Saving our Oceans

Studying the capability of naturally occurring substances to neutralize pollutants (fertilizers, microplastics, oil spills) in ocean water.

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Question/Problem statement

Can naturally occurring substances help fight pollutants such as microplastics, oil spills, and fertilizers in the oceans?



Abstract

Save Our Oceans: Studying the capability of naturally occurring substances to neutralize pollutants (fertilizers, microplastics, oil spills) in ocean water

Ocean pollution caused by fertilizer runoff, microplastics and oil spills poses a real and present danger to ocean ecosystems and marine life. We currently either do not have a solution or have largely chemical based solutions to fight these pollutants. This project attempts to study the potential of utilizing abundantly available and naturally occurring substances as a solution to the problem. Multiple substances were studied for each category of pollutants. Ocean water was obtained and samples were prepared to emulate the pollution caused in real-life scenarios. Background research was conducted to identify four natural substances in each category, based on their physical and chemical nature. Measured concentrations of natural substances were mixed in the pollutant samples. Remnant pollutant content(or indicators thereof) was measured every alternate day over a period of 3 weeks. Results obtained were plotted on a graph and compared for the four substances across each pollutant category. It was concluded that, peppermint oil for microplastic pollution, potato root for fertilizer runoff pollution and rice husk, and orange peel extract for oil spill pollution worked best to neutralize the respective pollutants and were very effective as natural-based solutions. As a next step, the long-term effects of adding studied natural substances to ocean water specifically to fishes and marine life remain a subject of future research. Other recognized limitations of the experiment included a non-existence of the effect of natural phenomenon such as dilution by ocean currents, storms and waves.

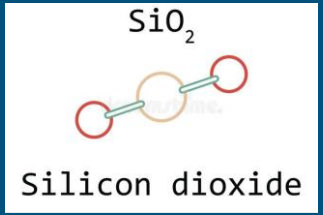
Hypothesis

If the following natural substances are added to polluted seawater, they will be effective at neutralizing said pollutants effectively;

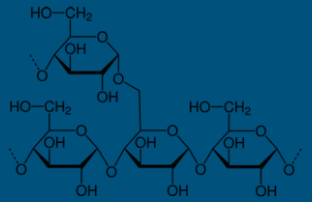
Microplastic Pollution	Oil Pollution	Fertilizer Pollution
Natural neutralizing substances studied - These were chosen due to their naturally occurring alcohol content. Alcohol is expected to dissolve plastics over time and also dissolve in water in effect disintegrating microplastics. 1. Peppermint Oil 2. Clove Oil 3. Amrutharishtam 4. Dasamoolarishtam	Natural neutralizing substances studied - These were chosen due to their sorbent nature in cooking/household use. 1. Lentil Flour 2. Walnut Shell Powder 3. Orange Peel Extract 4. Rice Husk	Natural neutralizing substances studied - These were chosen due to their high affinity to utilize nitrates and phosphates 1. Yogurt Bacteria Culture 2. Peppermint Root 3. Potato Root 4. Aloe Vera Plant Juice

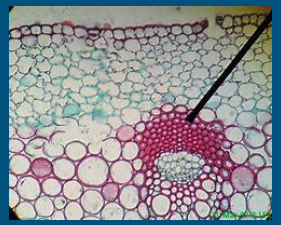
Background research - Oil pollution

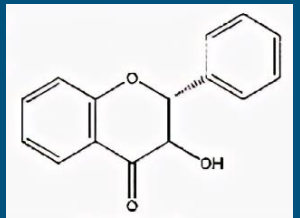
- Rice husk
  - Rice husk contains “cellulose (50%), lignin (25%–30%), silica (15%–20%), and moisture (10%–15%)” – Science Direct
  - Rice husk is made up of 20% silica and silica is know do be able to absorb large quantities of oil
- Lentil Flour
  - “Lentils contained an average of 28.6% protein, 3.1% ash, 4.4% fiber, 0.7% ether extract, 63.1% total carbohydrate (nitrogen-free extract), 44.3% starch and 4,186 kcal/kg of gross energy. Lentil starch contained 36.1% amylose.” – science pub
  - Starch is used to absorb oil in plenty of fried foods. Since Lentil flour is 44.3% starch it should reduce the amount of oil in water samples.
- Walnut Shell Powder
  - Contains sclereids which are made of sclerenchyma cell tissues.
  - Sclerenchyma cells serve as storage cells for starch. Starch absorbs oil
- Orange Peel Extract
  - Contains phytochemicals such as flavonoids
  - Orange peel is typically used for absorbing oil from skin



