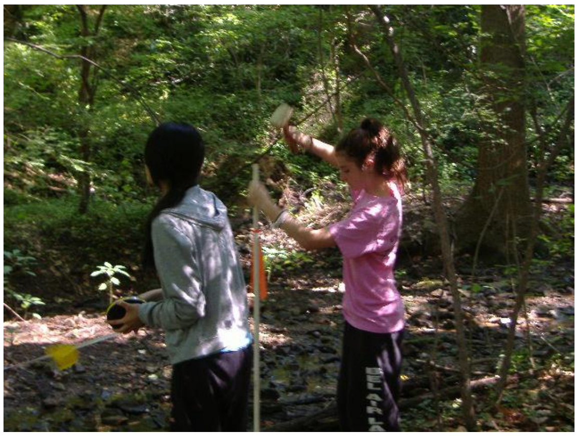
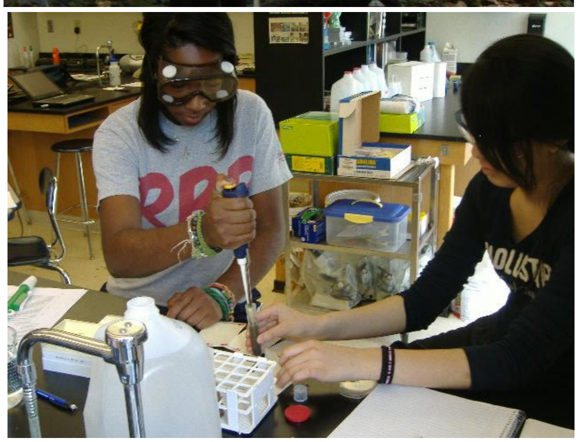
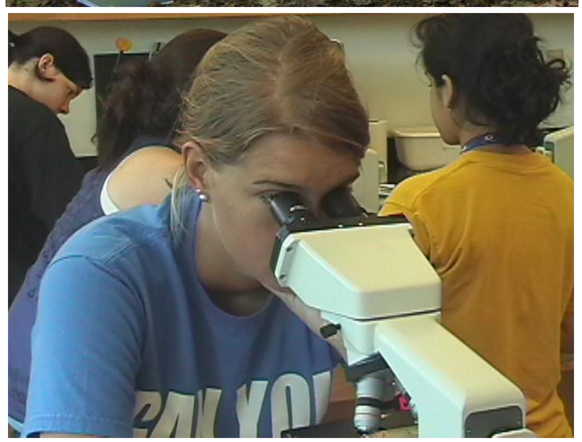
Decomposition's Impact on Soil Chemistry



By Jeannie Kim, Beth League, Maggie Wilder, and Chelsea Robert

Abstract:

Decomposition plays a significant role in an ecosystem, specifically affecting the environment with the release of sulfur. Sulfur lowers the pH level, thus making the soil more acidic which inversely increases the Aluminum level. The data collected from the 2009 E.S.S.R.E. program revealed unusually low pH levels and high Aluminum levels in Site 1 (N 39.35794; W 076.63977). Our group hypothesized that the large amounts of decomposing matter in this site was the cause for the low pH levels and high Aluminum levels. We tested our hypothesis by taking multiple soil samples from each site, with one location at each site near decomposing matter and one without. We then tested each soil sample for pH, Sulfur (ppm), Aluminum (ppm), Mold (#/cc soil), and Yeast (#/cc soil). After analyzing the collected data, our hypothesis was proven correct.

Introduction:

Decomposition is the natural process where certain microbe populations and small invertebrates break down the tissues of dead organisms into their individual chemical components. It happens quickest in hot, moist conditions (releasing the chemicals faster), and as a consequence, one of the groups of microbes most actively involved in decomposition are the fungi.

Fungi are organisms incapable of photosynthesis and obtain “nutrition by consuming other organisms or organic material” (Brock, 2006). Individual funguses “will usually come in one of two physical forms. Either as unicellular yeast, or more commonly, it will exist as a multicellular mold” (Brock, 2006). Molds have a better chance of survival in sites with neutral pH levels, where there would be little yeast. While both forms exist in the soil, molds are more common in conditions favoring decomposition. Here, where there is a greater proportion of mold to yeasts, more decomposition is taking place.

