RESEARCH REPORT

Biological Toilets and Grey Water Systems: A Critical Evaluation of Their Application in Canadian Housing

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BIOLOGICAL TOILETS AND GREYWATER SYSTEMS

A Critical Evaluation of Their Application in Canadian Housing

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ABSTRACT

This critical evaluation of biological toilets focuses on the large type and greywater treatment systems for use in year-round residences in Canada. It is based on previous state-of-the-art reviews and manufacturers' literature submitted in connection with CMHC's Healthy Housing Design Competition. Biological toilets have a role to play in the solution of seasonal onsite waste disposal problems in rural and remote areas. At the present time, year-round use is limited to those situations where water supplies are scarce or soil absorption is limiting. Improved designs, as they become available, tend to be more expensive and complex. This mitigates the original appeal of biological toilet systems for household use, which was their low cost and simplicity.

Keywords: Biological toilet, composting toilet, greywater treatment.

EXECUTIVE SUMMARY

This report was commissioned by the Research Division, CMHC, to provide a critical evaluation of biological toilet/greywater treatment systems. This technology was first proposed for year-round use in the "Codicile", the winning Toronto house of CMHC's Healthy Housing Design Competition. The evaluation is based on two previous state-of-the-art reports prepared independently in Canada and the USA, a current magazine article, and manufacturers' data supplied in relation to the Healthy Housing Design Competition. The report does not constitute a survey of available units on the market nor a guide to the operation and maintenance of biological toilet/greywater treatment systems.

Biological toilets were introduced into the North American market in the early 70's from Scandanavia, where they had mainly been limited to seasonal use. Concerns over aggressive marketing for year-round use led authorities in Scandanavia and North America to require testing and certification. With these procedures in place in the early 80's the number of competing devices was dramatically reduced.

The independent, third party testing showed that these units were not true composting units, as they did not achieve the high internal temperatures associated with composting. They are better described as biological toilets, the term used throughout this report, operating under aerobic conditions to achieve waste degradation and liquid loss through evaporation.

There are two basic types of certified biological toilets commercially available in Canada. The large type, which is preferred for year-round use because of its capacity and few moving parts is separated from the toilet. The small type sits in the bathroom with the toilet seat on top of the treatment tank. This type utilizes electrical heating coils, forced ventilation, and mixing devices to promote rapid aerobic decomposition and evaporation.

Biological toilets cannot accomodate greywater - all of the household wastewater, with the exception of toilet wastes. An approved greywater system must accompany a biological toilet. The design, technical feasibility, and economics of available greywater treatment systems have yet to be proven and generally accepted.

The list of potential applications for residential housing presented in the report shows that biological toilets have a role to play in the solution of seasonal, onsite waste disposal problems. This is born out by the sales of biological toilets, which generally have been in rural and remote areas to serve cottages, public recreational facilities, homes, institutions, and small commercial buildings.

In comparison with other methods of handling wastes from the unserviced home, biological toilets are not inexpensive. Prospective buyers may be turned away by the relatively high purchase cost, the installation cost, the operation/maintenance cost plus the cost of an approved, separate greywater system.

At the present time, the year-round use of biological toilet systems is limited to those situations where water supplies are scarce or soil absorption is limiting. The exceptions are those environmentaly conscious owners who are willing to accept the asthetics and costs involved.

Improved designs as they have become available tend to be more expensive and more complex. This mitigates the original appeal of biological toilets for household use, which was their low cost and simplicity.

RÉSUMÉ

Ce rapport a été commandé par la Division de la recherche de la SCHL en vue d'évaluer les toilettes et les installations d'épuration des eaux ménagères biologiques. Cette technologie a d'abord été proposée comme dispositif permanent pour le «Codicile», une habitation de Toronto dont le concept a été primé lors du Concours SCHL de conception de maisons saines. La présente évaluation se fonde sur deux rapports antérieurs traitant de l'état des connaissances dans ce domaine particulier préparés séparément au Canada et aux États-Unis, sur un article de revue actuel de même que sur les données du fabricant fournies dans le cadre du Concours de conception de maisons saines. Ce rapport ne passe pas en revue les dispositifs offerts sur le marché et ne constitue pas non plus un guide sur l'utilisation et l'entretien des toilettes et les installations d'épuration des eaux ménagères biologiques.

Les toilettes biologiques, qui nous arrivaient de Scandinavie où elles étaient principalement affectées à un usage saisonnier, sont apparues en Amérique du Nord au début des années 1970. La commercialisation énergique préconisant leur emploi à longueur d'année a incité les autorités de la Scandinavie et de l'Amérique du Nord à exiger leur mise à l'essai et leur certification. Avec l'implantation de ces méthodes au début des années 1980, le nombre de dispositifs concurrentiels a connu une baisse spectaculaire.

La mise à l'essai par une tierce partie indépendante a démontré qu'il ne s'agissait pas de véritables appareils de compostage, puisqu'ils n'atteignaient les températures intérieures élevées qui sont associées au compostage. Il convient mieux de les qualifier de toilettes biologiques, terme employé tout au cours du rapport, car elles fonctionnent dans des conditions aérobies favorisant la dégradation des déchets et la perte de liquide par évaporation.

Il existe deux types fondamentaux de toilettes biologiques certifiées, offertes au Canada. Le gros appareil, préférable pour l'usage à longueur d'année en raison de sa capacité et du peu de pièces mobiles est distinct de la toilette. Par contre, le petit appareil se loge dans la salle de bains, l'abattant placé par-dessus du réservoir de traitement. Ce type fait appel à des serpentins de chauffage électriques, à la ventilation forcée et à des dispositifs mélangeurs dans le but de favoriser une décomposition aérobie et une évaporation rapides.

