RURAL CONSERVATION CLUBS PROGRAM

FARM POLLUTION CONTROL ALTERNATIVES ASSOCIATION

"Milkhouse Wash Water Control Using A Vegetative Filter "

FINAL REPORT

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By Luc Brunet, M.Sc., P.Eng.

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Introduction

Ontario has approximately 8000 dairy producers. A recent survey by OMAFRA (Cuthbertson, 1995) indicated that 14 litres per cow per day (3.1 gallons) are used to clean milking and milk handling equipment. The cost of disposing of milkhouse wash water is an expense to the producer. Only 50% of dairy farms had an acceptable treatment or storage system for milkhouse wash water.

Currently, there are two recommended methods for disposing of milkhouse wash water in Ontario. The first method involves treating the wash water through a septic tank and treatment trench system. There have been some problems with these systems in the past, particularly when not managed or installed properly. A septic tank and treatment trench system is not suitable for heavy clay soils. The second method involves storing the milkhouse wash water in a long term liquid storage facility. Some store both the liquid manure and the milkhouse wash water in the same tank. Although the above methods work satisfactorily when managed properly, there is a need to explore lower cost solutions.

Another increasingly common practice is to collect the wash water and to store it in a tank. The stored water is then used to wash parlour and holding area floors.

New methods for disposing of milkhouse wash water have been tested in recent years. Alfred College of Agriculture and Food Technology (ACAFT) has tested a modified septic system featuring a raised peat bed (Weil and Malcolm, 1991). They have also developed a flocculator which adds lime to the wash water and removes most of the phosphates and suspended solids.

Another new method has been tested at Kemptville College of Agricultural Technology (KCAT). Wash water is reused in domestic and industrial applications such as in washing machines and the washing of the tank-trucks at dairies. Farmers have not accepted the practise of recycling milk pipeline wash water due to a lack of commercial equipment and a fear of increased bacterial counts in raw milk. And although recycling does not replace the need for a treatment system, there are several advantages to reusing wash water. Tests show (Brunet, Cuthbertson, Hunter and Seguin, 1996) that substantial savings in hydro, soap and wash water volume can be achieved. Researchers at KCAT have found that recycling wash water on the farm can be done without affecting water quality.

Vegetative filters have been used in parts of the United States to treat milkhouse wash water and yard runoff for approximately ten years (Barker et al., 1986; Magette et al., 1986; Schweret al., 1981; Sherman et al., 1982; Stearns et al., 1982; Vanderholm et al., 1979). The principle is to treat runoff and/or milkhouse wash water by infiltration, settling, dilution, filtration, and absorption of pollutants. Research at various institutions has concluded that vegetative filters are 80% effective. Since vegetative filters have never been used in Ontario, it was proposed in 1994 to study the effectiveness of vegetative filters under Ontario conditions by putting such a system in place on a dairy farm in eastern Ontario. A vegetative filter was constructed in 1995 on the farm of Peter Nooyen near Metcalfe, Ontario, for this purpose. This is the final report on the monitoring period extending from the spring of 1995 to the summer of 1996.

Literature Review

Most of the research on vegetative filter strips has been conducted in the United States over the last fifteen years, although at least one project has been conducted in Canada.

Vanderholm and Dickey (1979) evaluated the performance of both channelized and overland flow vegetative filters in Illinois on a number of farms. Results indicated that a nutrient removal of 95% was obtained on a mass balance basis and 80% on a concentration basis. They found that the overland flow filter provided better treatment than the channelized filter. They also determined that contaminant removal was directly related to flow distance and contact time with thefilter. For the design of vegetative filters they recommend a minimum contact time of two hours, based on a one year two hour rainfall event.

Based in part on the work done by Vanderholm and Dickey, Stearns et al. (1982) developed a set of vegetative filter design criteria for Illinois conditions. The typical vegetative filter system would include a settling basin, effluent transport system, distribution manifold and the vegetated filter strip. The design criteria are mainly based on the amount of runoff generated from livestock yards, although milkhouse wash water is also accounted for.

Lagace et al. (1987) evaluated the use of a vegetated filter strip for the treatment of beef feedlot runoff in Quebec. A settling basin and vegetative filter were designed for treating runoff from a 75 head operation. The results indicated that a removal of more than 99% of most pollutants was obtained. Results also indicated that the settling basin does not play as important a role in Canadian conditions as it does in warmer climates.

Barker and Young (1986) successfully demonstrated the use of vegetated filter strips for treating feedlot runoff and milkhouse wastewater in mountainous areas. Because the slope of the filter exceeded that recommended by other researchers, they designed the filter as a series of terraces separated by berms. The berms were used to slow down the flow and to redistribute the runoff across the width of the filter strip. Results indicated that the filter reduced organic and nutrient loads by 98%.