During the decomposition process, these organisms release two critical elements that affect their surrounding environment the most: sulfur and carbon dioxide. When carbon dioxide is released, it is absorbed by the surrounding plants to be used for photosynthesis, but when sulfur is released, it stays in the soil and reacts with other components such as the oxygen, water, and iron in the soil to form sulfuric acid. Specifically, the sulfur dioxide (SO_2) combines with the hydroxide (OH) of H_2O to form sulfuric acid (H_2SO_4). The sulfate (SO_4-) and hydrogen ions then dissociate, and plants absorb the sulfate for their use (which lowers the sulfur level in the soil), leaving behind the H+ ion which remains in the soil, lowering the pH and making it more acidic.

Sulfur levels in the soil therefore affect other critical elements such as Aluminum. Aluminum is a common mineral that is found in the soil and the amount of its active version (Al^{+3}) is correlated inversely with the pH level. As the pH increases, the Aluminum decreases and vice versa.

Since high levels of active Aluminum can damage plant roots, preventing them from taking in nutrients such as potassium, magnesium, and nitrogen (The Lake Erie Regional Grape Program, 2008), this complex relationship between fungi, sulfur, pH, and aluminum in the soil has a profound impact on the health of an ecosystem. Hence, when the annual E.S.S.R.E. Biota Survey (2009) revealed large amounts of plant life in Site 1 (N 39.35794; W 076.63977) in spite of unusually low pH levels with high Aluminum levels, this anomaly led us to hypothesize that the current, active decomposition of large trees in Site 1 is altering the soil chemistry by releasing larger amount of sulfur that is altering the soil chemistry there.

Methods:

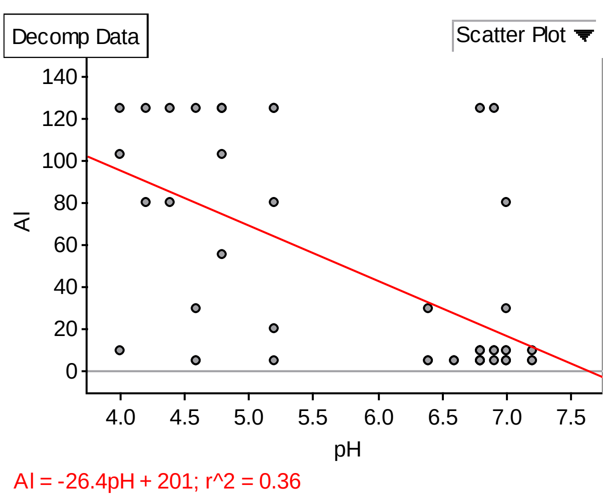
Five pairs of soil samples (columns 15 cm deep by 2.5 cm in diameter) were taken from five different locations in E.S.S.R.E. Microclimate Sites 1(N 39.35794; W 076.63977), 3(N 39.35797; W 076.63836), and 4(N 39.35733; W 076.63840). The first of each pair were taken respectively near decomposing plant material in Site 1, Quadrant 2; Site 1, Quadrant 4; Site 4, Quadrant 2; Site 4, Quadrant 1; and Site 3, Quadrant 1. The second set were taken respectively in Site 1, Quadrant 2; Site 1, Quadrant 4; Site 4, Quadrant 4; Site 4, Quadrant 3; and Site 3, Quadrant 4 in areas with little or no decomposing plant material.

All soil samples were tested using the LaMotte Combination Soil Outfit Model STH-14 Series test kit for the amount of sulfur (ppm), aluminum (ppm), pH, and humus (ordinal scale) present. Simultaneously, all samples were tested for yeast density (#/cm^3) and mold density (#/cm^3) using serial dilutions to the 10^{-2} level. 100 μl aliquots of each dilution were plated on their own individual 3M Petrifilm™ Yeast and Mold Count Plate. This entire process was repeated each day for five days from July 15th, 2009 to July 20th, 2009.

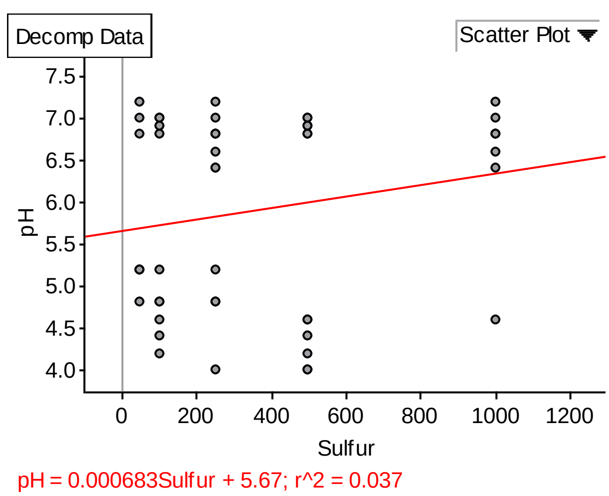
Results:

Graphs 1 and 2 show the correlation between key chemicals involved in the decomposition process; while graphs 3-6 show the correlation with key elements and organisms involved.

