Investigating the Relationship Between Salinity and Concentration of Microorganisms on Water Clarity in Vancouver's Lakes and Ponds

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Abstract

This study investigates the relationships between salinity, microbial concentration, and water clarity in five distinct lakes and ponds in Vancouver: Central Park Upper Pond, Nitobe Memorial Garden Pond, Minuro Lake, Deer Lake, and Burnaby Lake. Using a refractometer for salinity measurements, a hemocytometer for cell counts, and a custom lux-measuring tool for light's penetration through samples, the study aims to test two hypotheses: that higher salinity increases water clarity and that higher microorganism concentrations reduce water clarity. The results demonstrated that microbial concentrations correlated inversely with lux readings. However, the hypothesis about salinity's effect on clarity was unsupported, as all sampled water sources read zero salinity. Notably, Burnaby Lake displayed unique characteristics, where microbial concentrations correlated proportionally with lux readings, indicating a significant pollution impact. These findings demonstrate that water clarity is directly and indirectly influenced by environmental factors, highlighting the need for future studies to further investigate these dynamics.

Introduction

Water clarity is an important factor affecting the health and productivity of lake ecosystems. High turbidity (cloudy water) reduces light penetration, consequently limiting phytoplankton photosynthesis and oxygen production, which are crucial for aquatic life (Michigan Sea Grant, 2024). This study investigates the relationships between salinity, microbial concentration, and light penetration in Central Park Upper Pond, Nitobe Memorial Garden's pond, Minuro Lake, Deer Lake, and Burnaby Lake. I will measure salinity using a refractometer, microbial concentration with a hemocytometer, and light penetration with a custom-built lux-measuring tool.

I hypothesize that: 1) increased salinity will positively correlate with water clarity by joining suspended particles and settling them, reducing suspended particles in the surface water, and 2) increased microorganisms concentrations will negatively correlate with water clarity due to increased light absorption. This is based on previous research showing a negative correlation between water clarity and total suspended solids (TSS), where TSS includes particles larger than 2 microns. Salt ions can cause TSS to bind together and settle, reducing TSS at the surface of the water; however, microorganisms larger than 2 microns also contribute to TSS, so higher microbial numbers increase TSS (Fondriest Environmental, Inc., 2014).

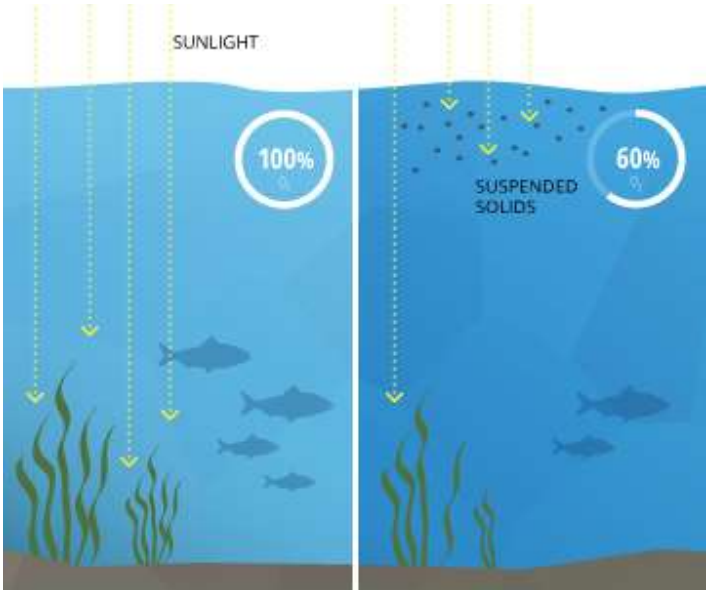

Figure 1. Total Suspended Solids (TSS) reduce the amount of light penetrating the water. Fondriest Environmental, Inc. (2014). *Turbidity, total suspended solids and water clarity* [Illustration]. Fundamentals of Environmental Measurements. Retrieved from https://www.fondriest.com/environmental-measurements/parameters/water-quality/turbidity-total-suspended-solids-water-clarity/

Understanding these interactions is crucial for managing and protecting valuable urban lake ecosystems. This research will contribute to our understanding of factors affecting water quality in coastal areas and may suggest strategies for improving water clarity and ecosystem health in similar systems.

