Dominica Tropical & Field Biology Study Abroad 2016:
A Comparison of Urban, Rural and Agricultural Water pH

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ABSTRACT

Natural resource pollution within an island ecosystem can negatively impact human and animal health. In this study, samples from fresh water streams and rivers were collected and tested over a three-week period to compare the pH levels of various environments on the Caribbean island of Dominica, West Indies. I recorded pH level, water source substrate, elevation, GPS location and location characteristics for each sampling site. I found that water samples collected from the majority of urban city centers had higher pH levels compared to samples collected from rural and agricultural areas. In addition, the rural and agricultural areas on the island reported very similar pH results. The pH levels recorded on the island ranged between 6.4 and 9.1, which lie within the habitable zone for aquatic life in fresh water sources. There was a positive trend between pH level and elevation. Based on the results, I can conclude that there is no evidence of contamination to the fresh water sources tested on the island, and therefore, fresh water in streams and rivers throughout Dominica is safe for consumption.

INTRODUCTION

The Commonwealth of Dominica, West Indies is an independent island of volcanic origin located between the French islands of Guadeloupe in the north and Martinique in the south. The country occupies an area of 750 square kilometers and has a population estimated at 72,000 persons (Environmental Advisors Inc., et al., 2011). On the Caribbean island of Dominica, solid waste, agricultural waste, manufacturing waste and industrial waste disposal are the major sources of both point and non-point pollution of fresh watersheds and coastal zones (Raymond, 2014). The single greatest source of marine pollution in Dominica is due to improper treatment and disposal of sewage waste. In addition to the sewage collected on the island, Dominica is also a common port of call for cruise ships plying the Caribbean. Solid waste is collected from these ships and disposed of, for a fee, at landfills on the island (Singh & Xavier, 1997). In the absence of suitable sanitation, much of this waste finds its way into the rivers and coastal areas of Dominica. In addition to wastewater, most of the land-based pollution comes from the quarries on the island. The problem is most evident where the quarries discharge their waste directly into marine habitats ultimately leading to siltation of coral reefs and fishing banks (Environmental Advisors Inc, et al., 2011). Other land-based sources of marine water pollution in Dominica are the discharge of household detergents and the release of spent engine oil into drains and waterways. All of these sources cause habitat degradation and loss of biodiversity.

The pH, or "power of hydrogen" of a liquid, is a numerical value determined by the molar concentration of hydrogen ions in the liquid. The pH is a unitless figure between 0 and 14, which defines how acidic or basic a body of water is along a logarithmic scale. Acidic values have a pH from 0 to 7, with 0 being the most acidic. Basic values range from 7 to 14, with 14 being the most basic. A pH of 7 is considered neutral. A water sample's physical, chemical and biological characteristics help to determine whether it is suitable for normal aquatic life or human consumption. pH is a critical factor in determining the health of a waterway. Most organisms within a specific aquatic location have adapted to life in water of a certain pH. Therefore, even slight pH changes negatively impact biodiversity in an aquatic environment.

The majority of aquatic creatures prefer a pH range of 6.5 to 9.0, although some can live in water with pH levels outside of this range. Extreme pH levels usually increase the solubility of elements and compounds, making toxic chemicals more "mobile," thus increasing the risk of absorption by aquatic life (Water on the Web, 2016). While humans have a higher tolerance for changing pH levels, there are still some health concerns to note. For example, water pH values greater than 11 can cause skin and eye irritations in humans, as does a pH below 4. In addition, a pH value below 2.5 has been found to cause irreversible damage to skin and organ linings (Water on the Web, 2016).

There are many factors, both natural and man-made, that have the potential to affect pH in water. Most natural changes occur from interactions with surrounding rock and other organic materials, such is the case with the volcanic substrates found on Dominica. Anthropogenic causes of pH fluctuations are typically related to pollution. Point source pollution, known as any single identifiable source of pollution from which pollutants are discharged, is a common cause that can increase or decrease pH depending on the chemicals involved. Non-point source pollution occurs as a result of runoff. These chemicals can come from agricultural runoff, wastewater discharge or industrial runoff (NOAA, 2008). Mining operations produce acid runoff and acidic groundwater seepage if the surrounding soil is poorly buffered. Wastewater discharge that contains detergents and soap-based products can also cause a water source to become too basic.

MATERIALS AND METHODS

While on the island, I visited various cultural and ecological sites with nearby rivers and freshwater streams. Over a three-week period, I collected a total of 27 individual water samples from urban centers, rural areas and agricultural sites. At each sample location, I filled a 45-mL plastic conical tube (Falcon, Model #352098) with water and labeled the tube with its corresponding location name. To ensure proper location reporting, I recorded the GPS coordinates and elevation for the sample site.

