Biology SL

Internal Assessment

The effect of the pH level of soil on its ability to support plant biodiversity

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Background:

Soil is the most important facilitator that provides support for a plant to grow. Soil provides the plant with nutrients, minerals, water and helps in other natural processes crucial for the plants survival. Sometimes, the extent to which a particular type of soil can support plant growth can vary. This may depend on the amount of moisture present in the soil, it's fertile, the amount of nutrients or it's pH level. The pH of a soil is important because it determines the ease with which plants can take up nutrients from the soil. My experimentation will not harm any living organism and I wont disturb the environment that I conduct my experiment in. I chose this topic because I am passionate about environmental sustainability and would like to peruse it as a career. Knowledge in this aspect, would help devise new ways for afforestation.

Research Question:

How does the pH level (4.5, 5.3, 6.9 ,7.8, 9) of the soil affect the diversity of plants in it, at different locations in The Aga Khan Academy, Hyderabad? My aim is to compare the diversity of plant species in different locations of my 100-acre school campus with respect to different amounts of pH in the soil using the Simpson's Diversity index as a measure. I will focus on how the pH level of a soil can affect the diversity of the plants it can sustain. *The pH level of a soil is the measure of its acidity or alkalinity on a scale of 1 to 14*[1]. A pH of 7 is said to be neutral and acidic if more or alkaline if lesser.

Hypothesis:

I think that the most abundant diversity will be present in a soil with a pH level that is closer to 7. The plant cover should reduce as the pH level increases or decreases form pH 7. For example, in a soil with a pH of 6 we should be able to find more evenness and richness as compared to the one that we might be able to find in a soil with a pH of 10.

Variables:

Variable	**Method of Manipulation**

[1] *ESF Education*. N.p., n.d. Web. 5 Oct. 2015. <http://www.esf.edu/pubprog/brochure/soilph/soilph.htm>.

Independent Variable (pH Level of Soil)	I will be choosing sample locations with different pH levels for this study. The measurements will be made using a pH meter which has an uncertainty of ($\pm$0.2.)
Dependent Variable (Plant Diversity)	The diversity of plants present will be the dependent on the pH level of the soil. I will measure this with a visual count.
Controlled Variables	**Method of Control**
1) *The size of the sample area*	This will be done by using a quadrat of the same size throughout the experiment while taking all samples. It is important because all the samples should be of a similar size ($1m^2$) to make an accurate comparison.
2) *The time period in which the readings are taken*	This will be done by taking all the readings within a period of one day. This way, the weather or any other factor will not be able to affect the reading of a particular sample location. It is important because due to factors like rain, landscape maintenance or gardening, some of the natural vegetation could be lost. This is why it is important to take all the readings within a day to reduce the likelihood of such an instance.
3) *The method I use to measure the pH of the soil*	This can be done by using the same pH meter for all the readings so that the data is more accurate. If the pH readings are not accurate enough, then my data might be biased due to an error that could have easily been avoided.
4) *The amount of soil diluted in water to have proportionate readings*	This can be done by taking a fixed amount of soil and mixing it with a fixed amount of water before measuring its pH level. This is important because the pH level has to be measured in a proportionate amount for all samples for the data to be accurate.

5) *The method of counting vegetative cover*	This can be done by me collecting all the data just by myself. I would best know the personal method / style that I employ to take the measurements and would easily be able to reproduce the same method/style across all sample locations. This is important if I want to produce un-biased and accurate data.
6) *The measure used to compare all the raw data*	To compare the sets of data collected from the sample locations, I will be using the Simpson's Diversity Index. This way I will have one measure to compare all values in an un-biased manner.
7) *Sampling method*	I will follow a random sampling with the quadrat placement method so that I have un-biased data.
Uncontrolled variables	The variable that I cannot control would be the weather.

Apparatus Required:

1. To build the Quadrat:
    - 4 Pipes of 1 meter in length
    - 4 corner connectors for the pipes
    - 50 meters of thread
    - 1 bottle of super-glue
    - 1 1.5-meter scale
    - Scissors
2. To measure the pH levels of soil:
    - 20 beakers with a capacity of 250 ml
    - 5 petri dishes
    - 1 electronic weighing scale
    - 5 lab spoons
    - 5 stirrers
    - 1 liter of distilled water

- 1 pH meter
- 1 log book
- 1 hand shovel

3. To measure the vegetative cover:
   - 1 Quadrat (1m x 1m)
   - 1 log book

Procedure:

Building the Quadrat (Preparation)

1) Join all the 1 m pipes using the corner connectors, making a square of 1m x 1m.
2) Use superglue to seal all the connections.
3) Use the scale to divide and mark each pipe at a distance of 10 cm to be left with 10 equal sections.
4) Repeat this process on the other 3 sides.
5) Take the thread, pull it across to the other end and tie it exactly where the corresponding opposite marks meet.
6) Repeat the same for the other two sides.
7) Use superglue to strengthen each of the knots.
8) You should now be left with a quadrat of length 1 m x 1m with 100 squares inside.

