

Membrane Filtration of Hog Manure

A cost-effective and environmentally sound solution

□ Background

An increasing problem has been the treatment of waste resulting from the operations of large hog farms. The trend in recent years has been the consolidation of the hog industry as many smaller farms have been incorporated into larger “mega farms”. While this greatly increases the economies of scale and reduces the cost of production, it also has with it some new challenges. The concentration of animals and the waste produced can put a strain on the local environment.

Since this is a fairly new development, hog producers, governments, and trade associations are now dealing with finding appropriate solutions for waste management. These new operations are increasingly coming under regulatory scrutiny. The main concern has to do with the maintenance of the storage lagoons for the wastewater.



Lagoon Break

Large earthen structures are difficult to maintain and unpredictable during bad weather

Regulators are trying to decide how and when to regulate these structures. In some extreme cases in North Carolina, the use of Lagoons has been banned outright. In other cases spills from these lagoons have resulted in stiff penalties for contamination of local waterways.

V◇SEP Advantages:

- ✓ Existing Storage Lagoon can be converted to a duck pond
- ✓ Provides a closed loop system with recycled water
- ✓ Manure nutrients are concentrated up to 20% total solids
- ✓ The system footprint is only about 100 SF (9.3m2)
- ✓ Methane, Ammonia, & Sulfide odors are greatly reduced
- ✓ Hog Farm would not require use of any land as sprayfield
- ✓ System isn't affected by rain, bad weather, or loading rate

Lagoon/Digester Disadvantages:

- ✓ Offensive Methane, Sulfide, and Ammonia odors
- ✓ Requires large areas of land for use as sprayfields
- ✓ Liner leaks or levy breaks are a constant risk
- ✓ Nutrients are lost to digestion and volatilization
- ✓ Fertilizer component cannot be economically transported
- ✓ Land application may not coincide with best field conditions
- ✓ Release of pathogens and viruses threatens health safety

While lagoons when combined with aerobic or anaerobic digestion can be effective, there are a number of drawbacks and risks associated with them. In addition to all of these drawbacks, the use of huge earthen structures is fraught with risk. Errors in judgment or mistakes by maintenance crews can result in the spills of millions of gallons of untreated waste into nearby waterways. A company's operating costs can be put in turmoil by unexpected penalties or clean up costs from these unexpected events. Reducing risk has value and the amount of risk is something often evaluated by investors and shareholders.

□ Criteria for New Technologies

New Logic seeks to provide a more effective reliable treatment system for animal manure waste. New Logic has been providing Membrane Filtration of wastewaters since 1987. The use of V◇SEPs cutting

edge technology will allow hog farmers to better manage the use and reuse of water and to control the lagoon level for existing structures.

Some operations may desire to eliminate the lagoon system altogether. Because of the competitive nature of the industry, in addition to being more effective in treating the waste problem, new technologies must be cost effective as well. As with any capital equipment purchase, as cost/benefit analysis should be done.



Manure management is a fundamental part of swine production. Any treatment system must be carefully considered with the following considerations in mind:

Criteria for New Technologies

- ◆ Maximum nutrient retention and utilization
- ◆ Minimum Land, Labor, & Capital required
- ◆ Odor and Spill Control
- ◆ Animal and Human health considerations
- ◆ Risk under adverse conditions
- ◆ Operating costs & use of chemicals if any



□ New Logic's Solution

Technological advances in membrane filtration systems and membranes have created an opportunity for the efficient and economical treatment of wastewater from large hog farms. The "Vibratory Shear Enhanced Process" or V◇SEP™ developed by New Logic Research makes it possible to filter effluent streams without the fouling problems exhibited by conventional membrane systems. The V◇SEP membrane system utilizes a reverse osmosis membrane which will remove the BOD, COD, TSS, Phosphorus, and Nitrogen from the effluent of hog farm wastewater.

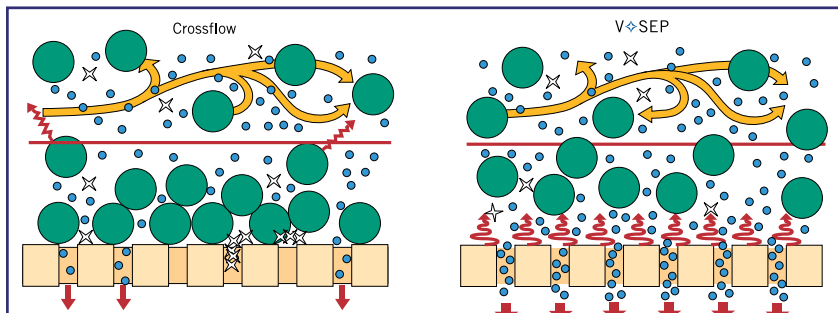
V◇SEP is capable of handling thick slurries and concentrating the feed stream to a sludge which can be dried. The filtrate from this can be reused for washdown operations, used as animal drinking water, or sewer. The V◇SEP can be used by itself or in conjunction with other

