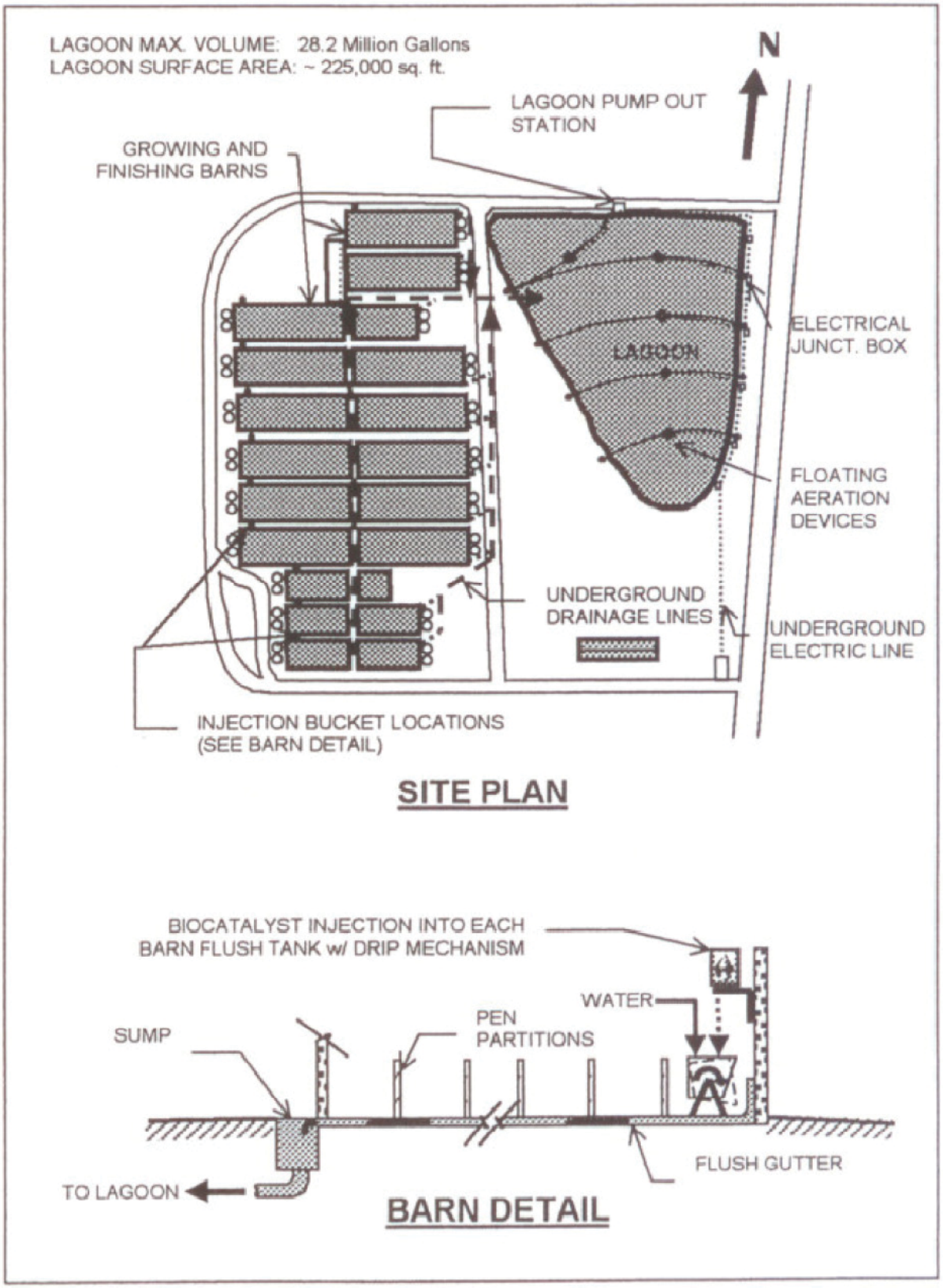
Nutrient Reduction in Swine Waste Using: Bio-Organic Catalyst Technology and Low-Power Aeration

This paper is a summary of the results of a 12-month field trial of a new treatment approach for reduction of nutrients in animal wastes. The subject swine production facility and anaerobic treatment lagoon are described along with the treatment approach utilizing a combination of bio-organic catalyst technology and low-power surface aeration devices. Results are compared to an untreated lagoon at a nearby similar swine production facility. Results show the untreated lagoon total nitrogen (TKN) levels average 28% to 48% higher than the treated lagoon, and phosphorus (P20s) levels averaging 100% higher.

