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Role of Cigarette Butt in Poor Plant Growth and Nitrate Levels

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ABSTRACT

4.5 trillion cigarette butts are littered worldwide per year. Beyond the environmental damage that the cigarette butts themselves propagate through the ecosystem, the effects on plant reproduction and growth that cigarette butts pose is relatively unstudied. The hypothesis was that microplastics from cigarette butts will decrease the plant's nutrition by decreasing nitrate levels in the soil and will also affect a plant's growth based on the toxic materials in the cigarette butts. My procedure was that before I started the experiment, I would collect materials and make water solutions, and grow the microgreen seeds. From Day 1, I would transfer and label seed groups and experimental test groups with toothpick signs. Every day at 8 am, I would water each of the 15 seedlings with 1 mL of water or cigarette butt water. I would measure the height of each sample and take the average. I would send it to the lab for plant tissue testing. My final steps were to take the averages of height and mineral values for each experimental group, plot trends using the averages over the days, analyze data, and trace the individual trends of each seedling height and health for 11 or 16 days. Based on the given data of each graph of Brassica Oleracea over a 11-day period and Helianthus Annuus over a 16-day period and plant nutrient reports, I can safely conclude that cigarettes butts do affect plant growth and nitrate levels.

Introduction

Cigarette butts' litter have detrimental effect on soil and water ecosystem. Cigarette butts and their plastic filters can stay in landfills for up to a decade before finally decomposing, many not even making it to a waste site in the first place. The range of adverse effects across and throughout the food web from harmful chemicals such as: Nicotine, Cadmium, Lead and Arsenic have on the environment are well documented. Therefore, it is vital that people are informed of the effects that they may have by choosing to litter cigarettes instead of properly disposing of them in their designated areas. The toxins within cigarettes may contaminate surrounding environments and lead to decreased growth of especially critical species, posing a threat to agricultural productivity. Microgreens are a good model because they grow faster and one can measure them every day to quantify differences, making them a more easily accessible organism to test.

"Despite scientific awareness of the issue of cigarettes and plants for over 100 years, this remains an under-researched topic. But given the importance of plants as our primary producers of food, not to mention their role in making our environment more pleasant, there is clearly a need to reduce cigarette butt litter." - (Green 2019)

Methods

Materials used: Broccoli Microgreens (*Brassica Oleracea)*
Sunflower Microgreens (*Helianthus Annuus*)
Cigarette Butts (500) Soaked in Water for 3 months

Spray Bottle
Soil
Trays to grow the microgreens
Ruler to measure height in centimeters

Preparation: Water preparation – Soak 500 cigarette butts in water for 3 months to create the pollutant caused by the litter. Prepare the experiment water to start conducting the trials.

Seed preparation – Soak the sample size sunflower microgreens seeds in control and experiment group separately for 8 hours the day prior to start the experiment

Day 0:
1. Collect materials and make water solutions
2. Plant seeds in the tray

Day 1:
1. Transfer and label seed groups and experimental test groups with toothpick signs
2. Keep the same environment conditions for Control and Experiment group.
   Since this experiment was conducted at home, I used a place where there was direct sunlight and controlled temperature of indoors was always set at 68 F.
3. Each day at 8am, water each of the 15 seedlings with 1 mL water

Day 2 – Day 10 or Day 16 (*Brassica Oleracea*)
1. Measure height of each seedling per experimental group and control group and record the data
   i. Use a ruler and line up the bottom with the soil surface, marking the measurement in journal every day (in cm)
   ii. On the final day of experimentation, use a small spoon to scoop a tablespoon of soil from each of the 15 seedlings in each experiment groups, label in plastic bags, and send to lab for testing.

Day 2 – Day 16 (*Helianthus Annuus)*

Measure height of each seedling per experimental group and control group and record the data
   i. Use a ruler and line up the bottom with the soil surface, marking the measurement in journal every day (in cm)
   ii. On the final day of experimentation, use a small spoon to scoop a tablespoon of soil from each of the 15 seedlings in each experiment groups, label in plastic bags, and send to lab for testing.

Final Steps
2. Take averages of height and mineral values for each experimental group (control versus microplastics each day), plot trends using the averages over the days, and analyze data
3. Trace the individual trends of each seedling height and health for 11 or 16 days
   i. Collect daily data with journal observations and pictures
   ii. Measure plant height
   iii. Send for soil testing and plant nutrition testing

Risk and Safety

Potential risks include nausea due to the water soaked in cigarette butt which is used to water the plants daily.
Risks also include burning sensation, abdominal pain, and vomiting.