Methods

Field Sampling:

Water samples were collected from five distinct water sources: Central Park Upper Pond, Nitobe Memorial Garden Pond, Minuro Lake, Deer Lake, and Burnaby Lake. Three samples were collected using sampling cups from different locations within each source to better represent each water source. Note: due to safety concerns, samples were collected only from areas along the shore where I could safely reach my hand to the water's surface. For each sample, the following parameters were recorded: location, weather conditions, water temperature, and time of collection. This information was recorded in the lab notebook. Label each of the three samples clearly to distinguish between them. In order to avoid potential errors, sampling did not occur during or after rainfall, as rain can lead to soil erosion and dilute the water source, resulting in an inaccurate representation of the overall water body. After collecting the samples, the sample cups were placed in cold storage to prevent microorganism proliferation.

Laboratory Analysis:

Every time entering the laboratory, I use warm water to dissolve the frozen samples, and then I shake the samples well before opening the lid for measurement.

Colorimeter:

I aimed to measure the impact of various wavelengths on the absorbance properties of my water samples, specifically 430 nm, 470 nm, and 635 nm. I chose these wavelengths since chlorophyll b (every phytoplankton needs to have this pigment) absorbs primarily at 453 nm and 642 nm (Khan Academy, n.d.). After connecting the colorimeter to the calculator and powering on both, I calibrated it using dH2O in a clean cuvette, setting the absorbance to zero for each wavelength. For each measurement, I filled a clean cuvette with the sample, wiped it dry, and placed it in the colorimeter. Repeat for all fifteen samples and record everything in the lab notebook.

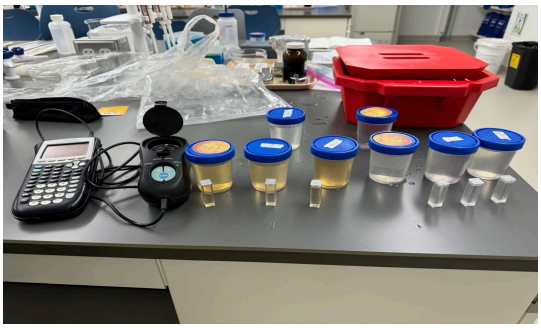

Figure 2.Colorimeter, calculator and samples

Refractometer:

I measured the salinity of each sample using a refractometer. I placed a few drops of each sample on the prism, closed the cover, and recorded the salinity in my lab notebook. Clean the prism with 70% ethanol after each measurement.

Hemocytometer :

To determine the concentration of microorganisms in the water sample, I used a hemocytometer to count the number of cells in each sample. First, I adjusted my microscope to 10x magnification. I then placed 20 microliters of the sample onto the

hemocytometer. Using a slide, I positioned the hemocytometer under the microscope to observe the cells. Because of the low cell count in the samples, I counted the entire hemocytometer and recorded it in my lab notebook. After completing the count, I cleaned the hemocytometer with 70% ethanol before moving on to the next sample. I repeated this process, including distilled water, for a total of 16 measurements.

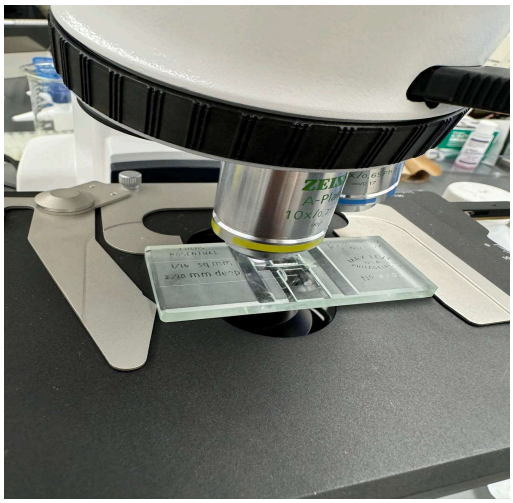

Figure 3. Hemocytometer and microscope, using 10x magnification

Lux Measuring:

To measure the amount of light penetration through the samples, I built a tool using some cardboard boxes to ensure consistent positioning each time. First, I cut a circular hole in the center of a large box, allowing a flat-bottom glass container to fit securely without falling through. Then, I created a smaller box to ensure my phone's camera was perfectly aligned with the glass container. to assemble, I placed a lamp inside the larger box, stable it so it would emit a consistent light source. I then placed a container with 100 mL of sample water on top of the large box, allowing the light to penetrate the sample. Finally, I used a light meter app on my phone, positioned inside the smaller box

on top of the larger box, to take measurements. After waiting a few seconds, I recorded the light intensity readings. After that, I will clean everything with 70% ethanol and repeat the process 16 times, including dH2O for control.

