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# *A Guide to* Swine Manure Management Methods

***Manure can be a value-added resource when properly managed. This report takes a look at some of the methods available and explains the basic science behind them.***

Manure produced by livestock operations contains the feed nutrients that animals were not able to use. Prairie livestock operations generally use manure as a source of nutrients for crop production, and should be considered a manageable, valuable fertilizer resource.

Storage of the manure for some length of time is usually necessary. The stored manure is sometimes treated, either before or during storage.

The reasons for treatment include:

- Odour control
- Energy recovery
- Reduction of manure volume—especially where extended transportation is necessary
- Reduction of nutrient content—in some circumstances where insufficient land is available to receive the manure
- Enhance (speed up) the decomposition of manure

Presently on the Prairies, very little manure would be considered treated. Most is simply stored until such time as it can be applied to cropland or pasture as fertilizer.

## Aerobic Treatment

Aerobic treatment is useful in treating liquid manure for odour reduction, chemical oxygen demand (COD) and biochemical oxygen demand (BOD) reduction, and pathogen control.

Aerobic treatment is usually a batch process or, semi-continuous (batch feed). In a batch process, all of the treated material is removed from the facility before refilling with untreated slurry. In a batch feed or semi-

*Environmentally sound storage, processing, and application techniques make manure a properly managed, value-added on-farm fertilizer resource.*

## The Manure Management Language

***COD*** - Chemical Oxygen Demand. The amount of oxygen used to break down organic and inorganic matter contained in water.
***BOD*** - Biochemical oxygen demand. The amount of oxygen used to break down only the organic matter contained in water.
***Biogas*** - A mixture of methane, carbon dioxide, and other gasses. This mixture of gasses is produced by bacteria living in the manure.
***VFA's*** - Volatile Fatty Acids. One of the main reasons manure has an objectionable odour. VFA's are an intermediate product in the formation of biogas.
***Methane-producing bacteria*** - The good guys. They work to convert VFA's into biogas, which can then be put to good use producing electricity or heat.
***Hydraulic retention time*** - the length of time (usually measured in hours or days) that the slurry remains in the digestor.

continuous process, some of the treated material is displaced by the addition of untreated material to the digestor.

Aeration is accomplished by bubbling air or oxygen through the slurry, mixing the slurry mechanically or pumping the slurry through the air.

Aeration can be used to treat slurry as a pre-treatment or as a treatment during storage. Treatment during storage is not common, because of the power—and associated additional cost—required to achieve significant aeration of a large manure storage.

*Above ground storages can be legislated in places where soil conditions would pose risks to drinking water if earthen storages were used.*

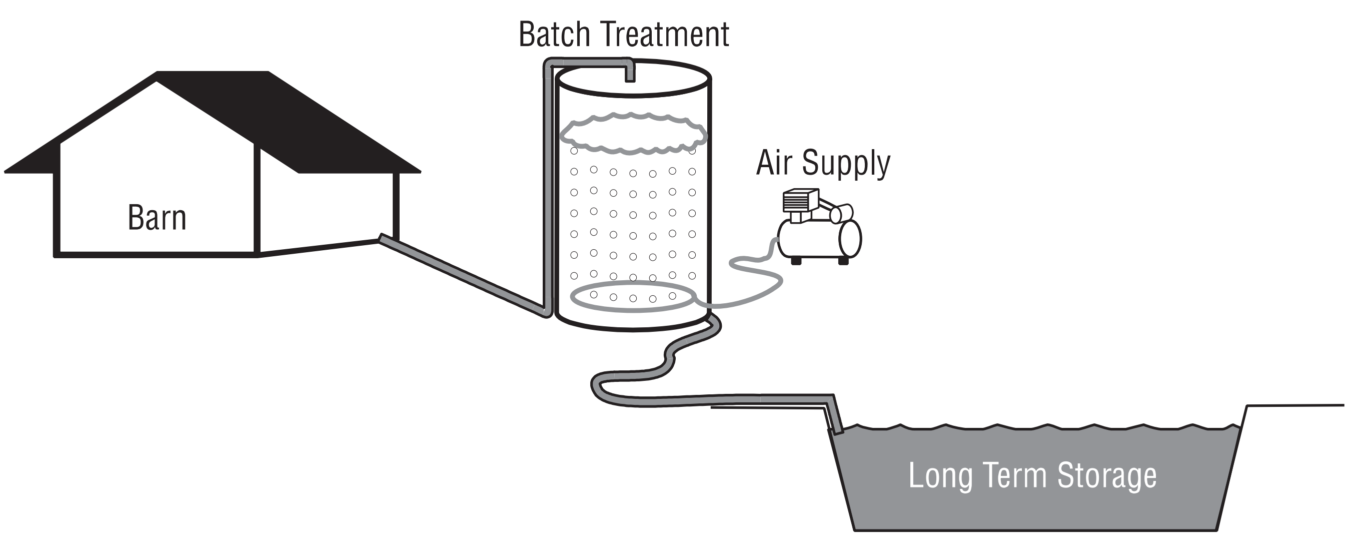
Pre-treatment in a separate reactor is more cost-effective. If slurry is pre-treated for two to seven days before going to storage, odour can be suppressed for a significant time.

