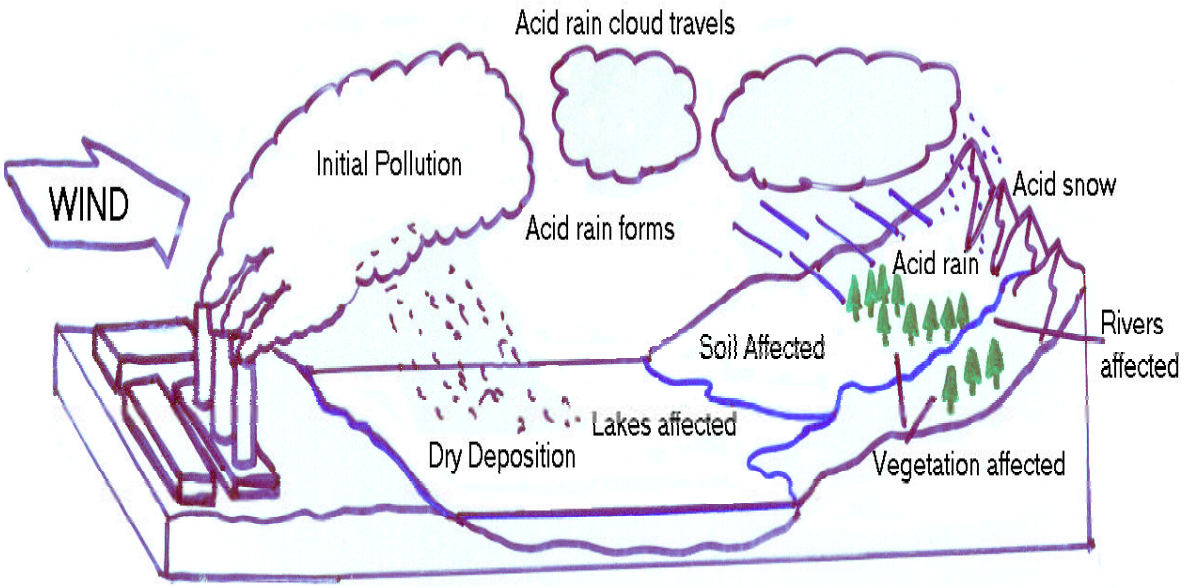

ACID DEPOSITION AND ITS EFFECTS ON STREAMS

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ABSTRACT

Acid deposition is a growing problem that affects many forms of life on Earth. Because of acid deposition, many species of plants and animals on Earth have been dangerously depleted (Miller, N. 2002). For that reason, this study was conducted to find out the effects of acid deposition on two streams and what characteristics help the stream to withstand these effects. Using LaMotte test kits, which are specially designed for use by high school students, the class conducted tests on the water, soil, and the riparian zone (including the bank, slope, and the canopy area) of the two streams. Also, macro organisms were collected in the two streams using d-nets. The results showed that the hypothesis, which stated that if the clay and/or calcium content in the soil is high then the water in the near by stream will be less affected by acid deposition, was supported. Some indicators of this were, the stream that had the higher calcium content and a longer, more gradual slope tested to be healthier, having a higher pH, pollution sensitive macro organisms and a more diverse canopy layer. From these results, it can be determined that a stream can withstand the effects of acid deposition according to the characteristics of the water and soil surrounding the stream. Some of these characteristics are high calcium content in the soil and water, and a large diversity of macro organisms and plants.

INTRODUCTION

The 10th grade class of RMSC 2002 will study the effects of acid deposition on the eco-systems of two particular streams and determine the characteristics, of each, that counteract the effects of acid deposition.

The byproducts of non- renewable energy contribute to acid deposition. Not all acid deposition is a result of emissions from fossil fuels, some occur naturally. Acid deposition is precipitation with a low pH.

