Research done by Emily Gates, Justine Li, Cori Salmeron, and Beth Siwinski.

The Effects of Water on the Different Components of the Nitrogen Cycle

Abstract

The nitrogen cycle is dependent upon three chemicals; ammonia, nitrite, and nitrate. The levels of these chemicals can make the nitrogen cycle either strong or weak. Many different factors affect the levels of ammonia, nitrite, and nitrate but in our experiment we controlled for the amount of water to see how it affected the chemicals. In our experiment we controlled for the amount of water be measuring the amount of water in each site and then adding water to each site making the amount of water relatively equal in all three sites. By balancing the amount of water we aimed to see if water influences the levels of nitrate, nitrite and ammonia; thus affecting the health of the nitrogen cycle. Our first trial proved our hypothesis because water affected nitrogen in the predicted ways. However in our second trial external forces invalidated the control and our experiment results were thus unsupportive of our hypothesis. In the second trial the soil was dried out in all three sites, and when we added water to the sites it only returned the water levels to the original levels before the addition of water. Therefore our hypothesis was proved in the first trial but as a result of the changes in the environmental conditions of the experiment it was not proved in the second trial.

Introduction

Observing that there were significant differences in the ammonia, nitrate, and nitrite levels in the original biota survey, while there were no significant differences in the bacteria levels, this became a topic of interest for our research experiment. We discussed the differences in each of the three sites (Site 2: N 39.35740; W 076.63893, Site 3: N 39.35797; W 076.62836, Site 4: N 39.35733; W 076.63840) and noticed that there was a significant difference in water levels among the three sites. Looking at the actual sites, one could understand why there was such a difference. Site 2 is located right behind a dam from a stream, it is covered in English Ivy and very steep with a large tree canopy. Site 3 is also located on a hill with a large area of rhododendron bushes and is a very rocky area with the stream running through the middle of it. Finally, Site 4 is a filled-in pond that is very swampy and muddy without much of a tree canopy to shield out the sun. After reviewing the data collected from the biota surveys we found that there were discrepancies in the levels of ammonia, nitrate and nitrite (E.S.S.R.E. 2003). (The highlighted p-values are the ones that are statically significant for researching purposes. Since the differences are so significant, we thought it would be interesting to find out what was it that made the data so different in the different areas.

	Site	t	p
Bacteria	2 vs 3	8.0258	6.306E-08
	2 vs 4	4.8465	0.00015692
	3 vs 4	0.177043	0.86175
Ammonia	2 vs 3	1.43056	0.1803429
	2 vs 4	1.483239	0.1660868
	3 vs 4	0.228325	0.821573
Nitrite	2 vs 3	same data	1
	2 vs 4	4.69041	0.00066031
	3 vs 4	4.69041	0.00066031
Nitrate	2 vs 3	2.1612002	0.05087132
	2 vs 4	1.4440584	0.17099822
	3 vs 4	0.9413131	0.35792414

These chemicals are components of the nitrogen cycle and because they had unusual levels in the biota survey (see chart above), we were interested in finding out the cause of the odd numbers. We developed this experiment to further inspect the causes of the abnormal ammonia, nitrate and nitrite levels. The nitrogen cycle is a process by which organic nitrogen is converted into inorganic nitrogen, which is the only type of nitrogen that can be used by plants and microorganisms. Nitrogen is a predominate part of the environment, making up approximately 78.03% of the atmosphere. Although this element is useful to many organisms, only some bacteria can fixate nitrogen, turning nitrogen into different forms, which other organisms and plants can use. Eventually, plants and organisms die, and are decomposed by the bacteria, the nitrogen becomes ammonia. The plants absorb some of the ammonia, leaving the rest to the microorganisms to turn the ammonia into nitrite and nitrate (Microsoft® Encarta® Online Encyclopedia, 2003).

Seeing that the chemicals in the nitrogen cycle were not normal (there was no positive correlation between bacteria population and nitrate, nitrite, and ammonia levels), this consequently became our research topic. Since this pattern seemed highly irregular, we decided to base our research on the patterns of the nitrogen cycle.

