Paper No. 004126

An ASAE Meeting Presentation

Lagoon And Wetland Treatment Of Dairy Manure

by

Peter E. Wright
Senior Extension Associate
Department of Agricultural and Biological Engineering
Cornell Cooperative Extension
Ithaca, NY, USA

Stephen P. Perschke
Area Engineer
UDSA Natural Resources Conservation Service
Batavia, NY, USA

Jim Derringer
Scott Weber

Written for presentation at the
2000 ASAE Annual International Meeting
Sponsored by ASAE

Milwaukee, Wisconsin
July 9 - 12, 2000

Summary:
Dairy manure from flushed barns is being treated with a system consisting of two parallel shallow solid retaining lagoons in series with a deep facultative lagoon. This system produces flush water for the dairy barns, solids from the shallow lagoons and a semi treated effluent. This effluent is then applied to a wetland system for further treatment. The shallow lagoons that collect the solids are alternatively drained and the solids are gathered and dried for sale off the farm. The effluent from the facultative lagoon is pumped to a series of terraces. Each terrace is separated from the next with a grass filter area. As the effluent flows through the terraces and filter areas both the mass and nutrients decline. The effluent is collected at the bottom of this wetland system and pumped to the top though out the summer. The reduced volume of effluent with low nutrients is then spray applied to a field for disposal. This system has the potential of being used on many dairy farms for odor control and nutrient reduction. The mass flows, nutrient concentration, and cost of this system will be documented.

Keywords:
Manure treatment, Odor control, Dairy farms, Economics, Nutrients

Introduction

This treatment system has the potential to substantially reduce the nutrient loading and odors from dairy manure economically. Dairy farms are under increasing pressure to store their manure and land apply it according to a nutrient management plan. By reducing odors manure can be applied in the summer, reducing the potential for runoff or leaching, without neighbor objections. By reducing nutrients these plans can be implemented on farms without having to add more land for nutrient uptake. This will allow farms to continue to produce cheap wholesome food profitably.

Objective

The objectives of this paper are to show the material flow, nutrient content, and costs of the manure handling and treatment system on Farm D. The advantages and disadvantages of this system are described so that managers and Agricultural engineers can decide if this system will meet the needs of other farms.

Farm D

This dairy farm is a 350 cow operation located in a rural community in western NY. The owner and manager is meeting his business plan goal of milking 350 cows. Farm D's main goal is to produce milk. The farm owner wants to minimize investment capital and labor. Concentrating on milk production, buying feed and forage cheaply, reducing manure handling and spreading costs, and reducing labor costs are specific strategies that the farm owner uses to achieve his goal.

Farm D currently milks approximately 350 cows. Replacements are raised off site. The farm owns approximately 100 acres adjacent to the barns, approximately 60 acres of this was existing crop fields (hay and corn). Figure #1 presents a plan view of the property owned by the dairy and the layout of the lagoons and wetland treatment process. Prior to installing the manure treatment system, Farm D paid an outside contractor to haul its manure and spread onto neighboring crop fields. Farm D decided to install this manure treatment system because the system is designed to remove nutrients from the waste stream and requires minimal daily maintenance.

The farm also wanted a flushing system. Flushing systems are effective cleaning alleys, reasonable in cost to install and low cost for maintenance and operation. Labor costs for alley cleaning are very low in a flushing system. The water flush leaves the alleys clean with no ponded water and no manure remaining. The initial cost of the system with earthen storage and recycle of the liquids is about the same as other manure handling systems. Some of the costs are site specific. Having topography suitable for gravity flow makes this systems more feasible. The operating cost can be quite low. Pumping

the recycle water to use for flushing to a storage tank is the main cost. The system can be operated completely automatic to flush the alleys as the tanks are filled.

The barns need to be laid out with proper slopes and long alleys for flushing to work effectively. Because of the existing layout compromises had to be made. For most flushing systems disadvantages include that there will be added volume of manure and water to land apply and potentially added odors. Because the farm chose a lagoon and wetland system these potential disadvantages did not materialize. Large storage areas are needed making suitable soils for earthen storages important to keep initial costs down.