Les toilettes biologiques ne peuvent pas recevoir les eaux ménagères, à l'exception des déchets de toilette. Un système d'épuration des eaux ménagères approuvé doit accompagner une toilette biologique. La conception, la faisabilité technique et l'aspect économique des systèmes de traitement des eaux ménagères disponibles restent encore à être éprouvés et généralement acceptés.

La liste de leurs utilisations possibles dans l'habitation que dresse le rapport montre que les toilettes biologiques peuvent contribuer à régler les problèmes saisonniers d'élimination des eaux usées sur place. Ce fait est corroboré par les ventes de toilettes biologiques, qui desservent surtout en secteur rural ou en région éloignée les chalets ou cottages, les installations récréatives publiques, les habitations, les établissements et les petits bâtiments commerciaux.

Par comparaison avec les autres méthodes de traitement des déchets d'une habitation dépourvue de services correspondants, les toilettes biologiques ne sont pas bon marché. Les acheteurs en perspective peuvent être rebutés par le prix relativement élevé, les frais d'installation, les frais de fonctionnement et d'entretien en plus du coût d'un système approuvé d'épuration des eaux ménagères distinct.

À l'heure actuelle, l'emploi à longueur d'année d'une toilette biologique se limite là où l'alimentation en eau est peu abondante et où l'absorption du sol est restreignante. Les propriétaires soucieux de l'environnement qui sont prêts à accepter leur côté esthétique et les coûts à engager constituent l'exception à la règle.

À mesure qu'ils font leur apparition, les modèles améliorés sont généralement assortis d'un prix plus élevé et gagnent en complexité. Cette situation atténue l'attrait qu'avaient à l'origine les toilettes biologiques pour usage domestique, qui se caractérisaient par un coût peu élevé et leur simplicité.

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1.0 INTRODUCTION & PROCEDURE

One of the two winners of Canada Mortgage and Housing Corporation's Healthy Housing Design Competition in the Urban Infill Category is a privately owned "Codicile", to be located along a public lane west of Logan Avenue and north of Danforth Avenue in Toronto. The proposal aims to build a three-storey dwelling on an area not much larger than would be occupied by a two-car garage. The proposal submitted by Martin Liefhebber Architect Inc. was based on principles of environmental responsibility contributing to the fundamental needs of inhabitants with a minimum demand for energy consuming resources.

The design components of the "Codicile" include a two-storey solarium, roof garden and a biomass burning stove. The house will not make use of the energy grid and will also be free of the water supply and wastewater infrastructure. The house will rely on rainwater and recycled wastewater for its water requirements. The winners proposed to use biological toilet and separated greywater technology for wastewater treatment and recycling. These systems would be self-sufficient to the full extent possible, supporting the principle of zero discharge.

This plan to use a biological toilet and greywater treatment in the proposed "Codicile" infill Healthy House prompted the Research Division, Canada Mortgage and Housing Corporation to commission this independent, critical review of the technology for its application in Canadian Housing, both for seasonal and year-round use. The review focuses on the large type of biological toilet, which is more appropriate for year-round use and possible application in the "Codicile".

The report gives the background on the development and concepts of biological toilet technology. The two basic types, large, separated from the toilet; and small, combined with the toilet, are described in some detail, including advantages and disadvantages of each. Separate treatment and disposal of greywater are also addressed.

Applications of biological toilet technology for housing in Canada are identified. They are almost exclusively in remote situations away from community services in areas where conventional septic tank based systems are not suitable or affordable. Ongoing improvements to biological toilet systems, which may lead to wider use in year-round housing, are also discussed.

Limited capital cost and operating cost information is presented. Other factors contributing to costs are identified where actual costs are not available mainly due to the specific, site-related nature of these systems.

The text concludes with a summary evaluation, which stresses the limited application of biological toilet technology based on presently available components. The Appendices include a list of biological toilets certified by the National Sanitation Foundation, Ann Arbor, Michigan; and off-the-shelf prices of large biological toilet systems.

This critical evaluation is based on two previous state-of-the-art reviews (3), (6) and one current magazine article (4) and material supplied by two, large-type manufacturers in relation to the CMHC Healthy Housing Design Competition (1) (2) (5) and (7). The report does not include a listing of all available units on the market, nor an owner's guide to the operation and maintenance of biological toilet/greywater treatment systems.

2.0 BACKGROUND

Biological toilets were introduced into the North American market in the early 70's from Scandanavia. In North America they were marketed primarily for year-round use, whereas in Scandanavia, biological toilets had limited seasonal use. More recently the market for the large-type toilets has been for intermittent "public facilities", such as parks, beaches, roadside rest areas, small commercial establishments and military use in remote areas away from conventional services.

Scandanavian authorities, concerned with expanded marketing for year-round installations, initiated a testing program which led to the development in 1981 of a standardized testing procedure for the approval of composting devices for either vacation or permanent homes. In the USA, the National Sanitation Foundation (NSF) in Ann Arbor, Michigan, an independent, non profit testing organization, adopted its Standard 41 for Wastewater Recycle/Reuse and Water Conservation Devices. For a fee, NSF tests biological toilets for structural soundness, liquid containment, odour production, moisture, and fecal coliform content of the end-product. At present only three units have been certified by NSF as listed in Appendix A.

As a result of regulatory agencies and purchasers wanting only certified units, the number of competing devices has dramatically reduced. Further, the testing procedures and results have served to better define what is taking place in the biological toilets, contrary to initial claims of system manufacturers. Continuing industry support of standards and testing procedures on process features, structural integrity, and durability of component parts will further enhance the development and public acceptance of biological toilet systems.

