

The Impact of Moisture on Sulfur and Fungi Levels



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Abstract

The decomposition process is essential to the recycling of nutrients, and one of the principal organisms responsible for this process are the saprophytic fungi. Fungi cause the decomposition process to occur more quickly, meaning when there are more fungi, decomposition occurs more frequently. One resultant nutrient of the decomposition process is sulfur, an essential nutrient for plant life and growth. During the 2013 E.S.S.R.E. biota survey, this essential nutrient was found in extremely varied levels across all four microclimates. Moisture levels also varied significantly across all four microclimates; hence, we hypothesized that an increased moisture level was creating a rise in fungi population due to their ability to repopulate more quickly in the moist conditions. Since fungi are responsible for the decomposition process, we also predicted that they were the source of higher than usual levels of sulfur. A line of 5 plots were established in a bed of English Ivy 30 cm apart from each other. 3 samples were taken from each plot to establish a positive control. Then each plot received varied amounts of water. 3 more samples were collected. All samples were tested for fungi density, and sulfate levels. We found that both sulfur and fungi increased as the soil moisture saturation increased, supporting our original hypothesis. Due to lower than anticipated statistical significance, we concluded that expanding the research zone and increasing the number of samples would be the recommended course for future research.

Introduction

Decomposition is a process essential to soil health, plant life, and the ecosystem as a whole. Numerous microbes (such as bacteria and fungi) take part in this process by breaking down organic matter into the fundamental elements of life such as carbon dioxide, nitrate & ammonia, sulfate, and other essential nutrients. Without these nutrients that decomposition releases for plants to absorb, the entire local environment would collapse as plants (and animals dependent on them) would perish (Fogel, 2002).

Two critical factors that influence the rate at which the microbes decompose organic matter are soil moisture and temperature. Fungi in particular need proper temperatures and water amounts to perform the decomposition processes, and since fungi can decompose at a more consistent rate than that of bacteria (due to their larger size) (Ingham, 2000), a healthy balance of soil fungi, wet conditions, and warm temperatures aid the decomposition process the most, making the summer months ideal for decomposers. The additional saturation of the soil and warm air temperatures of the summer months increase the rate at which the fungi reproduce, grow, and therefore increase both the rate at which matter decomposes and the rate at which nutrients are returned to the soil. The fungi responsible for this break down of organic matter are known as saprobes or sapotrophs (Fogel, 2002).

One critical element released during this decomposition process is sulfur, and fungal decomposition is especially critical to this process because it yields sulfur in its usable organic forms. Saprophytic fungi convert sulfur compounds such as sulfur dioxide (SO_2) by combining it with hydroxide (OH) from water (H_2O) to form sulfuric acid (H_2SO_4) (Ingham, 2000). The acid then dissociates in the soil into sulfate (SO_4^-) and the hydrogen ions, making the sulfate available in a form plants can absorb (World of Scientific Discovery, 2007) and which they use to create essential amino acids, proteins, and other biochemical they need to survive.

Given this clear link between sulfur, water, and fungi, we found it odd that during the 2013 E.S.S.R.E. biota survey (E.S.S.R.E., 2013), there were statistically anomalous levels of sulfur throughout the four different E.S.S.R.E. microclimates, ranging from 140 ppm in Site 1 to 758 ppm in Site 2 to 67 ppm in Site 3 to 2,000 ppm in Site 4 (E.S.S.R.E., 2001). **Such anomalous sulfur levels could indicate a disruption in the decomposition processes that produce the sulfate in the first place, and since rainfall during the summer of 2013 had been significantly above average (20.32 cm, nearly 12 cm greater than the average for June since 2005 [The Weather Channel, 2013]), we wondered whether this excess amount of precipitation might be the source of the possible disruption of the decomposition taking place in the E.S.S.R.E. microclimates. Therefore, we hypothesized that the increase in soil moisture levels due to unusually wet weather was altering the rate of decomposition, causing the radically different sulfur levels throughout all four microclimates.**

