EFFECT OF DIFFERENT LEVELS OF USED ENGINE OIL ON THE PHYSICOCHEMICAL PROPERTIES OF SOIL, EARLY ESTABLISHMENT AND THE RATE OF GERMINATION OF PEPPER (*Capsicum spp*.)

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Abstract

The contamination of soil with used engine oil poses significant environmental challenges, affecting soil quality and plant growth. The main aim of this study was to investigate the impact of varying concentrations of used engine oil on the physicochemical properties of soil, as well as its effect on the early establishment and germination rate of pepper (*Capsicum spp*.) plants. Pepper seeds were sown in soils treated with different levels of used engine oil (0 ml, 100 ml, 150 ml, 200 ml, 250 ml, 300 ml). The emergence rate, seedling height, stem width, and number of leaves were monitored over two weeks. Additionally, the physicochemical properties of both contaminated and uncontaminated soils were analyzed, for pH, organic carbon content, and nutrient levels Phosphorus, Magnesium, Potassium and Sodium. Seed emergence and growth parameters were significantly affected by oil contamination. Control soil showed the highest seed emergence (10.00±0.00 at day 20) and seedling height (7.06±0.49 cm at week 2). In contrast, the highest contamination level (300 ml) resulted in the lowest emergence (6.00±0.00 at day 20) and reduced seedling height (2.90±0.44 cm at week 2). Stem width and number of leaves were similarly reduced in contaminated soils. Physicochemical analysis revealed that contaminated soils had higher pH and lower organic carbon content compared to uncontaminated soils. This study demonstrates that, higher concentrations of used engine oil adversely affect the germination and early growth of pepper plants by lowering the emergence rates, reducing plant height, stem width, and number of leaves, indicating severe stress on the plants. Changes in soil physicochemical properties, such as increased pH and decreased organic carbon, likely contribute to the reduced growth performance. Varying concentrations of used engine oil significantly impact both the physicochemical properties of soil and the early growth of pepper plants.

Keywords: Concentrations, contamination, emergence, growth, nutrient

Introduction

Indiscrimate disposal and leakage of used engine oil into agricultural lands pose significant threats to crop growth and soil fertility. Used engine oil is composed of hydrocarbons, heavy metals (e.g., lead, zinc, cadmium), and other contaminants that can persist in the soil and affect plant physiology. Polyaromatic hydrocarbons (PAHs), in particular, are reported to inhibit seed germination and root elongation by disrupting cellular processes and nutrient uptake mechanisms in plants, (Amuah *et al*.,2024)

Germination process is a critical physiological stage in the plant life cycle where seeds transition from dormancy to active growth. Factors influencing seed germination, such as soil moisture, temperature, and chemical environment, has significant impact on early plant establishment. Pepper (*Capsicum spp*.) is an economically important crop known for its sensitivity to environmental stressors during germination and early growth stages. Studies carried out by Johnson *et al.,* (2018) have reported that, exposure to used engine oil can reduce seed germination rates and inhibit early root and shoot development in pepper plants. High concentrations of oil contaminants may interfere with water uptake and nutrient absorption, leading to stunted growth and reduced vigor. The extent of damage depends on factors such as oil concentration, duration of exposure, soil type, and climatic conditions.

Smith and Brown (2021) also reported that, pepper seeds exposed to low concentrations of used engine oil exhibited delayed germination and reduced seedling biomass compared to control groups. Higher oil concentrations further exacerbated these effects, highlighting the sensitivity of pepper plants to oil contamination during early developmental stages.

The study on the effect of different levels of used engine oil on the physicochemical properties of soil, early establishment, and the rate of germination of pepper holds substantial significance for both agricultural practices and environmental sustainability. Understanding how soil physicochemical properties are altered by oil contamination is crucial for assessing soil health and productivity (Polyak, *et al.,* 2024). Moreover, investigating the impact of oil contamination on the germination and early growth of pepper plants is essential for ensuring food security and mitigating environmental risks associated with industrial waste disposal. In view of these, the study was carried out to investigate the impact of varying concentrations of used engine oil on the physicochemical properties of soil, as well as its effect on the early establishment and germination rate of pepper (*Capsicum spp*.) plants. MATERIALS AND METHODS

Procurement of Experimental Materials

The seeds of experimental plant of interest (pepper) were obtained from a pool of sellers from Wurukum market in Makurdi. The used engine oil was collected from mechanic village Kanshio. The perforated polyethene bags were also obtained from Wurukum market. The top soil used in the study was obtained from the soil found around the Faculty of Science office building at a depth of 9cm using a shovel.

