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ENVIRONMENTAL SUMMARY HARVESTING AND USE OF PEAT AS AN ENERGY SOURCE

Submitted to
Environment Canada

24 February 1986

Monenco Maritimes Limited
Fredericton, New Brunswick

In Association with

K.D. Phinney, P.Eng.
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Mr. M. Guilcher, P.Eng.
Chief - Water Pollution Control Division
Environmental Protection Service
Fifth Floor, Queen Square
45 Alderney Drive
Dartmouth, Nova Scotia
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Dear Mr. Guilcher:

Re: Peat - Environmental Summary

We are pleased to submit our final report which provides a review and summary of information concerning the environmental aspects related to the harvesting of peat and its use as a source of thermal energy.

We thank you for your assistance during the project.

Yours very truly,

D. N. Meeking
D.N. Meeking
Project Biologist
Monenco

K. D. Phinney
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Project Manager
Consultant

RÉSUMÉ

Ce rapport présente une analyse critique et un résumé de l'information concernant les effets écologiques possibles de l'exploitation de la tourbe et de son utilisation comme une source d'énergie thermique. Les procédés pour l'assèchement, la combustion et la conversion de la tourbe en combustibles solides, liquides et gazeux sont analysés. Le rapport décrit les divers procédés, les sources de problèmes écologiques possibles, les méthodes de traitement des déchets et définit les autres renseignements et la recherche requis pour permettre de mieux comprendre les questions de l'environnement apparentées à l'utilisation de la tourbe comme source d'énergie thermique.

L'assèchement des tourbières en vue de l'exploitation de la tourbe peut modifier la qualité hydrogéologique, hydrologique et de l'eau du bassin hydrographique local. Des études spécifiques sur place et une planification attentive de l'activité d'exploitation de la tourbe s'imposent pour s'assurer que la capacité d'assimilation du bassin hydrographique, en aval de la tourbière, ne soit pas dépassée.

L'assèchement mécanique de la tourbe, surtout après son prétraitement par les procédés de carbonisation et d'oxydation en milieu liquide produit des effluents liquides volumineux qui sont très colorés et qui contiennent des concentrations élevée de demandes biochimiques et chimiques d'oxygène ainsi que d'azote ammoniacal et total. Ces effluents sont assujettis aux procédés de traitement biochimique aérobique et anaérobique mais peuvent nécessiter un traitement supplémentaire pour la décoloration, l'élimination des matières en suspension et des matières organiques réfractaires. Les fumées produites pour l'assèchement thermique de la tourbe contiennent des matières organiques volatiles distillées provenant de la tourbe.

Il faut faire une sélection attentive et une utilisation bien contrôlée des fournaises de combustion pour la tourbe afin de minimiser le risque de décharge de matières organiques non brûlées, y compris les aromatiques polycyliques dans les fumées. La combustion de la tourbe produit de faibles émissions d'anhydride sulfureux mais peut également produire des émissions de bioxyde d'azote en raison de la teneur relativement élevée de la tourbe en azote.

La conversion de la tourbe en combustibles solides, liquides et gazeux produirait des effluents de l'assèchement et/ou des fumées de l'assèchement thermique. De plus, les procédés de gazéification et de liquéfaction produisent des quantités relativement petites d'eaux usées. Ces eaux usées, qui contiennent des substances organiques, des métaux à l'état de trace et des composés sulphuriques d'azote nécessiteraient un traitement biochimique et physique-chimique élaboré pour permettre leur écoulement.

ABSTRACT

The report provides a critical review and summary of information concerning the potential environmental effects related to the harvesting of peat and its use as a source of thermal energy. Processes for the dewatering, combustion, and conversion of peat into gaseous, liquid and solid fuels are considered. The report provides a description of the various processes, the sources of potential environmental concerns, waste management methods, and defines the further information and research that is required to enable a more complete understanding of environmental matters related to the use of peat as a source of thermal energy.

The drainage of peat bogs to enable the harvesting of peat can result in alterations to the hydrologic, hydrogeological and water quality of the local watershed. Site specific environmental studies and careful planning of the peat harvesting operation are required to ensure that the assimilation capacity of the watershed,downstream from the peat bog, is not exceeded.

The mechanical dewatering of peat, particularly following its pretreatment by wet carbonization or wet oxidation processes, produces voluminous liquid effluents which are highly coloured and contain elevated concentrations of both biochemical and chemical oxygen demands as well as total and ammonia nitrogen. These effluents are amenable to both anaerobic and aerobic biochemical treatment processes but may require additional treatment for the removal of colour, suspended material, and refractory organics. Flue gases from the thermal drying of peat contain volatile organics distilled from the peat.

Careful selection and well controlled operation of peat combustion furnaces are required to minimize the potential for the release of uncombusted organics, including polycyclic aromatics, in the flue gases. The combustion of peat generates low emissions of sulphur dioxide but may generate emissions of nitrogen oxides due to the relatively high content of nitrogen in peat.

Processes for the conversion of peat into gaseous, liquid and solid fuels would generate effluents from dewatering and/or flue gas from thermal drying. In addition, gasification and liquefaction processes generate relatively small quantities of highly concentrated wastewaters. These wastewaters, containing organic substances, tracemetals, and reduced nitrogen and sulphur compounds would require extensive biochemical and physical-chemical treatment to enable their discharge.

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PART ONE
INTRODUCTION

1. INTRODUCTION

This report provides a review and summary of information concerning the environmental aspects related to peat harvesting, dewatering, combustion, and conversion into liquid, gaseous and solid fuels.

Sources of information for the review consisted primarily of reports produced during Environment Canada's program to develop environmental protection criteria and technologies related to the use of peat as a source of thermal energy. Other information available in the open literature has also been included, particularly in those sections of the report concerning the combustion and conversion of peat into liquid, gaseous and solid fuels.

It should be noted that Section 6 of this report provides a tabular summary of the potential environmental concerns and environmental methods identified in the earlier sections.

PART TWO

PEAT HARVESTING

2. PEAT HARVESTING

This section of the report considers the environmental aspects related to the harvesting of peat.

2.1 PROCESS DESCRIPTIONS

2.1.1 Harvesting Processes

Peat is extracted from bogs using either "dry" or "wet" harvesting methods. At present, nearly all of peat harvesting in the world is carried out by dry methods. Dry methods involve drainage of the peat bog followed by harvesting to produce either peat sods or milled peat. The harvested peat is allowed to dewater in the field to a water content of between 30 and 50 wt%, prior to transport to the consumer. Wet harvesting methods involve the extraction of peat without the necessity for prior drainage of the bog. Peat can be extracted using barge-mounted backhoes or by suction of the peat from the bog using pumps. Wet harvested peat is conveyed directly to a process plant for the removal of water.

Descriptions of the various harvesting methods are given in the following sections.

2.1.2 Dry Harvesting Methods

The development of a dry harvesting operation requires the construction of all weather access roads to the bog area and drainage of bog areas to allow for eventual extraction and field drying of peat.

Drainage of peat extraction areas is necessary to lower the water table in order that the area can support harvesting equipment. The drainage system consists of perimeter and interval ditches. The perimeter ditch, located along the perimeter of the harvesting areas, is typically 2-4 m deep, initially, and is periodically deepened as the peat is extracted.

Interval ditches, located at approximately 20 m intervals within the harvesting area, drain into the perimeter ditch. These ditches are normally 1.3 to 1.5 m deep, initially, and are also periodically deepened as the peat is extracted.

Trees and other woody vegetation are cleared from the bog area prior to contouring of the peat extraction areas. This contouring creates a crown for each of the peat extraction areas in order to ensure that rainfall runs off into the interval ditches.

Subsequent extraction of the peat is carried out by either producing sods or milled peat. Sods are produced by tractor-drawn equipment which cuts to a depth of approximately 1 m into the peat, macerates it, and then extrudes the peat as a cylindrical sod approximately 8 to 10 cm thick and 25 to 35 cm long. The sods are allowed to field dry to a water content of approximately 30 to 35 wt%.

Milled peat is produced by tractor-drawn equipment which scrapes and then mills a 12 to 15 mm thick surface layer of peat into a powdery form. The milled peat is formed into windrows and allowed to field dry to the desired water content.

Field dried peat is normally stored in piles on firm ground.

2.1.3 Wet Harvesting Methods

The wet harvesting of peat can be carried out on either undrained or drained areas, depending on the particular methods of extraction. The simplest methods involve draining of the bog only as necessary to enable extraction of peat by backhoes. More advanced methods involve the use of barge mounted excavators with series of screens and pumps to remove plant roots and other foreign materials prior to maceration and pumping of the slurried peat to a processing (dewatering) area. High pressure pumps can also be used to strip the peat off the bog to a sump from where it is slurried and pumped either to a field for drying or to a processing area.

2.2 ENVIRONMENTAL CONCERNS

2.2.1 Aquatic Environment

The potential for alterations to watershed hydrology and water quality, due to the drainage of peatlands are the primary environmental concerns related to peat harvesting. These alterations may lead to changes in the ecology of the downstream aquatic habitat.

The drainage of peatlands as well as the clearing of trees and other vegetation results in sudden and increased flows from the peat area into local watercourses at least during the initial drainage period. The presence of the drainage works will also cause changes to the rate and duration of surface water flows which were historically characteristic of the area (Sallantaus and Patilla, 1985). In addition, drainage of the peatland will cause a lowering of the water table leading to a potential for the ingress of groundwater from neighbouring bogs as well as from more mineralized upland areas.

The more obvious environmental effects of these alterations to peatland hydrology include the increased discharge of suspended and colloidal materials into local receiving streams, at least during the construction and early operation of the drainage ditches, and changes to the hydrological characteristics of downstream watercourses (rate and duration of flows). Less obvious and more difficult to definitively specify are the potential environmental effects related to the water chemistry of peatland drainage.

The water chemistry of peatlands strongly depends on the chemistry of the peat as well as the sources of water contained within the peatland (Glooschenko et al, 1985). The water chemistry of peat bogs reflects the lack of inflow of ground and surface waters, direct precipitation being the only source of water into the bog. Conversely, peat fens exhibit water chemistry which is largely influenced by the inflow of surface and ground waters.

In the absence of the inflow of more mineralized and alkaline ground and surface waters, the water chemistry of bogs is determined largely by the dissolution of peat substances. Thus, water in bogs tends to be acidic (pH ∿4), contain dissolved organic matter, be relatively low in concentrations of mineral species, such as alkali and alkaline earth elements (Na, K, Ca and Mg), be somewhat elevated in iron and manganese species due to the presence of their organic complexes, and contain carbon dioxide. The water in fens also contains dissolved organic matter but tends to be more alkaline (pH ∿6-8), with higher concentrations of alkali and alkaline earth elements.

The water from both bogs and fens may undergo aerobic processes near the surface and anaerobic processes at lower depths within the peat deposit. Thus, the chemical composition of the water can vary significantly with depth (Glooschenko et al, 1985).