Some of the reasons there is such a big need for energy in the United States is because of the population growth, and an increase in the amount of appliances available Non-renewable energy is basically what the world is living on today. Society of today is run by electricity which is mainly supplied by fossil fuels. Burning of these fossil fuels to produce the electricity causes harmful emissions. There is not a day that goes by that electricity is not used in life. The fossil fuel energy sources are being used up as quickly as ever. The electrical powerhouses that are considered our homes are causing more problems then may be realized; damaging the air we breathe and the ground we walk on. Harmful emissions from fossil fuels such as SO_2 (sulfur dioxide), NO_2(nitrite oxide), and CO_2 (carbon dioxide) are released into the air daily, because of the burning of fossil fuel that power homes, and come back down as acidic rain.

The vast majority of energy across the world comes from non renewable energy sources. Energy sources such as coal (which supports 51% of our energy needs), biomass (2%), nuclear (20%) and petroleum (3%) give off harmful gases and waste that raises the acidity of the rain and harmfully affects the ground and stream chemistry ("Producing," 2002). All of these resources will eventually run out. The non-renewable fossil fuels have many uses but many hazards as well. Some of the problems that come with using fossil fuels are the risk of a spill when it is being transported, and the constant concern that the fuels will run out. Other problems that come with fossil fuels are the acidic runoff and acid deposition when coal and oil are mined.

Oil is one of the main fossil fuels that the world depends on. Oil is a commonly used material because is it so easy to acquire and store ("Energy," 2001). Such catastrophes as the Exxon Valdez oil spill have happened as a result of mass amounts of these resources being transported. The Exxon Valdez was an oil tanker that crashed near Alaska spilling massive amounts of oil, severely damaging the surrounding environment. When oil spills, it lays on top of the water, stopping the oxygen from being dissolved, which suffocates all aquatic life.

Mining is also detrimental to the environment. In the process of mining for coal, dangerous chemical reactions are allowed to take place. The mining exposes underlying pyrite to water and oxygen causing them to react and to form sulfuric and nitric acid. This process is called acid mine drainage. This acid is then carried by water into near by streams, ruining ecosystems and making streams uninhabitable.

The burning of coal and other fossil fuels can be just as bad as the mining. The combustion of fossil fuels, from emissions from cars and factories, releases sulfur dioxide and nitrogen oxide into the air. These gases react with water/air/atmosphere causing acid deposition. Acid deposition is precipitation with a low pH. When sulfur dioxide (SO_2) reacts with water (H_2O), it creates sulfurous acid (H_2SO_3):

$$SO_2 + H_2O \rightarrow H_2SO_3$$

Sulfuric acid can also be created when sulfur dioxide reacts with oxygen (O_2):

$$SO_2 + \tfrac{1}{2}\, O_2 \rightarrow SO_3 + H_2SO_4$$

Nitrogen oxide (NO) reacts with oxygen (O_2) to form nitrogen dioxide (NO_2):

$$NO + \tfrac{1}{2}\, O_2 \rightarrow NO_2$$

When two nitrogen dioxide (NO_2) molecules react with water (H_2O), it forms nitric acid (HNO_3) and nitrous acid (HNO_2):

$$2NO_2 + H_2O \rightarrow HNO_2 + HNO_3$$

Also, nitrogen dioxide (NO_2) can act in response with hydrogen (OH) to create nitric acid (HNO_3):

$$NO_2 + OH \rightarrow HNO_3$$

There are several ways acid deposition is naturally counteracted by the environment. These things are called buffers. Buffers help neutralize the affects of acid deposition. A riparian bank with high calcium content is an excellent buffer. Calcium is commonly found in lime stone and is used in acid mine drainage projects to help stabilize the pH of water to make it habitable, the same reaction would occur with acid deposition. The chemical reaction that makes this possible is:

$$CaCO_3 + 2H^+ \rightarrow Ca^{+2} + CO_2 + H_2O$$

Another good buffer is clay. Clay has filtering properties that can filter out acid by their negatively charged atoms .These atoms attract the positively charged free hydrogen atoms in the acidic rain and bond with them and keep them in the soil, therefore delaying them from entering the stream. The slope of the riparian bank also plays a definite role in helping stop acidic runoff from going into a stream. A gradual slope covered with trees will slow down the rate of acidic rain entering the stream. This gradual slope will also help in filtering out some of the pollutants. It will also allow time for the acid to bond with the soil and for the acid to be absorbed by the plants.

