

Effects of Temperature and Potential Growth of Cyanobacteria in Eutrophic Lakes

Commented [MP1]: Some things you are missing from your report include:
3 graphs or figures from the papers you review.
A literature cited section, listing all papers you read at the end of your paper

Student name: Rajasekhar Samudrala

Instructor: Dr. Matthew I. Pyne

Limnology- Biol(5409)

Department of Biology

Lamar University

Abstract

Eutrophic lakes are most likely to be **invested** by cyanobacteria. In freshwater lakes, cyanobacteria are more likely to occur as a result of changes in the climate. The existence of cyanobacteria threatens the existence of aquatic animals. Cyanobacteria is dominant over the other species due to multiple reproductive ways, uses light for photosynthesis, buoyant on the surface of the water, multiply in large numbers, and have mucilaginous colonies. This paper aims at giving a review of the literature on the studies conducted on the effect of temperature and growth of cyanobacteria in Eutrophic lakes. The paper also aims at giving a review of the measures that can be taken to mitigate the effect of temperature and growth of cyanobacteria in eutrophic lakes.

Introduction

Eutrophic lakes are most likely to be **invested** by cyanobacteria. In freshwater lakes, cyanobacteria are more likely to occur as a result of changes in the climate. The existence of cyanobacteria threatens the existence of aquatic animals. This happens when the cyanobacteria form in large numbers on the surface of the lake and **therefore reducing the amount of oxygen** and light penetration in the lake (Chen et al., 2014). As a result, water quality reduces, thereby affecting the ecosystem. Most aquatic animals and plants are more likely to die as a result of a lack of oxygen and sunlight. Aquatic food webs have been affected negatively by these bacteria. A change in ecosystems will be felt from the adverse effects of these bacteria. Cyanobacterial bloom is more likely to increase as a result of climatic changes. Cyanobacteria increase will lead to danger to human life as a result of drinking lake water with toxins released from the bacteria.

Commented [MP2]:

This probably the wrong word. Invested means to “expend money into something with the hope of getting a profit”. Do you mean “invade”?

Commented [MP3]:

Again wrong word

Commented [MP4]: Why reduce oxygen? They produce oxygen through photosynthesis. What process makes them reduce oxygen. Also, this issue of reducing oxygen is not brought up again in your paper.

The economy will be affected due to the increase in the cost of treatment and public health issues (Chen et al., 2014).

Several reasons why cyanobacteria are dominant in the lakes over other phytoplankton do exist. These reasons give these bacteria a competitive advantage over them. Cyanobacteria have multiple reproductive ways making to multiply quickly in large numbers over a short period. The bacteria is buoyant on the water surface and uses more light for photosynthesis. Cyanobacteria can multiply more quickly in water compared to other phytoplankton. Mucilaginous colonies are less likely to occur sink, and this makes cyanobacteria float on water, thus utilizing the oxygen and the sunlight. Cyanobacteria also produce toxins that threaten the life of other phytoplankton. All these factors have contributed to the multiple growths of the bacteria. Winter, therefore, plays a vital role in the growth of phytoplankton in the lake. An increase in temperature results in increased growth of the cyanobacteria.

Numerous studies have been conducted to establish the impact of climate change on the growth of the cyanobacteria. Most studies have indicated that an increase in temperature has resulted in more growth of cyanobacteria. Cyanobacteria is likely to live in the water when temperatures exceed 20 degrees Celsius while other phytoplankton survives in the water in temperatures below 20 degrees Celsius. The increase in temperature is also more likely to result from increasing in nutrients resulting in eutrophication. Future climatic changes are likely to affect the existence of phytoplankton, zooplankton, and cyanobacteria blooms.

Objectives of the Paper

- i. This paper aims at giving a review of the literature on the studies conducted on the effect of temperature and growth of cyanobacteria in Eutrophic lakes.

Commented [MP5]: What does "multiple growths" mean?

Commented [MP6]: Why?

