DRINKING WATER AND AQUATIC ECOSYSTEM QUALITY IN BELIZE

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An evaluation of the drinking water and aquatic ecosystem quality was conducted in December of 2007 in Belize's Rio Bravo Conservation Area. Specifically, a chemical analysis was performed to search for high levels of certain contaminants. The tests focused on chloride/chlorine, nitrate/nitrite, phosphate, lead, pesticides, alkalinity, and total hardness. Data were collected from 18 sites around the Rio Bravo area. Drinking water was tested in nearby villages around the Hillbank Conservation and Management Area in the Rio Bravo, as well as in New River Lagoon and its tributaries, including Ramgoat Creek, Harry Jones Creek, and Irish Creek near Hillbank. The chemical analysis yielded high phosphorus levels in virtually all of the sites; however, these levels would only pose a threat to the aquatic ecosystems of the New River Lagoon. All of the water tested was determined to be hard to very hard, containing many Ca^{2+} and Mg^{2+} ions. The overall determination of the chemical analysis for the drinking water was that it appeared safe at the time of testing. However, the New River Lagoon and its tributaries could experience dramatic changes with high phosphorus levels if a high level of nitrogen were introduced.

Literature Review

Rainwater is the most common source of potable water in Belize. However, the composition of both roofs and containers used to collect rainwater could impact the water's chemical composition. For example, water falling on roofs treated with oil-based lead paint or collected in cisterns that are not properly maintained could become unsafe for human consumption (UNICEF-PAHO, 1996). In addition to possible contamination, rainwater is an unreliable year-round water source, so hand-dug wells are used as a secondary source of water. Many of these wells can be contaminated easily because of their relative closeness to homes and human waste. Poor sanitation practices and disposal of household wastewater in open water could also contaminate other sources of drinking water, such as streams, rivers, and lakes (UNICEF-PAHO, 1996).

While the presence of microbes in drinking water has been the most common concern, there is growing awareness of the need to understand the chemical content of drinking water. Contaminants can arise from soil leach-off or result from the water purification process. "Contaminants in ground and surface water will range from natural substances leaching from soil, runoff from agricultural activities, controlled discharge from sewage treatment works and industrial plants, and uncontrolled discharges or leakage from landfill sites and from chemical accidents or disasters" (Van Leeuwen, 2000, p. S52). Because Belize is largely an agricultural country, these contaminants from soil run-off are of specific importance. "Organic compounds, pesticides, disinfectants and disinfectant by-products are usually introduced by human activity" (Van Leeuwen, 2000, p. S52).

The presence of nitrates and nitrites, which are products of fertilizers, in water sources is cause for concern. For example, high nitrate levels have been found to cause methemoglobinemia, which can cause infant death (Gelberg, 1999, p. 34). Anna M. Fan and Valerie E. Steinberg (1996) found that high levels of exposure to nitrates and nitrites had negative effects on the reproductive systems of experimental animals (however, most studies were conducted with nitrites). The human body converts nitrates to nitrites, which helps to form methemoglobin in the blood (p. 37). Human consumption of nitrates and nitrites in drinking water was also analyzed by Scragg and Dorsch from Southern Australia in 1982 and 1984. They investigated the association between nitrate levels in mothers' drinking water and congenital malformations in their infants. They examined 218 cases documented between 1951 and 1979 and found 43 that involved central nervous system defects. Their findings suggested an association of water containing nitrate levels of 5 ppm and higher with neural tube defects (Fan & Steinberg, 1996, p. 39). The current standard set by the EPA is 10 ppm for nitrate levels in water and 1 ppm for nitrite levels. The methemoglobinemia cases attributed to nitrates resulted from levels higher than the standard (Fan & Steinberg, 1996, p. 40). No documented cases have been recorded where a health concern was attributed to any low levels of nitrate in drinking water.

Phosphorus is not of great concern when it comes to human health. However, it can be detrimental to the environment when there are high levels. Both phosphorus and nitrogen in high levels limit plant growth and have been associated with fish kills. Heightened levels of both nutrients encourage algae growth. Bacteria that decompose dead algae consume oxygen, decreasing levels of oxygen in water (Murphy, 2007). Total phosphate content in water should not exceed a range of 0.05 mg/L to 0.1 mg/L, depending upon whether the water sources discharge directly into a lake or reservoir (Muller and Helsel, 1999; Murphy, 2007).

