An Examination of the Relationship Between pH, Aluminum Levels and Soil Texture on the Roland Park Country School Campus

by Libby Cole, Beccy Josowitz, Amanda Ortel,
Alexis Paskert, & Becky Polon

Abstract:

We extracted 20 samples of soil from the backwoods of Roland Park Country School and carried out pH, aluminum, and soil texture tests in an attempt to find the reason for the variance between the ESSRE summer research program survey results, and the Kentucky Agricultural Experiment Station Misc. Report 383. Their report was regarding the amount of clay in relation to the pH and aluminum levels and their correlation did not occur in the ESSRE summer research survey results. We found no correlation between the clay and the pH and aluminum levels. After extended analyses we came up with ideas that could have caused the difference between the ESSRE program and the Kentucky program. There were three outlying sample results that we believe could have come about from anything ranging from the percentage of sand to a monoculture location where the three abnormal samples were extracted. This lab report provides analysis, charts, and graphs documenting our thoughts and conclusions on the experiment.

Introduction:

During the first half of the E.S.S.R.E. summer research program, our group took a survey of microclimate number one. We tested the soil for various organisms such as algae, protozoa, zoosporic fungi, heterotrophic bacteria, earthworms, nematodes, and arthropods. We also tested the soil for salts/ions, pH levels, and soil texture percentages. Lastly, we performed a transect analysis on the quadrat in order to find plant percentages. Microclimate 1 was a riparian zone, which therefore experiences seasonal flooding. There was a monoculture of ivy on the floor of the ecosystem. Microclimate 2 was a streambed with rotting materials and had a lot of different plants. Microclimate 3 had a lot of rhododendron and ferns and the stream ran through the middle of it. Lastly, microclimate 4 was a bottom wetland with a lot of sandy soil. We shared our analyzed data with the other three groups and found that there might be a correlation between soil texture, pH, and active aluminum levels.

We decided to research further on the topic and so we reviewed the Kentucky Agricultural Experimental Station Misc. report 383, which was regarding the relationship between the percentage of clay in the soil, pH levels, and active aluminum levels. The study showed that from their previous research, when there was a 2:1 ratio of clay minerals in the soil, that caused the pH levels to drop, therefore causing the active aluminum levels to raise. Overall, the main message of the study was that when there is a combination of low pH levels and high clay mineral percentages, the active aluminum increases dramatically.

Another factor that intrigued us was the fact that the data, which was shared from all of the four groups after the survey, did not match the data from the Kentucky study. Therefore, we decided to study whether the reason that our data did not correlate with theirs was because of some difference in the soil texture. We therefore examined the backwoods as one individual ecosystem, instead of four different microclimates, taking 40 samples total (over 2 different days) over each of the four microclimates (in order to cover the whole ecosystem). We tested each sample for the pH level and active aluminum level using the LaMott soil test kit as well as using the jar method to find the percentages of soil makeup. The results from these tests gave us the information necessary for our conclusion.

Procedure:

To begin, we took a series of 20 soil samples 15 cm in length throughout the backwoods of Roland Park Country School using a soil core sampler that was about 2.54 cm in diameter. Five samples were taken from each of the 4 microclimates, measuring approximately 20 meters by 20 meters in area, which were determined in a previous biota survey experiment by the ESSRE program in Baltimore, Maryland. These samples included soil from the same quadrants from which the highest and lowest levels of aluminum were found during the preliminary biota survey. In microclimates 1 and 2, one sample was taken from quadrants one, three and four, and two from quadrant two. In microclimates 3 and 4, one sample was taken from quadrants one, two and three, and two samples were taken from quadrant four.

As we extracted the samples we recorded which microclimate and which quadrant the sample was taken from. We then took the samples back to the lab and began aluminum, pH, and soil texture testing. (Hall, 1996) To test for both aluminum and pH, we used a LaMotte STH Series soil test kit. To do the aluminum test, we used a 14 ml sample of a 3% acetic acid, 10% sodium acetate soil solution and titrated a 5 ml (by volume) soil sample using a 99% isopropanol 0.1% hematein solution. After one minute, the color was compared to a chart and determined to be either Very Low, Low, Medium, High, or Very High. Ordinals from 1-5 were assigned, 1 being Very Low and 5 being Very High, and then recorded in data charts.

To perform the pH tests, we used a 10 ml test tube with 1/3 soil and 2/3 Model Demineralizer to titrate the soil sample using a 0.008% polycrylamide solution. We put 1 ml of the solution (once it had settled) into the large depression of a spot plate, and another ml into the other large depression on the plate. We added two drops of a 28% ethanol, 2% methanol, $<$0.1% bromythol blue solution to one of the samples on the spot plate and compared the resulting color reaction against a color chart. We chose the narrow range indicator (either Bromcresol Green, Chlorphenol Red, Bromthymol Blue, Phenol Red, or Thymol Blue) and added two drops to the second sample on the spot plate. We compared the color reaction against a color chart.