3.0 BIOLOGICAL TOILET CONCEPTS

A biological toilet is a system which in accepting feces, urine, toilet paper, and in the large systems organic kitchen wastes, eliminates excess liquid through evaporation and drainage and aerobically decomposes the solid material to a humus-like end product.

The overall solids content of human body wastes is less than 10 percent. Without a bulking agent and sufficient loss of moisture, biological action would be anaerobic giving off few calories for evaporation and producing offensive odours. The toilet's two main functions are evaporation of excess liquid and degradation of organic materials. A biological toilet does not truly "compost" because the heat loss from evaporation through venting is too great to reach the high (lethal) temperatures characteristic of true composting.

Actual temperatures reached in a large biological toilet are only minimally above ambient conditions. These units now have been equiped with heaters and fans in northern installations to maintain minimum ambient 18°C temperatures year-round.

The carbon and nitrogen (C/N) ratio of human body wastes needs to be supplemented by the addition of kitchen or garden wastes to avoid over-production of ammonia from the mass which can be offensive to users; and numerous creatures in the treatment tank, which may climb up the chute to the toilet seat to escape the ammonia toxicity. The amount of bulking agent required for maintaining porosity of the mass is more important, however,than the C/N ratio.

Originally the end-product was claimed to be a safe humus or soil-like material. In practice there has been a general reluctance to use the end-product in the garden except for burial around shrubs and other non-edible ornamental plants. End-products of poorly operating biological toilets have shown positive for specific pathogens - parasitic, bacterial and viral. Even the better operating units can exhibit positive samples for parasites.

4.0 BIOLOGICAL TOILETS

There are two basic types of approved biological toilets commercially available in Canada. Each stabilizes human excrement with or without separated household garbage by aerobic decomposition in an enclosed chamber. The liquid fraction is evaporated and the moisture exhausted from the home through the vent pipe. For each type, start-up requires priming the chamber with readily decomposable carbonaceous material and, periodically, adding additional quantities.

(1) The large-type, separated from the toilet with few moving parts, consists of a tank with inclined floor and a capacity of at least 0.8 cu m. (27 cu. ft.). The treatment chamber is usually located in the basement. Human wastes enter from a chute connected to the toilet stool above and kitchen garbage wastes enter by a separate chute from the kitchen.

(2) The small-type, with an electric heater also has a fan and a mixing device. These small units require a minimum space for installation, usually .05 to .1 cu. m (2-4 cu. ft). The entire unit sits in the bathroom with the toilet seat on top of the treatment tank.

A biological toilet cannot accomodate greywater - all of the household wastewater with the exception of toilet water. An approved greywater system must accompany a biological toilet.

4.1 LARGE, INCLINED SEPARATED FLOOR TYPE

This type of biological toilet, first introduced in the late 1930's by Richard Lindstrom of Sweden, is marketed today as the "Clivus-Multrum". The design is based on the realization that the combination of human excreta with organic kitchen or garden wastes under conditions of extreme aeration will result, with time, in an acceptable compost. The units were approved by NSF in 1982.

4.1.1 Description

One of the striking characteristics of the "Clivus-Multrum" is its size [4 m (8 ft.) long, 1.1 m (3.5 ft.) wide, 1.5 m (5 ft.) high]. The tank is made of high-density polyethylene of 9 mm (3/8 in.) nominal thickness enclosing 13 mm (½ in.) of polyurethane foam insulation.

These large toilets rely on receiving the kitchen garbage wastes in addition to the toilet wastes. The waste materials are deposited without water into a treatment chamber located on the floor below

through a chute from the toilet stool and by a second chute from the kitchen. The treatment chamber, usually located in the basement or heated space, has a sloping bottom and may be divided into sections.

In general, the waste materials deposited in the upper end of the chamber are oxidized by aerobic micro-organisms as they slowly move down the sloping chamber bottom. Different venting systems are used to maintain proper process conditions. Average day-time temperatures within the unit should be maintained at 18°C (65°F) or above. In cold environments, a small, external space heater may be needed.

During the treatment process, any odours and vapours produced are vented upward through the roof. Ventilation is provided by a 115V, AC, 2-amp blower with 7.5 cu. ft. per min. (265 cfm) at free air. DC ventilation options are available.

By the time the lower end of the chamber is reached, the waste materials have been converted to a stable end-product occupying about 10% of the original waste volume. Over time, the humus-like end-product accumulates at the chamber bottom and must be removed by the means provided. About 5 to 10 percent of the waste added remains as an end-product to be removed. This represents at least 0.1 cu m (4 cu.ft.) per year.

The liquid end-product chamber is provided with a drain. Liquid can be drained by gravity or pumped to a sump for removal from the building to a leach field or other approved means of final disposal. In cool, humid climates, Clivus Multrum indicates the maximum amount of liquid end-product could be 20 l (4 gal)/day)

4.1.2 Advantage/Disadvantages

The advantages of large biological toilets are:

(a) Both human wastes and organic kitchen wastes treated,
(b) Fewer removals of end-products,
(c) Better buffering against shock loadings, and
(d) Lower operational and maintenance costs.

In contrast, the following aspects may be considered disadvantages in comparison to conventional systems or other types of composting toilets:

(a) Higher capital costs,
(b) In cold environments external heater necessary to maintain desired room temperature,
(c) Large unit requires two floors leading to other installation problems,
(d) Proper vent installation critical to satisfactory operation,
(e) Starter material required at the beginning of operation and periodically thereafter as indicated,
(f) Care to be taken as to what materials are disposed of in the toilet,
(g) Overloading with liquid wastes critical,
(h) Possible problems with flies at the beginning of operation, and
(i) Both liquid and solid end-products to be removed and disposed of as required on site.