The presence of dissolved organic matter results in drainages from bogs and fens which are characterized by colour and both chemical and biochemical oxygen demands. The dissolved organic matter also favours the presence of metal-organic complexes within the drainage (Shotyk, 1985). Thus, drainages from peatlands may contain at least detectable concentrations of aluminum, iron and manganese in addition to many other trace elements (Washburn and Gillis, 1983, 1982; Glooschenko et al, 1985; Shotyk, 1985). Unfortunately, there is very little information on the speciation of these elements in drainages and on their behaviour when the drainage is mixed with receiving streams.

The acidity of bogs is caused primarily by the presence of water-soluble organic acids, ranging from low molecular weight carboxylic acids, such as acetic and oxalic, to high molecular weight, structurally complex fulvic and humic acids. Many other organic species present in lesser concentrations contribute to the total dissolved organic matter (Washburn and Gillis, 1983, 1982).

Peatlands are also a source of other nutrients, such as nitrogen and phosphorus. These are present in water as both organically and inorganically bound species.

Summaries of the water chemistry for various peatlands in Canada and elsewhere are given in Tables 2-1, 2-2, 2-3 and 2-4 from available information (Washburn and Gillis, 1983, 1982).

The potential changes in the hydrology and water quality of receiving streams as a result of the drainage of peatlands is unequivocally site specific. Thus, while the hydrologic and water chemistry factors that may result in changes can be specified, the environmental effects on receiving streams cannot be stated in general terms. Knowledge of the local aquatic environment is required to define its sensitivity to alterations caused by the forced drainage of peatlands.

The surge of drainage from peatlands during and for some period following construction of the drainage system has the greatest potential for immediate and observable environmental affects. This can be attributed primarily to the suspended solids and colloidal materials resulting from disturbance of the peatland. These factors may result in siltation of aquatic habitat, avoidance reactions by aquatic organisms, and changes to biological productivity. Similarly, the presence of increased acidity, nutrients, colour, and oxygen-demanding substances may adversely affect the aquatic environment (Olsson and Naslund, 1985). Determination of the duration and significance of any such effects will be complicated by the changes in the hydrology and water chemistry of peatland drainage over the years. Thus, while the early period of drainage may be characterized by the discharge of "native" bog water, drainage in later years may be associated with markedly different water quality due to changes to both the morphology of the harvested peat area and its sources of water inflow (Johansson and Olofsson, 1985; Sallantaus and Patilla, 1985).

TABLE 2-1

Peat Drainage Water Quality

Parameter	Fen[a]			Bog[a]		
	Range	Median	N[b]	Range	Median	N[b]
pH	3.6-7.4	4.8	12	3.4-7.9	3.9	22
Calcium (mg/L)	0.8-43	4.9	11	<0.1-74	1.8	22
Sulphate (mg/L)	3.8-6.0	-	4	0.4-22.1	6.0	13
Aluminum (mg/L)	0.08-0.38	-	5	0.05-0.73	-	5
Iron (mg/L)	0.3-8.2	1.0	8	0.1-4	0.4	8
Manganese (mg/L)	0.005-1.1	0.07	8	0.007-0.15	0.02	9
Total Nitrogen (mg/L)	0.6-9.5	1.2	6	0.8-6.3	2.8	5
Total Phosphorous (mg/L)	0.007-0.18	0.07	9	0.02-0.19	0.07	8

Source: Adapted from Washburn and Gillis, 1982

[a] - for fens and bogs in various areas of the world

[b] - number of data

TABLE 2-2

Peat Drainage Water Quality - Trace Elements

Parameter	Range[a]	Median	N[b]
Arsenic (mg/L)	<0.05	-	9
Copper (mg/L)	<0.01-0.01	0.008	14
Lead (mg/L)	<0.03	-	8
Mercury (μg/L)	0.05-9.2	2.6	8
Zinc (mg/L)	0.01-0.11	0.03	11

Source: Adapted from Washburn and Gillis, 1982

[a] For peat fens and bogs in various areas of the world

[b] Number of data

TABLE 2-3

Peat Bog Water Quality - For Three Bogs in Canada

Parameter	Range	Median	N[b]
Aluminum (mg/L)	0.009-0.51	0.35	4
Iron (mg/L)	0.14-0.96	0.27	7
Lead (mg/L)	0.01	-	8
Manganese (mg/L)	0.002-0.98	0.01	7
Mercury (µg/L)	<1	-	7
Zinc (mg/L)	0.004-0.091	0.016	7
Total Nitrogen (mg/L)	0.87-7.5	3.0	7
Total Phosphorous (mg/L)	0.05-0.25	0.05	7
Total Inorganic[a] Carbon (mg/L)	1.7-8.4	2.3	7
Total Organic[a] Carbon (mg/L)	21-93	51	7
Chemical Oxygen Demand[a] mg/L)	43-326	126	7

Source: Adopted from Washburn and Gillis, 1983

[a] dissolved

[b] number of data

TABLE 2-4

Water Quality of Bog Discharge During Peat Harvesting at High Point Bog - Newfoundland

Parameter	Range[a]	Median	N[b]
Suspended Solids (mg/L)	1-52	3	15
Turbidity (JTU)	0.6-13	-	15
pH	3.8-4.6	4.3	15
Calcium (mg/L)	0.11-3.91	0.26	12
Magnesium (mg/L)	0.15-1.29	0.21	14
Aluminum (mg/L)	<0.025-0.15	0.05	14
Iron (mg/L)	0.27-2.71	0.69	14
Manganese (mg/L)	0.01-0.27	0.03	13
Mercury (μg/L)	<0.05-0.4	0.05	7
Nitrate (mg/L)	<0.05-4.2	0.1	15
Total Organic Carbon (mg/L)	25-32	30	15

Source: Washburn and Gillis, 1983

[a] - Sampling during summer-fall period

[b] - N - Number of data

2.2.2 Terrestrial Environment

The use of peatlands as a wildlife habitat is largely eliminated by the harvesting of peat. Adaptive, mobile species such as moose and deer may not be affected due to the availability of neighbouring undisturbed areas. Other less adaptive mammals and birds will be displaced from the area.

The lowering of the local groundwater table as a result of the wet harvesting of peat may extend to areas outside the peatland. This can result in interference with local groundwater supplies as well as producing soil conditions which favour upland rather than wetland vegetation.

Emissions of peat dust during dry harvesting operations can be a major nuisance and potential health hazard due to irritation of skin, eyes, and the respiratory system (Riihimaki et al, 1980).

2.3 ENVIRONMENTAL MANAGEMENT METHODS

A thorough knowledge of the predevelopment hydrology, hydrogeology, water chemistry and ecology of the peatland and its associated watershed is essential for the environmental management of peat harvesting developments. A knowledge of the ecology is necessary to enable projections of the sensitivity of terrestrial and aquatic resources to alterations to the environment caused by peat harvesting. Similarly, the degree of changes in surface and ground water flows within the watershed can be estimated from the hydrological and hydrogeological characteristics of the area. Such information can be combined with watershed, peatland and local groundwater water quality data to enable some indication of at least the types of water quality changes that can be expected at various degrees (i.e. surface area) of peatland development.

Knowledge of the local environment will allow for the development of harvesting plans that take into account potential environmental effects. In this regard, it is likely that the provision of sedimentation ditches and ponds, to remove settleable particulates from peatland drainage, will remain the only treatment method associated with peat harvesting operations. The necessity for and practicality of further treatment operations, such as the removal of turbidity, acidity, colour, oxygen-demanding substances, other organic substances, and various trace elements, are very problematic. Development of drainage plans so as to ensure that the assimilation capacity of the watershed is not exceeded is likely to be the most effective and practical approach to protection of the aquatic environment.

Peatlands, after the completion of harvesting activities can be reclaimed for both agricultural and forestry uses. This is routinely carried out in other peat harvesting areas of the world such as Finland, Ireland, Sweden, and Germany. Alternatively, the harvested area can be allowed to flood and thereby remain as a wetland.

2.4 RESIDUAL ENVIRONMENTAL CONCERNS

It is probable that the ability to accurately predict the effects of peat harvesting on aquatic environments will remain a difficult task, despite the ever increasing information on the water chemistry of bog waters. Thus, it is likely that any future peat harvesting developments will be accompanied by uncertainties concerning the subtle effects of drainages on the aquatic environment. Careful predevelopment investigations and planning of the harvesting operations, and monitoring during the development and operating phases will minimize environmental concerns.

2.5 INFORMATION DEFICIENCIES AND RESEARCH NEEDS

The speciation of trace elements, particularly metals, in peat drainages and their reactions with receiving stream waters to form other chemical species will continue to be of interest as regards to the potential for toxicity to aquatic organisms. Similarly, information is lacking on the effects of increased turbidity and colour, caused by peatland drainage, on aquatic environments.

PART THREE
PEAT DEWATERING

3. PEAT DEWATERING

This section of the report provides a review of the environmental aspects related to processes for the removal of water from peat.

