The Relationship of Clay Percentage, pH Values, and Algae Levels in Soil

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Abstract

Clay particles in the soil have a direct impact on the pH of soil, and cause the soil to be more acidic, which increases algae population. In the 2017 ESSRE Biota Survey, it was observed that there were significant differences in percentage of clay in areas where there were also significant differences in algal growth. Likewise, it was observed that these significant differences were located in more acidic areas. Our hypothesis was that differences in clay percentages in the soils were trapping acidic substances, resulting in lower pH and the consequent increase in algae population. We took three 15-centimeter-deep soil core and algae samples in a different area each day in ESSRE Microclimate 1 and Microclimate 2 for 3 days, with the location with the lowest amount of all three variables (percentage of clay, pH, and levels of algae) acting as our negative control. We tested the soil cores for pH and percent of clay and observed algae slides at 40X. Our analysis showed that there was a significant difference in the relationship between clay and algae, but not one in the relationship between either of the other factors. In the future, we would experiment in areas closer to a water source and test the amount of moisture in the soil, as well as the percent of clay and the amount of algae.

Introduction

Algae are eukaryotic organisms containing chlorophyll that range from microscopic and single-celled to large and multicellular. They play a critical role in food chains as well as supplying the vast majority of atmospheric oxygen on earth. Algae can be found nearly anywhere there is light for them to photosynthesize and water for reproduction, including soils. Many soil species are extremophiles because of their ability to survive in the very high temperatures and low pH levels commonly found in many types of soil (EoL, 2017). These acidophilic microbial algae can be found in soils worldwide and have developed several strategies for keeping a neutral pH level such as a positive membrane potential and a positive charge outside the cytosolic membrane (Aguilera, 2013 and Gerloff-Elias, Spijkerman, & Proschold, 2005).

One environmental factor that can impact the acidity of a soil is the amount of clay in it. As the clay and organic matter content increases, the ratio of reserve to active acidity also increases (Plants & Soils Sciences eLibrary, 2015). Clay particles in the soil have a direct impact on the pH of soil, as clay absorbs acidic substances with a pH lower than 6 faster and deeper into the soil, and because soils with a high percentage of clay usually also have a higher soil organic matter content, the presence of these compounds can also contribute to changes in soil pH (Yan & Masliyah, 1996 and McCauley, Jones, & Olson-Rutz, 2017).

The ESSRE 2017 Biota Survey revealed a correlation between the decrease of pH and the percentage of clay in ESSRE Microclimate 1 (N 39.35794; W 076.63977) and Microclimate 2 (N 39.35740; W 076.63893) (ESSRE, 2017). The average pH for Microclimate 1 was 5.7 and Microclimate 2 was 5.2, while the average percentage of clay for Microclimate 1 was 2.68% and Microclimate 2 was 5.46%. Additionally, the survey revealed a correlation between the clay percentage in these soils to the algae population with the average amount of algae found in Microclimate 1 being .82 per mm^2 and in Microclimate 2, 1.1 per mm^2. Therefore, because the survey revealed that the algae population thrived where it was most acidic and where there was the highest percentage of clay, we hypothesized that soil with a high percentage of clay in soil may be trapping acidic substances inside of it, thereby lowering the soil's pH and creating the conditions in the soil for a larger algae population.