Experiment is conducted safely under adult supervision by wearing masks and safety goggles.

Results

Helianthus Annuus microgreens After conducting a series of tests, the following results were obtained.

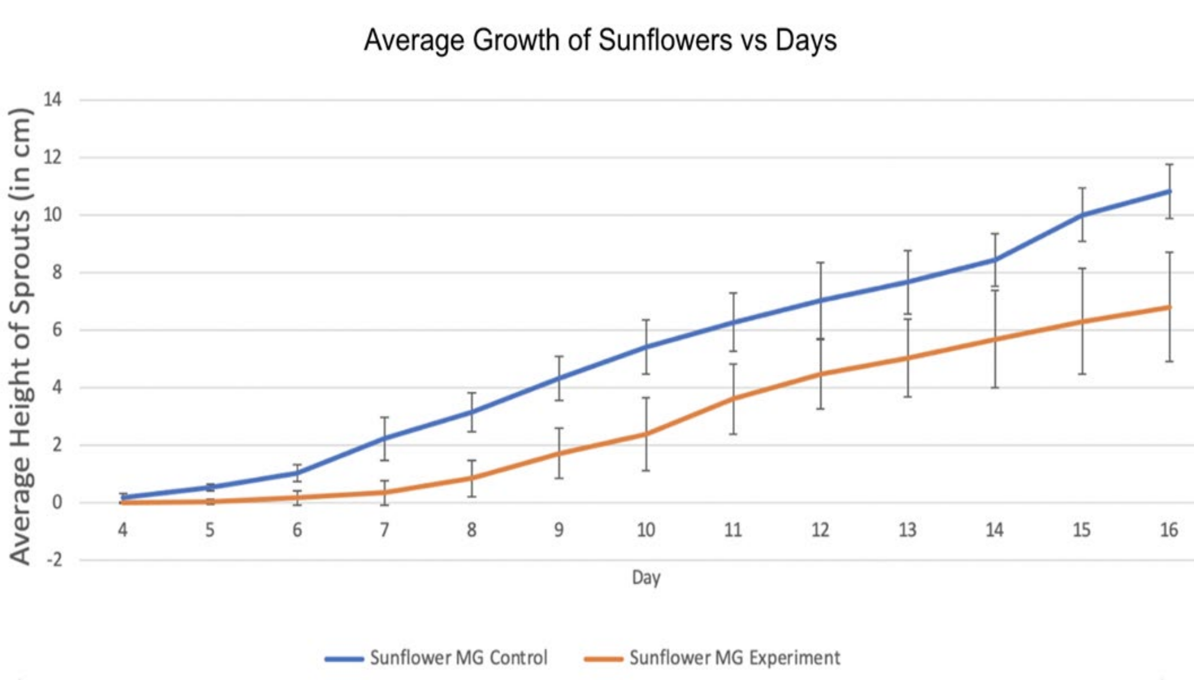

Figure 1. Average Growth of Sunflower Microgreens. This visual is intended to display the average growth from the start of harvesting to when sunflower microgreens are known to stop growing

Table 1. Data Tables for Average Height for Helianthus Annuus Experiment group

***Helianthus Annuus* Experiment (in cm)**													
Sample No.	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	Day 16
S1	0.1	0.3	0.5	1.4	1.4	1.7	2	3.2	3.5	4	4.1	4.5	4.7
S2	0	0.1	0.6	1	1.2	2.4	3.5	4	5.6	6	7.1	8.1	8.5
S3	0	0.1	0.6	0.7	1.5	1.7	1.9	2.5	3.9	4	3.9	4.5	5
S4	0	0.1	0.5	0.5	0.6	2.9	4.4	5.5	6.1	7.3	8.5	9.7	9.7
S5	0	0	0.3	0.7	0.7	1.7	2	2.7	3.4	3.9	4.4	5.7	5.7
S6	0	0	0	0.1	0.3	0.4	0.5	2.5	3.9	4.2	4.3	4.5	4.7

