Report for 2002TX49B: Reduced Phosphorus Pollution from Dairies by Removal of Phosphorus from Wastewater through Precipitation of Struvite

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Report Follows:

Reducing Phosphorus in Dairy Effluent Wastewater through Flocculation and Precipitation

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Objective

The objective of my research is to find methods to reduce the phosphorus concentration in dairy effluent wastewater through removal of suspended solids and precipitation of calcium or magnesium-ammonium phosphates.

Hypothesis

The majority of phosphorus in fresh dairy effluent is associated with suspended solids. Removal of solids before wastewater enters the holding lagoons would considerably reduce phosphorus content of water that is held in the lagoons, and reduce phosphorus applied to land when the water is used for irrigation. In addition, based on chemical solubilities, it should be possible to precipitate soluble phosphorus remaining in wastewater as calcium and magnesium-ammonium phosphates if the pH of the wastewater were raised with an addition of ammonium hydroxide. Combined with flocculation of solids, precipitation of soluble phosphorus could leave wastewater applied to fields with agronomically manageable levels of phosphorus.

Materials and Methods

Fresh dairy effluent samples were obtained from a 2000-head dairy in Comanche, Texas. Samples were collected before the wastewater entered the lagoons and stored at room temperature in 50-gallon plastic drums. The drums were open to the room air through a small hole in the barrels' bung. Solids were re-suspended once when the barrels were placed in the laboratory and then allowed to settle with time. Subsamples were withdrawn from the barrels at the time of resuspension and at weekly intervals thereafter.

Flocculation

Suspended solids in the subsamples were flocculated with a mixture of diallyl-dimethyl ammonium chloride (DADMAC) and a medium charge density, high molecular weight, cationic polyacrylamide (PAM). The flocculant was mixed with 40 mL of effluent and allowed to settle. After the floccules settled, clear solution was decanted and analyzed for phosphorus, sodium, ammonium, calcium, magnesium, zinc, manganese, copper, iron, and potassium. Concentrations in flocculated samples were compared to untreated samples.

Precipitation

Studies were conducted to determine when and how high the pH should be raised to precipitate phosphorus. These studies involved filtering the solution after flocculation and then adding ammonium hydroxide solution to 40 mL of the effluent to produce pHs

from 8.8 to 9.3. Other studies focused on the effect that flocculated material had on precipitation and that concentration of flocculant used to remove the suspended solids had on precipitation.

Results

Flocculation

After adding the DADMAC/PAM treatment and mixing the effluent, flocculation occurred in a short time (Figure 1). Within minutes, floccules, aggregates of suspended solids, formed and either floated to the top or sank to the bottom of the column. Whether the floccules floated or sank appeared to be related to the amount of air entrapment in the aggregated masses.

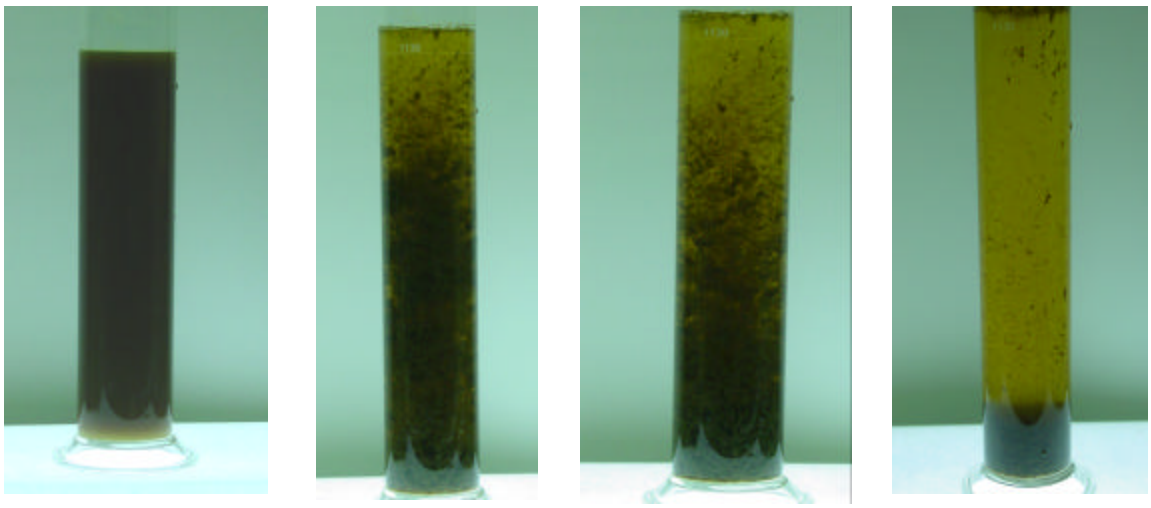

Figure 1: Flocculation of suspended solids in effluent with DADMAC/PAM flocculant. Left to right: untreated effluent, treated effluent 30 seconds after, 1 minute after, and 10 minutes after addition of flocculant.