Silicon dioxide

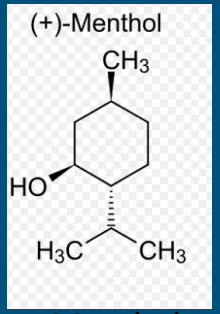

Starch


Sclerenchyma cells

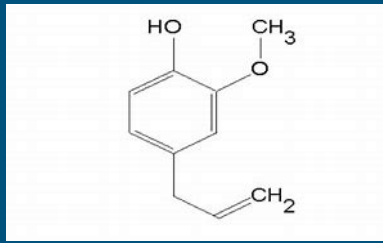

Flavonoid

Background research - Microplastics pollution

- Amrutharishtam
  - Amrutharishtam's main ingredient is Giloy
  - Giloy increases the amount of superoxide which is a reactive oxygen species which are known to be able to dissolve microplastics.
- Dasamoolarishtam
  - Dasamoolarishtam contains several antioxidant enzymes
  - These antioxidants contain large amounts of superoxides, a reactive oxygen species.
- Clove Oil
  - Clove Oil contains many antioxidants like Eugenol, Thymol, and flavonoids.
  - These antioxidants contains large amounts of superoxides, a reactive oxygen species.
- Peppermint Oil
  - Peppermint Oil prominently contains Menthol
  - Menthol is an antioxidant. Menthol contains large amounts of superoxides, a reactive oxygen species.



Menthol



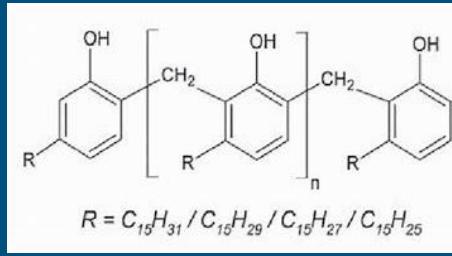
Eugenol

Superoxide

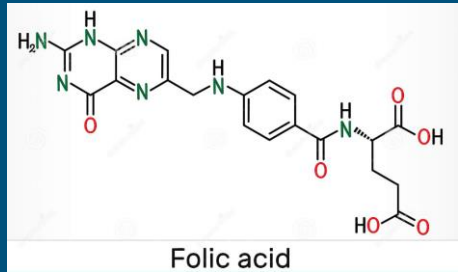
Background Research - Fertilizer pollution

- Yogurt Bacteria Culture (Lactobacillus Fermentum)
  - Lactobacillus is a “good” bacteria which lives inside intestines.
  - Lactobacillus helps the body absorb phosphorus which is present in large amounts in fertilizer.
- Aloe Vera Juice
  - Aloe Vera contains Aloen glucoside, Barbaloen, Resin, Aromatic oil, Ganlic, and Emodine
  - Resin is considered to be able to absorb nitrate, which is present in large amounts in fertilizer
- Peppermint Root
  - Peppermint Root contains Potassium, Calcium, Vitamin A, Vitamin C, and Folate
  - Folate is considered to be able to absorb phosphorus.
- Potato Root
  - Potato Root is mainly composed of carbs like starch
  - Potato root absorbs large amount of phosphorus to help with root development

Lactobacillus



Resin Molecules - Aloe Vera



Folic acid

Material Used

1. 90 liters of seawater obtained from the oceans.
2. 75 jars X 1.2 liter capacity (in lack of large beakers)
3. Grease (Oil spill pollutant)
4. Fuel Oil (Oil spill pollutant)
5. Shredded microplastics (pollutant)
6. Household garden fertilizer (pollutant)
7. 2200ml of soap solution - 200 ml of Dish Soap mixed with 2 liters of Water(to measure the amount of oil in the water sample)
8. Phosphate detection kit(to measure the amount of fertilizer in the water sample)
9. API Nitrite, Nitrate, and Ammonia detection kit(to measure the amount of fertilizer in the water sample)
10. Microscope(to observe the microplastics closely)
11. Fluorescent light(to observe microplastics when looking through the microscope)
12. 0.25 and 4 millimeter sieves (to filter out microplastics)
13. Weighing scale
14. A glass stirrer
15. A glass/plastic container for emulated oil

Natural neutralizing substance against microplastic pollutant

16. 50 ml of Peppermint Oil(natural neutralizing substance)
17. 100ml of Dasamoolarishtam(a polyherbal ayurvedic liquid mixture) (natural neutralizing substance)
18. 50 ml Clove Oil(natural neutralizing substance)
19. 100 ml Amrutharishtam(a polyherbal ayurvedic liquid mixture) (natural neutralizing substance)

