include other portions of the organic waste stream for which there are fewer alternate uses.

Wood wastes will be the primary bulking agents. Many of these products are currently under-utilized. Fish waste composting therefore offers the opportunity to utilize two waste streams to generate a useful end product.

The inter-agency process that culminated in the development of the composting facility is described in a paper presented at this conference by Mr. John Willow, Fisheries Development Officer, with the B.C. Ministry of Agriculture, Fisheries and Food.

This project has been plagued with numerous inconsistent regulatory requirements arising primarily as a result of mostly irrelevant "not in my back yard" issues. The extent of these problems has been of such a magnitude that they have threatened the completion of the project and have imposed operating criteria that potentially jeopardize the financial self-sustainability of the facility as a result of expensive increases to the operating costs of the project. The history of the regulatory and social development of the project are described in a paper by Mr. Brian Egan, Facility Manager, presented at this conference.

This paper will describe the design and operating characteristics of the facility. The handling of fish waste required some unique adaptations that would not be anticipated in a more conventional composting facility.

In addition, the desire to develop and utilize made in British Columbia technology has resulted in some new equipment and composting systems. Further detail regarding equipment or elaboration of the system than is outlined in this paper can be obtained from the author.

Design Considerations

An agitated, in-vessel system was selected as the appropriate technology to provide an effective and efficient composting plant. This conclusion was based on two basic criteria. It was concluded that fish composting undertaken on a year round basis in the high precipitation climate of Canada's south west coast should be conducted within a roofed structure to minimize nutrient leaching and provide assured access to the composting facility regardless of climatic conditions. Having decided on the requirement for a roof, maximization of process volumes on a per square metre basis to optimize compost production in an expensive building resulted in the decision to utilize an agitated, open, in-vessel system. The design also provided good opportunities to monitor and regulate the process for research purposes.

Design overview

The facility consists of a building with two major components connected by a breezeway. The one building is the mixing and composting building. The other is a storage building for amendment receiving and storage, compost curing and compost storage. This portion of the building also has provision for screening or grinding and bagging of the finished product.

Fish waste is received in the form of silage from fish farms, offal from fish processors and relatively fresh whole fish from hatcheries. The fish by-product is discharged into a 25 cu. m. receiving tank when it arrives at the facility. Maceration by opposing augers is achieved prior to transfer via an enclosed paddle conveyor to a mixing vessel. Amendment(s) are transferred by a front end loader to a traditional gutter cleaner type conveyor which conveys the amendment(s) to the 15 cu. m. mixing vessel. The mixing vessel is a conventional feed mixer frequently used in agricultural livestock operations. The unit is stationary, utilizes four 40 cm. diameter augers to circulate and mix the "green" compost in approximately 15 min. The "green" compost is discharged to a conveyor which piles the material prior to transfer by a front end loader to one of four aerated compost reactors.

The compost turner is expected to operate six days a week allowing an 18 day retention time. Compost that has completed "active" composting in the reactors is transferred by way of a second gutter cleaner at the end of the reactors to the compost storage building. Compost piles are moved on a monthly basis for three months. Supplemental aeration can be provided to these piles if required. It is anticipated that sufficient maturation will be achieved within four months. The finished product will then be screened or ground and sold bagged or in bulk. Oversize material or finished compost may be re-cycled in the system.

Structures

The compost storage building is 20 m x 61 m. It is a prefabricated steel structure with a concrete floor and 3 m concrete walls on 3 1/2 sides. The building is open on one side and has full length ridge ventilation. Provision has been made to permit additional ventilation to compost generated from the reactors if necessary or desirable. The walls above the concrete are enamelled steel with some translucent fibreglass panels.

The composting building is composed of a 15 x 18.3 m prefabricated galvanized, insulated steel building. It acts as a header house for two 7.25 x 46 m greenhouses that each cover two of the reactors. The greenhouse cover is double layered inflated greenhouse polyethylene. The entire floor is concrete, including the floor below the aeration bed for the reactors. An alleyway between the reactors allows ready access to the reactors for data collection or sampling purposes.

Waste-water

Waste-water is collected via drains in the compost storage building and the compost mixing building. In addition the receiving tank has a concrete catchment area surrounding it that has a collection drain. An apron around the receiving area collects any wash water or spillage from the trucks delivering fish products. The first third of the reactor bays slopes towards the compost mixing area where a drain collects any leachate from the active composting area. All the waste-water drains to a 20,000 l receiving tank. The tank is compartmentalized to restrict transfer of solids. The first two compartments are aerated to speed biological breakdown of any solids. Liquid levels are monitored and alarmed to warn of limited capacity. Waste-water from the sump will be reused to wash equipment or supply additional water to the compost piles.

Aeration

Aeration within the reactors is provided by 12 - 5 hp blowers serving three zones in each bay. Positive pressure supplies air from below the reactors through 200 mm and 175 mm PVC imbedded in a 30 cm layer washed 4 cm stones. A thin layer of wood chips provides an interface between the stone matrix and the composting mass. Each fan is rated at 48 cu m/min at 12 cm static pressure. Provision has been made to permit expansion to 6 zones per bay by the addition of more blowers should that be deemed desirable in the future.

