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Treatment of Milk House Wash Water

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Introduction

Milk house wash water is produced from the cleaning and sanitization of milk containers and milking equipment. Incidental manure also enters the water. This water may contain high levels of carbon, measured as chemical oxygen demand (COD), phosphorus, nitrogen, and other pollutants that if not properly removed or assimilated in the soil can contaminate surface and ground water. Small dairy farms face the challenge of efficiently and effectively treating this wash water.

Vertical flow constructed wetlands have the potential to reduce COD and nutrients by using both aerobic and anoxic environments in different cells. However, during cold weather ice formation on the surface of the wetland inhibits treatment. A unique design variation has two vertical levels of flow distribution. During warm periods flow is discharged on the surface to irrigate the plants. In winter, the flow is applied below the surface to prevent ice buildup.

The objective of this research was to determine the effectiveness of a vertical flow constructed wetland with dual flow distribution (VFW) to treat milk house wash water.

Wetland Design

The VFW was designed by Aqua Technologies, Ontario Canada, and Michigan State University. The system was installed at a small dairy farm in Ingham County, Michigan, that milks approximately 30 cows, 2 to 3 times corresponding to a wash water flow of 200 to 280 gal/day. Installation was completed by Aqua Technologies, Michigan State University, and the owner of the farm.

Figure 1: Schematic of the vertical flow constructed wetland.

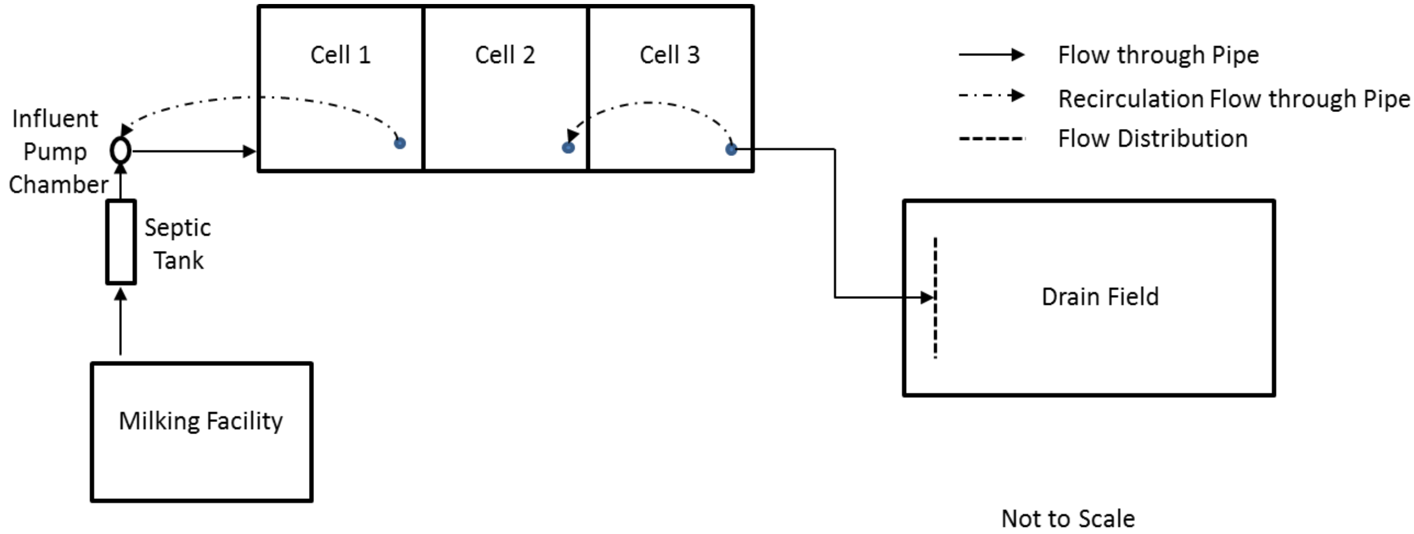


Figure 1 shows a plan view of the VFW. Each cell is 16 ft wide by 16 ft long and 4 ft deep. The cells are lined with a water tight membrane (Figure 2). Pea gravel was used as the media because of its high porosity to minimize the potential for clogging. The initial vegetation consisted of Irish Virginica and Spartina Pectinata (cord grass), in approximately equal quantities. Vegetation helps keep the media open and provides oxygen in summer when it is needed the most because of the high rate of microbial degradation and the low solubility of oxygen in the water.

Milk house wastewater first enters a 500-gal septic site where solids settle and scum floats. The water then proceeds to the influent pump chamber where it is mixed with recycled effluent water from cell 1. Dosing into cell 1 is controlled by a level switch. During warm weather the water is dosed to the surface of each of the cells of the VFW (Figure 3). In colder seasons, flow is subsurface discharged, approximately 18 inches below the surface, so that freezing does not occur. Water percolates through the media to the bottom of the cell where it enters a drainage tile which allows it to flow to the cell's effluent sump (Figure 2). A pump moves the effluent back to the influent pump chamber and another pump, operated by a level switch, moves excess water to cell 2. This cell is designed to remove most of the carbon (as measured by chemical oxygen demand) and nitrify ammonia to nitrate. The second cell is kept saturated by the use of a riser in the effluent pipe before the water falls into the effluent sump. Water is not recycled.