Odour is reduced by enhancing the breakdown of volatile fatty acids (VFA's), which are very closely associated with the production of odour. Treating manure aerobically before spreading can reduce odour by 50 to 80 per cent.

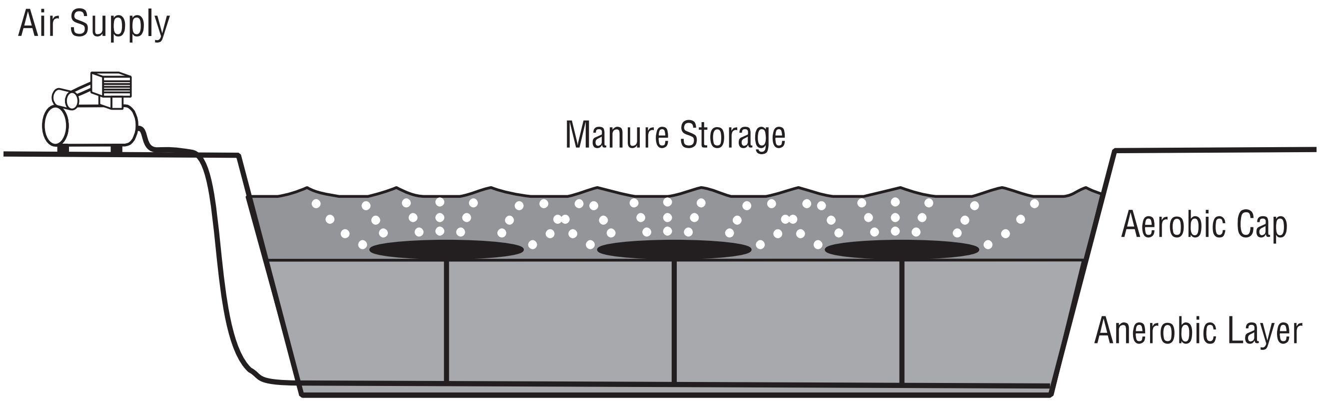
Chemical oxygen demand (COD) and five day biochemical oxygen demand (BOD) are measures of the biodegradability of the slurry. In cases where slurry must be disposed of by release into a river system due to extreme shortages of land, aerobic treatment may be used to reduce the COD/BOD to "acceptable" levels.

If a material with high oxygen demand is released into a river, its continued decomposition will consume oxygen from the water, threatening the survival of aquatic life.

## Aerobic Treatment - Batch or Semi-Continuous Process



# Aerobic Cap




Many dangerous pathogenic bacteria such as Cryptosporidium and Salmonella are anaerobic—which means they cannot exist in the presence of oxygen. They will be controlled by aerobic treatment

On the down side, aerobic treatment can cause excessive loss of nitrogen as nitrogen gas, nitrous oxide or even ammonia if excessive aeration rates are used. This loss of nitrogen to the atmosphere can create concerns of acid rain in some instances. Another concern is the potential loss of the economic value as nitrogen fertilizer.

