APPENDIX D

Alternate Methods of Manure Treatment and Use

INTRODUCTION

To date, many attempts have been made to adapt municipal or industrial waste treatment technologies to dispose of livestock manure. The treatment process may be designed to solve odour problems, recover nutrients or energy from the manure, increase the fertilizer value, reduce the volume, or decrease the pollution potential of the manure to allow safe discharge in the environment. In very intensive production countries, such as The Netherlands, manure management practices are strictly regulated and enforced to minimize pollution problems. In these circumstances, treatment systems can be justified economically. In countries where fuel is very expensive or not readily available, the energy recovered from methane gas production is worth the labour investment.

For the majority of pig producers in Manitoba, most odour problems can be solved by a combination of good management and the separation of pig farms from residential areas. Manure produced can be easily disposed of on the available crop land. As long as energy and feed prices are relatively low, the most cost-effective management system is to store the manure, followed by application of the manure on cropland. However, there are some circumstances where another method of treatment is desirable. This section presents some of the management systems that have been studied and outlines the feasibility and possible benefits of each system.

BIOLOGICAL TREATMENT

Aerobic Processes

The aerobic processes that may have some application in Manitoba are:

- biofiltration
- sequential batch reactors
- storage aeration
- pre-storage aeration
- composting.

Biofiltration
Biofiltration is a recent waste treatment process where aerobic bacteria growth and activity is promoted by fixing them on a very porous and solid media (clay beds, straw stalks, plastic discs, etc.). Once colonies of aerobic bacteria are established on the media, the liquid waste stream is trickled on the bacteria-media matrix, along with a flow of air. Alternatively, the waste stream could be pre-aerated.

Biofilters require backwashing to remove excess bacteria which would otherwise plug the matrix. This sludge has to be managed either as waste to recirculate into the treatment system, dispose of, or process. There is no reduction in the volume of liquid to store or apply. Installation and maintenance costs are much higher that the equivalent cost of application.

Sequential Batch Reactors
Sequential batch reactors are also relatively compact waste treatment systems where the growth of aerobic bacteria is controlled for efficient biodegradation of organic matter and denitrification of nitrogen in the liquid.

A series of tanks are typically used. In the first tank, a mixture of bacteria is entered (or reintroduced by recirculation) into the aerated and agitated waste stream. The liquid waste is either held in this tank for sufficient time to allow maximum bacterial activity, or transferred to a holding tank. Most systems are designed to allow strong nitrification (conversion of organic nitrogen and ammonia into nitrates). The liquid stream is then allowed to settle in an idle tank, where ideally, denitrifying bacteria convert nitrates into, elemental nitrogen and where solids (small clumps of bacteria) can settle. The treated liquids are then disposed of separately from the settled solids (sludges). The economical feasibility of this system for livestock manure has not yet been proven anywhere in Canada.

Storage Aeration

Storage aeration is used to maintain the manure in an aerobic state. When manure has sufficient amounts of oxygen present, very little odour is produced, and a significant amount of nitrogen can be removed from the manure by microorganisms. Where the land base available for application is limited, it may be necessary to try to reduce the nitrogen content of the manure before it is applied on the land. However, in most parts of Manitoba, the manure has value as a source of nutrients for plants, and the landbase is large enough to apply all the manure produced without risk of pollution.

During the summer, liquid manure can be treated aerobically by using mechanical aeration equipment. Mechanical aerators operate by either pumping air bubbles into the manure, or by spraying the manure into the air. A high energy input is required to supply enough oxygen to the manure and keep the manure well mixed, and as with all mechanical equipment, a certain amount of maintenance is required to keep the system functional. The energy costs and labour requirements needed to keep a large volume of manure aerobic are high. Generally, total aeration is only used when the manure is to be applied in an area where odour control is important and soil incorporation is not possible. It is not practical to aerate manure that has been collected and stored under anaerobic conditions during the winter. Aeration is only feasible when the storage is emptied in the spring and fall, and aeration is used as a method of odour control during the summer.

