



Evaluating Technologies for Reducing Nutrients in Dairy Effluent Demonstration of an Electrocoagulation System

PROJECT BACKGROUND

The Texas State Soil and Water Conservation Board, Texas Cooperative Extension, and the Texas Water Resources Institute are collaborating to demonstrate and evaluate technologies aimed at reducing phosphorus by an average of 50% from dairy lagoon effluent applied to waste application fields in the North Bosque and Leon River Watersheds. In 2005, they evaluated the Electrocoagulation system on a 700-head lactating cow dairy in the Bosque River watershed.

ELECTROCOAGULATION (EC) SYSTEM OVERVIEW

The EC system was demonstrated by Ecoloclean Industries, Inc., Crystal City, Texas. This system uses a series of devices and chemical pre-treatment to separate nutrients and metals from dairy lagoon effluent (Fig. 1).

The focal point of this system is the EC unit. It contains charged electrodes that cause precipitation of phosphorus metals as liquid flows over the electrodes (Fig. 2).

EC SYSTEM CONFIGURATION

During the first sampling event, Ecoloclean made numerous modifications to the system's configuration as Ecoloclean optimized its system. The optimized system is shown in Fig. 1.

Influent from the lagoon was pumped into a large mixing tank where it was mixed with alum and an anionic emulsion polymer (Fig. 3) to facilitate coagulation and separation of solids.

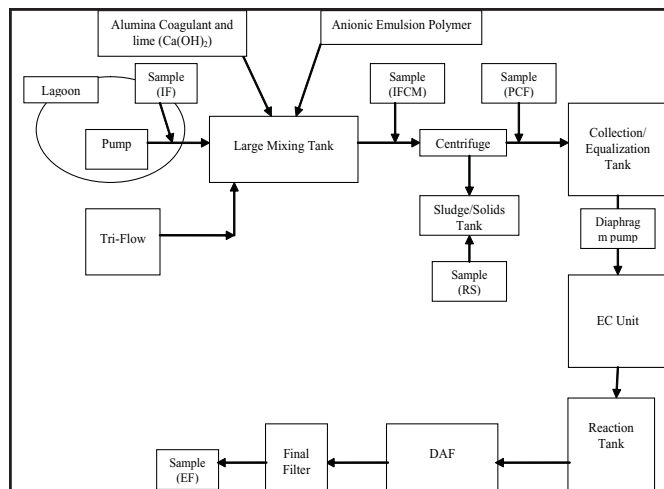


Fig. 1: Schematic of EC System's Component Configuration for July 7 thru August 2, 2005



Fig. 2: EC Unit with Iron Electrodes Built on a Filter Press Frame

Influent with chemical pre-treatment left the mixing tank and entered a centrifuge (Fig. 5) that separated solids and some metals from liquid in the influent. From here, liquid passed through a collection/equalization tank and on to the EC unit. In the EC unit, the liquid was passed over charged electrodes that give off ions, causing coagulation and precipitation of phosphorus and metals.

Liquid moved from the EC unit to a reaction tank with a mixer that allowed sufficient time for complete chemical reactions to occur. A pump then moved the liquid to a dissolved air flotation (DAF) unit that introduced small air bubbles that attracted solid flocculents. The bubbles rose to the top of the tank and were skimmed off of the surface.

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After leaving the DAF unit, the liquid was passed through the final filter which further removed impurities from the liquid and yielded the final treated effluent.

Other system components used at least once but then removed were a poly feed tank with mixer where flocculent was mixed with the solids precipitated by the EC unit to facilitate settling and two clarifier tanks that allowed settling of coagulated solids.

RESULTS

The EC system performance was based on six sampling events beginning June 27 and ending August 8, 2005. Ten sets of 15 (250 mL) grab samples were taken during each sampling event. Sampling quantities and locations were not consistent until the third sampling event due to system setup changes; from this point on, samples taken were:

- 2 sample sets of lagoon effluent (IF)
- 2 sample sets of mixture leaving the large mixing tank (IFCM)
- 2 sample sets of liquid leaving the centrifuge (PCF)
- 2 sample sets of solids exiting the centrifuge (RS)
- 2 sample sets of system effluent (EF)



Fig. 3: Mixing tank with chemical additions

Samples could not be taken at the outlet of each system component due to budget limitations. The lack of a mass balance led to the inability to define any one component's performance or contribution to the EC system. The overall project goal to evaluate the entire system's effectiveness was accomplished despite the limited number of sampling locations.

Table 1: Percent change per measured constituent from system inflow to outflow (negative percentages indicate an increase in measured values)

Parameter	Separation Efficiency
Solids	
• Total Solids (TS)	45.5%
• Total Fixed Solids (TFS)	28.5%
• Total Volatile Solids (TVS)	68.2%
• Total Suspended Solids (TSS)	-21.8%
Nutrients	
• Soluble phosphorus (SRP)	99.5%
• Total phosphorus (TP)	96.2%
• Total Kjeldahl Nitrogen (TKN)	51.2%
• Nitrate-Nitrite Nitrogen (NNN)	77%
• Potassium (K)	38.6%
Metals	
• Manganese (Mn)	24.5%
• Calcium (Ca)	55.8%
• Sodium (Na)	17.8%
• Magnesium (Mg)	51.6%
• Iron (Fe)	-1554.5%
• Copper (Cu)	71.5%
• Aluminum (Al)	-391.3%
Other Components	
• pH	-2.6%
• Conductivity	28%

Generally, concentrations of all constituents analyzed from the lagoon effluent (influent pumped to the EC system) varied among sampling events. This variation may be attributed to the inlet location and depth in the lagoon that may have varied from week to week during these sampling events. Varying inlet locations for dairy lagoon pumps are typical due to changing lagoon levels and the floating pump platforms moving around the lagoon.

Table 1 shows that on average the entire system was effective at decreasing the percentage of most effluent constituents. TSS, Fe, Al, and pH, were the only components that showed a marked increase. Increases in TSS, Al, and pH can most likely be attributed to the addition of Alum, polymer, and the 'mud mix' to the system. The average increase in Fe in the treated effluent is a result of the EC unit emitting ions from the iron electrodes.

Overall performance of the system exceeded the TMDL goal to remove at least 50% of the SRP.

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ECONOMICS

Cost estimates for the operation of the EC system (Fig. 4) was approximately \$0.12 per gallon of treated effluent. These costs include fees for system setup and operation by representatives from Ecoclean Industries, Inc. This estimate does not include costs for residual material removal from the dairy, size of the dairy, the number of cows, and the amount of inflow to the lagoon could affect costs as well.

When compared to conventional treatment methods, EC technology costs are much higher. Costs for conventional treatment typically range from \$5 to \$32 per 1,000 gallons of treated effluent while EC would cost about \$120 to treat 1,000 gallons.



Fig. 4: General layout of the EC system

CONCLUSIONS

Results from six sampling events showed that the system removed TP and SRP on average by 96% and 99.6% respectively from the dairy lagoon effluent. The performance of the entire system with respect to removing metals was sporadic, only Mg was observed to have consistent reductions at each sampling event. The rest of the metals had a wide range of reductions and increases without any apparent trends from event to event. The inconsistencies in the performance of this system for both the metals and the solids is very possibly linked to the changes made in the system's configuration and the changes in the chemical pre-treatment from event to event.

This technology far exceeded the goal of reducing P by at least 50% in lagoon effluent.

REMAINING ISSUES

Disposal of residual solids remains to be an issue with this technology. This system produces a low moisture, concentrated solids by product that might be sold to commercial composters.



Fig. 5: Sample collection at the centrifuge

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