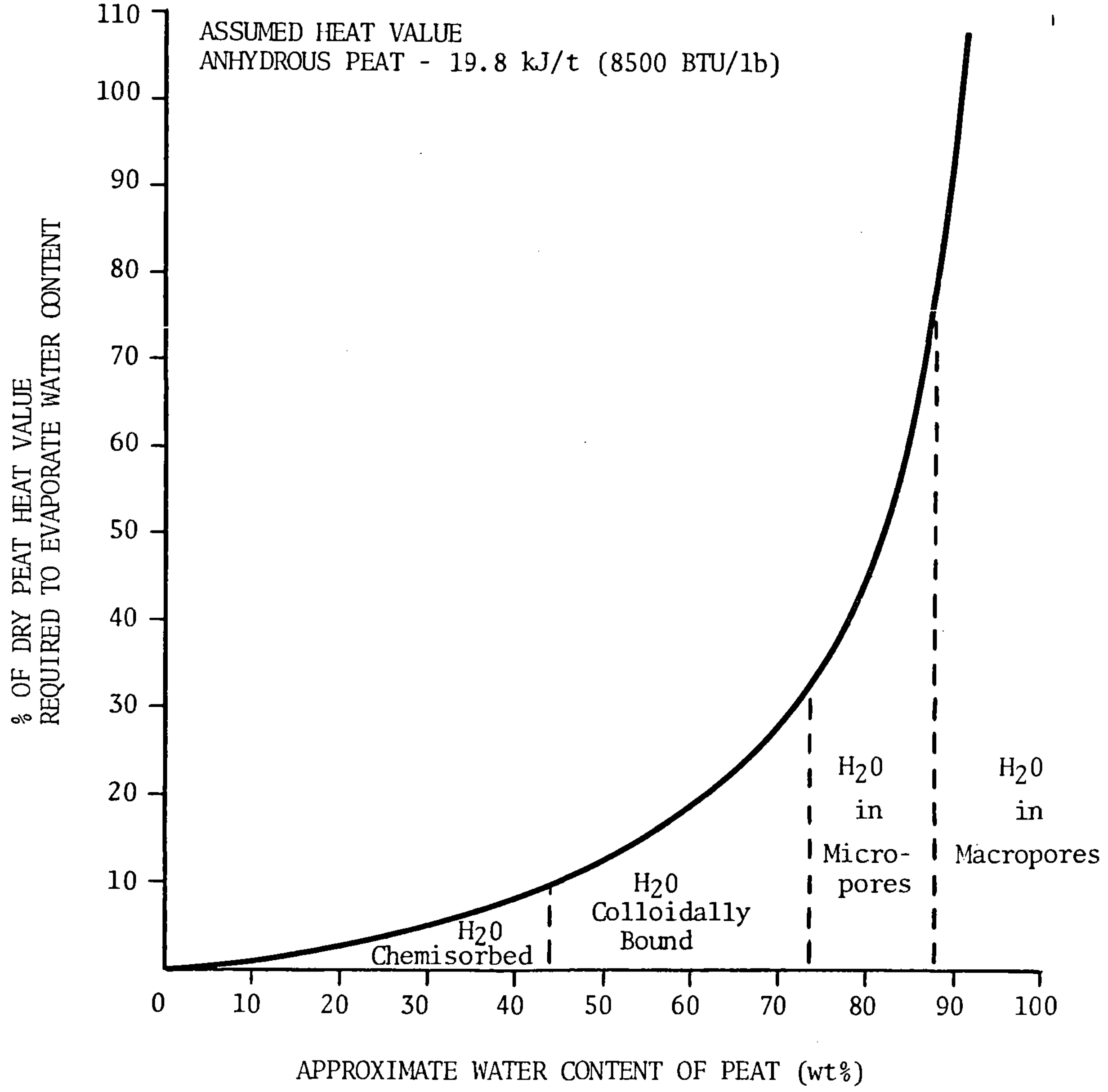
3.1 PROCESS DESCRIPTIONS

Peat as recovered from a bog may contain more than 90 wt% water content. As such, peat is unsuitable as a fuel since, as shown in Figure 3-1, more than its energy content would be required just to remove the water. In general, peat should contain less than 50 wt% water to be used as a source of thermal energy. In some cases, such as for the manufacture of peat briquettes, it may be necessary to dewater peat to less than 15 wt% water content.

Under favourable climatic conditions peat can be air dried in the field to a water content of 35 to 50 wt%. However, this effective but relatively slow process limits the rate at which dewatered peat can be produced. In Canada, it is estimated that the annual rate of production would be in the order of 100 to 200 t/ha of dewatered peat (Monenco, 1981). This rate may not be adequate to support particular energy requirements. Hence, research is continuing in Canada and elsewhere to develop effective and energy efficient dewatering methods.

The dewatering of peat is an energy intensive process, primarily due to the containment of water within a finely porous structure, as indicated in Figure 3-1. This results in very large filtration type resistances to the removal of water by the application of mechanical energy (in the form of pressure filtration devices). The water can be removed by evaporation processes; however, the energy requirements associated with the liquid to vapour phase change make this method prohibitive for dewatering, except for the removal of residual water content.

Various processes have been or are currently in development for the removal of water from peat (Monenco, 1983). Mechanical dewatering



Source: Adapted from Chornet et al, 1981

FIGURE 3-1
WATER IN PEAT

methods, based on the application of pressure to breakdown the fibrous structure of peat and squeeze out water, are currently in operation. These methods can reduce the water content of peat to approximately 65 to 70 wt% (Tsaros, 1981). Thermal dewatering (drying) methods can reduce the water content of peat to less than 15 wt% (Tsaros, 1981).

Dewatering processes which involve modifications to the chemical composition of peat are also in various stages of development. Peat can be mechanically dewatered to 35 to 50 wt% water content after exposure to elevated temperatures and pressures. The exposure of peat to these conditions results in alterations to its chemical structure, including dissolution of as much as 10% of the peat solids into the associated water. Both the Ontario Research Foundation and the Institute of Gas Technology (ORF, 1984) as well as others (Kyllonen and Peltola, 1985; Bettinger et al., 1983) have been actively engaged in the further development of these processes. Pretreatment by wet oxidation occurs by supplying sufficient oxygen to enable combustion of only a fraction of the wet peat contained in a reactor. The combustion under wet conditions, which occurs at temperatures ranging from 200 to 350°C, supplies the thermal energy for the pretreatment reactions. Wet carbonization involves exposure of the wet peat to elevated temperatures and pressures while contained in an inert atmosphere (100 to 250°C and 3500 kPa).

Block flow diagrams for the various dewatering processes are given in Figure 3-2.

3.2 ENVIRONMENTAL CONCERNS

Pressates

The primary source of wastes from peat dewatering processes is the water removed from peat. Voluminous quantities are removed due to the high initial water content of peat (i.e. 90 wt% or more). Other less voluminous wastes include vent and flue gases if thermal pretreatment and/or thermal drying processes are used (Figure 3-1), as well as wastes from the combustion of peat or other fuels to generate heat for these

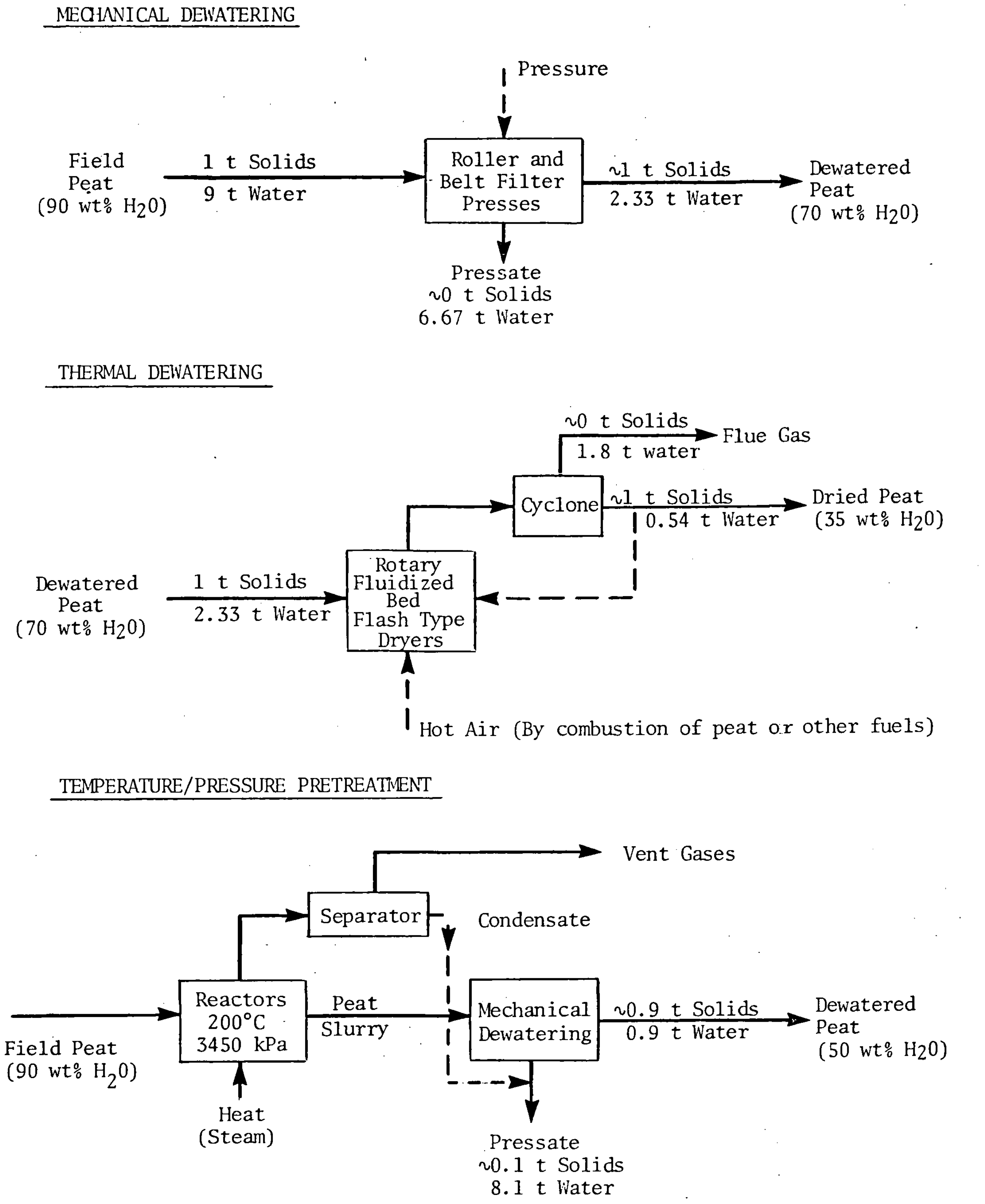


FIGURE 3-2

PEAT DEWATERING PROCESSES

processes. Wastes associated with the combustion of peat are considered in Section 4.

The quantities of water that must be removed from peat to enable its use as a source of thermal energy are indicated in Figure 3-3. Thus, for example, to produce 50000 kg/h of process steam approximately 1600 m^3/d of water would require removal from 2000 t/d of wet peat (90 wt% water content) in order to generate fuel peat at 50 wt% water content. Similarly, operation of a 100 MWe electric power generating station would result in the production of approximately 13000 m^3/d of wastewater in order to produce fuel peat at 50 wt% water content.

The quality of water removed from peat is dependent on the particular dewatering processes as well as the characteristics of the peat bog. Tables 3-1 and 3-2 provide a summary of wastewater characteristics for various dewatering processes.

Water removed from peat is characterized primarily by the presence of:

- colour
- colloidal solids (turbidity)
- free and total acidity (weak acids)
- oxygen demanding substances, and
- nutrients (nitrogen and phosphorus).

In addition, the water may contain various trace metals as well as other inorganic species.

The oxygen-demanding substances, measured as chemical and biological oxygen demands, are due to organic compounds of peat origin. These compounds consist of sugars and their derivatives as well as more complex, less easily fermented, and refractory components (ORF, 1984; Washburn and Gillis, 1982). These latter components may consist principally of relatively stable polymeric (aromatic) organic substances, such as humic and fulvic acids, containing hydrophilic functional groups which favour the presence of these substances in water removed from peat.