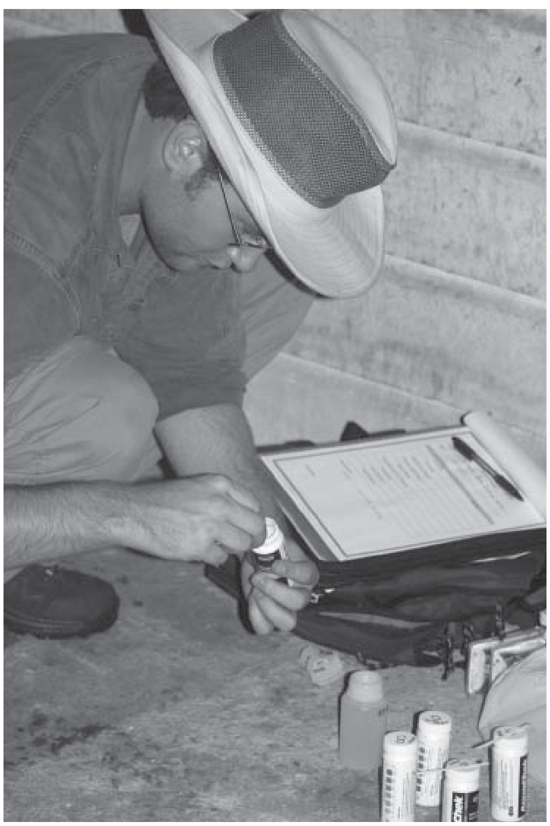
Lead is always a concern among health professionals. According to the EPA, lead can lead to physical or mental delays in children and infants and kidney problems and high blood pressure in adults. Lead was tested in the water, but before testing I did not anticipate finding significant amounts of it.

Water hardness is the most common problem with drinking water. Ground water makes up almost a quarter of the fresh water supply on earth. Soil and rock act as a natural filter for water, but also add minerals. High levels of minerals, specifically calcium and magnesium, are responsible for hardening water (Wilson et al., 1999). While water hardness may not be desirable, it is not a safety issue. Hard water can be safely used for drinking, cooking, and bathing (Wilson et al., 1999).

Protocols

In an effort to address the concern of drinking water in rural Belizean communities, a chemical analysis was performed to determine the potability of drinking water at schools and rural villages. The water was tested for nitrates and nitrites, which might be present from fertilizer runoff, chlorine, pesticides, and lead.

This project emerged from past water quality testing done only in the lagoon. In preparation for my project, I investigated the types of tests that should be conducted. As a result, I decided that lead, nitrate/nitrite, phosphate, chlorine, and alkalinity tests would be the most useful. Once on the ground in Belize, I learned about the fish kills that had occurred in the region, and I decided to test the New River Lagoon and its tributaries. No prior research was done on testing aquatic ecosystem water, but the same tests were applied. The testing allowed for a solid background in what the ecosystems looked like and how they could be linked between the fish kills and possible pollution.



Analysis of Data

The data was collected using test strips that could cause significant errors. Because of their simplicity, test strips only indicate a range and not an accurate, precise number.

Another problem is that moisture can impact the results. If the test strips are exposed to heavy moisture, the results can provide an inaccurately higher number. The samples were also only tested once due to a limited number of tests available. It would have been more precise if multiple trials were performed. This would show any variance in the test strips and whether they were contaminated before testing. However, from the data collected, it would be fair to say the numbers were fairly consistent and no significant changes were noticed.

Another error could have resulted from taking the water back to the lab for testing. This was not done often, but in some circumstances it was, especially when testing for lead and pesticides. The fact that the water was sitting in the plastic bottles for an extended period of time before being tested could have skewed the results. Holding the water, especially in warm conditions, can change its composition, especially if it contains bacteria and organisms that produce various byproducts. The breakdown of certain chemicals could change the composition and change the results of the tests.

For future testing, it would be advised that test strips be used only as a preliminary test, which can still be done on site. In addition, water should be taken back to the lab and tested. However, the water should be stored in a cooler to keep it away from the heat and alleviate any possibility of changing the chemical composition.

Conclusion

From the data obtained, all of the water tested did not show significant signs of contamination. (For detailed description of the tests, see Appendix.) However, tests did indicate high levels of phosphorus, with the highest reading from Bergen's Creek at 30 ppm. The New River Lagoon and its tributaries, including Ramgoat Creek, Harry Jones Creek, and Irish Creek had consistent levels of phosphorus at 5 ppm. Most of the drinking water test sites indicated high levels of phosphorus, but nothing at a dangerous level. Even though these high phosphorus levels were obtained, further research needs to be done to determine whether phosphorus alone is capable of promoting algal blooms without the presence of high levels of nitrogen. There was no indication of algae formation when testing was performed.

