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Effect of Moss Killer on Dissolved Oxygen and Turbidity of Western Washington Lakes

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ABSTRACT

Several studies have been conducted on the effects of various pollutants on freshwater water systems in Washington state; however, research into the effects of increased concentrations of zinc, particularly via moss control products (representing a significant portion of the accumulative zinc pollution in Washington waterways) is scarce. The goal of this study is to shed light on the effect of moss control on the health of native aquatic microbial communities in Western Washington, measured via rate of change of dissolved oxygen and turbidity levels. Samples from Green Lake, Martha Lake, and Lake Washington were collected and introduced to varying concentrations of moss control, and the dissolved oxygen and turbidity levels of these samples were monitored over five days. It was discovered that there is a statistically significant negative correlation between concentration of moss control and both dissolved oxygen and turbidity. More research is needed to verify and further investigate these relationships.

Introduction

Both in the media and academic circles, much attention has been given to the dangers of microorganisms such as bacteria to human health and the environment. In particular, many studies have been conducted on the negative effects of various types of aquatic bacterial contamination, such as the spread of Coliform bacteria in sources of drinking water in Washington (*Coliform Bacteria*, n.d). However, comparatively little research has been conducted on the role of aquatic microorganisms in promoting both human health and supporting local aquatic ecosystems in Washington. In fact, the term microorganisms refers to a very large assortment of organisms that can have negative, positive, and neutral effects on humans and the environment. For example, probiotics, or beneficial bacteria, can help the body's functions through benefits like increased production of digestive enzymes, prevention against cancer formation, and even fighting against more pathogenic and dangerous microbes (Ranjbar, 2004). Similar to these probiotics, there are vast varieties of aquatic microorganisms in particular that provide food, produce necessary vitamins, and initiate or support immune responses to invading pathogenic microorganisms for larger organisms, contributing to the overall health of an ecosystem (Fisheries, N. O. A. A, 2020).

However, with the constantly-changing aquatic ecosystems and the increase in water pollution due to an increase in human activity, some of these aquatic ecosystems may be at risk. In particular, heavy metal pollution has played an important role in contributing to the pollution in freshwater lake and river systems. Water is inherently adept at absorbing various chemicals and pollutants, making it extremely susceptible to heavy metal pollution. Although there are trace amounts of these metals naturally in the water, sources such as mining, industrial excess, and pesticides can enter surface waterways and groundwater through run-offs and leech high concentrations of these contaminants, which has been proven to be extremely toxic for larger aquatic organisms like fish even with lower doses (Ali & Ilahi, 2019). However, relatively little research has been done on the effects of heavy metals on aquatic microorganisms, which operate on a different scale and may therefore behave differently in response to pollutants.

Of these heavy metals, zinc pollution in Washington state is not as well studied when compared to other heavy metals, with a coefficient of variance in zinc loading of 0.68. Although there are other metals with a higher uncertainty, such as copper with a coefficient of variance of 0.75, these metals are not nearly as highly polluted in Washington and therefore do not have as high priority in research as zinc (Bookter, 2017). Within zinc pollution, however, there are a variety of sources that must be studied individually, since each source is distributed in different ways to waterways and have different inherent chemical compositions. According to the Washington Department of Ecology, a stunning 42.8% of all zinc pollution stems from moss control (Bookter, 2017). In addition, moss control has an uncertainty coefficient of variance of 0.50, despite its volume. Thus, it is imperative that the effects of moss control on aquatic ecosystems is studied to a greater extent.

With the relatively little literature on the effects of heavy metals on aquatic microorganisms and the effects of zinc pollution on aquatic ecosystems, in particular using moss control products as a medium, it is crucial that more research is conducted on the effects of moss control on aquatic microorganisms. Although there have been studies regarding zinc's effects on aquatic organisms like fish, no research has focused on moss control products and its effects on the population of aquatic microorganisms in lake water, especially in Washington state's coastal freshwater systems. By utilizing measures such as dissolved oxygen (DO), which can track respiration rates of microorganisms, and turbidity, which can estimate population of visible microorganisms in water column, the health and population of microorganisms within a sample of water treated with moss control can be tracked over time. Thus, this study will center itself around the effect of moss killer on the turbidity and dissolved oxygen of Western Washington lake water.

