Human Activity and Soil Hostility

Jonathan Choi[1] and Daniel Dudek[2]

[1]Mission San Jose High School, [2]University of Texas Arlington

ABSTRACT

The composition of soil can be broken down to a mixture of both abiotic and biotic matter. This composition can include animal waste, minerals, water, and even air. The complex nature of soil can consequently be affected by a large number of factors. These factors may range from simple weather alterations to complex human alterations to environments that could easily impose effects on soil. To see the effects humans can have on soil, this experiment was conducted in which three counties with varying levels of human activity (measured in population) had samples of soil collected to be tested for varying levels of pH and nutrients. Correlation tests were conducted to capture any significant correlation between the different levels of human activity and the variables tested in the soil. The results of these tests suggested that there was no significant correlation between varying degrees of human activity and soil pH and nutrient levels.

INTRODUCTION

Soil has undoubtedly structured and shaped the basis of countless human civilizations since the beginning of time. It molded agriculture and was a necessity for human survival amidst our Neolithic Period (1). This would lay a blueprint for an incredibly dependent relationship in which humans would look to the Earth's soil for crops to bear, for both survival and even economic purposes. It is also undeniable that even during contemporary times, soil is an important attribute for nations' agriculture to be successful and a critical part in determining the quality of human life (2). Additionally, it is stated that around 78% of the average per capita calorie consumption worldwide sources back to crops that were grown directly in soil, and the remaining 20% sourcing back to foods that depend on soil indirectly (1). Thus, soil can be seen as a crucial determinant in the health of nations and even ecosystems. In its healthiest form, soil is an extremely dense source of nutrition and an area for many plants to thrive (3). As a result, being able to gauge the health of soil is essential as soil can also be seen as the spine of nations' economies.

On the manner of soil health, it is imperative to answer how soil can be maintained in the healthiest state possible. Soil health and conditions can be monitored through a superfluous number of ways, but measurement of pH, N, P, and K should be sufficient. The pH of soil, determines numerous things, soil bacteria, nutrient leaching, nutrient availability, toxic elements, and soil structure (4), and a measurement of the pH level will indicate if the soil is adequate for healthy plant growth. This measurement does not represent how fertile the soil is but can affect the nutrient composition and concentration in the soil (4). As a result, soils can have all the nutrients a plant may need for growth but have a hostile pH level (4). Moreover, it is useful to test levels of N, P, and K which respectively represent nitrogen, phosphorus, and potassium. Nitrogen benefits soil health by means of being a nutrient that plants can absorb and utilize to promote the growth of leaves on the plant itself (5). While phosphorus is responsible for the plant's development of roots and growth of its flower or fruit (5). Likewise, potassium is responsible for all functions of the plant to work efficiently and correctly (5). The pH and the nutrients of the soil can, therefore, determine which plants are able to be grown and if the soil is deemed to have a pH in the extremities, it can be considered to be hostile (6). As conducted in an experiment by Jaswant et al., they gauged various soil conditions from a pH range of 4.5 to 9.5 (6), thus insinuating that hostile soil conditions can be determined by extremities. Moreover, the ideal soil pH is considered to range from 6.5 to 7.5, as in this range plant ranges are most readily available 6). To clarify, nutrient availability is partially due to pH levels, as levels greater than 7.5 have been known to induce reactions between phosphate ions, and calcium and magnesium, creating less soluble compounds (6). On the other hand, more acidic values will result in phosphate ions readily reacting with aluminum and iron, creating less soluble compounds (6). As a result, in experimentation, hostile soil qualities should be noted as soils with pH levels lesser than 6.5, greater than 7.5, or in the extremities of the pH scale.