I then used the Eco Testr pH 2 Waterproof pH Tester (Oakton, Model # WD-35423) to record the pH from each water sample. To get a pH reading, I removed the cap off the pH tester and fully submerged its sensor into the water sample. I stirred the solution once with the testing device and waited 10-20 seconds for the digital reading to stabilize. To avoid cross-contamination of the samples, I rinsed the testing device with tap water after each individual reading. Once complete, I discarded the water sample and properly cleaned the sealable plastic conical tubes for reuse.

RESULTS

A total of 27 water samples were collected on the island in various environments. Once sampling was completed, I assigned each testing site into one of three categories: urban centers, rural areas and agricultural sites. I plotted each location on Google Maps, as seen in Figure 1. Due to the mountainous terrain in Dominica, the majority of landscapes sampled were categorized as rural sites. The recorded pH readings for all sites ranged from 6.4 to 9.1.

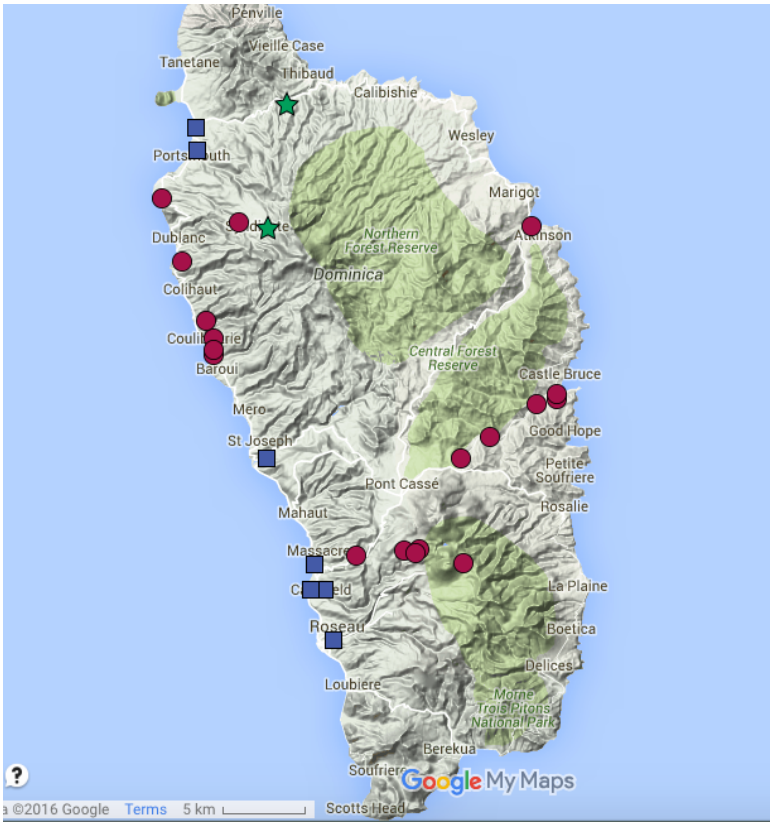

Figure 1. Sampling sites in Dominica where water samples were collected for pH analysis, organized by environment. Red circles indicate rural areas, blue squares indicate urban centers, and green stars indicate agricultural areas.
Google Maps link: https://www.google.com/maps/d/edit?hl=en&hl=en&authuser=0&authuser=0&mid=1t1m3qneb0w-xlo8ihlq-fpuvp9a.

A total of 19 rural sample sites were recorded on the island. The pH of rural sample sites ranged from 6.4 to 9.1. The Hot Springs at Freshwater Lake exhibited the lowest pH of all the samples, registering a pH reading of 6.4. For comparison, the pH of pure water is 7.0. At pH levels below 6.0, flora and fauna in the stream usually begin to show effects.

