#1013

The Effect of Organic vs. Synthetic Fertilizer Growth on Blue-Green Algae

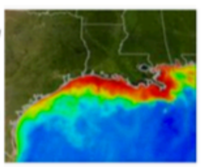
Sequence: No. 1013

INTRODUCTION

Each year, excess nutrients such as nitrogen and phosphorus from fertilizers wash into the Gulf of Mexico from the Mississippi River. These nutrients cause quick algal blooms mostly composed of blue-green algae that then decompose lowering the concentration of oxygen in the water. This leads to hypoxic conditions in which low oxygen levels in the water cannot support aquatic life. These areas of hypoxia are known as Dead Zones. Over the past several years, the Dead Zone in the Gulf of Mexico has expanded to 6,334 square miles, the 16th largest in a 35 year period (**see Image 1**). Although there is not currently one overarching solution to eliminate the Gulf of Mexico Dead Zone, it has been proposed that organic farming utilizing organic fertilizer in the Mississippi River Watershed may help minimize this problem. Organic fertilizers have organic materials that improve soil structure and crop growth, leading to less nutrient runoff. They also generally release nutrients more gradually than synthetic fertilizers, which could cause less of a dramatic growth of algae and lead to less intense algal blooms. This research project focused on the effect of organic fertilizers vs. synthetic fertilizers on blue-green algae, the algae largely responsible for the Gulf of Mexico's annual Dead Zone.

The study monitored the effect of both a high and low concentration of an organic fertilizer as well as a high and low concentration of a synthetic fertilizer on the growth of blue-green algae. Blue-green algae were grown in containers consisting of 400ml of spring water and varying concentrations of either organic or synthetic fertilizer. There was a control, in which the blue-green algae was grown without any fertilizer. The hypothesis of the study was that blue-green algae growth with organic fertilizer would overall have a lower concentration than the blue-green algae growth with synthetic fertilizer, and the oxygen levels would rise and be depleted quickly with the synthetic fertilizer, but would remain more stable with the organic fertilizer.

Image 1: Dead zone in the Gulf of Mexico: Red area denotes 2 milligrams per liter of oxygen or lower, the level which is hypoxic. "dead zone." *National Geographic Society*, 21 January 2011, https://www.nationalgeographic.org/encyclopedia/dead-zone



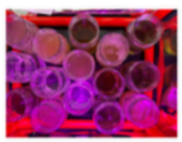


Image 2: Containers of Blue-Green algae

MATERIALS AND METHODS

Fifteen containers each of which contain 400ml of spring water each were started with 10 ml culture of blue-green algae from Carolina Biological Supply (see **Image 2**). Three containers were labeled high organic A, B, or C, and had high concentration of organic fertilizer added. Three containers were labeled low organic A, B, or C, and had low concentration of organic fertilizer added. Three containers were labeled high synthetic A, B, or C, and had a high concentration of synthetic fertilizer added. Three containers, labeled low synthetic A, B, or C, had a low concentration of organic fertilizer added. There were also three controls, labeled control A, B, or C, that contained no fertilizer. The 15 containers were kept in a chamber that had a 16 hour light on and 8 hours of dark. The nutrients of nitrogen, phosphorus and potassium were proportionally similar in all the samples (see logbook for calculations). The organic fertilizer contained additional organic materials. The quantitative data collected is blue-green algae concentrations and dissolved oxygen (DO) concentration in the containers using a Vernier SpectroViz Spectrophotometer and a Vernier optical dissolved oxygen probe. The qualitative data collected is the color of the containers. To maintain safety masks were worn. Hands were washed before and after every data collection.

Figure 1: Graph showing the concentration of blue-green algae over 8 weeks measured using the 396.0nm chlorophyll absorption peak (see logbook for reason why 396.0nm wavelength was chosen)

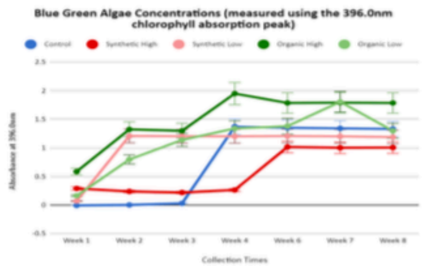


FIGURE 1 RESULTS: The blue-green algae with high concentration organic fertilizers statistically grew to higher concentrations than the others. The synthetic high fertilizer grew the lowest concentration of blue-green algae. It also grew at the slowest rate.

-The samples with organic high and low concentrations both increased at steady rates from week one, reaching a plateau around week 4.

-The samples with synthetic high and low concentrations had different growth patterns.