Measuring the pH level of the sample locations (Preparation)

1) In your area of study, pick any 5 locations (A, B, C, D and E) that are equally apart from each other in terms of distance.
2) Go to each location and use the hand shovel to dig up and collect soil samples to fill up the 250 ml beaker and label each A, B, C, D, and E respectively.
3) Bring all the 5 samples back to the lab. Take sample 'A'. Place a petri dish on the weighing scale. With the help of a lab spoon, fill the petri dish with exactly 20 grams the soil sample. Add 75 ml of distilled water to another beaker and add the 20 grams of sample soil to this beaker and stir it well. Label this beaker as 'A', correspondingly.

4) Let the sample rest for 3 minutes. Next, take the pH meter and dip it in the sample for 3 seconds and pull it out. See the reading and make note of the pH level. Repeat this process 2 more times and take the average of the 3 readings.
5) Repeat steps 3 and 4 for the rest of the samples, B, C, D, and E.

Measuring the vegetative cover (Data Collection)

1) Go to location 'A' and throw the quadrat randomly. Identify each species you see within the boundaries of the quadrat and make note of their frequency in your log book. Repeat this process 4 more times in the same location and record all the readings.
2) Repeat step 1 for locations B, C, D, and E as well. You should have a total of 25 readings now. Transfer this raw data onto excel so it can further be processed.
3) On excel, convert all the raw data to one single measure. I have chosen the Simpson's Diversity Index as a way to compare all the data. Do so for all the data collected.

Risk Assessment:

This experiment does not involve any harmful chemicals or tools. I do not think that there is any risk involved. Although, I think that one would need to be careful while using a spade to dig and also while choosing the locations for taking samples based on their accessibility. One should also be aware of the animals in the habitat and make sure neither them nor the animals are harmed in any way.

Data Collection:

The data was collected from 5 different locations of my 100-acre campus. The sets are labelled as A, B, C, D, and E and are marked with their respective pH readings as well. Below are the raw data readings:

Table 1. Qualitative Analysis for Locations

Location	Observations
A (pH 4.5)	At this location, I observed that there was a low amount of vegetative cover as compared to the other sites. I was able

	to count a total of 4-5 species. The were mostly just small plants. The land was quite dry and barren.
B (pH 5.3)	At this location, I was able to see an increased vegetative cover. The location had 6-7 species and they were medium sized plants as well.
C (pH 6.9)	At this location, I had the best observations. I counted 9-10 species. The location was the greenest, with a lot of plants and also had lots of trees around.
D (pH 7.8)	This location had 7-8 species and the vegetative cover was comparatively lower. The plants were
E (pH 9)	This location again had a drop in the number of species which was about 5-6. The vegetative cover was quite low with small plants only. The land was mostly barren and dry.

Table 2. Raw Data Collection for Location A pH 4.5($\pm$0.2)

Type/Frequency	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5
Species A	07	03	01	02	02
Species B	06	00	00	00	00
Species C	05	03	02	01	05
Species D	04	01	01	04	03
Species E	00	00	00	00	00
Species F	00	00	00	00	00
Species G	00	00	00	00	00
Species H	00	00	00	00	00
Species I	00	00	00	00	00

Table 3. Raw Data Collection for Location B pH 5.3($\pm$0.2)

Type/Frequency	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5
Species A	07	09	08	06	12
Species B	06	05	06	03	00
Species C	04	00	00	00	03
Species D	01	08	04	07	04
Species E	02	08	03	12	00
Species F	05	08	04	09	04
Species G	00	00	00	00	00
Species H	00	00	00	00	00
Species I	00	00	00	00	00

Table 4. Raw Data Collection for Location C pH 6.9($\pm$0.2)

Type/Frequency	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5
Species A	08	09	03	05	08
Species B	02	08	04	06	05
Species C	07	01	06	05	05
Species D	06	08	03	07	06
Species E	03	06	07	04	03
Species F	04	09	04	05	01
Species G	09	03	06	08	04
Species H	04	09	03	07	07
Species I	05	07	04	05	02

Table 5. Raw Data Collection for Location D pH 7.8($\pm$0.2)					
Type/Frequency	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5
Species A	06	02	09	12	04
Species B	08	03	11	08	07
Species C	05	09	06	00	00
Species D	08	01	09	09	03
Species E	04	08	08	07	06
Species F	02	08	02	03	05
Species G	01	03	03	06	00
Species H	00	00	00	00	00
Species I	00	00	00	00	00