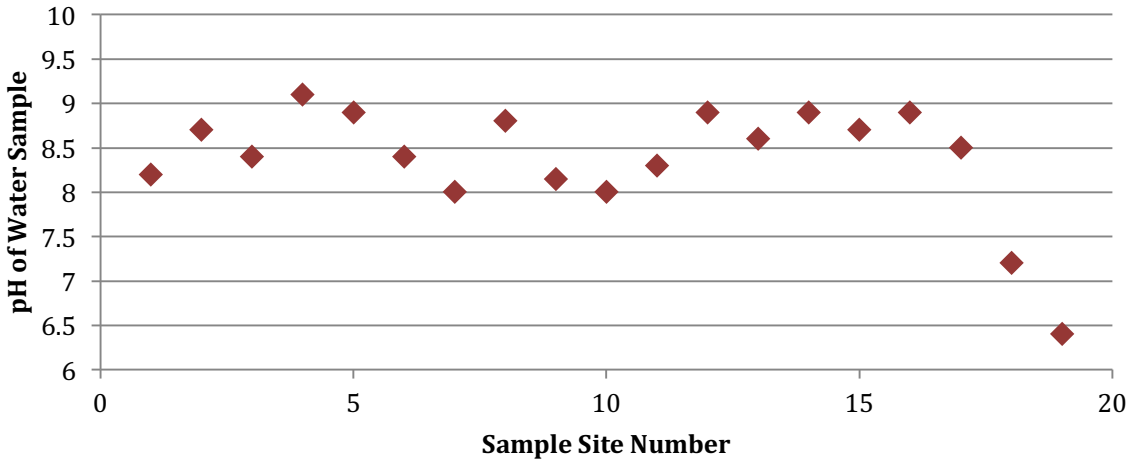

Figure 2. Recorded pH values for all rural sites tested on the island. A total of 19 sites were sampled.

A total of 6 urban sites were sampled on the island. The pH samples ranged from 7.9 to 9.1. The stream sampled at Garth's Apiary recorded the highest pH on the island, exhibiting a pH of 9.1. The stream in this locations trickled through the middle of a junkyard, which was littered with abandoned vehicles, garbage and metal debris.

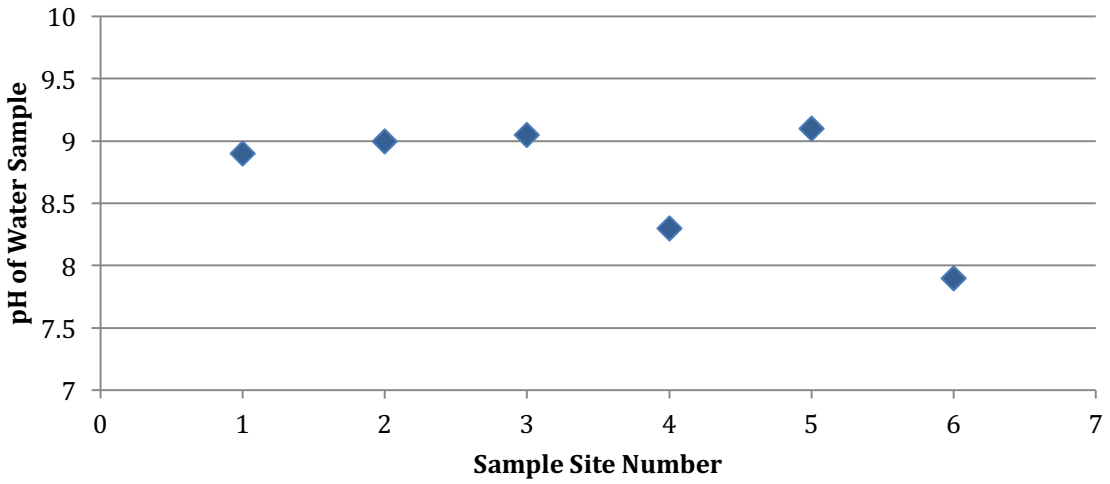

Figure 3. Recorded pH values for all the urban sites sampled on the island. A total of 6 urban sites were tested.

Finally, a total of 2 agricultural sites were sampled on the island. The samples were almost identical, exhibiting a pH of 9.4 and 9.5. There were various crops observed at these locations, including mangos, bananas, plantains, guava, cucumbers, dasheen, peppers, etc. There was no evidence that agricultural runoff was contaminating the nearby fresh water sources.

