Assessing the Contaminants in Bottled vs. Tap Water

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1. Abstract

For distribition to consumers, the U.S. Environmental Protection Agency (EPA) defines standards for drinking water to meet, ensuring it does not contain an excess of hazardous contaminants. Much of the water consumed across the U.S. has been found to violate these standards (Langin et al., 2018). This study aimed to assess the contaminants prevalent in bottled and Long Island tap water, predicting that results would remain consistent with researchers as stated in Daughton, 2004. The researcher found much success using a LaMotte colorimeter with water quality test kits to determine the presence of Sulfate, Fluoride, Copper, Zinc, Manganese, Nitrate, Iron, and Chlorine in local and bottled water sources. For every test conducted, at least one water source violated the EPA safe standard. Additionally, LaMotte biopaddles were used to test for the presence of coliform bacteria. After repeated trials, it was found that Fiji bottled water was contaminated with 10^4 colony forming units of fecal coliform bacteria. Overall, this experiment found that Brita and school filtered tap water, as well as Poland Spring bottled water were the only water sources that did not violate any EPA standards. The prevalence of this issue in America poses a threat to public health, as excess amounts of: Iron can lead to hemochromatosis- which can damage the liver, heart, and pancreas; Copper can result in vomiting, diarrhea, stomach cramps, nausea, liver damage, and kidney disease; Flouride can cause dental and skeletal flourosis; and coliform bacteria can lead to diarrhea, nausea, headaches and fatigue.

2. Introduction

Background

The water quality phenomenon is an extremely vital issue needing answers in today's society. The EPA has not regulated their water standards in over 20 years, which poses some major questions regarding whether the water people are drinking today is safe. Especially on Long Island where the only source of clean drinking water is groundwater aquifers, water supply is so limited that it is essential to understand how to utilize it in the most efficient way possible. This can be achieved through awareness of wastewater treatment, along with taking fertilizer precautions. By the time tap water ultimately reaches a person's home, it has already been contaminated with various chemicals and metals. Similarly, this impurity is true with bottled water. Before it is packaged and sent away for the public to drink, bottled water is often treated with chemicals in efforts to clean the water. These chemicals have been shown to have adverse

health effects in many cases across the United States.

Especially on Long Island, where the only source of clean drinking water is groundwater aquifers, and supply is so limited that it is essential to understand how to take care of the most valuable resource on earth ("The Nature Conservancy", n.d.). Some ways in which this goal could be attained are raising awareness about the treatment of wastewater, along with taking fertilizer precautions ("The Nature Conservancy", n.d.). Beyond considering just the health factors, it is important to consider the environmental effects that buying bottled water has (Themelis & Ulloa, 2007). New York City currently exports its own trash, as landfills are increasing in number around the U.S, and this could have a major effect on our future and global warming (Themelis & Ulloa, 2007). Only around 30% of plastic water bottles in the US is recycled, and this means that the other 70% is going to landfills whether regulated or unregulated (Themelis & Ulloa, 2007). There are 325 energy recovering landfills in the United States, which means the other 1,600 are producing enormous amounts of methane being released into the air (Themelis & Ulloa, 2007). Methane is released from the breaking down of organic waste, which means climate change will only continue to worsen (Themelis & Ulloa, 2007). This gas, which has 23 times the global warming potential than carbon dioxide, is going to continue to be a problem that we must regulate and keep watch over (Themelis & Ulloa, 2007).

According to a study by Saylor, Prokopy, and Amberg (2011), a complex issue related to the consumption of bottled water is the perception and bias of health risks from tap water. Most Americans pay for bottled water (as much as 10,000 times more than tap water or about $10 per gallon) indicate that they highly value clean drinking water, and may distrust the quality and safety of tap water (Saylor et al., 2011). For example, in a 2002 Gallup poll, the number one reason Americans gave for buying bottled water was ‘‘health-related issues’’ while taste was the

second most important factor (Saylor et al., 2011). Perceived risks can play a role in the people's shift away from tap and toward bottled water, especially after contamination events (Saylor et al., 2011). Media attention on ‘‘trust-destroying events’’, such as outbreaks of illness caused by contaminated tap water, has also weakened public trust in the water supply while falsely inflating confidence in bottled water (Saylor et al., 2011).