Figure 4-9, Setting up cardboard for lux measurement. (Top Left): I cut a hole in the center of the large box that is smaller than the glass container, so light can go through it. (Top Center): light penetrates the glass container and dH2O. (Top Right): setting another box to go on top of the larger box, the phone's camera would be set to align with the hole. (Bottom Left): top view of the whole system. (Bottom Right): another angle for the system(the phone is not in the picture yet)

Result:

This section presents the results obtained from analyzing the data using Python to create graphs that illustrate the relationship between cell concentration and lux readings at different sampling locations.

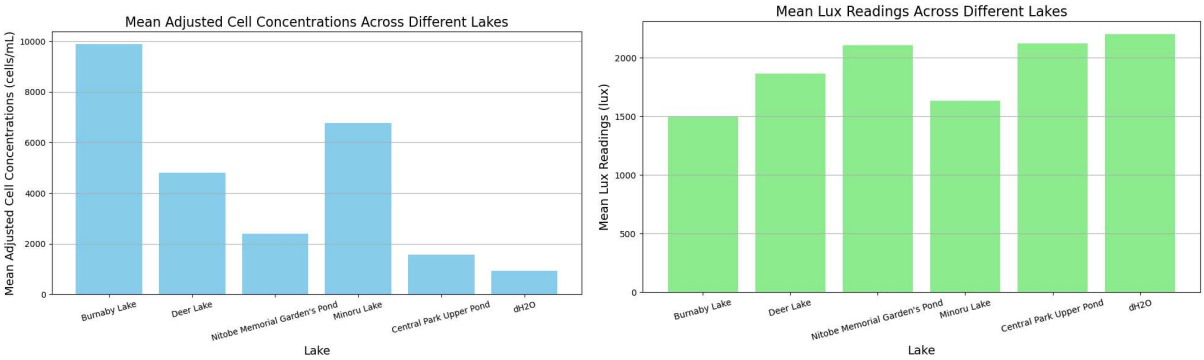

Figure 10 presents the average cell concentration across all water sources. Burnaby Lake had the highest microbial concentration average while dH2O had the lowest microbial concentration.

Figure 11 presents the average Lux Readings across all water sources. dH2O had the highest lux reading while Burnaby Lake had the lowest average lux reading.

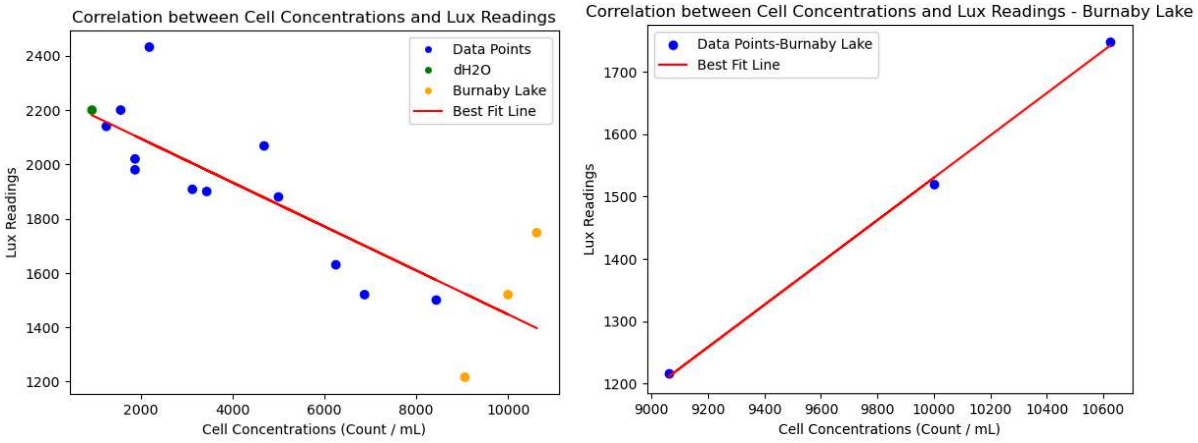

Figure 12 illustrates the correlation between cell concentration and lux readings at the sampling locations. The data points are color-coded, with blue representing data from all lakes, green representing dH2O as a control, and orange representing Burnaby

Lake. The graph reveals a general trend where increasing cell concentrations correlate with decreasing lux readings. However, there is a significant deviation in the trend observed in Burnaby Lake from the other locations.

Figure 13 shows a specific correlation between cell concentration and lux readings for Burnaby Lake. In this lake, increases in cell concentration correlated with increases in lux readings.

It is important to note that data obtained from the colorimeter and refractometer could not yield any meaningful results. The colorimeter readings were too similar to the control (dH2O), making differentiation between samples impossible. Additionally, the refractometer consistently measured a value of 0 across all samples, as all water sources tested were freshwater.