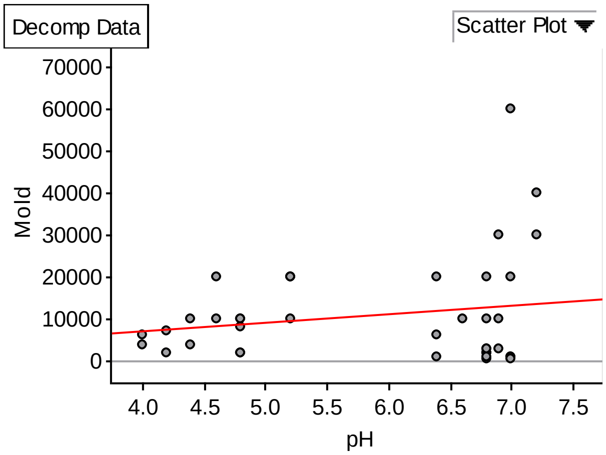
Graph 1



Graph 2

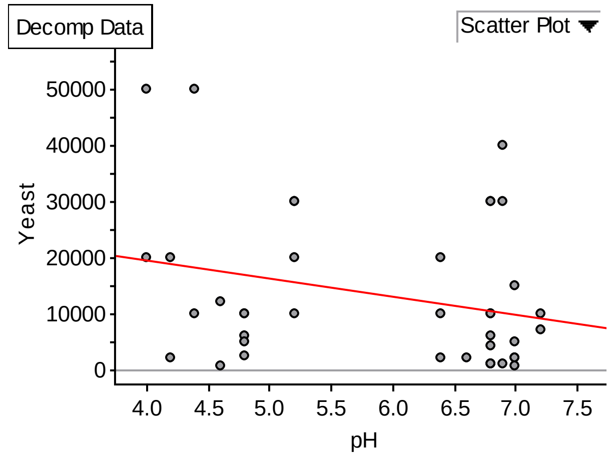


Graph 3



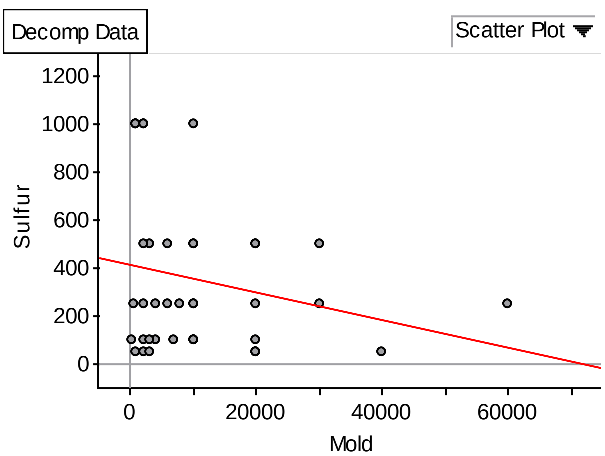
Mold = 2050pH - 1100; r^2 = 0.035

Graph 4



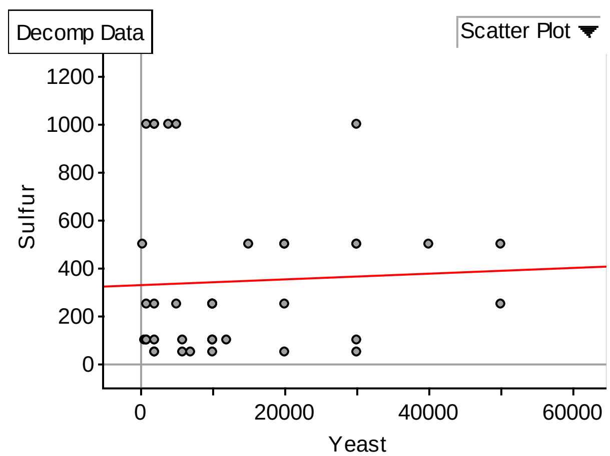
Yeast = -3190pH + 32000; r^2 = 0.071

Graph 5



Sulfur = -0.00573Mold + 410; r^2 = 0.049

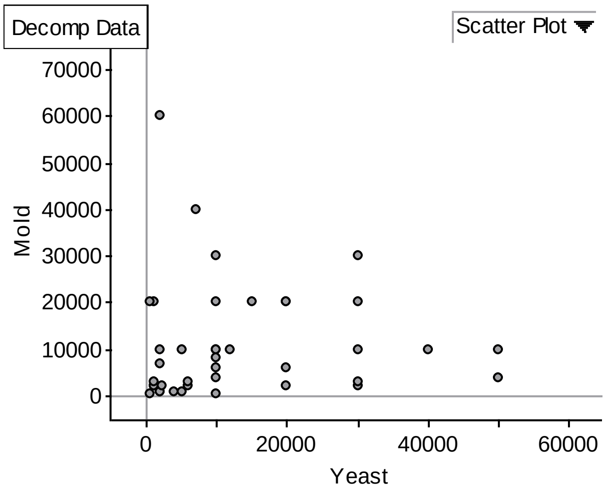
Graph 6



Sulfur = 0.00121Yeast + 330; r^2 = 0.0026

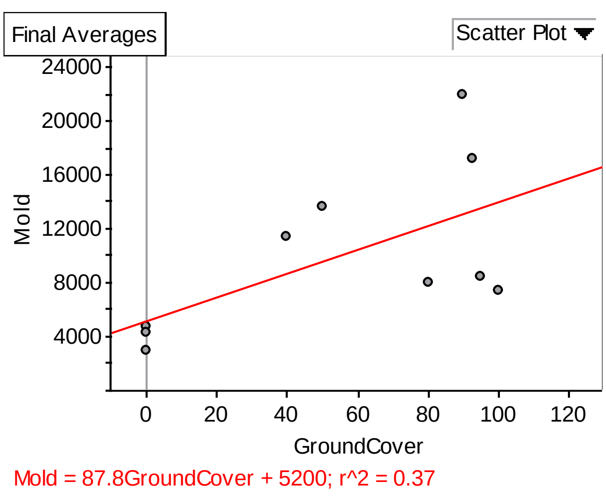
Graph 7 illustrates the relationship found during our research between the two forms (mold vs. yeast) that the various species of soil fungi can take.