A Minnesota company is currently testing a bubbleless aeration device to reduce ammonia driven off during aeration, possibly also reducing power required for aeration. If these tests are successful, PAMI recommends a demonstration site be set up on the Prairies to test the technology under our conditions and to create awareness of this new technology.

## Aerobic Cap

An aerobic cap is a twist on the aerobic treatment process where only the upper layer of the storage is aerated, preventing the odorous compounds formed by the anaerobic processes from being released at the surface. The advantage of anaerobic cap treatment is that only a portion of the manure storage need be treated, thereby reducing costs.

## *Energizing Gases*

The gas collected from an anaerobic digestor can be:

• Burned in a boiler to maintain a higher temperature in the digestor, which will speed up digestion

• Cleaned and then burned in an internal combustion engine, usually for the production of electricity, but sometimes to power vehicles.

## *Anaerobic Treatment*

The anaerobic process involves approximately 3 steps of microbial action:

1) Insoluble materials such as carbohydrates, fats and protein are transformed into soluble material (liquefaction).

2) Volatile fatty acids (VFA's) are formed from the soluble material. VFA's are a major cause of storage odour.

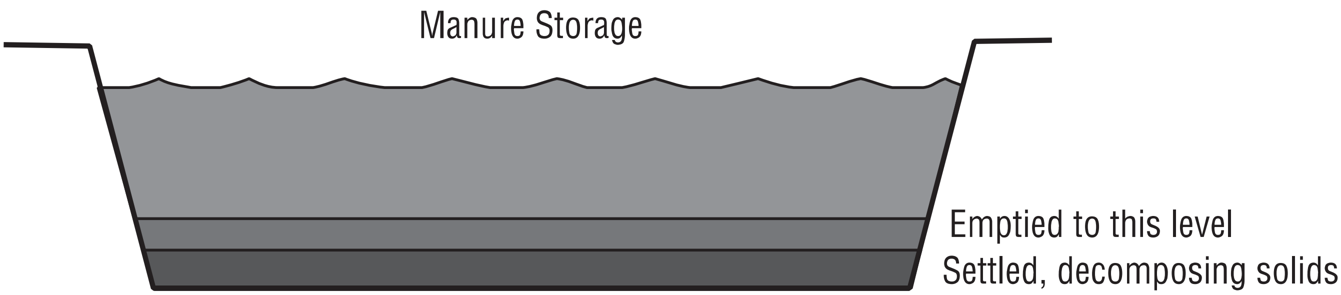
## *What about the "Robics"?*

There are two types of biological processes for treating manure - aerobic and anaerobic.

In aerobic treatment, oxygen is provided to speed up the decomposition of organic compounds found in the manure. The bacteria that thrive in an oxygenated environment tend to produce less odour than anaerobic bacteria, and even use the compounds produced by anaerobic bacteria as feedstocks for producing less noxious compounds.

Anaerobic treatment is a process where manure is decomposed in the absence of oxygen. This process results in the production of biogas, a mixture of methane, carbon dioxide and other gases, which may be captured for energy recovery.

# Anerobic Lagoon




3) The VFA's are converted into biogas—partly methane—by methane-forming bacteria.

Liquid manure that has been treated anaerobically emits significantly less odour than untreated or raw manure, even after significant storage time. Anaerobic digestion conducted in a controlled environment—a digestor—maintains almost all of the nutrient content in the treated slurry.

## Anaerobic storages

Anaerobic storages are combination treatment/storage facilities where natural anaerobic processes are used to decompose the manure solids. Although some anaerobic digestion takes place naturally in earthen storage facilities typically used on the Prairies, they are not considered to be anaerobic treatment storages.

However, methane-forming bacteria which convert VFA's to biogas require warm temperatures to function. Therefore, anaerobic storages work well in the southern U.S. where ambient temperatures are higher than northern climates and there is no cold winter season.