- ii. The paper also aims at giving a review of the measures that can be taken to mitigate the effect of temperature and growth of cyanobacteria in eutrophic lakes.
- iii. This paper aims to give a conclusion and personal suggestion regarding these problems.

Review and Synthesis

Cyanobacteria have been in studies for the past 130 years. The bacteria **has been** in existence for many years, and it has been known to cause adverse effects. Cyanobacteria are also referred to as blue-green algae. The scientific names for species are *Cyanophyceae*, *myxophyceae*, or *Cyanophyta*. Cyanobacteria is prokaryotic, but in the past years, it was termed as eukaryotic “algae.” Cyanobacteria are known to form potent blooms, and it has been referred to as “CyanoHABs” (O’neil et al., 2012). The incidence of cyanobacterial blooms has been said to increase in freshwater lakes, which has resulted in economic losses. **Studies suggest that the occurrence of these cyanobacteria blooms is likely to be caused by several factors except the increase in temperature of surface water.** Multiple factors, therefore, contribute to the existence of cyanobacteria.

Eutrophication has resulted in the widespread introduction of cyanobacteria. The widespread growth of cyanobacteria threatens water sources and recreational services, thus reducing the quality of water bodies. Most of the water bodies that have been greatly affected by these bacteria and include lake Eric in the united states of America, Lake Kasumigaura in Japan, lake Victoria in Africa, and Lake Okeechobee in Florida. Other lakes include Lake Taihu in China and the Baltic Sea located in Europe (Deng et al., 2014). Several studies have been conducted to explain the magnitude of these problems. For instance, in a study conducted in the large lakes in the south of the Alps to determine the effect of nutrient availability and temperature on phytoplankton development, results indicate the following: there was a positive

Commented [MP7]: Run spelling and grammar check to catch some of these grammatical errors

Commented [MP8]: What studies? If you mention studies, you should list the sources. Also, the sentence is written in a way that makes the reader think that temperature is not important. I think what you are trying to say is that there are environmental factors IN ADDITION TO THE INCREASE IN TEMPERAURE that cause cyanobacterial blooms.

relationship between an increase in temperature and the existence of these cyanobacteria. Water temperature contributed significantly to the existence of the bacteria (Salmaso et al., 2012).

In another study conducted to investigate the effect of settled cyanobacteria bloom and various changes in temperature on phosphorus cycling in shallow lakes was conducted. From the study, results indicated that sedimentary ion reduction was enhanced, and sulphate reduction took place. The release of phosphate increased due to cyanobacteria bloom. The temperature also increased. There was an increased release of phosphorus from the sediments when the temperatures increased. The presence of cyanobacterial resulted in eutrophication of aquatic lakes. This process was increased by an increase in temperature (Chen et al., 2014).

It has not yet been established how warming or an increase in temperatures results in up and down movement of water, thus affecting the variability of water animals. In an experimental study to determine how warming modified growth of trophic cascades and eutrophication in the freshwater bodies, warming manipulation was done in a 16-month experiment. Results indicated that warming facilitated the growth of fish and other primary producers. Winter temperatures reduced the growth of algae blooms (Kratina et al., 2012). This research study concluded that moderate temperatures enhanced stabilization of the ecosystem. Studies have also suggested that an increase in temperature and eutrophication affected the structure of the fish and other planktons in the ecosystems. There was a reduction in the size of the fish and other planktonic communities as a result of eutrophication (Bourai et al., 2020).

Data from more than 1000 lakes in the United States were collected and analyzed to determine the relationship between nutrients and temperature changes on the existence of cyanobacteria in oligotrophic, eutrophic, mesotrophic, and hypertrophic lakes. The results indicated that cyanobacterial biomass increased in high temperatures and nutrients. The study

Commented [MP9]: The way this sentence is written states that the Cyanobacteria CAUSED the release of phosphate. Or do you mean the opposite, that a release of phosphate caused the cyanobacterial bloom?

Commented [MP10]: These sentences are confusing. I think you are trying to make series of connections. Warming caused a release of phosphorus from sediments, A release of phosphorus caused an increase in cyanobacteria. The increase in cyanobacteria made eutrophication worse.