Graph 7

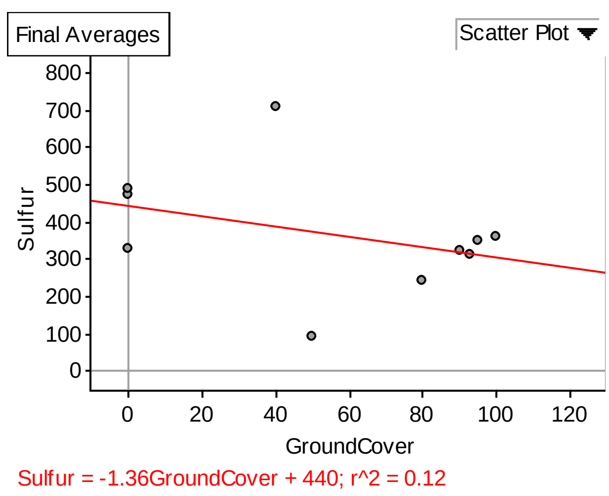


Graphs 8-9 represent information on the correlation between plant diversity, and key components of the decomposition process (these data were collected after the formal experiment was concluded).

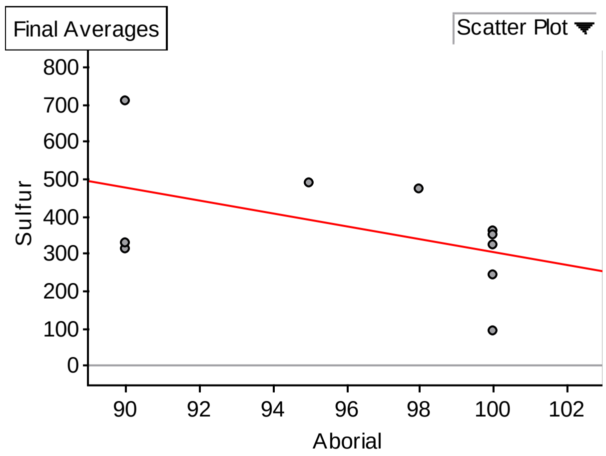
Graph 8



Graph 9

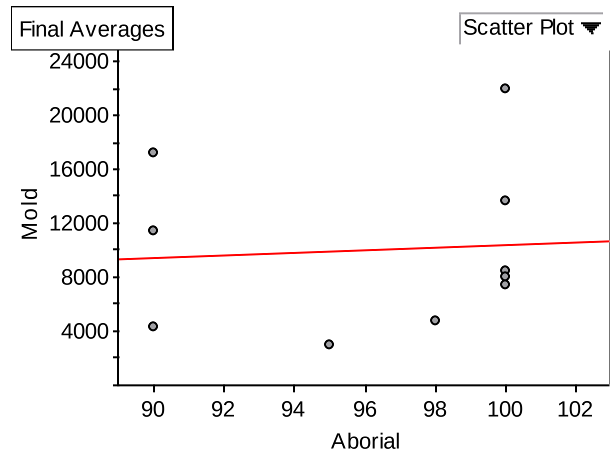


Graph 10



Sulfur = -17.2Aborial + 2030; r^2 = 0.23

Graph 11



Mold = 90.0Aborial + 1300; r^2 = 0.0046

Discussion:

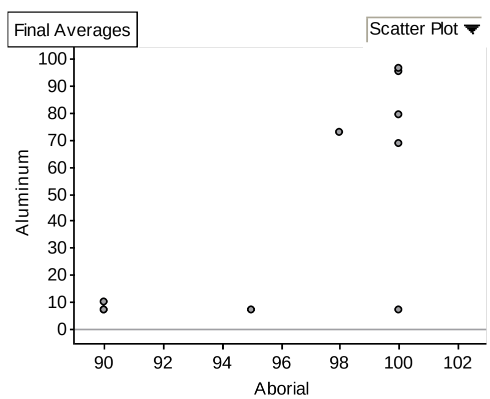
The results of the experiment show that our hypothesis was correct: the presence of decomposing matter is releasing sulfur that is causing the unusually low pH levels and correspondingly high aluminum levels in the E.S.S.R.E. microclimates. As graph 1 shows, the expected inverse relationship between pH and aluminum levels was observed, and as the pH in our soil samples increased the amount of aluminum in them decreased. Furthermore, our results also show as the pH levels rise the density of mold does as well, which is an expected relationship given that the mold form of fungi prefer a more neutral environment (see graph3). Graph 4 likewise confirms the expected relationship between pH and yeast, and graph 7 confirms the normal relationship between the two forms that fungi can take.

However, the relationship between pH and sulfur levels that we observed seems to contradict our hypothesis because as the sulfur level increased the pH increased as well (see graph 2) which is the exact opposite of the expected relationship. Likewise, given that increased densities of mold should result in more decomposition and therefore more sulfur being released into the soil, graph 5 would seem to indicate as well, that our hypothesis is incorrect.

Graph 5, though, caused us to wonder if perhaps the locations with large amounts of mold were in fact causing more decomposition to occur but that the reason a corresponding increase in sulfur levels in these locations was not occurring was because there were larger quantities of plant life in those locations which were absorbing the sulfur for their use. Therefore, we did further research to test for plant density at each of our experimental locations. We tested for plant density at each research location using a densitometer to determine the proportional density of both ground cover and aboreal cover. If our supposition was correct, we would then expect to find more sulfur and more mold were there are larger amounts of plant life.

As graphs 8- 11 show our supposition is correct. This clarifies the low sulfur and pH level, meaning the anomaly seen in graph 2 between sulfur levels and pH in the soil is most probably due to differences in the amount of plant life where we took our soil samples rather than any actual alteration in the usual relationship between sulfur and pH in the soil. Hence, graphs 8-11 actually confirm our hypothesis, and in fact, it **is** the decomposition process in the E.S.S.R.E microclimates that is the source of the unusual aluminum levels traditionally found there.

Interestingly enough, while our experiment seems to have solved a long standing anomaly observed in the ESSRE microclimates (namely the extremely low levels of aluminum), our data generated a new dilemma. When we examined the relationship between the percentage of aboreal cover and the quantity of aluminum in the soil, we observed a positive, almost exponential relationship. (see graph below).



Given the known toxicity of aluminum, this situation is highly problematic. We suspect that perhaps over the decades the species of plants located in our back woods have become tolerant to the increasing levels of aluminum in the soil. In fact, perhaps some of the species of plants have been undergoing microevolution. Hence, we recommend for further research that members of species of plants found in our backwoods that are from locations known to have normal amounts of aluminum and be translocated to controlled areas in the ESSRE microclimates to compare their respective growth patterns. In addition, we recommend examining individual plants from the backwoods to see if there are any genetic differences from members of the same species found elsewhere.

When the pH and the sulfur results were graphed and further tested, the information showed the opposite of what was expected.

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Acknowledgements:

We would like to thank Mr. Brock, Liz, and Rabia for your help and intelligence as well as the ongoing support and encouragement throughout this program. We also thank the Roland Park Country School for allowing us access to their campus for our campus.