On the Canadian Prairies, since the methane-producing bacteria which process VFA's into biogas are not active in winter, the VFA's accumulate. In spring, the VFA's (and their odour) are released from the storage as it warms. Generally, the worst period for odour production occurs during agitation..

Earthen, concrete, and steel storages as well as anaerobic storages can be covered for capture of biogas, but the amount of biogas produced in cooler climates may not be sufficient to make recovery worthwhile. However, some specially designed storage covers are available to capture the gas, if desired.

Anaerobic storages are not agitated for pumpout. They are never completely emptied so that the bacteria population remains high.

### *Digestive Tip*

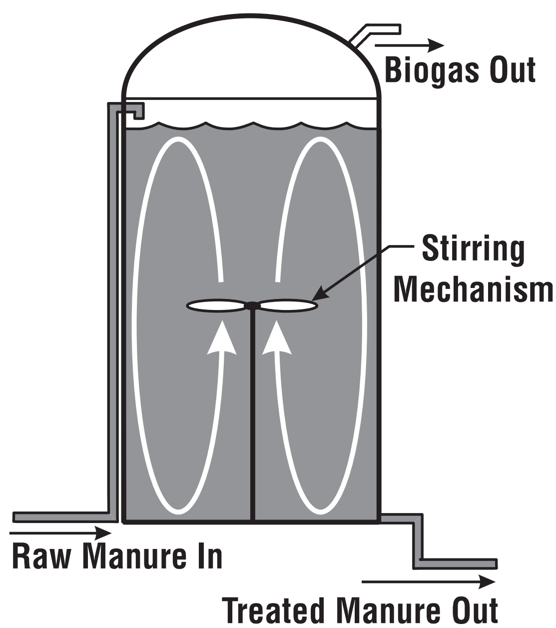
If necessary, the solids content of the slurry may be reduced before being fed into a digestor by passing it through a solids separation system. Although a higher solids content increases biogas production, extreme levels of solids will overload the digestor and reduce performance.

## Anaerobic Digestors

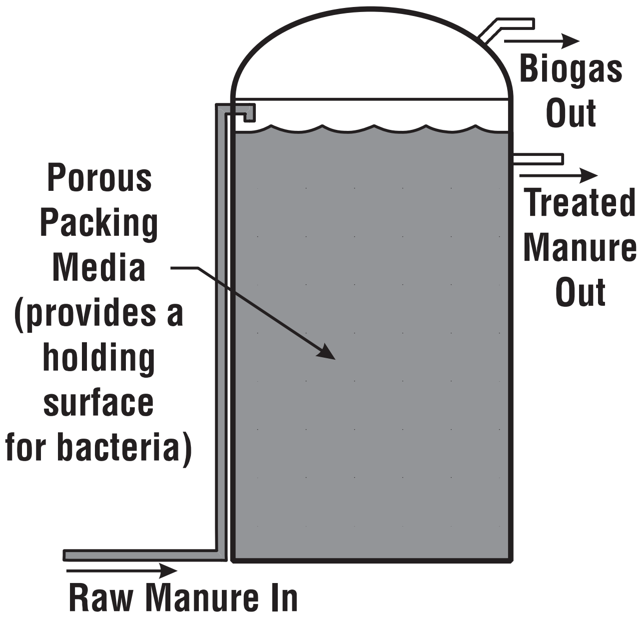
Anaerobic digestors produce and collect biogas and maintain conditions that are favourable for methane-producing bacteria.

In cooler climates, slurry in anaerobic digestors must be heated to between 25°C and 35°C to promote growth of methane-producing bacteria. The heat required to fuel the boiler can often be produced by using part of the biogas emitted from the slurry. The remainder of the biogas can be used to fuel an electrical generator or for space heating.

Anerobic Digester
(Continuously Stirred Tank Reactor)



## Fixed Bed Anaerobic Reactor




The costs of installing an anaerobic digestor that collects the biogas can be quite high. Therefore, their economic viability is often dependent on the price at which the excess energy can be sold to a local electrical utility.

