The Effects of Worm Population on the Rise and Fall of Levels of Aluminum in Soil

By,

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Abstract

Our independent research experiment began with an article written by Bitok Publikations concerning a possible connection between earthworm populations and aluminum levels. Bitok researches hypothesized that because the earthworms were constantly moving soil, it was harder for aluminum to concentrate in areas with high earthworm activity. We noticed a slight connection between our levels of earthworms and our levels of aluminum and decided to further explore this explanation. (Bitok 1998) We expected that this would be the reason for our consistently unexplainable aluminum results, but after our research we discovered that there was in fact, no substantial evidence that this was the case. This was seen in our equation, aluminum=-0.00335worm + 78; r^2 = 0.000011. We disproved our hypothesis.

Introduction

Each square inch of soil is different. It is composed of hundreds of different types of nutrients. For many years now Roland Park Country School has studied ‘the backwoods’, which is a semi-dense wooded area behind the school. This wood has been subjected to many different types of experimentation. Most recently the Environmental Studies Summer Research Experience for Young Women interns. This program has been in place at Roland Park Country School for three years and counting. This year we once again tackled the problem of aluminum.

Aluminum is abbreviated Al and is a light weight, slivery, soft metal. It can be used for many things, including the manufacturing of Aluminum Foil. For all of the years that we have been performing Aluminum tests in the backwoods we have found that every year the Aluminum levels in the back woods to be obscenely high. This is normally found in soil with extremely high pH value. A high pH value would mean that we would have very little plant life. (Moor 1998) The wood that we were studying contained an abundance of plant life and an average pH, so there shouldn’t have been high Aluminum levels at all. (Keele 2003)

Aluminum is one of the world’s most abundant metals, and is a main plant growth inhibitor in acidic soils. This is why the woods still manages to have abundant plant life, because our soil is non-acidic, but none of this explains the high aluminum levels in our woods. (Travis 1998)

We decided to try and answer the aluminum question during our preliminary research were we stumbled across a site that stated that earthworms turned the ground and when it was turned the levels of aluminum decreased. It also said that earthworms loved non-acidic soil. (University of Manchester 1997) Through our experiments we aimed to prove a point that the high aluminum levels were not caused by the pH levels but by the earthworm population. We believe that the higher the earthworm population, the less the concentration of aluminum in the soil. (Bitok 1998)

Method

The first thing that we did was to go to three different sites that were previously marked off in the woods behind Roland Park Country School. Site 2 was at the bottom of a hill, just past cement damn, with a creak that runs through quadrates three and four. The sight was densely covered with English ivy and in a majority of areas poison ivy. Site two’s general GPS location is N 39.357925, W 72.1392325. Site 3, is located at the top of the hill. It has a creek that runs straight thru the middle of the entire sight. There was an abundant amount of Rhododendrons in quadrate 2 and 3. The sight sloped down on both sights, placing the stream in the “valley” of the sides. Site 3’s general GPS location is, N 39.35797; W 076.63836. Site 4, was a swamp. There was a stream that ran thru quadrate 2, 3, and 4. Quadrate 2 had a dense patch of Jewelweed. Site 4’s general GPS location is, N 39.35733; W 076.63840 During the first week and a half of our internship, we conducted biota surveys on the sites. Among many differences that we noticed between the three sites, one of them was the difference in the number of worms and the level of Aluminum. Places with less number of worms, had higher levels of Aluminum in the soil. After researching earthworms we found that earthworms churning the soil effect the levels of aluminum from this information we drew up a research problem, and a hypothesis. Is there a correlation between low earth worm counts with high aluminum levels vs. high earth worm levels and low aluminum levels? We figured that earth worms churning the soil, effects the level of aluminum. We hypothesized that the lower the earthworm level the higher the aluminum levels because there would be less worms to churn the soil and the higher the earthworm levels the lower the aluminum levels would be in the soil because there were more worms to churn the soil. To determine whether or not our hypothesis was correct we designed an experiment. (Brock 2003)

First we chose 13 sites to dig in, Sites A (S2 Q2), B (S2 Q3), C (S4 Q1), D (S3 Q1), E (S4 Q3), F (S3 Q3), G (S4 Q2). We chose these sites based on the original earthworm numbers in the biota survey. We went into a site and then entered the quadrate, within each quadrate we chose three random places to place our ½ bye ½ meter squares. When we chose our spots, and put out our quadrate squares, then using a trough, we dug 15 cm deep. As we dug, we put the dirt into a bucket, and counted every worm. As we dug we recorded the number of worms in our field note books so we could keep accurate data. Once we reached 15 cm down in the entire ½ by ½ meter square, we dumped the dirt from the bucket into the hole. Then using a soil core that was 14.5 cm high and 2 cm wide, we took a soil sample from where we had been digging. We put this soil sample in a properly labeled zip lock bag. Then we stomped on the area we just dug up, so the soil was compacted down, and we put any leaves that rested on top, back where they were. In between each time we took a soil sample, we rinsed out soil core in the creek, so we didn't contaminate our samples. We did about 3 or 4 quadrates at a time.