The blowers are regulated by timers, however provision has been made to allow for temperature regulation and coupling to a microprocessor in the future.

Odour Control

The compost mixing building and the greenhouses are ventilated by a 25 hp exhaust fan providing 340 cu m/min at 12 cm static pressure which keeps the building at a slightly negative pressure relative to the atmospheric pressure outside the building. The aeration blowers have been designed to avoid supplying more air at a rate greater than the exhaust fan can remove. The mixing building and the greenhouse building are well sealed to minimize any opportunity for odours to escape the building. A separate line from the exhaust fan to the receiving tank reduces the escape of odours during the periods when fish by-product is being received. Hydraulically activated lids on the receiving tank remain closed except when fish by-products are being received.

The exhaust air from the structure and receiving tank is vented through a biofilter. The biofilter is 12 x 40 m. The filter medium is 1 m deep and consists of a mixture of composted dairy manure containing sawdust and shavings, mineral soil and wood chips. The biofilter is buffered with calcium carbonate to slow acidification and extend its functional life expectancy.

The Compost Turner

During the conceptual stages of the project the purchase of a compost turner was envisaged. However, none of the systems reviewed offered the opportunity to come within an existing budget. While reviewing various systems on the market, contact with Dr. Chuck Henry, University of Washington was made. Dr. Henry was working on the development of a drum composter. A small prototype unit had been developed and a second somewhat larger unit was being completed. After considerable review of the concept and collaboration with Dr. Henry, the University of British Columbia signed a licensing agreement with the University of Washington to work together to develop a commercial scale operating unit.

The proposed concept centred on the use of a rotating drum travelling in a concrete reactor to agitate and move the composting mass down the reactor bay. Short fingers on the outside of the rotating drum carry the compost under the drum and deposit it beyond the drum. The drum moves along a supporting track on the reactor walls while turning the composting material. In order to return to the head of the reactor bay the drum is elevated above the compost.

The drum composter offers a number of potential advantages. The concept is simple and involves relatively few moving parts. This should enhance durability and make repairs relatively easy. While not yet assessed it is expected that the energy required to agitate and move the compost will be less than other units. The construction costs appear likely to be very competitive with other types of units on the market.

The unit constructed for this facility is 3 m in diameter and 2.5 m wide. This unit has been built with a number of features that will permit us to assess it's performance over a range of operating conditions. The turner has been designed to be reversible. This will allow us to move it back and forth in the reactor bays thereby permitting agitation of the compost while extending the retention time indefinitely. The rotational speed and the travel speed are variable to assess the behaviour of the machine under different operating conditions. The machine has also been designed with a feedback provision that permits the forward speed of the drum to be related to the torque required to turn the drum. This feature allows the drum to move through light material expected near the end of the active composting process while slowing at the initiation of composting where torque requirements are expected to be higher due to moisture content and particle size. Numerous safety features on the turner protect the machine and operators.

The compost turner is transferred between bays by a self propelled dolly that travels between the bays on a track recessed into the floor.

Conclusions

The development of this facility provides a mechanism to solve a regional waste problem and develop new technology while providing the University and the Pacific Bio-Waste Recovery Society opportunity to expand research programs into composting and participate in technology transfer.

The future development of higher uses for fisheries by-products will permit better utilization of a quality protein product and permit composting of alternate waste streams.

Government, Community, University and industry cooperation in a proactive approach are responsible for these positive benefits.

COMPOSTING OF FISH MORTALITIES

by

P.H. LIAO, A.T. VIZCARRA AND K.V. LO
Department of Bio-Resource Engineering
University of British Columbia
2357 Main Mall
Vancouver, B.C.
Canada

INTRODUCTION

British Columbia is still the leading producer of farmed salmon in North America; about 16,500 tonnes were produced in 1991. There are currently about 125 operating salmon farms in B.C.. Of these, twenty are single-site operations owned by independent operators and 105 are corporate sites owned by 16 different companies.

Along with the growth of the fish farming industry, the disposal of fish morts has emerged as a major waste disposal problem. Environmental regulations require that disposal of morts be done on land; they cannot be dumped into the ocean where the farms are located. In the absence of other viable technologies, the composting of fish morts is a practical solution to this waste disposal problem.

The objectives of this study were twofold. The first objective was to develop a low cost, effective system for the composting of fish farm mortalities suitable for small or medium sized operations. The second was to evaluate the quality of the fish composts produced using different ratios of bulking agent (sawdust) to fish morts.

MATERIALS AND METHODS

Reactor Design

Three uninsulated wood-frame vertical reactors were used in the experiments. They had a uniform square cross-section of 0.9 m x 0.9 m, but they differed in overall height. The reactors were equipped with plastic pipes which served as air ducts supplying oxygen to the compost pile. A fine screen mesh was installed about 0.25 m above the bottom to segregate the compost pile and the aeration pipes. Air was delivered by a Regenair blower. Aeration at a rate of 0.2 l/min kg volatile matter was provided to the composting piles for 6 hours daily. Solid state temperature sensors were used. A Packard Bell XT computer equipped with Advantech data acuisition/multiplexer board was used for the aquisition and storage of temperature data.