Objectives

The objective of this project was to evaluate the performance of a vegetative filter strip used for treating milkhouse wash water under Ontario conditions by installing and monitoring a vegetated filter strip at a dairy farm in eastern Ontario. This research would fulfil the following objectives:

a) To evaluate the performance of a vegetative filter strip for the treatment of milkhouse wash water.

b) To evaluate the effectiveness of a vegetative filter strip during the winter and early spring when vegetation is dormant.

c) To evaluate the environmental impact of vegetative filter strips used under Ontario conditions.

Filter Strip Design

The "Illinois Vegetative Filter Design Criteria" (Stearns et al. 1982) was used as the main design tool for the vegetative filter strip itself. Modifications were made as appropriate for the collection system and the effluent transport system. Conservative design values were used throughout the design. Refer to Fig. 1 for a diagram of the system installed at the farm of Peter Nooyen.

Three filter strips were used in the study. One strip was used as control (3 m x 183 m) and the other two (12 m x 183 m each) were loaded alternately. It was expected that for Ontario conditions it would be necessary to switch to a second strip in the winter to prevent overloading of nutrients on the first strip.

The soil at the vegetative filter location is a loam and the land slopes to the South at approximately 2%. Based on past research this requires a filter length of 183 m in order to provide a 2 hour contact period.

The following equation is used to determine the required filter strip area:

FAA = (VR x 100) / ((2 hours x SI) - 4.3 cm)

where: FAA = Field application area (square meters)
VR = Volume of feedlot runoff (cubic meters)
SI = Surface infiltration rate (cm/hour)

In the above equation, the term 100 is for unit conversion, the 2 hour term is the design contact time, and 4.3 cm is the maximum amount of rain for a 1 year, 2 hour design storm event.

Based on an estimated SI of 3 cm/hour for a loam, and a calculated total weekly runoff of 48.2 cubic meters (for both the yard runoff and milkhouse wash water volume), the equation becomes:

FAA = (48.2 x 100)/((2 x 3) - 4.3)
= 1302 square meters

The minimum width of the strip becomes: 1302 m^2/ 183 m = 7.11 m

Based on a survey conducted by Weil et al. the average P loading in milkhouse wash water is 161.5 mg/L. This would result in a total P loading of 6.7 kg/year. According to current crop recommendations (OMAF publication 296) for forages, a medium P fertilizing rate is 30 kg/ha. Therefore the area required to dispose of 6.7 kg of P would be

0.223 ha. For this reason it was decided to increase the design width of the strip to 12 m in order to not exceed the recommended loading rate.

Collection Tank and Effluent Transport System

Most research suggests the use of a wedge shaped concrete settling basin varying in depth from 0.6 m to 1.2 m and in width from 2.4 m to 4.6 m. The effluent then enters a vertical perforated pipe and flows by gravity to the filter strip. In those studies, the settling basin was designed mainly to settle out manure solids before the effluent was allowed into the pipe. The basin would be emptied out by front end loader approximately twice per year. Because this research project deals mainly with treating milkhouse wash water rather than yard runoff, it was felt that a more sophisticated collection system should be used. A septic tank, which is designed to skim off floating scum and settle out heavier solids, seemed to be an excellent choice since it was commercially available. An 800 gallon conventional septic tank was installed to collect effluent from the milkhouse.

A stainless steel submersible sewage sump pump located in an overflow tank adjacent to the septic tank pumped the effluent through a 1.5" diameter PVC pipe to the top of the filter strip. The distribution manifold at the top of the filter strip consisted of conventional 4" diameter sewer pipe with ½" holes spaced evenly at 2.0' on centre along the 40' wide strip. Two different designs were tested for the distribution system. Refer to Figure 2 for a schematic of the two distribution systems. In order to further assist in the distribution of wash water leaving the distribution manifold, a 6" deep, 6' wide gravel spreader was installed underneath the distribution manifold. The gravel helps to protect the native soil from erosion, as well. A directional valve located between the two filter strips permitted switching from the first to the second filter strip when needed.

Monitoring

The main piece of monitoring equipment purchased was an automatic water sampler. The sampler was installed at the bottom of the strip to record the quantity and quality of any runoff during a rain event. A collection ditch was constructed at this location along the width of the two strips to intercept any runoff and redirect it to the water sampler. A bale counter hooked up to a floating ball in the collection pail determined the volume of water exiting the strip. Similarly, another bale counter was installed in the sump pump collection tank at the top of the strip to measure volume of wash water being discharged onto the filter strip. A rain gauge had also been installed at the site in order to record rainfall data.

