Environmetal Systems and Societies

May 2021

RQ : To what extent does species diversity of plants vary in an undisturbed area and a disturbed area?

Context :

To commence with, the exponential population increase has led to various problems that has detoriated the biodiversity around us such as; exploitation of resources, habitat fragmentation, habitat loss, selective breeding, introduction to alien species, changes in abiotic and biotic factors and high level of pollution. This has resulted into loss of species diversity in the human intervened areas. Residing in a residential area I only see a few plant species in my park, which are only planted here due to their aesthetic value. On contrary in open areas such as Gautam Buddha University (GBU) , which is far from the human establishments has comparatively greater plant species than the park in sector 44. Most of the endemic plant species in GBU are unknown to common people, but have been in the region since the beginning but are not seen in residential areas anymore as they hold low aesthetic values.

Ample of reports highlighted the declining flora and fauna situation in the Delhi NCR areas due to rapid urbanization. The growing urbanization and industrialization is stated to be the main cause for the endemic species to lose their natural habitat[1], especially in the urban areas like Noida and its surroundings.

One of the important qualities which determines the balance in the environment is species diversity. The species diversity can be measured through the Simpson diversity index which takes in account the number of species and their relative abundance. In order to determine the extent to which humans contribute to the problem of declining biodiversity, I have decided to

[1] Causes of EARTH'S declining biodiversity. (2019, February 05). Retrieved March 23, 2021, from https://healingearth.ijep.net/biodiversity/causes-earths-declining-biodiversity

conduct this investigation and see how diversity varies in an undisturbed area and a residential area.

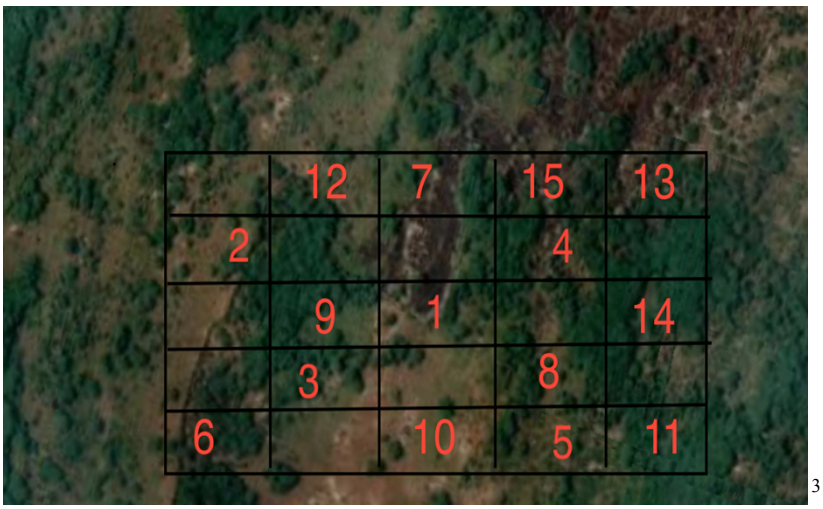
<u>Locational context</u> :

Hence, we take samples from 2 different areas in Noida region and calculate the species diversity. The two areas selected are a residential park in my sector and second is the Gautam Buddha University open field (GBU). The size of RWA Park is relatively small compared to the open area of GBU, however equal amount of land was demarcated to conduct the experiment.



[2] (RWA Park in Sector 44.)

[2] Overview. (n.d.). Retrieved February 24, 2021, from https://www.google.com/earth/



[3] (Open field near GBU, Greater Noida.)

The reason for choosing the 2 areas are the major differences between them in terms of human intervention. GBU is an open field, which has minimal intervention and RWA park is a place where there is high human presence and intervention. The area considered in both the sampling is same, that is 100 square meters. The sampling technique which is going to be used will be random sampling.

Planning and Preparation :

Sr. No.	Materials
1	Soil NPK and pH indicator kit
2	notepad
3	Pen
4	Camera
5	Measuring tape

[3] Overview. (n.d.). Retrieved February 24, 2021, from https://www.google.com/earth/

6	Cups of soil from GBU Campus- 3
7	Cups of soil from Sector 44 Park- 3
8	1 quadrat of 1 x 1 meter
9	Gloves
10	Medical kit

Table 1: Material used

Hypothesis :

The RWA Park will have lesser species diversity when compared to the open field area near GBU due to differences of human intervention in the two areas. The open field area of GBU is not intervened for any means whereas the RWA park is in the centre of a hugely populated sector. In areas such as parks only plants that are wanted are harvested, just for aesthetic purposes. Moreover the abidingness of plants is controlled in the parks, they are restricted to a certain limit, unlike in the open areas. However, I do expect to see a good evenness amongst the plants in RWA park due to the fact that it is monitored and controlled by the RWA committee. In GBU I expect to see abundant species and richness as it's not controlled by humans, but the evenness may vary and not be optimum.

Variables :

Independent Variables	**Dependent Variables**
The areas which are being sampled (the RWA Park in Sector 44 and the open field in GBU	• The Number of the plant species found and their abundance from the two places

	● The density of plants found ● The NPK and pH value of the soil

Controlled Variables :

Variable	Method of controlling	Reason of controlling
The method of sampling (random sampling) and the procedure for conducting the lab.	A random generator will be used at all places and same methodology will be followed.	If different sampling methods are used then the gathered data may vary.
Size of quadrats made for collecting samples are fixed for the two areas (1 x 1 meter)	Same quadrats will be used at all locations	If the size of the quadrats vary the sample collected will vary.
The number of location within the 2 selected areas would be constant	15 different location within the RWA park and GBU will be sampled.	This will be done in order to have same amount of sample size for both and minimize any bias.
The person carrying out the data collection	The investigation and data collection will be done by me only	In order to have the same judgment.
Using the same equipment (soil testing kit, quadrat, etc)	Used the same materials and equipments all the time	To avoid variability in results due to use of different equipment

Methodology :

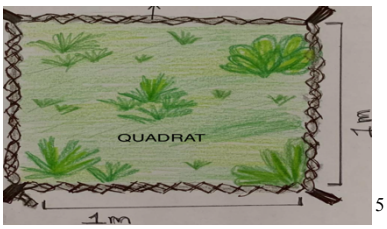
One day before the trip to the observation sites:

- A green area having good amount of grass was randomly selected for sampling in both the places as greener area has more chances of biodiversity. The method used was random sampling so that it provides the chance for equal selection of the individual plants and organisms. It makes sure that the bias involved is minimal[4].

On the day of the trip to the observation sites:

- The quadrats were randomly selected in the area that was being surveyed. A grid was made with the help of 2 measuring tapes by placing them at right angles to each other. Using a random number generator, the 'x' and 'y' coordinates were ascertained for locating the coordinates. The random number generator is used twice- once for the 'x' coordinate and once for the 'y' coordinate.
- Collected samples (only seedlings were considered and not saplings) from one quadrat using the above procedure. The species of plants obtained is noted down with the help of notepad and pen. Repeated this for another 14 times in different spots within the area, making it total 15 different spot trials in the area being considered. Ample of areas within the locations were tested in order to be able to find accurate results, also the selected areas were quite big, hence 15 samples are viable. The picture below illustrated the quadrat's dimension that was used.

