Dominica Tropical Field Biology Study Abroad 2017: Urban Effects on Water Quality in Oceans and Rivers

Kristen Sarna
Texas A&M University
June 2017

Abstract:

Pollution is growing threat to water supplies on earth. Even remote islands like Dominica are beginning to see the effects of pollution on their water. Dominica gets their water from the rivers and much of their food from the ocean and because of that can be impacted greatly by pollution. Phosphate and nitrate are very effective markers for pollution from agriculture, sewage, and other forms of runoff. This project tested the amounts of pollution in rivers and their mouths in Dominica. This project showed that in terms of ocean pollution, bays with river runoff are at the highest risk as the land traps the pollution in the bay. This can be seen in the phosphate content of the mouth Castle Bruce which at 0.7ppm of phosphate is much greater than the pollution in Castle Bruce river at 0.4ppm. In river pollution, factories and houses along the rivers can have huge effects on the cleanliness of water which could be seen in the high amount of pollution in the Boeri and Belfast Rivers. Overall six of the thirteen sites that I tested came out to have either high levels of phosphate or nitrate caused by pollution.

Introduction:

As population grows and urbanization booms, there have been adverse affects on our environment. One especially potent effect has been pollution of both freshwater and saltwater. From nutrient runoff to oil spills, earth's water is forced to absorb massive amounts of pollution every day. A popular phrase used to justify pollution is that "the solution to pollution is dilution" (National Geographic, 2015). Essentially the idea is that once pollution makes it into a body of water, it will runoff into the ocean and "disappear". All it is really doing however is dissolving into the water.

One of the most common types of pollution is from phosphates (Jyothi, Kiran, and Ravindhranath, 2012). Phosphate is a necessary component for the life of aquatic plants and animals. Phosphate can enter bodies of water from an abundance of sources; untreated sewage water, agricultural runoff, and the like. Excess phosphate in water can have very negative effects on aquatic life. When there are lots of additional nutrients algae and plants will be able to grow extraordinarily quick as well as perform a large amount of photosynthesis. Because plants need oxygen in order to perform photosynthesis, they have to use an abundance of the dissolved oxygen in the water. This causes all other life forms in that area to be left with no oxygen supply which is called anoxia. Eventually the oxygen dependent organisms in that area will die off. This process is called eutrophication and was estimated to have already created 405 “dead zones” in 2008 (Scientific America, 2008). Once eutrophication occurs in an area of water, it has major effects on the societies that are dependent on that ecosystem (Yang et al. 2008)

Just like phosphate, nitrate is a necessary component of aquatic ecosystems but it is harmful when there is too much nitrate present. A heavy amount of nitrates can cause a similar situation of eutrophication and anoxia. Too many nitrates in water can also be harmful when you try to drink the water; it can cause a lack of oxygen that makes it hard to breath. When babies drink water with too much nitrate present, it can cause methemoglobinemia or “blue baby syndrome” because they are not getting enough oxygen to their brain (Southern Nevada Health District, 2017). Because of this, in most countries nitrate levels are carefully monitored.

Another important aspect of water quality is conductivity. Conductivity measures the dissolved inorganic chemicals within a water sample. While salt is by far the most prevalent dissolved ion in water, it can also tell us about other chemical components in bodies of water like calcium and sulfate (Moore et al. 2008). When the conductivity of water is drastically higher than normal, that could point to an increased amount of ions (potentially pollutants) in that body of water.

While there are many factors that contribute to the quality of water, phosphate and nitrate give us a good way to measure dissolved organic compounds that pollute a body of water (Moss, 2008). And conductivity gives us a good way to test for inorganic compounds found in a body of water. Through testing these three components much can be concluded about the quality of the water.