Discussion:

Throughout this study, I observed that the colorimeter was unable to accurately measure lux (with the exception of Burnaby Lake), where all water samples read zero, the same as dH2O. This may be because the concentration of microorganisms in the samples was insufficient to absorb the wavelengths emitted by the colorimeter. Therefore, I was unable to use the colorimeter and Beer's Law to perform calculations.

My initial hypothesis that higher salinity would lead to higher light penetration was also not supported. All the water samples I collected were freshwater, with the refractometer reading 0. Therefore, I could not establish any correlation between salinity and light penetration. Future investigations should focus on areas with significant salinity fluctuations, potentially including coastal environments where seawater interacts with freshwater systems.

However, my second hypothesis regarding the relationship between microbial concentration and light intensity was supported. Throughout the experiment, there were some potential sources of error, such as weather factors, temperature, and time, which could lead to microbial proliferation during transportation to the laboratory. Additionally, certain cells may not have been counted during the hemocytometer analysis, but overall, these discrepancies can be considered negligible. I found that there is an inverse relationship between microbial concentration and light readings, with a correlation coefficient (r) of -0.83. As microbial concentration increases, the lux readings decrease, consistent with findings from Fondriest Environmental, Inc., which state that microorganisms are also part of total suspended solids (TSS) that block light penetration into the water.

In the data, I found an interesting pattern in Burnaby Lake. Based on the averages, Burnaby Lake had the highest average cell counts, but it had the lowest light readings. Interestingly, when looking at the three samples in Burnaby Lake independently, I found that the three samples in Burnaby Lake followed a trend of increasing light readings with increasing cell counts. During my field investigation, I noticed that the water of Burnaby Lake had a distinct odor, like a sewer smell. According to my research on the Internet, this phenomenon is because Burnaby Lake is heavily polluted by the surrounding industries. (Burnaby Lake Park Association)

Due to these reasons, the water is rich in nutrients, which promotes the growth of microorganisms. Therefore, the number of microorganisms in Burnaby Lake is significantly higher than that of other lakes. Other suspended solids or TSS brought by polluted water also block light penetration which affects the growth of microorganisms,

since it is closely related to light, and more light helps to produce more microorganisms. Therefore, the reason why Burnaby Lake shows an inverse relationship may be partly due to this. On the other hand, industrially polluted water can be toxic, which may cause the death of microorganisms in the ecological environment. This is why clear water usually means less pollution, which means that more microorganisms can survive, resulting in higher concentrations. However, these explanations are only hypothetical, as I did not perform experiments to explicitly investigate whether industrial pollution causes microbial mortality, nor whether industrial pollution causes TSS increases. In addition, the previously unsuccessful relationship between salinity and water clarity warrants further investigation. These are important directions for future research.

Conclusion:

The study found that increases in microbial concentrations correlated with decreases in light readings, and the assumption that higher salinity would result in a higher clarity of water is unable to be performed since all lakes have a salinity of zero.

Acknowledgements:

We acknowledge the land as a cultural life force, a source of inspiration, and the site of community. We strive to respect this place and its memory in our writing and teaching. We also appreciate and honor the past, present, and future Musqueam storytellers and caretakers of the land.

I am deeply grateful to Prof. Celeste Leander and Teaching Assistant Miriam Fenniri for their guidance, assistance, and support during the laboratory work for this

study. I would like to thank Mindy Chow for generously providing the equipment necessary to conduct my experiments. Additionally, I am thankful to UBC for providing the resources and space needed to pursue this research. Finally, I appreciate the valuable advice, comments, and edits that improved the quality of this work.

Citations and Literature Cited:

Burnaby Lake Park Association. (n.d.). *History*. Retrieved from https://burnabylakepark.ca/who-we-are/history/

Fondriest Environmental, Inc. (2014, June 13). *Turbidity, total suspended solids and water clarity*. Fundamentals of Environmental Measurements. Retrieved from https://www.fondriest.com/environmental-measurements/parameters/water-quality/turbidity-total-suspended-solids-water-clarity/

Khan Academy. (n.d.). *Light and photosynthetic pigments*. Retrieved from https://www.khanacademy.org/science/biology/photosynthesis-in-plants/the-light-dependent-reactions-of-photosynthesis/a/light-and-photosynthetic-pigments

Teaching Great Lakes Science. (n.d.). *Water clarity*. Retrieved from https://www.michiganseagrant.org/lessons/lessons/by-broad-concept/earth-science/water-quality/water-clarity/