Ammonia, nitrate, and nitrite have a distinct relationship with each other and with the bacteria counts. When ammonia levels are high, the nitrite levels are also high, while the nitrate levels are low. When nitrate levels are high, the other two chemicals should be in low levels in the soil. When the bacteria counts are high, the nitrate should also be high because of the amount of bacteria converting ammonia and nitrite into nitrate. These specific relationships between these four variables are what define the nitrogen cycle and are very important to understanding our results.

Methods

The effects of water on the nitrogen cycle was an easier experiment to control for than if the experiment was based on the effects of sunlight. We also thought that water would have more of an effect on the cycle than sunlight, being that water affects most everything it touches. Our experiment is not the direct effect of water on the nitrogen cycle, but rather the effect of water on the microorganisms' ability to continue the nitrogen cycle. Since the bacteria levels were pretty regular between the sites, we did not have to alter the bacteria levels. We also had to control the amount of decomposing material, so we cleared the plots of vegetation. To control the amount of sunlight, we tacked down a 20cm by 20cm piece of black plastic bag to block out the sunlight. We took soil samples from each of the sites and after dehydrating them we found the amount of water that we needed to use in our experiment. We then took a 15 cm deep and 2 cm wide soil sample from each of plot to have the "before water" samples taken. We chose to match the water levels in all three sites by adding water to Site 2 and Site 3 to make them equal to the original amount of water in Site 4. Afterwards, in the first and second quadrats of Site 2 we added 2.712 liters, and in the first and fourth quadrats of Site 3 we added 2.928 liters (both measurements of water being developed based on the differences in the original amount of water between Sites 2 and 3 and the first and fourth quadrats of Site 4) and tacking down the plastic bag, we left the experiment outside for 24 hours, leaving the bacteria population enough time to cope with the altered environment. During those 24 hours, we tested all 15 "before water" samples for nitrate, nitrite, and ammonia, and did the serial dilutions to count the bacteria three days later. After the 24 hours, we all went out to take an "after water" sample from each of the 15 sample plots. We then performed extractions on all of the 15 soil samples and we tested the samples for nitrite, nitrate and ammonia in addition to creating petrifilm sheets for count bacteria.

