Background Paper Marcus Stevens December 25, 2015*The Effects of Phosphate on Algal Growth* Algae are simple aquatic organisms. Algae are essential to many ecosystems because a multitude of organisms rely on them as their energy source. As well as providing energy, they are also photosynthetic organisms, meaning they rely on the sun for their energy and oxygen. They ultimately support a large portion of an ecosystem, providing it with the necessary oxygen on which other organisms feed. According to jrank.org, algae can either be unicellular or multicellular and can occur in salt or fresh waters, even on the surfaces of moist soil or rock. “Algae actually consist of seven divisions of distantly related organisms. These are considered together more as a matter of human convenience, than as a reflection of their ordered, biological, or evolutionary relationships” (*Algae and their Characteristics).*

Algae can occur in very extreme conditions. “For example, species of green algae have been observed in hot-water springs at Yellowstone National Park, in highly acidic volcanic lakes, in the extremely saline Great Salt Lake and Dead Sea, and on the surfaces of snow” (*Algae - Factors Limiting The Productivity Of Algae*). These various environments, however, are potentially stressful to the algae, limiting their productivity. Most algae survive in less stressful habitats, where the only limitations to their productivity are the available nutrients, and because they are photosynthetic, the amount of available sufficient light.Two other limiting factors that affect the growth and productivity of algae are: suitable temperature for algae to thrive, and the amount of available carbon dioxide. “In general, the productivity of freshwater algae is primarily limited by the availability of the nutrient phosphate (PO4-3), while that of marine algae is limited by nitrate (NO3-)” (*Algae – Factors Limiting The Productivity Of Algae*).

The importance of algae in an aquatic ecosystem is noteworthy. It is a vital organism in the food web since it is photosynthetic, providing oxygen for the environment. It also has a key role in the food web. Photoautotrophs are usually found on land in the form of trees and flowers. “However, there are a substantial number of photoautotrophs [such as algae] in the marine environment as well,” according to bigelow.org’s article *Fitting Algae into the Food Web.*  Despite the fact that these are extremely small primary producers, marine [algae](http://www.bigelow.org/edhab/glossary.html) are vital to our planet's productivity since they are at the base of the marine food web (*id.*). Since these different types of algae are part of the base of the food web, the dynamic flow of their population could significantly affect the rest of the aquatic ecosystem.

Algae can be utilized by different organisms for food supplements as well. According to oilgae.com, they are complete proteins with essential amino acids that are involved in major metabolic processes, like enzyme production. Algae contain high amounts of simple and complex carbohydrates which provide an exceptional source for additional fuel, such as enhancing the immune system. Algae even contains fatty acids, like Omega 3 and 6, playing a key role in generating energy. They even an abundance of trace elements, vitamins, and minerals. As long as the quantity does not become a problem because of the nutrients, algae can be quite useful and safe.

There are even industrial usages of algae that benefit humans and the environment. For example, algae can be used to reduce the amount of harsh chemicals used to treat sewage. Other studies have shown that algae has the ability to absorb Co2 from the air, ultimately lowering Co2 levels in the atmosphere.

Phosphates, like nitrates, are extremely vital nutrients for algae growth. Perhaps one of the most important energy components in a cell, Andesine Triphosphate (ATP), is partially made up of phosphate. ATP is utilized by all organisms because of its ability to generate energy, therefore, phosphate is essential to all organisms. This especially is true when talking about algae growth.

Phosphates occur in minute quantities in all aquatic environments, and for the most part, are necessary for life to be sustained and to thrive. However, phosphates are detrimental to aquatic life when it occurs in abundance. Phosphates, in the form of fertilizers, are essential to agriculture. But these harmful fertilizers seep through land water and flow into streams, creeks, ponds, lakes and other larger bodies of water. When the fertilizers are exposed to these bodies of water, the phosphates and other dissolved minerals are enriched in the ecosystem. This is the process of eutrophication.

Eutrophication, in some circumstances, brings with it an excess amount of phosphates, making it the greatest threat facing aquatic life today. It is typical in eutrophic waters to have a surge in algal growth, either as multicellular forms of algae or as suspended microscopic phytoplankton. Once the increased period of growth is finished, the algae decays. That decomposition fuels bacterial growth, depleting the dissolved oxygen levels down to hypoxic (low in oxygen) or anoxic (devoid of oxygen). This dissolved oxygen is what marine life depends on; without it, there would be no aquatic life.

Similarly, algal growth on the surface of a body of water is extremely harmful to marine life living at the seabed of the water. While the algal blooms continue, the plants on the seabed are being deprived of their essential sunlight, preventing photosynthesis and disrupting plant growth (*Cloern, Krantz, and Hogan, 2013*). According to Lara Fabrizi in her article, *Eutrophication of water bodies,* further consequences for human activities in eutrophication are: the decrease of water quality, aesthetic flow and navigation water problems, and dead zones that contain no life.