S7	0	0	0	0.2	0.4	1.7	3.4	4.5	4.7	5.3	5.8	5.7	6.9
S8	0	0	0	0.3	2.2	2.2	2.4	3.2	3.6	4	5.6	7	8
S9	0	0	0	0.14	1	1.2	1.5	3.2	4.1	4.9	5.1	6	6.5
S10	0	0	0	0.3	0.3	1.5	3	3.5	4.2	5.3	6	5.7	6.5
S11	0	0	0	0	0.1	0.4	0.5	2.3	3.2	3.5	3.9	4.1	4.2
S12	0	0	0	0	1.2	3.2	4.2	6.7	7.5	8	9.7	10.2	10.5
S13	0	0	0	0	1.5	2.8	3.5	4.3	5.1	5.7	6	7.1	8
S14	0	0	0	0	0.1	0.7	0.8	2.6	3.4	3.5	5	5.7	5.5
S15	0	0	0	0	0.3	1.2	2.2	3.4	4.9	5.8	6	6.1	7.6
Average	0.00667	0.04	0.16667	0.356	0.85333	1.71333	2.38667	3.60667	4.47333	5.02667	5.69333	6.30667	6.8
Std Dev	0.02582	0.0828	0.25261	0.42582	0.63004	0.86839	1.25974	1.22851	1.20147	1.36144	1.68246	1.83749	1.89774

Table 2. Data Tables for Average Height for Helianthus Annuus from control group

***Helianthus Annuus* Control (in cm)**													
Sample No.	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	day 11	day 12	day 13	day 14	day 15	day 16
S1	0.4	0.7	1.5	3.8	4.4	5.5	6.3	7.1	7.7	8.3	8.9	9.9	11
S2	0.4	0.6	0.9	1.6	3	4.7	5.9	6.6	7.3	7.7	8.5	10	11.1
S3	0.2	0.4	1.1	3.1	3.9	5	6.9	7.6	8.9	9.2	9.3	11	11.2
S4	0.2	0.4	0.5	1.8	4	5.2	6.8	7.9	9.7	10.3	10.5	11.4	12.1
S5	0.1	0.5	0.8	1.2	2.6	4.5	6.3	7.5	8.3	8.5	9.2	11.1	11.6
S6	0.1	0.4	1.2	3.1	4.1	5.2	6.1	7.2	7.7	8.1	8.2	9.5	10.8
S7	0.2	0.5	1.1	2.5	2.7	3.8	4.3	5.4	6	6.7	7.3	8.5	8.3
S8	0.2	0.7	1.2	1.8	2.8	3.6	4.4	4.8	5.1	6.2	7.9	9.6	11
S9	0.2	0.6	0.8	1.9	2.7	3.5	4.1	5.3	5.9	6.8	8.2	11.2	11.6

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S10	0.5	0.8	1.4	2.9	3.5	4.8	5.3	6.4	7.2	7.8	8.4	9.5	10.8
S11	0.2	0.5	0.8	1.6	2.2	3	4.9	5.8	6.1	6.3	6.4	10.9	11.3
S12	0	0.5	0.8	1.4	2.5	3.5	4.6	5.3	5.5	7.1	8.9	10.3	11.3
S13	0	0.5	1.1	2.6	3.4	4.6	5.8	6.4	7.4	7.8	8.3	9.4	10.8
S14	0	0.4	1.5	1.9	2.6	4.5	4.7	5.6	5.8	7.2	8.4	9.3	9.8
S15	0	0.6	0.9	2.2	3	3.6	4.7	5.3	6.8	7.1	8.2	8.6	9.6
Average	0.18	0.54	1.04	2.22667	3.16	4.33333	5.40667	6.28	7.02667	7.67333	8.44	10.0133	10.82
Std Dev	0.15675	0.1242	0.28983	0.74495	0.67802	0.77059	0.94526	1.00157	1.315	1.10742	0.92335	0.93493	0.94431

Table 3. Sunflower Microgreen (*Helianthus Annuus*) Nutrient Data

Sample Identification	Survey* Range	Control	Experiment
Nitrogen (N) %	2.00-5.00	4.68	3.63
Phosphorus (P) %	0.25-.60	0.61	0.59
Potassium (K) %	2.00-5.00	3.14	2.21
Calcium (Ca) %	1.50-3.00	0.55	0.84
Magnesium (Mg) %	0.25-1.00	0.66	0.59
Iron (Fe) ppm	50-750	97	91
Boron (B) ppm	35-150	21	18
Zinc (Zn) ppm	25-100	102	78
Copper (Cu) ppm	4-25	23.6	20.7
Manganese (Mn) ppm	50-1000	84	44
Sodium (Na) %	<0.20	0.04	0.03
Silicon (Si) ppm	?	251	160

