Nutrient Levels of the Sibun vs. the Sangamon River

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**Introduction**

With a length of roughly one hundred and thirty-one miles and numerous tributaries, the Sibun is one of Belize’s principal river systems. It originates in the rugged northeastern sector of the Maya Mountains and winds its way through mountain valleys, lush forests, citrus groves, and cave structures before emptying into the Caribbean Sea just south of Belize City. It is crucial to the biodiversity of Belize and supports a myriad of species. Part of the watershed’s success in sustaining such a wide array of organisms may be attributed to the many tributaries which feed into the river. These tributaries usher in nutrients which aid in the establishment of a baseline for the food chain. With such an expansive amount of life depending on the Sibun River, it is imperative that the nutrient levels remain within a range that can adequately support the surrounding biodiversity (Cox 10-11). This research project will examine the concentration of nitrates and phosphates within the Sibun River to the Sangamon River in Illinois.

Nitrate is an important nutrient for plant growth. However, in surplus amounts nitrates can negatively impact water quality. All aquatic organisms emit wastes when they expire, producing ammonia. Certain bacteria convert the ammonia to nitrites, which is then transformed by different bacteria into nitrates. Nitrates also come from soils, which contain nitrogen compounds within organic matter. Similarly to the ammonia in water, bacteria change the nitrogen compounds in the soils to nitrates. Other sources of nitrates include fertilizer runoff, sewage, and industrial discharges. Rainwater can often wash fertilizer and animal manure –both high in nitrates- into streams, causing an excess amount (“Nitrates and Their Effect on Water Quality”). Although nitrates are essential plant nutrients, in large amounts nitrates can speed up eutrophication, and as a result, cause large upsurges in aquatic plant growth and biodiversity. Consequently, dissolved oxygen, temperature, and other indicators of stream health are affected. Surplus nitrates can cause hypoxia -low levels of dissolved oxygen- and can become toxic to warm-blooded animals at high concentrations (“Water: Monitoring and Assessment”). High concentrations of algae and other aquatic plants prohibit sunlight from reaching far enough into the water. Since plants and algae need sunlight, those that do not receive an adequate amount of sunlight will die. These dead organisms will fall to the bottom of the pond, where the number of bacteria which consume decaying organic material will significantly rise. These bacteria will take up oxygen, resulting in the level of dissolved oxygen within the water falling to a level at which many aquatic organisms cannot survive (“Nitrates and Their Effect on Water Quality”).

Like nitrates, phosphates are crucial for plant growth, and are similarly hazardous when they are found in an abundance. Soil and rock weathering is the primary source for phosphates found in the environment. Other sources include runoff from fertilizer, failing septic systems, disturbed land areas, drained wetlands, and animal manure. Plants intake the inorganic phosphorous provided by the aforementioned sources. As the plants consume the inorganic phosphorous, they alter it to organic phosphorous as it becomes a portion of their tissues. Subsequently, animals intake organic phosphorous by eating these aquatic plants, other animals, or decaying material. Since phosphate is found in a limited supply in fresh waters, even the slightest rise can set off a chain reaction of events in a stream including enhanced plant growth, algae blooms, hypoxia, and the death of many organisms (“Water: Monitoring and Assessment”).

This research project will determine the water quality of the Sibun and the Sangamon River by observing the concentrations of nitrates and phosphates within each river. These results will then be compared to the ideal ranges of nitrates and phosphates for natural water, in order to determine which river is less polluted. The ideal range for nitrate levels in natural water is 0.9 to 3.15 mg/L, while the phosphate level in rivers and streams should not exceed 0.02 mg/L (“Water Quality”). Due to differences in rainfall, temperatures, sizes, seasons, and perhaps federal regulations for pollution, some variances in the phosphate and nitrate levels are to be expected. However, despite the differences in geographical location, limited evidence exists for consistent variances between tropical and temperate streams in nutrient dynamics. Rather, ecological processes within tropical streams appear to be motivated by the same factors that are significant to temperate streams, such as groundwater input and catchment geology (Boulton, *et. al*). Although both the Sangamon River and the Sibun River are exposed to runoff and other pollutants in some form, I hypothesize that the Sangamon River will contain higher concentrations of both nitrates and phosphates, due to higher agricultural use. The time of the year for the Sangamon River will definitely be a factor, as it’s likely that the melting snow and ice will increase runoff.