Process-wise the large size of the system is its greatest advantage. Other factors being equal, the biological toilet with the longest solids residence time will function the most satisfactorily.

4.2 Non-Separated, Small-Type with Auxiliary Heating

The small-type unit has an integral toilet seat and treatment chamber. All utilize electrical heating coils and forced ventilation to promote rapid aerobic decomposition and evaporation. They usually also incorporate a mixing device. The NSF listed Sun-Mar Biological Toilet made by Sun-Mar Corp., Burlington, Ontario, is an example of this type.

4.2.1 Description

These non-separated toilets have a much smaller decomposition chamber which is attached directly to the toilet seat, the entire unit being located on the same floor. The toilet wastes are deposited directly into the treatment chamber (some garbage wastes may also be added). The wastes in the chamber are oxidized by aerobic microorganisms.

As with the separated systems, the chamber is vented to ensure aerobic conditions and to remove moisture. Any odours and vapours produced are conducted through the vent pipe to the roof with

the aid of a fan. The required humidity and temperature conditions are maintained by the electrical and mechanical devices in the toilet.

Closer control of temperature, humidity and mixing results in more rapid stabilization producing a finished product in a much shorter time. These units require emptying every two months to a year depending on loading, capacity of unit, and size of receiving trays. Some toilets have a tray for removing the end-product. In others, it must be removed with a spade. All models of this type are equipped with a scraper to mix the contents. The scraper may be fixed in the system, or be provided as a separate item.

Installed power capacities vary between 130 and 500 watts. The fan, which draws air through the waste, requires approximately fifteen to twenty-five watts of power. Air temperature is thermostatically controlled at approximately 40 to 50°C.

4.2.2 Advantages/Disadvantages

The claimed advantages of small, non-separated composting toilets are their:

(a) small size,
(b) lower purchase price, and
(c) modest electrical power consumption.

Because of their size, they sit on the bathroom floor in the place of the standard water closet and, therefore, are easily adapted to existing homes. The hook-ups typically include a 10 to 15 cm (4 to 6 in.) diameter vent to the roof and an electrical outlet.

The early Northern Canada experience with these biological toilets pointed out a number of problems which may occur even with current models if subject to poor installation, overloading and neglected maintenance:

(a) sensitivity to hydraulic overloading,
(b) insufficient mass to sustain composting process,
(c) objectionable anaerobic odours,
(d) mechanical and
(e) electrical failures.

These findings for non-separated composting toilets show that they require an extra degree of owner maintenance, knowledge and effort over the larger, separated toilets.

Any biological toilet requires more care and attention than a conventional flush toilet in the maintenance of the process and the sanitary disposal of the final end-products.

5.0 GREYWATER

Households equipped with boilogical toilets must also provide for the treatment and disposal of wash water from kitchen sinks, lavatories, bath tubs, showers, clothes washers and dishwashers. This wash water is called greywater, whereas toilet wastewater alone is referred to as blackwater. The greywater contains substantial quantities of chemical pollutants, pathogenic and indicator organisms, and heat. It must, therefore, be disposed of in a manner that will not create a public health problem and will not adversely affect the environment.

5.1 Greywater Treatment and Disposal

Greywater must be treated and disposed of in a sanitary manner and not be allowed to drain on top of the ground or be placed in a simple, soak-away pit without pre-treatment.

At present, most biological toilet owners have to treat their greywater in the manner prescribed by their regulatory agency's requirements for combined domestic wastewater i.e. a septic tank followed by a subsurface absorption system such as a leaching bed or seepage pit. Some jurisdictions, however, permit systems originally designed for combined wastewater to be reduced in size for greywater treatment.

In the Province of Ontario, for example, where greywater from plumbing fixtures and appliances is to be disposed of, a "sub-standard" septic tank and tile bed, holding tank, or aerobic system and tile bed may be used. Here, "sub-standard" means that the minimum standard size available tank may be used with a reduced leaching area (2/3 rds) since blackwater is not present.

The following systems listed below, while not yet fully tested, are given in increasing order of complexity and thus overall cost. Before adapting any of these approaches to a particular on-site situation an owner should check with the local regulatory agency for advice and approval.

(a) Leaching chamber with no pre-treatment,
(b) Gravel filled seepage pit with no pre-treatment,
(c) Pretreatment filter,
(d) Intermittent sand filter,
(e) Recirculating trickling filter.

Clivus Multrum in marketing its bilogical toilets advises owners to consult the local regulatory agency for regulations and site-specific design requirements on discharge of greywater and treated liquid from its treatment tank.

The Company promotes the following methods of greywater treatment and disposal, which are offered as recommendations only.

1. **Greywater Discharge Through Pre-Treatment Filter for Pre-Treatment and Discharge Into Infiltrator TM Leach Field--Open System:** Greywater is discharged into a pre-treatment filter for filtration of hair, lint, and food particles, and drains via gravity or is pumped into the Infiltrator TM leach field system.

2. **Greywater Evapotranspiration System--Raised Soil Boxes--Closed or Open System:** Greywater is discharged from a pre-treatment filter, and Clivus liquid is discharged from the Clivus tank, and both are pumped or drained via gravity beneath the surface of the soil under raised soil boxes by way of PVC piping, which is perforated beneath the surface of the raised soil box plants. The roots of ornamentals benefit from the fertilizer. This system can also be designed with a waterproof liner below the soil surface if discharge into the ground is not allowed.