Natural neutralizing substance used against oil spill pollutant

20. 25 grams of Lentil Flour
21. 25 grams of Walnut shell powder(natural neutralizing substance)
22. 25 grams of Orange peel extract(natural neutralizing substance)
23. 25 grams of Rice husk(natural neutralizing substance)

Natural neutralizing substance against fertilizer pollutant

24. 25 grams of yogurt bacteria culture(natural neutralizing substance)
25. 50 grams of peppermint root(natural neutralizing substance)
26. 50 grams of potato root(natural neutralizing substance)
27. 50 ml of aloe vera plant juice(natural neutralizing substance)

Procedures

1. Approximately 90 liters of seawater was obtained from the open ocean.
2. Each jar (75 samples in all) was filled with 1 liter of seawater.
3. 30 teaspoons of grease and 300 ml of fuel oil were mixed in a separate container to create a simulation of an oil spill for the experiment.

Preparation of samples (Emulation of pollutant and natural substance treatment);

a. 25 samples - Microplastics pollutant samples -10 milligrams of shredded microplastics under 4 millimeters small were added into 25 jars and stirred with a stirrer. Each of four natural substances in measured quantity (based on background research) were added to 5 jars each(for 5 trials).One set of jars was left as the control sample.

b. 25 samples - Oil spill pollutant samples - 1 teaspoon of Grease/ fuel oil mixture was added to each of the 25 jars. Each of four natural substances in measured quantity (based on background research) were added to 5 jars each(for 5 trials). One set of jars was left as the control sample.

a. 25 samples - Fertilizer pollutant samples - 3 grams of fertilizer were added into 25 jars and stirred with a stirrer. Each of four natural substances in measured quantity (based on background research) were added to 5 jars each(for 5 trials). One set of jars was left as the control sample.

See the diagram in the next slide for distribution of samples with respective pollutant vs. neutralizer substances;

Experiment samples

Sample with 10 milligrams of shredded micro plastic 1 liter of ocean water	1st trial	2nd trial	3rd trial	4th trial	5th trial
Sample with peppermint oil (10 ml)					
Sample with Dasamoolarishtam (20 ml)					
Sample with clove oil (10 ml)					
Sample with Amrutharishtam (20 ml)					
Control sample					

Samples with 5ml of mixture of grease and fuel oil in 1 liter of Ocean Water	1st trial	2nd trial	3rd trial	4th trial	5th trial
Sample with 5 grams of lentil flour					
Sample with 5 grams of walnut shell powder					
Sample with 5 grams of orange peel extract					
Sample with 5 grams of rice husk					
Control sample					

Samples with 3 gms of garden fertilizer from Home Depot in 1 liter of Ocean Water	1st trial	2nd trial	3rd trial	4th trial	5th trial
Sample with yogurt bacteria culture (5 gms)					
Sample with peppermint root (10 gms)					
Sample with potato root (10 gms)					
Sample with juice from Aloe Vera plant(10 ml)					
Control sample					

Procedures (Contd.)

4. The jars were left open outdoors and safe location which received sunlight and wind (to as closely emulate real life conditions of the ocean).

5. Following measurements were taken every two days to test remnant pollutant content (microplastic content, fertilizer content, and oil content in each of the jars were tested).

a. To test remaining fertilizer content in water - A seawater testing kit was used to measure remaining nitrate, phosphate, nitrite and ammonia in the sea water with fertilizer pollutants.
b. To test remaining oil content in water - A standard dish soap based water solution was used to test for remaining amount of oil in each sample.
c. To test remaining microplastics content in water - Water was filtered through 0.25 mm sieve for observation through a microscope using fluorescent light.

Procedures (Contd.)

6. To measure the amount of microplastics in the water, it was run through a 0.25 millimeter sieve to separate the microplastics and water. The microplastics from the sieve were observed under a microscope and a fluorescent light was shone on it to count the number of microplastics that were visible under the light. Contents were then remixed to continue to the experiment.

7. To measure the amount of remnant oil in the water, a 20 ml of the sample was separated and used in separate beaker. A pipet was used to add 20 drops of soap solution to it. The soap solution was shaken vigorously and observed to see if any floating oil content remained in the water sample. If floating oil remained, the process was be repeated until no oil is visible floating in the sample. The number of drops of soap solution used to completely dissolve all the oil was recorded.

