FIELD-SCALE EVALUATION OF TWO LAGOON-BASED SWINE WASTE TREATMENT ALTERNATIVES

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ABSTRACT

Two field demonstrations of alternative swine waste treatments were begun during Spring '97. The Partial Lagoon Aeration project was conducted at a 7,300 head capacity feeder-to-finish operation, in Sampson County, that consisted of seven swine houses and two lagoons. The test lagoon was built in September 1991; the control lagoon was built in July 1994. The test lagoon had smaller surface area and greater depth than the control lagoon. A ½-hp floating aerator (Lagoon Saver Model A, Key Dollar Cab Co.) was used for the project. The manufacturer reported a 1-acre effective aeration area for that model (Mr. Henry Svehaug, 1996, Key Dollar Cab Co., 114 SW 5th, Milton-Freewater OR 97862, personal communication). The aerator may be more accurately described as an impeller. The propeller served to bring liquid from deeper in the lagoon to the surface, where it could then spread out.

The nutrient concentrations observed within the test lagoon liquid during the April through October '98 period were less than those observed during the same period of the previous year as follows: TKN, 17.7%; ammonia-N, 17.1%, and total phosphorus, 22%. During the same time periods, the nutrient concentrations within the control lagoon were not significantly different. The aerator was turned off on November 1, 1998. Sampling will continue through Spring '99, so as to observe if the test lagoon nutrient concentrations revert to pre-aeration levels. The aerator used very little electricity (5670 kWh) during the project, with a total energy cost of approximately $340.00 for the entire 19 months.

The Polymer Enhanced Solids Separation project was conducted at a 14,400 head capacity feeder-to-finish operation, in Bladen County, that consisted of 12 swine houses and 3 lagoons. The houses were grouped such that the effluent from four houses discharged into its own lagoon. Two of the lagoons were conventional treatment, whereas the third lagoon received waste liquids that were mixed in a pumping pit and passed through a solids separator. All of the lagoons went into operation during 1995. The separator was a Model 250 inclined belt press unit, manufactured by Key Dollar Cab Co., Inc. (Mr. Henry Svehaug, 114 SW 5th, Milton-Freewater OR 97862). The conventional lagoon closest to the test lagoon was selected as the control.

The test lagoon contained approximately 13% less total Kjeldahl nitrogen and 12% less total phosphorus than did the control lagoon. Weather (freezing conditions) and usefulness of the separated solids were two of the key reasons why the solids separator was sometimes by-passed. Overall, the separator was by-passed approximately 30% of the time. Bench-scale separation evaluations indicated that the 1/32" screen would be a more efficient choice, than the 1/16" screen, for situations either with or without polymer additions. Addition of 60 mg/L polyacrylamide (PAM) cationic polymer was determined to be the optimal dose, based on improved removal efficiency and polymer cost.

INTRODUCTION

The two field demonstration projects described here were among the 11 selected in 1996 through competitive proposal submission for funding with monies designated by the North Carolina legislature. In both cases, technologies to reduce lagoon liquid nutrient concentrations were evaluated. The project sites were operating, conventional, lagoon-based facilities. Both sites were feeder-to-finish operations.

OBJECTIVES

The objective of the Partial Lagoon Aeration project was to:

1. Evaluate the effect of partial lagoon aeration on the concentrations of nitrogen present in a swine waste lagoon.

The objectives of the Polymer Enhanced Solids Separation project were to:

1. Evaluate the effectiveness of an inclined belt press separator, with and without addition of feed-approved cationic polymer, for the separation of swine waste solids from liquid wastes under actual operating conditions. Nutrient concentrations within the test lagoon would also be compared to those within the control lagoon.

2. Investigate the utilization of separated swine solids (*e.g.*, fermentation, composting).

METHODS AND PROCEDURES

Partial Lagoon Aeration

Separate samples were collected from the test lagoon at both the aerated and non-aerated ends. Samples were also collected from the control lagoon. These samples were sent to NCDA&CS Agronomic Division and to the NCSU Environmental Analysis lab for analyses. Samples were collected every other week during the first four months, then every three weeks during the remaining months. The aerator was directly connected to a power meter, so energy usage and associated costs could be determined.

Polymer Enhanced Solids Separation

The test facility was sampled from four sites: flushtank, pumping pit, post-separation (but prior to lagoon entry), and within the lagoon. The control facility was sampled only at the lagoon. Lagoon and waste samples were collected every other week for the first four months, then every three weeks for the remaining months. These samples were sent to NCDA&CS Agronomic Division and to the NCSU Environmental Analysis lab for analyses. During the first 16 weeks that a new batch of hogs were present, samples from the pumping pit were collected every other week for polymer evaluation at the USDA-ARS lab in Florence SC.