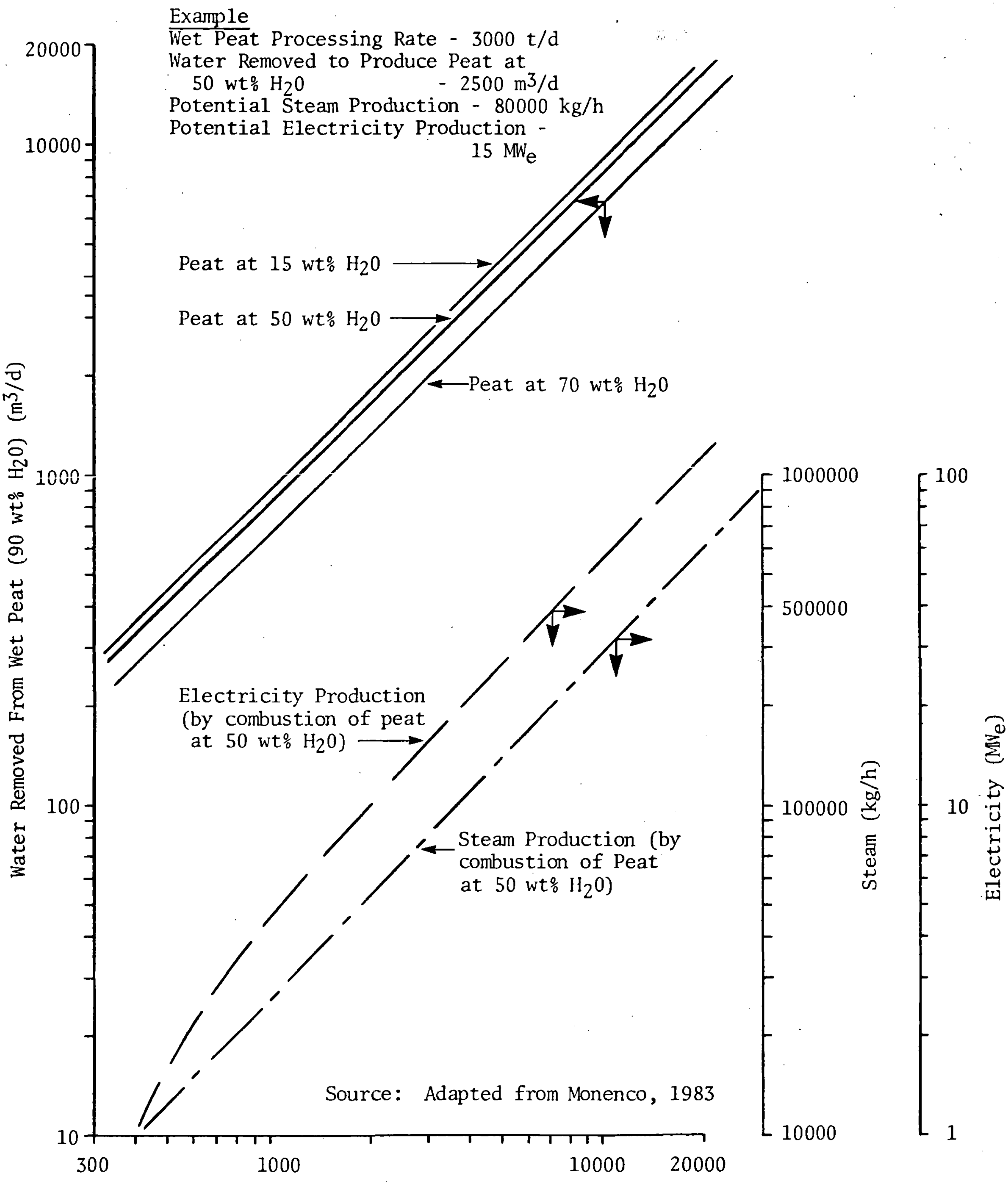


FIGURE 3-3

WATER REMOVAL AND ENERGY PRODUCTION FROM PEAT

TABLE 3-1

Pressate Water Quality

	Peat Bog[a] Water	Mechanical[a] Dewatering - No Pretreatment	Low Severity[b] Heat Treatment	ORF Wet Oxidation[b]		Wet Carbonization (Finland)[c]	IGT Wet[d] Carbonization	Wet[e] Carbonization (Michigan,USA)	Partial Wet[e] Oxidation
				Reactor Condensate	Pressate	Pressate	Pressate	Pressate	Pressate
Colour (Hazen Units)	-	-	280	40-105	4500-10000	-	-	-	-
Suspended Solids (mg/L)	-	-	19	24-980	65-550	-	734-1046	-	-
Total Solids (mg/L)	-	-	387	48-1320 (248)	7760-9920	-	8853-9300	3728	3463
Total Volatile Solids (% of total solids)	-	-	100	50-91	82-88	-	94	87	86
pH	-	-	4.7	2.7-3.1	3.1-3.7	3.3	3.4-3.7	6.2	5.2
Total Acidity (to pH 8.3; mg/L as $CaCO_3$)	-	-	30	850-2100 (1625)	3370-5960	-	-	-	-
Major Cations									
Calcium (mg/L)	-	-	18	388-621	-	-	130	-	-
Magnesium (mg/L)	-	-	1.6	19-35	-	-	38		
Sodium (mg/L)	-	-	<1	15-26	-	-	5.3		
Potassium (mg/L)	0.19-0.59	0.75	1.5	7.1-20	0	-	14		
Oxygen Demand									
COD (mg/L)	43-326	1390	760	4800-12900 (7090)	11900-13600	13000	13617-14250	4753	4376
BOD_5 (mg/L)	-	-	153	2800-4940 (3650)	4610-6180	7600 (BOD_7)	5310-5355	1965	2020
Nitrogen									
TKN (mg/L as N)	0.87-7.5	38	18	8.4-65 (31)	400-547	250	166-190	-	-
NH_3 (mg/L as N)	-	-	6	7-55 (14)	180-307	80	42-57	-	-
Total Phosphorous (mg/L)	<0.05-7.5	1.0	-	<0.05	9.9-25 (20)	20	13.8-15.4	-	-
Fulvic and Humic Acids (mg/L as C)	-	-	<5	<100	18-414 (104)	-	-	-	-
Sulphate (mg/L)	-	-	8.6	5-10	150-470	-	47-64	-	-
Phenolics (mg/L as phenol)	<0.005	<0.005	0.64	3.9-350 (19)	1.4-22.9 (6.5)	-	-	-	-

() - median value

[a] Source: Washburn and Gillis, 1983
[b] Source: ORF, 1984
[c] Source: Kyllonen and Peltola, 1985
[d] Source: ADI, 1985
[e] Source: Bettinger et al, 1983

TABLE 3-2

Trace Metals in Pressates

	Peat Bog[a] Water	Mechanical[a] Dewatering - No Pretreatment Pressate	Low Severity[b] Heat Treatment Pressate	ORF Wet Oxidation[b] (Wetox^R) Pressate	IGT Wet[b] Carbonization Pressate
Aluminum (mg/L)	0.09-0.51	4.72	<0.5	57-150	10
Antimony (mg/L)	-	-	0.001	0.003-0.017	0.001
Arsenic (mg/L)	-	-	0.005	0.05-0.06	0.053
Barium (mg/L)	<0.005-0.11	21	-	-	-
Cadmium (mg/L)	-	-	-	0.02-0.06	-
Chronium (mg/L)	-	0.005	-	0.5-1	0.17
Cobalt (mg/L)	-	-	-	0.05-0.07	-
Copper (mg/L)	-	-	-	0.05-0.39	0.68
Iron (mg/L)	0.14-0.96	2.03	1.6	87-187	20
Lead (mg/L)	-	-	-	0.15-0.39	0.15
Manganese (mg/L)	0.002-0.98	0.045	0.08	1.4-2.8	1.7
Mercury (μg/L)	-	-	-	0.2-0.9	0.54
Molybdenum (mg/L)	-	-	-	0.3-0.49	0.33
Nickel (mg/L)	-	-	0.04	0.05-0.28	0.06
Titanium (mg/L)	0.005-0.026	0.043	-	-	-
Vanadium (mg/L)	-	0.005	-	0.14-33	0.06
Zinc (mg/L)	0.014-0.091	0.024	0.06	0.21-0.62	0.46

---

[a] Source: Washburn and Gillis, 1983

[b] Source: ORF, 1984

The pretreatment of peat at elevated temperatures and pressures results in pressates (and condensates) with the highest content of dissolved materials. This is evident from the data given in Table 3-1 and is consistent with the breakdown of complex compounds into simpler and more readily water soluble substances.

Direct release of the relatively voluminous effluents from peat dewatering operations could result in environmental effects such as:

- increased turbidity and colour
- increased acidity
- oxygen depletion due to biological oxygen demand
- eutrophication as a result of excessive nutrients (nitrogen and phosphorus)
- increased concentrations of refractory organic substances
- increased concentrations of trace metals
- toxicity to aquatic organisms (ORF, 1984).

Vent Gases

The vent gases from the pretreatment and the flue gases from the thermal drying of peat (Figure 3-2) must also be of some environmental concern. Studies carried out by Ketola et al, (1983) and Lappi et al (1983) have shown that components volatilized from peat include: fatty, hydroxy, dicarboxylic and phenolic acids, alkanes, isoprenoids, polycyclic hydrocarbons, alchohols, and sterols.

3.3 ENVIRONMENTAL MANAGEMENT METHODS

Bench and pilot scale investigations (ADI, 1984,1985; Kyllonen and Peltola, 1985; Frankel and Drabkin, 1985; Bettinger et al., 1983; ORF, 1985). as indicated in Table 3-3, have demonstrated the technical feasibility of reducing the oxygen demands of pressates by the use of anaerobic and aerobic biochemical technologies. Block flow diagrams, process design criteria and operating conditions are provided in Figures

TABLE 3-3

Anaerobic Treatment Studies

Type of Pretreatment	Source of Peat	Reference	Test Scale/Digester Type	Influent COD	Influent BOD_5	Effluent COD Reduction	Effluent BOD Reduction
				mg/L	mg/L	%	%
Partial Wet Oxidation	Quebec, Canada	ADI,1984	Bench/standard and high rate	4300 - 12000	1400 - 4700	60-70	80-90
Wet Carbonization	Maine, U.S.A.	ADI,1985	Bench/standard rate	2750 - 19000	3770 - 7815	65	85
Wet Carbonization	Michigan, U.S.A.	Bettinger, et al.,1983	Bench/standard rate	4753	1965	37	88
Wet Carbonization	Finland	Kyllonen & Peltola, 1985	Pilot/standard and high rate	13000	7600 (BOD_7)	44-55	75-95
Partial Wet Oxidation	Nova Scotia & Ontario, Canada	ORF,1985	Pilot/Fluidized Bed with Activated Carbon Media	11300 - 14300	6500-6600	41-62	45-91

3-4 and 3-5 for the well-documented treatability investigations carried out by ADI using samples of wet carbonization process pressates supplied by the Ontario Research Foundation (ADI, 1984) and the Institute of Gas Technology (ADI, 1985).