**Materials and Methods**

* 60 Nitrate #1 TesTabs® from LaMotte® Water Test Kit
* 60 Nitrate #2 TesTabs® from LaMotte® Water Test Kit
* 60 Phosphate TesTabs® from LaMotte® Water Test Kit
* Nitrate color chart
* Phosphate color chart
* 2x protective nitrate sleeves
* 2x 10 ml test tubes with caps
* 2 pipettes
* 10 containers for collecting samples (must hold at least 30 ml)
* Distilled water
* Timer

1) Label each of the ten containers with a number from 1-10.

2) Collect samples from the river using the numbered containers. Be sure to fill each container with at least 30 ml of the sample to ensure that there is enough sample to conduct multiple tests.

3) Pour 5 ml of a sample into the test tube. Drop one phosphate tablet into the tube and secure the cap.

4) Shake the tube until the phosphate tablet is completely dissolved. Once the tablet is dissolved, set the timer for five minutes.

5) After five minutes have elapsed, compare the color of the water to the phosphate color chart and record the results.

5) Pour 5 ml of the first sample into a test tube. Place one nitrate #1 tablet into the tube and secure the cap and shake until dissolved.

6) Once dissolved, place one nitrate #2 tablet into the test tube. Secure the cap and immediately cover the test tube in a protective sleeve (optional if testing indoors). Shake the tube for two minutes, then set the timer for five minutes.

7) After five minutes have elapsed, compare the color of the water to the nitrate color chart and record the results.

8) Conduct steps 2-7 a total of three times for each of the ten samples collected, resulting in three phosphate tests and three nitrate tests for *each* of the ten water samples collected. Performing the test three times per sample is a cautionary measure that prevents any fluke tests from skewing the results.

9) Repeat entire procedure for the second river to be tested.

10) Analyze results and compare them to ideal phosphate and nitrate levels for natural water. According to Purdue University, phosphates levels should not exceed 0.02 mg/L and nitrate levels should be within the range of 0.9 mg/L to 3.15 mg/L (although the data recorded from the nitrate and phosphate color charts is presented in parts per million, it is acceptable to compare the ppm results to the mg/L ranges since they are the same ratios).

In this research, the two rivers to be tested are the Sibun River in Belize and the Sangamon River in Illinois. I will use the T-Test to analyze my results, since the T-Test is best equipped for comparing two bodies of water that are entirely independent of each other. My null hypothesis is that there is no significant difference between the concentrations of phosphates and nitrates of the Sibun River and the Sangamon River (μ1 = μ2). My alternative hypothesis is that the Sibun River possesses lower concentrations of phosphates and nitrates than the Sangamon River (μ1 ≠ μ2, μ1 < μ2).

**Results**

|  |  |  |  |
| --- | --- | --- | --- |
| Sample | Test | Phosphates (ppm) | Nitrates (ppm) |
| 1 | 1 | 4 | 5 |
| 1 | 2 | 4 | 4 |
| 1 | 3 | 4 | 4 |
| 2 | 1 | 3.5 | 3 |
| 2 | 2 | 3 | 2 |
| 2 | 3 | 4 | 2 |
| 3 | 1 | 1.5 | 2 |
| 3 | 2 | 2 | 3 |
| 3 | 3 | 4 | 3 |
| 4 | 1 | 1.5 | 3 |
| 4 | 2 | 2 | 2 |
| 4 | 3 | 2 | 3 |
| 5 | 1 | 1.5 | 3 |
| 5 | 2 | 2 | 2 |
| 5 | 3 | 2 | 2 |
| 6 | 1 | 2 | 4 |
| 6 | 2 | 2 | 4 |
| 6 | 3 | 2.5 | 4 |
| 7 | 1 | 3 | 1.5 |
| 7 | 2 | 2 | 2 |
| 7 | 3 | 4 | 3 |
| 8 | 1 | 4 | 1.5 |
| 8 | 2 | 4.5 | 1.5 |
| 8 | 3 | 4 | 1.5 |
| 9 | 1 | 3 | 2 |
| 9 | 2 | 2 | 2 |
| 9 | 3 | 4 | 2 |
| 10 | 1 | 2 | 3 |
| 10 | 2 | 2 | 3 |
| 10 | 3 | 3 | 3 |