Table 4. Sunflower Microgreen (*Helianthus Annuus*) Soil Data

Sample Identification	Survey* Range	Control	Experiment
Electrical Conductivity	1.0- 3.0	1.3	5.8
Nitrate Nitrogen	15-35	22	4
Calcium	2000-4000	1040	1969

Brassica Oleracea

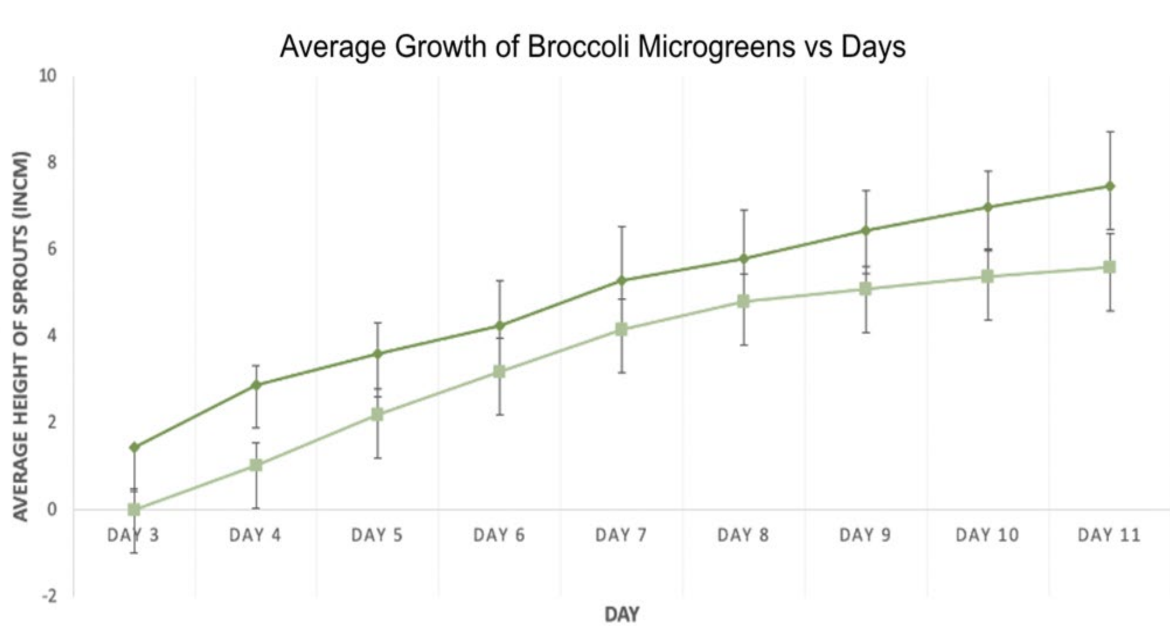

Figure 2. Average Growth of Broccoli Microgreens. This visual is intended to display the average growth from the start of harvesting to when broccoli microgreens are known to stop growing.

Table 5. Data Tables for Average Height for Brassica Oleracea Experiment group

***Brassica Oleracea* Experiment (in cm)**									
Sample No.	Day 3	day 4	Day 5	Day 6	Day 7	Day 8	D nay 9	Day 10	Day 11
S1	0	1.1	3.2	4.4	4.6	5.6	5.7	5.8	5.9
S2	0	0.5	1.4	2.8	4.7	5	5	5.7	5.9
S3	0	1.1	2.5	3.9	5.4	6.1	6.5	6.5	6.5
S4	0	1.5	2.7	3.3	4.5	5	5.3	5.6	5.8

S5	0	1.9	3.4	4.5	4.3	4.3	4.6	4.9	5.1
S6	0	1.3	1.76	2.5	5.4	6	6	6	6.1
S7	0	0.5	2.9	4.1	5.2	5.6	6	6.3	6.6
S8	0	1.4	2.5	3	4.1	4.2	4.3	4.6	5.1
S9	0	0.3	2.1	3.5	3.7	5	5.2	5.4	5.6
S10	0	0.9	2.5	4.6	5.2	5.9	5.5	5.8	6
S11	0	1.2	1.9	2.5	4.3	4.6	4.8	5.2	5.7
S12	0	1.2	1.5	1.9	1.5	3	4	4.4	4.8
S13	0	0.7	2.1	3.6	4	4.8	5	4.5	4
S14	0	0.5	0.9	1.2	2.5	2.7	4	5.3	5.5
S15	0	1.3	1.4	2	3	4.2	4.4	4.6	5.2
Std Dev	0	0.4496	0.71762	1.03363	1.1115	1.01419	0.75863	0.66598	0.67174
Avg	0	1.0267	2.184	3.18667	4.16	4.8	5.08667	5.37333	5.58667