3. **Greywater Evapotranspiration or Evaporation Greenhouse System--Closed System:** Greywater passes through the bottom of the Clivus treatment tank, mixing with the liquid end-product and runs to a series of pipes below the surface of the soil. If there is sufficient greywater to reach the waterproof liner below, it drains to a sump pump. A pump then sprays the greywater over the surface of the soil by means of a series of overhead pipes and is evaporated.

4. **Greywater Evaporation Boxes:** Greywater passes through the bottom of the Clivus treatment tank, mixing with the compost liquid, and discharges through a series of pipes in the evaporation box. The box is located facing south in order for the sun to provide maximum evaporation.

5. **Raised Soil/Sand Planting Beds:** Shrubs, flowers, and ornamentals are planted in raised, topsoil/sandfilter beds with alternate upper and lower

perforated feed pipes. These raised beds are applicable for areas with high ground water or limit in soils (gravel, clay, rock).

In addition to recommending owner-built systems, Clivus Multrum also offers its greywater filter (LPF-20), which consists of a self-contained tank with twin sock filters, storage capacity, and submersible pump, including 19 mm (3/4 in.) garden hose discharge coupling. The filter is used ahead of a greywater subsoil irrigation container with 710 mm X 914 mm (28 in. X 36 in.) surface area and depth of 710 mm (28 in.). The planter tank contains topsoil, sand, gravel, actifill and drain filter. The pretreated greywater is fed by a subsoil irrigation injection pipe system. The filtered water collected at the bottom drain is normally stable enough to be stored for surface irrigation as needed.

5.2 Comments

The design, technical feasibility, and economics of these alternative greywater treatment and disposal systems have yet to be proven and generally accepted. Further research and development, including field studies, are necessary to properly evaluate their suitability in Canada.

Potential home purchasers may decide against biological toilets upon learning of the requirement for greywater treatment. With greywater treatment included the economics are not competitive with conventional systems except where soils are limiting.

The separation of toilet waste creates greywater - a wastewater with different characteristics - requiring satisfactory treatment and disposal. The proponents of separated wastewaters are optimistic that alternative greywater disposal systems will prove to be less dependant on soil conditions, and thus more economical to install, especially on difficult sites. Such an approach may save some communities with a few troublesome lots from abandoning otherwise unsatisfactory on-site treatment for an expensive sewer program or no development at all.

6.0 APPLICABILITY OF BIOLOGICAL TOILETS FOR HOUSING IN CANADA

In general, where the wastewater from the home can be readily handled on-site by sub-surface disposal, a standard septic tank and soil absorption system should prove to be the most acceptable and economical method of sewage disposal. If, on the other hand, soil conditions prevent liquid waste systems from operating in a conventional manner, the biological toilet may provide a partial solution to the disposal problem. For all applications, a means to handle the remaining greywater must be found without sacrificing the environment or causing public health problems.

For northern locations, the major advantage of a composting toilet is the elimination of flushing water, as the supply and storage of potable water with the subsequent disposal of wastewater are very costly. Even for vacation homes, poor soil conditions may prevent the installation of conventional tile fields where there is a threat of nutrients leaching into recreational lakes.

6.1 Potential Applications

Possible applications of biological toilets include remote properties, cottages, new environmental homes, upgrading existing properties, and servicing new lots under adverse conditions.

6.1.1 Remote Recreational Properties

Biological toilets could be used at cottages, chalets or hunting cabins where hydro and pressure water systems are not provided.

6.1.2 Cottage Properties

Biological toilets may be suitable in those cottage situations where overloading is less likely to occur. However, for any cottage with a pressure system, greywater treatment may be required beyond the level of a simple leaching pit. In Ontario, for example, for new construction on existing undeveloped lots, approval for a biological toilet and leaching pit may only be granted if it is unlikely that building improvements would be undertaken, which would result in the need for an improved sewage disposal system.

On the other hand, for weekend beverage drinking households, intermittent overloading will most likely occur as the proportion of urine to excrement will be high. Continuous cottage use during the peak summer periods of July and August can not be considered intermittent as far as the operation of the toilet is concerned.

6.1.3 Remote Residences

For year-round homes in isolated regions, disposal of greywater by leaching pit, or underdrained filter may be acceptable, permitting the installation of biological toilets.

6.1.4 New Energy-Saving Homes

Generally, where suitable soil for greywater disposal is available, a biological toilet and/or other water saving device(s) could be incorporated into the design.

In more demanding situations, such as the "Codicile" Healthy House, specialized professional input is required to assure that biological toilet technology will meet regulatory requirements and occupant expectations.

6.1.5 Basement Remodelling

A biological toilet may be installed in the basement instead of a water closet where it is otherwise necessary to lift the liquid waste to the septic tank or to the municipal sewer connection.

6.1.6 Retrofitting Existing Septic Tank Tile Fields

Many residences, especially cottages, have old sewage disposal facilities which would not be acceptable by today's standards. These systems may now be over-loaded as a result of improvements to the dwelling, changes in family occupancy, or the installation of modern water consuming devices.

In these cases two alternatives are possible:

(i) Providing a biological toilet to reduce the overall sewage flow about 30 percent so the absorption field will no longer be overloaded.

(ii) If necessary, also building a new absorption field of reduced size to serve as the greywater disposal system.

6.1.7 Greywater Holding Tanks

In almost every rural community there are likely to be a few homes that cannot be served by conventional on-site disposal systems at reasonable cost. An isolated house high-up on a steep, rocky hill or a few houses on a small island with a high water table illustrate the situation. In such instances, completely contained sanitary waste storage systems chould be employed so that no pollution load will be placed on the immediate environment.

One option is a biological toilet to eliminate the blackwater and a holding tank for the remaining greywater thus reducing the volume of wastewater to be hauled away from the site.