INTRODUCTION

The purpose of this report is to summarize the results of a 12-month trial treatment of waste water generated by the Furnas Finisher swine production facility located near Arapahoe, Nebraska. The treatment uses a new treatment process developed by Worldwide Environmental Technologies Corporation (WETCO) which has significantly reduced the nutrient content in the discharged water and reduced odor levels.

This 18,600-head grower-finisher facility is owned and operated by Furnas County Farms, which is controlled by Sand Livestock Systems, Inc. Waste management at the facility is via flush tanks with shallow gutters in each of 19 barns (two flush tanks per barn). The wastewater is treated in a single, anaerobic lagoon before being pumped out for irrigation of surrounding farmland. This lagoon has a maximum capacity of approximately 28 million gallons with depths varying from 6 to 24 feet, and has been operated for several years. Fresh water is used for flushing. Lagoon water is not recycled. Land application of the wastewater is regulated by the State of Nebraska based upon an annual maximum number of pounds of total nitrogen allowed per acre, measured as Total Kjeldahl Nitrogen (TKN).


LAGOON MAX. VOLUME: 28.2 Million Gallons
LAGOON SURFACE AREA: ~ 225,000 sq. ft.
N
LAGOON PUMP OUT STATION
GROWING AND FINISHING BARNS
LAGOON
ELECTRICAL JUNCT. BOX
FLOATING AERATION DEVICES
UNDERGROUND DRAINAGE LINES
UNDERGROUND ELECTRIC LINE
INJECTION BUCKET LOCATIONS (SEE BARN DETAIL)
SITE PLAN
BIOCATALYST INJECTION INTO EACH BARN FLUSH TANK w/ DRIP MECHANISM
WATER
PEN PARTITIONS
SUMP
FLUSH GUTTER
TO LAGOON
BARN DETAIL

TREATMENT APPROACH

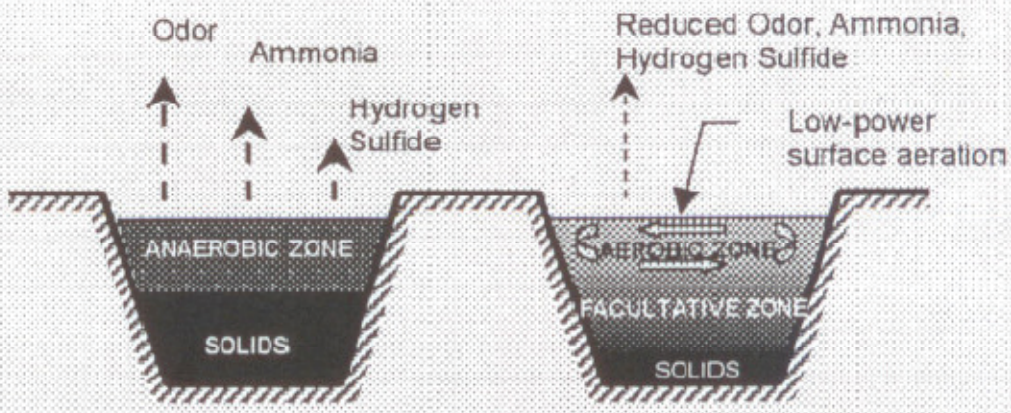
The treatment included an initial surface treatment of the lagoon with a liquid bio-organic catalyst, a continuous injection of the bio-organic catalyst into the barn flush water, and the installation of low-power floating circulation/aeration devices. The bio-organic catalyst product used in the trial is EcoSystem Plus™ (ESP), manufactured by Neozyme International, Inc. The treatment combines the action of the ESP product with the lower-power surface aeration equipment. The bio-organic catalyst breaks down volatile organic compounds which are a component of odor, and solubilises organic matter in the wastewater to present them to the bacteria in a more easily digestible form. The bioorganic catalyst also increases the efficiency of conventional aeration by causing the formation of microscopic size bubbles, resulting in the formation of an aerobic zone in the upper level of the lagoon with very low power requirements. This aerobic zone allows for the biological nitrification of ammonia compounds that are then denitrified in the lower anaerobic portions of the lagoon releasing the nitrogen as gas into the atmosphere. These changes also reduce the formation of hydrogen sulfide gas (another major odor component) by forcing the anaerobes to rely more upon nitrate than sulfate compounds for their metabolism.