Table 6. Raw Data Collection for Location E pH 9($\pm$0.2)					
Type/Frequency	Reading 1	Reading 2	Reading 3	Reading 4	Reading 5
Species A	08	01	08	05	10
Species B	05	11	00	03	00
Species C	08	03	00	00	00
Species D	07	04	06	03	12
Species E	01	00	00	04	00
Species F	02	00	00	12	04
Species G	00	00	00	00	00
Species H	00	00	00	00	00
Species I	00	00	00	00	00

After the collection of the raw data, the data had to be converted to a measurable value that could be used to compare each of the samples. For this, I chose to use the Simpsons Diversity Index. "*Simpson's Diversity Index is a measure of diversity which takes into account the number of species present, as well as the relative abundance of each species. As species richness and evenness increase, so diversity increases.*"[2] The formula for this index is:

$$D = 1 - \left(\frac{\sum n(n-1)}{N(N-1)}\right)$$

'D' is the notation for 'Simpsons Diversity Index'. The 'n' represents the total number of organisms in 'a particular species. The 'N' represents the total number of organisms of all species combined. Following are the calculations of the Simpson's Diversity Index for all locations. Sample calculation:

$$N = 10$$

$$N(N-1) = 10 \times 09 = 90$$

[2] "Simpson's Diversity Index." Simpson's Diversity Index. N.p., 16 Oct. 2015. Web. 16 Oct. 2015. <http://geographyfieldwork.com/SimpsonsDiversityIndex.htm>.

$$\Sigma\, n(n-1) = 17.44$$

$$D = 1 - \left(\frac{\sum n(n-1)}{N(N-1)}\right)$$

$$D = 0.80622222$$

Following are the tables of the processed data:

Table 7. Simpson's Diversity Index for Location A pH 4.2($\pm$0.2)

Type	n	n(n-1)	Σ n(n-1)	N	N(N-1)	D
Species A	03	06	17.44	10	90	0.8062
Species B	1.2	0.24				
Species C	3.2	7.04				
Species D	2.6	4.16				
Species E	00	00				
Species F	00	00				
Species G	00	00				
Species H	00	00				
Species I	00	00				

Table 8. Simpson's Diversity Index for Location B pH 5.3($\pm$0.2)

Type	n	n(n-1)	Σ n(n-1)	N	N(N-1)	D
Species A	8.4	62.16	142.96	29.6	846.56	0.8311
Species B	04	12				
Species C	1.4	0.56				
Species D	4.8	18.24				
Species E	05	20				
Species F	06	30				
Species G	00	00				
Species H	00	00				
Species I	00	00				

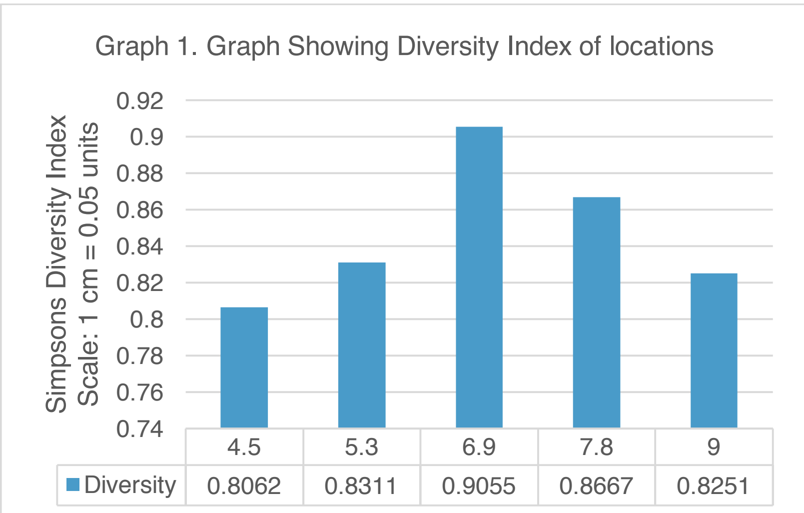
Table 9. Simpson's Diversity Index for Location C pH 6.9($\pm$0.2)

Type	n	n(n-1)	Σ n(n-1)	N	N(N-1)	D
Species A	6.6	36.96	214.88	48.2	2275.04	0.9055
Species B	05	20				
Species C	4.8	18.24				
Species D	06	30				
Species E	4.6	16.56				
Species F	4.6	16.56				
Species G	06	30				
Species H	06	30				
Species I	4.6	16.56				

Table 10. Simpson's Diversity Index for Location D pH 7.8(±0.2)						
Type	n	n(n-1)	Σ n(n-1)	N	N(N-1)	D
Species A	6.6	36.96	179.44	37.2	1346.64	0.8667
Species B	7.4	47.36				
Species C	04	12				
Species D	06	30				
Species E	6.6	36.96				
Species F	04	12				
Species G	2.6	4.16				
Species H	00	00				
Species I	00	00				