Commented [MP11]: What do you mean up and down movement of water? The physical moving of water up and down the water column? This is not talked about for the rest of the paragraph. You talk about trophic levels in the rest of the paragraph.

Commented [MP12]: How was it stabilized. More fish? What do you mean "stabilized"?

Commented [MP13]: You have already established this in your previous paragraphs. What is the point you are making in this paragraph?

indicated that the existence of the cyanobacteria was dependent on the trophic state of the water body. The more the lakes were eutrophic, the more there was the existence of the bacteria (Rigosi et al., 2014).

Commented [MP14]: Again, you already made this point in previous paragraphs. (see your Chen et al 2014 reference above)

Significant Efforts to Mitigate the Problem

Despite these problems occurring, there have been significant changes that scientists are trying to help mitigate eutrophication by cyanobacteria bloom. These strategies are aimed at helping reduce the danger that is being caused by the bacteria. Today, human life is at greater danger due to the production of toxins that can be threat health of a human being. As a result of global warming, lake temperatures are more likely to increase. Ice is also melting, and little ice formation is taking place. All these factors are posing a greater danger to ecosystems and threatening aquatic food webs as cyanobacteria are more likely to increase. Industrial organizations and governments should come up with measures to help mitigate this problem before it gets out of control.

Several measures have been deployed to ensure that the situation does not lead to adverse effects. These measures are either aimed at reducing the toxins released from cyanobacteria, which are harmful to human health or trying to reduce the growth of the cyanobacteria bloom. First, regulating toxins release from cyanobacteria is essential in mitigating these problems. Toxins have caused degradation of freshwater bodies globally. Cyanobacteria release microcystin in the water bodies, which causes great danger to human health when consumed. Microcystin is likely to cause damage to the nervous system and liver problem. To curb these problems, several studies have been conducted to determine how toxins released from the cyanobacteria can be reduced and managed (Walls et al., 2018).

Manipulation of temperature experiments has been done in the past years, and results indicated that cyanobacteria toxin amount increased in an increase in temperature (Walls et al., 2018). From the incubation experiments conducted by Walls (2008) on microcystin production, the production of microcystin toxin was lower in temperatures of between 3 degrees Celsius and 19 degrees Celsius compared to those that were incubated at temperatures between 20 and 25 degree Celsius. The use of water temperature can, therefore, be used as an essential mitigating factor to reduce the toxins produced. Water temperatures in eutrophic lakes should always be measured and monitored to determine the extent of production of the toxins by the cyanobacteria (Walls et al., 2018). The use of this model has been beneficial as it will help the health experts in looking for next step measures to ensure that the surface water temperature is below 19 degrees Celsius.

Commented [MP15]: How do you change the temperature of an entire lake?

The second mitigation procedure that is more likely to cause a reduction in the cyanobacteria is the reduction of nutrients. As mentioned earlier, the increased temperatures and nutrients increase the number of cyanobacteria. This will be successful by using the mechanism of nutrient cycling. This will increase competition for nutrients by the plankton community on the surface waters. Nutrient cycling will ensure that all organisms in the water system will have access to nutrients. This reduces the surface nutrients for cyanobacteria, thus suppressing their existence since they are usually found on the surface of the water. Water management agencies should consider this as a factor as it will help in reducing the adverse effects caused by cyanobacteria. This is mostly applicable when in the hypoxic zones (O'neil et al., 2012).

Commented [MP16]: What is nutrient cycling? You need to explain what it is.

Water managers should also work on changing climatic conditions. This seems almost impossible to accomplish in real life. This can be achieved in several ways. This will reduce or eliminate harmful cyanobacteria. Changing the climate condition will alter rainfall patterns.

Commented [MP17]: Why?

Commented [MP18]: Combine the two sentences

Another way through which this will impact the delivery of nutrients for the aquatic ecosystems.