RESULTS AND DISCUSSION

Partial Lagoon Aeration

Figures 1-6 depict analytical results from the aerated and non-aerated ends of the test lagoon, as well as from the control lagoon. Disruptions to the test lagoon that mix sludge with the lagoon liquid are readily observable, particularly in the total phosphorus and chemical oxygen demand results (Figures 4 & 6).

Polymer Enhanced Solids Separation

Figures 7-12 depict analytical results from the control and test lagoons. The COD results (Figure 12) suggest an increasing trend in chemical oxygen demand levels; however, the Partial Lagoon Aeration project COD results (Figure 6) showed similar results during the same time period. The bench-scale results using the cationic polymer with the 1/16" screen are presented in Figure 13. The dashed lines represent the average removal obtained over the five trials. Bench-scale removal was also evaluated using a 1/32" screen: 1/16" screen without polymer, 5.8% (range 1.5 to 9.3%); 1/32" screen without polymer, 15.3% (range 12.7 to 17.9%); 1/16" screen with polymer, 22.7% (range 21.1 to 25%), and 1/32" screen with polymer, 57.5% (range 47.2 to 64.2%).

SUMMARY AND CONCLUSIONS

Partial Lagoon Aeration

Measurable decreases in test lagoon concentrations of TKN, ammonia-N, and total phosphorus were observed. During the same time periods, the nutrient concentrations within the control lagoon were not significantly different. The aerator used very little electricity (5670 kWh) during the project, with a total energy cost of approximately $340.00 for the entire 19 months. The aeration equipment was unobtrusive and relatively trouble free. Economic evaluation of the system is being conducted.

Polymer Enhanced Solids Separation

The test lagoon contained less total Kjeldahl nitrogen and total phosphorus than did the control lagoon, even though the separator was by-passed approximately 30% of the time. Weather (freezing conditions) and usefulness of the separated solids were two of the key reasons why the solids separator was sometimes by-passed. Increased use of the separation equipment may be promoted by installing a shed around the separator. Also useful would be a readily apparent use for the separated solids, so that the producer sees it as a benefit; not as an additional drain on personnel time.

Bench-scale separation evaluations indicated that the 1/32" screen would be a more efficient choice, than the 1/16" screen, for situations either with or without polymer additions. Addition of 60 mg/L polyacrylamide (PAM) cationic polymer was determined to be the optimal dose, based on improved removal efficiency and polymer cost. Economic evaluation of the system, with and without polymer addition, is being conducted.

ACKNOWLEDGMENTS

Project funds were provided by the North Carolina legislature through the NC Department of Environment and Natural Resources. Management of the 11 projects was conducted by the North Carolina State University Animal and Poultry Waste Management Center (Dr. Mike Williams, Director). Thanks go to the livestock facility owners, Mr. Nash Johnson and Mr. Kermit Williamson, without whose cooperation these field projects would not have been possible. Thanks also go to Star Maready (NCCES, Duplin Co.), George Upton and Dan Bailey (NCCES, Sampson Co.), Rachel Huie (NCSU Environmental Analysis Lab), and Lynn .Worley-Davis (NCSU Poultry Science).

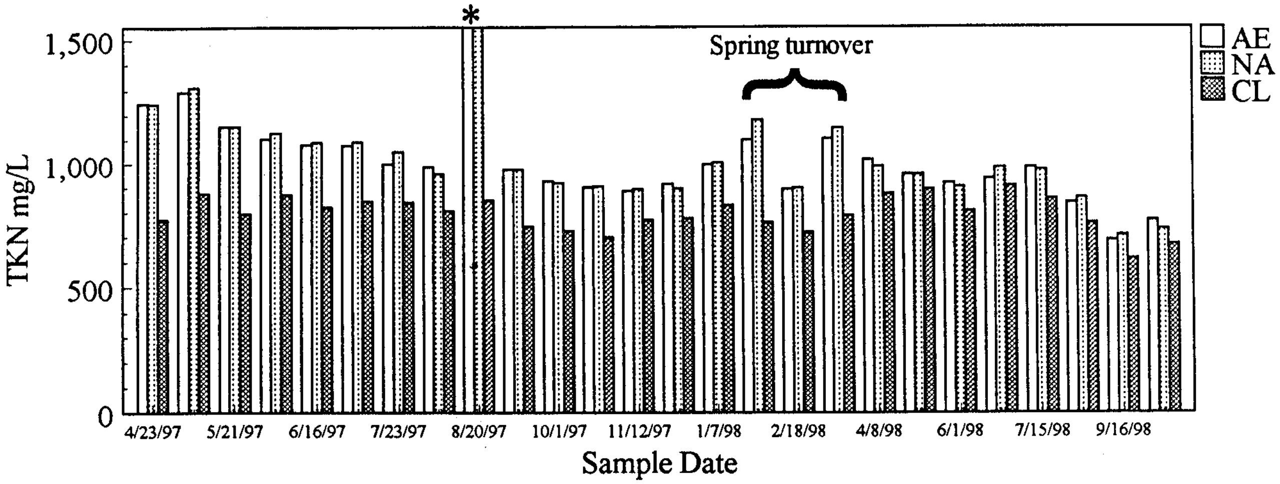

Figure 1: Aerated end (AE), Nonaerated end (NA), and Control lagoon (CL) concentrations;
* indicates samples may have contained some sludge along with the liquid