However, some anaerobic digestors have as their primary purpose odour control, with biogas production being a by-product that can be used to help pay for the digestor.

### *Three main types of anaerobic digestors*

**Continuously stirred tank reactor (CSTR)**

These operate at a solids content of five to 14 per cent, with a hydraulic retention time of 20 to 30 days. These digestors are fed continuously or intermittently, with digested slurry exiting through an overflow to a storage area such as a tank or earthen storage. CSTR digestors are relatively large—as large as 320,000 gallons (1 450 000 litres)—and can be quite costly.

**Plug-flow digestors**

These processors use a longitudinal (tube-like) reactor, so that the slurry remains unmixed but is discharged from the reactor in the same order that it is fed in. Plug-flow digestors operate at a solids content of 8-12% with a hydraulic retention time of approximately 30 days. Cost of these digestors is also high, due to long retention times.

**Fixed-bed reactor**

These are a recent development in anaerobic digestors. They have much shorter hydraulic retention times—several hours to several days—than the CSTR or plug-flow digestors.

However, fixed-bed reactors must operate at a lower solids contents because of the porous packing material contained inside the digestor tank. This material captures and holds methane-producing bacteria, maintaining a high population, even with the slurry flowing. The packing material provides increased surface area for bacteria to adhere to and the slurry passes through the packing material.

The high bacterial population processes the slurry more quickly, resulting in much shorter retention times than other digestors.

A smaller fixed-bed digestor can process the same amount of manure as a conventional digestor with as much as 10 times the volume.

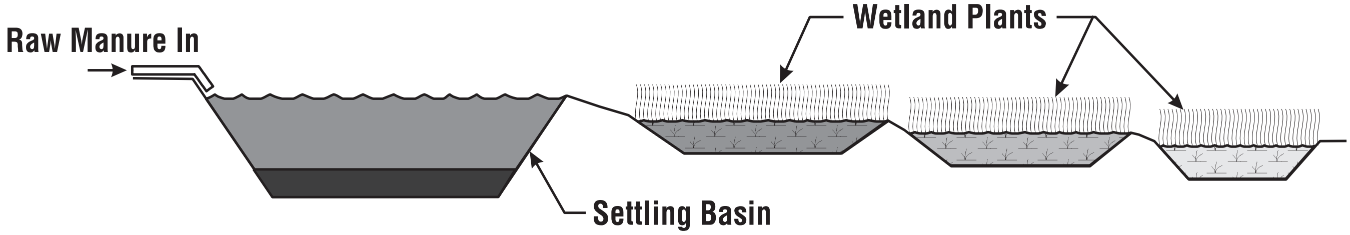
This type of digestor would be more feasible for Prairie conditions than the other two types, because its smaller size takes less energy to heat the slurry to the proper temperature.

# *Other choices*

### *Artificial Wetlands*

Most artificial wetlands are made up of a series of shallow holding ponds, stocked with aquatic plants such as cat tails. Runoff water from feedlots, effluent from separated slurry or storage effluent is directed into the system where the plants consume the manure nutrients.

## Artificial Wetlands



To completely remove the nutrients from the system, the plant growth should be harvested and removed.

Usually, solids are settled out in a storage before the liquid enters the wetland. However, a mechanical separator could also be used. After passing through the system, the water might be reused as wash water for livestock facilities, a water source for fish ponds or discharged into a stream if sufficiently clean.

Artificial wetlands can be designed with a large enough surface area to eliminate all of the water through evapotranspiration.

It is still not clear how well artificial wetlands will work in Prairie climates. Further investigation should be done to determine whether or not artificial wetlands are suitable for the Prairies.

### *Fish Ponds*

Fish ponds are commonly used as a sink for hog manure in many parts of the world, including developing countries in Africa and South America.

The manure provides nutrients for algae in the pond which in turn, feed the fish. Tilapia and carp are the two types of fish most often used for this process.

Problems may arise if a large amount of the algae dies. While decomposing, dead algae consumes oxygen from the water. If sufficient quantities of oxygen are consumed, the fish may suffocate.