Literature Review

It is important to note that there are many underlying factors that may have an effect on whether moss control products will have an effect on the aquatic microbial community. In particular, zinc pollution creates changes in the environment on the molecular level, but these changes are significant enough that they are able to create large-scale disturbances that affect entire organisms. In fact, there are numerous studies that have researched the particular effects of zinc on aquatic organisms, such as one in China where it was found that decreasing pH can lead to increased sensitivity to zinc pollution in aquatic organisms (Li et al., 2019). According to the researchers, generally zinc (as well as other heavy metals) binds to certain proteins in the organism. Many organisms require this zinc for certain molecular functions to perform correctly. However, an excess of zinc can decrease the amount of proteins available for zinc to bind with, leading these extra zinc molecules to bind with other proteins and enzymes, which subsequently poisons the organism. This effect was even observed in algae, whose growth was inhibited by the higher concentrations of zinc the researchers introduced. Since the effects of zinc operate on the microscopic scale rather than the macroscopic level, it is thus plausible from this study that aquatic microorganisms like bacteria may also display similar inhibitory effects to growth and/or poisoning. In fact, zinc has already been proven in the past to play a critical role as a structural protein and helper molecule in bacterial cells in particular, aiding in catalyzing enzymes (Suryawati, 2018). However, some researchers have also discovered that tolerance to heavy metals is not uncommon among both algae and bacteria (Bong et al., 2010). As microorganisms evolve, they will slowly adapt to their changing environment. In particular, it was found that many bacterial cells also contain systems and mechanisms that limit the flow of zinc into and out of the cells, maintaining homeostasis within the cell (Suryawati, 2018). This self-defense mechanism is likely a product of the variety of environments these bacteria have been exposed to, necessitating a method to adapt to varying concentrations of heavy metals. In fact, for many bacteria, this mechanism plays an essential role in virulence and therefore success of the species. Yet, the toxicity of zinc can be further increased by certain environmental factors, which may overcome these defenses. Not only does pH affect the toxicity of zinc as mentioned earlier, but increases in temperature and decreases in DO levels can increase the toxicity of zinc as well (Skidmore, 1964). Additionally, salinity may create a divide between the effects of zinc on freshwater microorganisms and saltwater microorganisms. Thus, considering the diversity of microorganisms, their environments, and their various self-defense mechanisms against heavy metals and zinc in particular, it is imperative that more research is conducted to test whether microorganisms in specific environments are able to adapt to increasing levels of zinc.

Unlike other studies that have previously been conducted on the topic, this research will focus directly on a specific region of interest, Western Washington freshwater lake systems. Since the toxicity level of zinc varies greatly depending on the specific conditions of the environment and the specific characteristics and tolerances of aquatic microorganisms living in that environment, a general study on the effects of zinc pollution cannot be applied to all regions; instead, it must be focused on a specific region, revealing a gap in the current body of knowledge. This study aims to fill a part of that gap by exploring the effects of zinc on Western Washington via moss control, which is a method of zinc pollution distribution that is extremely pertinent to Washington in particular (Bookter, 2017).

It is also important to have a strong understanding of the characteristics and nuances of Washington's waterways. For the purposes of this study, important and relevant information about Washington lake systems in particular will be reviewed. Washington lakes are extremely biodiverse, even compared to its other aquatic ecosystems (*City of Seattle,* 2007). They serve as habitats for various fish and bird species, as well as countless insects and other species that thrive in lake habitats. This is due to the collection of debris flowing into these lakes throughout the area around it. Even among these, there are various subsets of lakes that have different characteristics. Oligotrophic lakes are large, deep, clear, and contain very little nutrients, which means that they are comparatively less biodiverse and have lower populations of microorganisms. On the other hand, eutrophic lakes are smaller, shallow, often have a coloration in the water, and contain a rich assortment of nutrients that support a biodiverse ecosystem and a large population of microorganisms. From these characteristics, particularly through biodiversity and algae bloom history, Green Lake and Martha Lake are likely more eutrophic, while Lake Washington is more oligotrophic ("2016 Freshwater water quality", 2017). This is important to note, since the samples in this experiment will be collected from these three lakes, and an assumption is being made that these lakes are representative of the entire region of Western Washington. This also supports the idea that different regions may have different characteristics that make them unique, ultimately justifying the need for specialized studies in specific regions.

