Investigating Local Water Systems through Alkalinity and Nitrate Data

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Abstract

Students from Madison Plains High School, London, Ohio have collected and analyzed hydrology data from local water sources. Nitrate and alkalinity levels experienced an overall increase from September 2012 to February 2013. Research has shown that there is a possible correlation between hydrology data and local climate. Also, A possible cause of increased data observed by student is local agriculture practices.

Research Questions and Hypothesis

The class developed a question while testing data: How does climate affect alkalinity and nitrate levels? The goal was to determine how climate affected Alkalinity and Nitrate levels from streams and compile the data averages monthly. The hypothesis was agricultural practices caused a change alkalinity and nitrate levels.

Introduction

The students at Madison Plains High School, Ohio, (39°47.36” N, 83°28.91” W) in the Biology II class are involved in a research study through the Global Learning and Observation to Benefit the Environment (GLOBE) program. Collection sites included locations in Madison, Franklin, Pickaway and Fayette counties in Ohio (Figure 1). During the months of September 2012 through February 2013, students collected and analyzed nitrate and alkalinity levels (Table 1) from local water systems and have noticed a significant rise in alkalinity and nitrates in streams, creeks and water ways.

Over the course of six months, nitrates levels have increased nine times since the beginning of the data collection. Alkalinity level in a water source determines a solution’s capability to buffer acidic solutions with higher concentrations of hydrogen ions (Brachmann). Fresh drinking water should have a level of 20 to 200 ppm (Cole & Wells, 2002). If the levels are too high compared to standard levels, the water will be considered full of minerals. Lime which is full of minerals adds concern of excessive acid in the water which is harmful to organisms. Organisms which encounter too much acid in their system will have infected cells in the body which will cause health problems (Rounds, 2012). Alkalinity is easily shown by the amount of carbonates and bicarbonates in the water. If the water is from a stream with limestone bedrock, the water will be filled with calcium bicarbonate (Stromberg). The water will lose carbon dioxide while the pH rises. After the water travels downstream, it will lose carbon dioxide to the atmosphere by evaporating the carbon dioxide molecules. Photosynthesis will take place after which leads the deposition left of calcium carbonate to the stream. (Stromberg).

Nitrates also impact water quality. Nitrates provide nutrients for plants that are necessary for their growth (Barbara & Nancy, 2010). Without nitrates, plants would be unable to grow and form properly. Nitrates are not generally found in high amounts, above 2 mg/L, in any body of water (Table 4). High nitrate levels can be associated with poor sewage disposal and in rural areas with fertilizer use (Barbara & Nancy, 2010). Fertilizer run-off can contaminate water systems by adding more nitrates (Stromberg). Another possible cause for an increase in nitrates is when bacteria begin breaking down substances, such as animal feces, This decomposition releases ammonia (NH_3^+) into the water as they breakdown proteins and combine with oxygen molecules to form nitrates (Cleveland, 2000).

Materials and Methods

Sample water was collected by the students at designated collection sites, where a sample bottle was filled with stream water. The collection of water occurred from 11 A.M. to 1 P.M. Eastern Standard time, to insure consistent solar radiation.

Nitrate levels were tested by using a LaMotte test kit (LaMotte code 3615). A test tube was filled with 5 mL of the sample water and then 0.5 mL of Mixed Acid Reagent was added. The test tube was capped then mixed. After two minutes, 0.1 g of Nitrate Reducing Reagent was added. The tube was capped and inverted thirty times in one minute to ensure the solution was thoroughly mixed. The mixed solution then was allowed to sit for 10 minutes. The sample test tube was inserted into the Axial Reader provided in the kit. The test tube's color was matched with a color sample standard to determine the level of Nitrates measured in parts per million (ppm). This process was repeated three times then averaged.

The alkalinity levels were evaluated using the LaMotte test kit (LaMotte Code 4533-DR-01). A titration tube was filled with five mL of the water that was collected. One BCG-MR Indicator Tablet was then added into the water. The water was swirled around slightly until the tablet dissolved causing the solution to turn a blue-green color. The titrator was filled with Alkalinity Titration Reagent B. While gently swirling the tube, the titrator was slowly pressed down on the plunger until the solution color changed from blue-green to purple. After the solution was turned completely purple the test result was read directly from the scale where the large ring on the titrator met the barrel. The results were then recorded as ppm. This entire process was completed three times then averaged.

