Effect of pH on Plant Diversity in Metro Vancouver

Choi, Moses R.

Abstract

Plant species are known to be affected by soil bacteria (Chu et al.). The pH of the soil, which is greatly affected by nearby water sources (Khatri et al.), influences these bacterial species (Chu et al.). This relationship between plant diversity and the pH of local water sources was investigated in the Metro Vancouver region. Various bodies of water in this region were randomly selected and plant species count and pH were measured in streams connected to the bodies of water. A Pearson's correlation coefficient ($R = -0.066$) was used to see the strength of the correlation between pH and plant species count overall. There was no significant correlation (p-value: 0.8385 with $n = 12$) between the two variables. There was also variation in the plant species present and pH of nearby water streams in each location which indicates others factors the influence plant diversity. Interplant interactions are a potential source of the observed variation in plant species count between observations. Furthermore, pH values outside the optimal zone (pH = 7-8) were not observed and therefore more extreme pH values may have a more significant effect (Chen et al.).

Introduction

pH is one of the many variables that affect the environment of plants. While pH has been shown to have no direct effects on plant diversity (Xue et al.), it has a significant effect on the surrounding microbial environment (Chu et al.), which in turn influences plant diversity (Liu et al.). However, each ecosystem is unique in terms of environment and plant species and these studies were primarily done either in laboratory settings or outside of North America. Therefore, multiple ecosystems within Metro Vancouver were examined to see if these correlations between pH and plant diversity seen in previous studies can also be observed here. Ecosystems near freshwater have been chosen specifically because it has been shown that the water sources have a greater effect on soil pH than other natural sources such as rain and plant metabolism (Khatri et al.). As anthropogenic pollutants have been affecting freshwater pH (Khatri et al.), understanding its effect on plant diversity is crucial for better environmental conservation. The BC provincial government regularly monitors the pH of not only tap water but freshwater sources for this reason.

There are slight variations in water pH due to anthropogenic factors like fossil fuel emissions, but also natural factors like rain, elevation and glaciers. An increase in elevation has been correlated with a decrease in pH and snow melting from mountains can increase pH in spring due to minerals that are released when they melt (Strang and Aherne). Even with these variations, most freshwater sources in Metro Vancouver have pH values between 7-8 throughout the year. This range is considered to be the optimal zone for plant and marine life (Ministry of Environment). However, it was uncertain if smaller variations within this range had an effect on plant diversity as the majority of previous studies used a much wider range of pH values for their experimental studies (Chu et al., Liu et al.) If these variations in pH influences plant diversity, a strong correlation between the measured pH value and plant species count would be observed.

Methods

4 lakes were randomly chosen across Metro Vancouver. Then, a 5m length along a stream that flowed directly in or out of the lake was sectioned off and the number of plant species adjacent (<1m away from the stream) to the water source within that section was counted (Figure 1). The majority (>50%) of the visible parts of the plant had to be within the section to be counted. This was repeated 3 times for a total of 3 sections per stream. If the stream did not have 3 independent sections, then a stream that was connected to the same water source (e.g. same lake) was used as a substitute for one or two of the 3 samples. All observations were done on the same stream per body of water for this study. Next, a pH meter was used to measure the pH value of the water. The pH meter kept measuring until the given measurement stopped changing (by 0.01) for at least 5 seconds. Two measurements was be taken for each section of the stream for accuracy. Additional measurements were taken if the two measurements were significantly different (>0.10 difference in pH) and done until at least 2 were within the 0.10 range.

