A Subsurface Flow Constructed Wetland to Treat Milking Centre Washwaters

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Introduction

Milking centre washwaters include the rinse waters from the milking lines as well as any floor washwaters from milking parlours. Milking lines are rinsed four times during each milking session with water, acid, sanitizer and again with water. The washwater may also include manure and bedding residues from parlour floor rinsing. The washwater can be 10-20 times more concentrated than domestic sewage, with organic matter ranging from 500-2600 mg/L BOD₅ and solids ranging from 200-1000 mg/L TSS [1]. As well, phosphorus, which is contained in milk, manure and sanitizing products, promotes algae and aquatic plant growth, which in excess can be harmful to the environment.

The common methods of managing washwaters are to either add the washwaters to a liquid storage or liquid manure storage and land apply the material or discharge the washwaters to a septic system [2]. Dairy farms with solid manure practices are not permitted to add washwaters to the manure pile and therefore must manage the washwaters separately. Conventional septic systems are prone to failure from the high grease content of the washwaters, which can ultimately clog the septic bed.

This project studies the use of a subsurface flow constructed wetland with a passive phosphorus filter to reduce washwater concentrations to levels suitable for discharge to a septic bed.

System Design

The Lawrenceholme Dairy Farm milks 35 cows in a tie stall operation with a milking parlour. The farm is located in Spencerville, Ontario, 50 km south of Ottawa. The washwaters include rinse waters from the milking lines (2 times per day), parlour floor (2 times per day) and bulk tank (2 times per week).

A subsurface flow wetland system was designed to reduce solids and organic matter concentrations to below septic tank effluent levels and to reduce phosphorus concentrations prior to discharge into septic bed trenches. The system was designed for 1700 L/d based on recommendations from the milking equipment manufacturer. Two 3600 L septic tanks were installed prior to the wetland cell to remove settleable solids and grease. The second tank was retrofitted to act as a grease trap by installing 4 inch 90 degree PVC pipes into the baffle wall to lower the openings to 1/3 the liquid depth from the bottom of the tank. Each tank has a nominal retention time of 2 days.

The wetland system was designed with a hydraulic retention time (HRT) of 7 days. A plan and side view schematic of the system are presented in Figures 1 and 2.
The inlet pipe consists of a 4 inch perforated PVC pipe laid in the top 10 cm of gravel. The end caps should not be glued in order to facilitate cleaning. The wetland cell consists of a 30 mil impermeable liner placed on a bed of sand (to protect the liner) filled with 0.6 m of granular material. The liner is extended up the sides of the wetland and is toed into the side berms. The exposed sides of the liner are covered with soil to avoid degradation from UV rays. At the outlet of the wetland cell, the liner forms an overflow weir at 0.5 m depth. This avoids the need to puncture the liner with an outlet pipe, which is difficult to do without specialized equipment. The inlet zone consists of 1.0 m of 2.5 cm (1”) washed gravel, followed by 9.0 m of 1.2 cm (½”) washed gravel then 2.0 m of 2.5 cm (1”) washed blast furnace (BF) slag.

The slag was obtained from the IVACO rolling mills in L’Orignal, Ontario. Slag is a waste product from the steel production industry, which contains high concentrations of calcium oxide (CaO) as well as high concentrations of aluminium and other cations, which precipitate and adsorb phosphorus from solution. The washwaters then flow through a further 3.0 m of gravel and into a septic bed. The last section of gravel was initially filled with peat; however, the peat clogged at the slag/peat interface and had to be removed and replaced with gravel. Wetland plants (reeds and cattails) can be transplanted from a nearby ditch at a density of 9 root segments per m² or 1 clump of plants per m², as was the case in this installation.
Operation and Maintenance

There are three basic O&M items to consider:

1) Maintain the pump from the milking parlour to the septic tank;
2) Pump out the two pre-treatment tanks on a regular basis (every 3-4 months); and
3) Cut the grass around the berms.

Pumping out the tanks is easiest with a vacuum pump but can also be accomplished with a solids handling sewage pump; however, some dilution may be required. The solids can be pumped directly into a solid manure spreader and land applied. If solids are allowed to accumulate in the tanks and overflow into the wetland cell then the header pipe could become clogged and require cleaning.

The wetland plants do not need any attention. They will die off naturally in the fall, creating an insulation layer over the bed, and new shoots will develop in the spring.

System Performance

System performance in terms of organic matter and solids removal is presented in Figures 4 and 5. The combination of two pre-treatment tanks and a subsurface flow constructed wetland cell performed very well in reducing both $\text{BOD}_5$ and TSS concentrations to septic tank effluent (STE) quality (< 200 mg/L) [3]; which represents removal rates of 90 and 94%, respectively. These results demonstrate the importance of reducing both organic matter and solids prior to the septic bed, in order to avoid premature clogging and failure of the septic bed.

![Fig. 4. BOD$_5$ Concentrations (Avg. ± Std. Dev.)](image)

System Construction: a) Pre-treatment tanks; b) Excavation with sand base; c) Liner extending over berms; d) BF slag and gravel installed with transplanted reeds.
Phosphorus data is presented in Figure 6. The BF slag filter exhibited good removal during the first 4 months of operation, reducing TP concentrations by 74%. This coincided with high pH values from calcium dissolving from the slag surface, suggesting that the removal mechanism is primarily precipitation in a high pH environment (pH=10.1±1.6). However, over the following 12 months an average removal rate of only 35% was observed at an average pH of 7.9±0.4. This suggests that once the surface calcium has dissolved, the long term removal rate using this slag material is reduced to approximately 35%.

Summary

The system has performed very well in reducing both organic matter and solids to levels acceptable for discharge into a conventional septic bed. The BF slag filter was only partially successful in reducing phosphorus levels, with a long term removal rate of 35% observed. Roughly half of the influent nitrogen was removed in the pre-treatment tanks with no removal observed in the wetland cell itself. With regular pumping of the pre-treatment tanks, a subsurface flow constructed wetland followed by a septic bed can provide a low maintenance solution to treating milking centre washwaters.

References


Nitrogen data is presented in Figure 7. Significant removal was observed in the pre-treatment tanks (57%), where manure solids were removed through settling. No nitrogen removal was observed in the wetland cell. This is expected as subsurface wetland cells are anoxic and do not support the oxidation of ammonium.
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