6.1.8 Greywater Disposal by Evapotranspiration

There may be locations where regulatory officials will approve of biological toilets with greywater storage and evapotranspiration systems.

Nearly all precipitation falling on an evapotranspiration bed will drain into it and will become part of the water to be evaporated. For this reason, the system is limited to those areas where rainfall does not exceed evaporation on an annual basis or an individual monthly basis. While the use of plants or grasses to increase moisture transfer by transpiration is very effective in the summer growing season, it is ineffective during the critical evaporation months of winter and early spring.

For the Canadian climate, summer seasonal operations with minimal water use would have the most potential for success.

6.1.9 Greywater Filtration Systems

While more expensive to install and maintain, a filtration system combined with a biological toilet may provide a practical solution for a particular onsite wastewater disposal problem.

6.2 Summary

This listing of potential applications shows that biological toilets have a role to play in the solution of certain on-site waste disposal problems. This is born out by the sales of biological toilets, which generally have been in rural and remote areas to serve cottages, homes, institutions, and small commercial buildings.

For biological toilet systems to penetrate further into the market: improvements are required to the toilets themselves; practicable greywater disposal systems must be developed; user education must be intensified; and servicing organizations must be created to assure regulatory agencies of satisfactory operation. Ongoing improvements to biological toilet treatment systems are discussed in the next section.

7.0 IMPROVING BIOLOGICAL TOILET SYSTEMS

Improvements to the design and process control features of both types of biological toilets are ongoing. The trend is towards further automation and control of the processes involved. This is difficult to achieve without sacrificing simplicity and increased cost.

7.1 Small Toilets

The "Toile Tronic", made by Inland Fibre in British Columbia is an example of improvements to small composting toilets. It features a motorized, electronic agitator, blower and heater which can be programmed to function at six different speeds, according to the number of people using the system.

7.2 Large Toilets

In rural Alaska, waste disposal is compounded by the lack of: large quantities of water for sanitation systems; of open space with soils suitable for septic tank/absorption field systems; trained, technical expertise to run and maintain treatment systems; and extreme temperature fluctuations. Such problems have led to serious public health threats in Alaska's rural villages, where inadequate sewage disposal has threatened drinking water supplies.

Biological toilets have been used over the years as one method of dealing with waste disposal in rural and/or remote sites. In the early 1980's the AlasCan System was developed as an automated improvement on existing composting systems and combined the concept with a modern foam-flush toilet. The resulting system (patent pending) has been installed and is operating in several locations throughout Alaska.

At the present time AlasCan does not have the endorsement of regulatory agencies such as the US Environmental Protection Agency or the Alaska Department of Environmental Conservation. Similarily, the Municipal Approvals Section, Approvals Branch, Ministry of the Environment of Ontario, considers it to be premature (Nov. 1992) to classify the AlasCan System for use in Ontario.

Such approval from regulatory agencies is subject to independent third party testing/documentation respecting satisfactory performance of the system such as offered by NSF.

The AlasCan System has been tested (1990-1991) under

contract by the Environmental Technology Laboratory, University of Alaska, Fairbanks. Additional third-party testing is planned by Associate Professor John Olefsson, School of Engineering, University of Alaska,, Anchorage, with State and Federal funding.

These blackwater and greywater treatment systems seem at this time to represent a significant advancement in the state-of-the-art of rural wastewater management. For this reason the following discription of the AlasCan System is included in this report.

7.2.1 Foam Flush Toilet

The system incorporates a Japanese (Nepon Inc) "Pearl" ultra-low flush toilet (one cup of water per flush). A small air pump in the reservoir produces a biodegradable foam that covers the inside of the toilet bowl. The foam acts as an odour barrier, reduces splashing, and helps the one cup of water to provide the necessary flushing action. The power requirement of the pump is 8 watts per flush.

Use of a flush toilet permits waste lines to be sloped. This offers flexibility in the relative position of toilet and treatment tank.

7.2.2 Kitchen Wastes

The kitchen sink is equipped with a garbage grinder and water sprayer faucet. The kitchen and toilet wastes are piped separately to the treatment tank, located below in a basement or crawl space.

7.2.3 Biological Treatment Tank

The treatment tank is factory assembled. Its size is 140 cm (56 in.) high, 120 cm (48 in.) wide and 234 cm (92 in.) long. The unit is insulated and there is provision for auxiliary heating for extreme conditions.

The rectangular tank contains baffles, air channels, mixers (controlled by both timer and thermostat) and a small fan. Warm air from a warm air intake near the ceiling of the house is drawn through the accumulating organic wastes, permitting the aerobic decomposition process to take place. An automatic sprinkler periodically redistributes excess liquid evenly over the pile.

The treatment tank also contains , wood shavings and millions of red worms. Both are intended to enhance the decomposition process. A pair of screw conveyors are used to move the end product to the cleanout tray.

The corrosion resistant, waste treatment tank is made of fiberglass. It is internally divided into decomposition chamber, finished chamber, and excess liquid chamber. The tank is field assembled by welding.

All tanks are electrically assisted by standard 110/120 VAC, single-phase, 60 cycle power to operate the 15 watt, 0.14 AMP ventilation fan. Optional 12 volt DC, six watt, 0.50 AMP fan and photovoltaic systems are available for remote locations.

7.2.4 Greywater Treatment Tank

The separate, rectangular, greywater treatment tank is divided into three sections by internal baffles. (influent surge chamber, reaction chamber, and effluent settling chamber). Its dimensions are 140 cm (56 in.) high, 90 cm (35 in.) wide and 235 cm (92 in.) long.