With an increasingly urbanized population, however, the fragile balance between human growth and Washington's unique ecosystems must be maintained. Various initiatives such as the Restore Our Waters initiative aim to increase awareness of the issue to the general public, and water quality assessments are constantly being released to the public (*Current Water Quality Assessment*, n.d). However, more research needs to be conducted in order to 1.) justify the public resources being spent on environmental conservation campaigns, and 2.) provide a foundation of knowledge that can be used to craft unique solutions that are tailored to Washington's ecosystems. Thus, not only does this study help to fill a gap in the current body of knowledge, but it will also constitute an important and impactful support against the increasingly-growing overall issue of environmental conservation in Western Washington.

Hypothesis

Applying the mentioned prior research on the effect of zinc on organisms and microorganisms, the initial hypothesis of this study is that moss control products will have an adverse effect on the population of microorganisms in Western Washington lake water, culminating in a positive correlation with DO and a negative correlation with turbidity. Excessive zinc concentrations will either cause zinc poisoning in microorganisms or have no effect due to specific tolerances to zinc the microorganisms exhibit. By extension, the null hypothesis of this study is that moss control products will have no effect on the DO and turbidity of Western Washington lake water. These hypotheses act under the assumption that the three lakes that will be surveyed in this experiment (Martha Lake, Green Lake, and Lake Washington) are representative of the entire region of Western Washington.

Methods

In this study, a scientific experiment will be conducted as opposed to a meta-analysis or survey. This method is the most well-adapted one for this research, since the overall goal of the study is to find a relationship between excess dissolved zinc and its effects on the abundance of aquatic microorganisms in Western Washington aquatic ecosystems. By introducing moss killer to samples of these ecosystems through a scientific experiment and collecting data, a correlation between the two variables can be established (or lack thereof), thus either proving or disproving the null hypothesis. Additionally, quantitative data will be collected as opposed to qualitative data, since it will allow for a concrete analysis of statistical difference.

To collect water samples representing the environment of Western Washington, three local lakes were chosen: Martha Lake, Green Lake, and Lake Washington. The relative size of these lakes allowed for a larger population size, which is preferable when choosing a statistically representative sample. Multiple lakes were utilized in order to ensure that the results are representative of the entire region of Western Washington, rather than only one body of water. All samples were handled with gloves, and proper hygiene/sanitation such as hand-washing was followed immediately after handling samples. In order to get the best representation of each lake, shoreside docks were utilized to retrieve samples from as deep as possible while minimizing disturbance of the water in order to prevent artificially-induced water oxygenation and introduction of debris, which would affect dissolved oxygen and turbidity readings respectively. Deeper water is generally more representative of a lake system since the microorganisms in these waters will collect and reproduce in the unique conditions of the lake. From each lake, 1-gallon containers were filled to be distributed into experimental samples. These containers were placed into a larger box and lined with foam in order to further prevent induced water oxygenation during transportation. Samples were collected consecutively on the same day, each within one hour of each other, in order to control for differences in types of active aquatic microorganisms during different parts of the day.

Once the lake water was collected, each lake's sample was separated into three separate experimental units containing 750 mL of water, in the following formation:

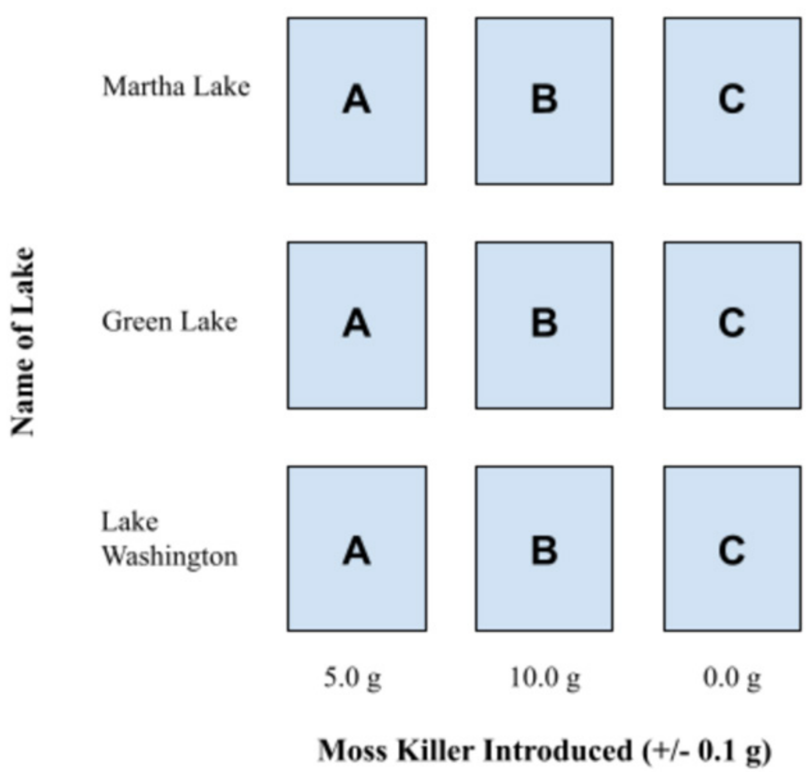

Figure 1. Assignment and Distribution of Sample Groups

As depicted in figure 1, the three samples for each lake will be labeled as A, B, and C. Five grams of moss control will be added to each container labeled sample A, and ten grams to those labeled sample B. The containers labeled with C will have no zinc added; instead, they will act as a control to serve as a point of comparison and to ensure that there are no confounding variables. After labeling and introducing moss control, the jars were subsequently lined up outdoors to simulate the same temperature as the lakes from which the samples came from.

In order to measure the effect of moss killer on the health of the population of microorganisms, DO and turbidity were chosen as responding variables for the experiment. By measuring the change in DO over a period of time in a lake sample, it is possible to determine the respiration rate of the aquatic microorganisms living inside the sample. In fact, this method was successfully used in another study on the effect of antibiotics on aquatic microorganisms as well (Gonia & Talarczyk, 2019). Since microorganisms convert oxygen to carbon dioxide as a natural process, the rate at which this oxygen is converted can be used to determine the number of microorganisms in the water. Similarly, measuring turbidity can also serve as a reliable indicator of the number of aquatic microorganisms, since a greater number of microorganisms will naturally cloud the water and increase turbidity. This pattern is often observed naturally in lakes as turbidity increases in summer months while the water becomes clearer in winter months. Other methods of measurement were considered, but rejected either due to lack of accuracy or insufficient resources. For example, an ATP kit measures the amount of adenosine triphosphate, a molecule used by all organisms to store and consume energy, in the water column. This allows for a more accurate measure of aquatic microorganism population than even dissolved oxygen and turbidity, but due to the high expense of these kits, this method was rejected. Another method that was considered was to take a very small droplet of the lake samples and count the microorganisms manually using a microscope, and subsequently multiply upward to find the total microbial population in the sample. However, due to the time involved in counting these microorganisms and the susceptibility to human error while counting microorganisms while they are constantly moving, this method was rejected as well. Even if microorganism count can accurately be identified within this droplet, the margin of error will also be multiplied upward when extrapolating the total population of microorganisms in the entire sample, leading to a greater uncertainty than other methods. Thus, DO and turbidity were utilized in this experiment as an alternative. Although DO probes and turbidity sensors are above budget as well, the science department of North Creek High School offered to lend out this equipment temporarily, along with a Vernier LabQuest 2 to interpret the data inputs from the sensors and display it on screen in a clear format.

Over the course of 5 days, measurements for each of the 9 samples via the DO probe and the turbidity sensor were made daily, at the same time and in the same order, as depicted in the diagram below. Measurements were started at 6:00 p.m. on each day and generally ended at about 7:15 p.m. Dissolved oxygen was measured before turbidity in order to prevent induced oxygenation caused by disturbances in the water column while collecting samples to be measured in the turbidity sensor via cuvettes. Measurements were strategically taken from the control groups first, in order to reduce possible cross-contamination. In addition, the DO probe and the cuvettes were cleaned in between each sample measurement using distilled water.

Volume 10 Issue 4 (2021)