This leads to solving the grand question of how human activity can impact the health of the soil around them. Examples of human activity include, but are not limited to, trampling, the increased intensity in agriculture, and acidification (7). In a study conducted in Scotland, it was noted that soil change was revealed due to the presence of human activity over a span of a few decades (7). Although this study acknowledged that these gradual changes are unable to be studied by means of traditional experimental science, the study acknowledged that there were two linked issues due to the approach of being reliant on observing changes in the field. The first problem was that human impacts could potentially have the same results as naturally occurring processes and the second problem being that human impacts could interact with each other, thus making it difficult to differentiate the effects of each activity (7). Despite the issues brought up in the study, it is predicted in our experiment that capturing the effects humans have on soil by gathering this information at one snapshot in time would be more useful in solving this question. Rather than pulling information over a gradual change in time, making observations between areas with varying degrees of human population density in one short time period could prove to show a result more representative to answer our question. This will make it possible to capture any statistically significant differences between areas with higher population numbers and lower population numbers. The differing levels of population numbers correlate to human activity due to the assumption that in areas with a greater number of humans present will surely have a higher level of activity, and vice versa with areas with lower populations of humans.

It is hypothesized that areas with higher human activity will have more hostile soil qualities for plants rather than areas with lower human activity. In support of finding an answer to this hypothesis, this experiment tested for variability and correlation of soil nutrient and pH among three counties which varied in human activity. As a result of this experimentation, the analyzed data insinuated that there was little to no correlation between human activity and soil health. Thus, there is insufficient evidence to confidently say that higher human activity does not necessarily result in more hostile soil quality.

METHODS

Area Selection

Firstly, I believed that the best way to sample the soil for testing was through a system of randomly generated locations. The ideal way, I thought, to avoid any experimental flaws while choosing locations to sample soil, was through a random selection of counties with varying degrees of human activity (low, moderate, and high human activity), and within those counties a set number of zip codes I could randomly pull. This was done through a random selection of three counties (Alameda, Santa Clara, and San Joaquin) that was accessible near me. These three counties would be representative of the varying degrees of human activity, as Alameda county had the highest population, thus high human activity, San Joaquin with the lowest high population, thus lowest human activity, and Santa Clara in between, with moderate human activity. Within each chosen county, three zip codes were randomly selected from the county's pool of zip codes. As a result, I had nine total zip codes (94555, 94544, 94539, 95121, 94087, 95126, 95202, 95385, and 95377) that were randomly selected to avoid any bias that could skew the results of this experiment. Within each zip code that was pulled, a grid overlay was placed over an image of the zip code's area on a map. Each unit of the grid was assigned a specific number, and then a random number was pulled from the grid three times. This was to further reduce any chances of selection bias. With 27 randomly-selected locations, I had pinpointed exactly where to extract soil samples from.

Sampling

At each of these locations, I had used a 21″ steel soil probe to reach the ideal 6″ depth (11) for extracting soil samples. These samples pulled by the probe were placed into air-tight plastic bags and ready to be tested.

Sample Testing

Testing the samples proved to be fairly stream-line as a soil test kit for pH, N, P, and K provided crucial solutions and papers to test the samples. Each soil sample was allowed to air dry, in which then it was run through respective tests which indicated the pH level, and the varying levels of N, P, and K. Data pulled from each sample was transferred

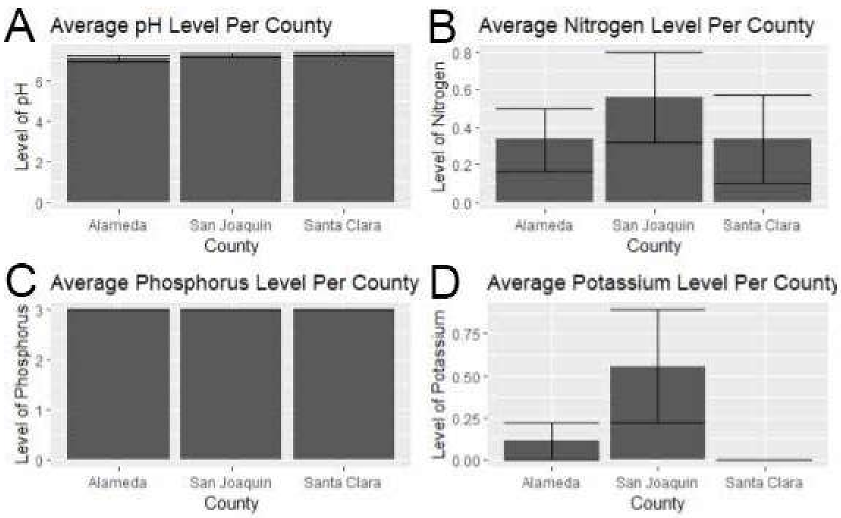

Figure 1: These graphs depict the average pH, Nitrogen (N), Phosphorus (P), and Potassium (K) levels per each county sampled from.