Commented [MP19]: Combine these two sentences

Change in the rainfall patterns increases the supply of freshwater and the nutrients which do not stay for long due to nutrient cycling. An increase in rainfall will lead to less stimulation of the cyanobacteria blooms. This mechanism highly depends on other factors such as light and temperatures, which are survival factors for the cyanobacteria (O'neil et al., 2012). Increased rainfall also increases the flow of water decreases the cyanobacteria blooms. This is possible as water flow reduces the residence time and stratification. It also increases the turbidity of the water, reducing the number of cyanobacteria (O'neil et al., 2012).

Commented [MP20]: Why does increased rainfall increase turbidity?

Another method of mitigation that would help in reducing cyanobacterial blooms is by maintaining a balance between phosphorus and nitrogen. Cyanobacteria exist globally in the freshwaters. Studies conducted have indicated that controlling the amount of nitrogen and phosphorus in the water can help in controlling the cyanobacteria blooms. By solving these, one has to understand the mechanism of action of cyanobacteria in excess nitrogen and phosphorus. Excess nitrogen and phosphorus lead to an increase in cyanobacteria in the freshwater lakes.

Commented [MP21]: What studies. Cite your sources.

Establishing a balance between the two can reduce the impact of cyanobacteria. Cyanobacteria uses phosphorus for nitrogen fixation; therefore, the bacteria do not require nitrogen as there is atmospheric nitrogen (Shan et al., 2019). Thus, suppressing the growth of bacteria will require excess nitrogen and a minimum amount of phosphorus. In a research conducted to analyze the environmental factors influencing variations and associations in cyanobacteria in large and or shallow eutrophic lakes, the following results were analyzed from the study (Shan et al., 2019). The study indicated that microcystin biomass was majorly influenced by phosphorus concentrations and the surface water temperature. From this study, results indicated that if

Commented [MP22]: Why excess nitrogen? Below, you state that it is phosphorus that needs to be reduced

phosphorus were reduced, the cyanobacteria blooms would reduce by considerably. This is a long term control that is likely to mitigate this problem (Shan et al., 2019).

Strengths and Weaknesses of Mitigation.

For mitigation to be successful, water managers have to come up with strategies that can help in eliminating the cyanobacteria. In the implementation of these strategies, some weaknesses and strengths exist.

Strengths

Mitigation strategies helps in resolving the issues that do exist. Strengths of the mitigation often come with the success. One of the strength of mitigation in elimination of cyanobacteria in eutrophic lakes is the prevention of future problems that might occur as a result of cyanobacteria. Examples include the prevention of ailments that are likely to happen a result of increased toxins produced by the bacteria such as liver damage. Secondly, mitigation is likely to save on the economic cost that would have been incurred as a result of cyanobacteria. Thirdly, mitigation strategies leads to the preservation of aquatic ecosystems. This leads to fresh ecosystems and water bodies.

Weaknesses

One of the weaknesses experiences in the mitigation strategy is the high level of expertise required in implementation of the mitigation strategies. For instance in trying to put a balance between the phosphorus and the nitrogen is not easy and requires multidisciplinary thinking to achieve it. Changing the climate also requires a high level of thinking making it hard for most countries to achieve it. Another weakness that is likely to happen as a result of mitigation is the cost. In most cases, the cost mitigation is always high. This is because it requires incorporation

Commented [MP23]: Or that is virtually impossible

of technology with which the installation cost becomes very expensive. Some of the mitigation strategies are not easy to achieve as they take time for implementation

Conclusions

Studies conducted have indicated that the existence of these bacteria on the surface water affects the aquatic ecosystem. This has become a significant threat to the existence of other animals in the waterbodies. Human health is also significantly impacted by the existence of the cyanobacteria as it produces toxins that are harmful to human health. Water specialists should, therefore, ensure that the consumption of water is safe from these harmful toxins. Significant factors that facilitate the growth of these bacteria include the temperature of the surface water and the availability of nutrients to feed the cyanobacteria. When these factors are monitored closely, the existence of these bacteria might be extinct.