8. Observations were regularly recorded in a data journal.

9. At the end of the experimentation the data observations were plotted and compared.

10. Samples used in the experiment were disposed off using proper safety measures.

Pollutants used to emulate pollution in ocean water

Garden fertilizer

Fuel oil/Grease mixture

Shredded microplastics

Pollutants Added to prepare samples

Example of prepared samples (With Fertilizer pollutant)

Natural substances added to samples

Natural substances added to oil pollutant samples

- Lentil Flour
- Orange Peel Extract
- Rice Husk
- Walnut Shell Powder

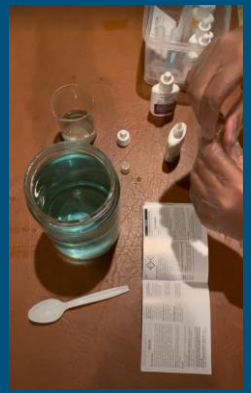
Natural substances added to microplastics pollutant samples

- Dasamoolarishtam
- Amrutharishtam
- Clove Oil
- Peppermint Oil

Natural substances added to fertilizer pollutant samples

- Peppermint Root
- Aloe Vera Plant Juice
- Yogurt Bacterial Culture
- Potato Root

Observations made at regular intervals

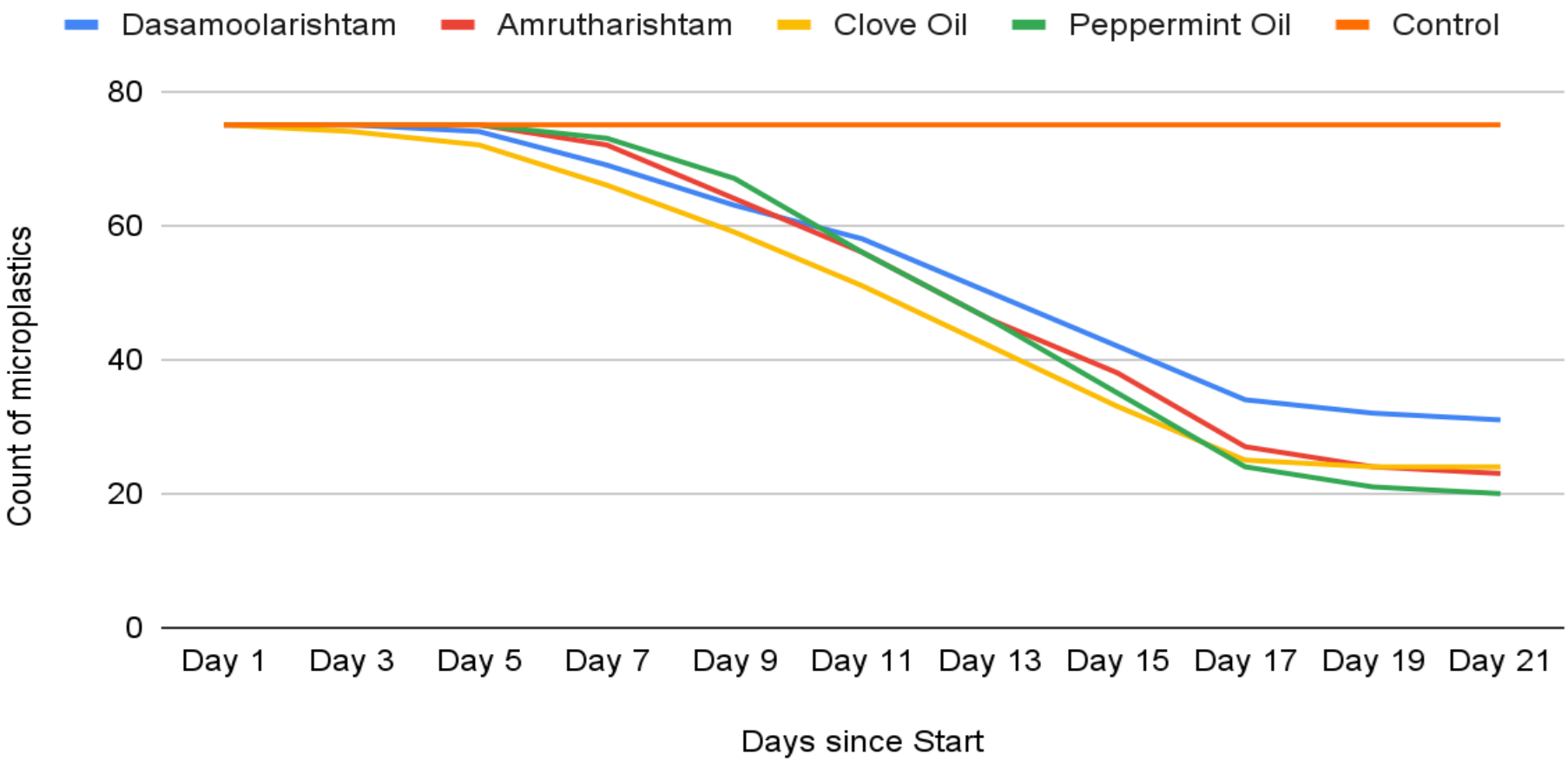


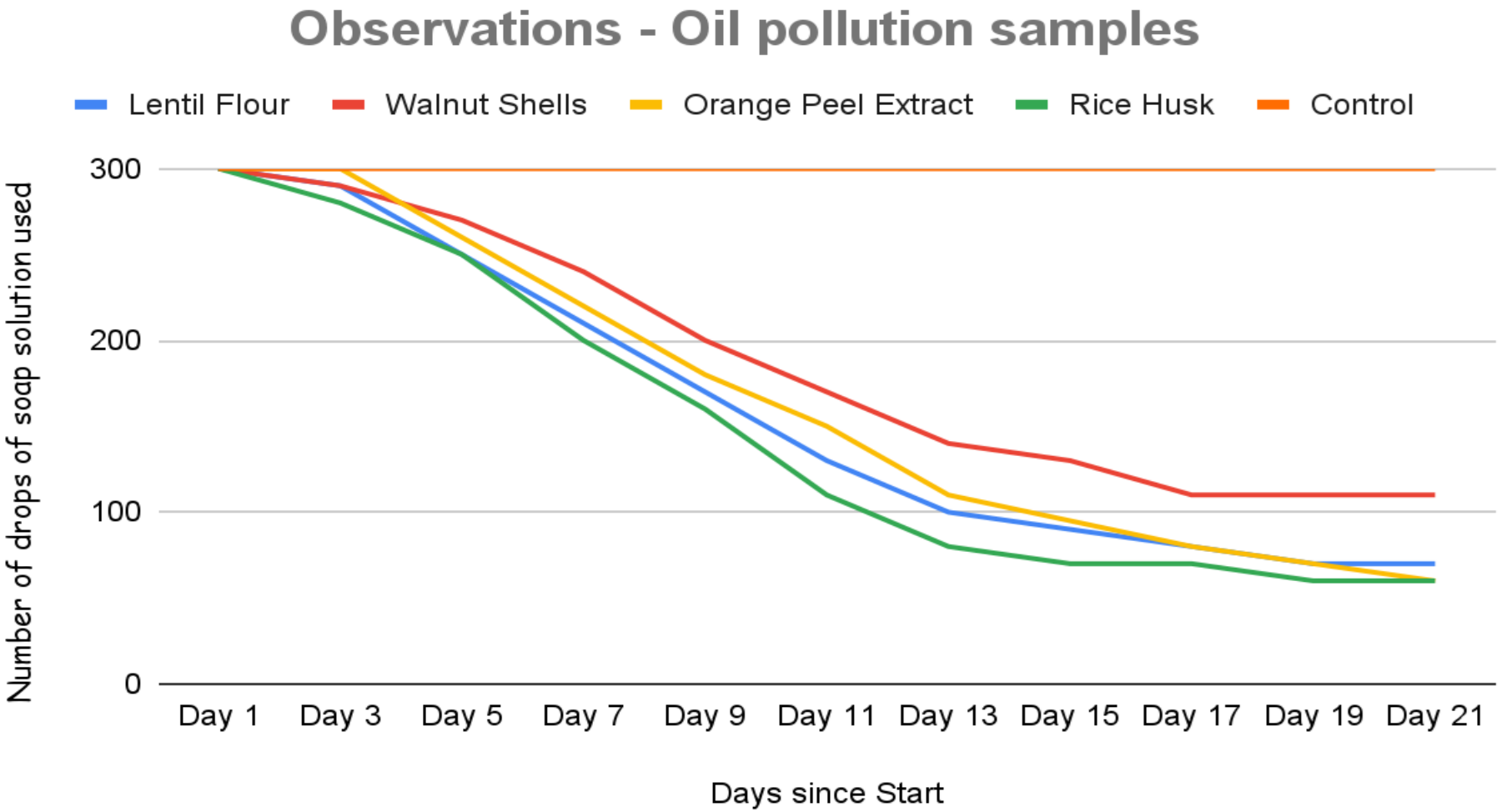
Microplastic pollutant - Samples for observation under a microscope - Day 1 through Day 5 - Peppermint Oil (as example).