Methods

A line of 5 plots (30 cm x 30 cm each) were established in a bed of English Ivy 30 cm apart from each other in ESSRE Site 4 (N 39.35733; W 076.63840). 3 soil core samples of 15 cm deep with a diameter 2.54 cm were collected from each of the 5 plots between 10:00 am and noon during July 2013 for a positive control. Each sample was simultaneously tested for sulfate levels (ppm) using LaMotte Combination Soil Model STH-14 test kit and for fungal density using serial dilutions with sterile water to 10^{-2} . 100 μL of each dilution for all 15 samples were then plated on their own individual 3M Petrifilm™ Yeast and Mold Count Plates. These plates

were left to grow for 72 hours and then evaluated to determine the population density of fungi (#/cm³) in the samples.

Following collection of the positive control samples, increments of stream water were added at 9:30am the next day in decreasing 0.5 L units to 4 of the 5 plots. The first plot received 2.0 liters of water, the second received 1.5 L, the third received 1.0L, and the fourth received 0.5L. The fifth plot received no water to serve as the negative control. Additional units of stream water were added following this protocol at 1:30pm, then again at 9:30 am the following morning in order to super saturate the soil.

2 days after the positive control samples were collected, 3 more core soil samples 15 cm deep and 2.54 cm in diameter were collected from each of the 5 plots. The samples were then simultaneously tested again for sulfate levels (ppm) and for fungal density (#/cc) using the previous two protocols. All data was then evaluated to determine the level of interaction between the moisture of soil, the fungi populations, and sulfate levels.