Once we had samples from our quadrates and the number of worms in our area we took the information back to the class room. There, we would enter our data and test for aluminum. It was very important to test for aluminum the same day we collected your sample. Before we actually preformed the test for aluminum, we had to create our general soil extraction using the La Motte Test Method. We created the general soil extraction for every soil sample. With each general soil extraction that we created we tested for aluminum using the La Motte test kit and method.

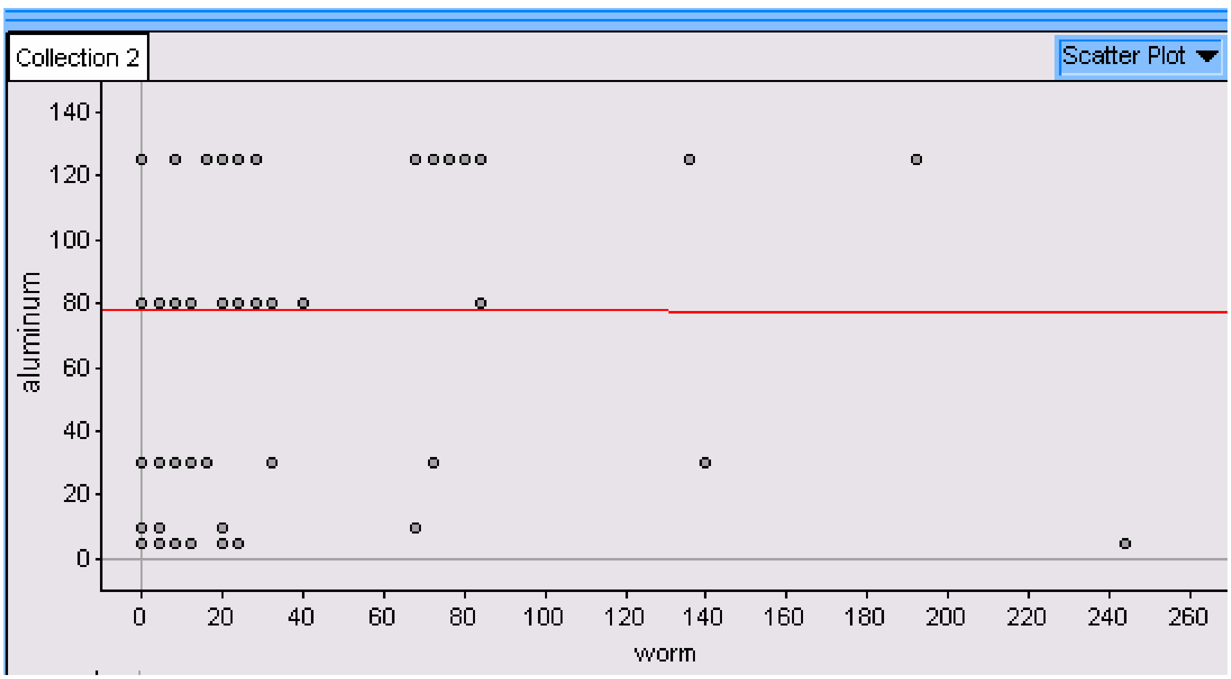
After the aluminum tests were finished, we organized our data. Using an excel spread sheet we set up a data table which showed the number of worms and the amount of aluminum for each site and trial. We multiplied the raw number of worms by four in each site to get the number of worms per meter. In the first trial, we did T tests between site "A" and "B", "B" and "C", "C" and "D", "D" and "E", "E" and "F", and "F" and "G". We did this to determine whether or not we had any significance, which we did; we came up with two data points. We determined that we did not need to do site “F” so it was dropped because the numbers were to extreme and therefore unreliable. Then we performed the second trial. After the second trial, we used fathom to graph all of our data. It was here where we realized that our “R” value was too low, thus we needed more data. So we did a 3rd and 4th trial on sites “H” (S4 Q4), “I” (S2 Q2), “J” (S2 Q1), “K” (S3 Q4), “L” (S3 Q2), and “M” (S3 Q3). We did everything to these sites that we did to A, B, C, D, and E.

Results/ Discussion

After looking at the graphs (graph 1 and residual plot) it became clear that the pattern of our data was that there is no pattern. Despite the statistically significant difference between the number of worms from west of the damn to east of the damn, there is no correspondence to aluminum changes. The average earthworm count, and aluminum level vary from site to site, but their changes do not affect each other.