[4] Reeger, A. (n.d.). Technically speaking: Why we use random sampling in reading research. Retrieved March 23, 2021, from https://iowareadingresearch.org/blog/technically-speaking-random-sampling



[5]

- Also, 3 soil samples were taken randomly from any of the 15 areas within the 2 locations (GBU and RWA park) making it a total of 6 samples.
- Followed the same steps for both the areas: RWA Park in Sector 44 and the open field in GBU.

A day after the trip to the observation sites:

- The collected soil samples from the two sites were tested to find the pH and NPK (Nitrogen, Potassium and Phosphorus) values using a soil testing kit.
- The Simpson's index is calculated using the formula:

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

D = Diversity index

N = Total number of organisms of all species found

n = Number of individuals of a particular species

Risk Assessment :

Both the sampling areas, i.e., the RWA Park in Sector 44, Noida as well as the Open field near GBU, Greater Noida were used for the research only after taking the due clearance and permission of the concerned officials. The soil samples were extracted carefully without harming the plants present there. Only 1 person went inside the quadrat to collect the soil

[5] Self-Drawn

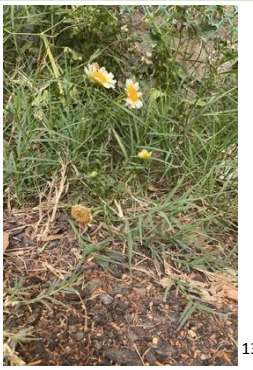
sample. Post the soil collection, the dug up land surface was evened out and the extra soil extracted was put back. For personal safety the first aid kit was present at all times during the sampling.

Results :

Eight different plant species found at the two locations of investigation:

SPECIES NAME	SPECIE IMAGE
Abutilon indicum	[6]
Creeping yellow woodsorrel	[7]
Malva sylvestris	[8]
Sweet Alison	[9]

[6] Self-clicked image
[7] Self-clicked image
[8] Self-clicked image
[9] Self-clicked image

Garden Lobelia	 [10]
Black nightshade	 [11]
Solanum villosum	 [12]
Leucanthemum	 [13]

The species were identified with the help of a local gardner and the application "NatureID"[14]

[10] Self-clicked image
[11] Self-clicked image
[12] Self-clicked image
[13] Self-clicked image
[14] Natureid: Identify plants, flowers, trees & leaves – apps on google play. (n.d.). Retrieved April 01, 2021,

<u>Raw Data</u> :

Species data were collected from 15 different areas of each location. The tables are given below:

Quadrat Sample No.	**Species**	**Number (*n*) ± 1**	**Total Individuals in Area (*N*)**	**Diversity Index** $\frac{N(N-1)}{\Sigma n(n-1)}$	**Percentage uncertainty of *n***	**Density in %** $\frac{n}{N} \times 100$
1	Leucanthemum	5	28	7.26	$\frac{8}{28}$ x 100 = 28.57%	17.86%
	Garden Lobelia	2				7.14%
	Malva sylvestris	8				28.57%
	Sweet Alison	2				7.14%
	Abutilon indicum	1				3.57%
	Solanum villosum	3				10.71%

fromhttps://play.google.com/store/apps/details?id=plant.identification.flower.tree.leaf.identifier.identify.cat.dog.breed.nature&hl=en_IN&gl=US

	Black nightshade	4				14.29%
	Creeping yellow woodsorrel	3				10.71%
2	Leucanthemum	6	33	7.71	$\frac{8}{33}$ x 100 = 24.24%	18.18%
	Garden Lobelia	2				6.06%
	Malva sylvestris	7				21.21%
	Sweet Alison	3				9.09%
	Abutilon indicum	1				3.03%
	Solanum villosum	4				12.12%
	Black nightshade	5				15.15%
	Creeping yellow woodsorrel	5				15.15%
3	Leucanthemum	3	28	6.63	$\frac{8}{28}$ x 100 = 28.57%	10.71%

	Garden Lobelia	1				3.57%
	Malva sylvestris	9				32.14%
	Sweet Alison	3				10.71%
	Abutilon indicum	1				3.57 %
	Solanum villosum	3				10.71%
	Black nightshade	4				14.29%
	Creeping yellow woodsorrel	4				14.29%
4	Leucanthemum	4	33	8.12	$\frac{8}{33}$ x 100 = 24.24%	12.12%
	Garden Lobelia	7				21.21%
	Malva sylvestris	6				18.18%
	Sweet Alison	5				15.15%
	Abutilon indicum	2				6.06%

	Solanum villosum	2				6.06%
	Black nightshade	5				15.15%
	Creeping yellow woodsorrel	2				6.06%
5	Leucanthemum	5	37	8.36	$\frac{8}{37}$ x 100 = 21.62%	13.51%
	Garden Lobelia	4				10.81%
	Malva sylvestris	4				10.81%
	Sweet Alison	8				21.62%
	Abutilon indicum	1				2.70%
	Solanum villosum	5				13.51%
	Black nightshade	5				13.51%
	Creeping yellow woodsorrel	5				13.51%

6	Leucanthemum	2	28	8.21	$\frac{8}{28}$ x 100 = 28.57%	7.14%
	Garden Lobelia	3				10.71%
	Malva sylvestris	2				7.14%
	Sweet Alison	6				21.43%
	Abutilon indicum	1				3.57%
	Solanum villosum	4				14.29%
	Black nightshade	5				17.86%
	Creeping yellow woodsorrel	5				17.86%
7	Leucanthemum	4	32	7.51	$\frac{8}{32}$ x 100 = 25%	12.5%
	Garden Lobelia	3				9.37%
	Malva sylvestris	9				28.13%
	Sweet Alison	3				9.38%

	Abutilon indicum	2				6.25%
	Solanum villosum	4				12.5%
	Black nightshade	5				15.63%
	Creeping yellow woodsorrel	2				6.25%
8	Leucanthemum	2	31	8.30	$\frac{8}{31}$ x 100 = 25.80%	6.45%
	Garden Lobelia	3				9.68%
	Malva sylvestris	6				19.35%
	Sweet Alison	4				12.90%
	Abutilon indicum	1				3.23%
	Solanum villosum	5				16.13%
	Black nightshade	6				19.35%

	Creeping yellow woodsorrel	4				12.90%
9	Leucanthemum	5	27	7.47	$\frac{8}{27}$ x 100 = 29.62%	18.52%
	Garden Lobelia	2				7.41%
	Malva sylvestris	7				25.93%
	Sweet Alison	2				7.41%
	Abutilon indicum	1				3.70%
	Solanum villosum	2				7.41%
	Black nightshade	3				11.11%
	Creeping yellow woodsorrel	5				18.52%
10	Leucanthemum	3	28	5.81	$\frac{8}{28}$ x 100 = 28.57%	10.71%
	Garden Lobelia	3				10.71%

	Malva sylvestris	9				32.14%
	Sweet Alison	1				3.57%
	Abutilon indicum	2				7.14%
	Solanum villosum	1				3.57%
	Black nightshade	7				32.14%
	Creeping yellow woodsorrel	2				7.14%
11	Leucanthemum	4	28	8.59	$\frac{8}{28}$ x 100 = 28.57%	14.29%
	Garden Lobelia	1				3.57%
	Malva sylvestris	6				21.43%
	Sweet Alison	2				7.14%
	Abutilon indicum	3				10.71%
	Solanum villosum	3				10.71%