The introduction of high power ultrasound energy with frequencies in the range 15 kHz to 1 MHz into liquid reaction mixture is known to cause a variety of chemical transformations (Hoffman, 1996). The chemical effects of ultrasound on chemical reactions were first reported by Richards and Loomis in 1927 (Hoffman, 1996). This early report was followed by a detailed investigation of the effect of ultrasonic irradiation on the autoxidation of iodide ion (Hoffman, 1996). In recent years, due to the growing need to illuminate undesirable chemical compounds, the use of high-energy ultrasound for harmful waste treatment has been explored with great interest (Hoffman, 1996). The application of ultrasonic irradiation for the controlled degradation of chemical contaminants in water has been investigated using a variety model compounds (Hoffman, 1996).

Chemical pollutants that are regulated under various international, federal, and state programs represent but a small fraction of the universe of chemicals that occur in the environment (Daughton, 2004). As a result of both natural processes and human influence, chemicals are becoming more prevalent in the water we drink (Daughton, 2004). Although the number of these targeted chemicals may be limited, they still have a significant risk to economic impairment and human health (Daughton, 2004). Examples of these chemicals are lead, mercury, and other pesticides and herbicides (Daughton, 2004). Several different dimensions can account for the universe of potential chemical toxins (Daughton, 2004). For instance, pollution, use of

fertilizer, global warming, and other accounts of environmental and human behavior have an effect (Daughton, 2002).

Because lead is highly utilized in products throughout the world, it inevitably ends up being distributed into the environment ("The Courier Herald", 2018). Throughout the years, lead has been banned from gasoline, paint, and various other products because of the health concerns it creates ("The Courier Herald", 2018). Led has also been found in drinking water, corroding from older pipes ("The Courier Herald", 2018). This is why in 1986, the Safe Drinking Water Act placed a limit on the amount of led allowed to be present in pipes and plumbing fixtures ("The Courier Herald", 2018). Lead poisoning often times does not have obvious immediate symptoms ("The Courier Herald", 2018). Eventually, it has the ability to impair hearing and speech development, as well as affecting the kidneys and other organs ("The Courier Herald", 2018). Lead poisoning is especially dangerous in the first two years of a human's life, as development is critical at this time, as it could result in behavioral and social issues ("The Courier Herald", 2018).

The water quality phenomenon is an extremely vital issue needing answers in today's society. The EPA has not regulated their water standards in over 20 years, which poses some major questions regarding whether the water people are drinking today is in fact safe. The research question was: what contaminants are present in bottled vs. tap water? It was hypothesized that tap water will have more metal contaminants while bottled water will have more chemical contaminants.

3. Materials & Methods

A LaMotte colorimeter was used to test for the presence of Sulfate, Fluoride, Copper, Zinc, Manganese, Nitrate, and Chlorine. Each chemical required a different procedure. For Nitrate, Manganese and Sulfate, their safety hazards were too dangerous to handle, so student recorded the data as the lab supervisor conducted the procedure. This method produced quantitative data. Furthermore, water was tested for the presence of 14 water contaminants using Baldwin Meadows Test Strips. These tests were conducted by completely submerging the testing strip into the water, and then waiting 30 seconds to compare results to the template colors on the back of the tube. This method was the least reliable because it was very hard to differentiate the difference between very similar colors and it produced data that was qualitative.