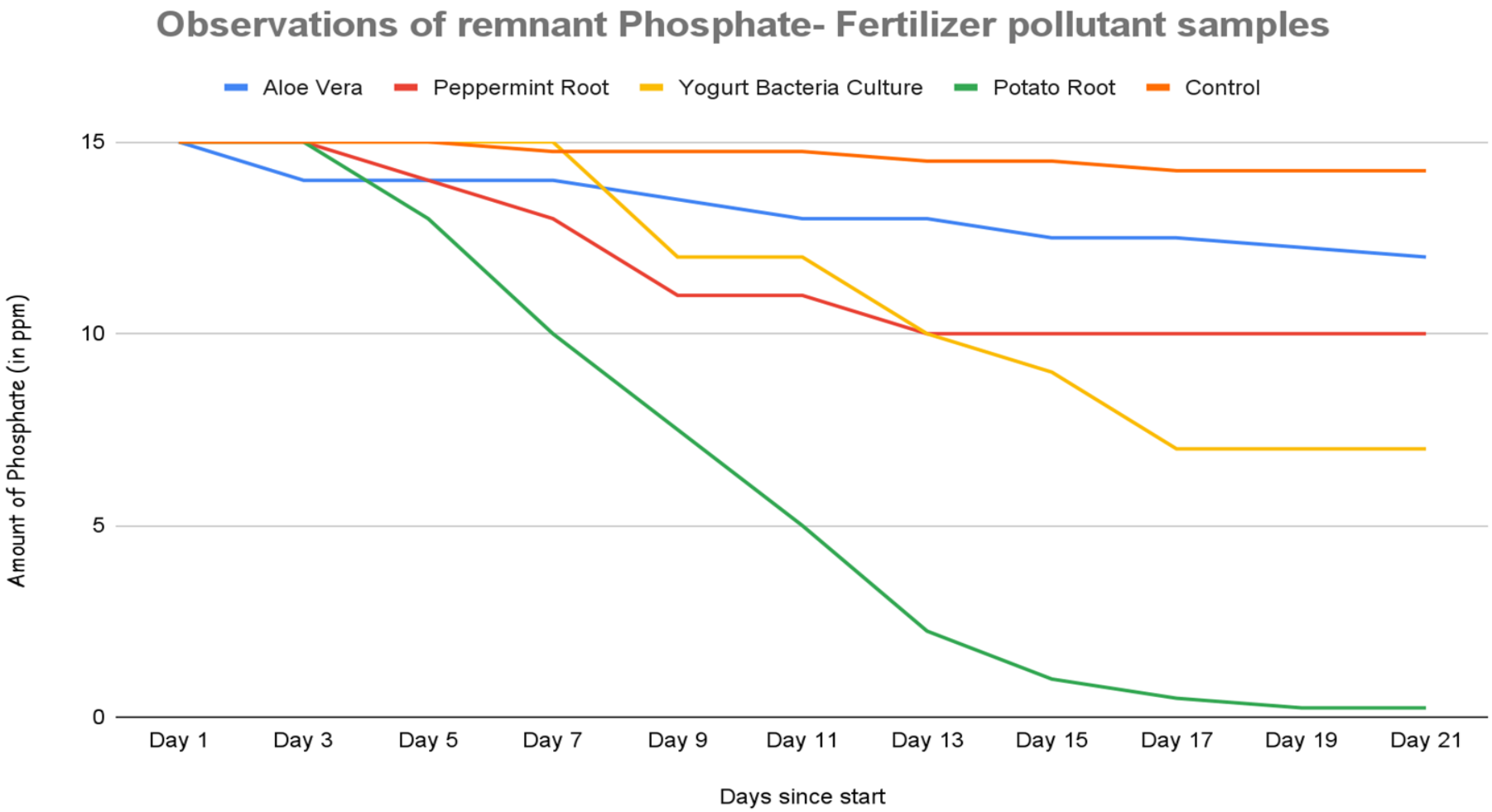
Fertilizer pollutant - Observation of remnant nitrates, nitrites, ammonia and phosphates.

