The Effect of Algae and Bacterial Additions to a CAFO Lagoon On the Conversion from Anaerobic to Aerobic Fermentation

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Livestock operations have always been willing to protect the natural resources associated with their operations. The philosophy behind regulations on commercial operations have evolved over the years from simply protecting natural resources to preventing perceived nuisance conditions. Regulatory agencies have responded to complaints by making rules that: (1) mandate separation distances between livestock facilities and property lines, (2) control timing of manure and wastewater applications and (3) control nuisance conditions through best management practices.

The swine industry has been plagued by the problem of offensive manure odors for many years. Of the treatment strategies developed by the swine industry, aeration appears to be the most effective way to remedy the odor problem. Among specific strategies evaluated, surface aeration has proven the least expensive and has the potential to be the most effective odor control for open manure storage. Regretfully, energy expense still precludes widespread adoption of surface aeration for odor control.

Last year a study was designed to help a Colorado dairy deal with the odor problem associated with their open lagoon system. The goal was to evaluate the conversion of an anaerobic livestock lagoon to an aerobic lagoon by the addition of algae and bacteria plus mixing. Theoretically, this conversion would be beneficial for two reasons. First, the conversion should reduce odor due to the biochemistry of aerobic digestion compared to anaerobic digestion. Secondly, the rate of digestion should be increased with aerobic digestion compared to anaerobic digestion.

The study was conducted at a dairy in northeast Colorado that has 1500 milking cows on 60 acres. This dairy is located near a small but rapidly growing town and was at risk of being closed due to odor concerns. Their manure disposal system involves a flushing system that circulates 250,000 – 400,000 gallons of water per day through their barns into a leaky dam system that separates solids (which are collected for composting) and then collects in an 8-acre lagoon that is approximately 12.5 feet deep and contains approximately 31 million gallons of wastewater. Approximately 30,000-40,000 gallons of fresh water were added daily. One of the challenges with this system was that the primary water loss was through evaporation. The lagoon was approximately two years old prior to the start of this study and had not yet been cleaned.

Algae addition was made possible by construction of a 12 x 72 foot green house to grow the algae (AgSmart Inc., Strasburg, CO[1]). The green house was completed in May 2003 and the algae were added to the lagoon on June 2nd, 2003. The green house contained six 1000-gallon tanks to grow the algae (patent pending). The algae solution was added 24 hrs/day to the lagoon through a flushing system of PVC piping system that distributed the algae on the lagoon bottom in six locations. In addition to the algae, a micro-diffuser system was installed (Keeton Industries, Inc., Wellington, Colorado[2]). This system used 28 micro diffusers (10" Keeton EPDM fine bubble Duraplate™) on the bottom of the lagoon. Air was pumped from two 2 hp compressors through half inch delivery tubing to each micro diffuser. In addition to growing and adding algae, multi-inoculums of microbes were also added to the lagoon (Keeton Industries, Inc.). The purpose of the microbial additions was to improve sludge digestion and nitrogen conversion.

To test the effects of these additions and the mixing protocol, lagoon measurements were made at a depth of 6' below the lagoon surface with an YSI 556 Multiprobe (Ted D. Miller Associates, Inc., Lakewood, Colorado 80227). Lagoon temperature increased significantly from June 4 through September 12, peaking on August 12th. Total dissolved salts (TDS) increased significantly compared to the first reading and remained higher over the observation period. The elevation in TDS was probably due to the vertical mixing of the pond via the micro-diffuser mixing system. The increase and then leveling off of TDS indicated that the micro-diffuser system was doing a good job of mixing the lagoon.

Biological oxygen demand measured over a five-day period (BOD_5) was high initially (13,113 mg/L-average of four surface samples) in June and got higher in September (16,372 mg/L) with mixing. March 2004 sampling indicated an average BOD_5 of 8698 mg/L, a 34% reduction from initial BOD levels and a 47% reduction from the highest level recorded. Dissolved oxygen was significantly higher at the July 10 reading compared to the high of 0.61 mg/L on December 5th. Colder water has the ability to increase retention of initial observation and increased to higher levels of dissolved oxygen, which may in part explain the spike upward in DO in December.

Hydrogen sulfide was measured on April 6, 2004 at 11 a.m. at seven sites on the lagoon perimeter.H_2S averaged 1.6 ppb and ranged from 0-5 ppb (Jerome 631-X, Arizona Instruments, Corp.). Phosphorus was 164 ppm initially (average of four surface samples), increased to 554 ppm in September due to mixing of the lagoon and declined to 458 ppm in March 2004. The 17% reduction of phosphorus from September to March may have been due to the demand for phosphorus for algae growth.

In August of 2002, there were six written complaints from neighbors about odor. Adjectives use to describe the odor included "horrific odor", "stench unbearable", and " another round of smelling the stench". When this project was started, the odor coming from the lagoon was overwhelming. Odor intensity was diminished in late July (two months after the start of algae addition), when DO levels averaged above 0.2 mg/L. When data was recorded on Oct.8, 2003, there was very little odor coming from the lagoon. No new written neighbor complaints about odor were received in 2003. This system has potential to reduce odors as well as provide an aerobic fermentation.

In general the cost of this system per cow declines as the size of the dairy increases. Using a1000 cow dairy as an illustration, the initial cost is about $40-60 per cow during the first year. This investment includes the greenhouse, tanks and micro-diffuser system plus the algae food and bacterial addition for the first year. After the first year, the cost is expected to decline to between 50 and 75 cents per cow per month. The system cost is based on a number of factors, such as the biological oxygen demand (BOD) loading rate, the volume of the waste stream, and the depth of the sludge layer in the bottom of the lagoon.

[1] AgSmart, PO Box 329, Strasburg, CO 80136

[2] Keeton Industries, Inc., PO Box 249, 13751 NCR 11, Wellington, CO 80549