	Black nightshade	4				14.29%
	Creeping yellow woodsorrel	5				17.86%
12	Leucanthemum	5	30	8.06	$\frac{8}{30}$ x 100 = 26.66%	16.67%
	Garden Lobelia	3				10%
	Malva sylvestris	7				23.33%
	Sweet Alison	4				13.33%
	Abutilon indicum	1				3.33%
	Solanum villosum	2				6.67%
	Black nightshade	3				10%
	Creeping yellow woodsorrel	5				16.67%
13	Leucanthemum	3	15	11.67	$\frac{8}{15}$ x 100 = 53.33%	20%

	Garden Lobelia	1				6.67%
	Malva sylvestris	2				13.33%
	Sweet Alison	1				6.67%
	Abutilon indicum	2				13.33%
	Solanum villosum	1				6.67%
	Black nightshade	3				20%
	Creeping yellow woodsorrel	2				13.33%
14	Leucanthemum	4	29	8.83	$\frac{8}{29}$ x 100 = 27.58%	13.79%
	Garden Lobelia	3				10.34%
	Malva sylvestris	5				17.24%
	Sweet Alison	2				6.90%
	Abutilon indicum	1				3.45%

	Solanum villosum	5				17.24%
	Black nightshade	4				13.79%
	Creeping yellow woodsorrel	5				17.24%
15	Leucanthemum	6	30	7.63	$\frac{8}{30}$ x 100 = 26.66%	20%
	Garden Lobelia	2				6.67%
	Malva sylvestris	7				23.33%
	Sweet Alison	2				6.67%
	Abutilon indicum	1				3.33%
	Solanum villosum	4				13.33%
	Black nightshade	5				19.97%
	Creeping yellow woodsorrel	3				10%

Table 2: Raw data calculation for GBU

Quadrat No.	Calculation	Diversity $\frac{N(N-1)}{\Sigma n(n-1)}$
1	N= 28, N-1= 27 $\Sigma n(n-1)$ = (5x4) + (2x1) + (8x7) + (2x1) + (3x2) + (4x3) + (3x2) =104	$\frac{28\,x\,27}{104}$ = 7.26
2	N= 33, N-1=32, $\Sigma n(n-1)$ = (6x5) + (2x1) + (7x6) + (3x2) + (4x3) + (5x4) + (5x4) = 137	$\frac{33\,x\,32}{137}$ = 7.71
3	N=28, N-1= 27 $\Sigma n(n-1)$= (3x2) + (9x8) + (3x2) + (3x2) + (4x3) + (4x3)= 114	$\frac{28\,x\,27}{114}$ = 6.63
4	N= 33, N-1= 32 $\Sigma n(n-1)$ = (4x3) + (7x6) + (6x5) + (5x4) + (2x1) + (2x1) + (5x4) + (2x1) =130	$\frac{33\,x\,32}{130}$ = 8.12
5	N= 37, N-1=36, $\Sigma n(n-1)$ = (5x4) + (4x3) + (4x3) + (8x7) + (5x4) + (5x4) + (5x4)= 160	$\frac{37\,x\,36}{160}$ = 8.36
6	N=28, N-1= 27 $\Sigma n(n-1)$= (2x1) + (3x2) + (2x1) + (6x5) + (4x3) + (5x4) + (5x4)= 92	$\frac{28\,x27}{92}$ = 8.21
7	N= 32, N-1= 31 $\Sigma n(n-1)$ = (4x3) + (3x2) + (9x8) + (3x2) + (2x1) + (4x3) + (5x4) + (2x1) =132	$\frac{32\,x\,31}{132}$ = 7.51

8	N= 31, N-1=30, $\Sigma n(n-1)$ = (2x1) + (3x2) + (6x5) + (4x3) + (5x4) + (6x5) + (4x3)= 112	$\frac{31\,x\,30}{112}$ = 8.30
9	N=27, N-1= 26 $\Sigma n(n-1)$= (5x4) + (2x1) + (7x6) + (2x1) + (2x1) + (3x2) + (5x4) = 94	$\frac{27\,x\,26}{94}$ = 7.47
10	N= 28, N-1= 27 $\Sigma n(n-1)$ = (3x2) + (3x2) + (9x8) + (2x1) + (7x6) + (2x1) = 130	$\frac{28\,x\,27}{130}$ = 5.81
11	N= 28, N-1=27, $\Sigma n(n-1)$ = (4x3) + (6x5) + (2x1) + (3x2) + (3x2) + (4x3) + (5x4) = 88	$\frac{28\,x\,27}{88}$ = 8.59
12	N=30, N-1= 29 $\Sigma n(n-1)$= (5x4) + (3x2) + (7x6) + (4x3) + (2x1) + (3x2) + (5x4) = 108	$\frac{30\,x\,29}{108}$ = 8.06
13	N= 15, N-1= 14 $\Sigma n(n-1)$ = (3x2) + (2x1) + (2x1) +(3x2) + (2x1) = 18	$\frac{15\,x\,14}{18}$ = 11.67
14	N= 29, N-1=28, $\Sigma n(n-1)$ = (4x3) + (3x2) + (5x4) + (2x1) + (5x4) + (4x3) = 92	$\frac{29\,x\,28}{92}$ = 8.83
15	N=30, N-1= 29 $\Sigma n(n-1)$= (6x5) + (2x1) + (7x6) + (2x1) + (4x3) + (5x4) + (3x2) = 114	$\frac{30\,x\,29}{114}$ = 7.63

Total Diversity for GBU =

$$\frac{7.26 + 7.71 + 6.63 + 8.12 + 8.36 + 8.21 + 7.51 + 8.30 + 7.47 + 5.81 + 8.59 + 8.06 + 11.67 + 8.83 + 7.63}{15} = 8.403$$

Calculating uncertainties

For *N:*

$\frac{8}{437} x\ 100 = 1.83\%$

For $\Sigma n(n - 1)$:

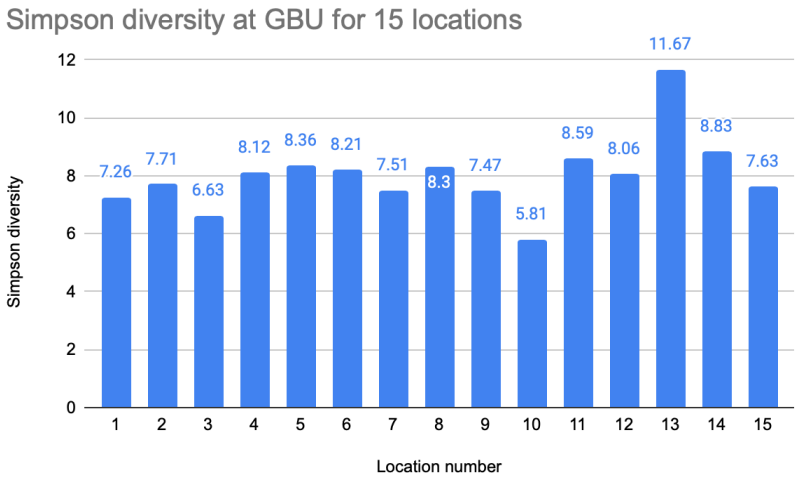
$\frac{8}{1625} x\ 100 = 0.49\%$

Total Percentage Error = 2.32%

Therefore, total error = $\frac{2.32}{100} x\ 8.403 = 0.195$

The diversity of GBU is 8.403 ± 0.195

Table 3: Refined data calculation for GBU



Graph 1: Values of D for 15 different areas at GBU site

Quadrat Sample No.	**Species**	**Number (*n*) ± 1**	**Total Individuals in Area (*N*)**	**Diversity Index** $\frac{N(N-1)}{\Sigma n(n-1)}$	**Percentage uncertainty of *n***	**Density** $\frac{n}{N}$
1	Leucanthemum	5	12	4.4	$\frac{4}{12}$ x 100 = 33.33%	41.67%
	Garden Lobelia	2				16.67%
	Malva sylvestris	3				25%
	Sweet Alison	2				16.67%
2	Leucanthemum	5	12	3.88	$\frac{4}{12}$ x 100 = 33.33%	41.67%
	Garden Lobelia	4				33.33%
	Malva sylvestris	2				16.67%
	Sweet Alison	1				8.33%
3	Leucanthemum	3	10	4.5	$\frac{4}{10}$ x 100 = 40%	30%
	Garden Lobelia	4				40%
	Malva sylvestris	2				20%

	Sweet Alison	1				10%
4	Leucanthemum	4	9	4.5	$\frac{4}{9}$ x 100 = 44.44%	44.44%
	Garden Lobelia	1				11.11%
	Malva sylvestris	2				22.22%
	Sweet Alison	2				22.22%
5	Leucanthemum	3	9	6	$\frac{4}{9}$ x 100 = 44.44%	33.33%
	Garden Lobelia	2				22.22%
	Malva sylvestris	2				22.22%
	Sweet Alison	2				22.22%
6	Leucanthemum	1	9	4	$\frac{4}{9}$ x 100 = 44.44%	11.11%
	Garden Lobelia	1				11.11%
	Malva sylvestris	4				44.44%
	Sweet Alison	3				33.33%
7	Leucanthemum	3	10	4.5	$\frac{4}{10}$ x 100 =	30%

	Garden Lobelia	1			40%	10%
	Malva sylvestris	2				20%
	Sweet Alison	4				40%
8	Leucanthemum	3	10	5.625	$\frac{4}{10}$ x 100 = 40%	30%
	Garden Lobelia	2				30%
	Malva sylvestris	2				30%
	Sweet Alison	3				30%
9	Leucanthemum	1	6	7.5	$\frac{4}{6}$ x 100 = 66.67%	16.67%
	Garden Lobelia	1				16.67%
	Malva sylvestris	2				33.33%
	Sweet Alison	2				33.33%
10	Leucanthemum	2	10	5.625	$\frac{4}{10}$ x 100 = 40%	20%
	Garden Lobelia	3				30%

	Malva sylvestris	2				20%
	Sweet Alison	3				30%
11	Leucanthemum	3	9	6	$\frac{4}{9}$ x 100 = 44.44%	33.33%
	Garden Lobelia	2				22.22%
	Malva sylvestris	2				22.22%
	Sweet Alison	2				22.22%
12	Leucanthemum	2	6	7.5	$\frac{4}{6}$x 100 = 66.67%	33.33%
	Garden Lobelia	2				33.33%
	Malva sylvestris	1				16.67%
	Sweet Alison	1				16.67%
13	Leucanthemum	1	6	7.5	$\frac{4}{6}$ x 100 = 66.67%	16.67%
	Garden Lobelia	2				33.33%
	Malva sylvestris	1				16.67%
	Sweet Alison	2				33.33%

14	Leucanthemum	2	7	7	$\frac{4}{7}$ x 100 = 57.14%	28.57%
	Garden Lobelia	1				14.29%
	Malva sylvestris	2				28.57%
	Sweet Alison	2				28.57%
15	Leucanthemum	2	5	10	$\frac{4}{5}$x 100 = 80%	40%
	Garden Lobelia	1				20%
	Malva sylvestris	1				20%
	Sweet Alison	1				20%

Table 4: Raw data calculation for RWA park

Quadrat No.	**Calculation**	**Diversity** $\frac{N(N-1)}{\Sigma n(n-1)}$
1	N= 12, N-1= 11 $\Sigma n(n-1)$ = (5x4) + (2x1) + (3x2) + (2x1) = 30	$\frac{12 \, x \, 11}{30}$ = 4.4
2	N= 12, N-1=11 $\Sigma n(n-1)$ = (5x4) + (4x3) + (2x1) = 34	$\frac{12 \, x \, 11}{34}$ = 3.88
3	N=10, N-1= 9 $\Sigma n(n-1)$ = (3x2) + (4x3) + (2x1) = 20	$\frac{10 \, x \, 9}{20}$ = 4.5

4	N=9, N-1= 8 $\Sigma n(n-1)$ = (4x3) + (2x1) + (2x1) = 16	$\frac{9x8}{16}$ = 4.5
5	N=9, N-1= 8 $\Sigma n(n-1)$ = (3x2) + (2x1) + (2x1) + (2x1) = 12	$\frac{9x8}{12}$ = 6
6	N=9, N-1= 8 $\Sigma n(n-1)$ = (4x3) + (3x2) = 18	$\frac{9x8}{18}$ = 4
7	N=10, N-1= 9 $\Sigma n(n-1)$ = (3x2) + (2x1) + (4x3) = 20	$\frac{10x9}{20}$ = 4.5
8	N=10, N-1= 9 $\Sigma n(n-1)$ = (3x2) + (2x1) + (2x1) + (3x2) = 16	$\frac{10x9}{16}$ = 5.625
9	N=6, N-1= 5 $\Sigma n(n-1)$ = (2x1) + (2x1) = 4	$\frac{6x5}{4}$ = 7.5
10	N=10, N-1= 9 $\Sigma n(n-1)$ = (2x1) + (3x2) + (2x1) + (3x2) = 16	$\frac{10x9}{16}$ = 5.625
11	N=9, N-1= 8 $\Sigma n(n-1)$ = (3x2) + (2x1) + (2x1) + (2x1) = 12	$\frac{9x8}{12}$ = 6
12	N=6, N-1= 5 $\Sigma n(n-1)$ = (2x1) + (2x1) = 4	$\frac{6x5}{4}$ = 7.5
13	N=6, N-1= 5 $\Sigma n(n-1)$ = (2x1) + (2x1) = 4	$\frac{6x5}{4}$ = 7.5
14	N=7, N-1= 6 $\Sigma n(n-1)$ = (2x1) + (2x1) + (2x1) = 6	$\frac{7x6}{6}$ = 7
15	N=5, N-1= 4 $\Sigma n(n-1)$ = (2x1) = 2	$\frac{5x4}{2}$ = 10

Total Diversity for RWA Park =

$$\frac{4.4+3.88+4.5+4.5+6+4+4.5+5.625+7.5+5.625+6+7.5+7.5+7+10}{15} = 5.903$$

Calculating uncertainties

For *N:*

$\frac{4}{130} x\ 100\ = 3.08\%$

For $\Sigma n(n\ -\ 1)$:

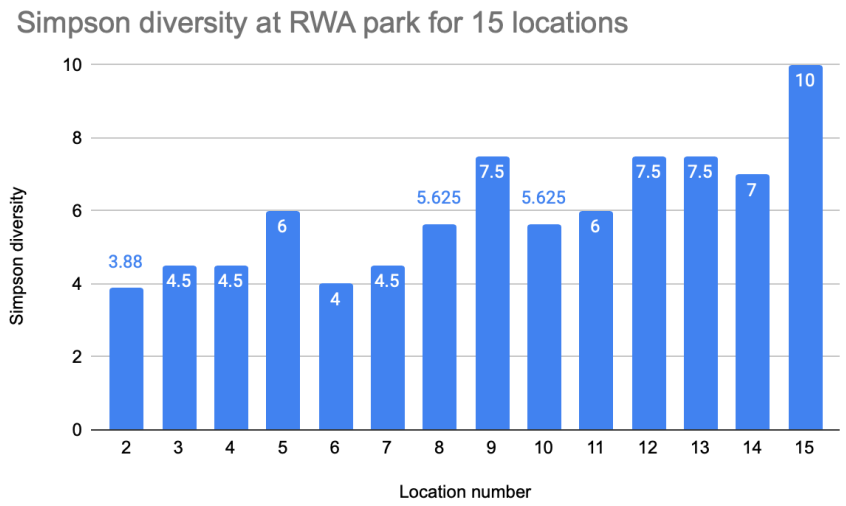
$\frac{4}{214} x\ 100 = 1.87\%$

Total Percentage Error = 4.95 %

Therefore, total error= $\frac{4.95}{100} x\ 5.903 = 0.292$

The diversity of RWA Park is 5.903 ± 0.292

Table 5: Refined data calculation for RWA park

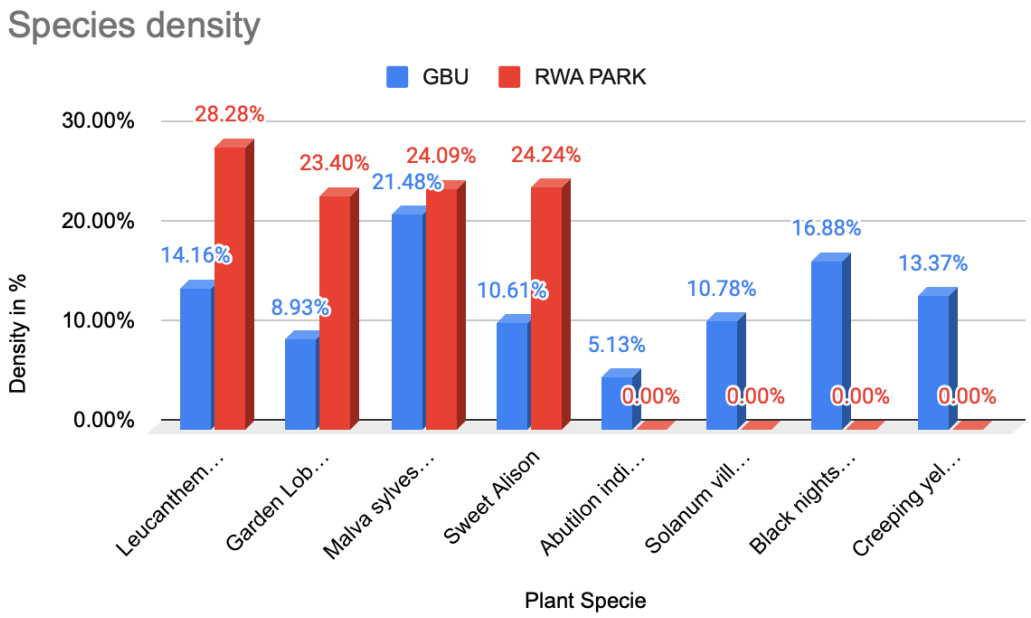


Graph 2: Value of D for 15 different areas at Sector 44

Processed Data :

Plant species	AREA 1- Open field near GBU	AREA 2- Sector 44 RWA Park
Leucanthemum	14.163%	28.275%
Garden Lobelia	8.928%	23.396%
Malva sylvestris	21.484%	24.089%
Sweet Alison	10.607%	24.24%
Abutilon indicum	5.13%	0%
Solanum villosum	10.775%	0%
Black nightshade	16.88%	0%
Creeping yellow woodsorrel	13.368%	0%

Table 6: Density of species in both areas 1 & 2

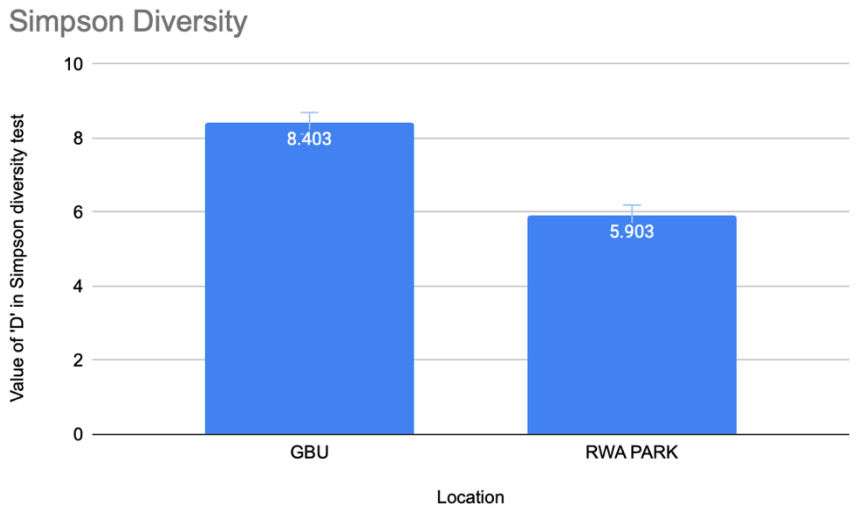


Graph 4: Density of species in both areas 1 & 2

The diagram above reiterates the fact that evenness was fairly decent at both the places and shockingly higher in RWA park than in GBU as mentioned in the hypothesis. The main reason for this is that the park is 'managed' by the RWA committee, the number of plants and types of plants to be harvested are controlled, unlike in GBU where there is no human control. The graph further highlights the fact about the low specie richness in RWA and high in GBU as there were 4 more species found in GBU.

AREA 1- Open field near GBU	AREA 2- Sector 44 PARK
8.403 ± 0.195	**5.903 ± 0.292**

Table 7: Diversity of species in areas 1 and 2



Graph 3: Diversity of species of both the areas 1 and 2

The lack of biodiversity in of RWA park relatively to GBU as shown in graph 3 highlights how the conditions in there are not optimum for the plant species present; human disturbance in RWA park is the primary reason for the low species diversity as selective plants are harvested, the abidingness is very low as the ground has been cleared to make playing fields, walking paths and fountains. However there is still quite high evenness amongst the species which could be attributed to the RWA planning team.

There is high biodiversity at GBU relatively as there were twice more species found in GBU than in the RWA park and there was fairly decent evenness amongst the plant species as well.