Combining hog production and fish production could hold some possibilities for the Prairies, since feed for the fish could be available at a low cost. The fish from the ponds might be processed into fish meal which could be used in formulation of hog rations. Fish raised this way could displace a certain amount of imports, and may even have some export potential. However, the practice of processing manure through other animals may be a questionable practice in the context of public health.

Research and testing for heavy metals, toxins and disease in these fish should be conducted before deciding whether to use them for human or animal consumption.

## *Solids Separation*

Separating the solids from liquid manure prior to storage reduces potential for odour by removing much of the “oxygen demanding” solids that contribute to odour production. Solids may be separated in a gravity settling basin or removed mechanically by using any one of a number of types of equipment.

By removing the solids, the effluent may be used for irrigation using continuous low volume systems or hydroponics. The separated solids can be dried or composted and sold as fertilizer or for direct land spreading.

### *Dehydration*

Dehydration can be used to quickly remove the water from slurry, leaving a low-moisture solid product that can be further processed by pelleting to form a spreadable fertilizer.

Canadian natural gas utilities including Centra Gas and SaskEnergy have been working on a pilot project using heat produced by natural gas to produce a dry, fluffy, nutrient-rich product from liquid hog manure. The cost of production is estimated to be very similar to the value of the nutrient content of the dry product.

However, the cost of this method only makes it feasible for large hog producers with a very limited land base upon which to dispose the manure. It currently costs hog producers an estimated $2.00 per pig to apply manure to the land, while the natural gas dehydration system would cost approximately $15.00 per pig.

However, the product could be sold to recuperate cost of processing, and possibly more value extracted by making better use of energy and water vapour in the exhaust stream.

### *Oligolysis*

This is an electrical treatment of manure that applies voltage to the manure across a set of iron electrodes. The current removes particles of iron from the anode. Once in the slurry, they combine with sulphide ions and ferrous sulphide precipitates out of the slurry.

This process reduces the amount of sulphide ion in the slurry which would otherwise combine with hydrogen to form hydrogen sulphide, one of the major odorous gasses produced by decomposing hog manure.

However, while the cost of treatment is not excessive, the treatment and consequential reduction of hydrogen sulphide does not greatly reduce the odour given off by the manure due to other gasses produced by the manure.