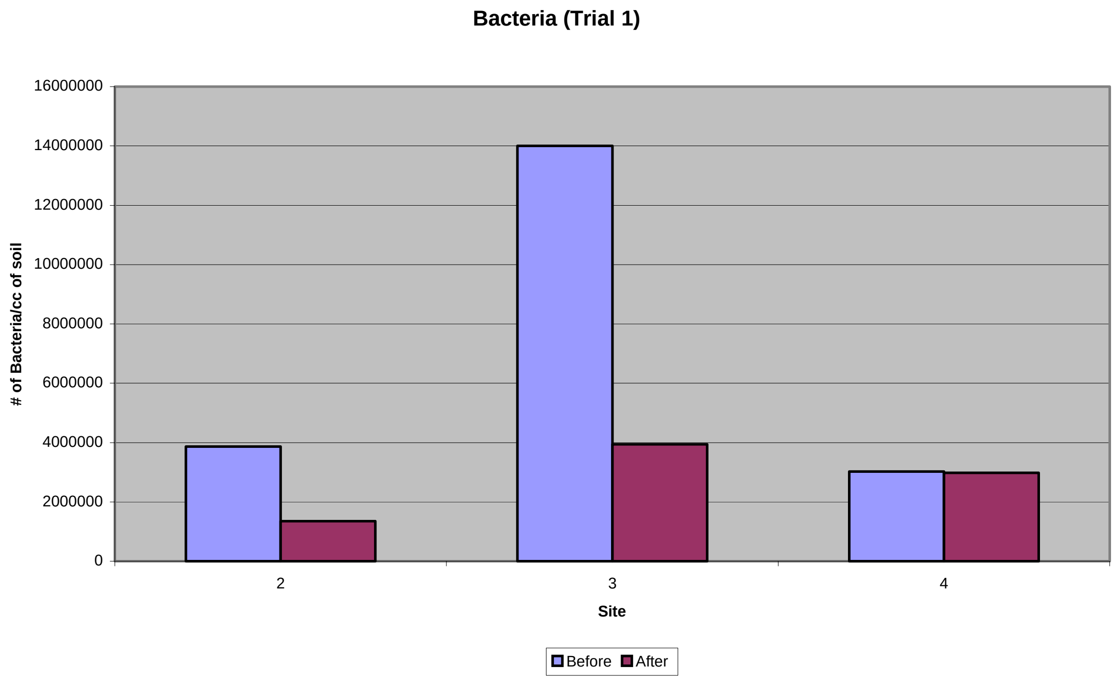
Discussion & Results

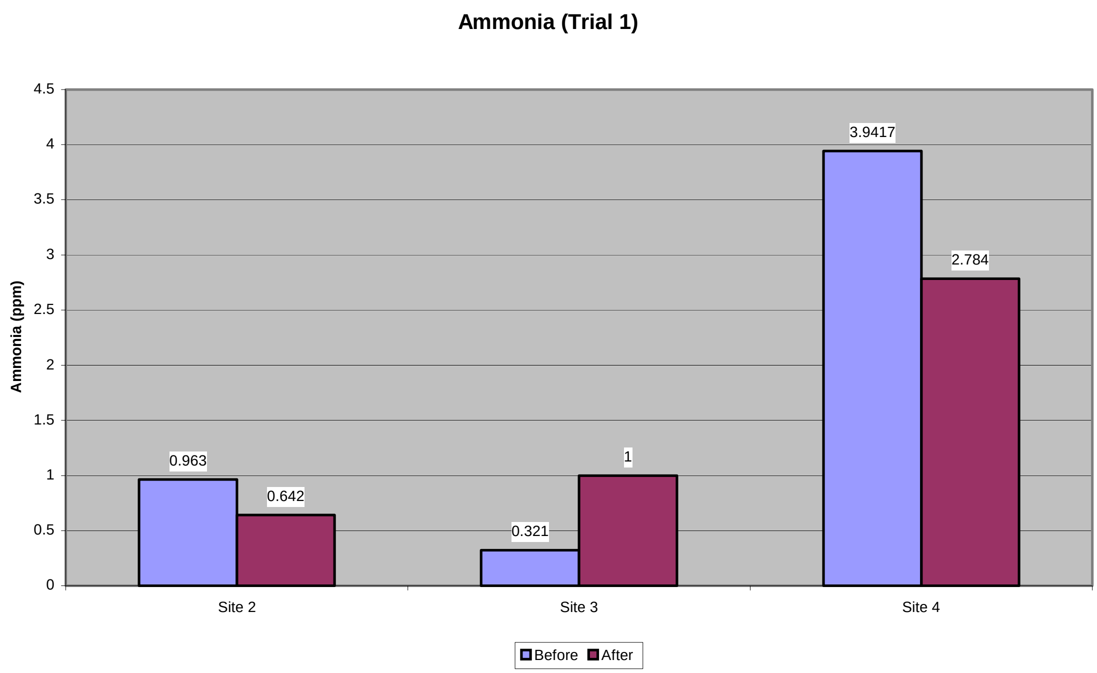
After analyzing our data in both trials, we can observe many patterns. As research has shown, as NH_3 and NO_2^- levels rise, NO_3^- levels decrease; and the reverse is true. In Trial 1, we can see that the pattern exists where after adding water, the NH_3 and NO_2^- levels increased as NO_3^- decreased in our experimental sites (Site 2 and Site 3). Our control site was Site 4, where all values, including bacteria levels, stayed relatively the same through Trial 1. There were major changes in bacteria population in Trial 1. Statistically speaking, we have proof that our hypothesis is true for Site 3 (there was no significance in any of the components of the nitrogen cycle, which was expected).