On the Caribbean island of Dominica, there is an abundance of both freshwater and saltwater. The island is very dependent on both rivers and oceans to provide water to drink and food to eat. Because the island is a vast network of rivers and streams fed by a semi-constant supply of rainwater, the Dominican people are settled heavily on the banks of the rivers (Friedman, 2008). Many people in Dominica get the water they use for everything from drinking to washing clothes straight from the rivers flowing near them. Because of this, pollution could have an especially potent effect in Dominica.

The population of Dominica is fairly small, only around 73,353 people on the island with 0% of those people living in formally classified cities. But as the population has grown by around 4,000 people since 2000, a concern for the wellbeing of the island is always water pollution (Worldometers, 2017). And although pollution may seem insignificant in the scope of how large the ocean is, it can have large effects on the fragile ecosystems in the coastal areas of Dominica.

A question that comes to mind when looking at this problem of pollution is how river pollution affects the ocean. Does the pollution just dilute into the ocean or does it build up near the shore? To answer this, I decided to look at pollutants in rivers and see how they affected the oceans as they carried the pollutants downstream. This involves looking at the nitrate, phosphate, and conductivity just above and just below the mouths of the rivers.

Materials and methods:

Before I arrived in Dominica, I used maps of the island to look for rivers close to centers of urbanization; although Dominica's terrain make huge cities unrealistic, they still have a few areas where the population has congregated. I used the proximity of rivers to the urban centers of Dominica to decide where to take my samples from. Another important part of choosing the river location was finding a corresponding point in the ocean. Because I was looking for the effects of pollutants in rivers on the ocean, I chose to look for points where the river ran into the ocean. I took a sample close to the mouth of the river and then walked down into the ocean to take a second sample. This allowed me to directly compare how pollution is affecting both freshwater and saltwater. Over the course of the trip I took sample from thirteen different points. I took one sample in the mountains to provide as a control for unpolluted water, two samples from some of the most diverse coral reefs around the island and the remaining ten samples were sets of mouths and rivers.

At my sample locations, I used Nalgene bottles to collect the water and at each site. Once we got back to the lab I used a LaMotte Nitrate-N/Phosphate Low Range test kit to test the levels in the different water samples I collected. After mixing the samples with chemicals, I would then compare the color of the water to a guide to determine the phosphate and nitrate. Because it requires a visual comparison, this method is not exact down to a very small degree. It does however provide a quick approximation of the pollution dissolved in the samples. After testing phosphate and nitrate, I then used an Extech pH/Conductivity EC500 Instrument to measure the conductivity of my samples. This allowed me to check for dissolved ions in the water. The conductivity meter that I used could not read the ocean's conductivity because it was too high. To solve this problem, I diluted the ocean samples down to one part sample and fifty parts freshwater. Then to correct the readings of the conductivity meter, I multiplied the conductivity measure by 51.

At the sites I also collected the GPS coordinates with a Garmin 78 GPS to record exactly where the sample came from. I did this so that I could plot the exact locations of all my samples on a map. This will help create a better image of where all my samples came from as well as help to show what possible pollutants would be affecting each body of water.

Figure 1
Map of the locations sampled.

Control:
Middleham Falls

Rivers:
Batalie River
Belfast River
Boeri River
Castle Bruce River
Check Hall River

Ocean/Mouths:
Batalie Mouth
Belfast Mouth
Boeri Mouth
Castle Bruce Mouth
Champagne Reef

Results:

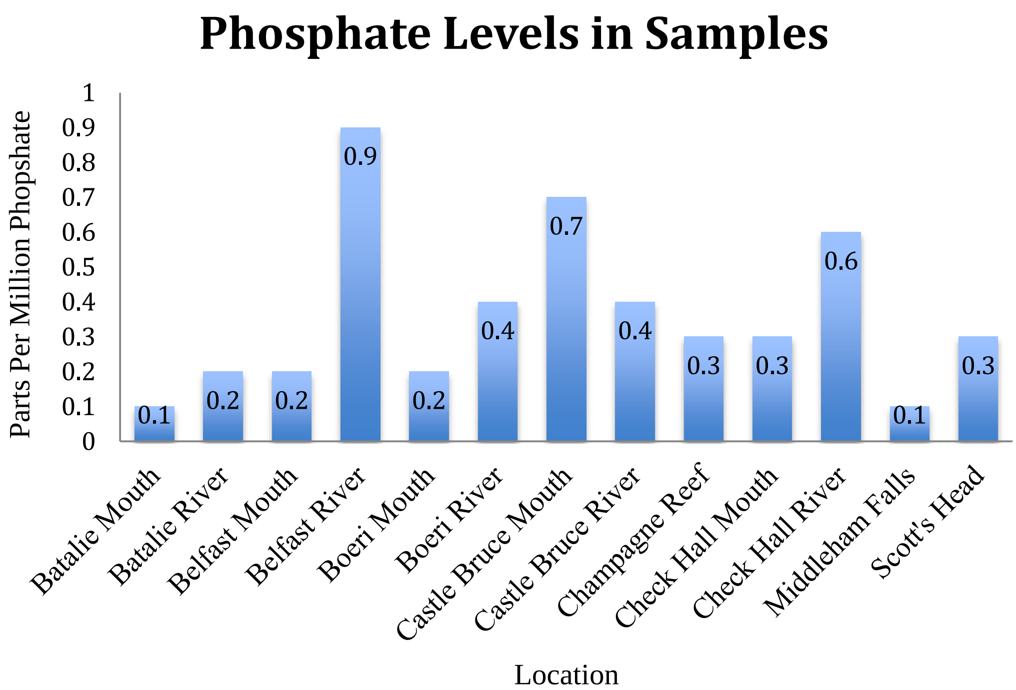

Figure 2. Phosphate levels in samples.

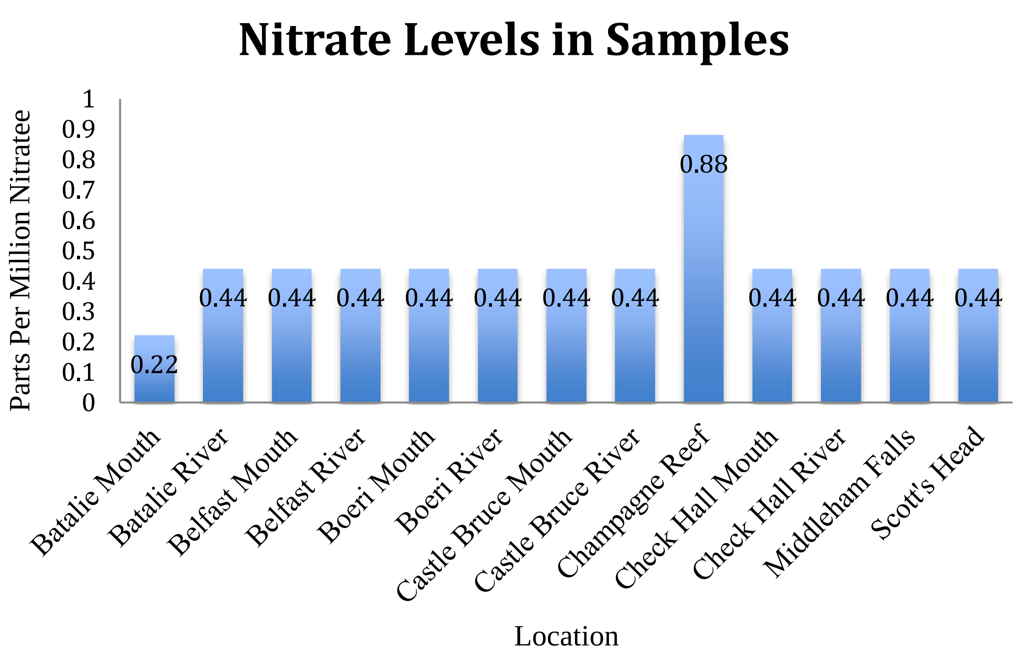

Figure 3. Nitrate levels in samples.