There are additional factors which also affects the growth of certain species is the soil such as acidity, alkalinity, and amount of Nitrogen, Phosphorus and Potassium in the soil. Deforestation and acid rain can change the soil properties enough to hinder the growth of different species and can decrease the species diversity. Further human intervention in the form of using fertilizer to promote productivity of plants also hinders with the biodiversity in

the area. Hence the soil testing was done further to identify the effect of such factors to make the compression between the biodiversity present in the two selected areas.

The pH value of the soil and the amount of Nitrogen (N), Phosphorus (P) and Potassium (K) from two different locations was noted down in the table below:

	Sample 1 (RWA)	**Sample 2 (RWA)**	**Sample 3 (RWA)**	**Sample1 (GBU)**	**Sample2 (GBU)**	**Samp (GBU**
Trial 1 for pH	4	4.5	5	6.5	6	6
Trial 2 for pH	5	4	5.5	6	6.5	
Trial 1 for N	$\geq 40 Kg/acre$	30 Kg/acre	$\geq 40 Kg/acre$	20 Kg/acre	20 Kg/acre	30 K
Trial 2 for N	$\geq 40 Kg/acre$	$\geq 40 Kg/acre$	$\geq 40 Kg/acre$	20 Kg/acre	20 Kg/acre	30 K
Trial 1 for P	35 Kg/acre	45 Kg/acre	35 Kg/acre	25 Kg/acre	25 Kg/acre	35 K
Trial 2 for P	35 Kg/acre	45 Kg/acre	35 Kg/acre	25 Kg/acre	25 Kg/acre	35 K
Trial 1 for K	100 Kg/acre	100 Kg/acre	150 Kg/acre	5 Kg/acre	5 Kg/acre	25 K
Trial 2 for K	100 Kg/acre	100 Kg/acre	100 Kg/acre	5 Kg/acre	25 Kg/acre	5 Kg

Table 8: pH value, amount of Nitrogen, Potassium and Phosphorus in the soil

Average pH of the soil at **RWA,**

pH average for trial 1= $\frac{4+4.5+5}{3} = 4.5$

pH average for trial 2 = $\frac{4+5.5+5}{3} = 4.8$

Average pH of soil at RWA = $\frac{4.8+4.5}{2} = 4.65$

N average for trial 1= $\frac{40+30+40}{3} = 36.67$

N average for trial 2 = $\frac{40+40+40}{3} = 40$

Average N of soil at RWA = $\frac{40+36.67}{2} = 38.33$

P average for trial 1= $\frac{35+45+35}{3} = 38.33$

P average for trial 2 = $\frac{35+45+35}{3} = 38.33$

Average P of soil at RWA = $\frac{38.33+38.33}{2} = 38.33$

K average for trial 1 = $\frac{100+100+150}{3} = 116.67$

K average for trial 2 = $\frac{100+100+100}{3} = 100$

Average K of soil at RWA = $\frac{100+116.67}{2} = 108.33$

Average pH of the soil at **GBU**,

pH average for trial 1= $\frac{6.5+6+6.5}{3} = 6.3$

pH average for trial 2 = $\frac{6+6.5+6}{3} = 6.3$

Average pH of soil at GBU = $\frac{6.3+6.3}{2} = 6.3$

N average for trial 1= $\frac{20+20+30}{3} = 23.33$

N average for trial 2 = $\frac{20+20+30}{3} = 23.33$

Average N of soil at GBU = $\frac{23.33+23.33}{2} = 23.33$

P average for trial 1= $\frac{25+25+35}{3} = 28.33$

P average for trial 2 = $\frac{25+25+35}{3} = 28.33$

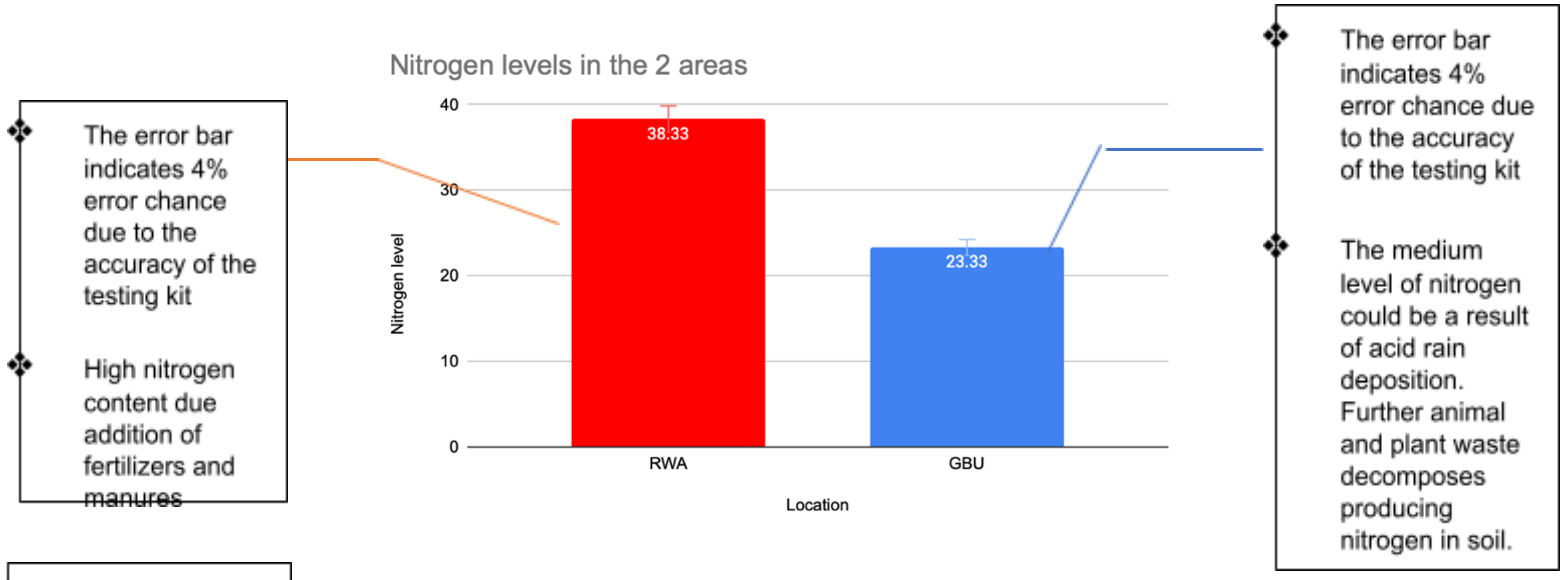
Average P of soil at GBU = $\frac{45+45}{2} = 45$

