Environmental Systems and Societies
Internal Assessment

Research Question: How does waste cooking oil pollution impact plant growth, specifically the germination and shoot length of mung beans (*Vigna radiata*) and linseeds (*Linum usitatissimum*), at varying concentrations (0% to 20%) over a 7-day period?

Word Count: 2100

1. Introduction

With the growth of household and restaurant dependence on cooking oil, pollution from used cooking oil has become a major environmental problem, especially in urban and industrial areas where cooking oil is often discarded at will for convenience. When released into soil or water, waste oil creates hydrophobic layers that reduce water absorption, disrupt nutrient cycling, and limit oxygen exchange, all of which are essential for healthy plant growth. Over time, this contamination can degrade soil quality, harm ecosystems, and complicate waste management efforts. Taking a longer view, this pollution can directly affect the normal growth and development of crops, leading to challenges for agriculture worldwide.

The focus of this investigation was to explore how waste cooking oil affects plant growth by studying the germination and shoot length of mung beans (*Vigna radiata*) and linseeds (*Linum usitatissimum*) at varying oil concentrations. These two plants were chosen because of their contrasting characteristics: linseeds are known for their resilience and rapid germination, making them a useful model for examining the physiological effects of environmental stressors such as oil pollution, while mung beans are sensitive to environmental change and serve as an indicator of how pollutants alter plant growth dynamics.

This study contributes to a broader understanding of the ecological impact of oil pollution by investigating how different concentrations of waste oil affect plant germination and growth, in line with sustainable development efforts.

2. Hypothesis

- **H_0:** There is no significant relationship between the concentration of waste cooking oil and the growth of the samples, observed by sample length and number of germinations.
- **H_1:** There is a significant relationship between the concentration of waste cooking oil and the growth of the samples, observed by the length and number of germinations.

3. Variables

Independent variable: Cooking oil concentration (g/25mL water), tested at 0%, 4%, 8%, 12%, 16%, and 20%.
Dependent variable: Number of seeds germinated and post-germination shoot length (cm) after 7 days.

Variable Controlled	Reason	Controlling Method
Seed type and quality	Genetic variation can affect germination rates	Same batch of seeds used, checked for uniform size and health
Water volume (25mL/dish)	Affects germination rate	Calibrated dropper/syringe used for consistency
Sunlight	Affects plant growth	All dishes kept in the same location, 7 hrs sunlight/day
Humidity	Affects transpiration and water loss	Same location used to limit fluctuations
Temperature	Affects germination rate	Kept between 20–25°C throughout
Type of waste oil	Different oils have different properties	Oil taken from the same source and cooking process
Water quality	pH/mineral content affects growth	Sourced from the same supply
Duration of experiment	Different durations would skew results	Fixed at 7 days for all treatments
Dish size	Affects root growth/water retention	Identical dishes used throughout
Number of seeds	Larger samples increase reliability	Same number of seeds per treatment group

Table 1: Controlled variables

4. Methodology

4.1 Materials

Material	Quantity	Uncertainty
Mung beans (*Vigna radiata*)	60 seeds	N/A
Linseed (*Linum usitatissimum*)	60 seeds	N/A
Petri dishes	12 dishes	N/A
Distilled water	~270 mL	N/A
Dropper	5 mL	± 0.01 mL
Measuring cylinder	1–100 mL	± 1 mL
Measuring cylinder	1–500 mL	± 5 mL
Waste cooking oil	30 mL	N/A
Ruler	15 cm	± 0.05 mm
Beakers	6 (250 mL each)	N/A
Labels	12 labels	N/A

Table 2: Materials used in the experiment

4.2 Procedure

1. Preparation of oil-water mixtures. Distilled water and waste cooking oil were combined in separate beakers to create six concentrations: 0% (25 mL water, 0 mL oil), 4% (24 mL + 1 mL), 8% (23 mL + 2 mL), 12% (22 mL + 3 mL), 16% (21 mL + 4 mL), and 20% (20 mL + 5 mL). Each mixture was stirred thoroughly to ensure even dispersion.

2. Preparation of Petri dishes. Thirty dishes were prepared for mung beans and thirty for linseeds (five repetitions per concentration, per seed type), each lined with a consistent amount of cotton wool as a moist substrate and clearly labelled.