This is a biological, extended aeration type treatment process requiring an air pump for air supply to the first two chambers and to return biological solids from the effluent settling chamber to the reaction chamber. A pump is used to remove excess accumulated solids from the greywater tank to the biological treatment tank.

The connected electrical load is 9kw hr/day. This makes it the least energy efficient part of the system.

7.3 Comments

The AlasCan System, while complete and apparently resident friendly, is expensive and mechanically complicated. A complete system, including consultation and installation, costs between US 10,000 and 12,000 dollars (1989). For Alaska this represents about double the construction cost of a conventional toilet and septic tank absorption system.

While conventional systems will continue to be used where local conditions permit, the AlasCan System offers technological solutions for housing in remote/rocky areas where honey buckets are now used; and reductions in waste discharges where holding tanks and trucked services are used.

8.0 COST CONSIDERATIONS

In comparison with other methods of handling wastes from the unserviced home, biological toilets are not inexpensive. They are, in general, less costly than conventional toilets, septic tanks and tile fields, but alone do not provide equivalent service. Prospective buyers may be turned away by the relatively high purchase cost, the installation cost, the operation/maintenance cost, plus the cost of an approved, separate greywater system.

8.1 Small Toilets

The purchase price usually varies depending on manufacturer and model, costing $1,000 or more. The "Toile Tronic" cited earlier sells for $1,500.

The small toilets are relatively easy to install, requiring only an electrical outlet and installation of the vent pipe. Total labour requirements are usually less than ten hours.

The small toilets, which utilize auxiliary heat to evaporate the waste liquid, have much higher direct operating costs. Units on the market have power requirements up to, and even exceeding, 500 watts. While the heaters are in general thermostatically controlled, average daily usage is in the range ot two to four kilowatts. Even if power rates are relatively cheap, electrical costs are significant.

Like the large units, they also exhaust quantities of air from the home. In winter, heating of replacement air is a significant, indirect cost of operation. These general comments do not apply to all units as those incorporating internal circulation of warm air use significantly less energy.

8.2 Large Toilets

Off-the-shelf purchase prices of the Clivus and AlasCan components in US dollars (1992) are given in Appendix B. The basic price for the Clivus M12 biological toilet is US $4,750. Prices for the Clivus greywater filter and subsoil irrigation tank were not made available.

Installation costs are additional. Installation of the large Clivus unit installation in new buildings requires about twenty four hours of labour to complete. Field assembly of pre-molded sections facilitates installation in existing homes.

The cost of operating a typical large toilet varies widely depending on its features, capacity, and usage. The large units in general are cheaper to operate than the small, electrically heated models. Experience has shown that Canadian installations should include auxiliary heating. Indirect costs for the large units, however, may be more significant than most purchasers realize. The large units rely on the ambient heat in the air to evaporate the moisture from the waste. To do this they utilize vents which draw the air from the home and exhaust it to the atmosphere. The cost of heating the replacement air can be quite significant at today's fuel prices.

A further operating expense is the cost of biological tank start-up material and bioaugmentation product if required to maintain satisfactory operation on a continuous basis. Also there may be component replacement costs due to the corrosive atmosphere within the units and general wear and tear.

The AlasCan biological tank is priced at US $7,500 and the greywater treatment tank at $2,500. As indicated previously, typical installed costs in 1989 in Alaska were US $10,000 to $12,000.

Annual operating costs in Alaska are given by AlasCan as US $452, without subtracting water savings and assuming associated labour costs (US $300) are carried out by the house owner.

9.0 CRITICAL EVALUATION

Biological toilets were originally designed for the sanitary disposal of human wastes in seasonal/recreational dwellings in rural areas of Scandanavia. Generally, today, the main market for biological toilets continues to be public facilities serving recreational needs, and accomodations in remote areas away from community services. Public exposure to this different type of sanitary facility at these locations may eventually help make the transition to residential acceptance easier.

For public health reasons, it is essential that no feces, urine, or partially treated end-products escape from the indoor biological toilet due to faulty workmanship or inadequate operation. The final products, especially when not completely stabilized, are a potential health hazard and must be disposed of in a sanitary manner. Residents are expected to empty the end products chamber regularly (about every three months) and continuously add some form of bulking agent.

For both environmental protection and public health reasons greywater must also be treated and disposed of in a sanitary manner. When disposing of greywater there is always the danger of spreading disease. Very little is known about the concentration of virus in greywater but based on bacteriological analyses, it seems assured that if someone in a household were shedding virus, the potential would exist for viral contamination.

To-date, none of the available biological toilets can be regarded as an automatic, maintenance-free device. The technical feasibility, economics and effectiveness of the various greywater treatment systems suggested and offered by the toilet manufacturers require further testing and evaluation for their suitability in Canada.

Possible residential applications of biological toilet systems have been identified in this report. Generally, these are where on-site conditions and costs do not favour the installation of conventional water carriage systems.

At the present time, other than for the ecologically sensitive who are willing to accept the aesthetics and maintenance problems/costs, the use of biological toilet systems in year-round homes is limited to those situations where water supplies are scarce or soil absorption is limiting.

The purchase of a biological toilet and the installation of an onsite greywater system means the average individual homeowner and family must adopt to a new plumbing device and assume responsibility for the operation and maintenance of a more sophisticated total system than they are accustomed. Further, capacity for temporary overloads from family social events is always limiting.

Improved designs, as they become available on the market, such as the AlasCan System tend to be more expensive to purchase and to operate. They require more knowledgeable operation and significantly increased power costs. This mitigates their original appeal for household use, which was their low-cost and simplicity.