Results

Figure 1

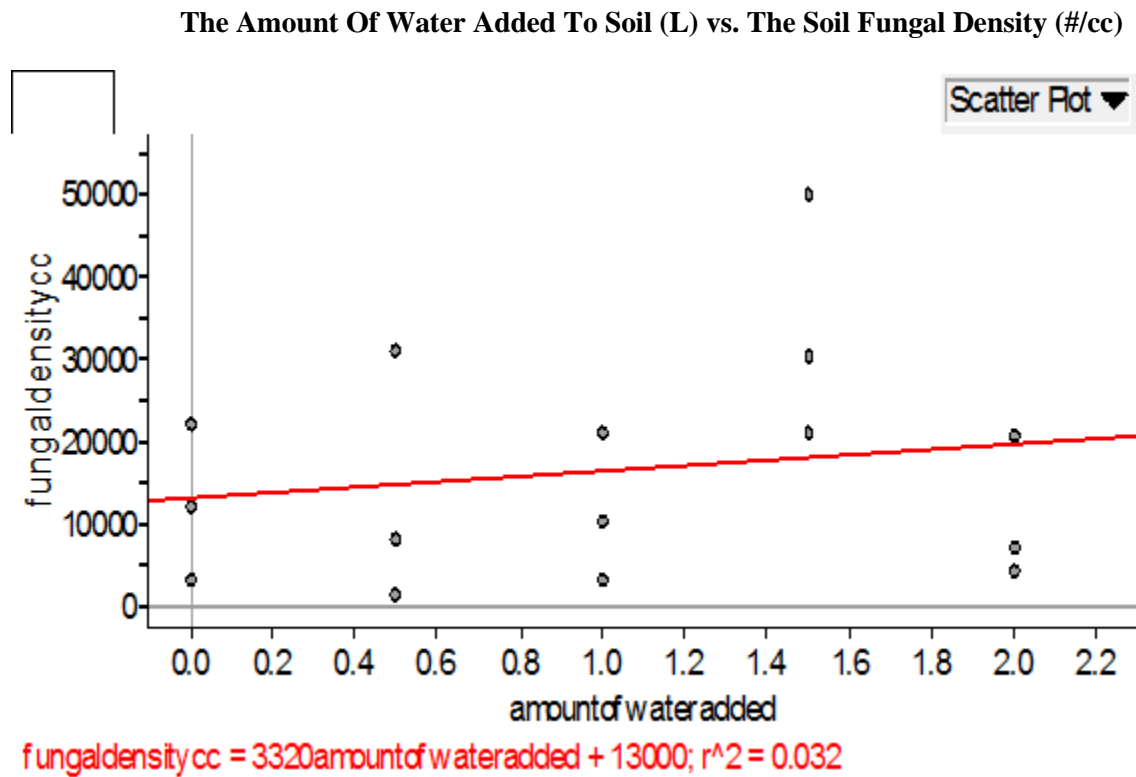


Figure 2

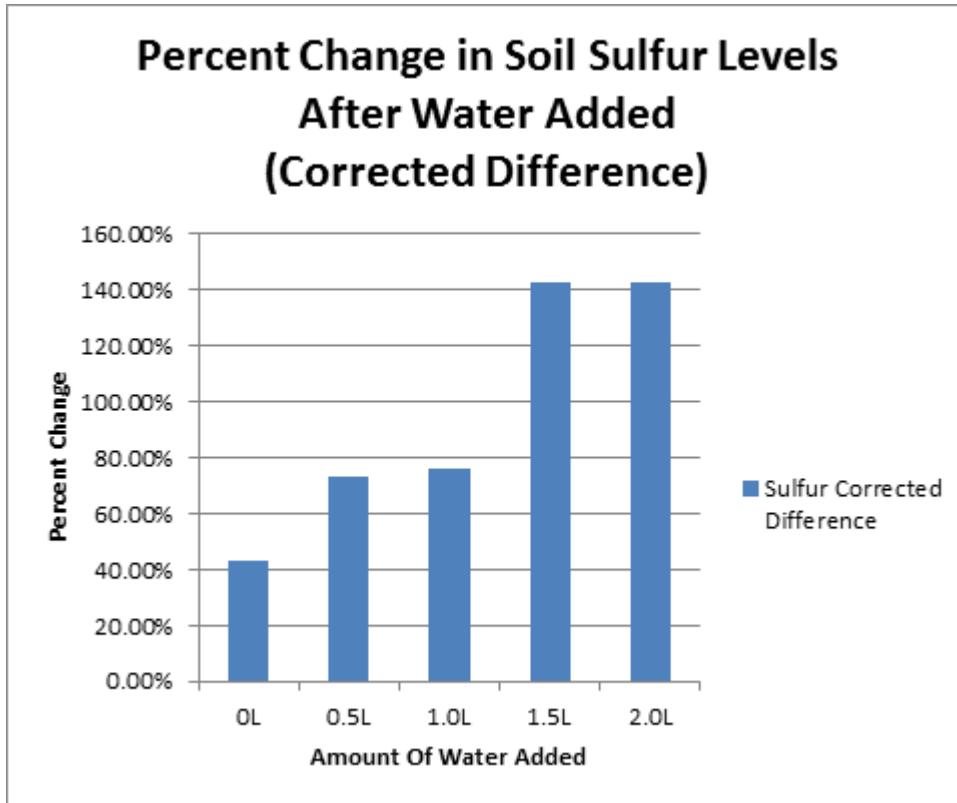


Figure 3

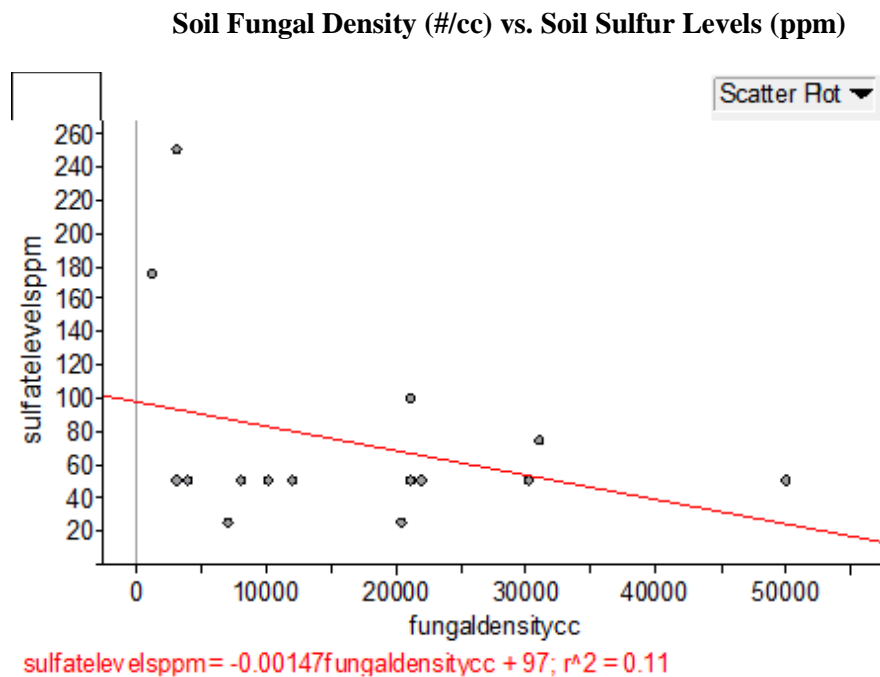


Figure 4

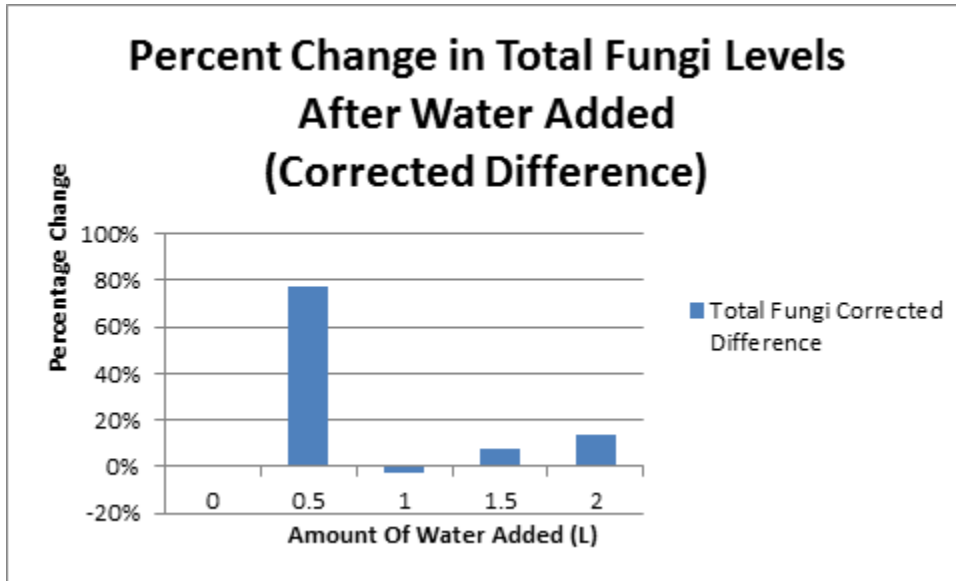


Figure 5

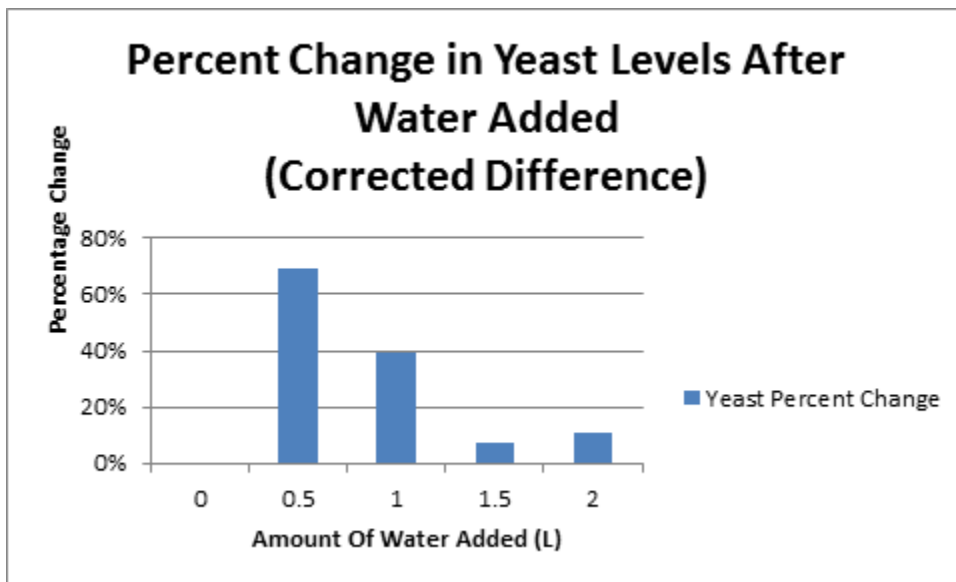


Figure 6

T-Test Results

Water added	Sulfur P values	Yeast P values	Mold P values	Total Fungi P value
0+0.5	0.18	0.1	0.48	0.09
0+1.0	0.17	0.78	0.3	0.91
0+1.5	0.22	0.71	0.31	0.79
0+2.0	0.33	0.92	0.53	0.81
0.5+1.0	0.42	0.12	0.43	0.1
1.0+1.5	0.49	0.85	0.94	0.86
1.5+2.0	0.85	0.65	0.33	0.92

Discussion

We originally hypothesized that the significantly different sulfur levels found throughout all four microclimates during the 2013 E.S.S.R.E. biota survey (E.S.S.R.E, 2013) were due to differences in the impact of moisture levels on the rate of decomposition. As figure 1 shows, there is a weak positive correlation ($r^2 = 0.032$) between the amount of water added and the density of fungi found in the soil, indicating that our additions of water to the research sites may have caused an increase in the number of fungi. Furthermore, figure 2 clearly shows that the sulfate levels also increased as the amount of water added increased (all $p < 0.33$; see figure 6); hence, the data provides some support for both expected correlations.