Analysis and Results

After averaging the data for Alkalinity and Nitrates from September 2012 to February 2013, the findings were intriguing. September had the lowest average for Alkalinity while February had the highest average (Graph 1). Alkalinity data had an increase from September to November. This pattern was the result of Site N increasing to 316 mg/L in November. In February Sites H and P had results above 400 mg/L (Table 2). November through January had consistent averages. Our class at the beginning of the year may have experienced some experimental error. At the beginning of the year, our class used two different Nitrate kits which gave students two different results.

The lowest average for nitrates was also in September and the highest was in February. The winter months of January and February gave the highest averages for nitrates (Graph 2). September through December the averages for nitrates stayed below 0.1 mg/L which is relatively normal (Cleveland, 2000). The increase in the winter month averages came from Sites A, E, L, and N. Each of these sites had a nitrate result of 0.8 to 1.0 mg/L in January. Then in February sites A, E, J, K, and O were 0.6 to 1.0 mg/L for nitrates (Table 3). Throughout our data set, our class had a lack of data. This was caused by the students' not collecting data when needed.

Conclusion

A noticeable trend of increasing levels in nitrates and alkalinity was observed. Runoff from agricultural fields may have spilled into our waterways throughout Central Ohio. The increase of alkalinity may be caused by the agricultural limestone that has been applied to fields in our area. Aglime, which is also known as agricultural limestone, is a crushed rock used in agriculture to control the acidity of the soil. The limestone and dolomite that are used to produce aglime contain varying amounts of calcium carbonate and magnesium carbonate. These carbonates react strongly with the acids in the soils and create a soil that is less acidic and more productive. (Wolfe, 2009)

Aglime is used for multiple reasons throughout Ohio. Aglime neutralizes soil pH and therefore can lower the costs of fertilizers. Most fertilizers are more effective in slightly acidic or neutral soils. In addition, aglime boosts the performance of certain herbicides. These herbicides are also most effective when soil pH is slightly acidic to neutral. Aglime also improves water infiltration, drainage, and the growth of beneficial microorganisms, all of which cuts down on the amount of fertilizer and herbicides needed and benefits the farm operation. (Wolfe, 2009)

The aglime applied to fields in the area could be a cause of the increase in alkalinity due to field runoff. This direct correlation between the aglime on the fields and the increase in alkalinity in the water ways needs to be further investigated in future studies. The stability of the aglime on the fields and the pH and alkalinity of the field runoff should be investigated to further draw conclusions concerning the alkalinity levels of the waterways in this study.

The increase in nitrate levels has also been observed. Although we found no direct correlation to alkalinity levels was found, the answer may also be in the fields. Nitrate levels may have increased due to fertilizers, animal waste and car exhaust discharges. The main contributor could be ammonia from fertilizers that can runoff into water ways. Anhydrous Ammonia is applied to fields in the early spring. The ammonia then saturates in the soil and later is washed into waterways. Fertilizers and ammonia break down into water systems over time. The hydrogen from the fertilizers bond with the oxygen in the water and provides more water molecules (H_2O University. 2007). The nitrogen from fertilizers bonds with the water molecules and causes higher nitrate levels in the water.

The rise in alkalinity and nitrate levels may be due to farming practices. When fertilizers and chemicals are applied to fields, it percolates into the water ways and can cause increases in nitrates and alkalinity. The increase in alkalinity can be related to any substance that is high in carbonates. In this case, lime may be affecting the overall alkalinity increase. Since 94% of Madison County is used for agriculture, this affects most collection sites of this study.

As climate data shows, precipitation in September, November, and February had a lowest average precipitation in the past 30 years. October and December had a higher average precipitation than the past 30 years. January had a similar average precipitation with the past 30 years. Overall the test months have seen slightly less precipitation compared to the past 30 years.

In September, October, November, and February there was a lower average temperature compared to the past 30 years. December had a higher average temperature than the last 30 years. January had a similar average temperature with the past 30 years. Overall the test months have seen a slightly lower temperature compared to the past 30 years (Weather Warehouse, 2013).