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APPENDIX A

BIOLOGICAL TOILETS/GREYWATER TREATMENT SYSTEMS CERTIFIED BY NATIONAL SANITATION FOUNDATION, ANN ARBOR, MICHIGAN IN ACCORDANCE WITH STANDARD NSF41-1983. AS OF OCTOBER 1, 1992

BIOLET INTERNATIONAL
WEID STRASSE 18
6300 ZUG
SWITZERLAND

CLIVUS MULTRUM INC
21 CANAL STREET
LAWRENCE, MA 01840
USA

SUN-MAR CORPORATION
5035 N. SERVICE RD., UNIT G2
BURLINGTON, ONTARIO
L7L 5V2

APPENDIX B

OFF-THE-SHELF PRICES - 1992
(US dollars)

CLIVUS RESIDENTIAL PRICE LIST

The Clivus Multrum basic package prices include all the components essential to the installation of the system, except the support cradle and starter bed material.

Contents of Basic Package for Component Models M-12, M-12M

Compost Tank Assembly (M-12, M-12M)
* polyethylene

Installation Assembly Kit
* caulking and all hardware for complete installation

Toilet Assembly
* includes stool, liner, seat and cover, stainless steel connector plate

Toilet Chute
* 14" diameter, 2' long section, stainless steel

Maintenance Tool
* Rake

Ventilation System
* one AC blower assembly and housing
* one vent support box
* one roof flashing 5-30º pitch
* one 6" diameter interior vent ducting (25 ft.)
* two sections 2 x 10" diameter insulated
* exterior vent pipe
* one storm collar
* one stainless steel topper
* DC systems available

Model Number	Description	Unit Price
M-12	Basic Package	$4,750
M-12M	Basic Package (Modular)	$4,750

Note: One toilet fixture/chute is included in the above prices. Refer to "Price" column when purchasing as individual items and to "Basic Package" column when purchasing with Clivus Multrum system.

FIXTURES

		Unit Price	Price when Purchased w/Basic Package
A-F102	**Toilet Assembly,** white fiberglass, includes stool, stainless steel liner, seat & cover, stainless steel connector plate, uses 12" diameter chute	310	250
A-F103	**Toilet Assembly for Handicapped, Seat 18" above floor,** white fiberglass, includes stool, stainless steel liner, seat & cover, stainless steel connector plate, uses 12" diameter chute	350	300
A-F108	**Toilet Assembly,** white fiberglass, includes stool. liner, seat & cover, stainless steel connector plate uses 14" diameter chute	310	250
A-F109	**Toilet Assembly for Handicapped, Seat 18" above floor,** white fiberglass, includes stool, liner, seat & cover, stainless steel connector plate, uses 14" diameter chute	350	300
A-F106	**Urinal Assembly,** white, includes urinal, PVC	275	225

P-S124	**Toilet Chute for 12"** diameter toilet, 2' long section, stainless steel	50	40
P-S125	**Toilet Chute for 14"** diameter toilet, 2' long section, stainless steel	50	40
P-S126	**Toilet Chute for 14"** diameter toilet, 3' long section, stainless steel	60	50
Optional Components			
P-C12	**Support Cradle** for M-12 and M-12M	250	200
P-C22	**Liquid storage cradle** for M-12 and M-12M	*	2,000
A-L102	**Liquid Removal Assembly,** (Mannual) includes hand pump, hose and fittings	135	120
A-L101	**Liquid Removal Assembly,** (Electric) includes electric pump, float switch, hose and fittings and pump isolation chamber	225/DC 362/AC	195/DC 300/AC
P-V139	**Interior Vent Ducting,** 6" diameter, lengths in 2' multiples, multi-ply tape construction, wire reinforced, flexible ducting	2/ft. @ 13.50	Included
P-V101	**Insulated Exterior Vent Pipe,** 10" ourside diameter (galvanized steel), 6" inside diameter (aluminum), 2' long section	50	Included
P-T105	**Liquid Storage 50 Gallon Tank**	223	*
P-T104	**Liquid Storage 100 Gallon Tank**	306	*
L-P10	**Primary Liquid Filter**	950	*
P-X151	**Clivus Multrum Starter Bed** 2 cubic feet/40 lbs per bag	12	10
A-V103	**Solar Powered Daylight Fan Assy**	719	*
	Solar Powered Electrical System	*	*

* **Consult Clivus Multrum for size & pricing**

APPENDIX B

OFF-THE-SHELF PRICES (1992)
(US dollars)

AlasCan PRICE LIST

CT-101-SI	BIOLOGICAL TANK - super insulated - assembled with exhaust fan, excess liquid recirculation system, mixers, augers, air channels, baffles and access door (white fiberglass coating)	$7500.
GWT-201-SI	GREYWATER TANK - super insulated - assembled, three chambered unit with air pump, diffuser and sludge removal system (white fiberglass coating)	$2500.
	FOAM FLUSH TOILET - Ceramic toilet assemblies contain all mechanical and electrical components, one liter foaming agent and toilet seat with cover	
STW-12-H	IVORY	$1250.
STW-12-1H	BABY BLUE	$1450.
STW-12-2H	WINE	$1450
NFt-301-WP	NON-FLUSHING TOILET - White polyethelene toilet assembly with seat and cover	$275
UL-401-I	FOAM FLUSHING URINAL - Ivory ceramic assembly contains all mechanical and electrical components and one liter of foaming agent	$1200.
	ACCESSORIES	
	FOAMING AGENT for foam flushing toilets and urinal	
FA-501-1L	One liter container	$5.
FA-501-10L	Ten liter container	$50.
SUM-601-1B	COMPOSTING TANK START-UP MATERIAL Per bag - four (4) bags required for initial installation	$25