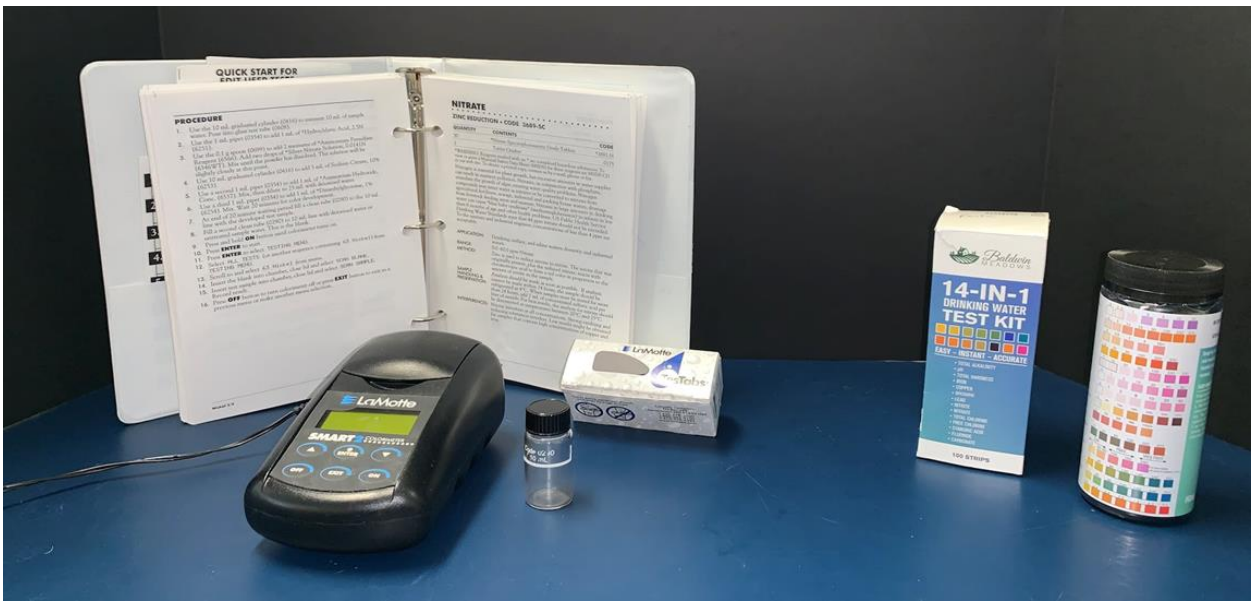

Figure 1: Some of the testing methods utilized in this experiment: the colorimeter set-up (left) and the testing strips (right). *Photo taken by researcher.*

Additionally, LaMotte BioPaddles were used to test for the presence of coliform bacteria in drinking water. BioPaddle was exposed to water sample for 15 seconds, removed paddle, emptied the vial, and let paddle in the vial incubate at 35 degrees Celsius for 48 hours.

4. Results and Discussion

Fiji bottled water was contaminated with 10^4 colony forming units of fecal coliform bacteria. Fiji bottled water is sourced from an aquifer in Fiji and yet over 50% of the Fiji population does not have access to clean drinking water (Fishman, 2010). Brita and school filtered tap water, as well as Poland Spring bottled water did not violate any EPA standards. Excess amounts of elements including iron, copper, and fluoride were found in both Long Island tap and bottled water which can lead to human health effects.

Figure 2: results of the LaMotte BioPaddles: the blue background and red dots represent the fecal coliform bacteria found in Fiji Bottled Water (left). The red agar with no colonies present is negative for fecal coliform bacteria (right). *Photo taken by researcher.*

4.2 Hypotheses

The hypothesis was supported, as bottled water violated more chemical standards such as Sulfate, Flouride, and Zinc, while tap water violated the more metal standards, including Iron, Copper, and Nitrate.

4.3 Uncontrolled Events, Errors, Repeatability, and Improvements

An undoubtable set back of this experiment was the difficulty of using Lamotte Test Strips because it was very hard to differentiate the difference between very similar colors and it produced data that was qualitative. This experiment demonstrated repeatability of the data because similar results were produced multiple times.

4.4 Significance

Especially on Long Island where the only source of clean drinking water is groundwater aquifers, water supply is so limited that it is essential to understand how to utilize it in the most efficient way possible. This can be achieved through awareness of wastewater treatment, along with taking fertilizer precautions. By the time tap water ultimately reaches a person's home, it has already been contaminated with various chemicals and metals. Similarly, this impurity is true with bottled water. Before it is packaged and sent away for the public to drink, bottled water is often treated with chemicals in efforts to clean the water. These chemicals have been shown to have adverse health effects in many cases across the United States.

4.5 Future Research

Researcher plans to continue this research during upcoming years attending university, taking advantage of the more advanced technologies available. Possible areas of continuation include investigating plastic components leaching into bottled water, as well as industrial contaminants such as perfluoroalkyl substances used in non-stick cookware and food packaging.

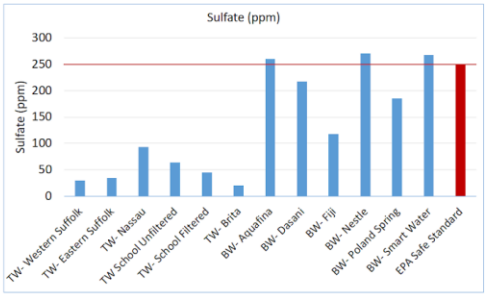

Figure 3: Smart Water, Nestle, and Aquafina bottled waters violate the EPA safe standard for sulfate.

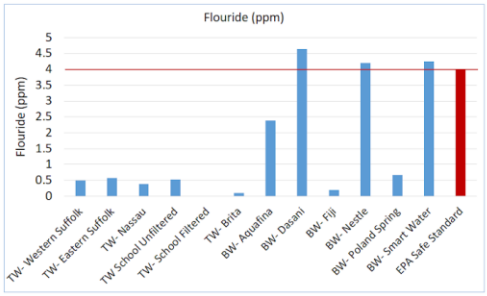

Figure 4: Smart Water, Nestle, and Dasani bottled waters violate the EPA safe standard for fluoride.