Substrates and Experimental Plan

The fish mortalities weighing about 1 to 2 kg were used in the experiments. They were partially frozen when added to the compost pile. Sawdust was used as the bulking agent.It had a total solids (TS) content of 52%. The cow manure used as a starter contained about 17% TS.

Two experimental run were conducted. In order to test the effects on the composting process of varying the weight ratio of fish morts to sawdust, ratios of

1:1, 2:1 and 3:1 were used. These corresponded to 100, 200, and 300 kg of morts in each reactor, respectively. Twenty kg of cow manure were also used for each reactor.

A layering method of arranging the compost pile was adopted, since it uses less equipment and labour. For run 1, the morts were equally divided into two layers per reactor. These were sandwiched between three equal layers of sawdust. For run 2, the morts were divided into two, four and six layers, yielding fish morts to sawdust ratios of 1:1, 2:1, and 3:1, respectively. The layout and the height of the composting piles are presented in Figure 1.

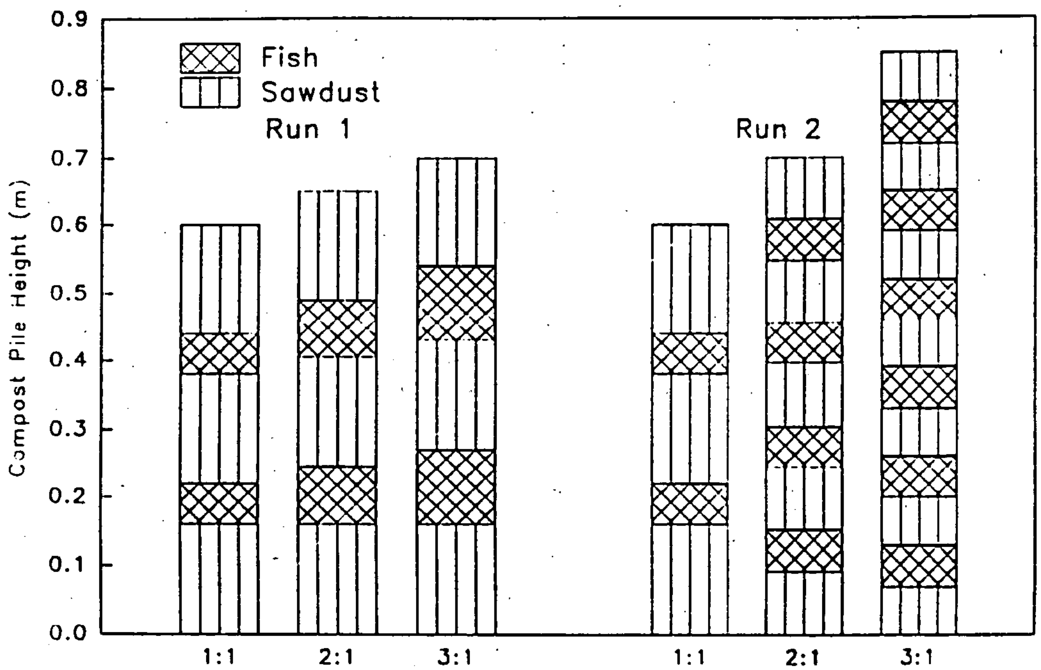


Figure 1. Initial heights of compost pile.

Chemical Analysis

Total solids, ash and pH were determined as described in the Standard Methods (American Public Health Association, 1985). The total organic carbon (TOC) content was calculated using the following equation (Golueke, 1977):

$$\% TOC = (100 - \% \text{ ash residue})/1.8$$

Total Kjeldahl nitrogen (TKN) was analyzed using a block digestor and a Technicon Auto Analyzer II. C:N ratio was computed on the basis of these analyses.

The experimental results were statistically analyzed using SYSTAT (Wilkinson, 1988).

RESULTS AND DISCUSSION

Temperature Profiles

Run 1

The mean temperature profiles of all three compost piles are presented together with the ambient temperature profile in Figure 2. The mean temperature in the 1:1 mix reached thermophilic levels on Day 5. It attained 55^{O}C by Day 7 and stayed at or above this level for about 16 days. A steady decline in temperature began on Day 23. After 60 days, the mean temperature was about 30^{O}C. The treatment therefore satisfied the EPA requirements for a Process to Further Reduce Pathogens (PFRP). However, the mean temperatures in both the 2:1 and 3:1 mix maintained 55^{O}C for only about a day. As of Day 60, the mean temperatures were about 25 and 40^{O}C for 2:1 and 3:1 mix, respectively.