3. Seed placement. Ten seeds were placed evenly spaced in each dish and gently pressed into the cotton wool, in contact with the moist surface but not fully submerged.

4. Monitoring and maintenance. Dishes were kept in natural sunlight at a controlled room temperature (20–25°C). Moisture was checked daily and 3 mL of the corresponding oil-water mixture was added each day to prevent drying.

5. Germination count. Dishes were observed daily for 7 days; a seed was considered germinated once the radicle emerged from the seed coat.

6. Growth measurement. Shoot length was measured on day 7 using a ruler (precision 0.1 cm), and the average shoot length for each concentration group was calculated.

4.3 Safety, Ethical and Environmental Considerations

Safety: Lab coats and gloves were worn to avoid skin contact with the oil; spills were cleaned promptly and glassware was handled carefully to avoid breakage.

Ethical: Although the ethical impact of using plants is minimal compared to animal studies, care was taken to consider how oil contamination affects the plants and surrounding environment.

Environmental: Used cooking oil was never disposed of down the sink. Small residues were cleaned with dish soap or oil-solvent products; larger quantities were stored and sent to an oil-recycling station.

5. Data Collection and Processing

5.1 Qualitative Observations

Before the experiment, mung beans were small (3–5 mm), bright green, glossy and football-shaped, while linseeds were 4–6 mm long, flat, oval, and dark reddish-brown. During the 7-day period, mung beans showed healthy, fast growth at 0–4% oil concentration but very little to no germination from 8% upward, with visible oil layers obscuring the radicles at higher concentrations. Linseeds remained comparatively healthy across the full concentration range, though growth slowed somewhat at higher concentrations.

Oil Conc. (%)	Mung (R1)	Mung (R2)	Mung (R3)	Mung (R4)	Mung (R5)	Linseed (R1)	Linseed (R2)	Linseed (R3)	Linseed (R4)	Linseed (R5)
0	4	5	4	3	4	10	11	9	10	10
4	7	6	8	7	7	6	7	5	6	6
8	1	1	2	1	1	6	5	6	6	5

12	1	0	1	1	0	6	6	5	6	6
16	1	1	0	1	1	6	6	7	5	6
20	0	0	0	0	0	7	7	6	7	7

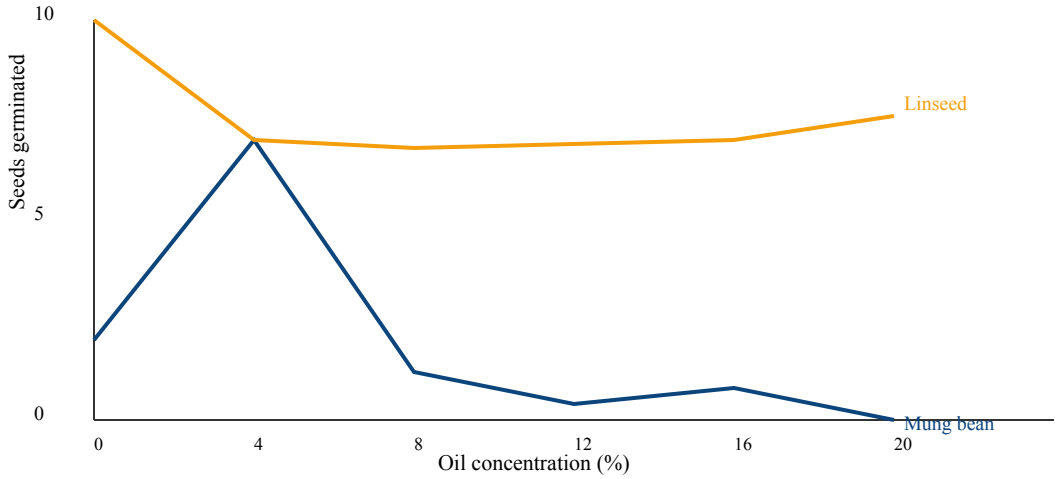
Table 4: Number of seeds germinated per cooking oil concentration after 7 days (5 repetitions)