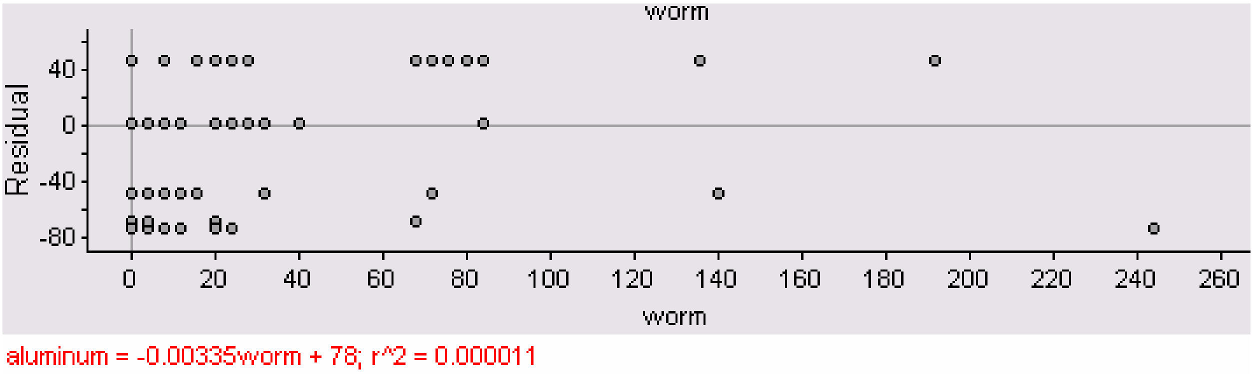
After T testing the worm counts from west of the damn and the worm counts from east of the damn we discovered that there was a significant change between the two sides. The ‘P’ value was .0003408313. Then we preformed a T test between the aluminum level west of the damn to the aluminum level east of the damn, and discovered that there was no statistically significant difference between the two. The ‘P’ value was .6993175331. This helps to prove our graph (graph one) to be true. There is a significant difference between earthworms, but not aluminum which means they can not correspond to each other. If they did have an affect on each other then both would have changed, or stayed the same. Proportionally, each value, the average aluminum value, and average worm count, would have changed equally together. Because the earthworms have a statistically significant change, there must be something else causing that change. This also means that there has to be something else making the aluminum levels as high as they are.

Graph 1:



The above graph, is a graph of the aluminum levels, and worm counts of every plot we dug in all four trials. The red line is the trend line. The trend line is showing that there is no pattern. As the number of worms increases, the aluminum level stays the same. To make sure that this graph is valid, we created a residual plot (below).

Residual Plot:



The above graph is a residual graph of Graph one. Because in the residual graph the data is evenly distributed it is the statistical proof, that Graph one is valid.

From this data, we can conclude that there is no correlation between earthworms and aluminum in the soil.

Conclusion

After performing out experiment, it can be determined that the numbers of earthworms do not affect the level of aluminum in the soil.

Even though we did not prove our hypothesis to be true, our experiment will help future scientist. Though we did not discover what makes the aluminum levels so high, or why there is a difference in the number of earthworms from the western portion to the eastern portion of the research area, we have ruled out the option of them affecting each other. But the big question remains, why are some of the aluminum levels so high?

There is a lot further research to be done on this topic. In 2001 and 2002 E.S.S.R.E. projects, soil texture has been ruled out. One idea we had is the yeast. We noticed that on our maps, where the yeast was higher, the aluminum is lower. The same is true for potassium. Despite the fact that we still do not know what causes the aluminum levels to be so high, we are one step closer.

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Bibliography

Brock, David 2002

http://faculty.rpcs.org /brockda/ESSRE.htm Background information on the ESSRE and our survey projects

Fifth Keele Meeting on Aluminum, (February 2003)

http://www.keele.ac.uk/depts/ch/groups/aluminium/Hiradate.pdf - In any acidic soil, aluminum is a plan growth inhibitor.

Matzner, E; Pijpers, M; Holland, W; Mandersheid, B (1998)

http://www.bitoek.uni-bayreuth.de/bitoek/de/pub/pub/pub_detail.php?id_obj=7191 – The act of earthworms moving soil may have a direct effect on the presence of aluminum in soil.

Moor, Fred, (1998)

http://homepages.which.net/~fred.moor/soil/ph/p01.htm - How pH affects the quality of soil and plant growth

Travis, J. (1998)

http://www.sciencenews.org/sn_arc98/5_30_98/fob2.htm - Aluminum is the most abundant metal on the Earth's crust

University of Manchester, UK, Life Sciences (1997)

http://www.angelfire.com/sk/monkeypuzzle/mbionet.html - Relationships between soil and earthworms