The trial began on May 1, 1998. WETCO constructed a total of five floating surface circulation/aeration devices and placed them in the lagoon. These devices each incorporate a 1-hp regenerative type blower and a fine bubble diffuser array placed about two-feet below the surface. In addition, WETCO dispersed a solution of biocatalyst and water over the surface of the lagoon using a barge mounted 425-gallon tank and electric pump/spray device. A total of 505 gallons of ESP diluted in water was applied between May 1 and June 12, 1998.

On May 1, 1998 WETCO also installed ten injection devices in each of ten barns. Each device used asgallon container and a drip device. These devices were set to inject by gravity flow a total of 50 gallons per week of undiluted bio-organic catalyst directly into the 220-gallon flush tanks. These tanks dump two to three times daily. Water flow from the on-site well used for animal consumption and flushing averages 5,000 gallons per hour, creating a biocatalyst concentration of about 60-ppm on an average weekly basis. Starting in November 1998 the biocatalyst concentration was reduced to about 30-ppm on an average weekly basis. In March 1999, the drip devices were replaced with a central, continuous-flow dilution and bio-organic catalyst metering device. The solution is distributed to the individual barns with a pipe header system.

Anaerobic Lagoon

WETCO Treated Lagoon



Anaerobic bacteria dominate the lagoon.

Bio-organic catalyst "microbubbles" and low-power surface aeration encourages aerobic bacteria to dominate the top layer. A middle zone of facultative (aerobic and anaerobic) bacteria is created.

Ammonia cannot be oxidized in the anaerobic zone, so it accumulates and volatizes into the air creating odor. Excessive ammonia levels limit bacterial growth and the degradation rate

Aerobic bacteria rapidly consume small, suspended solids and oxygen microbubbles convert ammonia to nitrate compounds (reducing odor).

Sulfates from manure are consumed by anaerobes, creating hydrogen sulfide gas (also creating odor)

Anaerobic zone slowly consumes large solids and nitrates created above. Nitrates are consumed rather than sulfates by anaerobes thereby blocking the formation of hydrogen sulfide gas (reducing odor).

With the slow degradation rate, solids can accumulate and must be periodically removed.

No build-up of solids, only small layer remains at bottom.

TREATMENT RESULTS

Samples of the wastewater were taken both by the operator and by WETCO to analyze changes in nitrogen and phosphorus compounds as well as other constituents. The data were analyzed for comparison to data from an untreated swine production facility of similar size and arrangement as a control, and for comparison with historical data. All samples were taken from the suction of the lagoon pump, located about four feet below the surface at the north end of the lagoon. This location was chosen for comparison with historical analysis data for samples taken from this same location. Samples taken by WETCO and the operator were analyzed in separate commercial laboratories to provide a check on possible sampling and analysis error. Analysis results are given in the following paragraphs.