Finally, with the remaining soil we determined the percentages of sand, clay and silt in each sample. To do this, we put the soil in a jar with a flat bottom and added water up to one inch from the top of the jar. We put phosphate based detergent into a micropipette (two inches) and added that to the jar with the soil and water. After shaking vigorously for approximately one minute, we allowed the soil to settle. We measured the height of the entire column of soil, and then measured the heights of the columns of sand and soil. We used these heights to determine the percentages of sand and silt in each sample, and subtracted from 100 to find the percentage of clay.

Results:

After we collected all of our data (see general graph G) we started to analyze it. First we used stem and leaf plots to see if there was correlation among active aluminum levels, pH levels, and soil texture. Since active aluminum was on an ordinal scale, we made one stem and leaf plot for each active aluminum level (levels 1 through 5 excluding 3). We excluded level 3 because that represented a medium active aluminum level, which was not part of our data. After each stem and leaf plot was created (see drawing A), we found where the numbers peaked for pH and for the soil texture percentages. We put this data into a graph and saw that there was no correlation between the peaks of the pH values on the stem and leaf plots and the peaks of the clay percentages on the stem and leaf plots.

However, we knew that there should have been a correlation so we went back and examined the samples that had changing active aluminum values from day 1 to day 2. We then examined their pH values as well and to determine which ones followed the Kentucky study pattern (where decreasing pH causes increased active aluminum and vice versa). We then decided to see whether these samples were clustered in a certain area in the ecosystem.

Using the maps of the four microclimates, we discovered that the samples, which followed the correct pattern, were evenly distributed all over the ecosystem. This showed us that the location of the samples was not the reason that they followed the pattern (see drawings B,C,D,E; sample 1=A, sample 2=B, and so on). We then found the clay, sand, and silt levels for each of the samples which followed the correct pattern and averaged them together to get one clay percentage, one sand percentage, and one silt percentage. We did the same for the samples which did not follow the correct pattern. We used three t-tests (shown in chart F) to compare the clay percentage from the samples that followed the correct pattern to those that did not, as well as silt, and then sand.

The t-tests showed that silt did not cause some samples to follow the correct pattern. We concluded this because the t_s was less than the $t_\propto$ when using an alpha value of .1. (Samuels, 1989) This showed us that we were more 90% confident that silt was not the causative agent. There was no statistically significant difference of silt between the two sets of samples. Another t-test (which was used for the clay percentage comparison) showed us that we were also 90% confident that clay was not the causative agent either for the same reason as the silt t-test showed. Therefore, for silt and clay, we are accepting the null hypothesis. The sand t-test, however, showed us that there was a statistically significant difference in sand between the two sets of samples because the t_s was greater than the t_∞ when using a .1 alpha value. This shows that we were 90% confident that the sand was the causative agent, and therefore, we rejected the null hypothesis for sand.

Drawings:

A)

Aluminum (1)

Clay% pH

0
9**1**
838055**2**
6**3**
550**4**8
0**5**4424
653563
701004041
0**8**
9

Key:
0**5**4
50=0**5**
54=54

Aluminum (2)

Clay% pH

0
1
05**2**
3**3**
44
0**5**555
63
74
8
9

Key:
0**5**5
50=0**5**
55=55

Aluminum (4)

Clay% pH

Key:
0**3**
30=0**3**
52
52=52

0
1
2**2**
0**3**
4
52
62
7
8
9

Aluminum (5)