A. Mean +/- SEM pH for Alameda (7.111 +/- 0.138), San Joaquin (7.277 +/- 0.087), and Santa Clara County (7.333 +/- 0.083), with N=9, showed overlapping bars.

B. Mean +/- SEM N for Alameda (0.333 +/- 0.166), San Joaquin (0.555 +/- 0.242), and Santa Clara County (0.333 +/- 0.235), with N=9, showed overlapping bars.

C. Mean +/- SEM P for Alameda, San Joaquin, and Santa Clara County (3 +/- 0), with N=9, showed overlapping bars.

D. Mean +/- SEM K for Alameda (0.111 +/- 0.111), San Joaquin (0.555 +/- 0.337), and Santa Clara County (0.000 +/- 0.000), with N=9, showed overlapping bars between Alameda and Santa Clara, and San Joaquin and Alameda.

to a spreadsheet, where data would be grouped depending on which county it was sampled from and the variable it was testing for.

Data Analysis

With all the data regarding pH, N, P, and K respective to each county and variable being tested, an ANOVA test was run to examine for any differences in group means. In this experiment, the ANOVA test is used to see if there were any significant differences in pH, N, P, and K averages between the different counties. To further analyze data, a Pearson test was run to examine any correlations between human activity and soil parameters. The Pearson test would reveal coefficient correlation values between each variable (population, N, P, and K), and as a result, indicate how strong of a relationship one variable has with another. Data organization and test calculations took place in the software, R. From the results of the ANOVA and Pearson test, I was able to present a statement reflective of the relationship between human activity and soil health.

RESULTS

The impact of human activity (measured in population) on soil was investigated by methods in which soils in varying locations were examined to see any significant results. Across three counties (Alameda, San Joaquin, and Santa Clara), samples of soil were collected and tested to capture the differing levels of pH, nitrogen, phosphorus, and potassium. Three zip codes per each county were selected to sample soil from to create a fair experiment. The data were then averaged per respective county and were organized and analyzed by R.

pH	Df	Sum Sq	Mean Sq	F value	Pr(>F)
County	2	0.2407	0.1204	1.182	0.324
Residuals	24	2.4444	0.1018		
Nitrogen (N)	Df	Sum Sq	Mean Sq	F value	Pr(>F)
County	2	0.296	0.1481	0.348	0.71
Residuals	24	10.222	0.4259		
Phosphorus (P)	Df	Sum Sq	Mean Sq	F value	Pr(>F)
County	2	6.31E-30	3.16E-30	1	0.383
Residuals	24	7.57E-29	3.16E-30		
Potassium (K)	Df	Sum Sq	Mean Sq	F value	Pr(>F)
County	2	1.556	0.7778	2.049	0.151
Residuals	24	9.111	0.3796		

Figure 2: ANOVA test results with p values per each variable of soil tested between the three counties (Alameda, San Joaquin, and Santa Clara). pH p value (0.324), Nitrogen p value (0.71), Phosphorus p value (0.383), and Potassium p value (0.151), all under the 0.05 significance level.

Of the four bar graphs created, the pH bar graph (Figure 1A) yielded results that were considered to be non-significant. Moreover, the nitrogen (Figure 1B), phosphorus (Figure 1C), and potassium (Figure 1D) bar graphs yielded results that too were considered to be non-significant. Bar graphs, with error bars representing the standard error of the mean (SEM) included, respective to each variable being tested in the soil resulted in data that overlapped among each other, thus suggesting non-significance.