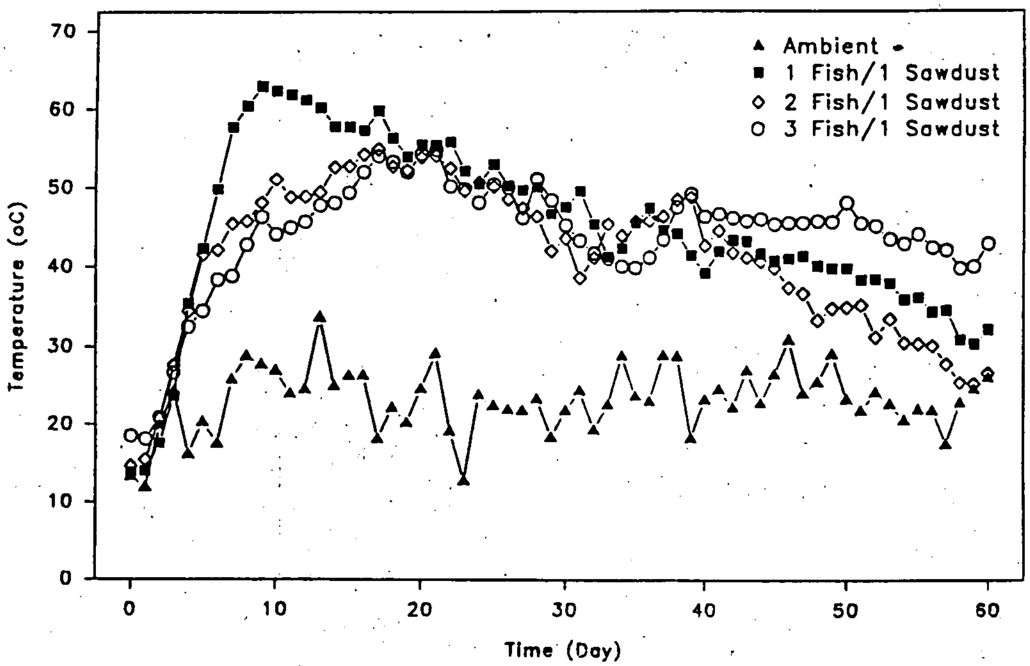


Figure 2. The mean temperature profile for Run 1

Run 2

The mean temperature profiles of all three compost piles during Run 2 are presented together with the ambient temperature profile in Figure 3. Since the fish morts frozen during storage were not completely thawed by the time Run 2 was initiated, the starting temperatures in all three treatments were below the ambient temperature.

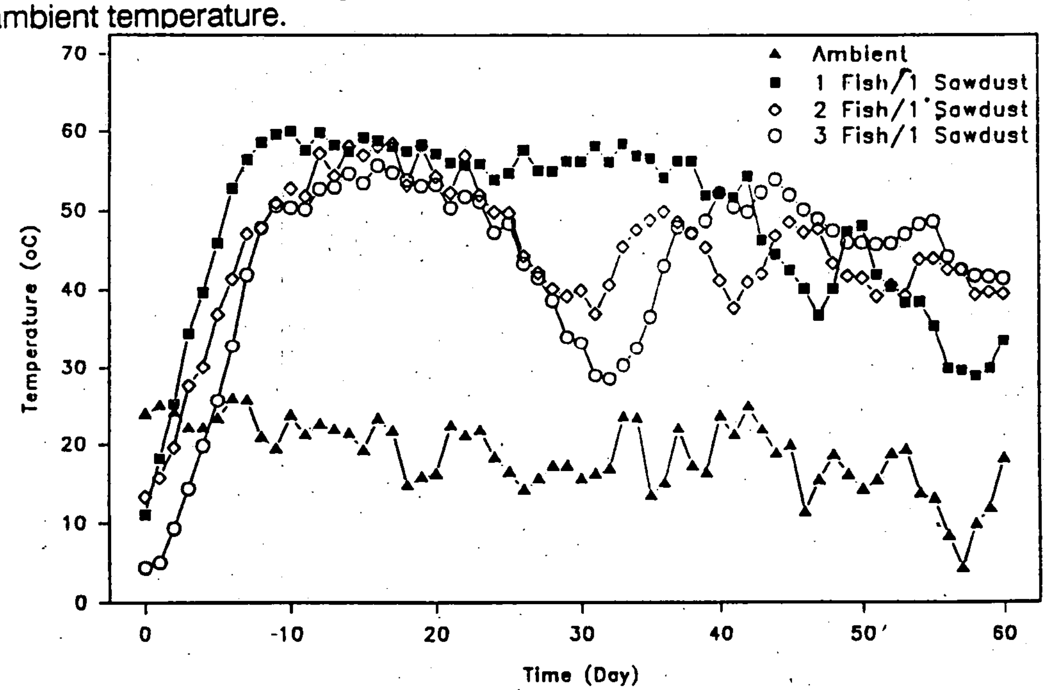


Figure 3. The mean temperautre profiles for Run 2

The mean temperature in the 1:1 mix reached thermophilic levels on Day 5. By Day 7 it had attained 55°C, and it stayed at or above this level until Day 38. The temperature dropped to 37°C at Day 47 and then went back up to a secondary peak of 48°C at Day 50. After 60 days, the mean temperature was about 30°C.

The mean temperature in the 2:1 mix reached 40°C by Day 7. By Day l2, it had attained 55°C, and it stayed in this region for about 11 days. Minor peaks with diminishing heights occurred on Days 36, 45 and 54.