Clay% pH

0
1
45555**2**
722373**3**
10**4**84
5342
7**6**13360
72003
0**8**4
9

Key:
0**4**8
40=0**4**
48=48

B) Microclimate 1

Quad 1 P	Quad 2 O
Quad 3 N	Quad 4 M, L

C) Microclimate 2

Quad 1 H	Quad 2 G
Quad 3 I	Quad 4 J, K

D) Microclimate 3

Quad 1 C	Quad 2 A, B
Quad 3 D	Quad 4

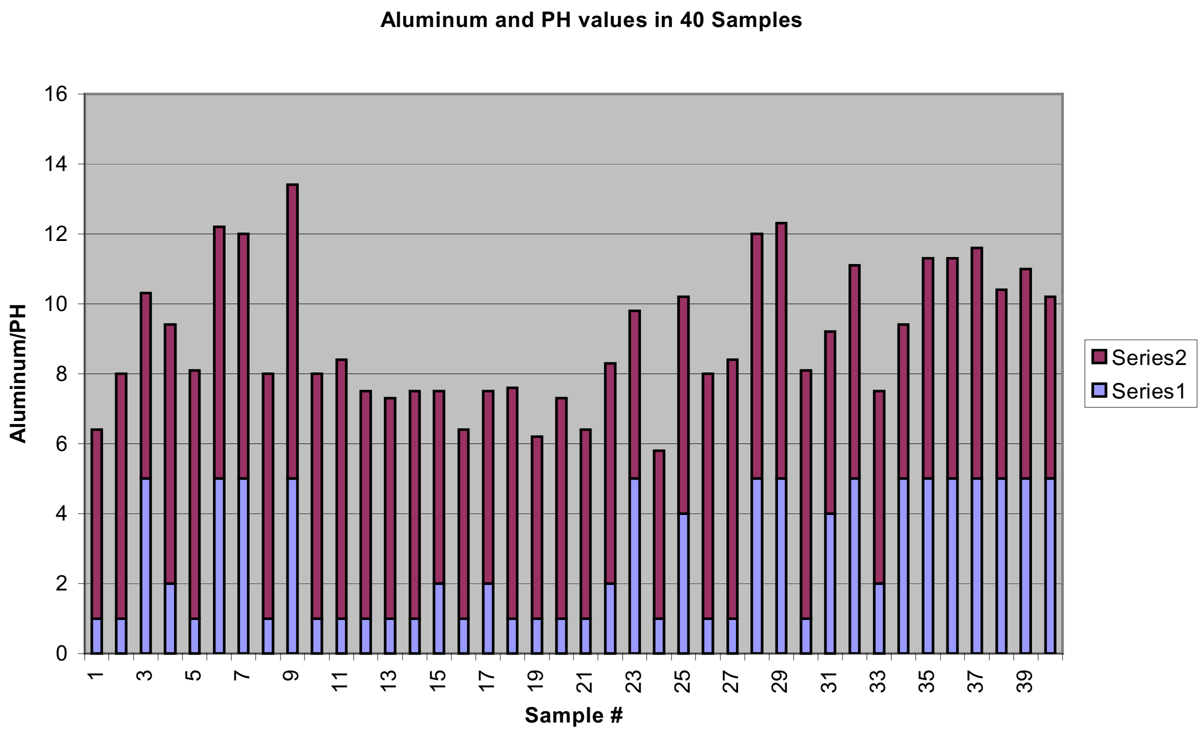
E) Microclimate 4

Quad 1 E	Quad 2 F
Quad 3	Quad 4

F)

	Alpha Value:	T test result:	Reject/Accept Null Hypothesis	Probablility:
Clay	.1	1.4799<1.701	Accept Null Hypothesis	.149
Sand	.1	1.724>1.69	Reject Null Hypothesis	.093
Silt	.1	1.1239<1.86	Accept Null Hypothesis	.295

G)



Discussion:

From our data and analysis, we can conclude there is a higher percentage of sand in the soil in the backwoods of Roland Park Country School where the aluminum levels do not change drastically from day to day when compared to those that do. After reviewing this fact, we realized that we ended up somewhere completely different from where we started. We started this experiment thinking that a much higher percentage of clay would cause pH to lower and therefore cause aluminum levels to rise. This would therefore cause our data to differ and not follow the pattern that was set by the Kentucky study. However, our results show that clay, statistically, has nothing to do with it. However, since sand is silicon dioxide and absorbs water and lets it pass through very quickly, we have doubts that the difference in sand in different soil samples is really the cause of the changes in aluminum in the soil.

After realizing this, we went back to our original data and pulled out the 3 outliers, which were the most drastic, and the most significant from the rest of our data. The 3 outliers were samples 7, 8, and 9 from day 1. Sample 7 is an outlier because it has a very high aluminum level over both days while the pH value stays at 7.0. Sample 8 is an outlier because the aluminum level changes from very low to very high from day 1 to day 2 while the pH value stays at 7.0. Sample 9 is an outlier because the aluminum level stays the same at very high from day 1 to day 2, however, the pH value was at 8.4 on day 1 but on day 2 it decreased to 7.3. We then went back and looked at where each of these 3 samples was taken and our data showed that sample 7 and 8 were taken in site 4 quad 2, and sample 9 was taken in site 4 quad 3.

This leads us to believe that there is something in microclimate 4 that is causing abnormal results. There are 2 obvious properties that microclimate 4 has which are different from all of the other microclimates. One is that site 4 is a wetland, and the other is that it has a monoculture of jewelweed. Therefore we can infer that there is a certain aspect of jewelweed or of wetlands that causes this abnormal difference in pH levels and aluminum levels in the soil. This would be an excellent future research question. We did not have time to investigate any other topics than sand, however, it would be very interesting to know whether it really is the jewelweed or the fact that site 4 is a wetland which is causing this abnormality.

Bibliography:

Hall, G.S. (1996) Methods For The Examination of Organismal Diversity in Soils and Sediments. Cambridge; University Press.

Kentucky Agricultural Station Misc. Report 383.

Samuels, Myra L. (1989) Statistics For The Life Sciences. Englewood Cliffs, New Jersey; Prentice Hall. 562-563.