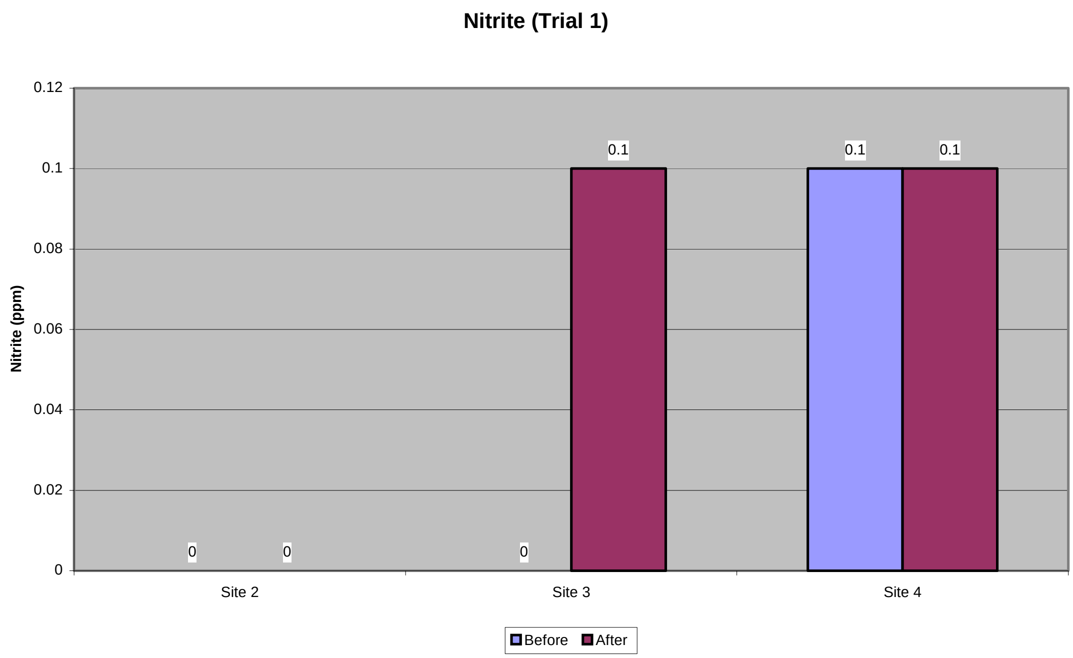
Initial vs Experimental

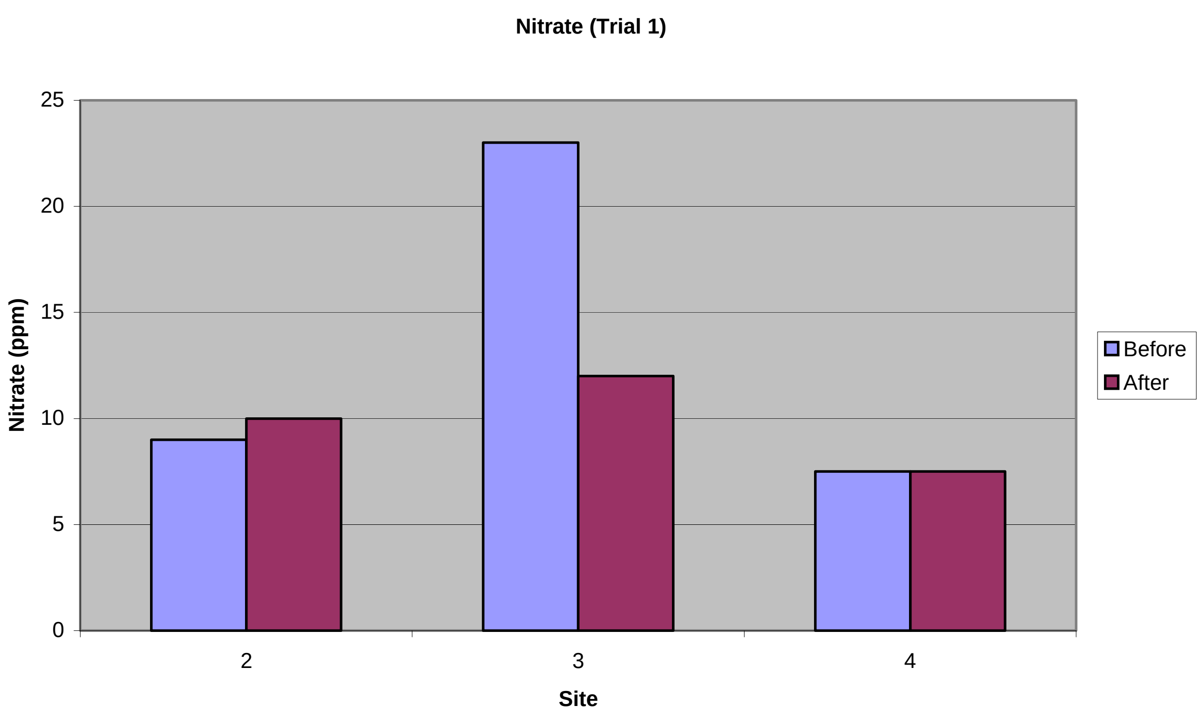
		Bacteria		Ammonia		Nitrite		Nitrate	
Site	Trial	t	p	T	p	t	p	T	p
2	1	1.4261	0.2202	1.2649	0.2429	no significance		0.4923	0.6357
	2	0.7717	0.48124	1	0.3739	no significance		1.5	0.1743
3	1	1.2119	0.2882	0.6465	0.5475	1	0.3739	1.072	0.3367
	2	2.4737	0.05921	no significance		no significance		0.4665	0.6616
4	1	0.033	0.975	0.7253	0.498	0	1	No significance	
	2	2.4742	0.06787	0.7351	0.4964	no significance		1.1094	0.3175

However, although we come near to proving it as well for Site 2, the numbers did not change enough to be considered proof for our hypothesis.