The Bion system chosen by farm D is a patented process that uses managed shallow ponds to separate the manure solids into aquatically stabilized solids. These solids are then harvested, dried, screened and sold as a soil amendment. The system recycles the biologically active liquid to move the manure through the ponds. The water from the first facultative lagoon is used to supply the flush water for the system. Odors are much reduced when this system is operating correctly. The effluent from the facultative lagoon is relatively low in nutrients. Ammonium nitrogen is lost into the air from this system. Some nutrients are moved off the farm as solids. There may be significant settling of phosphorus in the bottom of the facultative lagoon.

As the first facultative lagoon is filled, excess effluent is stored in the second facultative lagoon. During the warm season when evaporation exceeds precipitation the second facultative lagoon is used to charge the wetland/terrace system. This system continuously pumps water through a series of terraces creating overland flow that is caught by the next down stream terrace. The bottom terrace has the pump which pumps the water up to the top terrace to continue the treatment. Over time the water is evaporated, infiltrated and treated. As water leaves the system more effluent is added from the second facultative lagoon. At the end of the warm season any remaining water is land applied on the 60 acre crop field east of the terraces.

The manure treatment and handling system was installed in phases due to a limited financial situation faced by the dairy.

The first phase was initiated in the spring of 1996, when one solids settling cell and one lagoon were constructed. The process allowed Farm D to eliminate the expensive cost of hauling manure everyday; however, required land application of excess separated liquid onto adjacent crop fields. The liquid was land applied via spray-jet irrigators and could be pumped long

distances because of the low solids content in the liquid. The biosolids generated from the process was harvested, stored on-site, and removed for resale as a soil amendment.

The second phase was initiated in the summer of 1997 and completed in spring 1998. The second phase consisted of constructing a separator berm, which divided the one solids settling cell into two cells. Additionally, a second lagoon was constructed as well as the polishing wetlands. The process was completed and started in June 1998.

The costs of installing the lagoon treatment system included:

Capital Costs	
Survey	$5,900
Soil testing	$5,000
Treatment system design	$29,640
Flush system design	$2,500
Flush system	
Tanks	$4,191
Pumps	$9,318
Pipe	$16,907
Electric	$12,782
Installation of flush system	$32,356
Lagoon treatment system	
Excavation	$117,387
Aerators	$10,764
Barnyard BMPs	$6,369
Total	$253,114

Manure from the three freestall alleys are flushed about every 20 minutes. A 15 Hp pump continuously pumps effluent from the first facultative lagoon to 3 3,000 gallon tanks elevated above the Alleys. As the tanks are filled the flush valves automatically open flushing the alley. Although the barns are built on a 1% grade the frequent flushing does a good job of cleaning the alleys. The flush water is collected and flows to the solid settling cell that is in operation. There is no noticeable odor in the barn as the flush system is operated. The milking center water also goes into the system. The pipes, valves, and holding tank to deliver the flush water to the barns and return it to the wetland system cost $75,554 . This includes the 3 flush valves that each cost $2,000.

The settling ponds are designed to slowly build up solids forcing new flows through the existing solids on the way to the outlet. The excavation for the ponds cost $117,387 plus $5,900 for the survey. The outlet structures allow up to two feet of solid build up while letting the liquids drain out. When one

solid cell is full, the flows are directed to the other cell. Then the first solid cell is drained and harvested. The removal of the manure solids is done every year from each cell.

The liquids from the shallow solid cells outlet into the 8 foot deep facultative lagoon. There is evidence of biological activity since fairly continuos gas bubbles up in the lagoon. The five Hp aerator runs continuously in each of the facultative lagoons.

The facultative lagoons holds X.X million gallons of waste water. An intake suspended two feet below the surface recycles the waste water through a 15 Hp pump to the holding tanks in the barn. The electric rate on this farm is 10 cents per kW.