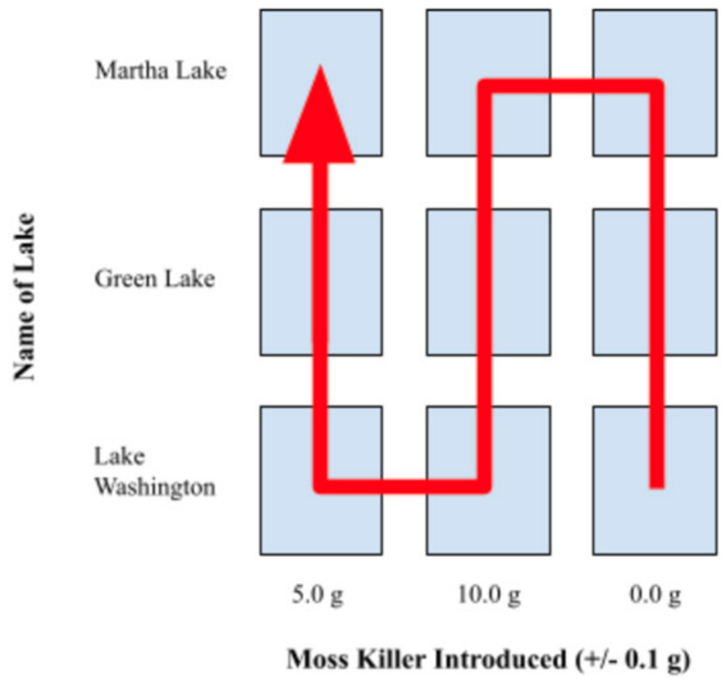

Figure 2. Sequence of Measurements Taken over Testing Period

At the end of the research period, the contents of the jars were properly disposed of by running the water through a filter to catch contaminants rather than being returned to the original aquatic ecosystems they came from, so as to prevent the samples from contaminating real ecosystems.

It must be understood that there are some limitations to this methodology. Firstly, by using samples and isolating them in jars, the experiment will not perfectly replicate the conditions of the original aquatic ecosystems. Secondly, due to the experiment's resource constraints, only three lakes could be sampled, and only three samples from each lake could be taken. Ideally, samples from a more diverse array of lakes and more trials for each lake can increase accuracy of the results and ensure that they are representative of the entire region of Western Washington.

Results

Below in figures 3 and 4 are graphs of the dissolved oxygen and turbidity values of each lake over time. Dissolved oxygen is measured in *mg/L*, while turbidity is measured in *NTU* (Nephelometric Turbidity Units). Each graph represents a lake, with the blue line representing the 5 gram moss control samples, the red line representing the 10 gram moss control samples, and the yellow representing the controls sample, as labeled below. Note that the graphs do not start at 0, but rather break at an appropriate spot in order to differentiate between data values. In place, the error bars can be used to give an estimate of significance. The given error bars are derived from the manufacturer's margin of error on the DO probe and turbidity sensor.

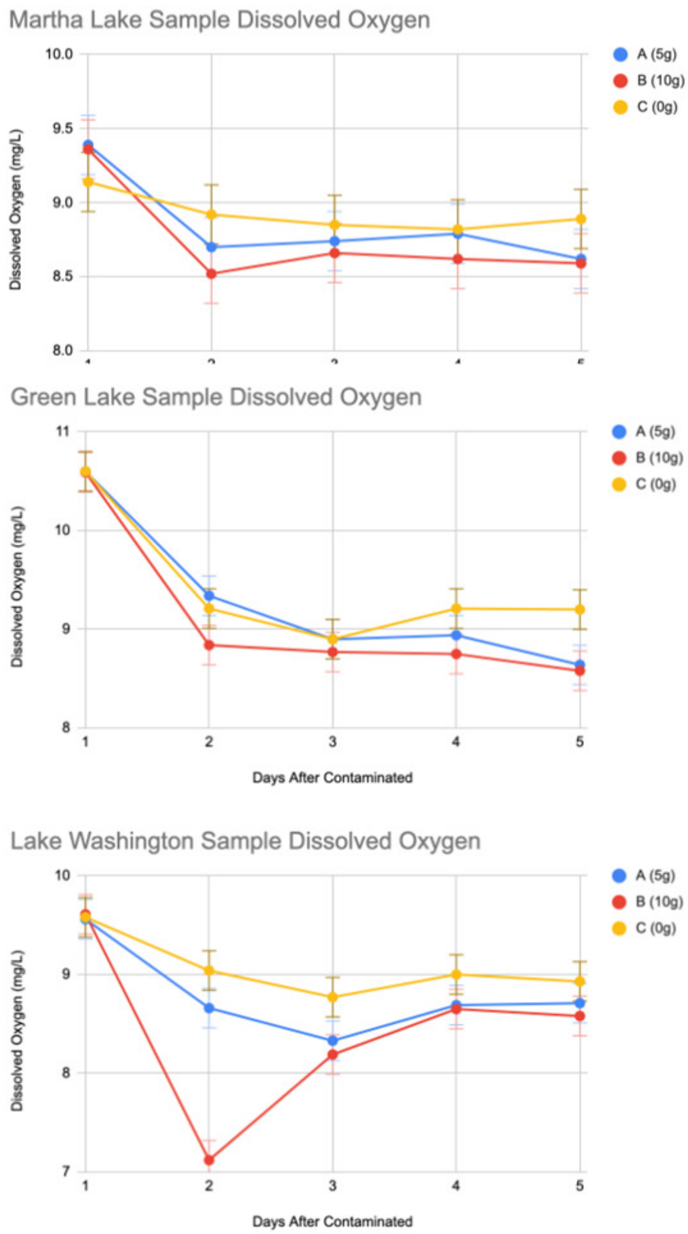

Figure 3. Graphical Representations of Dissolved Oxygen Change in Experimental Samples