The nitrate levels for the New River Lagoon and its tributaries were also constant at around 2 ppm, a level well below the EPA limit of 10 ppm in drinking water. This standard is also applied to aquatic ecosystems. The greatest concern of the water tested would be the high levels of phosphorus found in the New River Lagoon and its tributaries. If coupled with high levels of nitrate, an algal bloom could arise and fish kills could occur.

All sites tested for total hardness and total alkalinity indicated hard to very hard water. The hardness of the water does not negatively affect human health, but it will give water a non-pure taste. Since hard water occurs naturally, it is of no concern to this project.

Tests for lead and pesticides yielded no positive results. The sites tested for lead were large water containers that collected rainwater and were not in contact with any lead materials. Due to the limited number of pesticide kits, tests could not be performed at every site. Because no complete positives were obtained, it can be assumed that pesticides are not having an impact on the environment or the people, but further testing should be done to confirm these initial findings.

No chlorine was found in any of the sites tested. Chlorine is added to drinking water to purify it.

My research on drinking water shows that no significant chemical contaminants were found that could seriously harm people. This information will be useful not only to Belize but for further research. My work has provided a good basis for determining not only what to test, but where to test.

Reflection

I believe that my project brought new knowledge to the people living at Hillbank. They now have the information to understand what may have caused fish kills in the past. Perhaps Programme for Belize benefitted the most because one of the rangers with whom the McMaster School has worked over the past four years was taught how to use water testing supplies. The organization now has the capacity to easily monitor the water for any dramatic changes.

The research performed in Belize has made an everlasting impact on me. I truly feel that I have helped not only the Belizean people but also the wildlife and environment. My research establishes a good foundation for further testing and education. It could even help the Belizean government realize how vulnerable the water is, take action to stop pollution, and put up a safeguard to protect human health.

This trip has made me realize that I am a research person. Thanks to the McMaster School and the opportunity to travel to Belize, I have discovered that I have even more curiosity than I thought I did and am convinced that research is something that I can do for the rest of my life.

REFERENCES

Fan, A. & Steinberg, V. (February, 1996). Health implications of nitrate and nitrite in drinking water: An update on methemoglobinemia occurrence and reproductive and developmental toxicity. *Regulatory Toxicology and Pharmacology, 23*(1), Issue 1, 35-43.

Frutos, R. (August 6, 2003). Progress and constraints in developing integrated water resource management in Belize. National Meteorlogical Service: Belize. Retrieved from http://www.hydromet.gov.bz/Hydrological_Report.htm

Gelberg, K. H et al. (January 1999). Nitrate levels in drinking water in rural New York state. *Environmental Research 80,* Issue 1, 34-40.

Muller, D. K. & Helsel, D. R. 1999. Nutrients in the nation's water--Too much of good thing? Circular 1136. U.S. Geological Survey, Denver.

Murphy, S. (April 23, 2007). General information on phosphorus. City of Boulder/ USGS Water Quality Monitoring. Retrieved from http://bcn.boulder.co.us/basin/data/BACT/info/TP.html

UNICEF-PAHO. (1996). Situation analysis of rural water supply and sanitation in Belize. UNICEF / Pan American Health Organization. Part 5. Retrieved from http://www.bvsde.paho.org/muwww/fulltext/analisis/belice/belice.html

Van Leeuwen, F.X.R. (April 1, 2000). Safe drinking water: The toxicologist's approach. *Food and Chemical Toxicology. 38, Suppl. 1,* S51-S58.

Wilson, Amber et al. (June 1999). Household water quality: Water hardness. Virginia Cooperative Extension. Retrieved on from http://www.ext.vt.edu/pubs/housing/356-490/356-490.html

APPENDIX

Research Design/ Protocol/ How the research was conducted

Materials

- Hach Nitrate and Nitrite test strips – 25 test
- Hach Free & Total Chlorine test strips – 50 tests
- Hach Total Hardness test strips 0-425 mg/L – 50 tests
- Hach Phosphorus, Orthophosphate (reactive) test strips 0-50 mg/L – 50 tests
- Hach Chloride Quantab (High and Low Range) tests strips – 40 tests each
- Hach Total Alkalinity test strips 0-240 mg/L – 50 tests
- Watersafe Lead test kits – 10 tests
- Watersafe Pesticide test kits – 10 tests
- Plastic bottles

Protocol

- Water was collected and filled in plastic bottle
- Each test strip was dipped into water and each test had specific testing time for wait period which ranged from 30 seconds to 1 minute
- After wait period, the strip was compared to the parameter ranges indicated on the bottles of the tests
- The data was recorded

- The bottle of water was taken back to the lab
- The lead and pesticide tests were run back at the lab due to 10 minute wait period
- After 10 minutes, the tests were read and data was recorded