The mean temperature in the 3:1 mix reached 40°C by Day 8. It reached 55°C on Day 14 and stayed there for about 4 days. A sudden drop from 50°C to 29°C occurred from Day 25 to Day 33. However, the temperature was back up to 54°C at Day 44. A third peak of 50°C occurred on Day 55. As in Run 1, the mean temperature was still at about 40°C by Day 60.

The randomized block design adopted for the experiment treated the fish/sawdust mixtures as the variables and time (day) as the block. Statistical analyses indicated significant differences among the temperature profiles for the different mixtures. The ambient temperatures during the two runs were also significantly different, with Run 2 ambient temperatures being lower than those of Run 1.

Volumetric Shrinkage

The overall shrinkage in the compost piles in Run 1 were 37%, 33% and 41% for the 1:1, 2:1 and 3:1 mixes, respectively. The total shrinkages during Run 2 were more in proportion to the volume of fish mortalities, i.e., 27% in the 1:1 mix, 31% in the 2:1 mix and 41% in the 3:1 mix. The cumulative settlement of the compost piles during Run 2 is plotted in Fig. 4. Statistical analysis shows that these shrinkage curves are significantly different from each other. No further settlement was discernible beyond Day 40.

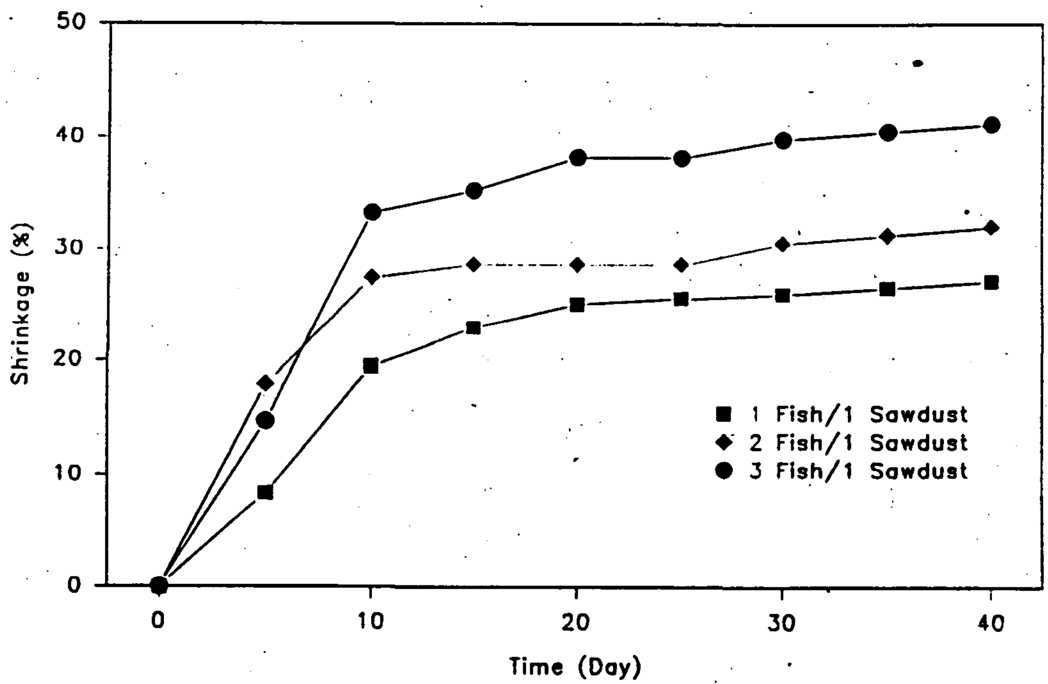


Figure 4. Shrinkage of compost piles

Quality of Compost

The quality indicators for the composts obtained after two months of composting are reported in Table 1. With the exception of the 1:1 mix in Run 1, the C/N ratios in all treatment samples were low. This is obviously due to the high nitrogen content in the fish morts. The compost resulting from the 1:1 mix was light brown, relatively dry, without bones but with brittle chunks of fish skin.It had an earthy smell with a trace of fishy odour. The compost resulting from the 2:1

mix was medium dark brown, moist, without bones but with slabs of flesh still intact. It had a fishy smell and an odour of ammonia. As to the compost resulting from the 3:1 mix, it was dark brown like the compost from the 2:1 mix, but there were even more slabs of intact flesh. This compost was also moister, and had a stronger fishy stench and ammonia odour.

Table 1. QUALITY OF FISH MORTS COMPOST AT DAY 60 OF RUN 1 AND DAY 61 OF RUN 2.