Furthermore, the ANOVA test (Figure 2) indicated that results were also non-significant based on a 0.05 significance level. Due to non-significant results, a Pearson correlation test was conducted where it would test for any correlations between population numbers, pH, nitrogen, phosphorus, and potassium.

This test (Figure 3) resulted in correlation coefficient values that did not exceed a relationship that is considered to be a strong relationship but rather a moderate relationship, in terms of the correlation coefficient that is +/-0.6 being a moderate relationship (8). Pearson correlation test (Figure 3) also indicated that all p values were greater than the 0.05 significance level, thus results are non-significant.

DISCUSSION

After analysis of the data, the data reveals a failure to reject the null hypothesis thus suggesting that there is no significant relationship between human activity (measured by population) and the quality of soil. This does not support the initial hypothesis in which it was predicted that areas with higher human activity will have more hostile soil qualities for plants rather than areas with lower human activity.

In the bar graphs representing the data collected between the three counties (Figure 1), they are all cases of non-significant results, as error bars overlap. Although we can not necessarily conclude that there is no significance due to overlaps, it is a clue that non-significance is of great possibility. Furthermore, ANOVA test results also suggested non-significant results, based on a significance level of 0.05 as all p values dramatically exceeded that level. Due to a non-significant suggestion from ANOVA (Figure 2), a closer inspection to analyze variable to variable correlation was conducted by means of Pearson's r (Figure 3). By utilizing R, data organization was easily computed and resulted in values revealing the strengths of each variable's correlation to another variable's. This further resulted in having no strong correlations as the strongest relationship was determined to be moderate while having no significant variation between some variables, phosphorus, and others. While having no significant results or particularly strong correlation, there were some pertinent results that were acknowledged.

Soil is a dynamic resource, meaning that it is always changing and responding to environmental factors. As seen in the experiment completed in 2011 by Zhipeng et al., soil responded very significantly due to land use, precipitation, temperature, and even elevation (9). Therefore, suggesting that soil is highly susceptible to changes, and thus varying human populations could induce changes in soil. This

r / p value	Population	pH	N	P	K
Population	1 / _	-0.56 / 0.1139	-0.6 / 0.0859	NaN / _	-0.34 / 0.3739
pH	-0.56 / 0.1139	1 / _	0.27 / 0.4802	NaN / _	0.23 / 0.5438
N	-0.6 / 0.0859	0.27 / 0.4802	1 / _	NaN / _	0.05 / 0.8977
P	NaN / _	NaN / _	NaN / _	1 / _	NA / _
K	-0.34 / 0.3739	0.23 / 0.5438	0.05 / 0.8977	NaN / _	1 / _

Figure 3: Pearson correlation coefficient test results between the variables: population, pH, N (Nitrogen), P (Phosphorus), and K (Potassium). Correlation coefficient results found there to be no significant variation between P with any other variables tested. Correlation coefficient relationship between population and pH, N, and K resulted in -0.56, -0.6, and -0.34 respectively. Correlation coefficient relationship between pH, and N and K resulted in 0.27 and 0.23 respectively. Correlation coefficient relationship between N and K resulted in 0.05

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leads to potential errors that could have occurred in experimentation.

A lack of support could potentially be due to a multitude of reasons. Firstly, a lack of a large sample size could have influenced the result of non-significance as smaller sample sizes will generally mean more variability (10). Thus, creating results that are not fully representative.

Additionally, there may have been an overwhelming number of confounds (e.g., varying organic matter and pre-mixed soils with designated nutrient and pH levels) that could have influenced the results of the experiment. These confounds could possibly be controlled in future experimentation through longer time spans of testing and use of replicates, as this experiment was done under tight time constraints. There could also be simple errors in testing (e.g., soil cross-contamination and lack of professional lab equipment) that could have skewed test results, thus leading to non-significance.