Discussion

The following ideas could be used to improve the investigation of nitrate and alkalinity levels for this study. Improvements should be made to increase the accuracy of the data collected. Samples should be collected on the same day at the same time to make sure that the information is most accurate, for example the first Saturday of every month. Samples should also be collected at the exact GPS location every time. Collecting additional information such as depth and width of the collection site could improve analysis of the study

A complete and accurate data from each collection site would be a beneficial factor in having consistent results. It will also make the information more detailed. In the current study, data was missing from different months, leaving gaps in the data and offsetting some of our conclusion. The students involved in the research project have to be dedicated and willing to collect all data, and follow the procedures and protocols correctly in order to better this study and get the most out of the GLOBE program.

Additionally, further research about the agricultural practices surrounding the collection sites would be beneficial to understanding the possible cause of the increase in the nitrate and alkalinity data collected during the study.

Acknowledgements

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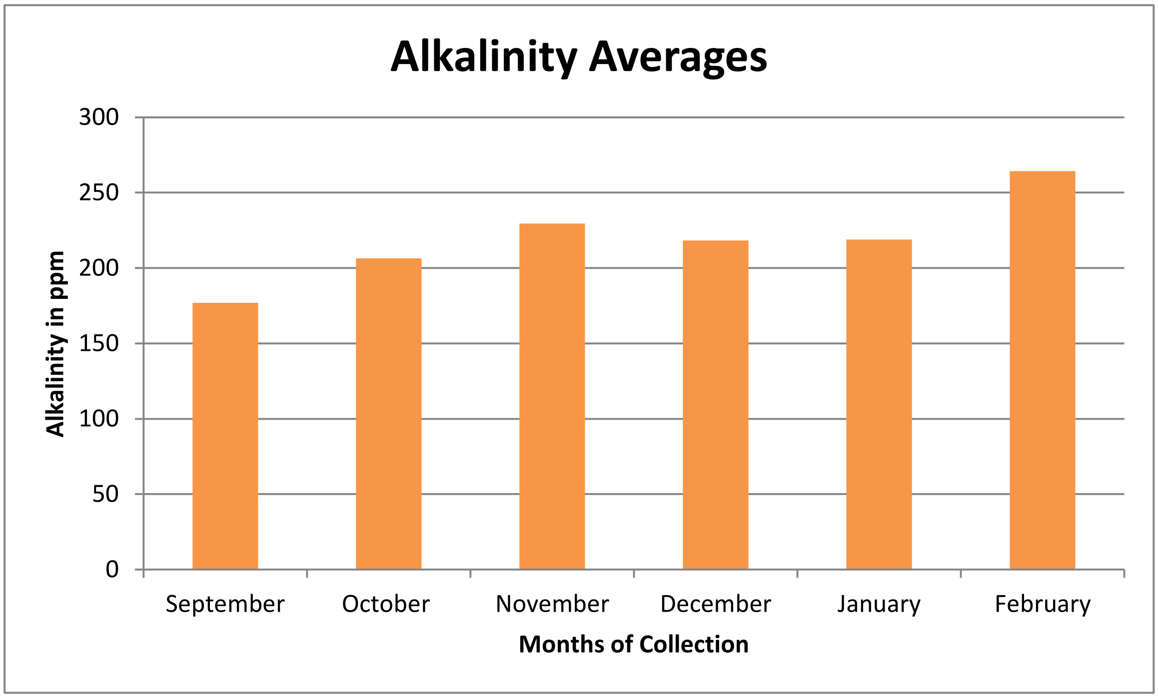
Data Summary