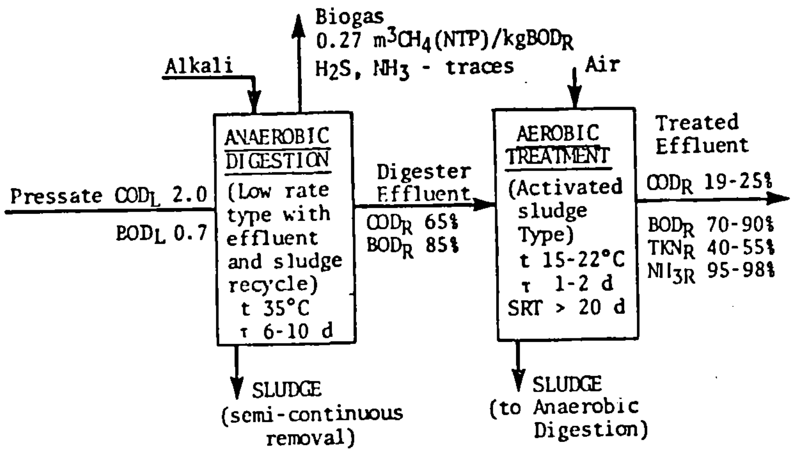
Anaerobic treatment of pressates enables a high degree of BOD removal while generating biogas (principally methane) which can be used as a source of thermal energy. The investigations by ADI and others (Kylloen and Peltola, 1985; Bettinger et al., 1983; Lyngfelt, 1982) have shown that anaerobic processes can be initiated and continued without major difficulties. The pressates have not demonstrated any toxicity towards the microorganisms responsible for anaerobic decomposition, while addition of nutrients for microorganism metabolism was not required due to the presence of nitrogen and phosphorous components in the pressates. However, the investigations have shown that close control of volatile acid levels is required to ensure that the optimum pH range for anaerobic decomposition is maintained. In some cases this may require the addition of alkaline reagents (ADI, 1985). In other cases, the hydrolysis of ammonia, present in the pressate, appeared to generate adequate alkaline conditions (ADI, 1984).

Sludge production during the anaerobic processes appeared to be minimal, corresponding primarily to refractory suspended solids present in the pressate.

While the anaerobic processes reduced the oxygen demand of the pressates, little change was observed in the concentrations of nitrogen, measured as TKN and ammonia. This is the expected result since the nitrogen, present as ammonia and organic compounds, is at or close to its minimum oxidation level.

The Ontario Research Foundation (1985) investigated the removal of ammonia and colour during the operation of a pilot scale fluidized bed anaerobic reactor, with activated carbon as the support media. The addition of a nitrogen purge to the reactor was ineffective in stripping ammonia from the wastewater at the operating temperature of 55°C and pH

BLOCK FLOW DIAGRAM



NOTES:
L - Loading kg/m³/d
R - Removal %
τ - Hydraulic Residence Time
SRT - Solids Retention Time

TEST CONDITIONS

Scale of Test

Volume of Digester	6.4 L
Volume of Activated Sludge System	1 L

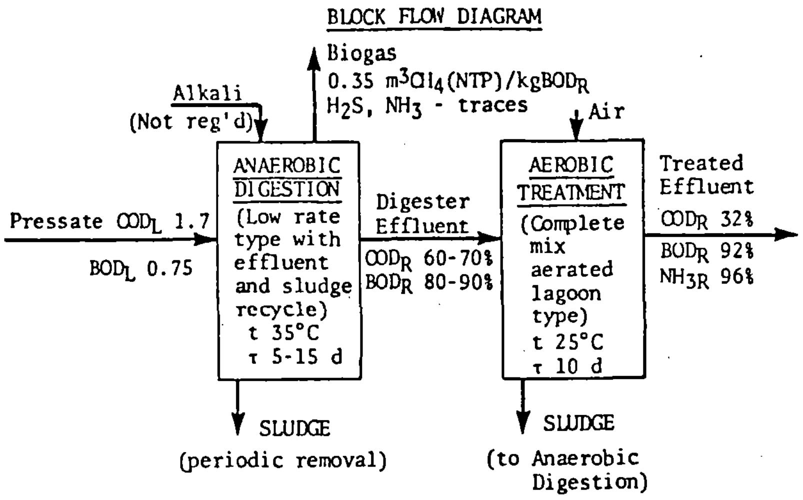
Duration of Test: 136 d for Anaerobic Digester; 81 d for Activated Sludge System

	Influent to Digester	Digester Effluent	Influent to Aerobic System	Treated Effluent
COD (mg/L)	2750-19000	1050-5700	3800-5100	2950-4400
BOD_5 (mg/L)	3770-7815	222-1180	197-908	50-441
TKN (mg/L as N)	170-202	138-183	88.9-198	51.5-118.0
NH_3 "	31.9-55.2	59.8-80.8	26.8-66.9	<0.5-44.4
NO_3 "	-	-	1.5-5.8	1.9-88.2
NO_2 "	-	-	<0.1	<0.1-13.3

Source: ADI, 1985

FIGURE 3-4
TREATABILITY OF IGT WET CARBONIZATION PRESSATE

BLOCK FLOW DIAGRAM



NOTES: L - Loading kg/m^3/d
R - Removal %
τ - Hydraulic Residence Time
SRT - Solids Retention Time

TEST CONDITIONS

Scale of Test

Volume of Digester	6.7 L
Volume of Aerated Lagoon	1.7 L

Duration of Test: 217 d for Anaerobic Digester; 137 d for Aerated Lagoon

	Influent to Digester	Digester Effluent	Influent to Aerobic System	Treated Effluent
COD (mg/L)	4300-12000	2600-5000	3800-4400	450-4400
BOD_5 (mg/L)	1400-4700	400-900	360-705	36-65
TKN (mg/L as N)	361-558	277-399	-	-
NH_3 "	168-268	169-254	207-254	6.8-14.4

FIGURE 3-5
TREATABILITY OF ORF WETOX^R PRESSATE

Source: ADI, 1984

of 8. Subsequent laboratory investigations indicated that a higher pH (∿10) would be required to improve the removal of ammonia by stripping. Colour was reduced from a range of 1100-1900 (Hazen units) to approximately 100-500 units during anaerobic treatment. The reduction was attributed, at least in part, to adsorption by the activated carbon support media.

ADI also investigated the effects of aerobic treatment processes to further reduce oxygen demand in the effluents from the anaerobic process and to ensure oxidation of odorous gases such as H_2S. Both activated sludge and aerated lagoon processes proved to be easily started-up and operated, and were very effective for the further reduction of oxygen demand (Figure 3-4). In addition, ammonia was oxidized to nitrate (>95% conversion). The limited reduction of chemical oxygen demand that was recorded for aerobic treatment is expected, since the effluent from the anaerobic system would contain a high degree of refractory organics.

3.4 RESIDUAL ENVIRONMENTAL CONCERNS

The investigations by ADI and others have shown that peat dewatering pressates are amenable to biological treatment processes. These processes will reduce oxygen demand while generating an energy source (biogas). However, the effluents from these treatment processes may still contain unacceptable levels of:

- colour
- turbidity
- chemical oxygen demand, and
- nutrients (particular ammonia or nitrates).

As well, particular trace metals may be of concern. Thus, further physical-chemical treatment processes may be required to produce an acceptable effluent.

The removal of nitrates from the effluents would be difficult due to the relatively slow rate of biological denitrification processes various levels of treatment, into peat bogs and other waterbodies.

The compositions of vent gases from peat pretreatment processes and flue gases from thermal drying processes should be defined during future investigations in order to determine the pollution potential of these discharges.

(i.e. $NO_3 \longrightarrow N_2$). Hence, it may prove to be preferable to remove ammonia from the anaerobic process effluent by air stripping, prior to aerobic treatment.

The degree to which treatment is required for any pressate will depend upon the peat dewatering process and the consequent composition of the pressate, the regulatory requirements, and the environment into which the effluent is to be disposed of. Return of the effluent to the peat bog appears to be the preferred situation, particularly when the compositions of the pressate and bog waters are "similar".

3.5 INFORMATION DEFICIENCIES AND RESEARCH NEEDS

Mechanical processes for peat dewatering to supply thermal energy requirements will generate large quantities of pressates (Figure 3-3). In some cases it may be feasible to return pressates to the peat bog with minimal if any treatment. In other cases this may not be possible due to adverse environmental effects or logistics of the particular peat development. Treatability studies have clearly shown the amenability of pressates to biological treatment processes. However, the results of these studies also indicate that the treated effluents, particularly for pressates derived from wet carbonization and partial oxidation peat pretreatment processes, may not be suitable for discharge into the environment. Thus, any future treatability investigations should also consider the application of processes for the removal of "residual" contaminants such as refractory oxygen-demanding substances, colour, colloidal materials, and ammonia. In addition, the effect of the biological and additional treatment methods on trace metals content of the treated effluents should also be considered. Future treatAbility investigations might also be accompanied by bioassay tests to determine the toxicity of both pressates and treated effluents to aquatic organisms.

Future investigations into the treatment and disposal of pressates should also consider the effects on water chemistry of the disposal, at

PART FOUR

PEAT COMBUSTION

4. PEAT COMBUSTION

This section of the report provides a review of the environmental aspects related to the combustion of peat to generate thermal energy.

4.1 PROCESS DESCRIPTIONS

4.1.1 Peat as a Fuel

As indicated by the data given in Table 4-1, particularly oxygen contents, peat can be ranked between undecomposed biomass and "young" coals as a source of energy upon combustion. Nominal properties of various forms of peat fuels are given in Table 4-2.

4.1.2 Combustion Technologies

Peat is most commonly used in grate and pulverized fuel types of furnaces (Monenco, 1983). Grate types of furnaces, with fuel input capacities ranging from approximately 1.5 to 30 MW, are used for the combustion of bulky fuels such as peat sods. Natural gas or oil is often used as an auxilliary fuel to initiate and maintain stable combustion conditions. Air for combustion may enter the furnace near the grate (primary air) as well as closer to the upper section (secondary air) to ensure combustion of volatiles. Some drying of the peat prior to combustion can be achieved by allowing the fuel to enter near the top of the furnace and "fall" towards the grate through the hot gases.

Pulverized peat-fired furnaces are similar to those for the combustion of lignite coals (Table 4-1)(Monenco, 1983). The fuel capacities of these furnaces range from approximately 30 to 300 MW. Peat is pulverized and then injected into the furnace to be burned while in suspension. Oil is normally used as an auxilliary fuel to initiate and maintain stable combustion conditions. As is the case for grate furnaces, secondary air provided to the upper section of pulverized fuel furnace ensures combustion

TABLE 4-1

Biomass and Fossil Fuels - Nominal Fuel Characteristics

Fuel	Fixed Carbon (dry basis)	Oxygen (dry basis)	Volatiles (dry basis)	Ash (dry basis)	Nitrogen (dry basis)	Sulphur (dry basis)	Heat Value (dry basis)
	wt%	wt%	wt%	wt%	wt%	wt%	MJ/kg
Wood	24	45	70-74	2-4	0.2	0.1	20
Peat	25-30	35	60-72	3-15	0.8-2.5	0.1-0.2	20
Lignite coal	45	25	40	15	1.0	1.1	21
Subbituminous coal	45-53	15	25-35	12-18	1.3	0.5	24
Bituminous coal	57	5	32	11	1.0	3-6	31
Anthracite coal	84	3	6	10	0.8	0.5-4.5	32
Fuel oil	83-86	-	-	0.3	0.3	0.5-6.3	43

Source: Monenco, 1983

TABLE 4-2

Peat Fuels

Fuel	Moisture Content	Bulk Volume (wet basis)	Heat Value (wet basis)
	wt%	kg/m^3	MJ/kg
Sod Peat	35-45	300-400	10-13
Milled Peat	40-65	250-400	8-12
Briquettes	10-15	700-800	17-19
Pellets	10-30	650-750	14-19

Source: Monenco, 1983

of peat volatiles. Partial drying of the fuel can be obtained by contact of the wet peat with recirculated gases during the pulverization process.