equipment for a comprehensive treatment system. The V◇SEP can also be used in conjunction with all kinds of bio-reactors. It can be used either ahead of or behind anaerobic digestion. Use of this process would greatly reduce the size and cost of the digester as well as increase the efficiency of it.

The V◇SEP Filtration system has been in production since 1984. Only recently has New Logic developed presence in the agricultural waste industry. There are currently several V◇SEPs in operation on hog farms in Korea. This has been done with the assistance of New Logic's Korean Representative, Environmental Vision 21. New Logic has recently pilot tested for remediation of the Phosphorus over-fertilization and contamination problem plaguing Dutch Hog Farms. There have also been many recent pilot tests for farms located within the USA & Canada

□ Case Study Location

This application summary covers the installed V◇SEP machines in operation at hog farms in Korea. In these installations, V◇SEP is used as a tertiary treatment system behind a grit remover and bioreactor. Assistance was provided by Environmental Vision 21, a Korean Company which specializes in bringing new technologies to market in Korea. There have been two filtration systems and a third one is being planned. The two installed units are located at Pochun and Kimhae, Korea,



Conventional membrane systems rely on laminar crossflow of the feed slurry across the membrane surface to keep the surface clear for filtration. V◇SEP's patented technology vibrates the membrane surface and can produce 15 times the permeation performance when compared to conventional membrane systems. With V◇SEP, the membrane surface is moving at a rate of 3/4" displacement 50 times per second.



Kimhae Korea - V◇SEP
 New Logic's patented V◇SEP equipped with 1300 SF (120m²) Reverse Osmosis membrane for the treatment of Hog Manure after a Sequencing Batch Bioreactor

□ Process Description

V◇SEP is capable of handling effluent streams in a single pass with very little pre-treatment. Usually just a 100 mesh prescreen is all that is required. In this case study, a bioreactor was used to lighten the load to the V◇SEP just enough to allow one V◇SEP machine to handle the load. The Block diagram below shows the treatment system. The raw feed slurry enters the grit remover at the left of the drawing with a little

(6.6 m³/hr) is handled by a single V◇SEP unit containing about 1300 SF (120 M²) of RO membrane. The footprint of the V◇SEP itself is about 16 SF (1.5 M²).

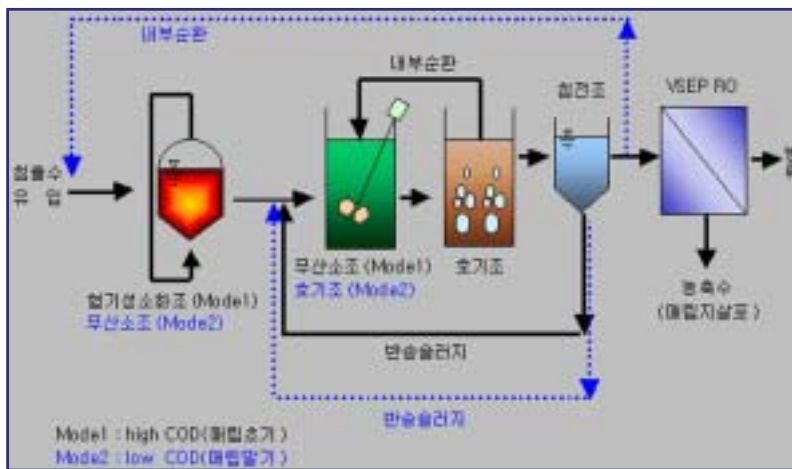
This rate of production would be equal to about 36,000 gallons per day. At 40 gallons per day per hog for waste and washdowns, the above system would handle up to 900 head of hog.

This system uses a Reverse Osmosis membrane with a 99% salt rejection rating. Performances will vary depending on conditions. Pilot testing has also shown significant differences between the waste of Boars and Sows. Feed used will also affect results.