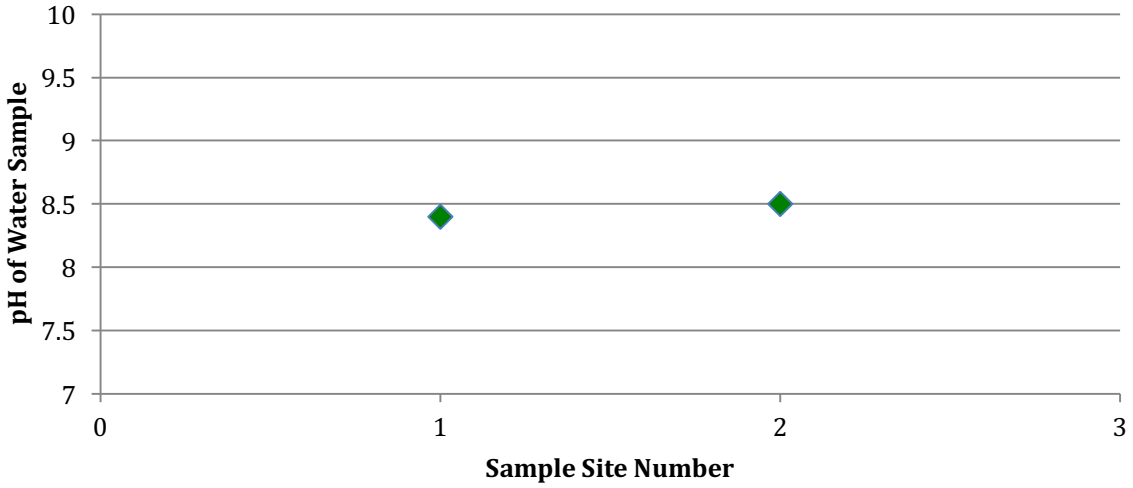

Figure 4. Recorded pH values for water samples collected at agricultural sites on the island. A total of 2 sites were sampled.

To best assess the health of the fresh water on Dominica, I calculated the average pH for each location type. The averages for agricultural sites and rural sites were very similar, 8.45 and 8.37 respectively, while the average pH for urban sampling sites was slightly higher at 8.71. The pH levels recorded on the island all ranged between 6.4 and 9.1, within the habitable zone for aquatic life in fresh water sources.

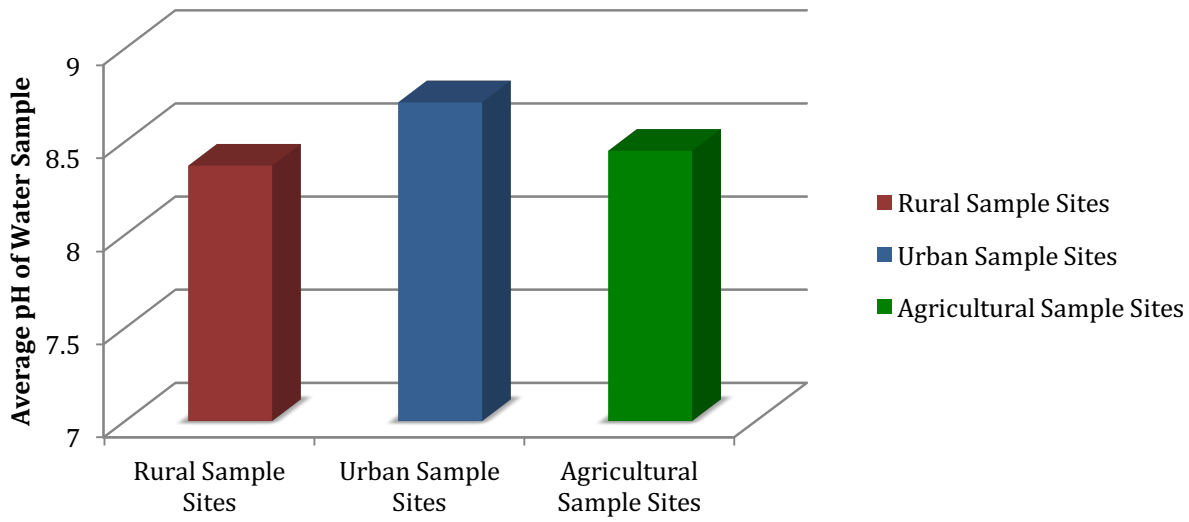

Figure 5. Comparison of the average pH levels for the three environment types where water pH was sampled: Urban sampling sites, rural sample sites and agricultural sample sites.

While collecting data, water sources from various elevations were sampled. To better assess whether elevation had any effect on water pH, I chose to plot elevation against pH in a scatterplot. There was a positive trend between pH level and elevation. The data suggests that as elevation increases, stream pH declines

