TREATMENT LAGOONS FOR ANIMAL AGRICULTURE

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The term "lagoon" is often misused. Farmers, the press and the public tend to call all earthen manure storage basins lagoons. The title lagoon, however, has a specific meaning. ASAE standards define a lagoon as "a waste treatment impoundment…(in which manure) is mixed with sufficient water to provide a high degree of dilution…for the primary purpose…(of reducing) pollution potential through biological activity. Treatment lagoons are not drawn below their treatment volume…except for maintenance."

Many of the problems associated with liquid manure handling systems — liner seepage, accidental overflows, catastrophic embankment failure, pathogen release, odor emissions and closure of earthen basins — are not unique to lagoon-based systems. These problems are shared by all liquid systems. Other white papers in this series touch upon these issues. The emphasis of this white paper is the biological treatment potential of lagoons.

Lagoons rely on physical, chemical and biological processes to degrade manure. Biological processes play the greatest role in degradation. Growth and maintenance of biological communities depend on temperature, food, the absence of toxic elements and the ability of organisms to remain in the lagoon long enough to reproduce.

Microbiological communities are vertically segregated in lagoons. Each layer performs a separate function in the overall treatment process. Photosynthetic organisms play a major role in the degradation of sulfur and nitrogen-containing compounds as well as odoriferous elements; therefore, the presence of the proper wavelengths of light to perform photosynthesis is also important in lagoon biology.

Lagoons function best when operated as flow-through systems with a mechanism to periodically remove effluent. The most common method of effluent removal is to recycle plant nutrients through irrigation to crops. Local patterns of rainfall and evaporation (and the amount of rain produced by isolated storm events) determine whether a lagoon has a net surplus of effluent or whether water must be added to the system to maintain material flow through the lagoon.

Two challenges must be addressed if lagoons are to remain a viable treatment alternative for animal agriculture. They are:

1. Inefficient recovery of plant nutrients;

2. Odor and ammonia emissions.

Up to 80% of all nitrogen entering lagoons cannot be accounted for in lagoon effluent, and a great portion of manure phosphorus entering lagoons is retained in sludge. Plant nutrients are less concentrated in lagoon effluent than in other manure treatment products, although lagoon effluent has a better balance of nitrogen to soluble phosphorus than most sources of manure nutrients. Lagoon effluent should be used in crop production on a nitrogen basis, irrigating effluent in multiple applications throughout the growing season. Managing effluent in this manner requires expensive, permanent irrigation equipment to apply what is essentially low-quality fertilizer. Nitrogen application is inherently out of sync with phosphorus since the majority of manure phosphorus is only recovered when solids are removed at the end of the sludge storage cycle, which may last as long as 10 to 20 years.

Large chemical compounds are transformed into smaller, more volatile compounds through biological degradation. These small compounds may be less odorous than those found in raw manure, but their volatility makes them more likely to be emitted into the atmosphere. Ammonia gas is produced during anaerobic degradation of proteins and urea. A portion of the ammonia created in lagoons is undoubtedly lost through atmospheric emission. Recent studies suggest that much of the atmospheric release of nitrogen may be in the form of harmless N_2 gas, however.

Lagoons located in temperate climates undergo annual cycles of storage, heating and organic matter accumulation. Cool season organic matter accumulation is most pronounced in extreme latitudes. The heating and organic matter accumulation cycles are problematic in that there is a tendency for lagoon layers to become unstable in the spring and fall, increasing the likelihood of odor emissions during these periods.

Mass of atmospheric emissions increases with lagoon size, and many of the problems of liquid manure handling — liner seepage, the consequences of catastrophic failures, wave erosion — are exacerbated by lagoon size. Current anaerobic lagoon design standards rely on volumetric organic loading rate to size the treatment volume. This means that lagoon size is directly proportional to farm size. A second consequence of relying on volumetric loading rate as the sole design parameter is that lagoon geometry cannot be changed without altering other potentially important design parameters, such as depth and surface area to volume ratio.

This paper does not specify a maximum size for lagoons nor does it advocate abandoning volumetric loading rate as a design parameter. Pretreatment to reduce the mass of organic matter entering lagoons is suggested as a method to limit lagoon size on larger farms. Improvements in lagoon performance will be realized when specific biological communities, prescribed to perform specific treatment steps, are engineered to be present in individual lagoon cells or layers. Design refinements are needed to reach this point. Research should focus on filling the following information gaps.

1. Achieve a greater understanding of the fundamental biological processes involved in manure degradation.

2. Achieve a greater understanding of the chemical transformations involved in lagoon treatment.

3. Achieve a greater understanding of the physical and climatic factors that lead to cyclic environmental conditions experienced by lagoon microorganisms in temperate climates.

4. Develop diagnostic tools capable of monitoring biological communities in natural environments.

5. Develop design parameters to promote specific, robust biological communities in lagoons, given a set of environmental conditions and influent characteristics.

Educational materials must be produced to train operators to maintain lagoons. These materials should be sensitive to the operator's need to work within the limitations of an agricultural production system. Curriculum should include:

1. Basic treatment biology;

2. The cyclic nature of lagoon operation;

3. Liquid balance to maintain proper lagoon operating levels;

4. Operating within an actual water year, not an average year;

5. Efficient nutrient use;

6. Maintaining structural integrity.

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