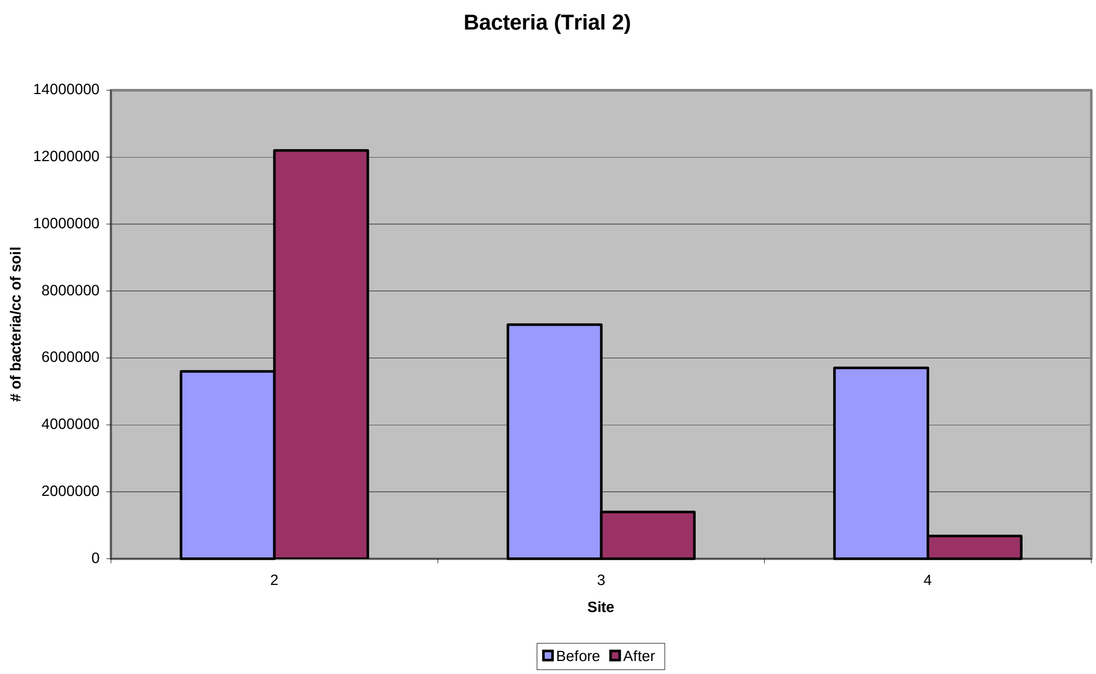


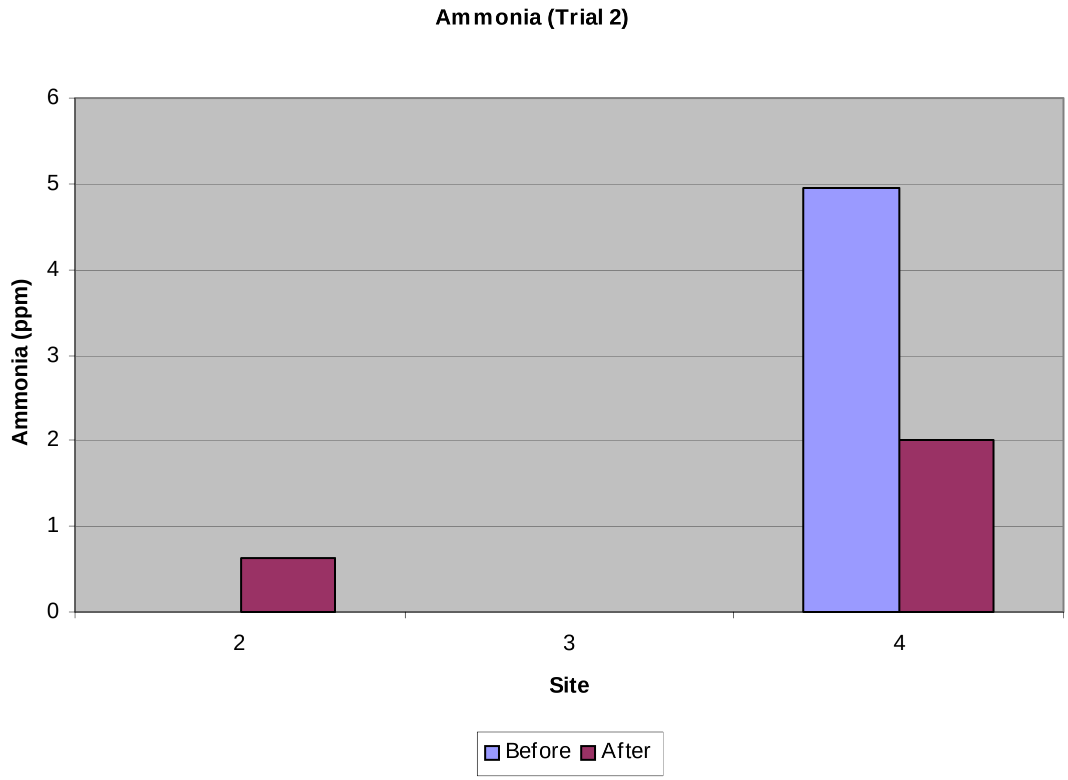


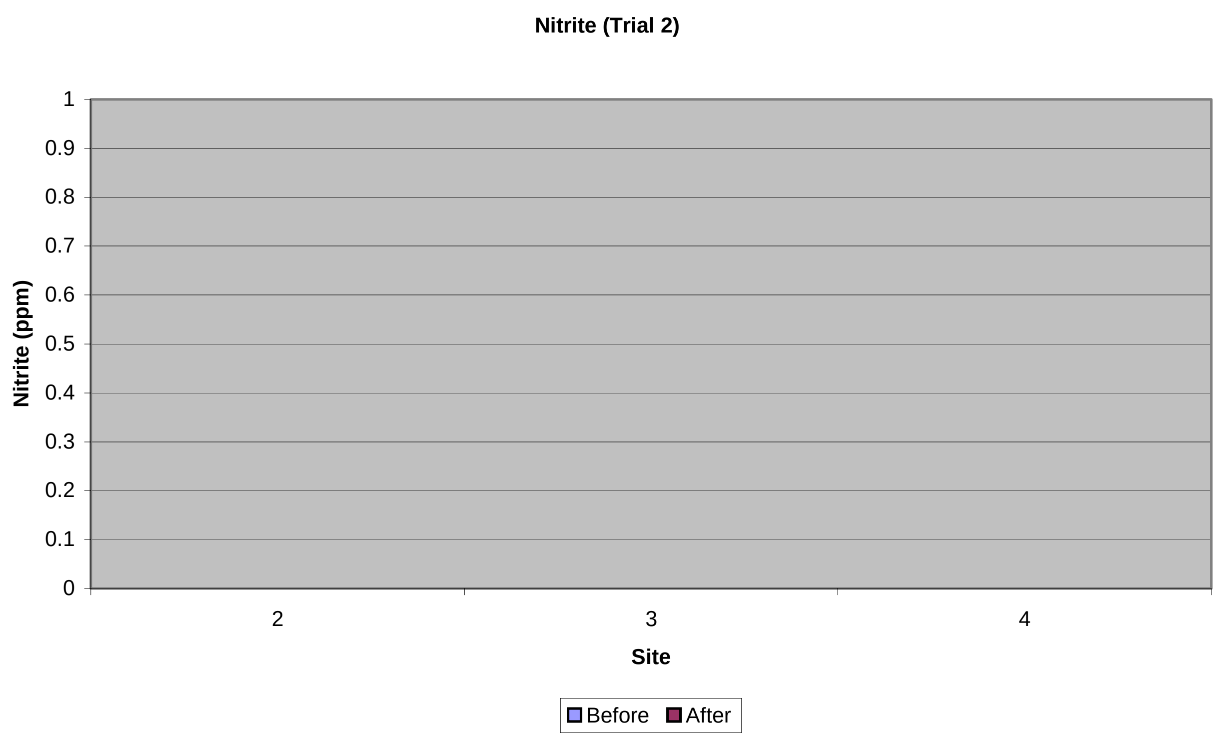
Seeing Site 2, Trial 2, Sample 1, "Initial" raw data, we can observe this normal nitrogen pattern that is not observed during the first trial.