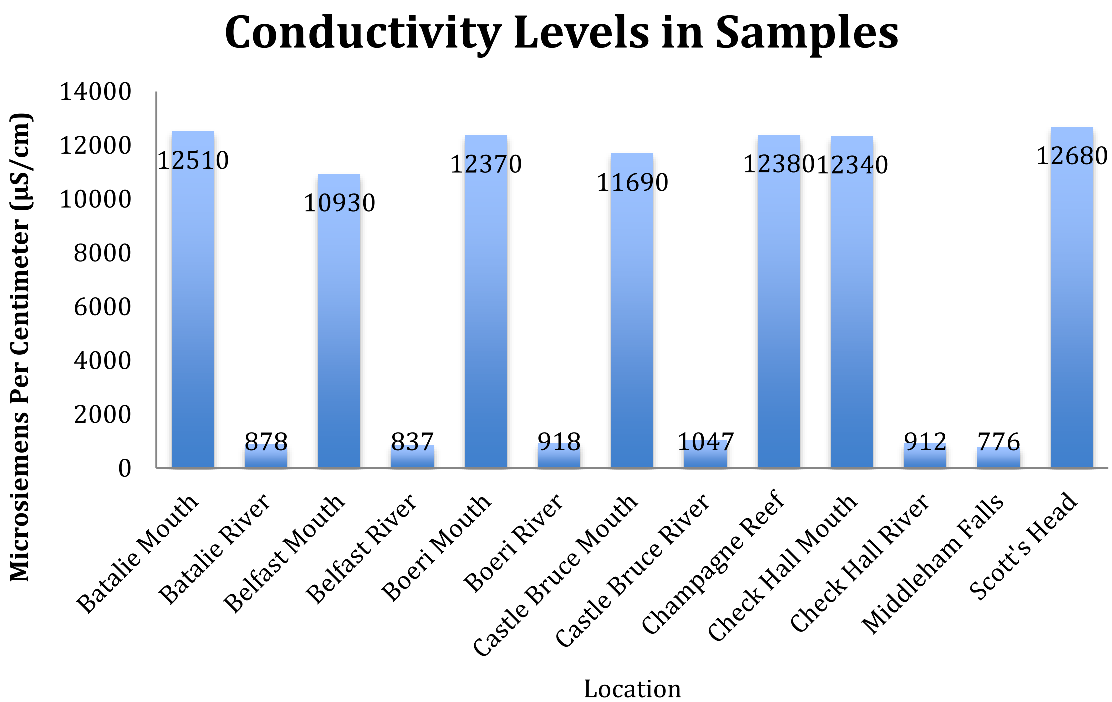

Figure 4. Conductivity levels in samples.

Figure 5
All data collected during this project

Location	Phosphate	Nitrate	Conductivity
Batalie Mouth	0.1ppm	0.22ppm	12510µS/cm
Batalie River	0.2ppm	0.44ppm	878µS/cm
Belfast Mouth	0.2ppm	0.44ppm	10930µS/cm
Belfast River	0.9ppm	0.44ppm	837µS/cm
Boeri Mouth	0.2ppm	0.44ppm	12370µS/cm
Boeri River	0.4ppm	0.44ppm	918µS/cm
Castle Bruce Mouth	0.7ppm	0.44ppm	11690µS/cm
Castle Bruce River	0.4ppm	0.44ppm	1047µS/cm
Champagne Reef	0.3ppm	0.88ppm	12380µS/cm
Check Hall Mouth	0.3ppm	0.44ppm	12340µS/cm
Check Hall River	0.6ppm	0.44ppm	912µS/cm
Middleham Falls	0.1ppm	0.44ppm	776µS/cm
Scott's Head	0.3ppm	0.44ppm	12680µS/cm