Figure 2: Empty VFW cell lined with drainage tile to collect percolated water.

As in cell 1, water is collected, transported through the riser into the effluent sump, and pumped to cell 3. This cell transforms the nitrate into nitrogen gas (denitrification). The third cell polishes the water, primarily removing excess carbon to very low levels. A pump in the effluent sump operates on a level switch to both recirculate part of the water back to the cell 2 effluent sump (which also serves as the influent sump for cell 3) and the balance to a drain field. The distribution is controlled by a valve on the recirculation line. All pumps are rated at 1 quarter horsepower. The drain field is 32 ft long and 16 ft wide with an approximately 2 ft bed of pea gravel.

Figure 3: Surface distribution of water onto the recently vegetated VFW during warm weather season.

Performance

Effluent COD levels were very low through the entire one year project period (Figure 5 on page 8). The "Septic Tank" designation is the water from the effluent end of that tank before dilution with cell 1 recirculation water. "Cell 1" and similar represent the effluent from that cell where "Cell 3" is the final VFW effluent before the drain field. The average VFW effluent concentration was 59 mg/L/gallon with a standard deviation of 87 mg/L. Most was removed in cell 1. These values were highly skewed by a surge in mid-March resulting from the need to dump a bulk tank of milk into the septic tank. The septic tank was ultimately pumped a few weeks later because of the accumulation of floating fats but, as shown, the VFW proved to be resilient as effluent levels did not rise significantly.

Very high reductions of ammonia levels resulted with an average effluent and standard deviation levels of 1 mg/L N and 1 mg/L N, respectively. Nitrate shows high unexplained influent and effluent variability but still excellent performance. The average value was 5 mg/L NO3 with a standard deviation of 5 mg/L NO3. Nitrate removal generally occurred in cell 2, as anticipated because this cell contained the microbial environment that encouraged denitrification.

Phosphorus (P) removal proved to also be very good with an average effluent level and standard deviation of 6 mg P/L and 4 mg P/L, respectively. This removal is not likely to be sustained as the mechanism is sorption to the pea gravel which generally has a low sorption capacity.

Figure 4: Drain field under construction.

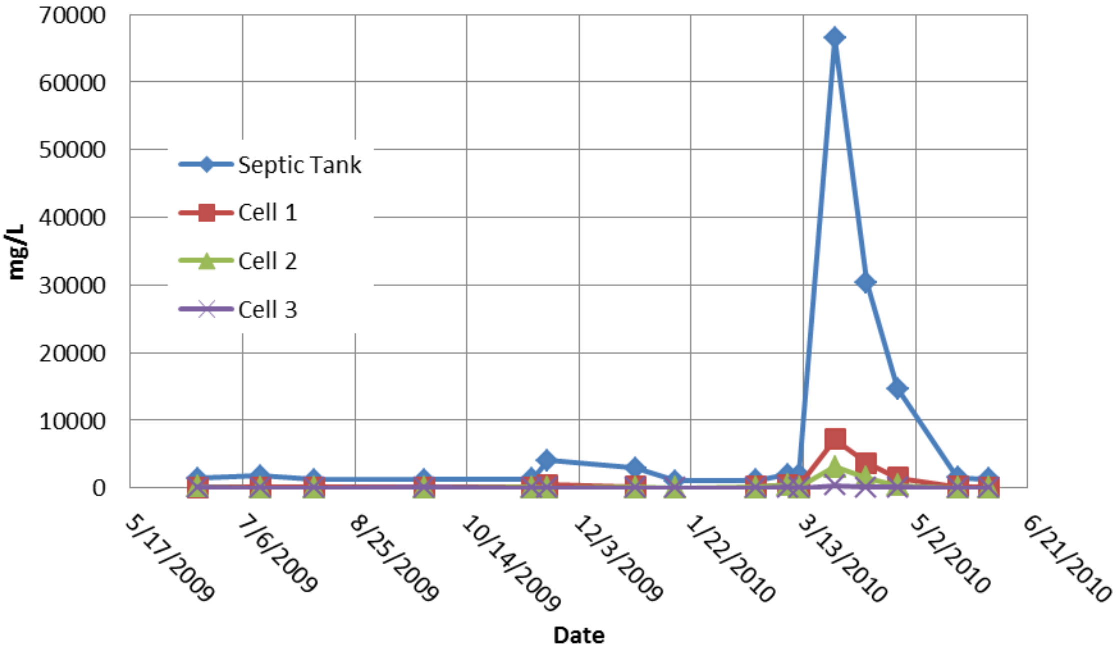
Conclusion

The VFW showed excellent, sustained performance for over 1 year, including over winter and when a bulk tank of milk went through the system. During this time period, the only maintenance directly associated with the VFW was to switch the level of flow distribution. Although the septic tank was pumped out, this likely resulted from the addition of milk.

The approximate cost of the VFW, including the drain field, was $19,000. Labor was the largest component followed by pea gravel media. The very low levels of pollutants in the effluent indicate that the size of the system could likely be reduced because the treatment potential of the drain field was not fully utilized. Further research to develop such a design and monitoring of the existing system is warranted.

Two other systems currently are operating satisfactorily at milking facilities in Canada, one of which has been on line for over 3 years.

Figure 5: Chemical oxygen demand (mg/L) as related to calendar date.



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