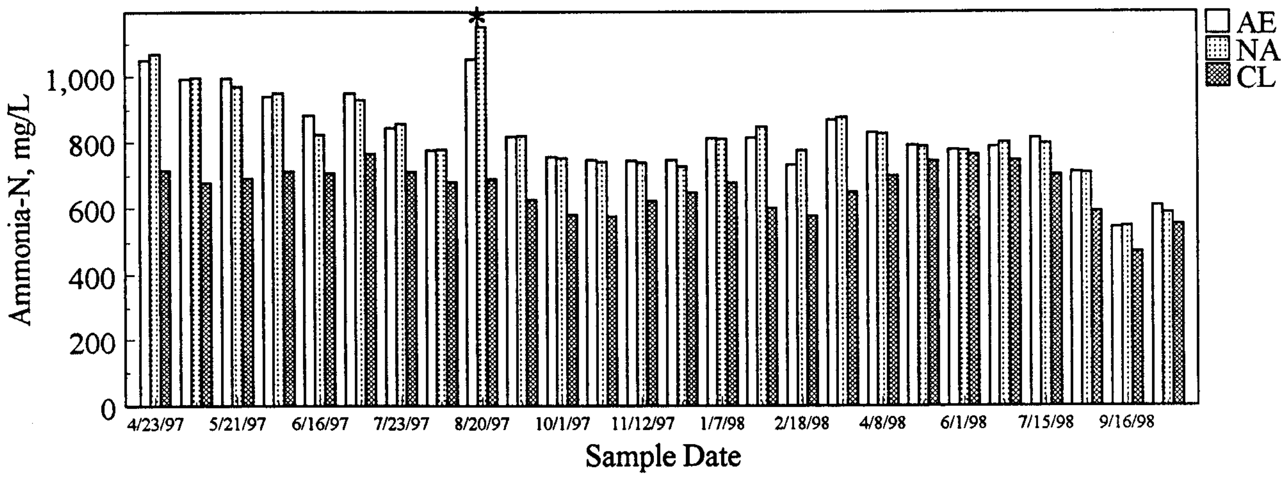

Figure 2: AE, NA, and CL ammonia-nitrogen concentrations, NCSU analyses

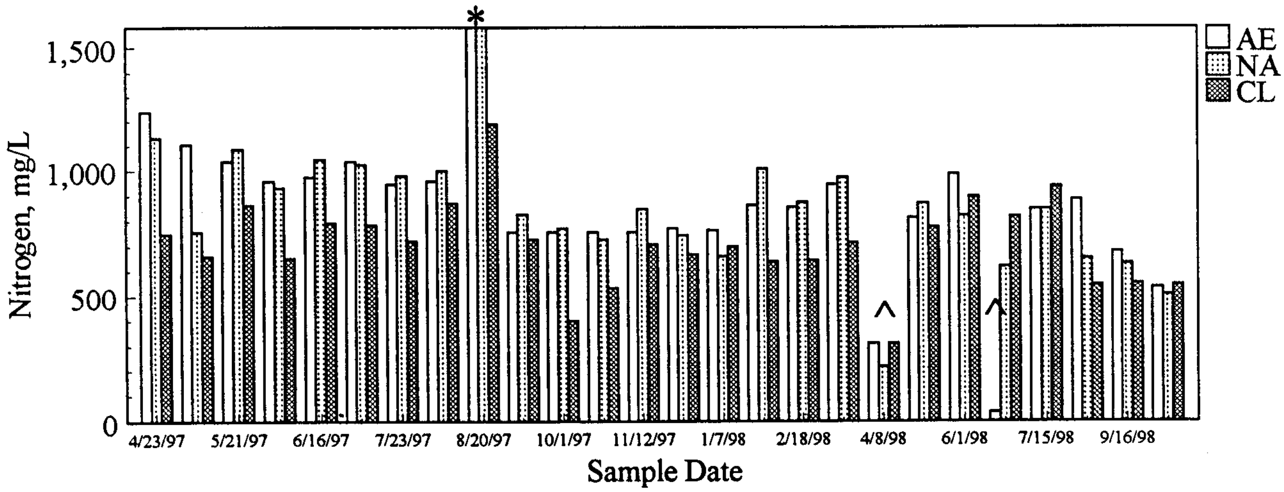

Figure 3: AE, NA, and CL nitrogen concentrations, NCDA analyses; ^ indicates possible outlier