Graph 1



Graph 2

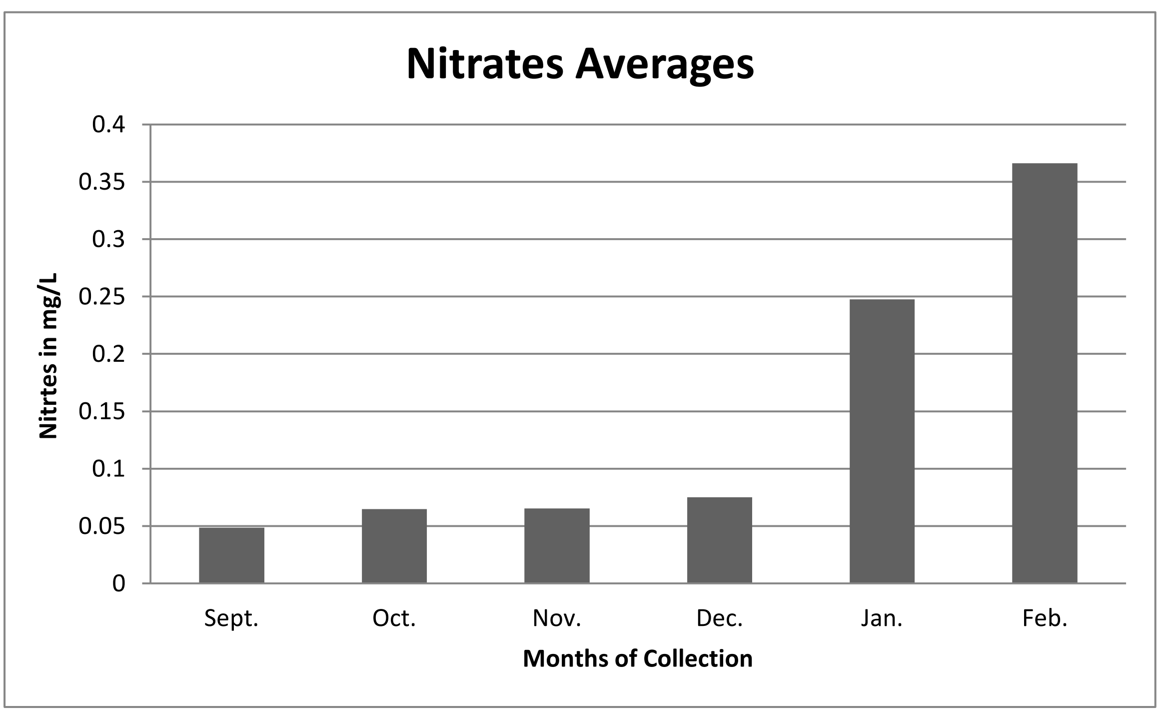


Table 1. Hydrology data collection site

Collection Site Name	Name of Body of Water	GPS Coordinates	County
A	Darby Creek	39°53'31.5"N 83°13'01.42"W	Franklin
B	Madison Lake	39°52'15.14"N 83°22'46.65"W	Madison
C	Deer Creek Lake	39°39'52.65"N 83°16'5.47"W	Fayette
D	Davis Ditch	39°42'32.99"N 83°13'41.46"W	Pickaway
E	Paint Creek	39°41'07.39"N 83°31'45.60"W	Fayette
F	Paint Creek	39°45'46.75"N 83°31'1.14"W	Madison
G	Gallbreath Ditch	39°45'30"N 83°19'20"W	Madison
H	Deer Creek	39°47'18.76"N 83°18'7.44"W	Madison
I	Mud Run	39°44'3.22"N 83°19'50.70"W	Madison
J	Walnut Run	39°50'N 83°23'W	Madison
K	Deer Creek Trib.	39°43'52.98"N 83°15'47.54"W	Madison
L	Deer Creek	39°37'11"N 83°12'43"W	Pickaway
M	Walnut Run	39°50'36.41"N 83°23'22.74"W	Madison
N	Rattlesnake Creek	39°43.955'N 83°36.79'W	Madison
O	Paint Creek	39°42'52.4"N 83°31'35.7"W	Madison
P	Bradford Creek	39°50'32.14"N 83°25'23.18"W	Madison

Table 2. Alkalinity data from collection sites
*all measurements in ppm

Collection Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
September	---	140	245	31	45	200	237	211.6	223	168	224	155	---	---	243	---
October	205	160	246	60	160	288	293	219	---	107	258	166	---	303	92	333
November	201	110	237	232	203	264	298	212.6	273	221	227	---	---	316	214	204
December	196	146	240	226	213	332	278	216	168	140	227	---	240	---	259	176
January	210	146	239	435	237.3	245	646	---	196.6	181.3	190.3	155	---	232	237.6	260
February	176	150	246	260	224	240	232	476	194	180	189	230	---	---	---	440