Fish/sawdust ratio	1:1		2:1		3:1	
Run	1	2	1	2	1	2
MC, %w.b.	34.6	52.4	45.2	51.5	41.3	54.4
C, %d.b.	52.7	53.2	52.5	52.8	52.4	52.7
TKN, %d.b.	1.87	3.26	3.20	3.07	3.59	3.33
C/N ratio	28.1	16.3	16.4	17.2	14.6	15.8
pH	7.2	7.7	8.3	8.8	8.1	8.9
NH_3-N, ppm d.b.	458	897	1686	1136	2089	1377
NO_3-N, ppm d.b.	740	1534	711	476	600	415

The overall results indicate that within the range of fish morts to sawdust ratios tested, whole fish were completely composted and thermophilic conditions attained. The physical and chemical properties of the composts met or exceeded all criteria for high quality composts. This indicates that the layering method of composting is feasible for the disposal of fish morts. Such a system requires less labor and composting equipment, and is therefore more cost effective. Such a system could therefore provide small and medium sized salmon farms with a simple way to utilize and dispose of their fish morts.

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BRITISH COLUMBIA'S INTEGRATED APPROACH TO FISH WASTE UTILIZATION: A CASE STUDY

by

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British Columbia's seafood industry is a major force in the provincial economy, generating a wide range of products worth an annual wholesale value of one billion dollars. Accounting for 20% of all food manufacturing in BC, the industry supports over 23,000 direct jobs, 8,000 of which are found in the 220 processing plants along the coast. The centres of seafood production and processing are the Lower Mainland near Vancouver, Prince Rupert on the northern coast and on Vancouver Island. A relatively new contributor to the industry's scope is salmon aquaculture. Fish farms in BC raised and harvested approximately 21,800 tonnes of fresh salmon in 1991 worth over $105 million to farmers.

The Problem

Inherent in the seafood production process is the generation of by-products and fish wastes: by-catch and farm mortalities on the production side, offal and 'stick water' (effluent) from processing plants. In 1988 an estimated 109,000 tonnes of fish offal was generated by the industry. With the advent of new fisheries such as hake for surimi production, shark and other underutilized species for specialty markets, the quantity of offal is steadily climbing.

Traditionally, fish wastes were dealt with in one or more of the following ways:

- the vast majority of fishing boat by-catch still goes over the side;
- the same is true with most stick water, though some level of treatment (screening usually) is required by environment regulators;
- fish offal (viscera, heads, frames, skin, etc.) can be rendered (reduced) into oil and fish meal, frozen for mink or fox feed, processed into pet food or just dumped

into the local landfill;

- salmon farm mortalities (commonly called 'morts' in the industry) are usually buried in small landfills (mort pits) on land near the farm, though in 1989 some rudimentary composting operations offered a rather limited utilization option. Reduction plants refuse to accept morts for rendering, primarily due to lack of freshness.

Unfortunately, insufficient utilization options mean that well over 60% of all offal generated in the province ends up in municipal or regional landfills. However, with the 'greening' of public and political wills, landfilling such highly odourous and viscous organic wastes is no longer deemed environmentally responsible by many coastal communities and most landfills have closed their gates to fish wastes.

The situation has been even more critical for processors on Vancouver Island. Firstly, all the major utilization facilities for fish waste are located in the Lower Mainland or in Prince Rupert. The majority of fish plants on Vancouver Island do not have access to a local waste facility or landfill and are forced to transport their offal to the Lower Mainland/Vancouver area for rendering or packaged and frozen for mink farms. The seasonal nature of the wild fisheries compounds the problem. When production levels peak during certain fisheries, the rendering plants are operating at full capacity with offal from local area processors. As a result, Island fish plants end up paying from $50 to $100 per tonne to truck, ferry and dump their wastes into a Lower Mainland regional landfill.

Seafood processors incurred significant costs trying to rid themselves of fish wastes. It is expensive to transport high water content wastes and tipping fees at virtually all landfills are rising steeply. In addition the promise of generating offsetting revenues is relatively insignificant as utilization operations only pay for the freshest offal (usually less than 48 hours old) from only a limited number of marine species.

The problems to this point have been fairly quantitative: high volumes of waste; insufficient utilization facilities; limited disposal options; and high disposal costs. A more subtle obstacle to new innovations in waste utilization and management has been traditional mind sets: fish processors who firmly believe their business is processing fish, not waste disposal; government regulating agencies who saw a waste product needing disposal rather than a high nutrient by-product worthy of further processing. Another complicating factor has been the lack of co-ordination between industry sectors, all levels of government and the public.

The Angles

With such a multi-faceted, yet inter-related set of problems, progress was slow in coming for industry. Most stakeholders were either addressing only their own localized situation or hoping someone else would solve it for them. However, as the problem became more acute, affected parties became aware that things must change and no one company or single community was going to resolve the disposal problem to everyone's satisfaction.

Agreement was needed among the various stakeholders. The reality of socio-economic imperatives and genuine frustration, coupled with both real and perceived environmental concerns provided a situation that could potentially build consensus:

- within industry;
- among local governments;
- between industry and government; and,
- with the general public.

To achieve a solid foundation of concerted effort among stakeholders, a "win-win" focus had to be created and maintained. Fortunately, the very nature of the problem lead to the identification of several key concepts or angles that were hard to find fault with:

- transform a former waste into a future product;
- local solutions create local jobs;
- meet economic needs <u>and</u> environmental concerns; and,
- a shared process justifies cost sharing, or vice versa.

All that was needed was a catalyst to bring together stakeholders to formulate an approach. Record salmon farm production during the traditional herring fishery in 1990 proved to be that catalyst.