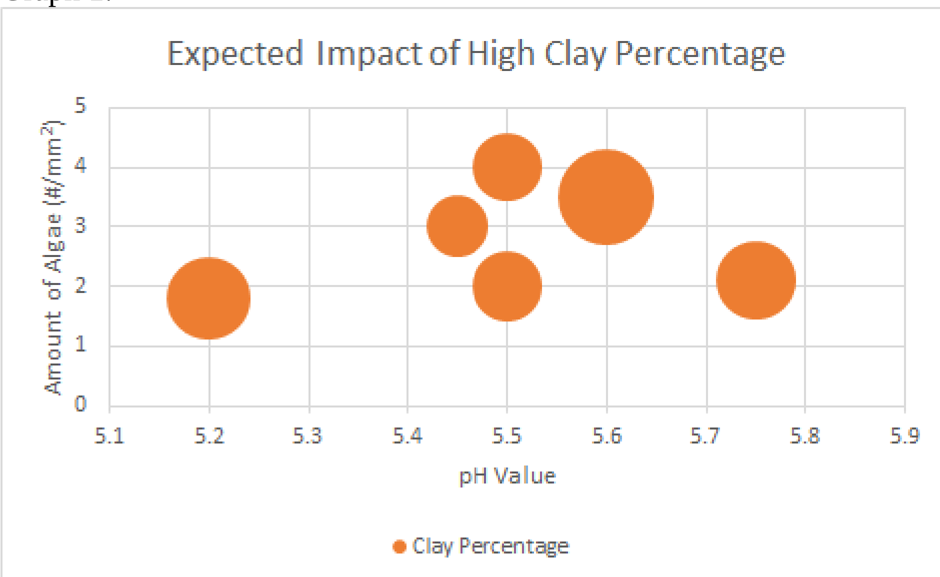
Methods

In E.S.S.R.E Microclimate 1 quadrant 1 (N 39°37.789; W 076°64.092), Microclimate quadrant 4 (N 39°35.817; W 076°64.066), Microclimate 2 quadrant 2 (N 39°21.495; W 076°38.377), and Microclimate 2 quadrant 4 (N 39°21.485; W 076°38.388), 12 25 x 75 mm microscope slides were inserted into the ground using the Pipe and Callimore implantation technique (1980). 3 slides were inserted into random areas of each quadrant based on the quadrant's percentage of clay. Directly next to each slide, a soil core 15 cm deep and 2 cm in diameter was extracted. This process was done on July 19, 24, and 25 of 2017. All slides were removed 48 hours after implantation and the density of algae (#/mm^2) determined using a light microscope at 40X (ESSRE, 2001). All soil cores were tested for pH and their percentage of clay determined.

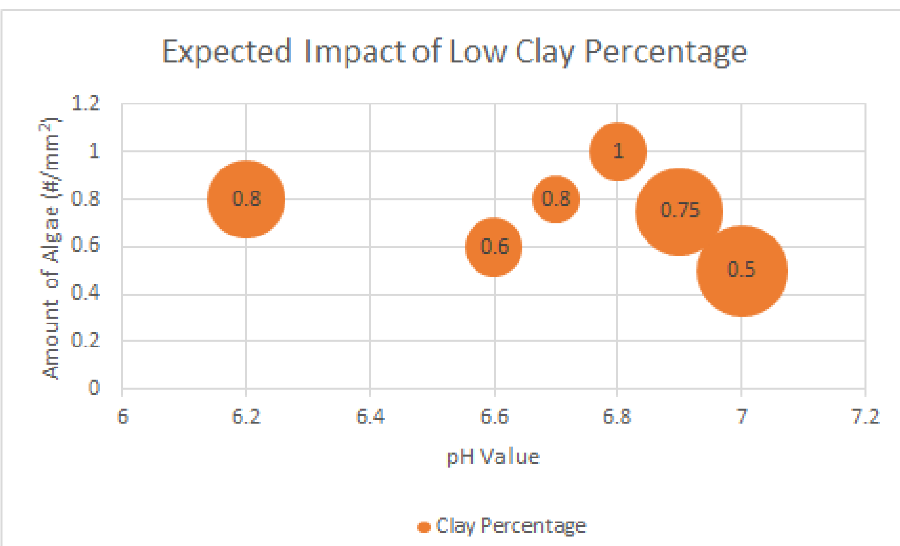
Results:

Graphs 1 and 2 show what the expected data for our experiment would be in support of our hypothesis: as the clay percentage increases, the pH value decreases, and the amount of algae increases.