Figure 6.
Average sample values and water pollution assessment

Average Values From Samples	
Phosphate	.362ppm
Nitrate	.457ppm
Conductivity of freshwater	894.67µS/cm
Conductivity of saltwater	12128.57µS/cm

Location	Status
Batalie Mouth	Clean
Batalie River	Clean
Belfast Mouth	Clean
Belfast River	Phosphate polluted
Boeri Mouth	Clean
Boeri River	Phosphate polluted
Castle Bruce Mouth	Phosphate polluted
Castle Bruce River	Phosphate polluted
Champagne Reef	Nitrate Polluted
Check Hall Mouth	Clean
Check Hall River	Phosphate polluted
Middleham Falls	Clean
Scott's Head	Clean

Values	Status
0-0.362ppm phosphate	Clean
>0.362ppm phosphate	Phosphate polluted
0-0.457ppm nitrate	Clean
>0.457ppm nitrate	Nitrate polluted

Discussions and conclusions:

When examining the results of the tests, there are a few things that stand out about the data. Firstly there are multiple locations with extremely high phosphate levels in the water, the Belfast River, Castle Bruce Mouth, and Check Hall River. The Belfast River had by far the highest phosphate content out of all the samples collected during this project. The most probable cause of the high levels of phosphate is a soap factory located just upstream of the point where the samples were taken. It is interesting though that the mouth of the Belfast River, just around 20 feet downstream from where the highly phosphate polluted sample came from, has only

0.2ppm of phosphate. Because there was so little pollution at the mouth of the river is seems that even at the very edge of the ocean the pollution had from the river had already dispersed. The mass amounts of water in the ocean most likely caused all the pollution from the river to dilute so that is why the phosphate reading was so low in the ocean.

The situation is actually reversed in the samples from Castle Bruce. The mouth of Castle Bruce (which flows into Saint David's Bay) has a high amount of phosphate pollution. Castle Bruce River has a fair amount of phosphate in it but it doesn't compare to the amount in the bay. There are not a lot of houses along Castle Bruce River, but there is a boxing plant right by it that could be contributing to pollution in the river. It is odd however that the ocean has a higher amount of phosphate in it than the river; Castle Bruce is actually the only one of my samples in which that occurs. While some of the pollution could be flowing down from the people living up the coast in Castle Bruce, there aren't any other major rivers flowing into St. David's Bay. The most reasonable explanation for all the pollution in the bay is that it is being trapped by the land jutting out on either side of the bay. At the mouth of the Belfast the pollution is free to disperse and dilute into the ocean. But at Castle Bruce, the pollution is trapped within St. David's Bay and builds up over time.

In the Check Hall River a similar situation is occurring as in the Belfast River. There is a lot of pollution in the Check Hall River but it disperses pretty quickly once it runs into the ocean. The Check Hall River runs through a small concentrated area of houses near by the airport, which is most likely contributing to the pollution in the Check Hall.

Another thing that stands out when examining the data collected is that there is very little variation in the amount of nitrate in the water. All but two of the samples have the same amount of nitrate in them. Champagne Reef had twice as much nitrate as the other eleven samples and the mouth of the Batalie River had half as much nitrate. Nitrate gets in the water from sewage, fertilizers, and other contaminants flowing down the banks and into rivers and eventually the ocean. There is almost nothing urban located along the Batalie River or mouth which would account for why there is very little nitrate in the water. It is interesting to note that while the mouth of the Batalie has less nitrate, the river still has as much nitrate as the other eleven samples. The reason for this is still unclear. The sample with the high amount of nitrate comes from Champagne Reef which is a popular reef on the coast of the island used for snorkeling and diving. The main causes of nitrate pollution are industrial waste and nitrogenous fertilizers. (Meride and Ayenew, 2016). Since Champagne Reef is located very close to the village of Soufriere. It is very likely that the high nitrate concentrations are linked to runoff from the nearby village.