Although the original plan called for water wells, these were not installed for two reasons. First it was suggested by colleagues that three years is not enough to measure any meaningful changes in the groundwater quality. Secondly, it was discovered that the cost of getting the wells installed by a knowledgeable consultant were considerably more than what had originally been budgeted. It is hoped that this project will be continued or extended beyond the end of the current funding period in order to study long term changes to groundwater quality.

To monitor the vegetative filter strip performance the effluent was sampled and analysed for microbial and chemical content, and soil samples were taken yearly. Composite samples were made up of six cores each.

Results

This project has suffered a number of setbacks that were beyond the control of the research team. In early 1994, when the proposal was submitted, it was planned to monitor the project over three growing seasons. Three years was thought to be the absolute minimum amount of time required to monitor the project. Unfortunately, the project was approved in late September, forcing a delay in the construction of the filter strip until the following spring. This effectively reduced the monitoring of the system to two growing seasons.

It also became clear that farmer co-operation might become an issue over time. Although it was originally agreed to that forages would be grown on the filter strip, the farmer decided without consultation in the spring of 1995 to grow corn, due to winterkill in the alfalfa the previous winter. In addition, there were several incidents where the system had been disturbed. For example, the distribution pipes had been moved on one occasion in order to allow a tractor to work near the top of the filter strip. On another occasion, the farmers' children had been playing near the pump house and disconnected the pump which feeds the distribution system. And, although the farmer had agreed to collecting rainfall data, this was never done.

Weather played a part in that the summer of 1995 was an extremely dry year, yielding no water samples at the bottom of the strip. Although 1996 yielded some samples, these were not enough to form a meaningful data bank.

Another devastating blow to the project came as a result of job changes for both project leaders in 1996. As a result of this, the little amount of data that had gathered in 1996, the only year yielding water samples, could not be analysed. Kemptville College, in the meantime, had been purging obsolete files from offices in preparation for the change over to the University of Guelph. Consequently, soil sample results and water sample results originally filed at Kemptville College could not be located at the time of this report.

Discussion

In spite of setbacks to the project, the system has proven dependable over two relatively harsh Ontario winters, and visual observations indicate that both distribution manifolds worked extremely well. Even pressure was observed along the 40' wide distribution manifolds for both distribution systems, indicating that the wash water was being distributed evenly across the filter. The gravel spreader helped in slowing down the flow and providing further distribution of the wash water.

The strip recovered well in the spring as a result of switching to the second distribution manifold. Although there is little or no data to support this, it became evident that wash water surface runoff will never reach the bottom portion of the strip. In fact, it appears that the length of the filter strip could be reduced substantially, especially for open soils such as sands and loams. During discharge it was observed that most of the wash water had infiltrated the soil within 40' of the top of the filter. This rapid infiltration would support the earlier hypothesis that contaminated runoff will never reach the bottom of the strip, but at the same time raises the concern that the top of the vegetative filter may become overloaded with nutrients over the long term.

Odour levels were monitored qualitatively during the study. As expected, some odour was detected during hot summer days, but only when standing within about 20' of the distribution pipe. Little or no odour was detected during the fall, winter, and spring. It appears that odour levels are not going to be a major concern, especially when the first rinse is fed to calves, as was being done on this farm. For farmstead planning purposes, however, filter strips should be treated the same as septic systems and kept as far away as possible from incompatible uses such as the well and the farm home.

Recommendations

It is recommended that the project be continued for at least five years in order to study the long term movement of nutrients and to establish a meaningful database. In order to accomplish this, it would be advisable to install a number of observation wells to monitor groundwater quality, combined with a thorough soil and water sampling program. For the observation wells, it is recommended that the new budget include some money to hire a consultant. Water samples should be analysed for various contaminants such as BOD, TKN, ammonia N, total P, and faecal coliform bacteria.

As well, it is recommended that, if the work is to be continued at the same site, there be a detailed written contract signed by both the farmer and the research team, outlining the obligations of each. In addition, the contract should include such things as the cropping rotations, fertilizer program and manure spreading schedule, as well as the location of observation wells and monitoring equipment which are not to be disturbed. It is also recommended that the farmer complete a nutrient management plan with a consultant or a representative from OMAFRA. This will ensure that the quality of the research will be maintained.

The project budget should include, in part, the salary of a summer student for each year, the construction of water wells, and expenses relating to detailed analysis of water and soil samples done at private laboratories.

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