Oil Conc. (%)	Mung Avg Length R1	R2	R3	R4	R5	Linseed Avg R1	R2	R3	R4	R5
0	1.2	1.3	1.1	1.0	1.2	1.8	1.9	1.7	1.8	1.8
4	2.1	2.0	2.2	2.3	2.1	2.5	2.6	2.4	2.5	2.5
8	0.5	0.6	0.4	0.5	0.5	0.9	0.8	0.9	0.9	0.9
12	0.7	0.8	0.7	0.6	0.7	1.2	1.1	1.3	1.2	1.2
16	0.4	0.5	0.3	0.4	0.4	1.0	1.1	1.0	1.0	1.0
20	0	0.1	0	0	0	0.5	0.6	0.5	0.5	0.5

Table 5: Length (cm) of mung beans and linseeds in each cooking oil concentration (5 repetitions)

6. Data Analysis

6.1 Graphs Analysis



Graph 1: Trend plot of oil concentration vs. number of seeds germinated (averages)

Mung bean germination peaked at 4% oil concentration (7 seeds on average) and dropped sharply to 0 seeds at 20%; a polynomial regression indicated R^2=0.6077, meaning oil concentration explains roughly 61% of the variation observed. Linseed germination started at 10 seeds at 0%, decreased to 6 at 4%, and then stabilised between 5.6 and 6.8 seeds from 8–20% (R^2=0.8535).

Average shoot length followed a similar pattern: mung bean length peaked at 2.14 cm at 4% and declined sharply to near 0 cm at 20% (R^2=0.597); linseed length peaked at 2.5 cm at 4% and declined more gradually to 0.52 cm at 20% (R^2=0.6177).

6.2 One-Way ANOVA Test

H_0: Oil concentration does not affect germination. **H_A:** Oil concentration affects germination.

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups (Mung, germination)	179.9	5	35.98	134.93	9.33×10^{-17}	2.62
Between Groups (Linseed, germination)	69.5	5	13.9	37.91	1.25×10^{-10}	2.62
Between Groups (Mung, length)	13.956	5	2.7912	389.47	3.78×10^{-22}	2.62
Between Groups (Linseed, length)	12.804	5	2.5608	731.66	2.11×10^{-25}	2.62

Table 8–11 (summarised): ANOVA results for germination numbers and lengths

Because all p-values are far below 0.05, H_0 is rejected in favour of H_A: oil concentration significantly affects both germination and growth for both species.

7. Discussion and Evaluation

The results showed a significant relationship between waste cooking oil concentration and the germination and growth of both mung beans and linseeds. Mung bean germination dropped from an average of 4 seeds (0% oil) to 0 seeds (20% oil), while linseed — though more tolerant — still showed reduced seed length from 1.8 cm (0%) to 0.52 cm (20%).

These findings are directly relevant to sustainable soil management, particularly in areas affected by oil contamination. The high sensitivity of mung beans suggests they could serve as a bio-indicator species for monitoring soil contamination, while the

comparative resilience of linseed raises the possibility of using it for soil remediation. This aligns with existing literature showing that oil contaminants disrupt soil microbial communities, further compounding effects on plant growth.

The strength of this experiment lies in its controlled variables and replication — light, temperature and watering were kept consistent throughout, and five repetitions per concentration improved reliability. Limitations include the use of only one type of waste oil, which limits generalisability, and the relatively short 7-day observation window. Future research could test additional oil types and extend the observation period, as well as examine effects on soil microbial communities and root interactions.

8. Application

Phytoremediation — using plants to absorb, contain or neutralise pollutants — offers a sustainable route to mitigating the effects of oil pollution. Since linseed outperformed mung bean in both germination and growth under oil stress, it may be a suitable candidate species for phytoremediation in soils affected by waste cooking oil contamination.

Phytoremediation is considerably cheaper than mechanical or chemical soil treatment and avoids introducing additional contaminants — making it attractive for resource-limited settings. However, linseed's germination and growth still decline at higher oil concentrations, limiting its effectiveness in heavily contaminated soils, and phytoremediation itself is a slow process unsuitable for emergency clean-up situations. Effectiveness would also likely vary with local soil composition and climate, which this study did not account for. Despite these limitations, linseed-based bioremediation remains a promising, scalable, and sustainable option worth further investigation.

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