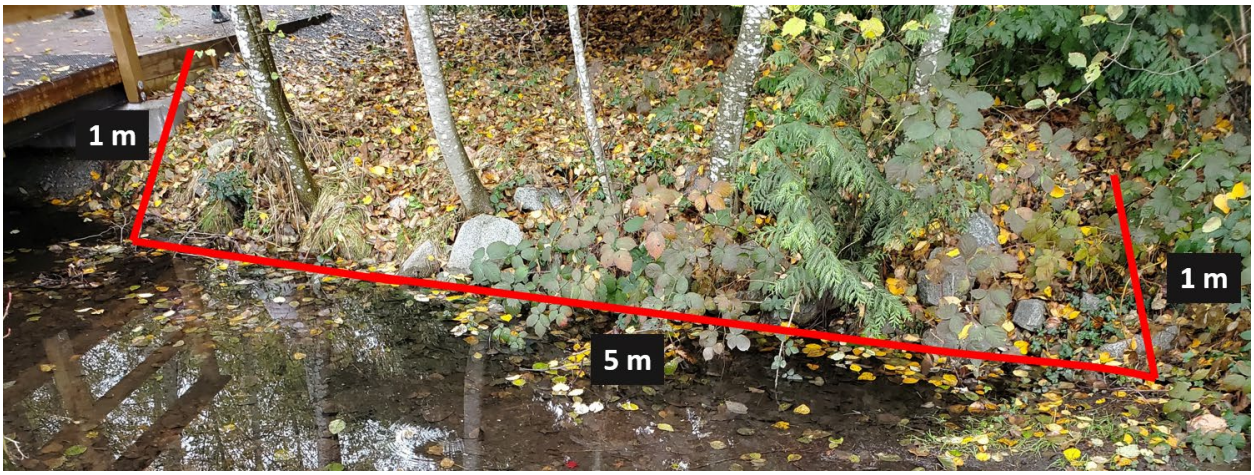

Figure 1: Sample plot for observation

Finally, a picture of each section was taken for future reference. A combination of *iNaturalist* and *Nature Vancouver*'s botany resources was used to identify the observed species of plants. Once all the relevant plant species have been identified, a subtotal was be taken for each section.

After the data was collected, the Pearson's correlation coefficient was used to analyze the strength of the correlation between the pH value and the plant species observed. The coefficient was then used to derive a p-value to either reject or fail to reject the null hypothesis that there is no significant correlation.

Results

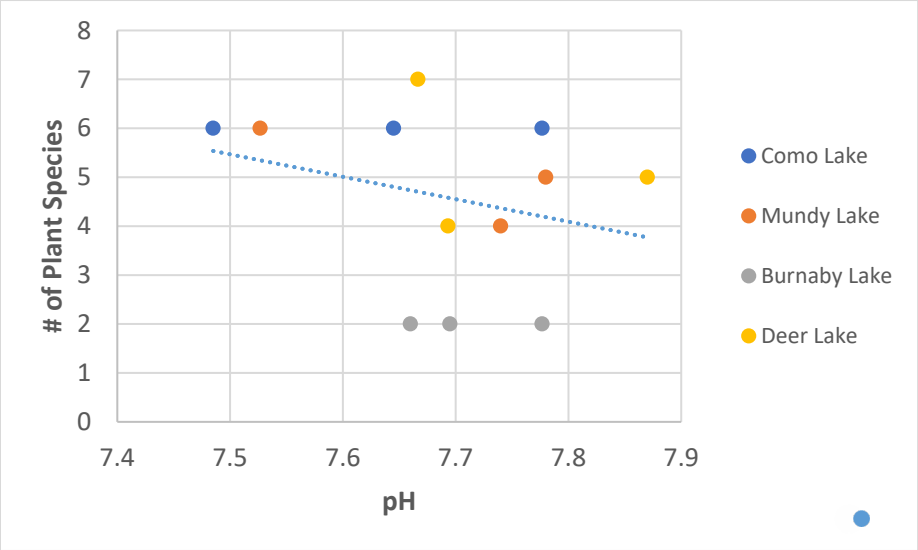

Figure 2: A scatter plot of the pH vs number of plant species in Metro Vancouver with a correlation line with a trendline. Pearson correlation coefficient (R) = -0.066, n = 12, p-value = 0.8385.

