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Purple Sulfur Bacteria in Anaerobic Treatment Lagoons

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Summary and Implications

Purple or pink colored lagoons, indicating the presence of purple sulfur bacteria, are less likely to be considered an odor nuisance than a more typical non-purple lagoon. The design and management factors that encourage the growth of purple sulfur bacteria are poorly understood. A study of eight purple and non-purple lagoons was initiated during the spring and summer of 1996. The intent of this effort was to identify critical factors that would allow purple lagoons to become a more predictable odor control alternative. A preliminary comparison of design and management factors assumed to be critical suggests more similarities between these two groups of lagoons than differences.

Introduction

A distinct purple to pink coloring is sometimes observed in anaerobic lagoons receiving swine manure. This distinct coloring, attributed to purple sulfur bacteria (PSB), is often observed with a reduction in offensive odors. Under anaerobic conditions, these bacteria use carbon dioxide (carbon source), hydrogen sulfide (electron donor) and ammonia (nitrogen source) for cell growth. The oxidation of sulfides contributes to a lagoon with fewer odorous emissions. In addition, PSB metabolize simple organic compounds reducing the pollution potential of the lagoon wastewater, remove toxic amine compounds, and produce anti-viral substances. Finally, they yield a high protein biomass which, if harvested, could be a potential feed product.

There are several species of PSB including *Chromatium* (purple-red, purple-violet and brown-red), *Thiocapsa* (pink to rose-red) and *Thiopedia*. These bacteria are phototrophic - meaning light is essential to their growth. Sulfides are also essential to their growth, although both high and low concentrations restrict their growth. Most PSB species survive only under anaerobic (no oxygen) conditions. Previous research has also suggested salinity is important to some species.

The goal of this project was to understand the conditions that encourage the growth of PSB. The objectives of our initial effort were to:

1. determine and contrast the design criteria used for both purple and non-purple swine lagoons;
2. determine the management criteria used in these same cases;
3. analyze and report data in case study formats that enable a) producers to improve the management and understand limitations of existing lagoons and b) designers to configure new lagoons that encourage growth of PSB.

Procedures

Eight pork producers with anaerobic treatment lagoons were identified. Five lagoons were selected based upon a previous history of turning purple while the three remaining lagoons were non-purple lagoons. During an initial farm visit, the producer was interviewed relative to:

- livestock numbers and weights (for estimating manure production)
- animal housing, feeding and watering systems,
- cleanup and flush water use,
- lagoon loading and effluent removal frequency and timing,
- lagoon size and other characteristics and
- animal nutrition programs with emphasis on copper, zinc and antibiotics in feed.

Two additional site visits were made in early spring and mid-summer of 1996 to obtain samples from the lagoons. Lagoon wastewater samples were taken by boat from multiple locations at the surface and at various depths. Additional measures were made of lagoon dimension and wastewater depth. Lagoon wastewater samples were analyzed for 18 distinct parameters including bacteriochlorophyll-a (indicator of PSB concentration), sulfide concentration, waste strength and characteristics and nutrient concentrations. The following discussion represents initial results and conclusions.

Results and Discussion

Of the eight lagoons sampled, none exhibited a strong purple coloring during late March or early April. By late July, lagoons, 6, 7 and 8, which had a

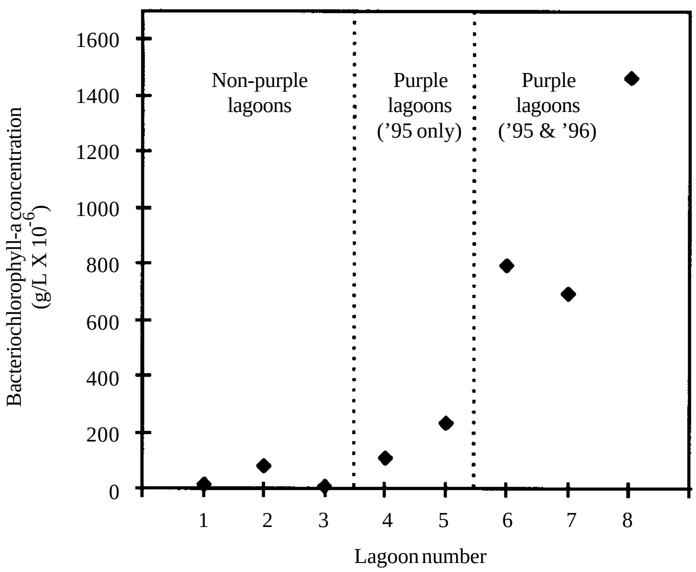
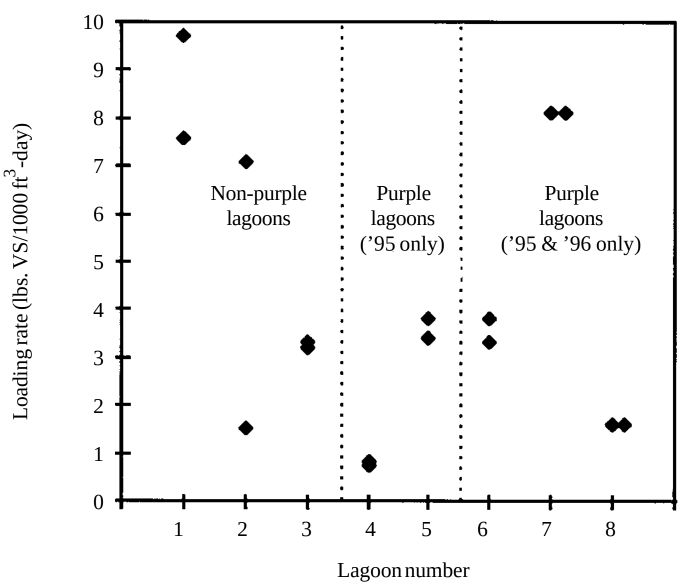