When examining conductivity it is a lot harder to make any decisive conclusions about the state of the water solely based of the microsiemens of conductivity in the water. Since conductivity is based off of dissolved ions in the water, a simple solution for the variation of conductivity could just be salinity. When we look the mouth of the Batalie and the mouth of the Boeri, they both have 0.2ppm of phosphate and 0.44ppm of nitrate (figure 5). However, the conductivity varies by 1440µS/cm. Because of this, my conductivity measurements did not drastically help me to identify the pollutants in the water and I based my final conclusions more heavily off of nitrate and phosphate measurements.

Using the average values I found from the phosphate and nitrate levels, I looked at areas of concern in terms of pollution (see figure 6). This is beneficial in identifying areas where more attention needs to be focused in maintaining the security of a clean water supply for the island of Dominica. Many people drink water straight out of the rivers so ensuring that they are not drinking water that could be harmful to them is crucial. The conclusions I came to based off of looking at average values lead me to the conclusion that even on the remote island of Dominica, there are still some serious concerns when it comes to water quality. My tests identified five areas of concern from phosphate pollution; the Belfast River, Boeri River, Castle Bruce River, Castle Bruce Mouth, and the Check Hall River. I also identified one area of concern from nitrate pollution; Champagne Reef. These areas should be the focus when it comes to any efforts to reduce human impacts on the water supply of Dominica. People living along these rivers should also be wary of the potential harmful effects that can come about from drinking polluted water. Efforts for conservation and environmental protection should also focus on areas like the Castle Bruce Mouth and other bays that trap and store pollution which can build up drastically over time.

Acknowledgements:

I would like to thank Dr. Woolley, Dr. Lacher, and Dr. Brundage for all their support in making this project possible by helping me map out my sites, driving me to locations, and assisting me in solving all the problems I encountered along the way. I would also like to thank the Terry Foundation and Texas A&M for supporting my travel and studies in order to be able to perform this project.

References:

Biello, David. "Oceanic Dead Zones Continue to Spread." *Scientific American*. 14 Aug. 2008. Web. 01 June 2017.

"Dominica Population (LIVE)." *Dominica Population (2017) - Worldometers*. N.p., n.d. Web. 06 June 2017.

Friedman, Vanessa Slinger. "Ecotourism in Dominica: Studying the Potential for Economic Development, Environmental Protection and Cultural Conservation." *Island Studies Journal* 4.1 (2009): 3-24. Institute of Island Studies, University of Prince Edward Island, 2009. Web. 07 June 2017.

Jyothi, M., K. Kiran, and K. Ravindhranath. "Pollution Control and Waste Management in Developing Countries." *International Journal of Water Resources and Environmental Engineering* 4.4 (2012): 73-85. Apr. 2012. Web. 07 June 2017.

"Marine Pollution -- Pristine Seas." *National Geographic*. Nation, 2015. Web. 01 June 2017.

Meride, Yirdaw, and Bamlaku Ayenew. "Drinking Water Quality Assessment and Its Effects on Residents Health in Wondo Genet Campus, Ethiopia." *Environmental Systems Research*. Springer Berlin Heidelberg, 21 Jan. 2016. Web. 08 June 2017.

Moss, Brian. "Water Pollution by Agriculture." *Philosophical Transactions of the Royal Society B: Biological Sciences*. The Royal Society, 12 Feb. 2008. Web. 07 June 2017.

"Nitrate and Ground Water." *Southern Nevada Health District*. 2017. Web. 01 June 2017.

Oram, Brian. “Phosphates” Water Research Center, 2014. Web. 01 June 2017.

"What Is Conductivity?" *Environmental Monitor*., 12 Aug. 2010. Web. 01 June 2017.

Yang, Xiao-e, Xiang Wu, Hu-lin Hao, and Zhen-li He. "Mechanisms and Assessment of Water Eutrophication." *Journal of Zhejiang University. Science. B.* Zhejiang University Press, Mar. 2008. Web. 07 June 2017.