The Pearson correlation coefficient (R = -0.066) was used to see the strength of the correlation between pH and number of plant species. This showed a negative correlation, meaning that plant diversity decreased with increasing pH. However, there was no significant correlation (p-value: 0.8385 with n = 12) seen between the two variables as shown by the very low R-value. There was rainfall present before and during observations and measurements that might have affected pH levels. Variations were discovered in both pH levels and number of plant species even from the same water source as seen in Figure 2. Burnaby Lake showed the least variation pH levels and number of plant species out of the 4 water sources.

Discussion

There was no statistically significant correlation between the pH and the number of plant species, and the observed correlation was most likely due to chance. Therefore, we failed to reject the null hypothesis and reject the alternative hypothesis that says there is a significant

correlation. This may be because all of the pH values ranged between 7.4-7.9 which are all typical values for fresh water in Metro Vancouver (Ministry of Environment). Since all these values fell within the optimal range for bacterial productivity, the soil bacteria had no significant differences with the different pH values that were measured in these environments just as it was seen in previous studies (Chen et al.) It was further observed that even within the same water source and streams (e.g. Como Lake), there was a great variance of plant species between each of the lengths of each stream.. For example, sample #1 and sample #3 from Como Lake had 6 observed plant species but only 1 overlapped with each other. Even though they were part of one continuous stream, the observed plant species were completely different, indicating that the water source does not have a significant effect on where plants grow within this range. Therefore, ensuring that anthropogenic activities do not push the pH value outside this range will minimize its impact on plant diversity.

The main determining factor for the location and diversity of plant species may be more due to plant-plant interactions. Interplant interactions has a significant effect on the plant's ability to prosper in the environment (Olofsson). Whether it is mutualistic or parasitic relations, one of plant species can significantly control the growth and spread of certain species from the same ecosystem. For example, the Himalayan blackberry, found in many of the locations used in this study, is known to hinder other plant species' growth by growing faster and blocking the sunlight for native species (Gaire et al.). Two observations in Mundy Lake that had Himalayan Blackberries present had less plant species present compared to the one sample that did not have them. Further studies are needed to see if there is a significant correlation between plant diversity and presence of invasive species.

A potential source of error is the misidentification of species. It is unlikely that this factor would affect the total number of plant species as the majority of the plants present had significantly different appearances from each other. However, identifying the exact plant species can help determine interplant interactions if there are any. For the pH measurements, multiple measurements were made until two values were within at least 0.10 of each other. Some observations had noticeable variances in pH even from the same water source. This may be due to their distance from the body of water or other sources. Therefore, another measurement was made later in the day for certain samples to ensure that the measurement was not due to chance or instrument. With the widely varying plant species and variations in pH observed even with the same body of water, more observations per body of water and additional streams for observation would reduce variation in this data. Further studies that includes bodies of water with pH values outside the optimal zone of 7-8 (e.g. near areas where snow melts or carbonate deposits) can be conducted to see if the correlation between plant species and water pH is strengthened in natural environments as seen in previous studies (Chu et al., Liu et al.).

Conclusion

There was no significant correlation made between plant species and the pH of nearby water sources in the observed range of pH (7.4-7.9). Environments with greater pH ranges must be observed to see the difference seen in previous studies and interplant interactions are a potential cause of variation in plant species. Keeping freshwater pH within this range will ensure minimal impact on plant diversity.

Acknowledgements

I would like to acknowledge the University of British Columbia for providing the opportunity and guidance for this study through the BIOL 342 course. I would especially like to acknowledge Dr. Celeste Leander from UBC for the additional guidance in the direction of this study.

Citations and Literatures Cited

Chen, Huaihai, et al. "Soil Moisture and PH Control Relative Contributions of Fungi and Bacteria to N2O Production." *Microbial Ecology*, vol. 69, no. 1, 2014, pp. 180–191., doi:10.1007/s00248-014-0488-0.

Chu, Haiyan, et al. "Effects of Slope Aspects on Soil Bacterial and Arbuscular Fungal Communities in a Boreal Forest in China." *Pedosphere*, vol. 26, no. 2, 2016, pp. 226–234., doi:10.1016/s1002-0160(15)60037-6.