TRIAL TREATMENT RESULTS

Furnas County Farms

Total Nitrogen

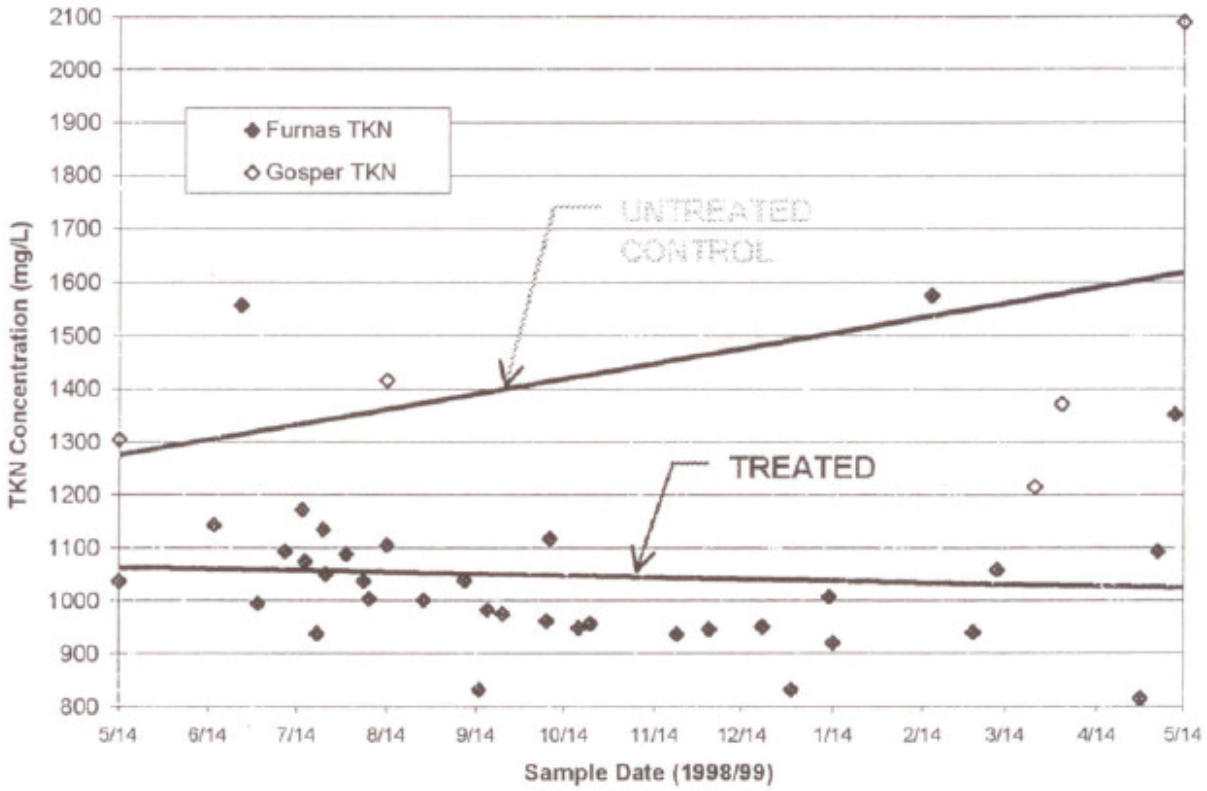


FIGURE 1

a. Nitrogen

The nitrogen analysis results indicate a downward trend since the beginning of the trial. An expected upward trend was observed in the spring months of 1999, however the lowest total nitrogen (TKN) level observed in the past four years at the lagoon was recorded for a sample taken during the trial on April 29, 1999 (815 ppm). This indicates that the treatment is has reduced TKN levels below those seasonal levels normally observed. This level is 20% below the level at the beginning of the trial (Figure 1). The decline should continue as the bio-organic catalyst dissolves years of accumulated sources of organic nitrogen and ammonia (amines) in the sludge on the lagoon bottom. Once dissolved, the bacteria then utilize these compounds. The rate these compounds can be utilized by the bacteria will slowly increase in the aerobic zone in the upper layer until the concentration of the nitrogen sources begins to drop. The data here also compared with similar data for samples taken at the untreated Gosper Finisher facility that has the same number of animals in inventory, the same feed mix, the same size of lagoon, and is exposed to the same weather patterns. The untreated facility has TKN levels averaging 28% higher than the treated facility over the twelve-month treatment period and 48% higher during the March through May 1999 period.

b. Phosphorus

Although not currently regulated by the State of Nebraska, Phosphorus concentrations were also observed during the trial. The phosphorus (P205) concentration followed a similar pattern as the total nitrogen (see Figure 2). The phosphorus concentration during the last three months of the trial has averaged about 50% lower than the concentration at the beginning of the trial. It is likely that the decline may be due to increased precipitation of phosphorus compounds into the bottom sludge due to increased rates of incorporation of phosphorus compounds into bacterial cell mass. Phosphorus levels at the untreated Gosper facility have averaged more than 100% higher than the treated Furnas lagoon over the twelve-month treatment period.