Other types of systems have been and continue to be developed in order to efficiently burn wet and bulky peat. The fuel capacities of these systems range from pilot plant size to approximately 30 MW (Monenco, 1983). Flue gas can be used to dewater peat in a flash dryer prior to its entry into the furnace (Figure 3-2). This process, which can reduce the water content to less than 30 wt%, enables the physical size of the furnace to be similar to that for the combustion of lignite coals. Cyclone types of furnaces have been developed to enable the combustion of peat at relatively high temperatures with low excess air requirements. This results in increased furnace efficiency. Fluidized bed combustion systems are continuing to receive attention due to their ability to handle sod to milled peat with minimal auxilliary fuel requirements and high thermal efficiencies.

4.2 ENVIRONMENTAL CONCERNS

The combustion of peat generates the types of wastes that are common to the use of other biomass and fossil fuels as sources of thermal energy. Thus, the properties of peat and the combustion conditions determine the characteristics of both the flue gas and the bottom ash (non-combustible portion of the peat).

Environmental concerns associated with flue gas emissions into the atmosphere include: sulphur and nitrogen oxides, particulates, trace metals, and organic compounds. Ashes are normally disposed of as landfill or by lagooning. In either case, the stability of ash towards leaching of trace metals is the major environmental concern.

4.2.1 Flue Gas Emissions

Table 4-3 provides a summary of flue gas emissions which have been reported for a number of peat-fuelled systems in Finland.

Sulphur Dioxide

Peat is characterized by relatively low sulphur contents compared to other fossil fuels (Table 4-1). This factor limits the potential emission of sulphur dioxide to a maximum which is within or close to the federal guideline of 258 mg/MJ of heat input (EPS, 1981). The data given in Table 4-3 for sulphur dioxide emissions are consistent with the above comments.

Nitrogen Oxides

The presence of nitrogen oxides in flue gases is due to oxidation of nitrogen (N_2) present in the combustion air as well as oxidation and degradation of nitrogen-containing substances in the fuel. The combustion of peat in most furnaces occurs at temperatures of less than 900°C. At such temperatures the rate of oxidation of nitrogen (N_2) is extremely low resulting in negligible generation of nitrogen oxides, from this source of nitrogen, during normal furnace residence times (Monenco, 1983).

Peat contains as much as 2.5 wt% fuel nitrogen, somewhat more than other biomass and fossil fuels (Table 4-1). Gibbs and Hampartsoumian (1980) have demonstrated that fuel nitrogen is a major source of nitrogen oxide emissions during the combustion of peat. However, the quantity of fuel nitrogen in peat does not appear to be a major factor in the generation of nitrogen oxides. Rather, the degree of contact between oxygen (in combustion air) and those substances containing nitrogen appears to be the most important factor in the generation of nitrogen oxides from fuel nitrogen. Thus, excess air, high temperatures and increased furnace residence times promote the conversion of fuel nitrogen to nitrogen oxides. Conversion of fuel nitrogen to nitrogen oxides was in the order of 2 to 15% for combustion of peat in a fluidized bed at excess oxygen concentrations of approximately

1 to 12% respectively. The peat, containing 2 wt% fuel nitrogen, was combusted at a temperature of 820°C (Gibbs and Hampartsoumian, 1979).

Monitoring data for nitrogen oxides in Table 4-2 indicate that careful consideration of the design and operation of peat combustion systems would be required if the federal emission guidelines for nitrogen oxides are to be achieved (168 mg/MJ of heat input as NO (EPS, 1981)).

Polycyclic Aromatic Hydrocarbons (PAH)

The combustion of peat is a potential source of emissions of polycyclic aromatics and other hydrocarbons into the atmosphere (Monenco, 1983). These hydrocarbons are of concern due to their carcinogenic nature. Several studies (Pohjola and Hasanen, 1985; Vesterinen and Huotari, 1985; Oravainen, 1985; Nichols et al, 1981; Alsberg and Stenberg, 1979) have identified these hydrocarbons in the flue and offgases from the use of peat as a thermal fuel (Table 4-3). The presence of these substances in at least trace amounts can be attributed to the relatively low temperatures during the combustion of peat (i.e. less than 900°C).

Vesterinen and Huotari (1985), and Pohjola and Hasanen (1985) have shown that incomplete combustion conditions, particularly low combustion temperatures, lead to increased emissions of polycyclic aromatics and other hydrocarbons. Low combustion temperatures can occur due to increases in the fuel moisture content, increases in the loading of fuel to the furnace, and lack of sufficient oxygen (excess air). Careful control of combustion conditions to ensure temperatures above 900°C and adequate excess air can be expected to minimize the emissions of these substances.

Particulates

Particulates (fly ash) can be very effectively removed from peat combustion flue gases using standard devices such as electrostatic precipitators, baghouses, and cyclones (Monenco, 1983). Careful selection of the device(s) is required to achieve the desired degree of particulate removal. The properties and disposal of the recovered particulates are considered in sections 4.2.2 and 4.3 respectively.

TABLE 4-3

Monitoring of Peat Furnace Operations in Finland

Type of Furnace	Reference	Rate of Energy Input	Fuel	Type of Particulate Separator	Dust Emission	NO_x	SO_2	Hydro-Carbons	Polynuclear Aromatic Hydrocarbons (PAH)	Comments
		MW			mg/MJ	mg/MJ as NO	mg/MJ	mg/MJ	µg/MJ	
Grate Type	Vesterinen and Huotari, 1985 1985	0.25-10.4	Sod Peat	Cyclones	27-155	87-223	255-280	0.87-36.2	0.26-6.78	N in peat - 2.75 wt% S in peat - 0.26 wt%
Grate Type	Vesterinen and Huotari, 1985	3.6-6.7	Milled Peat	Cyclones	205-535	79-116	174	-	0.8-1.5	S in peat 0.16 wt%
Gasification Type	Vesterinen and Huotari, 1985	5	Sod Peat	-	9.6-168	207-349	-	1.3-2.5	43-118	
Fluidized Bed Type	Vesterinen and Huotari, 1985	0.7-2.7	Milled Peat	Baghouse	65-207	97-274	-	2.17-11.7	3.75-132	
Suspension Type	Pohjola and Hasanen, 1985	~120	Milled Peat	Electrostatic Precipitator	5-20	120	<220	-	-	19% of fuel was oil; particulate removal ≥98%
Grate Type	Pohjola and Hasanen, 1985	~35	Sod Peat	Electrostatic Precipitator	5-90	100	<80	-	7	S in peat - 0.16 wt%
Cyclone Type	Pohjola and Hasanen, 1985	~15	Milled Peat	Cyclones	240-320	320	<220	-	-	Operation of cyclones was poor Combustion temperatures were >1500°C, hence "high" NO_x formation 8% of fuel was oil
Fluidized Bed	Pohjola and Hasanen, 1985	~65	Milled Peat	Electrostatic Precipitator	5-30	110	<190	-	32	6% of fuel was oil Particulate removal ≥98% Combustion temperatures were low (~800°C) hence low NO_x and higher PAH

Trace Elements

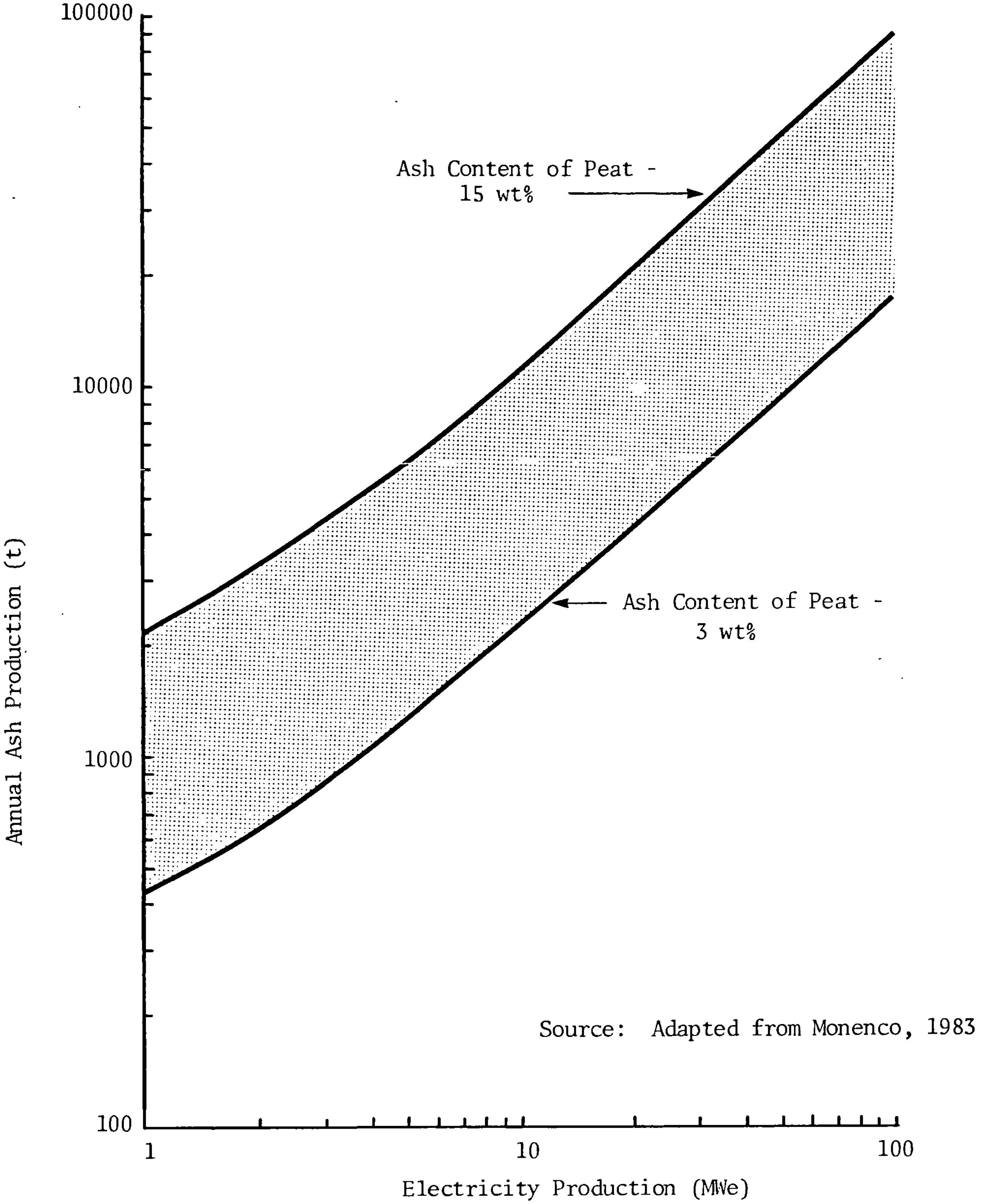
Peat, like coal, can contain at least traces of most of the elements listed in the periodic table (Monenco, 1983). In this regard, peat has a very significant capacity for the adsorption and chelation of metallic elements. During combustion, most of these elements are retained with the bottom and fly ashes. However, the most volatile elements, such as mercury, selenium, and the halogens, may be emitted as a vapour (Monenco, 1983).