Graph 1:

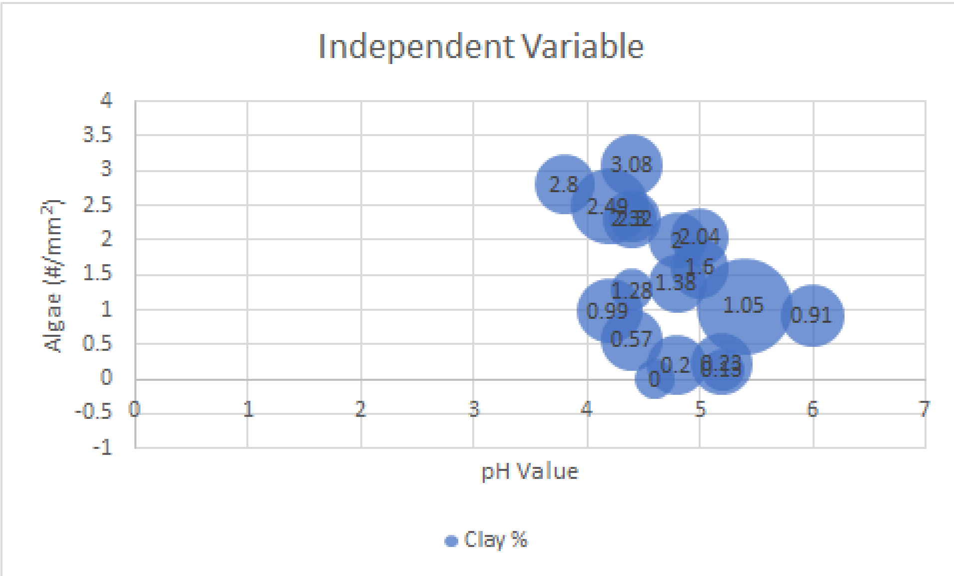


Graph 2:

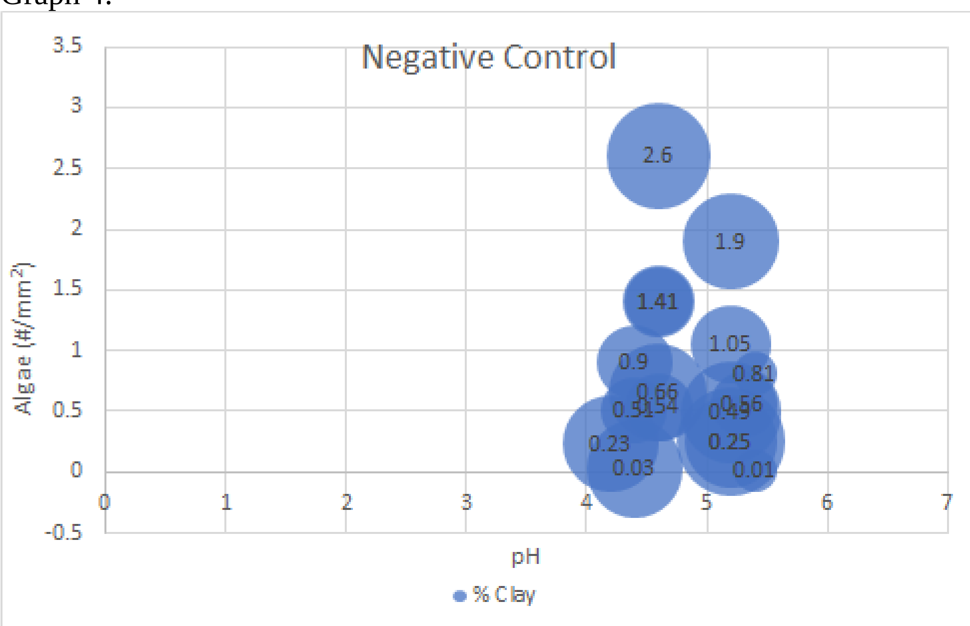


Graph 3:

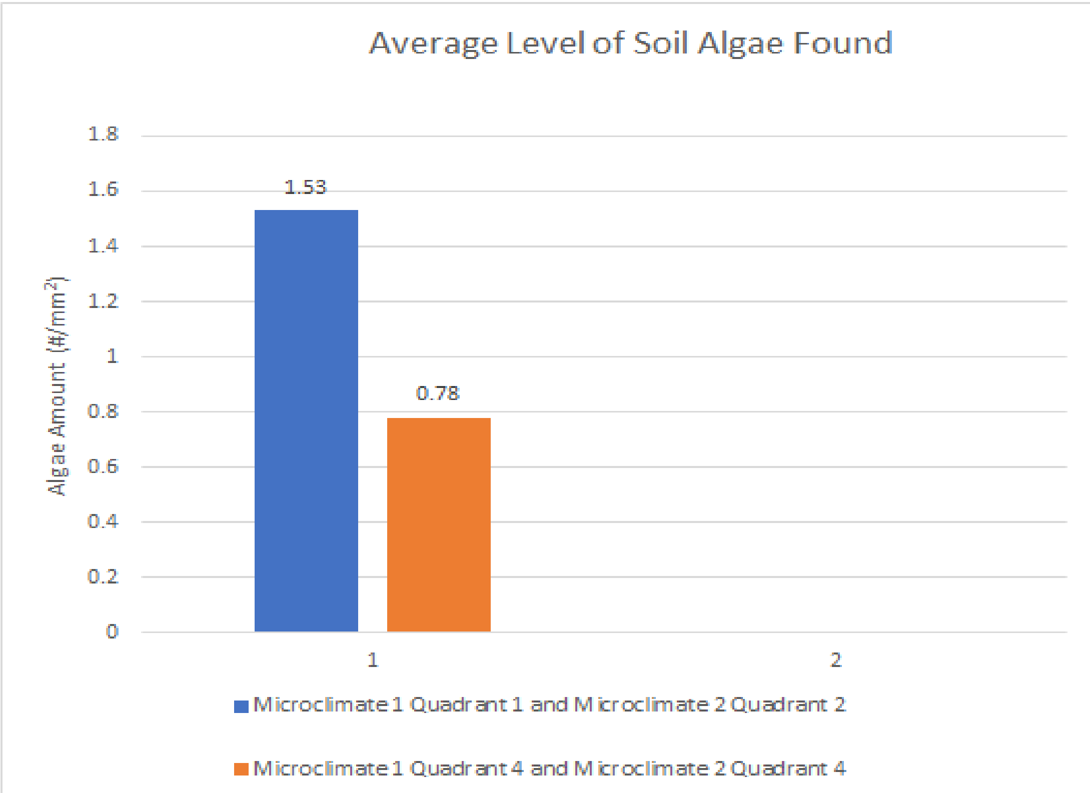
Graphs 3 and 4 represent the actual clay percentage, soil pH value, and amount of algae found



Graph 4:



Graph 5:



Graph 6:

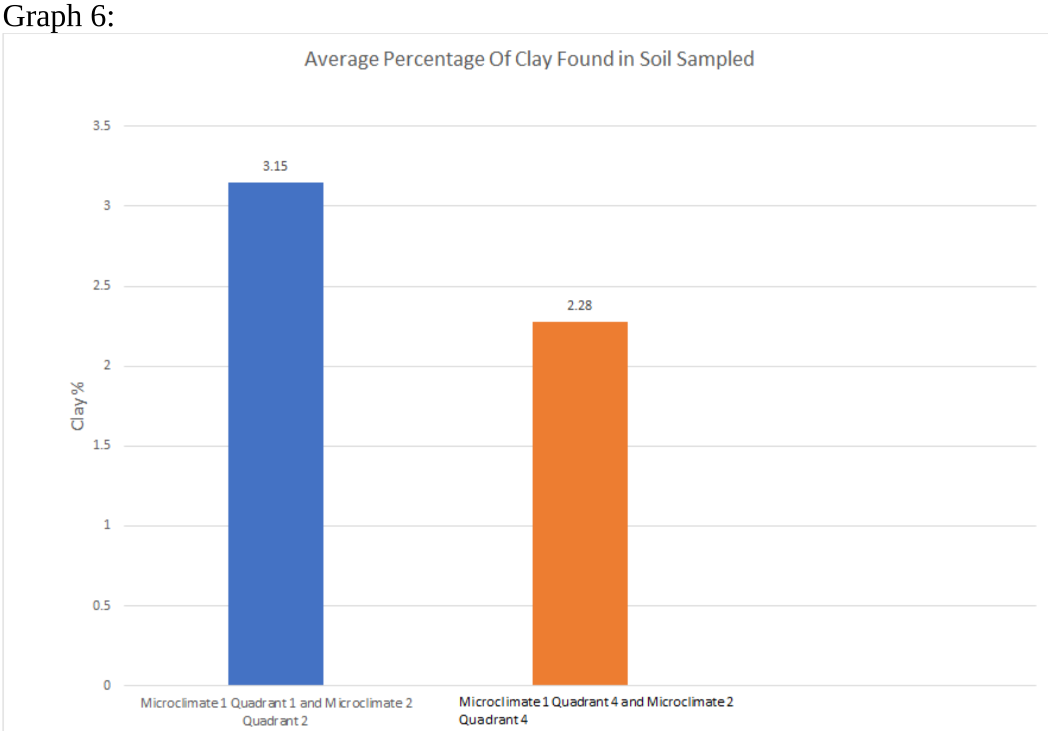


Table 1: p-Values for total values pH, Percent Clay, and Algae levels determined by t-testing.

pH	**Clay**	**Algae**
.61	**.048**	**.009**

Discussion:

When comparing Graphs 1 and 2, representing the expected pattern if our hypothesis was correct, with Graphs 3 and 4 representing the pattern obtained from our data collected from Microclimate 1 and Microclimate 2, it is clear that our hypothesis is not supported. Therefore, while the clay percentage and the algae levels fluctuated significantly between the two microclimates ($p=0.048$ and $p=0.009$ respectively), the percentage of clay in the soil did not impact the pH value or the consequent algal growth as we had predicted. Furthermore, as shown in Table 1, t-testing revealed that there was no statistically significant difference in the pH levels of the soils in the two locations ($p=0.61$). Therefore, the pH in Microclimates 1 and 2 was irrelevant to our findings.

However, as Graphs 5 and 6 show, there was a significant correlation between the average percent of clay (3.15%) found in Microclimate 1 Quadrant 1 and Microclimate 2 Quadrant 2 and the average amount of algae found there (1.53 per mm^2). Likewise, there was a significant correlation between the average percent of clay (2.28%) found in Microclimate 1 Quadrant 4 and Microclimate 2 Quadrant 4 and the average amount of algae found there (0.78 per mm^2). Moreover, the decrease in both percent of clay and amount of algae from one set of research sites to the other was highly statistically significant (for algae, $p=0.009$ and for clay, $p=0.048$). This proves that there was a direct correlation between the percentage of clay in the soil and the algae population in the two areas.

Upon further research, we realized that clay soils hold water well and drain slowly after it rains (RHS, 2017). Furthermore, clay particles also serve as a colloidal sponge by absorbing and holding onto dissolved nutrients, and therefore clay provides two of the critical components for algae growth (Sacher, 2006). Indeed, poorly drained, compacted soils with clay are especially prone to algae growth since water sits on the soil surface and sunlight provides additional warmth that accelerates algal growth. Therefore, based on our results, we would choose in the future to experiment in areas based on their proximity to a water source and test the amount of moisture in the soil, as well as the percent of clay and the amount of algae.

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Acknowledgments

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