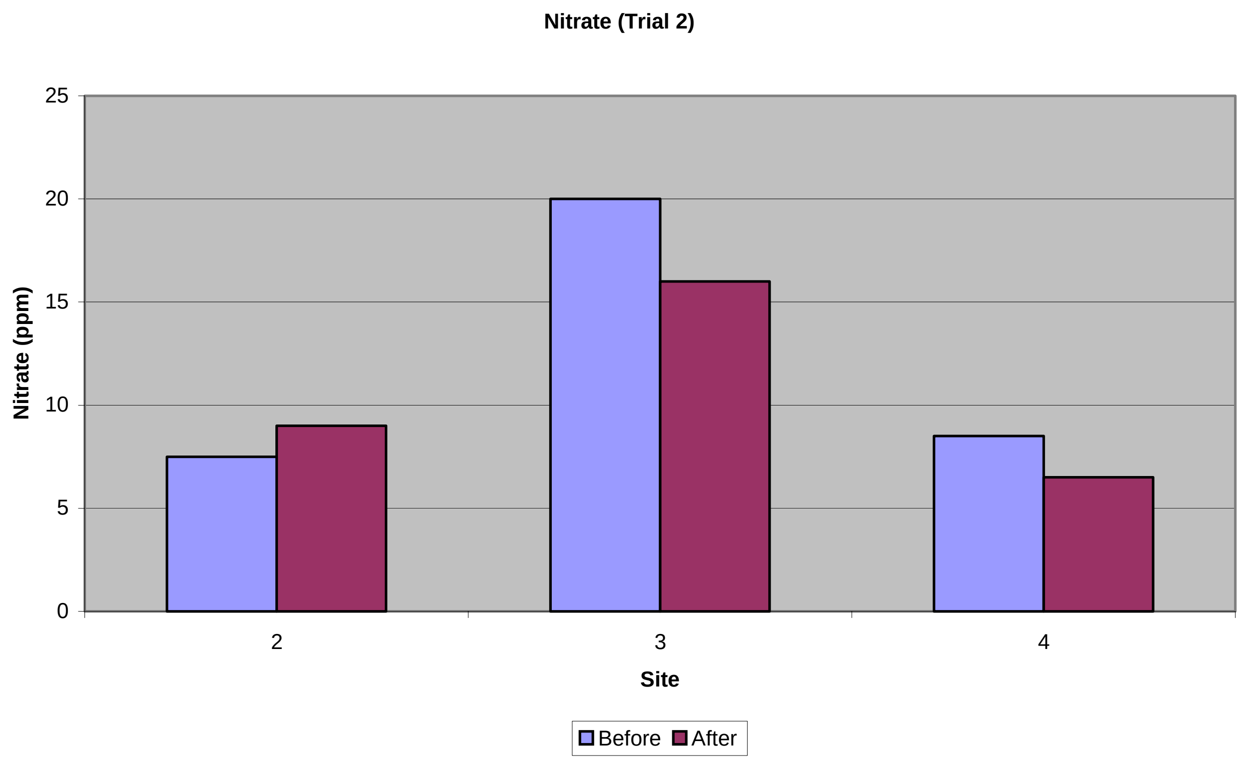
			Bacteria		Ammonia		Nitrite		Nitrate	
	Trial	Sample	Before	After	Before	After	Before	After	Before	After
Site 2	2	1	1000000	45000000	0	3.21	0	0	10	7.5
		2	7000000	700000	0	0	0	0	5	10
		3	4000000	3100000	0	0	0	0	7.5	10
		4	9000000	12000000	0	0	0	0	7.5	7.5
		5	7000000	300000	0	0	0	0	7.5	10
		Average	5600000	12220000	0	0.642	0	0	7.5	9

Also, we can observe that the nitrogen levels in Site 3 for Trial 2 that the nitrogen cycle is normal; as NH_3 and NO_2^- stay the same, NO_3^- stays pretty much the same as well.




Ammonia (Trial 2)
Ammonia (ppm)
6
5
4
3
2
1
0
2
3
4
Site
Before
After


Nitrite (Trial 2)
Nitrite (ppm)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2
3
4
Site
Before
After



Our graphs can validate Site 3 data, but we cannot completely consider this data to be valid due to the change in our control, Site 4. There were dramatic changes in all Site 4 data for Trial 2.

Conclusion

From our data, we can conclude that our hypothesis was correct, seeing that all of the data confirmed our hypothesis. Trial 1 confirmed our data, although we it was not proven. Trial 2 aided in validating our hypothesis further, due to the experimental change between trials for Site 2. However, this could possibly be the result of the environmental changes over the course of our two trials.

Site 4 used to be a pond, which was filled several years ago, therefore, water seems to get trapped in that area due to its location at the bottom of the hill. There is no substantial canopy, therefore exposing the ground to harsh UV rays. However, this appears to be an ideal location for jewelweed.

The weather over the course of our experiment can be found at http://www.erh.noaa.gov/er/lwx/climate/bwi/bwi0703.txt for our approximate location. Our experiment took place from 17th of July through the 22nd of July, not including the days to incubate the bacteria for counting. We can see that it was most windy on the last two days of the experiment, which may account for a drastic loss of water in Site 4 where there is barely any insulation from the wind due to its lack of trees. Between the two trials, there was an increase in sunshine, perhaps leading to the dehydration of the soil, also due to lack of cover. So for Trial 2, when we added the water, we rehydrated the soil back to its original state for Site 4, which might explain the drastic difference in the Before and After values for all nitrogen and bacteria. Thus, Site 4 in Trial 2 served as another affirmation of our hypothesis, because when the ground was dry, we observed that the aspects of the nitrogen cycle were off balance.

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