Electric costs are estimated to be $18,000 per year. Solid harvesting costs of $2 per cubic yard are subtracted from solid sales of about $5.25 per cubic yard for the approximately 14 cubic yards per cow per year to give a potential net profit from solid handling of ,000 per year. (350 cows) x (3.25 $/14) = $15,925

The annual costs of this system when operated for 20 years at 10% interest is about $91 per cow per year. This compares favorably with studies done in western NY that show the average farm spends $77 per cow per year on just spreading the manure. This lagoon and wetland treatment system includes collecting the manure and storage in the annual per cow cost. The total capital cost of the system compares with an estimated average cost of an additional $100,000 per farm for CAFO compliance, since again the manure collection system as well as odor control are included in this sytem.

Bion Technologies, Inc. is designing and installing these systems throughout the US. The capital costs for the Treatment system design of was paid to this company. The sale of the solids are to be handled through the company as well.

Predicting the amounts and concentrations of the nutrients in this system is difficult. Obtaining representative samples and estimating the losses from biological, chemical, and physical processes in this relatively uncontrolled system can be difficult. The biological reactions are not monitored or controlled and the temperature, precipitation, and evaporation are uncontrolled in the ponds. There can be a large effect on the nutrient concentrations.

A sampling program was initiated in June 1998 to track system performance and continued until October 1998. Samples taken throughout the process were analyzed for several parameters including BOD, total nitrogen and total phosphorus. The sampling results are graphically

presented in Table 1. The sampling results indicate a dramatic decrease in nutrient loading as the waste stream moves through the process. For example, 99% of the BOD, 98% of the total nitrogen, and 98% of the total phosphorus was removed.

Table 2 Nutrient samples from the system during the spring of 2000

Location	Total Solids %	Nitrogen %	Ammonia Nitrogen %	Organic Nitrogen %	Phosphorus %	Potassium %
Influent to Lagoon 1	1.46	0.14	0.09	0.05	0.01	0.12
Effluent from Lagoon 1	1.38	0.15	0.10	0.05	0.01	0.12
Lagoon 1 4 feet deep North end	7.32	0.3	0.16	0.15	0.08	0.12
Lagoon 1 Sludge at north end	6.72	0.24	0.08	0.15	0.07	0.13
Lagoon 2 4 feet deep south end	0.98	0.09	0.06	0.03	0.01	0.1
Lagoon 2 4 feet deep north end	0.90	0.09	0.06	0.03	0.01	0.1
Lagoon 2 8 feet deep north end	1.57	0.13	0.08	0.05	0.02	0.11
Lagoon 2 9 feet deep south end	1.25	0.11	0.07	0.04	0.01	0.11

Discussion

The phosphorous seems to be related to the solids in the system. Table 2 shows a direct relationship between the solid content and the phosphorous content. For every 1% of solids there is 0.01% of phosphorous.

Phosphorous that enters the wetland/terraces is assumed to be retained on soil particles in the system. Over time this may reduce the removal rate of phosphorous.

Nitrogen in the wetland/terrace system may be removed through nitrification when the water is aerated during overland flow and then denitrification as anaerobic conditions prevail in the ponded terraces and the bottom collection ditch.

Conclusions

The Wetland/Terrace treatment system in addition to the solid settling and facultative lagoons is a feasible system for dairy farms that will provide excellent odor control and waste water reduction. The costs of these systems are comparable or less than other manure handling systems. The management required is well within the abilities of most dairy farms.

There are advantages and disadvantages to this system that may be more or less important to each farm. The wetland system works very well with a flushing system to clean the barns. Gently sloping topography and relatively impermeable soils will keep the initial costs low. Farms that don't need all the nutrients in the raw manure or that don't have the land available to spread manure on will benefit from the nutrient and mass losses of this system. By-product sales are important in reducing the cost of the manure handling system. Marketing the separated solids will be important to help pay for odor treatment systems.

References

Bernhart, Alfred P. ,Evapotranspiration, Nutrient Uptake, and Soil Infiltration of Effluent Water. 1985, A. P. Bernhart 23 Cheritan Av. Toronto, Canada M4R1S3

Bion Technologies, Inc. 8899 Main Street Williamsville, NY 14221 716-633-4674, ww.biontech.com

Poulsen, Jeffrey The Bion Nutrient Management System, A Biology-Based Treatment Alternative In NRAES, Managing Nutrients and Pathogens from Animal Agriculture Proc. march 28-30, 2000 NRAES-130. Cornell Univ., Ithaca, NY.