4.2.2 Ash

Peat may contain approximately 3 to 15 wt% (dry basis) ash (Table 3-1) which is recovered as fly and bottom ashes after combustion. This ash content combined with peat's relatively low heat content, compared to higher quality thermal coals and oil, results in considerable quantities of ash to be disposed of, as indicated in Figure 4-1.

The major constituents of peat ashes are the oxides of silicon, aluminum, calcium and iron with lesser amounts of the oxides of magnesium, sodium and potassium (Monenco, 1983; Hartlen and Nilson, 1985). In addition, peat ashes, like coal ashes, are a source of at least traces of many other metallic and non-metallic elements. Trace elements which have been detected in peat ashes include: antimony, arsenic, barium, beryllium, cadmium, cobalt, chromium, copper, lead, nickel, manganese, molybdenum, selenium, strontium, vanadium, zinc, thorium and uranium (Pohjola and Hasanen, 1985, 1982; Hartlen and Nilson, 1985; Carlson, 1985). Contact of these ashes with water produces slightly acidic to highly alkaline solutions depending upon the contents of readily soluble alkaline oxides and condensed sulphurous and sulphuric acids (due to sulphur oxide emissions in the flue gases).

Ashes are most commonly disposed of as landfill and hence the potential for the leaching of salts and trace elements into ground and surface waters is of concern.



Source: Adapted from Monenco, 1983

FIGURE 4-1

PEAT COMBUSTION - ASH PRODUCTION

4.3 ENVIRONMENTAL MANAGEMENT METHODS

Proper design and operation of peat combustion furnaces is the primary environmental management method. The systems can be designed and operated to ensure that particulate emissions do not exceed emission guidelines and objectives (Monenco, 1983). Assurance of sufficiently high combustion temperatures as well as adequate levels of excess oxygen will minimize the emissions of uncombusted hydrocarbons. It appears that the combustion conditions for minimal formation of nitrogen oxides (i.e. low temperatures, low excess air, low furnace residence time) is contradictory to those for ensuring the complete combustion of hydrocarbons including polycyclic aromatics (i.e. high temperatures, high excess air, long furnace residence times).

Peat ashes can be disposed of in properly designed landfills. The landfills should be designed and operated so a to minimize the contact of the ash with ground and surface waters.

4.4 RESIDUAL ENVIRONMENTAL CONCERNS

The potential for the emissions of hydrocarbons and nitrogen oxides is of some concern with respect to the combustion of peat. This concern may be most pronounced for small, less well-controlled furnaces, such as domestic space heaters (Monenco, 1983). Various researchers have identified the highest emissions of polycyclic aromatics from such installations (Pohjola and Hasanen, 1985; Oravainen, 1985; Vesterinen and Huotari, 1985; Alsberg and Stenberg, 1979).

4.5 INFORMATION DEFICIENCIES AND RESEARCH NEEDS

Further understanding is required concerning the combustion behaviour of peat with reference to the formation of nitrogen oxides and the emission of hydrocarbons. Such an understanding will establish whether or not the design of furnaces and specification of operating procedures can be such as to minimize the emissions of hydrocarbons while ensuring that nitrogen oxides remain at acceptable levels.

PART FIVE
PEAT GASIFICATION, LIQUEFACTION AND SOLID FUEL PRODUCTION

5. PEAT GASIFICATION, LIQUEFACTION AND SOLID FUEL PRODUCTION

This section of the report provides an overview of the environmental aspects related to the conversion of peat to combustible gases, liquid hydrocarbons and solid fuels (coke, briquettes, pellets).

5.1 PROCESS DESCRIPTIONS

A summary of peat conversion processes is provided in Figure 5-1. Peat can be converted to gaseous and liquid fuels using technology which is similar to that for coal conversion (Perry, 1984). Thus, direct gasification involves the reaction of peat with steam and air or oxygen at high pressures and temperatures to convert the carbon in peat to various combustible gases, primarily carbon monoxide , hydrogen and methane. These gases can be used as a fuel or be further processed to produce a methane-rich gas. Gasification processes, as indicated in Figure 5-1, also produce tars and oils which can be used as fuel for the gasification process.

Liquid fuels can be produced by the hydrogenation of peat, with a consequent removal of oxygen, nitrogen, sulphur and ash. This can be accomplished by various processes as shown in Figure 5-1. Pyrolysis involves the thermal degradation of peat into char, combustible gases, tars, oils, and other liquid hydrocarbons. Liquid fuels can also be produced by direct hydrogenation of peat at elevated temperatures and pressures, or by the dissolution of the peat in solvents which act as hydrogen donors (indirect hydrogenation). As shown in Figure 5-1, all processes produce combustible gases which can be used as fuel for the liquefaction process.

Solid fuels can be produced from peat by the pressing of dried peat (less than 15% water content) into briquettes and pellets or by partial pyrolysis (coking) of the peat, followed by pressing into briquettes.

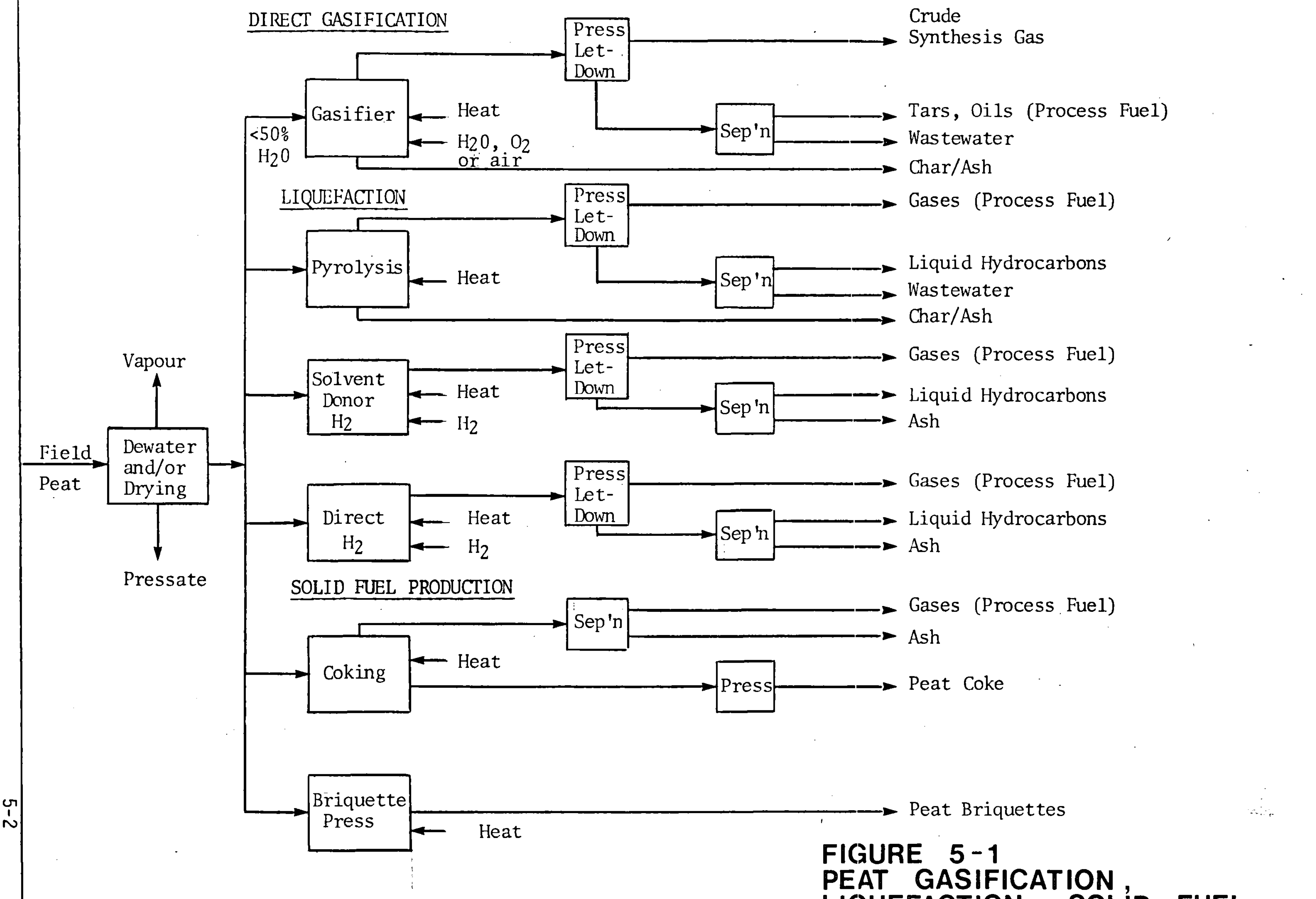


FIGURE 5-1
PEAT GASIFICATION, LIQUEFACTION, SOLID FUEL PRODUCTION PROCESSES

At this time, plants producing briquettes and pellet fuels are in operation in Europe. Gasification and liquefaction processes are at the development stage in Europe as well as North America.

5.2 ENVIRONMENTAL CONCERNS

As suggested by Figure 5-1, peat conversion processes will produce those wastes associated with the dewatering, drying and combustion of peat; these wastes have been considered in Sections 3 and 4 of this report. The conversion processes also produce ash and/or char containing inorganic consistuents as well as residual carbon. These solid wastes contain trace metals from the peat. Gasification and pyrolysis processes also generate wastewater containing hydrocarbons, nitrogen compounds (i.e. ammonia, thiocyanates, cyanides), sulfur compounds, as well as trace metals condensed from the reactor offgases (Monenco, 1983).

5.3 ENVIRONMENTAL MANAGEMENT METHODS

The management of wastes associated with the dewatering and drying of peat have been considered in Section 3. Section 4.2.2 and 4.3 consider the properties and disposal of peat ashes. Similar considerations apply to the disposal of chars, although chars can be combusted as a source of process fuel.