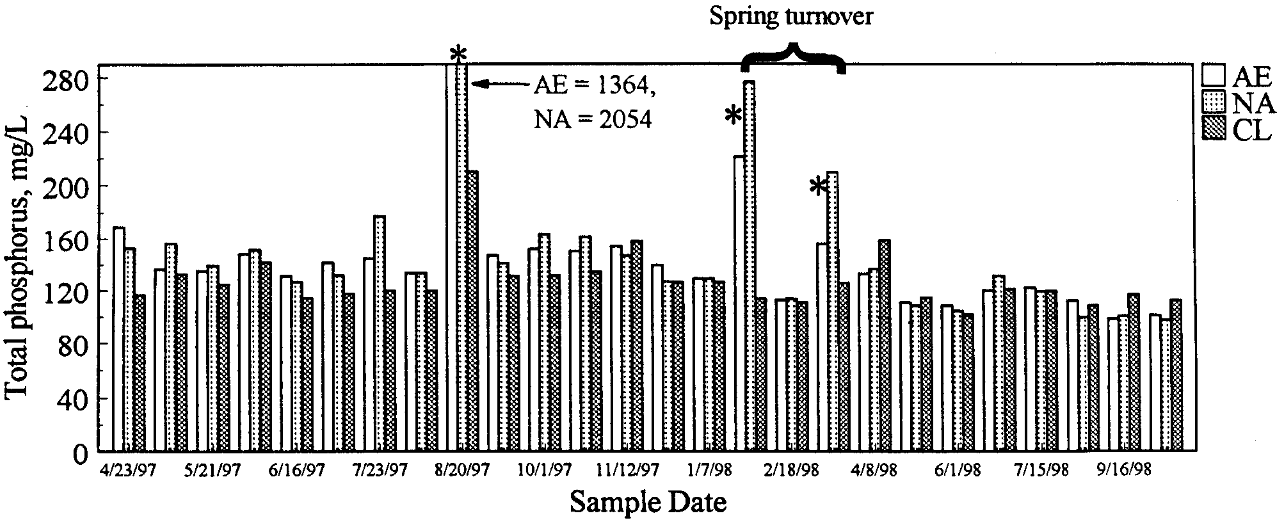

Figure 4: Aerated end (AE), Nonaerated end (NA), and Control lagoon (CL) concentrations; * indicates samples may have contained some sludge along with the liquid

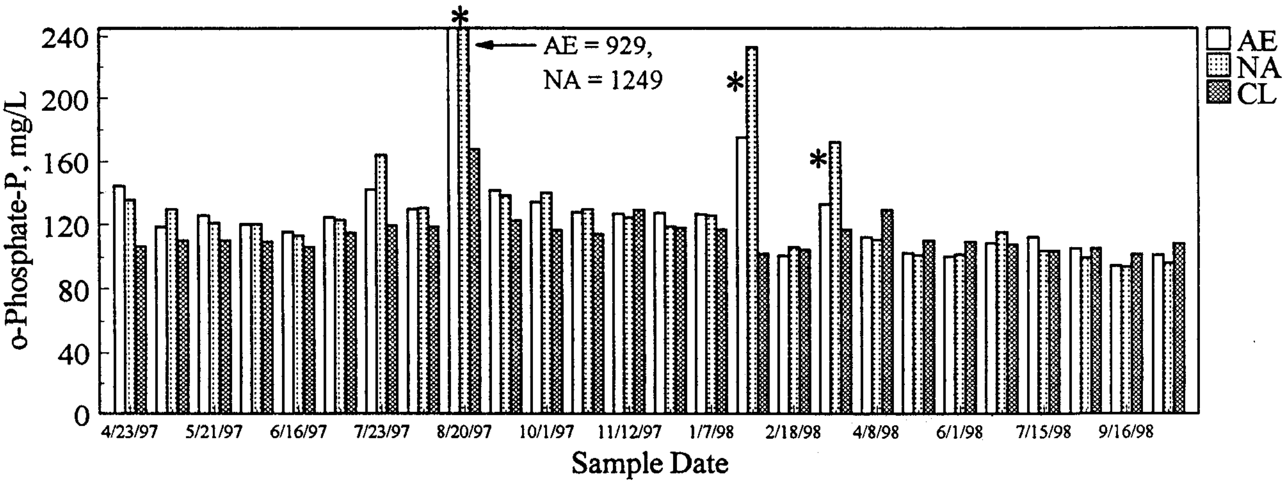

Figure 5: AE, NA, and CL ortho-phosphate phosphorus concentrations, NCSU analyses