The Approach

In the spring of 1990, Vancouver Island fish plants were processing over 50% of the province's aquaculture production while virtually all roe herring went to Vancouver or Prince

Rupert. As a result, mainland reduction facilities were filled to capacity with herring carcasses and large quantities of offal from Island fish plants were being turned away.

Processing companies on Vancouver Island realised they had a common problem and no clear solution. It was now not just a problem of economic hardship due to high disposal costs, but a question of continued operation in the face few alternative waste management options. Seafood company representatives got together and raised the issue with several regional and community governments and everyone agreed the problem was urgent and getting worse. This consensus evolved into an action. Industry and local government join forces to carrying a direct request to provincial ministers for leadership and assistance. At this June 1990 meeting (referred to as Aqua Forum), the Ministry of Agriculture, Fisheries and Food (MAFF) agreed to take the lead in finding solutions to the fish waste problem.

That same month MAFF created the provincial Fish Waste Task Force (FWTF) which struck a multi-sectoral committee tasked to:

- clearly identify the specific components of the problem;
- investigate immediate and practical interim disposal options;
- identify viable, long term fish waste utilization options; and,
- facilitate creation of short and long term solutions.

The committee included representation from seafood processors, salmon farming companies, agriculture sectors, regional governments, educational institutions, Mt. Washington Community Futures (representing federal interest) and the provincial ministries of Environment, Lands & Parks (MELP), Economic Development, Small business & Trade and MAFF.

By July an innovative twist on the concept of landfilling was made available to industry as a short term disposal solution. With assistance from MELP and MAFF, lumber companies in Campbell River and Port MacNiell made their wood waste landfills available for burial of offal and morts. These industrial landfills were located in old quarry sites and consisted of 12 to 20 meters of wood chips, sawdust and hog fuel. As anticipated, this proved to be an environmentally benign disposal operation. All leachate from the fish waste was absorbed, the cap of wood waste acted as a natural bio-filter eliminating all odour. After a year or two of anaerobic composting all evidence of fish heads, guts and bones should be gone. Based on the size and capacity of the two sites, permit approvals for secondary fish disposal was granted for only one year. Attention was then focused on trying to find longer term options based on principle of utilization, not disposal.

In consultation with both the BC Salmon Farmers Association and individual aquaculture companies, MAFF concluded that on-farm acid ensiling of morts offered a potentially desirable and practical means of resolving farmer's waste handling, storage and transportation problems. Ensiling would also increase possibilities for further utilization of farm wastes as a soil conditioner for silviculture enhancement or an input material for composting. After several months of research, equipment development, field trials and site visits to virtually every silage operation along the BC coast, MAFF published an ensiling manual and sponsored workshops on the subject. The salmon farming community has since expressed considerable interest in mort ensiling and many leading companies have incorporated the process as part of regular farm operations.

During this period, FWTF's technical committee identified composting as the process best suited to deal with the problem faced by Vancouver Island processors and fish farmers because:

a) ready availability of local waste products suitable for bulking agents (i.e., wood chips/sawdust/hog fuel);
b) the process will turn virtually all types/grades of fish waste (offal from salmon, ground fish, dogfish, etc., crustacean wastes and mort silage) into humus;
c) composting technology and methodology has been proven effective and is relatively well advanced;
d) market studies indicate a growing demand in B.C. and the western U.S. for soil enhancing products other than chemical fertilizers; and,
e) composting is viewed as an environmentally responsible process by which to turn wastes into a useful products.

Investigating a broader range of opportunities, Industry, Science & Technology Canada (ISTC) and MAFF co-sponsored a series of studies into the utilization of seafood wastes, by-products and underutilized species for products not used directly as human food. The reports produced during 1990-91 include:

- A Study of the Canadian Fisheries Waste Stream: The Pacific Coast Situation

- A Guide to Processes for the Production of Products for Non-Human Consumption from Underutilized Marine Species and Fisheries Wastes
- Opportunities for Fine Chemical and Pharmaceuticals from Marine Resources
- Potential Animal Feed Markets for Canadian Fisheries By-Products
- Market for Composted Fish Waste.

This work confirmed composting as a viable long term, though low end, utilization option for fish by-products and wastes.

Meanwhile, the Task Force called for fish compost project proposals. In order to secure seed funding in support of this initiative, MAFF successfully applied to the province's newly created Sustainable Environment Fund for a two year conditional grant totalling $300,000 (for capital costs only) to be awarded to the best proposal as selected by the cross-sectoral review committee.

The winning submission was by the University of British Columbia (UBC) for the creation of a comprehensive, agitated in-vessel fish waste compost facility at its Oyster River Research Farm. The FWTF and ministry specialists identified several aspects of UBC's submission that were key factors in its successful selection:

- the project's operational and technical merits;
- targeted long term financial self sufficiency;
- reliability of access to the facility by industry;
- strong emphasis on applied research and development aimed at further utilization of fish wastes and other waste streams;
- the proposed extension of the knowledge and expertise gained at the facility to other BC municipalities, regional districts and private industry sectors; and,
- a non-profit Society to oversee the business planning and operations of the facility. UBC, three industry sectors and two levels of government would be represented on the Society's Board of Directors.