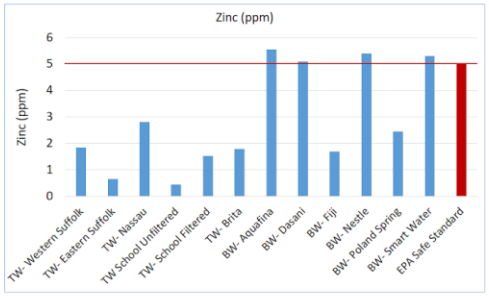

Figure 5: Smart Water, Nestle, Dasani, and Aquafina bottled waters violate the EPA safe standard for zinc.

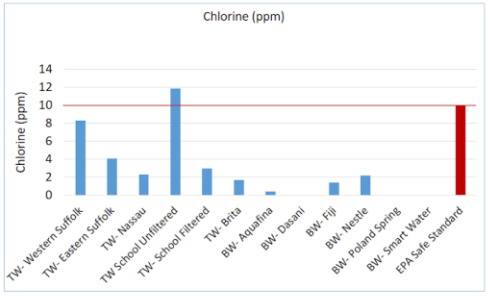

Figure 6: School unfiltered tap water violates the EPA safe standard for chlorine.

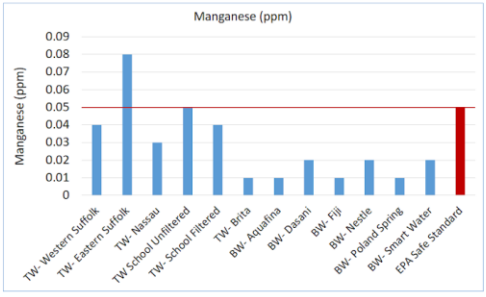

Figure 7: Eastern Suffolk tap water violates the EPA safe standard for manganese.

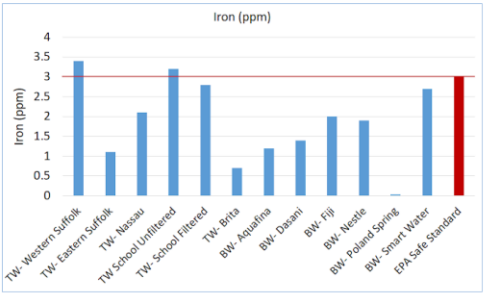

Figure 8: Western Suffolk and school unfiltered tap water violate the EPA safe standard for zinc.

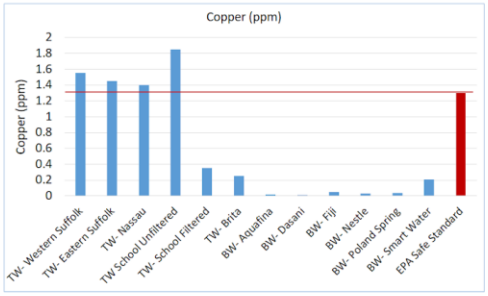

Figure 9: Western Suffolk, Eastern Suffolk, and school unfiltered tap water violate the EPA safe standard for copper.

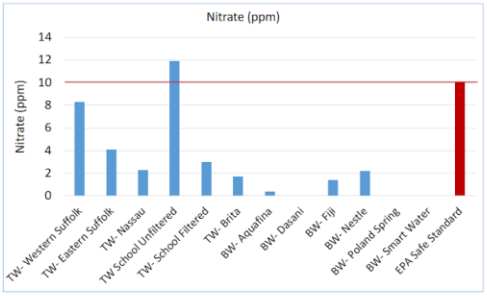

Figure 10: School unfiltered tap water violates the EPA standard for nitrate.

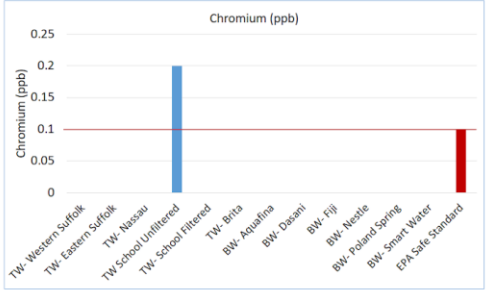

Figure 11: School unfiltered tap water violated the EPA standard for chromium.

5. Conclusions

The data collected supported the hypothesis. In addition, there were more metal contaminants in tap water and more chemical contaminants in bottled water. The data offered a small sample size of all the contaminants that people consume in their daily lives, which was the goal of this experiment.

6. References

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