However, figure 3 presents evidence that is highly problematic for our literal hypothesis. Figure 3 shows that there is a negative correlation between sulfate levels and fungi density ($r^2 = 0.11$), indicating that any positive changes in our research sites caused a negative change in sulfate levels, undermining the core of our hypothesis that is the impact of moisture levels on the rate of decomposition that is causing increased release of sulfate into the soil.

Yet while figure 3 shows data that is problematic for the hypothesis, if we analyze the data in greater depth, there are other correlations that suggest that our additions of water did directly alter the fungi density and consequently, the decomposition rates. As evident in Figure 4, there is a clear and distinct increase in fungi levels between the plots with 0 liters of water added and 0.5 liters of water added to the soil ($p=0.09$). While at the same time, the sulfate levels between these two plots increased significantly too ($p=0.18$). This correlation suggests that the two are in fact related, and that as the total fungi levels increased, so did the sulfate levels, supporting our hypothesis.

Furthermore, figure 5 shows that the number of yeast dramatically decreased from the plot where 1 liter of water was added to the plot where 1.5 liters of water was added ($p=0.12$); while figure 4 indicates that the total fungi present in the plot when 1.5 liters of water was added increased significantly ($p=0.10$). Since the total fungi density increased, while the yeast density decreased, there must have been a significant increase in the mold density to account for the

additional total fungi present. Simultaneously, figure 2 shows that the sulfate levels increased significantly in the plot with 1.5 liters of water added ($p= 0.22$), and since molds are the main kind of fungi that perform decomposition and release sulfur into the soil, this positive correlation further supports our hypothesis because it shows that the sulfate levels increased as the mold density increased.

Further research on the impact of moisture on fungal density and sulfate levels is strongly recommended. It is highly recommended that we test again with more samples and a wider research zone. We also recommend looking at whether or not there is a relationship between bacteria and sulfate levels by adding moisture to see how they are both affected by the different amounts of water as well.

Reference

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