Table 3. Nitrate data from collection sites
*all measurements in mg/L

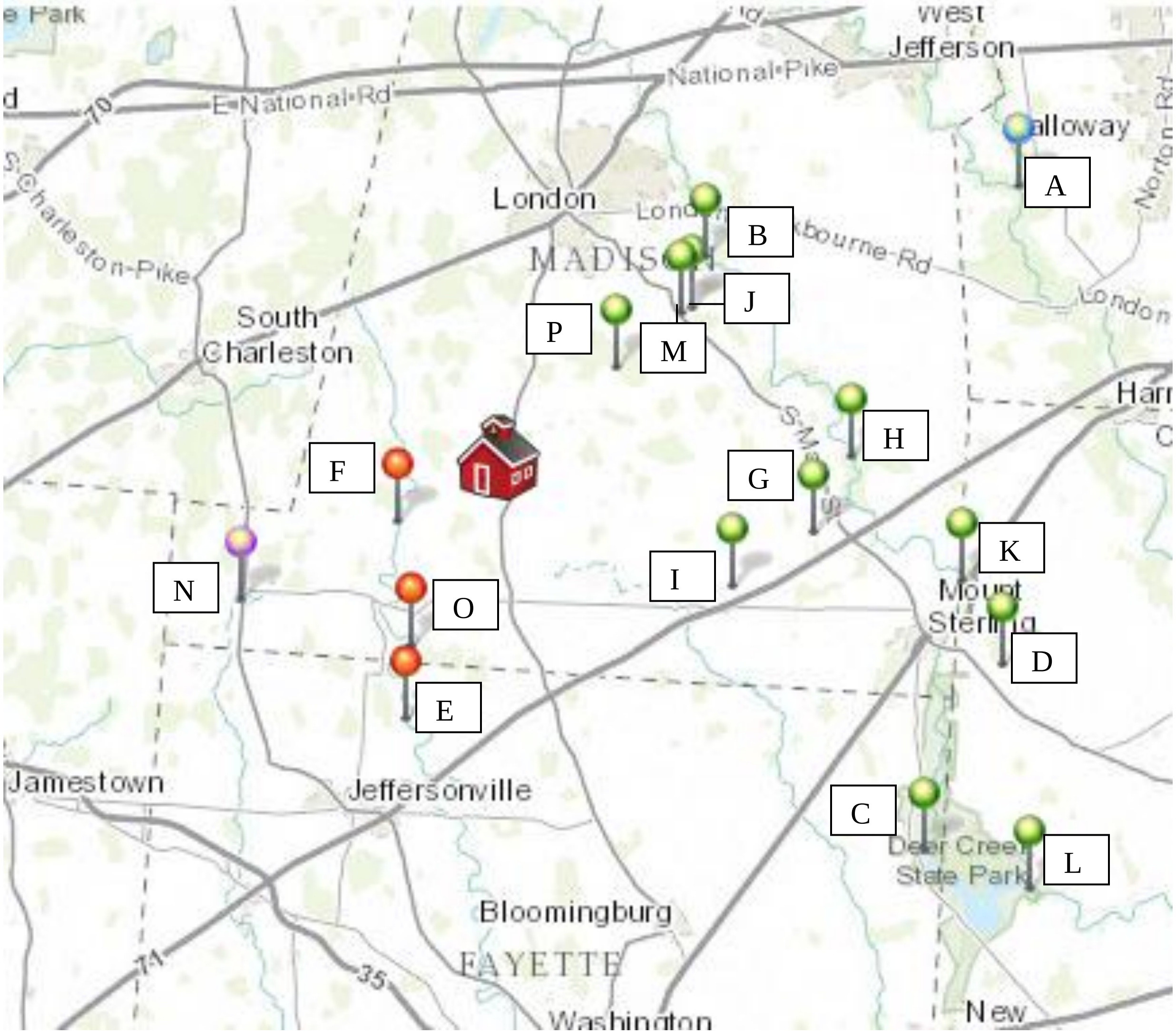
Collection Site	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
September	0	0	0	0	0	0	0	0	0.6	0.13	0	0			0	0
October	0	0	0	0	0	0	0	0.1	0	0	0	0	0	1	0	0
November	0	0	0	0	0	0	0	0	0	0.25	0	0	0	0.86	0	0
December	0.8	0	0	0	0	0	0	0.2	0	0	0	0	0		0.2	0
January	0.93	0	0	0	1	0	0		0	0.23	0	0.8	0	1	0	0
February	1	0.2	0		1	0	0.4	0.2	0.3	1	0.5	0.3	0		0.6	0

Table 4. Nitrate levels

*(Cleveland,2000)

Nitrate Levels (mg/L)	Condition
>.3 (mg/L)	Excellent
Between .3- .8 (mg/L)	Good
Between .8-2 (mg/L)	Fair
<2 (mg/L)	Poor

Figure 1. Map of Collection Sites



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