Sibun River

Sangamon River

|  |  |  |  |
| --- | --- | --- | --- |
| Sample | Test | Phosphates (ppm) | Nitrates (ppm) |
| 1 | 1 | 3 | 20 |
| 1 | 2 | 4 | 20 |
| 1 | 3 | 4 | 17 |
| 2 | 1 | 3 | 15 |
| 2 | 2 | 4 | 15 |
| 2 | 3 | 3 | 18 |
| 3 | 1 | 4 | 20 |
| 3 | 2 | 3 | 18 |
| 3 | 3 | 3 | 18 |
| 4 | 1 | 4 | 20 |
| 4 | 2 | 4 | 20 |
| 4 | 3 | 3.5 | 20 |
| 5 | 1 | 3 | 17 |
| 5 | 2 | 3 | 17 |
| 5 | 3 | 3.5 | 18 |
| 6 | 1 | 4 | 20 |
| 6 | 2 | 4 | 20 |
| 6 | 3 | 4 | 20 |
| 7 | 1 |  | 18 |
| 7 | 2 |  | 18 |
| 7 | 3 |  | 20 |
| 8 | 1 |  | 20 |
| 8 | 2 |  | 20 |
| 8 | 3 |  | 20 |
| 9 | 1 |  | 20 |
| 9 | 2 |  | 20 |
| 9 | 3 |  | 20 |
| 10 | 1 |  | 18 |
| 10 | 2 |  | 17 |
| 10 | 3 |  | 20 |

Each point on this graph represents an average of the three tests conducted at each site.

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The purple line indicates the highest amount of nitrates allowable in drinking water according to the EPA.

**Conclusion**

The results of this research proved my hypothesis. As predicted, the Sangamon River possessed higher concentrations of nitrates and phosphates than the Sibun River. All data collected was analyzed using T-Tests in order to observe whether there was a statistically significant difference between means of the nutrient levels in the two rivers, or if the results I obtained could be attributed to chance. The best indicator of measuring this difference is the p-value. The p-value is the likelihood of acquiring a test statistic result at least as (if not more) extreme as the results actually acquired, assuming that the null hypothesis is correct. The significance level of the p-value is commonly 0.05. A p-value less than 0.05 indicates that the null hypothesis is false, and denotes moderate evidence that there is a statistically significant difference. A p-value less than 0.01 denotes strong evidence that there is a statistically significant difference. The p-value for phosphate concentrations in the two rivers was 0.017, while the p-value for nitrate concentrations was p < 0.01. Both p-values indicate that there were statistically significant differences in the nutrient levels between the two rivers.

According to my results, my hypothesis was proven correct. There was some overlap between the phosphate results for the Sangamon River and the Sibun River, but overall the Sangamon had a higher mean concentration of phosphates than the Sibun. However, I was only able to test six of the ten samples collected from the Sangamon, due to a lack of supplies. If I was able to fulfill all of my testing, it’s possible that the p-value may have been larger than the one acquired (0.017). Adding additional tests may have proven that the two rivers have similar phosphate levels. By far the most surprising aspect of my research was the results of the nitrate tests in the two rivers. Although I predicted that the Sangamon River would have a higher concentration of nitrates than the Sibun River, I did not expect there to be such an extreme disparity between the two. The nitrate test results collected at the Sibun River were generally cohesive with each other, with a range from 1.5-5 ppm, which means that the nitrate levels were fairly, although not entirely consistent throughout the entire Sibun River. The amount of nitrates in the Sangamon were also fairly consistent throughout the river, with a range from 15-20 ppm. Yet the comparison between the nitrate levels of the two rivers is quite alarming. While the Sibun and the Sangamon had some phosphate tests in common, there is no intersect between the nitrate results of the two rivers. Figure 2.1 (see results) demonstrates the appalling difference between the nitrate levels in the two rivers; the two data lines representing each river do not meet once. Although my results are in line with my hypothesis, I did not predict it to be proven on such a large scale.