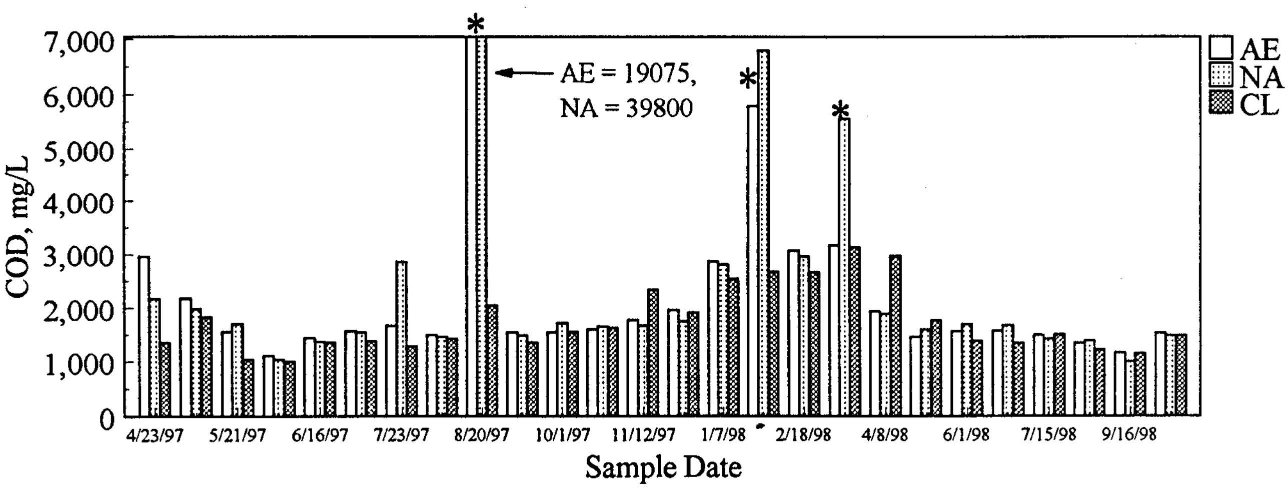

Figure 6: AE, NA, and CL chemical oxygen demand, NCSU analyses

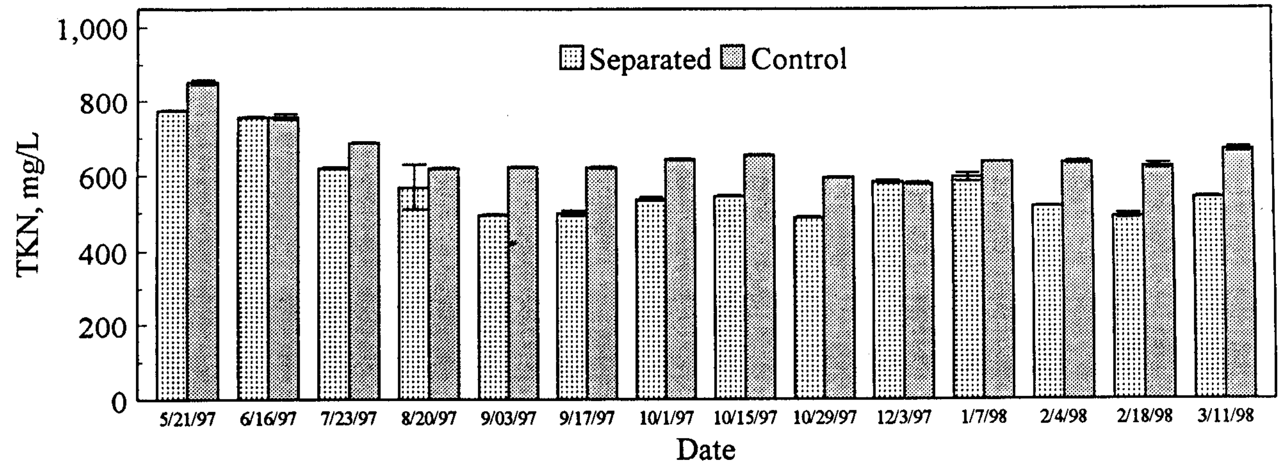

Figure 7: Separated and Control lagoon Total Kieldahl Nitrogen concentrations, NCSU analyses