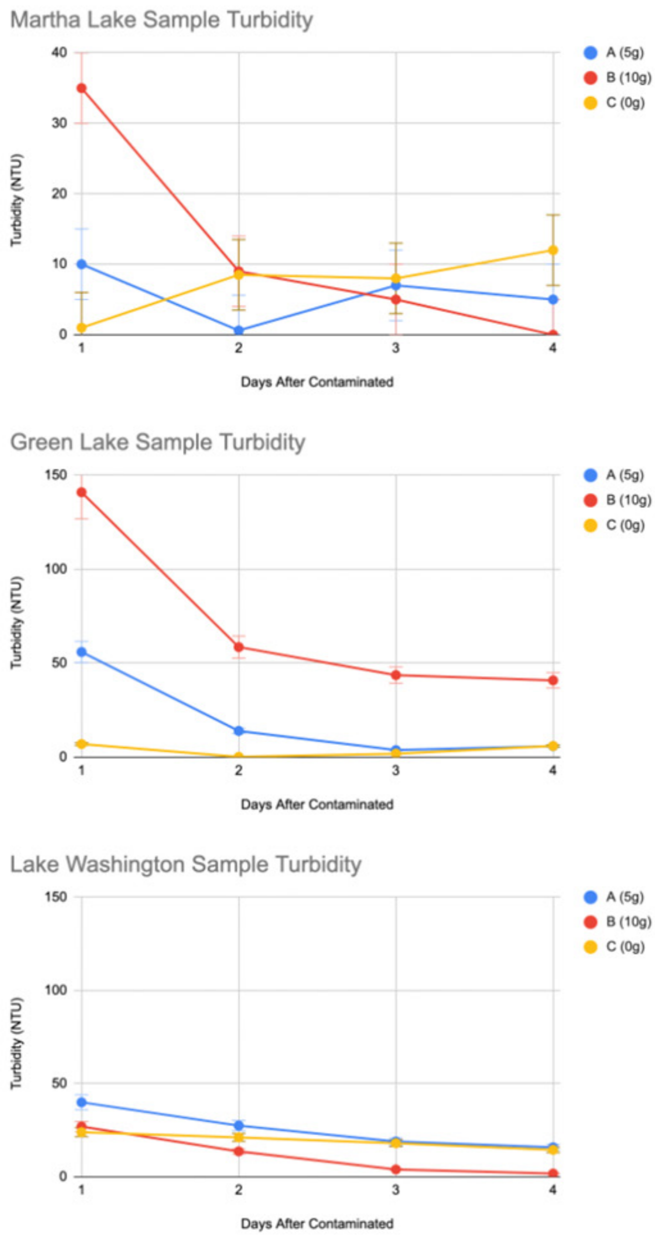

Figure 4. Graphical Representations of Turbidity Change in Experimental Samples

At first glance, sample group B generally maintained the highest DO concentration for each lake, with sample group A closely following and sample group C with the lowest. At many points on the graph, this trend is supported by the lack of overlap between error bars on each line. This supports a correlation between DO and moss control; however, more analysis must be conducted to statistically prove such a correlation. On the other hand, turbidity data displays mixed results that are more difficult to interpret qualitatively. Additionally, many of the turbidity values differed between samples A, B, and C at the beginning of the experiment due to the initial coloration of the water when moss control was introduced. Thus, in order to further condense these results and quantitatively represent them to prepare for statistical analysis, tables were constructed with the average rate of change in DO and turbidity for each sample below. The rate of dissolved oxygen is measured in *mg/L * d*, with *d* representing the non-SI value of a day (24 hours). The rate of turbidity, similarly, is measured in *NTU/d*.