Based on the chemical properties of soil and clay the hypotheses were formed. The first hypothesis is that if the clay and/or calcium content in the soil is high then the water in the near by stream will be less affected by acid deposition. The second hypothesis is that if the canopy layer (trees/plant life) is diverse and/or the slope is gradual then the stream will be protected against acid deposition.

METHODS

This study was conducted at two sites: North Glade Run and South Branch Bear Creek. The instructor did previous research to determine that there was a biological and chemical difference between the two streams. The maps used to choose the sites were the Soil survey of Garrett County, Maryland, and the Maryland and Delaware Atlas and Gazetteer. The information obtained from these was that the soil types were different and that the canopy was vegetated well at one stream and not at the other. With the information that was given from these resources, the prediction was made that the streams would differ in the test results.

For example, there was a significant difference in the soils and forested areas of each place. Also, neither site was near an acid mine drainage site. A closeness to an acid mine site would cause our testing to be off, because it would add sulfur to the water and lower the pH level.

There were three main testing areas at each site: the soil, the canopy layer, and the water. Each area is affected differently by the acid deposition. Most of the tests done on the soil were also done on the water to help to determine the correlation between the soil

and the water. The pH, calcium, and aluminum tests were done on the soil and water. The hardness, sulfate, and nitrogen were done only on the water.

There were two testing days, July 2, 2002 and July 10, 2002. During both days, the tests were taken between 11:00am and 3:00pm.

The canopy layer is the amount of vegetation that grows along the edge of the bank of a creek such as trees, bushes, and flowers. The more variety of vegetation the better, it holds the dirt in place more sufficiently. The plants also leave the soil healthier because plants absorb the CO_2, and replace it with oxygen, which is good for the stream and soil. Another good asset of having a well developed canopy layer is that when the leaves fall they will decompose and all the nutrients and other organic materials go into the soil. The canopy diversity was recorded using the Plant Identification book, Flora of West Virginia (Stausbaugh, Core, 1977).

The riparian zone is best suited to counteract acid deposition if the slope is long and gradual. A short steep bank will allow the water to run straight into the stream, not giving the soil a chance to soak up the water. The slope was measured using clinometers, a type of compass, (Suunto, made in Finland). By standing at the top of the bank, aligning the first hole with one eye, then lining the black line with the hole, finally align the black line with the sight, looking through the sight align every thing with a person's (of similar height) eyes that are at the bottom of the bank, and read the angle of degree.

The characteristics tested for the soil were the pH, calcium, aluminum, and the composition of the soil, including the amount of sand, silt and clay. The pH test, model ED-12, calcium test model AM-32, and aluminum test model AM-32, all were LaMotte Macronutrient test kits.

The qualities tested for the water were the pH, the amount of sulfate, calcium, aluminum, total hardness, the temperature, and the macro organisms. All of the chemical tests that were taken are LaMotte Water Quality Monitoring Outfit. The pH test, code 5858, nitrate, code3354, sulfur, model PSAT code 7778, the aluminum, model AL-2 code 3569, and calcium and hardness were combined in to one test kit, model PHT-CM-DR-LT code 4824-DR-LI. A regular water thermometer was use to take the temperature. The LaMotte test kit was chosen because they are specifically selected to meet the classes' needs. The LaMotte testing kits also have a good reputation. They were made for high school students, are easily transported, and provide instant results.