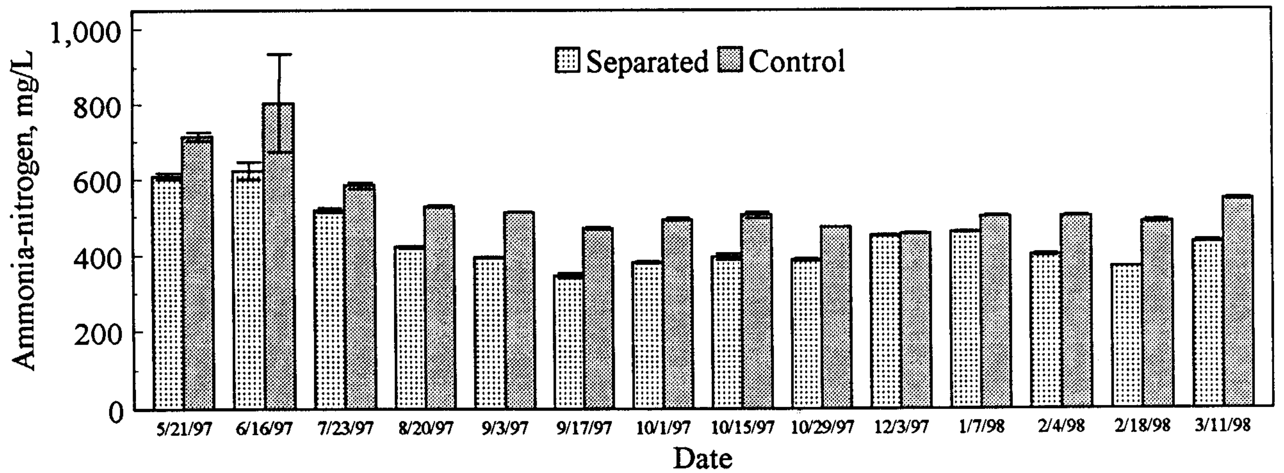

Figure 8: Separated and Control lagoon ammonia-nitrogen concentrations, NCSU analyses