Figure 1. Bacteriochorophyll-a concentration in lagoons (average of summer 1996 lagoon surface and one foot samples).



*Two distinct points for each lagoon represent loading rate as measured at time of spring and summer visits.

Figure 2. Volatile solids (VS) loading rate vs lagoon type*.

history of turning purple, were again bright purple in color. Lagoons 4 and 5, which had a history of purple coloring, did not exhibit this purple color and appeared more of a brown or gray color. Two of the three non-purple lagoons, 1 and 3, were very dark brown to black in color. The third lagoon (2) was green as a result of an algae bloom. All lagoons were highly anaerobic at the surface and at all depths sampled with the exception of lagoon 2, where an algae bloom caused elevated levels of oxygen in the wastewater. Anaerobic conditions are generally considered important for PSB growth.

To distinguish a purple lagoon from a non-purple lagoon, the concentration of bacteriochlorophyll-a was used in addition to visual observation. Non-purple anaerobic lagoons exhibited very low bacteriochlorophyll-a levels while purple lagoons exhibited greater concentrations (Figure 1). The lagoon with an algae bloom (2) and the two lagoons that failed to turn purple in 1996 (4 and 5) had moderate levels of bacteriochlorophyll-a. While there was a reduced level of PSB present in lagoons 4 and 5 compared to lagoons 6, 7 and 8, it appears these lagoons have the potential to be purple again in the future.

Sulfide concentration is considered important to the survival of PSB. For all lagoons, sulfide concentrations were in a similar range (1 to 6 mg of sulfide per liter) with slightly lower levels observed for purple lagoons than for non-purple lagoons. However, the observed ranges for sulfide in all lagoons were not at levels considered a limitation for PSB growth.

Producers are often encouraged to increase lagoon size in an effort to reduce odor nuisance potential and encourage growth of PSB. While oversizing lagoons remains critical to reducing odor nuisance, it may be less essential to survival of PSB. Volatile solids loading rate is a typical measure of lagoon size. All three purple lagoons had a volatile solids loading rate considered high by most design standards (Figure 2). Purple lagoon 7 had one of the highest loading rates observed for all lagoons. The lowest loading rate observed was for lagoon 4 which had a history of turning purple but which failed to do so in 1996. It would appear that loading rate may be less critical than previously anticipated for allowing PSB to prosper.

Management factors may play a role in encouraging purple lagoons. Since these bacteria require sunlight, dilution of the manure with barn flush and clean-up water was thought to influence the potential for sunlight penetration and PSB growth. The purple lagoons typically showed higher water

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dilution levels. However, measures of sunlight penetration of each lagoon with a standard Sechi disk[2] revealed penetration of 1 to 2 inches for all lagoons with little apparent differences between non-purple and purple lagoons. These results suggest PSB growth would occur very near the surface of the lagoon. However, PSB were distributed fairly evenly to all depths of the lagoons likely due to mixing caused by anaerobic activity and other factors.

Finally, anti-bacterial products in the manure were considered a potential factor affecting PSB survival. Copper, zinc and antibiotics from animal feed may impede the growth of PSB. The addition of copper and zinc to the lagoon (assuming the animal did not retain these elements) varied by a factor of 10 when compared on a per unit of lagoon volume basis. However, above average levels of copper and zinc addition were observed in both purple and non-purple lagoons. Lagoon 5, which had a history of turning purple, failed to do so during the summer of 1996 following an increase in zinc addition (30 times greater than previous use) to the animal feed as zinc oxide for a four month period. Additional research into the role of anti-microbial products relative to PSB growth is necessary before definite conclusions can be made.

Conclusion

This preliminary review of the data from eight lagoons has revealed more similarities than differences between purple and non-purple lagoons. Factors such as sulfide concentration, anaerobic conditions, volatile solids loading rate and copper and zinc loading rate do not vary substantially between purple and non-purple lagoons. These preliminary observations will receive additional scrutiny as all data collected from this research effort are examined further.

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[2]Black and white disk commonly used to measure clarity of lakes.