K average for trial 1= $\frac{5+5+25}{3} = 18.33$

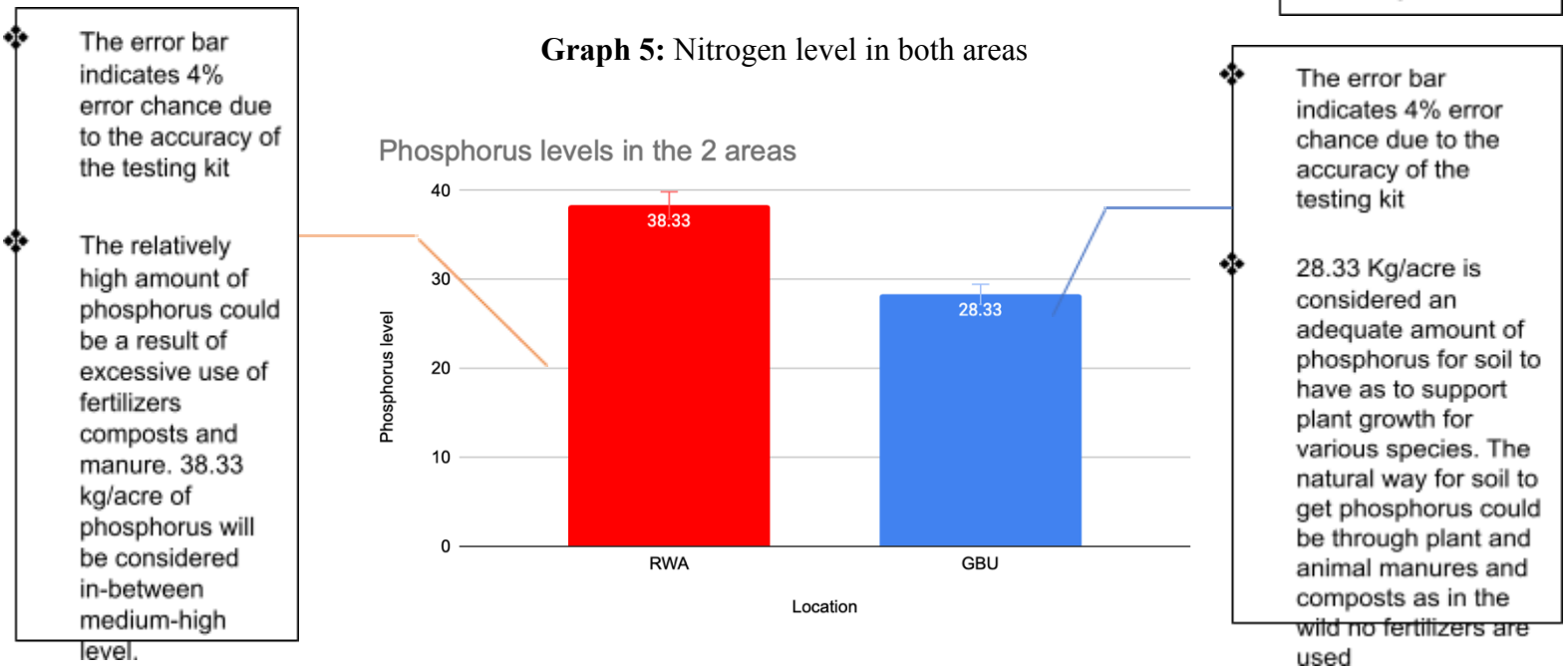
K average for trial 2 = $\frac{5+25+5}{3} = 18.33$

Average K of soil at GBU = $\frac{18.33+18.33}{2} = 18.33$

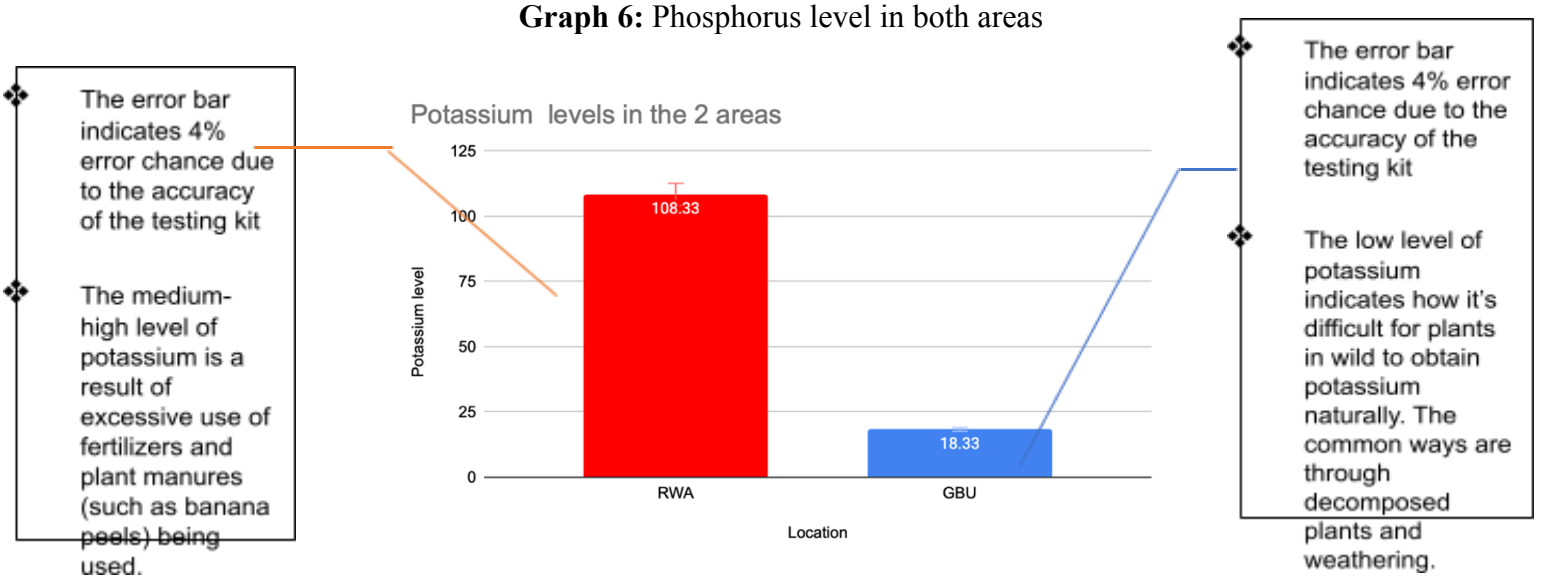
Table 9: Refined data calculations



Graph 5: Nitrogen level in both areas



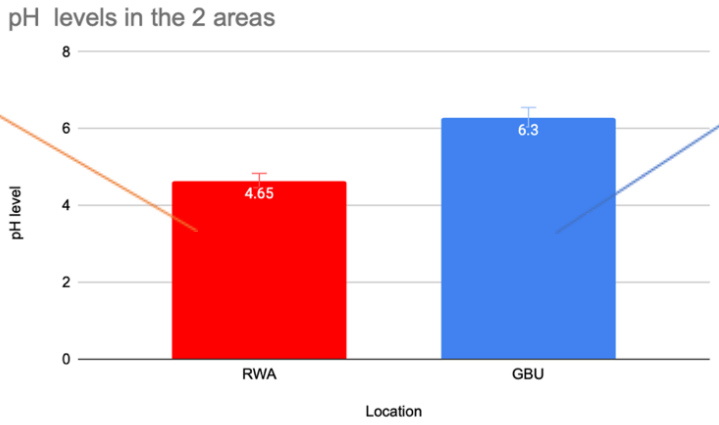
Graph 6: Phosphorus level in both areas



Graph 7: Potassium level in both areas

The error bar indicates 4% error chance due to the accuracy of the testing kit

The pH value obtained for the soil from RWA park suggest very high acidity. The high acidity could be a result of the fertilizers used, mainly due to nitrogen. Soil acidification could also be a result of acid rain.