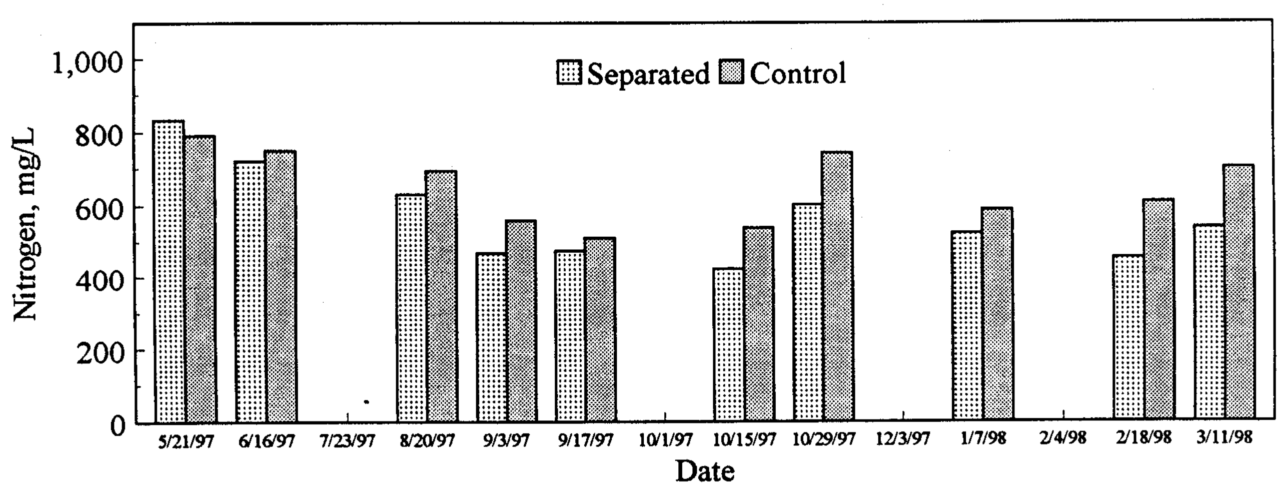

Figure 9: Separated and Control lagoon nitrogen concentrations, NCDA analyses

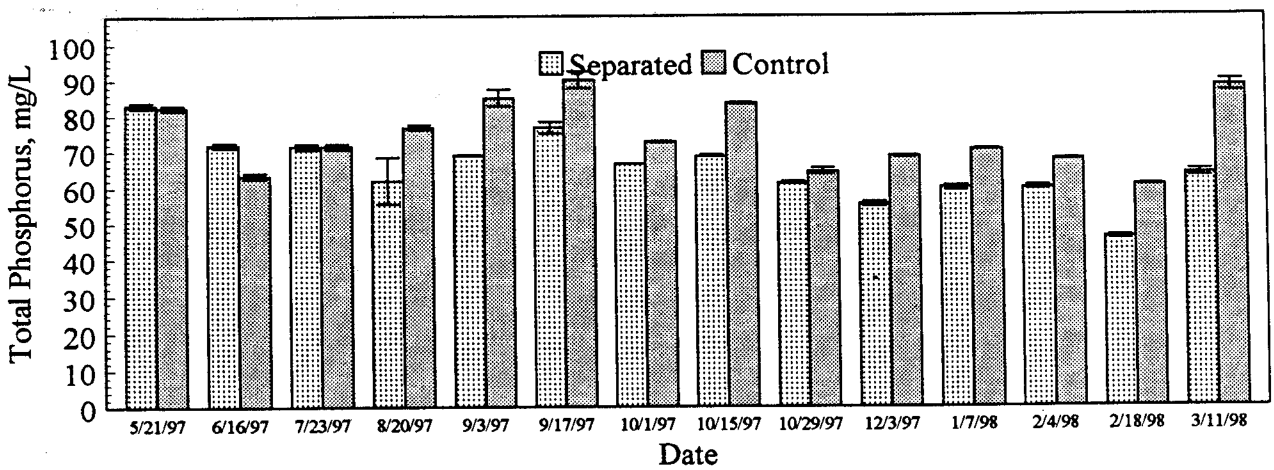

Figure 10: Separated and Control lagoon total phosphorus concentrations, NCSU analyses

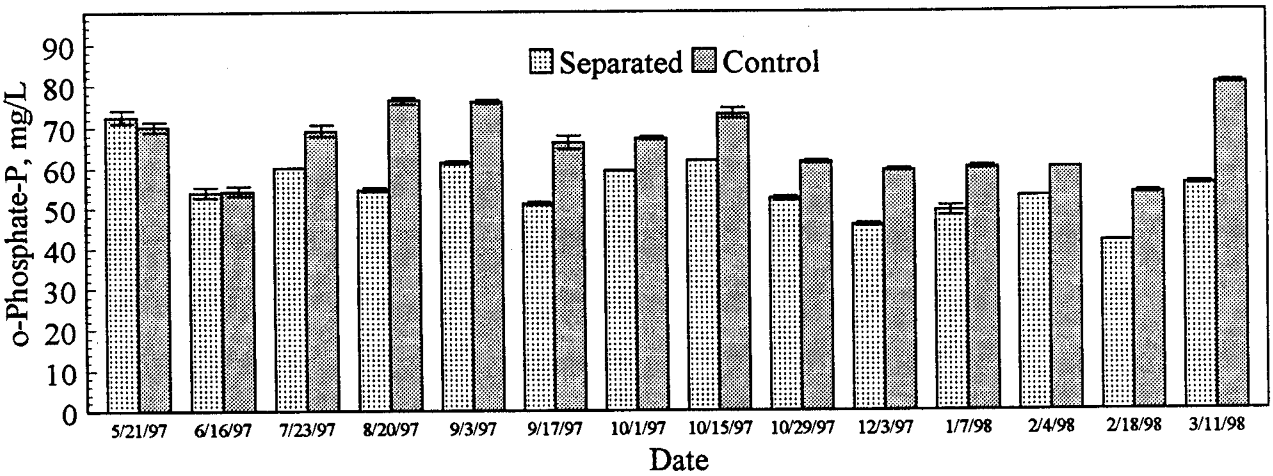

Figure 11: Separated and Control lagoon orthophospate-phosphorus concentrations, NCSU analyses