Oil pollutant sample - Measuring remnant oil in sample

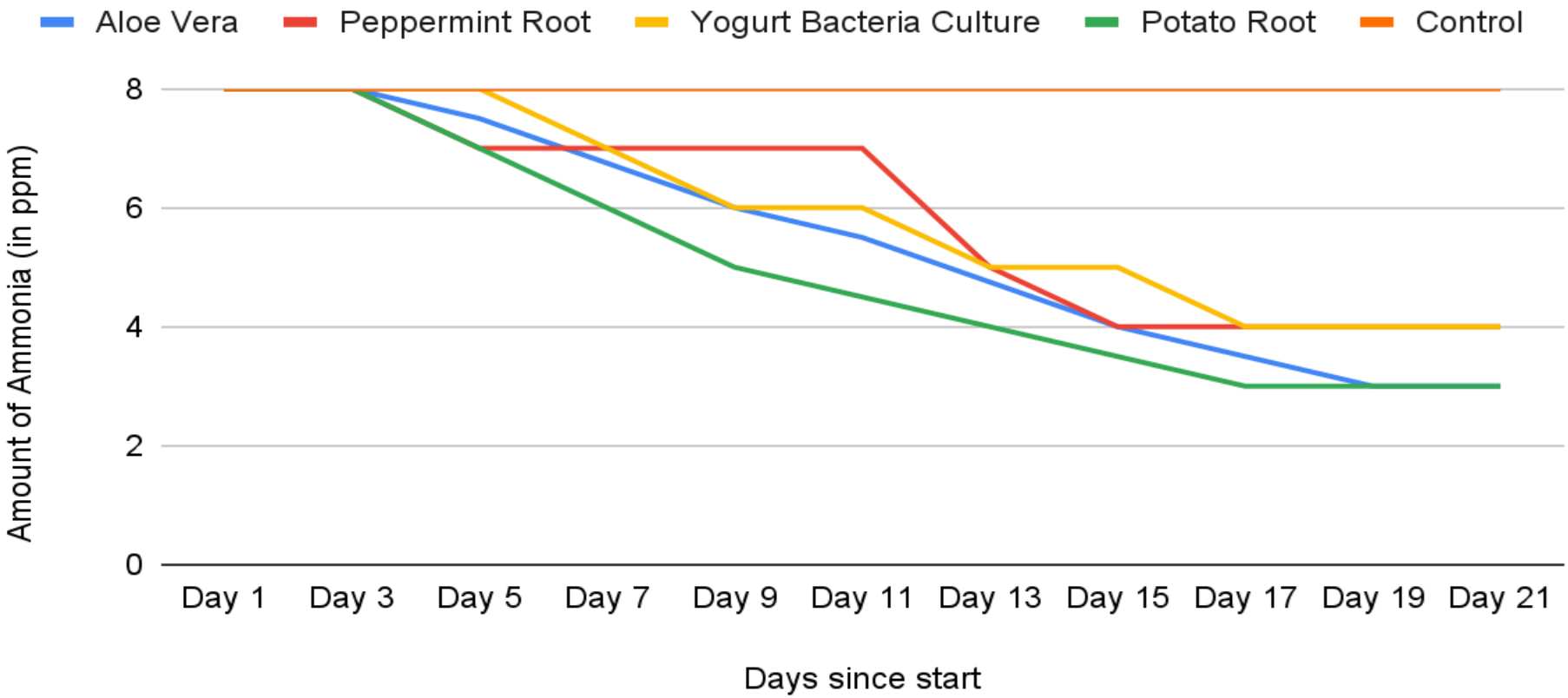
Observations - Microplastics pollution samples