Table 1. Rate of Change in Dissolved Oxygen (mg/L * d)

Lake Name	Sample A	Sample B	Sample C
Martha Lake	-0.193	-0.193	-0.063
Green Lake	-0.213	-0.258	-0.163
Lake Washington	-0.490	-0.503	-0.305

Table 2. Rate of Change in Turbidity (NTU/d)

Lake Name	Sample A	Sample B	Sample C
Martha Lake	-4.55	-12	2.75
Green Lake	-12.53	-25.03	-0.25
Lake Washington	-6.25	-6.33	-2.38

By representing DO and turbidity changes as rates over a period of time, a pattern can be observed. In Martha Lake, Green Lake, and Lake Washington water, samples from group B consistently held higher rates of DO loss and higher rates of turbidity loss than those from group A, which in turn held higher rates of DO loss and turbidity loss than those from group C. This trend suggests that a higher concentration of moss control products added to Western Washington lake water will decrease the dissolved oxygen concentration and decrease the turbidity of the water. However, this trend must be established through statistical analysis in order to prove a correlation between moss control and the DO and turbidity of lake water.

Analysis

According to figures 5 and 6, there is a possible observed correlation between concentration of moss control and the DO and turbidity of Western Washington lake water. In order to determine whether this correlation is statistically significant, a statistical significance test must be performed.

In this experiment, H_0 (null hypothesis) is that there is no effect of moss killer on the DO and turbidity of Western Washington lake water, while H_A (alternate hypothesis) is that there is a positive correlation between moss control and DO and a negative correlation between moss control and turbidity in Western Washington lake water. A Pearson correlation test was used to attempt to disprove the null hypothesis. However, several alternatives were considered during this stage. For example, multiple hypothesis tests, including the two-sample t-test for difference in means and the ANOVA test, were listed as possible methods to analyze the data due to the multiple categories the variables of the study fit into (Samples A, B, and C). However, the two-sample t-test could not be used because there are three distinct groups. The ANOVA test was considered as an alternative that allows for more than two groups, but since the independent variable represents continuous data (number of grams of moss control) rather than categorical data and since the goal of the study is to determine a correlation rather than statistical significance, the ANOVA test was not used either. This lack of categorical data was also the same reason that the chi-square test was not used. Instead, a correlation test was used. The Spearman Rank correlation was considered during this stage due to its comparative lack of preconditions, but it was rejected because it required a monotonic relationship, which this experiment lacks as determined by figures 3 and 4. Thus, the Pearson correlation test was chosen for its ability to prove a distinct correlation and its preconditions that matched the experiment's data.

To perform the Pearson correlation test, the rate of change in DO and turbidity for each lake's three samples were inputted into a TI-84 graphing calculator, and the linear regression function was performed on the data. Below are the resulting R values for each lake.

Table 3. Pearson Correlation R Values Per Lake Sample

Lake Name	Dissolved Oxygen	Turbidity
Martha Lake	-0.866	-1
Green Lake	-0.999	-1
Lake Washington	-0.894	-0.875

Since the values above cross the threshold for a strong correlation ($|R|>0.7$), it seems that there is a strong correlation between moss control and the DO and turbidity of Western Washington lake waters. However, due to the limited number of samples, the Pearson correlation test in this case has a very low power, meaning that the significance of these results is severely contested by a lack of data points. Thus, in order to increase the power of the test, the rates of change in DO and turbidity for all three lakes were combined, and a Pearson correlation test was performed for both DO and turbidity that included all nine samples, rather than only three per lake. In order to do this, the assumption was made that the combination of these lakes accurately provides a representative sample of the entire region of Western Washington, and the correlation test was generalized to Western Washington rather than only one lake. After the test was conducted, it was determined that the R value for DO is -0.415 while the R value for turbidity is -0.758.

Since the R value for DO is negative and crosses the threshold for a moderate correlation ($|R| > 0.3$), it is determined that with the data found in this experiment, there is a moderate negative correlation between moss control and the DO of Western Washington lake water. Similarly, with a negative R value that crosses the threshold of strong correlation ($|R| > 0.7$), it can be concluded that there is a strong negative correlation between moss control and the turbidity of Western Washington lake water.

However, there is an issue with this conclusion. A negative correlation between moss killer and DO implies a positive correlation between moss control and DO, which in turn indicates that moss control products increase the population of aquatic microorganisms. On the other hand, a negative correlation between moss killer and turbidity implies that moss control has a negative effect on the population of microorganisms in Western Washington lake water. Thus, to address the original research question, although there is a moderate correlation between moss control and the DO and turbidity of Western Washington lake water, this conflict leads to inconclusive results.