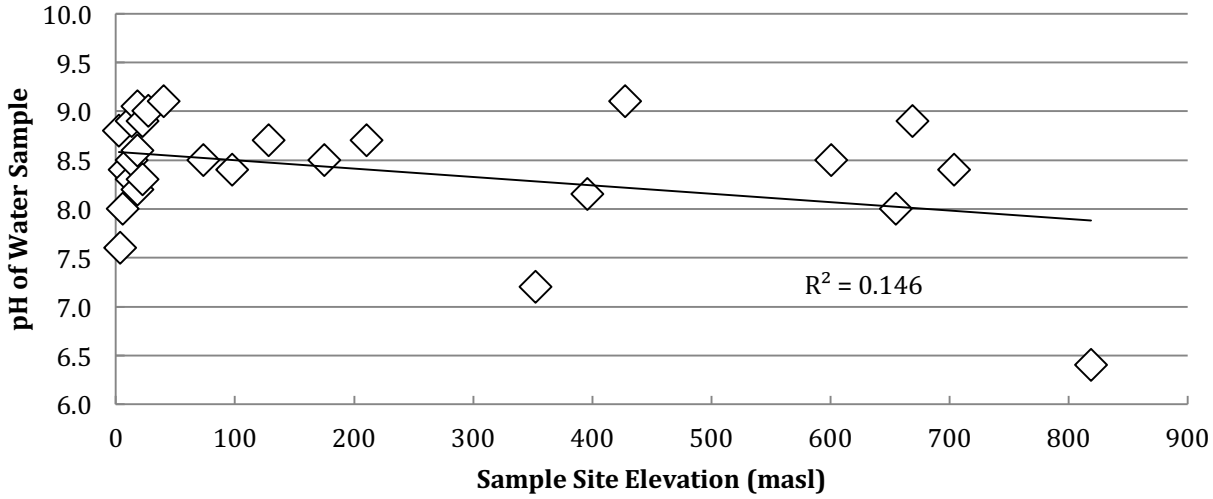

Figure 6. The correlation between pH level and sample site elevation (meters above sea level = m.a.s.l.).

DISCUSSION AND CONCLUSIONS

Generally, the water quality of streams and rivers is best in the headwaters where rainfall is often abundant. Water quality frequently declines as rivers flow through regions where land and water use are intense, and pollution from agriculture and industrial and recreation areas increases. Such was the case with urban sampling sites on the island. The headwaters for the urban streams and rivers on Dominica start hundreds often thousands of feet higher up in the mountains. While the documented pH for natural freshwater on the island hovers between 6.5 and 8.5 (Water on the Web, 2016), the results from this study showed an average pH of 8.71 for urban sampling sites. The higher pH levels could be due to wastewater discharge in the city that contains detergents and soap-based products, which would cause a water source to become increasingly more alkaline. In addition, because the majority of large cities in Dominica are near the shoreline, salt water mixing with fresh water could also cause an increase in water pH.

The lowest pH levels recorded on the island were at rural sample sites located in high elevations, and the data shows that pH levels increased as elevation decreased. Water quality is closely associated with the surrounding environment. Geology of a watershed is a major influence on water pH. For example, sulfur is a naturally occurring mineral that is found primarily near hot springs and volcanic craters. In the aquifer, groundwater comes in contact with solid materials dissolving them, releasing their constituents, including sulfur, to the water. If the water supply of a town originates directly from a volcano's groundwater system or from a stream that has been covered with volcanic ash, the water could become contaminated with foul-smelling gases or fine ash sediments. Some volcanic gases, such as sulfur dioxide, dissolve in groundwater, making the water more acidic (USGS, 2016). One rural sample collected at the sulfur springs near Freshwater Lake resulted in a pH recording of 6.4. The strong smell of sulfurous odors at the sample site is direct evidence of the presence of sulfur in the water source, which would have influenced the low pH value.

While on the island, I was able to sample two different agricultural sites of various elevations. The average pH for Agricultural Sample Sites was 8.45. I found no evidence of contamination due to agricultural run-off, and the pH of the water sources at and around the agricultural sites was within the habitable zone for aquatic life. Banana farming is the single largest agricultural activity in Dominica. However, in recent years, the banana industry has not been unable to effectively adjust to compete in an increasingly liberalized EU market, which is the principal market for its bananas. In 1999, there were 6055 farmers who exported some 27, 255 metric tons of bananas to the EU. However by 2009, the number of farmers had fallen to nearly 400 and the export tonnage to only 5,894 metric tons (Commonwealth of Dominica, 2012). This decrease in export tonnage, while bad for the Dominican people, was critical in maintaining the health of the Dominican environment.

In conclusion, this study showed that freshwater sources around Dominica are generally potable for animal and human consumption, as the pH levels fell within the clean water pH range. Through my research I learned that determining water quality is a complex and long-term process. Although my data pales in contrast to the volumes of data already collected by researchers on the island, completing this study was an extremely rewarding and enjoyable educational experience.

ACKNOWLEDGEMENTS

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