Other pilot tests have shown significant reductions in Chlorides, Sulfates, and other compounds. Previous test work on Dutch Hog manure showed Permeate quality as follows:

| | |
|-----------------|----------|
| SO ⁴ | 31 ppm |
| Cl ⁻ | 24.2 ppm |
| PO ⁴ | <0.2 ppm |
| NH ⁴ | 310 ppm |
| Cond. | 1500µs |

Ammonia can be further reduced in a number of ways. Acidifying the waste stream will alter the ammonical form to the insoluble ammonium which can be rejected by the membrane. Ammonia which occurs in higher pH, is soluble because of its charge properties is able to permeate RO membranes in small amounts.



Kimhae, Korea - V◇SEP Block Diagram

bit of recircled wash water. From here it goes to a holding tank and then to the bioreactor. Then it continues to the tertiary treatment, the V◇SEP machine itself.

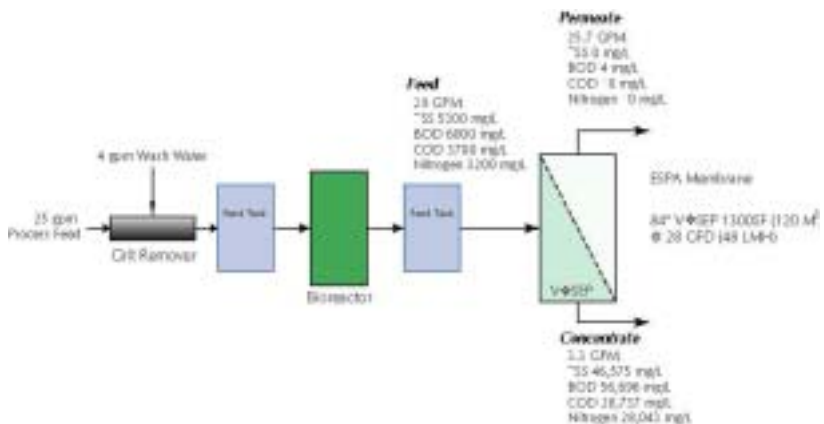
The Filtrate is partially reused in washdown operations and partially sewer. The Reject or Concentrate from the V◇SEP is sold as fertilizer to local farms and golf courses. Because of significant volume reduction, hauling costs vs nutrient value are very attractive.

□ Process Conditions

The wastewater treatment systems installed in Korea take raw wastewater from the storage lagoons at a rate of about 25 GPM (5.7 m³/hr). Water is added at the grit removal stage and the total flow of 29 gpm

□ Process Results

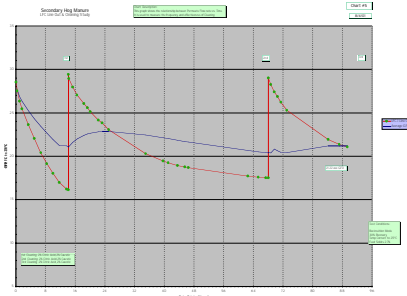
The V◇SEP produces a concentrated waste stream of reject that can be used as fertilizer. The permeate is partially reused and partially sewer. The following table shows the analytical results of the Kimhae installation.



| Typical V◇SEP Performance on Manure Wastewater | | | | | |
|--|-----|------------|-------------|-----------|------|
| Description | | Feed | Concentrate | Permeate | |
| Total Solids | TS | 26,900 ppm | 112,000 ppm | 5,770 ppm | 79% |
| Total Nitrogen | T-N | 2,120 ppm | 8,800 ppm | 450 ppm | 79% |
| Ammonia | NH4 | 1,464 ppm | 6,200 ppm | 280 ppm | 81% |
| Phosphorous | P | 1,464 ppm | 6,500 ppm | 205 ppm | 86% |
| Sulfates | SO4 | 1,170 ppm | 7,100 ppm | ND | 100% |
| Potassium | K | 1,362 ppm | 6,600 ppm | 53 ppm | 96% |
| Calcium | Ca | 400 ppm | 2,000 ppm | ND | 100% |
| Iron | Fe | 30 ppm | 150 ppm | ND | 100% |
| Zinc | Zn | 26 ppm | 130 ppm | ND | 100% |

□ System Throughput

The V◇SEP system performance is a function of temperature, % recovery, & % Total Solids in the feed slurry. The more concentrated and colder the feed slurry, the lower the throughput of the V◇SEP system. Temperature affects the viscosity of the liquid and viscosity affects the liquid fraction's ability to move through the membrane surface.



In general, one 84" V◇SEP is capable of producing 25-30 gpm of clean water filtrate from Hog Manure at a recovery of 80% of the total volume as permeate. This is equal to about 40,000 gallons per day of recycled water.