In addition, UBC Research Farm's history of commitment in helping Vancouver Island producers and processors search for solutions to their fish waste problems bode well for the project.

By early 1991, the Mt. Washington Community Futures Committee successfully accessed the Initiatives Program of Employment and Immigration Canada for a funding contribution of $430,000. The final $225,000 component of the capital cost-share structure came from fish processing companies, aquaculture firms and UBC itself. The non-profit Society overseeing the construction and eventual operation of the compost facility was chartered about this time as the Pacific Bio-Waste Recovery Society (Pacific Bio).

With nearly a million dollars of committed funds, a practical site location, Pacific Bio's Board of Directors in place and the will to proceed with the task at hand, everyone believed the Oyster River compost facility would be up and running by the end of the summer. Well, almost everyone...

Mistakes and Barriers

Mistake #1: It is possible to be too good a corporate citizen.

The 2.2 hectare site chosen for the compost facility is in the middle of 600 hectare parcel of agricultural and wooded land belonging to UBC's Research Farm. Contrary to information originally provided to the university, it turned out that such a composting operation fell into a grey area of the local zoning by-laws. In addition, regulations of the provincial waste management act are not clear as to whether or not the facility needed to have a waste permit. However, MELP officials suggested it may be prudent to apply for one now as a formality, since requirements were likely to change in the future.

As Pacific Bio had received significant funding support from government and, as a non-profit Society, wished to act in best interests of the community, the directors chose to 'do the right thing' and step through all perceived regulatory hurdles. This led to a series of public notices and hearings that provided the forum for the next barrier to manifest itself.

Mistake #2: Did not realize that not everyone wants a win-win environmental project in their back yard.

The infamous not-in-my-back-yard (NIMBY) syndrome, involving but a handful of local residents, has created more problems for the Pacific Bio project than anyone could imagine.

Early on in the process the Society recognized the need to inform the public of the projects intent, design and merits.

Once it was decided to apply for a different rural use land zoning, the Society's directors and local officials agreed that the required public hearing would provide an ideal forum for such an initiative. At that first hearing, a dozen well organized and determined Oyster River residents set against <u>any</u> development in their rural community emotionally voiced unfounded warnings of environmental degradation, public health hazards and corporate insensitivity. Unfortunately, MELP waste management officials declined an invitation to make a presentation at that meeting, and the chance to rationally address and possibly quell this small minority opposition was lost. As a result, the NIMBY forces have since aggravated the final two barriers.

<u>Mistake #3</u>: Assuming environmental protection agency would treat the project fairly and judge it on facts and regulatory precedent.

In their willingness to work with and not against regulatory officials, Pacific Bio believed that the environmental merits of the project, coupled with the obvious support of all levels of government, would negate the need to lobby the minister and senior bureaucrats in MELP. Instead, the Society relied on Waste Management's middle managers and technical officials to fairly apply MELP's policies, regulations and procedures.

Unfortunately, the small but persistent NIMBY group launched a letter writing campaign to a multitude of cabinet ministers expressing opposition to the compost facility. This strategy was apparently succesful as MELP incorporated restrictions into Pacific Bio's waste permit aimed at addressing those contentious NIMBY issues not readily, or comfortably, dismissible. These restrictions currently threaten to close the doors on a state of the art, environmentally benign compost facility before it is fully constructed.

<u>The Final Barrier</u>: The courts.

The NIMBY forces have been very persistent. Despite the fact they represent an extremely small and poorly supported minority within the local community, their actions have resulted in:

- a suit in BC Supreme Court against the regional district government for improper application of the Municipal Act of BC during the re-zoning by-law process. Final ruling was in favour of the regional government.

- a formal appeal to MELP of Pacific Bio's original waste management permit. The internal ministerial appeal authority reject most of the complainant's requests, but did incorporate others as additional restrictions on the Society's new permit.
- an appeal of the second waste permit. This appeal is currently before the Environmental Appeal Board of BC, which is an independent, third party judicial body.

This process has cost both time and money, but mostly time. Pacific Bio's fish waste compost facility is now a full year behind schedule. Fortunately, additional interim utilization options have been devised for industry.

Key Lessons for Success

What others can hopefully learn from this case study is the framework of an innovative approach to solving multi-sectoral environmental problems and how to avoid the same sort of mistakes that have so complicated what truly is a win-win-win project. The lessons learned by all those involved with Pacific Bio-Waste Recovery Society can be summarized as follows:

1) Develop early consensus among all stakeholders.

2) Focus on issues to find win-win options that relate directly to the needs of stakeholders, thus ensuring their commitment.

3) Ensure government regulatory agency politicians and senior bureaucrats are well informed and knowledgeable of the concept, intent and implications of the problem solving process as well as the ultimate project.

4) Early public involvement and education.

5) Themes must be consistent though information packaging should be customized for each specific target audience.

6) Maintain solidarity and commitment among your stakeholders. This task is made easier if lessons one, two and three have been heeded.