The pH test was done on the soil because acid deposition would cause the soil's acidity level to lower; it was also done on the water for the same reasoning. The calcium level was taken in the soil and water because calcium would raise the pH by a chemical reaction with the hydrogen atoms, acting as a buffer. The aluminum test in the soil was done to find out how much of the aluminum was in the soil. If acid deposition flows into the ground it can pick up the aluminum and deposit it into the stream (Brook Trout). High aluminum levels found in the water will kill the organisms; this could cause the results in gathering macro organisms to be incorrect. Also aluminum is an indicator of a low pH. The composition of the soil was measured to determine how much clay, silt, and sand is in the soil. If a lot of clay was found then the soil would have better buffering abilities. Sulfates were measured because the sulfates react with water, oxygen, and sunlight to form sulfuric acid. Nitrates, which make nitric acid, were measured for the same reason as the sulfates. The total hardness was taken to determine the buffering ability of the

water. The hardness of the water is mainly caused by the amount of calcium and magnesium found in the water, which are buffers.

D-nets were used to collect the macro organisms. By putting the d-nets on the bottom of the stream, in a riffle area, facing up stream, and stirring and turning the bottom, the macro organisms are swept into the net by the current. Then searching and separating the organisms begins. As they were separated from the dirt and mud, they were identified using booklets with pictures and descriptions (Walton, 2000). The different kinds, size and quantity was recorded.

The macro organisms were recorded because some of the organisms are more sensitive to acid deposition and would show how healthy the stream is by the diversity and the amount found. The temperature of the water was taken to reassure that it would have no effect of the findings of the macro organisms and the tests done on the minerals. If the water temperature is higher more of the minerals would be dissolved then if the water was colder. Also more oxygen can be dissolved in cooler temperatures, thus helping the macro organisms. The canopy was observed because a lot of different plants would mean different nutrients would be taken out and added into the soil, this would allow more plant to grow giving the bank an healthier variety. The roots of the plants would hold the bank in place and stop it from eroding. The plants would also soak some of the acid deposition up through their roots, making it more difficult for the acid deposition to reach the stream through the ground.

These tests helped determine the effects of acid deposition on the stream, and how the streams characteristics help to counter act the effects of the acid deposition.

RESULTS

North Glade Run was tested on July 2, 2002 at 10:55am. The water temperature was 20° C, and the weather was hot, humid, and hazy. The only plants that flourished were weeds, which provide no shade. South Branch Bear Creek was also visited on July 2nd at 1:30 pm. The water temperature was 23° C, while the weather was hot and humid, yet the canopy layer made it feel cooler due to the shade it provided.

The streams were tested again on July 10, 2002. The water at North Glade Run was 22° C, and the weather was overcast, cool, and rainy at times. There was a larger body of water and the water was murky. South Branch Bear Creek was tested at 1:00pm. It was overcast and beginning to rain. The water temperature was 18° C, and there was more rock in the soil than at North Glade Run.