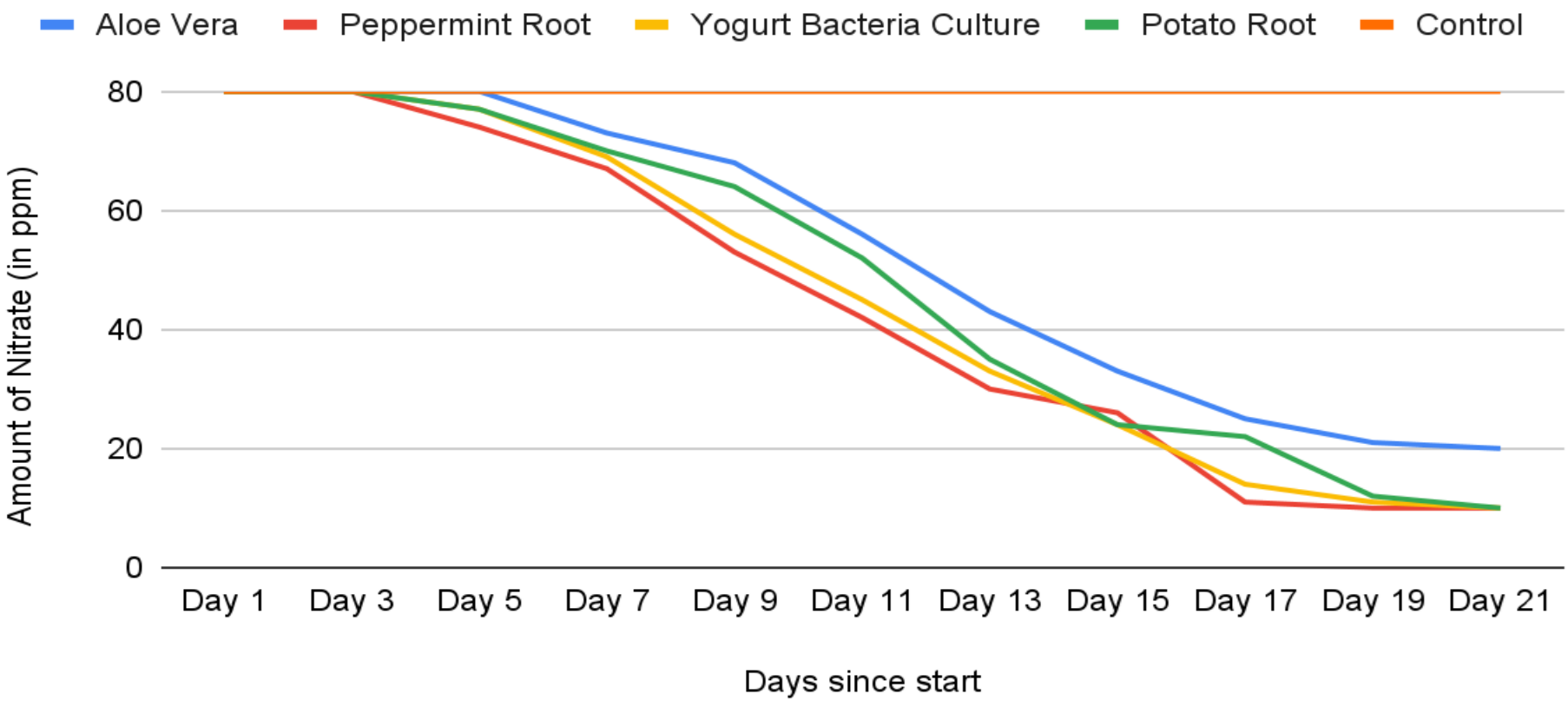

Observations - Oil pollution samples
Lentil Flour
Walnut Shells
Orange Peel Extract
Rice Husk
Control
300
200
100
0
Number of drops of soap solution used
Day 1
Day 3
Day 5
Day 7
Day 9
Day 11
Day 13
Day 15
Day 17
Day 19
Day 21
Days since Start


Observations of remnant Phosphate- Fertilizer pollutant samples
Aloe Vera
Peppermint Root
Yogurt Bacteria Culture
Potato Root
Control
15
10
5
0
Amount of Phosphate (in ppm)
Day 1
Day 3
Day 5
Day 7
Day 9
Day 11
Day 13
Day 15
Day 17
Day 19
Day 21
Days since start

Observations of remnant Ammonia - Fertilizer pollutant samples



Observations of remnant Nitrates - Fertilizer pollutant samples



Results

- For microplastics pollutant - Results showed that peppermint oil worked the best to neutralize microplastic pollution in the water. There were 20 microplastics left in the sample with peppermint oil.
- For oil spill pollutant - Results showed that rice husk and orange peel extract worked best to neutralize oil pollution. Samples where rice husk and orange peel extract were used as neutralizers, required 60 drops of soap solution for there to be no oil pollutant left in the water.
- For fertilizer runoff pollutant - Results showed that potato root worked the best overall for reducing phosphate, nitrate, and ammonia. After 21 days 3 ppm (parts per million) of ammonia in the water, 10 ppm of nitrate, and 0.25 ppm of phosphate were observed as remaining in the sample.

Conclusion

The results of my experiment supported my hypotheses. The results depicted that in fact, peppermint oil for microplastic pollution, potato root for fertilizer pollution and rice husk, and orange peel extract for oil spill pollution worked best to neutralize the respective pollutants. The experiment utilized high concentrations of the natural neutralizing substances in a very limited quantity of water (1 Liter for each sample) which was not constantly being diluted as it would in a real life scenario. It remains to be studied in a real life scenario where the neutralizing substances may get substantially diluted in the ocean as to how the results obtained might be different.