During storage, solids settled from the solution and total phosphorus concentration in the suspension decreased (Table 1). This mechanism of separation is slow and accounts for an accumulation of phosphorus at the bottom of a lagoon. This phosphorus in the bottom of the lagoon then has the potential to mineralize and form soluble phosphorus. Best management practices suggest if the solids were kept out of lagoons by a fast-acting flocculation processes such as shown using the DADMAC/PAM combination decreased costs of dredging and extended lagoon life would be realized. Additionally, recent studies indicate that the majority of the solids that enter lagoons are converted to methane by microbes and lost to the atmosphere. Methane is a greenhouse gas targeted for reduced emissions.

Table 1: Average % of Phosphorus removed over treatments and time

TREATMENT CONCENTRATION (MG/L)	DAY 1	DAY 8	DAY 15	DAY 30
0	0	39.76	48.83	64.33
0.13	8.41	54.25	51.39	70.06
0.42	11.05	60.06	53.81	68.30
1.3	37.03	62.84	57.86	75.34
3.73	65.21	70.85	60.63	79.30

Larger doses of flocculant were less efficient in reducing phosphorus concentration with time. The decreased efficiency of efficiency was most likely because there were fewer solids in suspension to be flocculated.

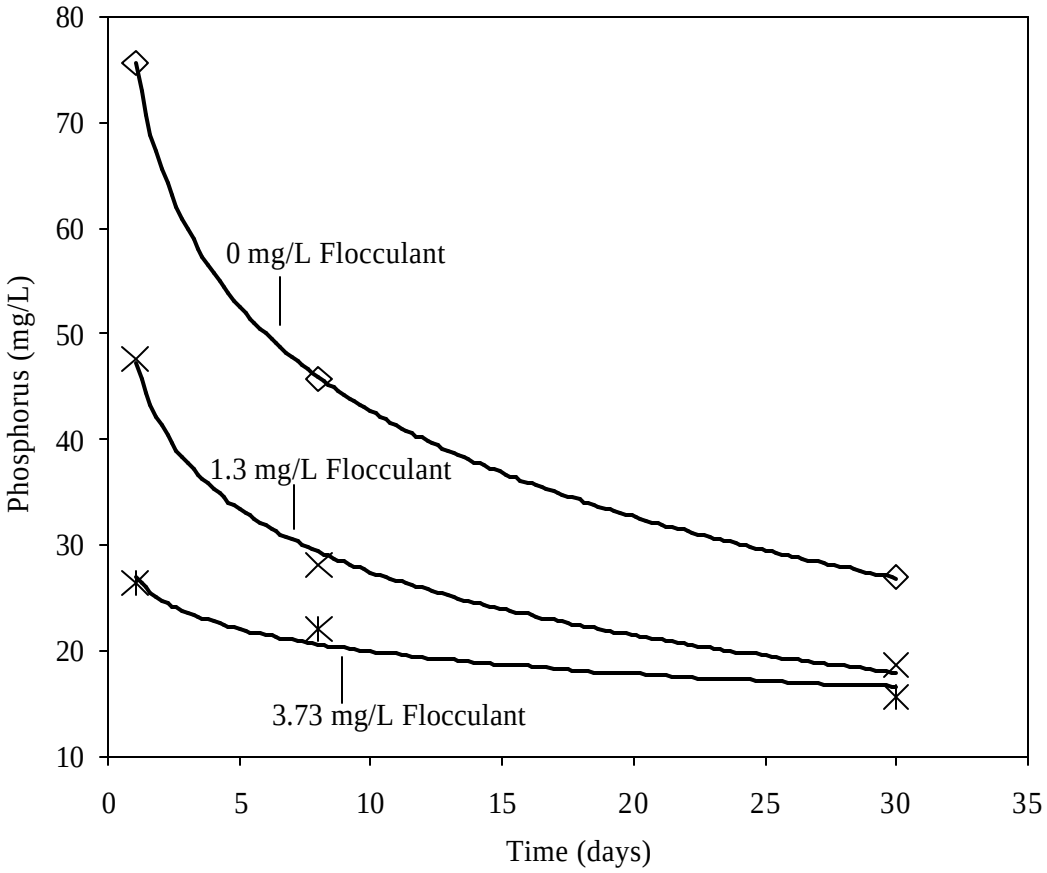

Figure 2: Total P remaining in solution or suspension as a function of time and concentration of flocculant.

Precipitation

When effluent pH was raised above 9 with addition of NH_4OH, soluble phosphorus and calcium declined considerably (Table 2). The concentrations of magnesium did not show a significant change after the pH was raised so the reduction in phosphorus was probably as one or a combination of numerous possible calcium phosphates compounds. The phosphorus which was removed by raising the pH was not precipitated out as struvite, an ammonium-magnesium phosphate. Struvite forms readily in effluent from swine operations, but not from dairy operations.

Table 2: Average Phosphorus and Calciumreduction after raising the pH to 9.1 with NH_4OH at 30 days after suspension.

FLOCCULANT CONC.	P BEFORE	P AFTER		CA BEFORE	CA AFTER	
mg/L	mg/L	mg/L	% reduction	mg/L	mg/L	% reduction
0	25	26	0	217	217	0
0.13	27	9	65	250	31	87
0.42	26	7	71	274	29	89
1.3	18	3	81	274	16	94
3.73	16	2	90	260	14	94

Conclusion

Phosphorus concentrations in dairy effluent can be reduced considerably by treating the effluent with flocculates to remove suspended solids and then with a base such as ammonium hydroxide to precipitate soluble phosphates.