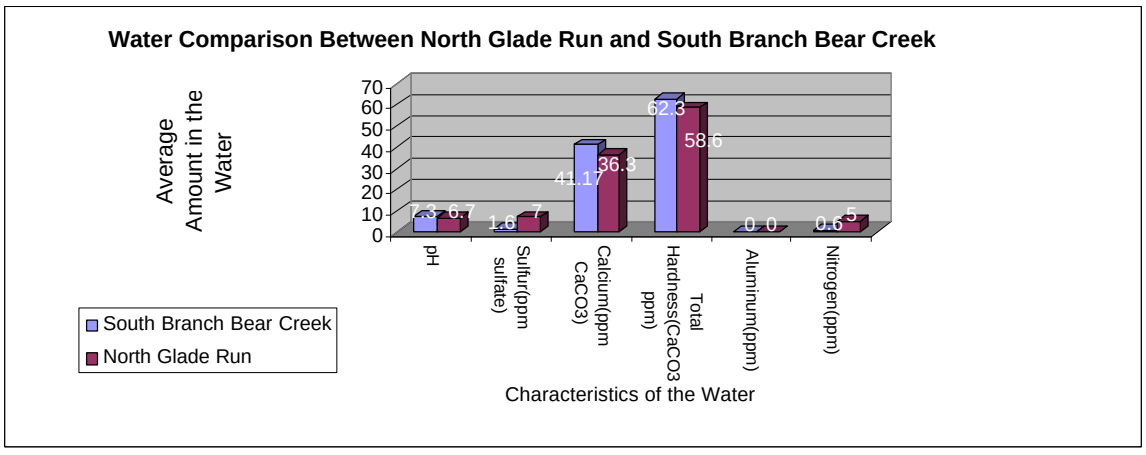

Fig. 1. – This figure shows the difference of water quality between the two streams.

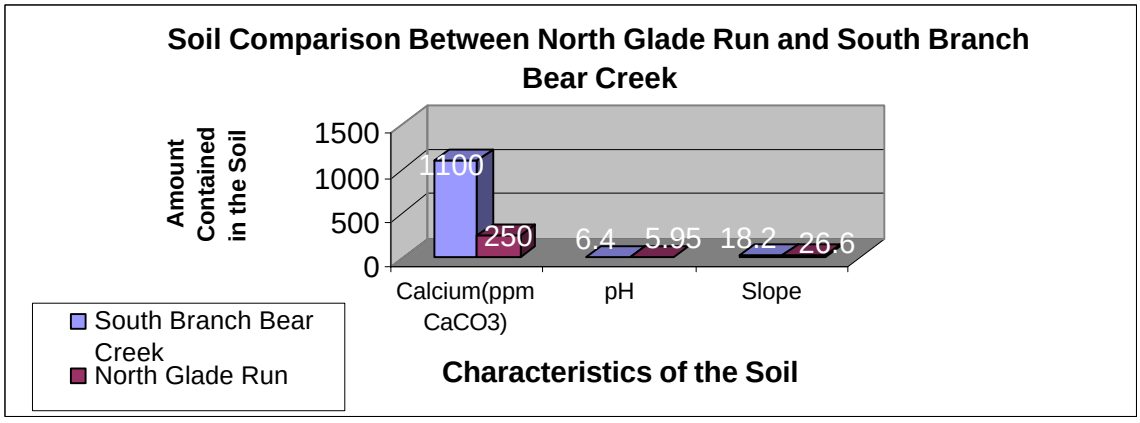

Fig. 2. – This figure shows the difference between the soil at South Branch Bear Creek and the soil at North Glade Run.

Due to the data collected, there are some obvious differences between the water and soil at each site. The water at South Branch Bear Creek contained more calcium, and had a higher total hardness. The soil at South Branch Bear Creek also contained more calcium than that at North Glade Run. North Glade Run on the other hand, had more nitrogen and sulfur in the water than South Branch Bear Creek. The water and soil at both creeks, however, had a healthy pH level.

The physical attributes of both streams varied considerably. North Glade Run's riparian bank was narrower, less gradual, and had a less diverse canopy layer than that of South Branch Bear Creek. It was also observed that there were more rocks lining the creek bed at South Branch Bear Creek than at North Glade Run. This is important because the rocks slow down water movement and allow the filtration process more time to occur. The clay, silt and sand content of the soil were tested; however, the results were inconclusive because the tests did not show a significant difference between the two streams.