Another alternative is the partially aerated storage. In this system, a mechanical aerator supplies enough oxygen to keep the upper layer of the manure aerobic. When the system is functioning properly, the manure at the bottom of the storage is decomposed anaerobically and the gases released from the decomposing manure at the bottom are absorbed and further decomposed as they rise toward the top, preventing odorous gases from being released. If the mechanical aerator fails to supply enough oxygen, or if the manure is not properly mixed, then offensive odours will be released. This method of treatment has not proven effective in Manitoba.

In Manitoba, liquid manure storage aeration systems are not commonly used. The cost of aerating the manure and maintaining the equipment are high. A major disadvantage of storage aeration is the loss of significant amounts of ammonia nitrogen, one of the most valuable plant nutrients in liquid manure. It is usually less expensive to control odours by building a pig operation in an isolated area, or by covering storage structures.

Pre-Storage Aeration

An alternative method of controlling odours from stored liquid manure is pre-storage aeration. A treatment tank is used to hold seven days of manure production. The manure is partially decomposed under warm, aerobic conditions, and then transferred to long-term storage. Although the manure is held anaerobically in the long term storage, the odour level is reduced because the manure is partially decomposed. The success of this system under Manitoba conditions is unproven.

Composting

Composting is a biological process in which microorganisms aerobically convert organic materials into a soil-like material called compost. During composting, the microorganisms consume oxygen while feeding on the organic matter and generate heat and large quantities of carbon dioxide and water vapour. The rate at which manure will compost depends upon the moisture content, the temperature, the level of oxygen available, the size of the manure particles and the relative quantities of carbon and nitrogen available to the microorganisms for use as food. The optimum solids content for composting is between 40 and 50 per cent. In the case of swine production, it is necessary to separate the solids content of pig manure. The fresh manure can be screened and the resulting solids, which are about 25 per cent moisture can be mixed with a bulky, absorbent organic material such as straw or sawdust and then composted. The liquids are collected and sent to storage. During the composting process, the volume of manure will be reduced by up to 50 per cent. Considerable losses of nitrogen also occur during the process.

To provide the conditions for composting, it is necessary to ensure an adequate supply of oxygen throughout the pile, maintain the pile at 40 to 50 per cent solids and mix the material on a regular basis. This process can be carried out using either a windrow system, aerated static piles, or an in-vessel system. The windrow method consists of placing the mixture of raw materials in long narrow rows typically 1.2 to 1.8 m (4 to 6 ft) high and 2.4 to 3 m (8 to 10 ft) wide. The windrows are initially turned on a fixed schedule for the first month to increase aeration and rebuild the bed porosity. After the first month, the windrow should be turned according to temperature. If temperatures within the pile are above 45°C, there is no need to turn. Aerated static piles are aerated directly with forced air systems to speed up the process. The in-vessel system confines the composting material within a building or container and uses forced aeration and mechanical turning to speed up the composting process.

Manure composting takes approximately six months depending on the level of management. When maintained properly, the composting process is aerobic and the release of odours should be minimal and the product will have an earthy odour. If the conditions are not controlled and the manure begins to decompose anaerobically, strong offensive odours can be produced and the process can take much longer.

So far, the markets for composted livestock manure are limited and the costs of composting may not be recoverable in the sale of the final product.

Anaerobic Processes

With controlled anaerobic treatment processes, such as anaerobic lagoons and anaerobic digesters, the temperature and the nutrient levels of the manure are regulated so that only desirable gases and end products are produced. Whenever manure is stored in a pit or a pile, the manure decomposes anaerobically, but because the process is not controlled, many different gases can be formed.