Khatri, Nitasha, and Sanjiv Tyagi. "Influences of Natural and Anthropogenic Factors on Surface and Groundwater Quality in Rural and Urban Areas." *Frontiers in Life Science*, vol. 8, no. 1, 2 Jan. 2015, pp. 23–39., doi:10.1080/21553769.2014.933716.

Liu, Lan, et al. "Relationships between Plant Diversity and Soil Microbial Diversity Vary across Taxonomic Groups and Spatial Scales." *Ecosphere*, vol. 11, no. 1, 2020, doi:10.1002/ecs2.2999.

Environmental Compliance Reports. Government of British Columbia, Ministry of Environment, 2 Oct. 2020, www2.gov.bc.ca/gov/content/environment/research-monitoring-reporting/reporting/env-compliance-inspection-report. Accessed 16 November 2020.

Approved Water Quality Guidelines. Government of British Columbia, Ministry of Environment, 31 July 2020, www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-

quality/water-quality-guidelines/approved-water-quality-guidelines. Accessed 16 November 2020.

Olofsson, Johan. “Positive and Negative Plant-Plant Interactions in Two Contrasting Arctic-Alpine Plant Communities.” *Arctic, Antarctic, and Alpine Research*, vol. 36, no. 4, 2004, pp. 464–467., doi:10.1657/1523-0430(2004)036[0464:panpii]2.0.co;2. Xue, Wei, et al. “Soil Heterogeneity and Plant Species Diversity in Experimental Grassland Communities: Contrasting Effects of Soil Nutrients and pH at Different Spatial Scales.” *Plant and Soil*, vol. 442, no. 1-2, 2019, pp. 497–509., doi:10.1007/s11104-019-04208-5.

Strang, Donna, and Julian Aherne. “Potential Influence of Climate Change on the Acid-Sensitivity of High-Elevation Lakes in the Georgia Basin, British Columbia.” *Advances in Meterology*, vol. 1, ser. 1-11, Mar. 2015. 1-11, doi:10.1155/2015/536892.

Appendix

Appendix A: Measured pH values & number of plant species per observations

Como Lake			
	Sample #1	Sample #2	Sample #3
pH	7.71	7.68	7.48
	7.84	7.61	7.61
	7.78		7.4
			7.45
Average pH	7.77666667	7.645	7.485
Plant #	6	6	6

Burnaby Lake			
	Sample #1	Sample #2	Sample #3
pH	7.71	7.65	7.69
	7.84	7.63	7.61
	7.78		7.68
Average pH	7.77666667	7.64	7.66
Plant #	2	2	2

Mundy Lake			
	Sample #1	Sample #2	Sample #3
pH	7.52	7.72	7.69
	7.54	7.76	7.61
	7.52	7.74	7.68
Average pH	7.52666667	7.74	7.78
Plant #	6	4	5

Deer Lake			
	Sample #1	Sample #2	Sample #3
pH	7.88	7.68	7.69
	7.86	7.67	7.61
		7.63	7.68
Average pH	7.87	7.66666667	7.69333333
Plant #	5	7	4

Red indicates measurements made later on in the day to recheck measured pH values

Appendix B: Plant species identified per observations

Plant Species Diversity												
	Como Lake			Mundy Lake			Burnaby Lake			Deer Lake		
Red Alder	X	X	X									X
English Holly	X											
Western Red Cedar	X	X								X	X	
Common Ivy	X					X				X	X	
Himalayan Blackberr	X				X	X					X	
Quack Grass	X	X		X								
Common Bracken		X	X	X							X	
Licorice Fern		X		X								
White Clover		X										
Creeping Buttercup			X									
Rhododendron			X								X	
Hardstem Bulrush			X									
Oak			X									
Deer Fern				X		X						
Lyell's Bristle Moss				X	X	X						X
Salal				X						X		
Brittle Bladderfern					X							
Bigleaf Maple					X	X						
Reed Meadowgrass							X	X	X			
Slough Sledge							X	X	X			
Western Swordfern										X	X	X
Daphne										X		
Great Horsetail											X	
Freeman's Maple												X
Wych Elm				X								