There are several different factors that could possibly explain the high contrast of nitrate levels between the two rivers. In a recent study of bodies of water near a golf course in Austin, Texas, seasonal changes played a significant part in monitoring nitrate levels. Nitrates existed in a much higher concentration during the winter season due to increased rainfall, plant dormancy, and decreased microbial and bacterial activity (Balogh et. al). This could potentially be an explanation for the high nitrate levels in the Sangamon River, as Illinois has recently experienced a record breaking winter with record-breaking precipitation and temperatures. When I tested the Sangamon River a few weeks after testing the Sibun, there was a notable difference in the elevation and velocity of the two rivers, with the Sangamon River being incredibly fast-moving, most likely due to winter precipitation and melting snow. The cold weather and high precipitation may have disrupted the nitrate cycle, leading to an increased amount of nitrates. Of course, since the Sibun is a tropical river, it experiences a higher average precipitation level per year than the Sangamon. However, the testing of the Sibun River occurred in March, during Belize’s dry season. Before testing, I originally thought that the climate of the rivers had little to do with the nitrate levels, but the results of my tests say otherwise. Seasonal variations may have at least some impact on factors such as rain, which can usher fertilizers into the river, causing a seasonal spike in nitrate levels.

However, although seasonal variations could be a potential cause of the high nitrate levels in the Sangamon River, a more plausible explanation is the higher amount of agricultural activity in Illinois. According to the United States Geological Survey (USGS), in the Sangamon River region application rates of nitrogen and phosphorus in synthetic fertilizer and manure are among the highest rates in the country. The USGS also notes that on average, the nitrate level of the Sangamon River from April-June is about 17 mg/L. On the contrary, from August-November, the nitrate level is significantly lower at an average of less than 0.01 mg/L, although in some areas it may exceed that amount. This is because pesticide concentrations in rivers have a seasonal pattern, as pesticides are heavily applied in spring, then ushered into the Sangamon River by spring and summer rains (Groschen et. al). So although climate *could* be a factor in nitrate levels, it is more accurate to say that the fairer spring climate of Illinois incites a higher application of pesticides.

One potential flaw in my research is the color scales which I used to identify the nitrate and phosphate levels in the two rivers. The phosphate scale contained four color blocks. Each was a different shade of blue and they were numbered 0, 1, 2, and 4. The nitrate scale also contained four color blocks. Each was a different shade of red and they were numbered 0, 5, 20, and 40. I had to compare the color of my sample with the charts in order to determine the nutrient level, and I believe the scales are too subjective to obtain accurate readings. Each of the color blocks was a vastly different shade from its neighboring blocks. If I obtained a sample that appeared to be in between the ‘5’ nitrate color block and the ‘20’ color block, I would have to estimate a number somewhere between five and twenty and label that number as the nitrate concentration in that sample based on which shade of red it was closer to. The results obtained from these test kits were adequate enough for me to conclude that the Sangamon River possesses higher nitrate and phosphate levels than the Sibun River, yet in the future, more accurate results could be obtained by using a less subjective color scale than the one provided in the LaMotte test kit. There was too much of a difference in the color shades to be able to accurately identify nitrate levels that fell in between the provided shades.

If future students were interested in testing river nutrient levels, there are many different routes for expansion. First, if it were possible, I would extend the time frame of this experiment to at least a year, in order to capture nutrient levels during all of the seasons for both rivers. Nitrates in particular appear to vary by season, due to different agricultural seasons and subsequently, different amounts of pesticide application. If it is not logistically possible to test for a year, it would be interesting to expand the testing sites to different locations upstream and downstream, in order to determine whether or not there is a significant difference in nutrient levels based on stream flow. I would also advise future students to find rivers relatively closer in size to test. The Sangamon River is about 236 miles long, about double the length of the Sibun River. I opted to test the Sangamon River because of locational convenience, but if students could find a way to test a river closer in size to the Sibun, it would be interesting to see if there are different results than the Sangamon vs Sibun comparison.

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