In analyzing possible limitations that may have affected the results of the experiment, most fall under one of two categories: 1.) confounding variables and 2.) random error.

In terms of confounding variables, one of the most influential was the coloration of the moss control product used in the experiment. Turbidity experienced a significant increase with the introduction of moss control, rather than as a result of an increase in microorganisms. To mitigate this, measurements were taken one day afterwards, to allow for the coloration to clear up. Additionally, algae particles in the water column may have affected the DO values via photosynthesis, which increases DO rather than decreasing it. Each lake sample should have the same amount of plant material, but regardless this introduces a confounding variable. Lastly, the assumption was made that the lakes used in the experiment would be representative of Western Washington. However, Lake Washington is oligotrophic while the other two lakes are eutrophic, explaining the higher DO values in Lake Washington samples (cold water retains more DO) (*City of Seattle,* 2007).

There were also random errors in the experiment. The most pertinent of these was the small sample size, due to a limited number of containers that could safely be kept and monitored. This is why only three lakes could be surveyed and only three samples from each lake could be measured. Due to the lack of samples, the data collected in the survey was more susceptible to outliers, and the power of the Pearson correlation test that was conducted is reduced.

Conclusion

After careful consideration and analysis of the data, it has been determined by this experiment that there is a moderate negative correlation between moss control and the DO of Western Washington lake water, and a strong negative correlation between moss control and the turbidity of Western Washington lake water, disproving the null hypothesis. However, these results seemingly contradict each other—the DO results suggest that moss control promotes the growth of aquatic microorganisms, while the turbidity results suggest that moss control inhibits the growth of these microorganisms. Although the turbidity results align with the alternate hypothesis, the DO results support neither the null hypothesis nor the alternate hypothesis.

Most previous studies on the topic suggest that an increased proportion of zinc, and by extension moss control, would either have no effect or a negative effect on the population of aquatic microorganisms, due to the possibility of zinc poisoning (Suryawati, 2018). Although the turbidity results seem to support this opinion, the DO results contradict the majority opinion of the general body of knowledge. A possible explanation is that the water samples had a zinc deficiency in the beginning. Since the samples were taken in the winter months, during which moss control is not normally used and the flow of nutrients into lakes is slowed, a zinc deficiency is possible. Furthermore, according to previous research, natural zinc concentrations play a key role in the structure and catalytic activity of bacteria (Suryawati, 2018). Thus, by artificially introducing zinc via moss control, the starved microorganisms may have utilized the extra zinc to their advantage, thereby increasing their rate of respiration and decreasing the rate of DO loss. Although this does not account for the simultaneous decrease in turbidity, it is possible that the introduction of a confounding factor via coloration of the moss control itself may have contributed to this turbidity change. As the moss control product settled, the water would naturally clear, leading to a decrease in turbidity.

Another possible explanation for the decrease in DO is a loss of biodiversity. According to previous research, some algae and bacteria experience a tolerance to heavy metals (Bong et al., 2010). In particular, they possess regulatory systems that prevent excess zinc from entering their systems and poisoning them (Suryawati, 2018). It is possible that introducing moss control to the water samples killed the microorganisms that did not exhibit this trait, allowing those that did to take advantage of the loss in competition and rapidly reproduce (Gonia & Talarczyk, 2019). Yet again, this would not account for the turbidity change—this would have to be explained by the coloration of moss control.

With these results, it has become more important that this study is further examined in order to shed light on the effects of zinc pollution within Western Washington. Although the results are inconclusive, it still provides a foundation for new avenues of research that could lead to new discoveries that spark policy changes. Firstly, it is important that this study is either replicated or refined in the future in order to confirm or dispute the results. Due to the constraints of this study, particularly due to the small sample size, there are a number of ways the methodology in this study can be further improved with more resources and more planning, mitigating the effects of confounding variables. Research could be performed to test whether the correlation found in this study constitutes a direct relationship. Additionally, the conclusions of the study and possible reasons for the study's inconclusive results suggest new areas of inquiry that other researchers can follow. For example, with the possibility of a zinc deficiency in the sampled lakes, more research must be conducted on the levels of natural zinc concentrations in Western Washington lakes. Additionally, research into the specific composition of moss control products may lead to new insights into the dangers of moss control as a means of distributing not only zinc contamination but also other pollutants. Although these areas of inquiry were not within the scope of this study, they can be explored in the future, utilizing this study as a baseline. It is imperative that these avenues are explored in order to reach a greater understanding of and eventually combat environmental pollution.

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