With an excess amount of phosphates in a system, an algal bloom could occur. Algal blooms are rapid increases in algae populations, in most cases causing the detrimental effects previously stated. Harmful algal blooms have the potential to affect humans as well, making some seafood, like shellfish, unsafe by releasing toxins that cause fatal illnesses, even contaminating our drinking water.

It is evident that whenever there is a major spike in algal growth, it is bad news for aquatic life. For example, according to Doretha B. Foushee in her article, *Algal Blooms in the Ocean,* in 2002, there was a major algal bloom, which died off and decayed near South Africa’s Cape Province. This caused a “rapid reduction in the water’s dissolved oxygen concentration, driving tens of thousands of rock lobsters to “walk out of the sea.” These lobsters were struggling for air all because of the algal blooms that occurred, depriving them of life sustaining oxygen.

Another algal bloom incident occurred in Lake Erie in 2014 that left more than 400,000 people without safe drinking water (*Abbey-Lambertz, 2014*). Alarming levels of microcystin, a toxin created by cyanobacteria algae blooms, were recorded in water treatment tests. Further scientific studies have influenced scientists to make recommendations to limit phosphate, the main pollutant that caused the Lake Erie algae bloom (*id.*). This supports the idea that phosphates increase the growth rate of algae, but raises important and legitimate questions about how it can be controlled.

“Common sources of nutrients are septic tank, farm fertilizer, livestock, and excessive plant or grass clippings” (*Pond Algae).* Preventative techniques for controlling nutrient runoff is one of the first steps in alleviating an overabundance of algae. One way that people have accomplished this is by utilizing algae to absorb the nutrient runoff before it reaches the water source. Another preventative measure to keep nutrients away from a water source is to simply keep fertilizers and septic fields away from water ways. Finally, one of the most important algae preventative techniques is aeration, a process in which air is circulated, amalgamated with, or dissolved in a liquid/substance.

In this experiment, the effects of different amounts of phosphates on an algal population will be tested. The tested algae will be Chlorella pyrenoidosa, a species of single celled Chlorella. Chlorella is a green algae and is believed to be one of the first organisms on earth, the first cell to contain one true nucleus, and approximately 540 million years old, according to sunchlorellausa.com. Specifically, algal culture will be obtained and combined with distilled water (to ensure that the experiment is not contaminated with trace metals, nutrients, or chlorine found in tap water) in multiple containers to which a light source and plant fertilizer are added. The results will be studied under a microscope before and after the mixture is exposed to light. Over the course of one to two weeks, observations of the color, opacity, and smell of the algal cultures in each of the containers will be made and recorded. In addition, at each observation interval, the number of algal colonies in a sample drop will be studied under a microscope. At the conclusion of the experiment, the results will be put into a graph to compare the algal growth versus the number of days.

**Purpose:** The purpose of this experiment is to study how algae grows with varying levels of phosphate exposure, and to better understand the conditions required for growth at each level.

**Hypothesis:** When varying levels of phosphate is applied to the algae, Chlorella pyrenoidosa, the phosphate will not significantly affect the algae’s growth.

**Bibliography**

Abbey-Lambertz, Kate. “These Disturbing Photos Show Why Algae Blooms Are A Growing Global Water Threat.” *huffingtonpost.com.* The Huffington Post. 7 Aug. 2014. Web. 24 Dec. 2015.

Cloern, James, Hogan, Michael, and Krantz, Timothy. “Eutrophication.” *eoearth.org.* The Encyclopedia of Earth. 8 Feb. 2013. Web. 24 Dec. 2015.

Fabrizi, Lara. “Eutrophication of water bodies.” *lenntech.com*. Lenntech. n.d. Web. 23 Dec. 2015.

Foushee, Doretha. “Algal Blooms in the Ocean.” *waterencyclopedia.com.* Jrank. n.d. Web. 24 Dec. 2015.

“Algae – Factors Limiting The Productivity Of Algae.” *jrank.org.* Net Industries. n.d. Web. 23 Dec. 2015.

# “Algae - Algae And Their Characteristics, Types Of Algae, Ecological Relationships, Factors Limiting The Productivity Of Algae.” *jrank.org.* Net Industries. n.d. Web. 24 Dec. 2015.

# “Fitting Algae into the Food Web.” *bigelow.org.* Bigelow Laboratory for Ocean Sciences.n.d. Web. 24 Dec. 2015.

# “Pond Algae.” *outdoorwatersolutions.com.* Outdoor Water Solutions. n.d. Web. 24 Dec. 2015.

“Uses of Algae as Energy source, Fertilizer, Food and Pollution control.” *oilgae.com.* Oilgae. n.d. Web. 23 Dec. 2015.

“What is Chlorella.” *sunchlorellausa.com.* Sun Chlorella USA. n.d. Web. 24 Dec. 2015.

# 

# 