TRIAL TREATMENT RESULTS

Furnas County Farms
Phosphorus

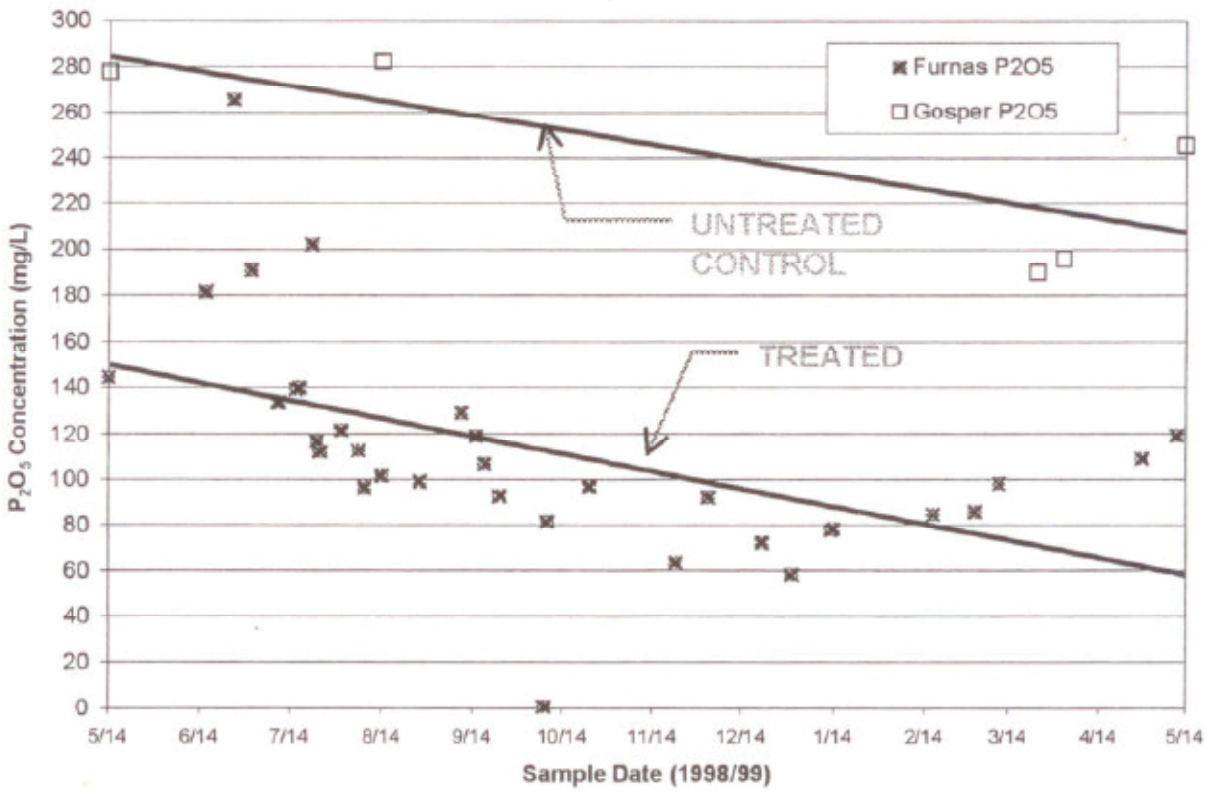


FIGURE 2

c. Odor

Because reliable methods of odor measurement are not available at this time, changes in odor generation from the lagoon are based upon observations of the Furnas County Farms operating personnel and WETCO field technicians. Both the facility operators and WETCO technicians reported significantly reduced odor levels during the summer and fall months. The manager of the facility reported that the odor levels were lower especially in the morning hours when the air is calm. Although odor levels increased somewhat in the spring months of 1999, this is a normal seasonal increase caused by lagoon turnover.

CONCLUSIONS

The treatment had the desired effect of reducing both odor and total nitrogen levels in the treated lagoon. Nitrogen has been reduced through creating conditions favorable for biological nitrification of ammonia in the upper stratum of the lagoon, and utilizing the anoxic conditions existing in lower strata for biological denitrification. An additional benefit of reduced phosphorus levels has also been observed. It is expected that additional treatment time will allow for the further degradation of accumulated nitrogen sources in the sludge, and the resulting further reduction in total nitrogen and phosphorus concentration in the water. The principle benefit of the treatment is reduced concentrations of total nitrogen in the field-applied lagoon water, which may result in irrigation of fewer acres, and reduced nutrient management costs for the owner.

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