□ System Components

The liquid manure would be pulled out of the existing Stage One Settling Basin using a self priming sump pump or centrifugal pump which would be installed on a floating buoy to pull liquid from the top foot of tank

level. The liquid will transfer into the V◇SEP treatment building and then pass through a degritting or pre-screening unit to remove large particles, (100 mesh). There are many types of mechanical screens that could be used. The picture on the right shows the type used at our Korean installation.



The manure then flows into a equalization feed tank where it can be heated if needed. This tank works on a demand basis and would be controlled by tank level. The transfer pump would activate to fill the tank based on the signal it gets from the tank level sensor. The the manure is pulled out of the tank near the bottom and pumped through a

protective bag filter and sent on to the V◇SEP machine itself. The bag filters and pumps are provided with the V◇SEP system and are skid mounted for easy installation. The picture at the bottom shows an example of this set up along with metering pumps for chemical cleaners used during the period cleaning of the membrane.



The V◇SEP system comes with a cleaning tank and many of the valves and other interface equipment. The system is "Plug and Play". The feed tank, degritting unit, heat exchangers, and boiler are not normally included, but, can be provided as part of a complete process package. The V◇SEP system is automated and controlled by a PLC (Programmable Logic Controller). Operator interface is limited to monitoring the system and making periodic adjustment to parameter settings.



Bag Filter, Feed Pumps, & Chemical Metering Pumps for Cleaners

From the feed pump, the manure is sent to the V◇SEP Filtration machine and split into two streams: a concentrated manure slurry and a clear filtrate with solids, metals, and sulfates removed. The vibratory shear created by the machine facilitates the use of membranes for filtration of the manure and keeps the membrane surface clear for transport of the water component through the membrane surface. In this case a reverse osmosis membrane is used for maximum rejection of multi-valent and monovalent ions.



Concentrate Holding Tank

The permeate is sent to the holding pond for water which will be reused. The concentrate will be sent back top the settling basin and “Batch Concentrated” until it has reached the desired concentration.

The V◇SEP machine is capable of 80% recovery of the water from the manure slurry. The final concentration of the reject is something that will need to be determined based on the needs



Kimhae, Korea - V◇SEP Block Diagram

of each individual farm operation. Provisions would be made for use on local fields by a network of pumps and spraying devices. Or, if fertilizer customers can be found, the slurry can be hauled and sold as a product.

Our Korean installations are accomplished using the sale of the fertilizer slurry. The picture here shows the type of truck used for transport of the concentrated manure.

Typical customers for the fertilizer include Potato farmers, golf courses, and orange growers. As with any fertilizer, the rate of application must be calculated. The benefit is that the fertilizer can be chosen to match the needs of the crop and can easily be controlled and planned.



□ Other Benefits

While some effects can be measured and calculated, some others cannot. These other benefits have real value, and while a dollar amount cannot be figured, the qualitative value is easy to understand. These benefits include:

- Less land required as sprayfields
- Easier process for future permits
- Improvement in pig and yield
- Better worker health & well being
- Less risk than earthen lagoons
- Public relations benefits
- Improved neighbor relations
- Esteem of peers in the industry

In addition one could expect reduced fines, legal expenses, and management time for conflict resolution

□ Summary

Technological advances in membrane filtration systems and membranes have created an opportunity for the efficient and economical treatment of wastewater from large hog farms. The “Vibratory Shear Enhanced Process” or V◇SEPTm developed by New Logic Research makes it possible to filter effluent streams using membrane technology.

Unlike other chemical treatment systems where chemical flocculants are added which substantially increase the volume of waste material, V◇SEP volume reduces the material to 10% of its original. Then with the following solidification by drying, the ending volume of dry solids is only 2% of the original volume. The dry solid can be used as landfill or sold as fertilizer. The remaining 98% of the volume is disposed of or reused as clean clear filtrate.

In addition to the cost savings involved, our Korean customer is taking full advantage of the public relations aspects of the new treatment system. V◇SEP represents a brand new cutting edge technology for dealing with this wastewater problem. Our customer has been able to sell the concentrated and dried fertilizer to local orange farms, potato farms, garlic farms, and golf courses. In addition they have received awards for resource recycling.

Farming has always been about recycling and reuse of nutrients. V◇SEP offers the best possible nutrient capture and reuse of not only the Nitrates and Phosphorus but also wise use of the valuable water resource. For more information about how V◇SEP can help you, please feel free to contact us.

*New Logic Research, Inc.
1295 67th Street
Emeryville, CA 94608 USA
510-655-7305
510-655-7307 fax
gjohnson@vsep.com
www.vsep.com*