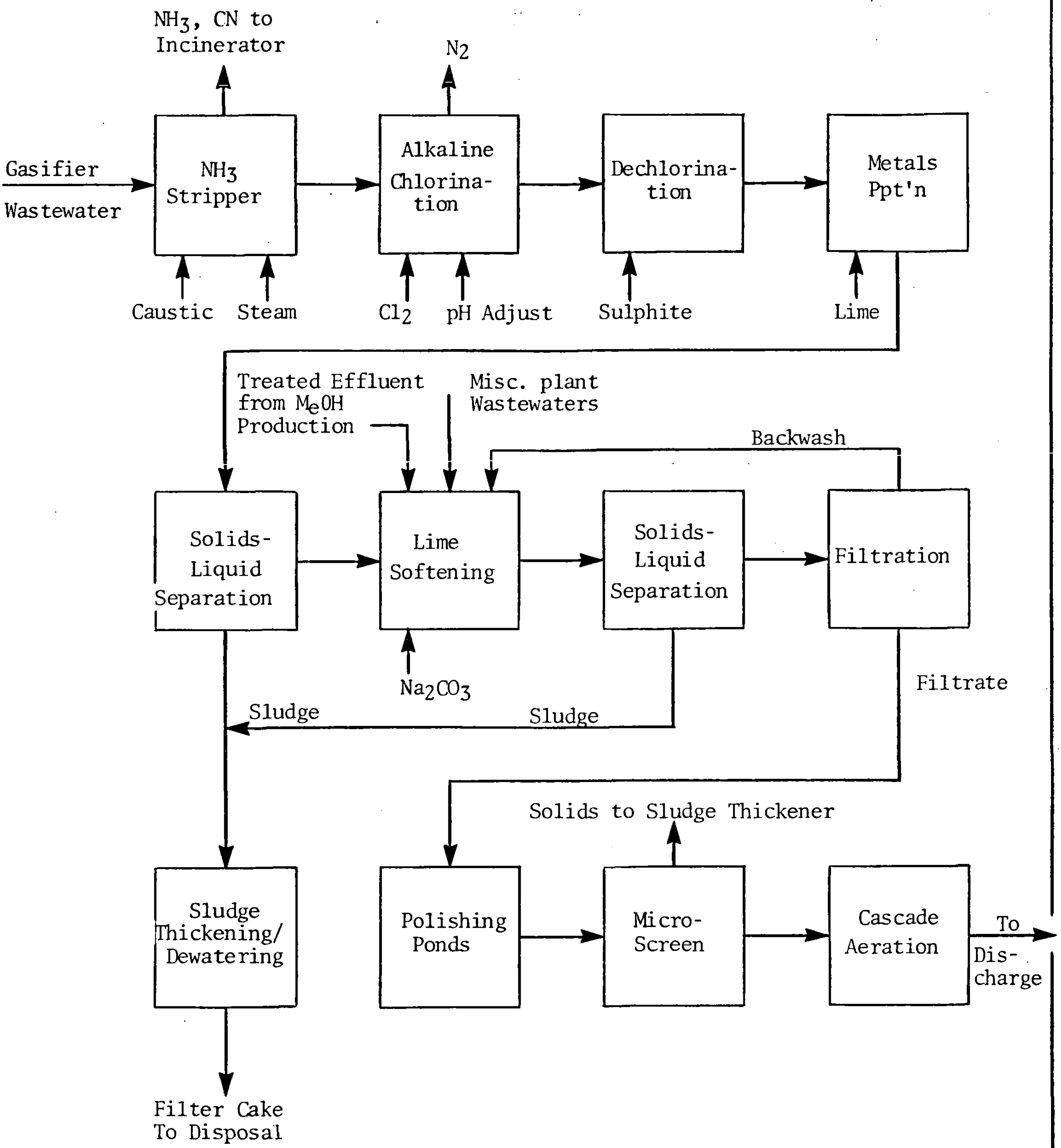
The management of any wastes produced by the further refining of crude synthesis gas and liquid hydrocarbon products of peat conversion are similar to those for the petroleum refining industry. The major waste resulting directly from peat gasification and pyrolysis processes is wastewater condensed from the reactor offgases (Figure 5-1). As previously noted these wastewaters are not suitable for discharge into the environment due to the presence of hydrocarbons, reduced nitrogen compounds (including cyanide), reduced sulphur compounds, and the more volatile trace metals condensed from the reactor offgases (Monenco, 1983).

The type of treatment that may be required to enable the discharge of reactor wastewaters is indicated by the proposed system for the Peat Methanol Associates project in the United States (Frankel and Drabkin, 1985). The project will involve the gasification of approximately 600,000 t/a of peat (30 wt% water content), with subsequent processing of the gas to produce methanol. The proposed treatment system for the gasifier wastewater is shown in Figure 5-2.

Gasifier wastewater, rich in ammonia and cyanide, will be steam stripped. Volatile organics will also be removed during the stripping process. The ammonia and cyanide rich offgas will be incinerated. Residual cyanide and ammonia will be converted to nitrogen by alkaline and breakpoint chlorination respectively. After the removal of excess chlorine, metals will be precipitated by the addition of lime slurry. Coagulation/flocculation and clarification will follow, producing a metals- and organics- (due to adsorption onto floc) rich sludge, and clarified overflow. The clarified overflow will be combined with miscellaneous plant wastewaters and treated effluent from the methanol synthesis area. The combined water will then be softened and filtered prior to discharge into a series of two polishing ponds (30 days residence time each), micro screen, and cascade type aeration system. Sludges will be thickened, dewatered by a filter press and disposed of in a landfill. All of these processes have been carried out at bench scale. The treated effluent, which will be discharged into surface waters, is expected to meet the requirements of the U.S. Environmental Protection Agency as specified by the project's National Pollutant Discharge Elimination System Permit.

5.4 RESIDUAL ENVIRONMENTAL CONCERNS

The point source types of wastes resulting from peat conversion processes can be managed to ensure the achievement of environmental protection criteria. Nevertheless, careful design and operation of these conversion processes will be required to ensure that unacceptable levels of fugitive emissions do not pose an environmental concern.



Source: Frankel and Drabkin, 1985

FIGURE 5-2
GASIFIER WASTEWATER TREATMENT

5.5 INFORMATION DEFICIENCIES AND RESEARCH NEEDS

The waste management implications can be defined at a level that is consistent with the current state of development of peat conversion processes. Any information deficiencies and research needs can be more appropriately specified as the conversion processes become more refined. However, as a general comment, efforts should be made during peat conversion research to record the properties of reactor offgases and condensates.

PART SIX
DISCUSSION

6. DISCUSSION

Summaries of potential environmental concerns and environmental management methods with respect to processes for the harvesting, dewatering, and conversion of peat into gaseous, liquid and solid fuels are given in Tables 6-1 to 6-4. The potential concerns related to peat harvesting are the most difficult to explicity define, particularly with respect to drainage aspects. The effects of peat harvesting on the water quality characteristics of both the bog and related watershed cannot be specified in other than general terms as indicated in Table 6-1. It is likely that very site specific investigations will continue to be required in order to assess the probable effects on the environment of specific peat harvesting proposals.

Sufficient information is available to define the potential sources of environmental concern with respect to processes for the dewatering, combustion, and conversion of peat into gaseous, liquid and solid fuels. This is particularly the case for the combustion of peat, for which industrial scale operations have been monitored. A similar status for peat dewatering and conversion processes can possibly best be achieved by orienting future research to specific proposals for the development of pilot and industrial scale operations. Sufficient information is available at present to define the potential concerns and to design the programs that should be carried out in order to establish the waste management processes that would be required with respect to the particular proposed peat development.

TABLE 6-1

Peat Mining

Process	Potential Environmental Concerns	Environmental Management
Bog Preparation and Peat Mining		
- Drainage	Release of bog water - potential for changes in: receiving stream hydrology; water quality (suspended solids, turbidity, colour, oxygen demand, organic content, acidity, heavy metals and nutrients); aquatic productivity and habitat	Planning and operation of bog drainage system so as to ensure assimilation capacity of watershed is not exceeded Settling ponds to minimize discharge of suspended solids
- Removal of vegetation	Loss of biotic productivity; loss of terrestrial habitat; lowering of local water table leading to tendency for upland rather than wetland vegetation	Reclamation to restore biotic productivity (silviculture, agriculture)
- Field drying of peat, storage and transport	Fugitive dust	Water spray, closed storage

TABLE 6-2

Peat Dewatering and Drying

Source of Waste	Potential Environmental Concerns	Environmental Management
Pressates from:		
1) Dewatering of Field Peat	- large quantities relative to bog water; pressates are similar or elevated in suspended solids, turbidity, colour, acidity, COD, BOD, nutrients and tracemetals	- Consider return of pressates to peat bogs under well controlled conditions
2) Pretreatment Processes (wet carb, wetox) including vent gas condensates	- large quantities due to dissolution of as much as 10 wt% of peat: pressates are elevated in turbidity, colour, acidity, COD, BOD, nutrients, refactory organics and may also contain tracemetals	- Consider return of pressates to peat bogs under well controlled conditions - amenability of pressates to anaerobic/aerobic treatment has been well established - in addition to aerobic, further treatment may be required for removal of turbidity, nutrients (NH_3), colour, refractory organics and tracemetals
Peat Drying Flue Gas and Pretreatment Vent Gas	- contain volatile organics distilled from peat	- organics can be condensed from pretreatment vent gases; at least traces (of organics) would, however, be released into the atmosphere - may be impractical to condense organics from large volume dryer flue gases or to incinerate these, hence potential for release of organics into the atmosphere

TABLE 6-3

Peat Combustion

Source of Waste	Potential Environmental Concerns	Environmental Management
Flue Gas	SO_2 - emissions should meet federal guidelines due to low S content of peat	None Required
	NO_x - conversion of N in peat may cause exceedence of federal guidelines	[a] Minimization of emission is favoured by low combustion temperature, low excess air
	Organics including PAH - emissions of organics can occur due mainly to low temperatures for peat combustion	[a] Minimization of emissions is favoured by high combustion temperature, high excess air and long furnace residence time
	Particulates - federal guidelines can be achieved	By proper selection and operation of particulate removal devices
Peat Combustion Ash	Source of salts and trace elements	Release of salts and trace elements can be minimized by design and operation of ash disposal sites (landfill) so as to minimize contact of surface and groundwaters with ash

[a] - There appears to be a conflict between conditions for minimization of NO_x emissions and those for minimization of organics emissions; further research is required.

TABLE 6-4

Peat Conversion to Gaseous, Liquid and Solid Fuels

Source of Waste	Potential Environmental Concerns	Environmental Management
Peat Dewatering and Drying	Refer to Table 6-2	Refer to Table 6-2
Gasification and Liquefaction	Wastewaters contain organic substances, reduced nitrogen compounds, reduced sulphur compounds, tracemetals	Extensive biological and physical-chemical treatment is required to enable discharge of the effluents
Ash/Char	Source of salts, tracemetals, uncombusted carbon	Char can be combusted as process fuel; release of salts and metals from final ash can be minimized by design and operation of ash disposal sites (landfill) so as to minimize contact of surface and groundwaters with ash

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