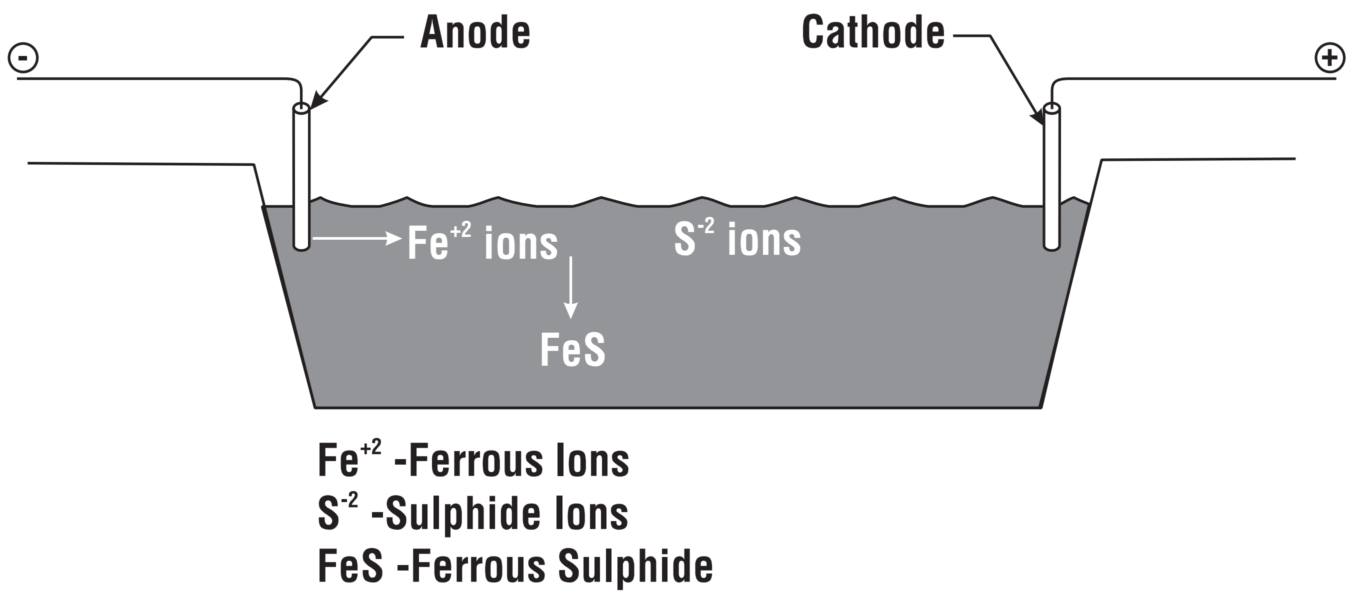
### *Additives*

Using additives for odour control have very little scientific data to support their claims of effectiveness.

A yucca plant extract called sarsaponin (a plant steroid) is marketed under several trade names as a hog feed additive. In U.S. trials, certain levels of sarsaponin increased feed efficiency up to 11 per cent and increased growth rate up to six per cent. It appears to reduce ammonia levels in the barn, but not necessarily odour. It also appears to reduce solids in the manure by up to 20 per cent.

Some additives are added to the slurry in a manure pit, or spread on the floor prior to washdown. They may

## Oligolysis




use bacteria to change microbe populations to more desirable types.

### *Membrane*

A Winnipeg company is using a membrane technology to treat municipal sewage in Mexico, claiming a 95 to 99 per cent recovery of water. They hope that this technology can be applied to the hog industry.

### *Proteus*

Proteus is a Modular Effluent Treatment System (METS) developed in Saskatchewan to treat municipal waste.

METS chemically treats the slurry to cause suspended solids to settle, where they are collected, dried and pelleted. The liquid is then treated further with filtration, aeration, ozonation, or other processes.

METS uses a computerized control system. Proponents of this technology feel that it has application in agricultural waste management, however the significant chemical inputs and technical control system may deter its use in manure management.

### *Composting manure*

Composting is essentially an aerobic digestion process used for solid wastes.

Slurries or separated solids can be composted if mixed with a carbon source such as straw, peat or wood shavings.

However, composting a slurry without separating the solids requires a great deal of additional material to retain the liquid. This would be very impractical due to the cost of the material and the energy required to turn or aerate the compost.

The carbon to nitrogen (C:N) ratio of the original manure determines how much carbon material should be added to manure to properly compost it. One reference stated that the C:N ratio of the finished compost should be less than 20:1, (that is one part nitrogen to 20 parts carbon).

Composted manure is a premium organic fertilizer and holds some potential as a marketable product in the gardening and landscaping market. For some markets, and even some on-farm application techniques, the compost would have to be pelleted so that the nutrient content could be upgraded to a specific blend with commercial fertilizers.

*Manure management doesn't end in the storage pit, and getting the most out of the nutrients for crop production involves more than surface application. Research suggests nitrogen losses to the atmosphere climb as high as 30% when slurry is applied topically, as with the irrigation gun shown here..*

# Odourless Options?

## Covers:

Covering storages is effective in reducing storage odour. Cover types include sealed covers (which may involve biogas collection), a straw cover, or a natural crust.

PAMI has led in the development of straw covering of hog manure storages, which is quickly gaining acceptance across the Prairies.

A natural crust on a storage is sometimes formed if feed particles such as grain hulls enter the storage and float to the surface.

## Application:

Several manure application techniques such as injection, dribble bars and incorporating manure as soon a possible can be used to minimize odour. PAMI is currently involved in a study of several manure application methods to determine the economics of each system, including nutrient loss, operating and capital costs, manure distribution variability, and other factors.

*Drawings used to illustrate different processes and treatments in this report are conceptual only. Actual systems and components may vary.*

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