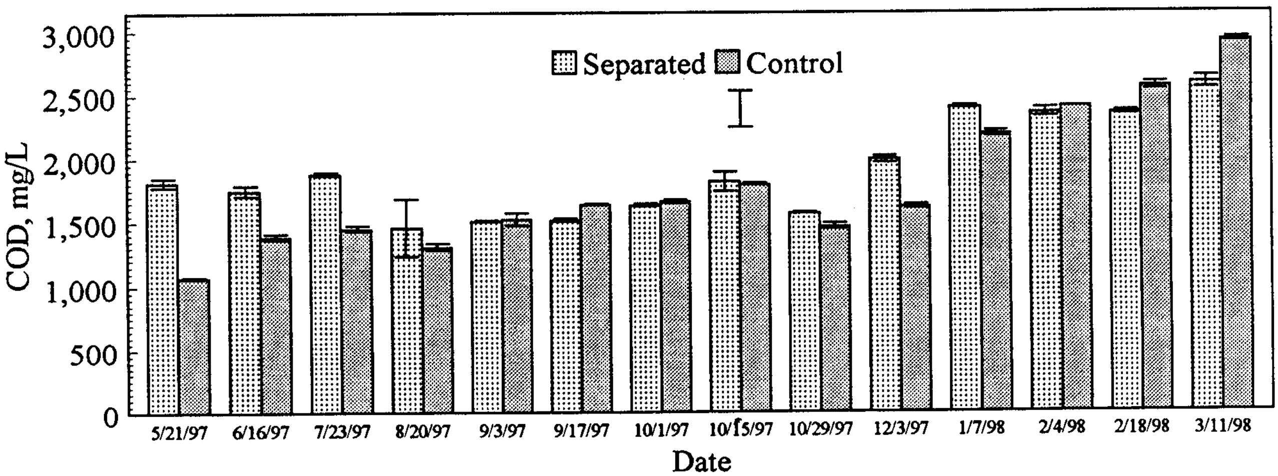

Figure 12: Separated and Control lagoon chemical oxygen demand, NCSU analyses

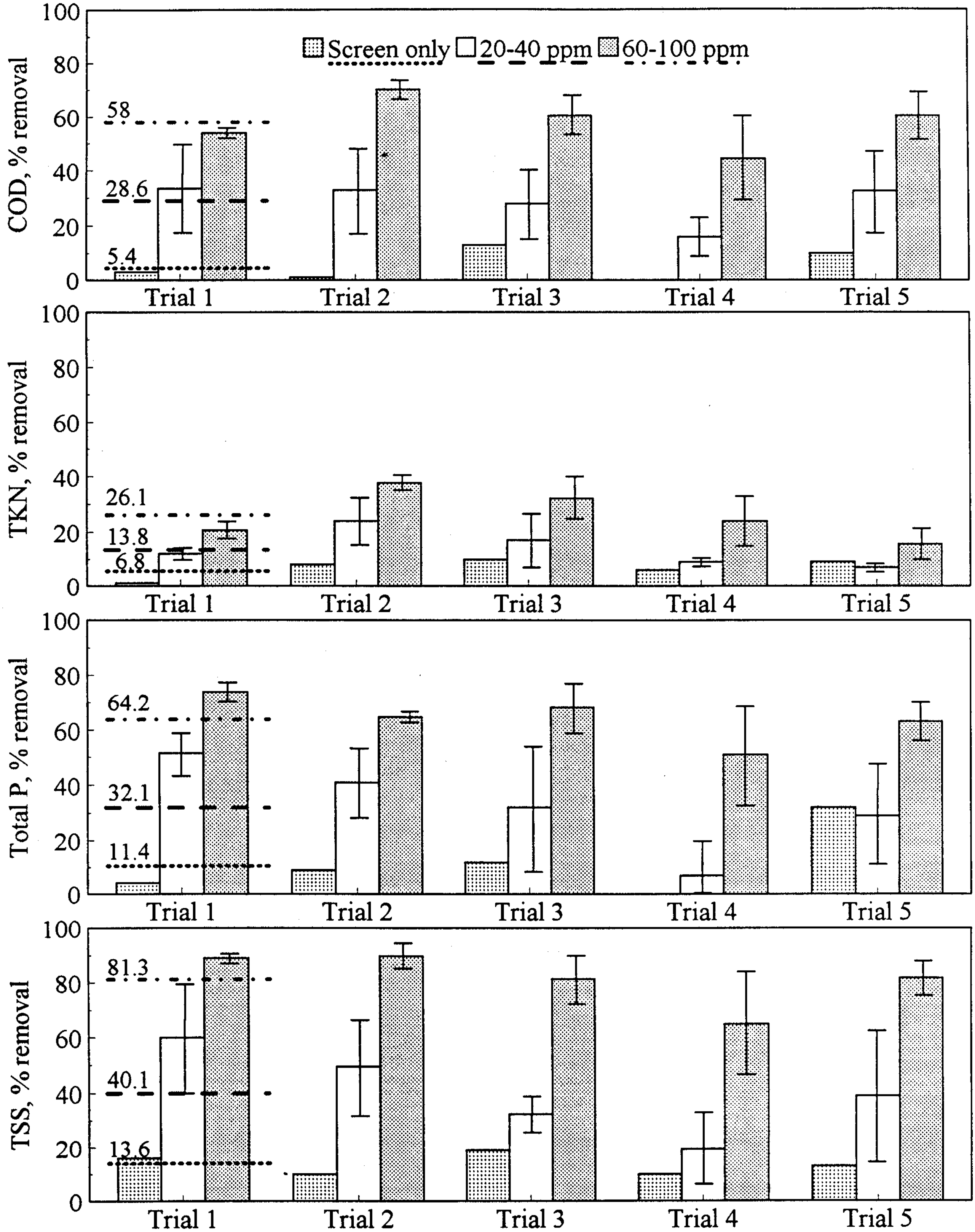

Figure 13: Bench-scale removal results using a 1/16" screen with and without cationic polymer addition, USDA-ARS evaluations