Table 11. Simpson's Diversity Index for Location E pH 9(±0.2)						
Type	n	n(n-1)	Σ n(n-1)	N	N(N-1)	D
Species A	6.4	34.56	91.66	23.4	524.16	0.8251
Species B	3.8	10.64				
Species C	2.2	2.64				
Species D	6.4	34.46				
Species E	01	00				
Species F	3.6	9.36				
Species G	00	00				
Species H	00	00				
Species I	00	00				

Graphical Representation[3]:



[3] Appendix T1

From the graph above, it is evident that my hypothesis was right. It is seen that as the pH level of the soil becomes closer to the neutral level of pH 7, at 6.9, the plant diversity is highest at a diversity index of 0.9055 as compared to the other locations with different pH levels. It is seen reducing as it moves away from the neutral pH; at pH 5.3 and 4.5 the diversity index is 0.8311 and 0.8062 respectively. On the other hand, as it increases above the pH of 6.9, towards 7.2 and 9, the diversity index again falls to 0.8667 and 0.8251. It is evident that my qualitative data supports my quantitative data. My observations have now been proven scientifically as well.

Conclusion and Evaluation:

In conclusion, my hypothesis was proved right; the trend evident was that as the pH level of the soil moved away from the suitable level of 7, the diversity index reduced. Another study had the similar findings; "*The 'ideal' soil pH is close to neutral, and neutral soils are considered to fall within a range from a slightly acidic pH of 6.5 to slightly alkaline pH of 7.5. It has been determined that most plant nutrients are optimally available to plants within this 6.5 to 7.5 pH range, plus this range of pH is generally very compatible to plant root growth*."[4] This proves that my experiment was successful and the results are reliable. One would be able to get the same results if the experiment is repeated correctly. In terms of my strengths, my results are completely valid as the variables were well-controlled and no external factor affected my experimentation. I feel that there were a few aspects of my experiment that I could have avoided and improved to produce even more accurate results.

Error	Improvement
Counting Plants by Looking	In taking measurements this way, I could have possibly missed a few plants or recounted them. I think what would have been better was if I had tagged every plant

[4] "Soil PH and the Availability of Plant Nutrients." *Nutrient Stewardship*. N.p., n.d. Web. 18 Sept. 2015. <http://www.nutrientstewardship.com/implement-4rs/article/soil-ph-and-availability-plant-nutrients>.

	I counted provided I had more time. This would make my readings more accurate.
Foot Injury	I sustained a foot injury during my experimentation because I was not careful. I could have been more careful and dressed appropriately to ensure my safety.
Taking Measurements on un-even Surfaces	This is another mistake that I realized quite late into my experiment. A few locations were slopes and had rocks around. This way, the quadrat was not placed perpendicular to the ground and was at an angle or elevated. This way, I might have ended up counting lesser or even more number of plants than there actually were in the bounded region. I could have made sure that all my sample locations were flat surfaces.

In terms of the impacts of uncertainty on my analysis, they wouldn't have really made much of a different because, the pH levels were far apart in terms of value. Overall, I was able to manage my time very well, complete the tasks on time as planned. Although, during the experimentation I sustained an injury in my foot which pushed back the experimentation process. This is one of the reasons that I could not employ the tagging method to measure frequencies. I was able to collect and complete everything in an organized manner. There was no opportunity to measure the standard deviation of in this experiment as the data was collected visually and the only calculations were made in the processed data using formulas. Also, we are advised to measure standard deviation if we have 10 reading or more; I had just 5. Overall, this was a really interesting experiment and I learnt quite a lot. I hope to conduct similar experiments in the future!

P1. Photographs of the Quadrat at a Location and the Lab Set up.

Bibliography

1) *ESF Education*. N.p., n.d. Web. 5 Oct. 2015. <http://www.esf.edu/pubprog/brochure/soilph/soilph.htm>.

2) "Simpson's Diversity Index." Simpson's Diversity Index. N.p., 16 Oct. 2015. Web. 16 Oct. 2015. <http://geographyfieldwork.com/SimpsonsDiversityIndex.htm>.

4) "Soil PH and the Availability of Plant Nutrients." *Nutrient Stewardship*. N.p., n.d. Web. 18 Sept. 2015. <http://www.nutrientstewardship.com/implement-4rs/article/soil-ph-and-availability-plant-nutrients>.

Appendix

3) Table for Graph Showing Diversity Index of the AKAH Campus:

pH Level	Diversity
4.5	0.8062
5.3	0.8311
6.9	0.9055
7.8	0.8667
9	0.8251