The type of gases and end products from anaerobic decomposition depends on the temperature and characteristics of the manure. The most common anaerobic process is carried out at mesophilic temperatures (20 to 40°C), which allows rapid growth of methane-forming bacteria. Alternatively, thermophilic digestion is also used for biogas production, where temperatures are kept between 40 to 70°C. Thermophilic digestion tends to be less stable than digester operation at mesophilic temperatures. More recently, bacteria strains were selected for a strong activity at psychrophilic temperatures (10 to 20°C) with liquid pig manure.

Anaerobic Lagoons

Anaerobic lagoons are often confused with earthen manure storages. Lagoons are carefully designed and managed to maintain optimum loading rates, retention time and temperature of the manure to maintain a balance between the acid-forming and methane-forming bacteria. Earthen manure storage structures are simply basins designed to store the manure between periods of application. Lagoons have been used successfully in warmer climates, but in Manitoba where low temperatures occur for much of the year, the methane-forming bacteria become inactive, and the rate of decomposition is slow. The result is that lagoons fill rapidly with solids that do not become stabilized. During the spring, when the manure temperature begins to increase, the acid-forming, rather than the methane-forming bacteria become active and begin to decompose the manure accumulated over the winter. When this occurs, the system is unbalanced and produce offensive odours.

Anaerobic Digesters

Anaerobic digesters are used to produce and recover methane gas from the decomposition of manure. Digesters consist of a large, airtight tank with devices for controlling the input of fresh manure into the tank, mixing the manure, maintaining the correct temperature, and drawing off methane gas and components of the digested manure. Methane production is affected by the temperature, loading rate, mixing, digestion time, and characteristics of the manure. To optimize the amount of methane produced by a digester, all the factors mentioned above must be carefully controlled. The control of these factors can be accomplished by intensive labour or by mechanization. In most regions of Canada, much of the methane produced needs to be used to warm up the digester to maintain gas production.

PHYSICAL TREATMENT

Dehydration

Dehydration is a process that can be used for odour control. Dry manure does not support the growth of either microorganisms or insects such as flies. As well, dry manure can be used as a soil conditioner, in much the same way as composted manure. The problem with dehydration is that the costs associated with moisture removal are high and can not be fully recovered from the sale of the final product.

Solids Separation

Separating the solid and the liquid portions of pig manure has several benefits. In some manure handling systems, it is sometimes desirable to recycle the liquids for flushing. Another reason for separation of the solids from the liquid manure is to allow the use of different treatment processes. Since most of the phosphorus is associated with the solids in liquid manure, separation is also considered as an alternative approach to phosphorus management. Removing the solids can serve a similar function to pre-storage aeration. The remaining liquid is less concentrated and therefore will produce less odour when it decomposes. Depending upon the degree of separation, the solids may be dry enough to be composted, and the remaining liquid will be easier to handle when applying on the land or aerating. The disadvantage of solids separation is the need for two separate manure handling systems.

Most long-term storage structures for liquid manure allow natural separation of the solids, as they effectively settle at the bottom of the structure. Separation can be done using filters or screens, or by allowing the solids to settle in a large tank or basin while removing the liquids from the top. The amount of settled solids can be increased by using chemical agents that act as a flocculant. Mechanical equipment is available, including centrifuges, cyclone separators, press augers, stationary and vibrating screens, in a variety of sizes. Depending upon the flow rate and the type of mechanical equipment used, up to 60 per cent of the solids can be removed. Settling basins can remove up to 85 per cent of the solids, depending on the design.

A method of separation that has been used in Manitoba is to transfer the fresh liquid manure to a covered concrete structure where the solids are separated by settling. Conventional manure pumps are then used to agitate and remove the solids. The liquids are transferred from the concrete tank to an uncovered earthen manure storage. This system has the benefit of using low cost, open storage for the large volume of liquids having a low nuisance potential, and a higher cost, covered storage for the smaller volume of highly concentrated manure which can produce the most offensive odours. Alternatively, two-cell earthen storage structures will also separately store solids and liquids; the first cell could possibly be covered. However, the effectiveness of this method of separation for odour control has not been quantified.