Table 1. – tree identification

	South Branch Bear Creek	North Glade Run
Different Types of Trees	Hemlock Rhodendron Yellow Birch White Ash Shagbark Hickory Sugar Maple Witch Hazel Black Willow Beach Tree Red Maple Red Oak Black Locust	Alnus Rugosa (Alder Tree) Cherry Tree Bushes Weeds

Table 2. – the classifications of macro organisms found at South Branch Bear Creek

Date	Class 1			Class 2			Class 3		
	Quantity	Name	Average Size	Quantity	Name	Average Size	Quantity	Name	Average Size
July 2, 2002	***NA***	***Mayfly***	***NA***	***NA***	***Crane (True) fly***	***NA***	***NA***	***Aquatic worm***	***NA***
	NA	***Stonefly***	***NA***	***NA***	***Damselfly***	***NA***			
	NA	***Stick bug***	***NA***	***NA***	***Crayfish***	***NA***	***NA***	***Red worm***	***NA***
	NA	***Water penny***	***NA***						
July 10, 2002	***6***	***Mayfly***	***½ cm***	***7***	***Crane (True) fly***	***NA***	***2***	***Aquatic Worm***	***NA***
	8	***Stonefly***	***¾ cm***						
	10	***Caddis fly***	***NA***	***4***	***Crayfish***	***5 cm***			

Table 3. – the classifications of the macro organisms found at North Glade Run

Date	Class 1			Class 2			Class 3		
	Quantity	Name	Average Size	Quantity	Name	Average Size	Quantity	Name	Average Size
July 2, 2002	***2***	***Stonefly***	***NA***	***NA***	***Crane (True) Fly***	***NA***	***NA***	***Aquatic Worm***	***NA***
				NA	***Cray-fish***	***NA***			
	2	***Mayfly***	***NA***	***NA***	***Dragon-fly***	***NA***	***NA***	***Water Beetle***	***NA***
				NA	***Dragon-fly larva***	***NA***			
July 10, 2002	***3***	***Baby Dobson-fly***	***1 cm***	***1***	***Dragon-fly***	***4 ½ cm***	***2***	***Aquatic Worms***	***2 cm***
	2	***Caddis-fly***	***$^5/_8$ cm***	***1***	***Beetle Larva***	***3 cm***	***1***	***Red Worm***	***1 cm***
	1	***Stonefly***	***NA***	***2***	***Crane (True) fly***	***3 ½ cm***	***1***	***Black fly***	***NA***
	2	***Mayfly***	***NA***	***1***	***Alder-fly***	***2 cm***			

It was found that South Branch Bear Creek had a more abundant biological system than that of North Glade Run. On the second day, 37 different macro organisms were collect at South Branch Bear Creek. However, these macro organisms only varied between 15 different species. North Glade Run did not have as many macro organisms, yet they were more diverse. There were 19 different species of macro organisms at North Glade Run but only 17 macro organisms were collected on the second day. Also, a higher percentage of the macro organisms that were collected at South Branch Bear Creek were classified as the most sensitive (class 1). At South Branch Bear Creek, 24 of the 37 macro organisms collected were class one. Only 7 of the 19 total macro organisms collected at North Glade Run were class one macro organisms.

CONCLUSION AND DISCUSSIONS

All of the data presented in this report appears to accept our hypotheses. When looking at South Branch Bear Creek, It easy to see that South Branch Bear Creek has high calcium level in both the soil and in the water so it will be able to buffer more than what a stream with a low calcium level will do. This goes with the hypotheses created that if the calcium and/or clay levels of the stream are low then the stream water will be less affected by acid deposition. At South Branch Bear Creek, the pH was higher, the stream water looked cleaner, and there was more plant life around the area. Also at South Branch Bear Creek there was a good diversity of macro organisms. The quantity and size were both found to be larger than North Glade Run. Quantity and size are both indicators of less pollution in this particular stream. This may be because of the amount of calcium as just mentioned. The soil test from both of these test sites also helped to support our hypothesis. Each of the soil samples was tested for pH, calcium, and aluminum. The sample was also tested for composition but the results from these tests were not clear; hence no conclusions could be drawn about the composition of the soil. However, the information obtained about the calcium and the pH of the soil related directly to the hypothesis because as previously stated South Branch Bear Creek had higher calcium levels and the average pH of this stream was very close to 7.The second hypothesis is that if there is a long, gradual slope and a diverse canopy area then the surrounding stream will be healthier. The stream at South Branch Bear Creek was healthier than North Glade Run because it had a larger diversity of plants and sensitive macro organisms plus the slope of the bank was more gradual than North Glade Run. Another factor that supports this hypothesis is that the pH of the stream at South Branch Bear Creek was closer to

neutral than North Glade Run. Therefore, the hypothesis is supported because the over all, the environment was better at South Branch Bear Creek.