-The low samples grew quickly and then plateaued by Week 2. The synthetic high concentration did not grow until Week 4 and then plateaued.

-The control samples did not show any growth until Week 3 and then plateaued with concentrations similar to the synthetic low.

Figure 2: Graph showing the dissolved oxygen concentration over 7 weeks using an optical dissolved oxygen sensor

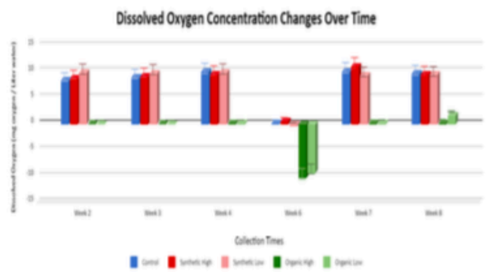


FIGURE 2 RESULTS: The dissolved oxygen concentration in the controls, synthetic high and lows are all statistically similar throughout the data collection. The organic samples have statistically lower oxygen concentrations throughout the data collection.

Figure 3: Qualitative representation of blue-green algae growth on week 6

- Front: left, high concentration organic right, low concentration organic
- Back: left, high concentration synthetic right, low concentration synthetic.

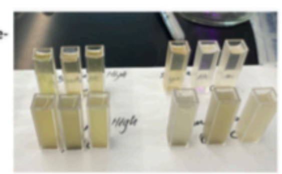


FIGURE 3 RESULTS: The organic samples appeared more turbid/cloudy than the synthetic samples

CONCLUSION/DISCUSSION

The data shows that the organic high concentration fertilizer grew statistically higher concentrations of blue-green algae than the other samples in this aqueous environment. In addition the high synthetic fertilizer had the lowest growth of the fertilizer samples up until week 5. Given that the nitrogen, phosphorus, and potassium were proportional in all active samples, the experiment does suggest that another factor may be contributing to the increased growth in the organic high concentration sample. The primary content difference between the fertilizers was that the organic fertilizers contained organic materials including feather meal, soybean meal, bone meal, sunflower hull ash, sulfate of potash and rock phosphate. The organic carbon containing compounds in the organic fertilizer may have been the primary reason for the highest growth. Carbon compounds could promote photosynthesis. Hence these organic materials contain the carbon that is an essential ingredient that promotes plant growth through photosynthesis and may have contributed to the highest concentration of blue-green algae growth seen in the high organic fertilizer sample. This data does not support the hypothesis that blue-green algae grown with organic fertilizer will overall have a lower concentration than the blue-green algae grown with synthetic fertilizer. On the contrary, blue-green algae growth was highest with the organic high concentration fertilizer. This may suggest that the use of organic fertilizer alone may not reduce the problems with algal blooms and the creation of dead zones in water basins.

The experiment also looked at concentrations of dissolved oxygen in the samples. The data search suggested that with higher concentrations of blue green algae, the DO would also increase because of the increased photosynthetic activity and release of oxygen. Yet, this was not shown in this experiment as the higher concentration organic fertilizer with the highest blue-algae growth had the significantly lower DO concentration than all other samples. It is possible that this contrary result was the result of a sampling error due to the higher turbidity in the samples containing organic fertilizer. Interestingly, the DO for all the samples stayed relatively the same, except for week 6. These was no data collection for week 5 because the school was closed for winter break. This anomaly would need to be further explored, but could have been caused by a temporary decrease in blue green algae concentrations and as the dead algae were decomposed by microbes, oxygen levels would have decreased. It's also possible there could have been an error with calibration of the DO probe that week. This could be possible as the relative proportions stayed similar.

Some of the benefits of organic fertilizers is believed to be its improvement in soil structure and contributing carbon based material to the soil to improve microbial growth allowing for slower release of nutrients and less nutrient run-off into water sources. This is a limitation of the experiment as it was not conducted in a soil environment. Thus this experiment could not mimic the slow release of organic materials into the soil, and thus the nutrients may have been utilized by the blue-green algae more quickly because the organic fertilizer was put directly in an aqueous environment. Further research should measure blue-green algae growth and oxygen levels, and additionally nitrogen levels, in run-off from soils treated with organic and synthetic fertilizers. The use of organic fertilizer alone may not reduce the problems with algal blooms and dead zones in the Gulf of Mexico. Reducing nutrient run-off through a multidisciplinary organic farming approach is likely necessary. Further research is necessary to understand the implications of the use of organic and synthetic fertilizers on minimizing the impact of nutrient run-off on algal blooms and dead zone formation in water basins.