In future experimentation, sampling should be done over a wider variety of locations, potentially world-wide, and over greater lengths of time. The need for taking samples of greater lengths of time was demonstrated in Ian C. Grieve's study conducted in 2001 in which it is mentioned that soil can change slowly and as a result cannot be studied by means of "classical experimental science" (7). Soil can change drastically over a span of just days to a span of multiple years (7) and so it is important to capture the full effect humans can have on soil through a wider scope of experimentation length.

Connecting Ian's study done in 2001 (7), Zhipeng et al.'s study in 2011 (9), and this experiment, it is crucial to see the conditions in which soil can be tested to show valid and accurate results are delicate. Time must be taken into consideration, with respect to variations in weather and even elevation. This experiment may have shown non-significant results, but between errors made and past experimentations, it paves a way for successful future experimentation.

ACKNOWLEDGMENTS

I would have not been able to complete this project without the help of a few others, so I would like to take this space to acknowledge them. A big thank you to my parents, Spencer Eusden, Daniel Dudek, and friends for their support and guidance along this journey.

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Aeroponic Experiment: The Efficiency of Aeroponics in Non-ideal Farming Conditions

Pascal Wettermark[1] and Spencer Eusden[2]

[1]Sugarbowl Academy, [2]Headwaters Science Institute

ABSTRACT

This experiment is about the efficiency of aeroponics in nonideal farming conditions. It was conducted in Truckee, California around 6,700 feet above sea level in very dry farming conditions. Studying aeroponics in harsh environments can be useful. Farming has never been considered in harsh environments, instead, we import our goods. Studying aeroponics in harsh conditions can prove to farmers that aeroponics can be used in harsh conditions, decreasing the need for imported goods. We hypothesized that aeroponics would use water more efficiently than soil-based farming. Results show that the aeroponics system used a lot less water but produces the same amount of plant growth. Aeroponics is a promising substitute for soil-based farming at high altitude in dry farming conditions. Aeroponics uses 90% less space therefore it can be applied in urban settings. Since aeroponics can be grown near urban and rural areas decreasing the need of transporting goods. This can reduce the amount of carbon emissions released by transportation. Most studies on aeroponics are done indoors therefore there isn't much data on outdoor aeroponics. My experiment provides evidence that aeroponics can be used outdoors at high altitudes in dry conditions. Future research should be focused on if aeroponics works in other unfavorable conditions. It will be really interesting to see if the water that isn't being used in the aeroponics system can be used over and over again or if it starts to get toxic for the plants.

INTRODUCTION

To explore the potential of aeroponics as a farming method, aeroponics was tested for how it would fare in terms of water usage and growth productivity, when used in high altitude, high desert (dry) climate. A traditional soil farming method was juxtaposed as comparison to aeroponics. The experiment was conducted in Tahoe, California at altitude 6,700 ft in planting zone 6b -7a (1), June - July, 2020. It included the planting, growing, and studying of spinach, arugula and radish seeds.

The world's population has increased from 1 billion in the 1800's to 7.7 billion today (2). The rapid increase in population has created a huge demand for food. Farmers have been able to meet this demand, but at a cost; space, water. In 2017, 23% of habitable land was used to grow crops (3) and 70% of freshwater is used for agriculture (4). Current farming methods are unsustainable given population growth and water and space intensive farming methods. One way to address this problem could be the use of new farming methods.

Aeroponics holds promise in this area. It is claimed to use 98% less water and 90% less space (5, 6). Some businesses, such as Plenty, have become very successful using aeroponics. With the use of aeroponics, these businesses can help reduce the likelihood droughts and deforestation and in the extension reduces wildfires and vegetation loss.

To date, most aeroponics systems are indoors primarily because it gives the farmer better control of the environment. Building indoor farms can be very costly (7). There are some aeroponic farming experiments taking place outdoors too. For example, one aeroponics experiment took place in Mindanao, an island in southern Philippines. Mindanao has ideal farming conditions with warm temperatures, regular rainfall, and it is generally protected from typhoons (8).

The research question at hand, focuses on aeroponics in non ideal conditions. What farming method, aeroponics or soil-based farming uses water more efficiently in high mediterranian conditions? Considering the successes of aeroponics in controlled or favorable farming conditions, the