The 1st hypothesis was if the clay content and/or calcium content in the soil are high, then the stream water will be less affected by acid deposition. The other hypothesis tested was that if there is a long, gradual slope and a diverse canopy area then the stream will be healthier, having a low acidity level. According to the final result obtained from all of the tests for both streams, both of our hypotheses were accepted and this information also indicated that South Branch Bear Creek was the healthier stream.

The weather was cool because there was a lot of shade from the canopy layer. By this time the overcast had cleared. The second time we visited North Glade Run there were a lot of obvious visual differences due to the rainfall from the previous week. The weeds had grown taller and the water flow was much stronger. At South Branch Bear Creek, the water flow had also risen and the vegetation showed signs of much growth.

Figure 1 compares the average water test result for the two streams. One could see that South Branch Bear Creek had lower levels of nitrogen and sulfur in the water but the amount of aluminum was the same as the amount in the stream water at North Glade Run. The level of total hardness was higher at South Branch Bear Creek also. The total hardness measures the amounts of calcium and magnesium and other heavy metals in the water. These two elements can act as buffers to aid in neutralizing the pH of the stream water. Calcium is one of the more common buffers and it was found in greater numbers at South Branch Bear Creek.

Another important test performed was the macro organisms test. The results for this test were recorded in tables 4 and 5. At North Glade Run, several class 1 organisms were found but they appeared to be young. This indicates that they are dying before they have a chance to fully mature. At South Branch Bear Creek however, the macro organisms were found in a greater abundance and they were mature indicating that these organisms had time to fully mature.

Due to the fact that the streams were only tested twice, several limitations arose. When all of the test results were finally available, one could see that some of the test results had varied slightly and for that reason it was hard to determine the normal levels at which the streams should be. The weather also posed a problem; the first day of testing it had not rained in weeks so the streams were very low. A day before the second day of testing there was heavy rain and on the day of testing it was still drizzling slightly outside. This could have posed a chance of somehow affecting the water and the soil of the two streams. Another limitation is that currently, the state of Maryland is under drought alert and this most likely affected the water level of both of the streams, which could have had an influence on many of the water tests. Another limitation is the precision the tests kits, some were color coordinated and it was hard to make a decision on to which the reading actually was. Time is also another limitation because further in depth studies could have been done if time could have been extended. Only two locations were selected and this could pose as a limitation because more results could be compared if there would have been more sites to test.

Several questions have arisen from this study including how the amount of precipitation affects the stream. Another question raised could be had Maryland not been in a drought, how would the test results vary? Several other questions could also be raised from these studies such as what other minerals in the water act like buffers, and what other type of chemicals are in the water that may kill macro organisms besides acid deposition?

To improve the accuracy and precision of the many tests performed, several changes could have been made to the experimental setup. The two sites should have been tested more times because the more times the test are performed, the more precise the results will be, and there will be more data to compare and draw conclusion from. There could have also been more sites to test so that there could have been a significant difference in the test results. This way the class could have fully identified the effects of acid deposition on a stream not able to withstand those effects. Also more time should have been available to us to fully develop the experiment and study the streams. If the study could have been performed over the course of a full year, the information available would be better to determine the quality of the stream in relationship to acid deposition. Another change that could be made to the experimental design is the reading charts of the test kits could have been more exact. Some tests kits contained number ranges as readings and others just had an indicator that ranged from very high to very low. The color indicators made it difficult to get a reading, especially when the result was in between two different colors. These vague results caused problems when time came to graph them because the perception of each result varied from student to student.

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