Table 6. Data Tables for Average Height for Brassica Oleracea Control group

***Brassica Oleracea* Control (in cm)**									
Sample No.	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11
S1	1.5	2.7	3.7	5	6	6.7	7	7.4	7.8
S2	1	3	3.6	4.2	5.5	5.9	6	7	7.5
S3	1.25	3	3.9	4.4	5.6	5.8	6	7.4	7.9
S4	1.5	2.6	3.1	3.2	5.9	6.5	7.4	7.9	9
S5	1.75	3.1	4.5	5	5.5	6	6.4	6.8	7.4
S6	2	3.7	4.1	4.9	6	6.3	6.6	6.6	6.5
S7	2	3.4	4.3	4.5	5.2	5.3	6.5	7.8	8.5

S8	1.5	2.7	3.5	4.4	4.4	5	6.2	7.1	7.5
S9	1	2.4	3.1	3.9	5.4	5.7	6.5	7.2	7.3
S10	0.75	2.5	3.5	4.6	5.3	6	6.3	6.5	6.6
S11	1.8	3	3.5	4	5.7	6	7	7.5	7.9
S12	2	4	4.2	4.5	4.5	5.8	7.2	7.4	7.7
S13	1.2	2.5	3.4	4.5	5.2	5.5	6.3	6.5	7.5
S14	0.5	2.6	3.6	4.7	5.8	6.2	6.3	6.6	7
S15	1.8	2	2	2	3.3	4.2	5	5	5.9
Std Dev	0.47414	0.5213	0.60592	0.77724	0.7269	0.62045	0.58171	0.71134	0.77244
Avg	1.43667	2.88	3.6	4.25333	5.28667	5.79333	6.44667	6.98	7.46667

Table 7. Broccoli Microgreen (*Brassica Oleracea*) Nutrient Data

Sample Identification	Survey* Range Brassica Oleracea	Control	Experiment
Nitrogen (N) %	3.10-5.00	7.16	4.16
Phosphorus (P) %	0.30-0.70	0.88	0.6
Potassium (K) %	2.00-4.00	3.09	0.99
Calcium (Ca) %	1.50-2.50	1.78	0.64
Magnesium (Mg) %	0.25-0.70	0.97	.43
Iron (Fe) ppm	60-300	138	176
Boron (B) ppm	35-250	21	13
Zinc (Zn) ppm	25-100	146	56
Copper (Cu) ppm	4-25	5.4	4.1
Manganese (Mn) ppm	30-250	224	44
Sodium (Na) %	<0.20	0.62	0.05
Silicon (Si) ppm	?	637	99

Table 8. Broccoli Microgreen (*Brassica Oleracea*) Soil Data

Sample Identification	Survey* Range	Control	Experiment
Electrical Conductivity	1.0- 3.0	1.3	5.9
Nitrate Nitrogen	15-35	25	4
Calcium	2000-4000	1426	2576

Discussion

Based on the above result, I was able to study the effects of cigarette butts on soil nutrients, water quality, and plant growth.

The experiment data shows that there is a considerable difference in the plant growth (measured in terms of height) when treated with cigarette butt water and regular water. The experiment group exhibited slow growth rate as compared to the control group. Within the scope of the study, the result indicates that cigarette butt negatively impacts plant growth. And since the graph showed a pattern of impacts on plant growth it also has cascading detrimental effect on plant nutrition. The plant nutrient data also shows the similar pattern of decreased levels.

The soil data from the experiment showed difference in the decreased nitrate level and elevated calcium levels compared to the control group which is consistent with previous research where elevated calcium and decreased nitrate level hamper the plant nutrient uptake. Decreased nitrate levels pattern is consistent in the study groups.

Conclusion

The microplastics from cigarette butts will decrease the nitrate levels of the soil by around 2 times less than the control group of regular water. The plant's height from the microplastics will also decrease by an average of 1 cm each day. This significance of this is that stunting plant growth and plant health are correlated with the plants' surroundings. To ensure quality plant growth and health, people must mitigate their litter to have adequate plant health and growth. Since the study was conducted only on 2 variety of microgreen plants, this opens the scope to perform more detailed analysis by increasing the sample size, running more trials, and conducting the experiment on seeds other than microgreens seeds so that one can get extended trial period. To further add onto this experiment, I can test agricultural plants to observe whether cigarette butts have the same effects on those.

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