The error bar indicates 4% error chance due to the accuracy of the testing kit

The pH result for GBU indicates a very low acidity, which might be a result of balanced nutrient profile

Graph 8: pH level in both areas

2-Sample T-test :

N (nitrogen)	P (phosphorus)	K (potassium)
0.0002336	0.01011955	0.000001581

Table 10: Values of 'p' obtained from 2-sample T test done on GDC

The 2-sample T-test establishes whether there is a significant difference between the means of the two data sets. In context of this IA the 2 data sets chosen were values of Nitrogen, Phosphorus and Potassium at two different location of GBU and RWA park. The level of significance is 0.05, which is universally accepted[15]. Any value ≤ 0.05 shows that the means of the two chosen data sets vary, hence they are different.

As seen in table 10, all values are less than our significance level of 0.05, implying the fact that there is a difference in the nitrogen, phosphorus and potassium level in both the places (RWA park and GBU).

Through the use of the 2-sample to test the co-relation and variance between 2 sites gets very easy to comprehend and calculate. The chances of making errors through misinterpretation or miscalculation reduces.

[15] Mcleod, S. (n.d.). Value and statistical significance: Simply psychology. Retrieved March 11, 2021, from https://www.simplypsychology.org/p-value.html

Discussion and Evaluation :

The graph 8 clearly shows low pH level for the soil in RWA park indicating high acidity. This could be a result of various factors such as monocultural practice; where in the same plants are grown over long periods, which results in same nutrient depleting from soil and making the soil loose its fertility. Additionally, use of pesticides results in toxification as increases the acidity of the soil. Even the use of fertilizers, which contain nitrogen have a major impact on making the soil more acidic. Other agricultural practices which makes soil more prone to erosion increase the risk of soil degradation.

On the other hand, pH level of the soil at GBU is slightly acidic. The possible reason for slight acidity in the soil at the undisturbed area could be acid rain leaching away basic ions (potassium, magnesium, calcium and sodium). Further the decomposed organic matter at GBU may also contribute to the slight acidity in soil. The level of acidity is very low and not concerning at all, it is highly suitable to support ample of plant species; therefor increasing the biodiversity in the area.

GBU (open field) is located in an isolated place and is not surrounded by any kind of industrial development areas or construction sites. It is not disturbed by human intervention and there is no waste accumulation in this area. There are lesser plastic materials or polythene bags littered in this area. The air around is relatively less polluted and it experiences

continuous addition of natural manure in terms of animal faeces and dead plants. Due to such factors there is high diversity of species in this location.

However, the RWA Park in Sector 44, Noida is exploited more by humans. There is rapid urbanization happening in the area. The pH of the soil is altered significantly due to the use of chemicals present in pesticides and fertilizers. It was also seen that there was accumulation of plastic waste and polythene bags in that area. Due to human induced pollution and other related factors there was a significant difference in the diversity of species when compared to the other area of the open field area of GBU. As a result the Simpson's Diversity Index (D) is low in this location as seen in graph 3.

The high level of nitrogen, phosphorus and potassium in RWA park poses major threat to the environment and the society.

1) High level of nitrogen in soil leads to soil, water and air degradation. Soil degradation happens due to acidification, water degradation can happen as a result of nitrogen leaching in ground water and air degradation happens due to the release of (N2O) nitrous oxide. N2O is 300 times more dangerous than CO2 in terms of global warming potential. Long-term use of nitrogen fertilizers such as urea, renders to soil infertility, where soil fails to respond to any further addition of nitrogen[16].
2) The excessive phosphorus levels at the RWA park can cause poor growth of plants and even death of some. High soil phosphorus decreases the plant's ability to garner important micronutrients such as zinc and iron, even when the soil has adequate

16 https://www.intechopen.com/books/nitrogen-fixation/nitrogen-fertilization-i-impact-on-crop-soil-and-environment

amount of those micronutrients[17]. Further, the leaking of phosphorus into water bodies such as ponds in the park can cause algae and other undesirable plants to grow.

3) Usually a low at low pH, the potassium content is also low[18]. However, this is not the case in the RWA park; this indicates towards a very evident human intervention in the form of fertilizers being used. Presence of high potassium can result in deficiency in other important nutrients such as calcium and magnesium.

Conclusion :

The above results clearly shows the impact we humans have on the biodiversity around us; an undisturbed area has high biodiversity (as shown through Simpson diversity test) when compared to a human intervened area such as the RWA park. The primary reason for this is the human intervention in the form of plastic disposal, usage of fertilizers and pesticides, land clearing, monoculture and other unsustainable agricultural practices. The NPK and pH tests further elaborate and explain the reason behind low species diversity.

Limitations :

Limitation	Suggested improvements/ How I overcame them
Due to Covid-19, experiments could not be done in lab and hence a soil testing kit was ordered and the tests were done at home. As a result, the reliability of the data decreases.	The situation was very uncertain, but nothing much could have been done. However, if in the future the tests are to be done better and reliable equipment could be used to increase the accuracy and precession of the data.

[17] https://agrilifeextension.tamu.edu/library/gardening/phosphorus-too-much-and-plants-may-suffer/

[18] https://nutrien-ekonomics.com/news/soil-ph-effects-potassium-and-phosphorus-fertilizer-availability-and-management/

There might be some human errors like observation of the plants. There are also some species which were not visible to the naked eye, which could have altered the results slightly.	Multiple trials (at least 3) could have been done to reduce the chances of making an error. However, doing 3 trials for 15 different areas within the 2 locations would have been very time consuming.
Not all species were known to me.	To overcome this problem I took help of a local gardener, who helped me identify a few species. The ones he couldn't identify were identified using an application called 'NatureID".
The soil testing results were based on the colour change of the soil water, this may be quite subjective and vary for different people.	Two trials were taken for each soil sample and 3 soil samples were taken from each location, making it a total of 6 data points for both the places GBU and RWA park.

Application :

The Open Field near GBU in Greater Noida was an open area before the Gautam Buddha University (GBU) campus came into existence in that area. However the open field in that area was untouched due to which the species diversity in that area was to be found to be higher. While the RWA park in Sector 44 is maintained by the local RWA, yet excessive urbanization in the area and the use of pesticides and insecticides in the park has led to a decline in the species diversity in that area. Therefore, the Noida administration could take necessary steps to prevent littering and pollution of the public parks as plastics such as HDPE (High-density polythene) further deteriorate the soil by decreasing it's pH and making it toxic. Also, the use of artificial pesticides and fertilizers should be discouraged. Instead RWA

committee should encourage the use of manure, compost and natural fertilizers in the public parks in. Other healthy agricultural practices can take place such as ‘crop rotation’, where in different types of crops are grown in different months to improve soil health, optimize nutrients in soil and fight pests. Further to improve the pH level of the soil at the park, the RWA committee could use soil conditioners such as crushed lime stone or chalk to counter soil acidification.

Further area of study :

Further different sampling methods such as transect, systematic and pitfall sampling can be used to see how it varies from random sampling that I followed. In this IA, I only counted the seedlings and not the saplings to measure the diversity. In the future as an extension, a test could be conducted only for saplings or both to compare the diversity in the two areas.

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