Experimental Design and Treatment Application

The experiment of the study was laid out using a Completely Randomized Design (CRD) structure. There were six different levels of treatment. Used engine oil treated with 5kg of soil in each of the polyethene bag obtained; 100ml, 150ml, 200ml, 250ml and 300ml polyethene bag of 5kg soil. These treatments were replicated three (3) times to give a total of (18) experimental units.

Soil Sampling and Treatment Application

The top soil collected was bulked, air-dried, crushed and sieved through 2mm sieve before weighing into the perforated polybags. The treatments (UEO) were thoroughly mixed with each of the 5kg soil before filling it in the polybags and allowed to stay for two (2) weeks before planting the pepper seeds.

Agronomic Experimentation

Seed Planting and Germination Count

The viability of the seeds was determined by simple floatation method. The pepper seeds were planted 2 per hole in each polybag at a planting distance of 10×10cm. After planting, the set up was watered and monitored twice a day, morning and evening. A systematic application of pesticides was used in other to prevent the seedlings from being attacked by some pests. Two weeks after germination (WAG), thinning was done to allow a seedling plant per hole and also weeding was done by handpicking regularly until harvest.

The germination count was done two weeks after planting (WAP) and the parameters such as days of emergence, the rate of germination and the percentage (%) germination count (GC) were considered using the relationship

$$\%GC = \frac{\text{No.of germinated seeds}}{\text{No.of seed planted per kg}} \times 100$$

Analysis of Soil Parameters

Organic carbon Determination.

Determination of organic carbon (OC) was carried out using the Walkley Black Method.

Phosphorus (p) Determination

Available phosphorus was determined by the Bray 1 method (Mackay *et al.,* 2017).

Soil pH determination

The soil pH reflects whether a soil is acidic, neutral, basic or alkaline. The acidity, neutrality or alkalinity of a soil is measured in terms of hydrogen ion activity of the soil water system was carried out using standard procedures by Zhang *et al*.,(2016).

Determination of soil Magnesium and Potassium

The magnesium and potassium contents in each soil sample was determined using the standard methods described by (Jones, 2001).

Determination of soil sodium

The sodium concentration in the soil sample was measured using a flame photometer, which detects the emission of light at a specific wavelength (589 nm for sodium) (Horneck, *et al.,* 2011).

Data Analysis

All the data collected during the study were used to calculate for their mean with standard deviation (SD±). The Means was separated using the Fisher's Least Significant Difference (FLSD) at 5% level of significance, using a Statistical Package for Social Science (SPSS) version 28.

Results

Effect of Used Engine Oil Treatment on the Emergence of Pepper seeds After Eight Days of Planting

The effect of Used Engine Oil on the emergence of Pepper is presented in Table 1a. The result showed that after 4 days of planting, only the plants in the control group emerged ($P<0.05$). At days 8 and 12, the plants that emerged in the control were significantly highest ($P<0.05$) compared to the Used Engine Oil treated groups. At day 16, More plants emerged also in the control, however, no significant difference ($P>0.05$) was observed compared to the soil treated with 150ml, 200ml and 250ml of the used Engine Oil. After 20 days of observation, the number of emerged plants was significant ($P<0.05$) more in the control group compared to all the Engine Oil treated groups. The least number was observed in the 150ml treated soil.

Table 1a: Effect of different level of Used Engine Oil Treatment on the Emergence of Pepper Seed

Concentration (mL/v)	Seed Emergence				
	Day 4	Day 8	Day 12	Day 16	Day 20
0. (control)	3.00±1.41	7.00±2.83	8.00±0.00	8.00±1.41^{b}	10.00±0.00
100	0.00±0.00^{a}	3.00±1.41	3.00±1.41^{f}	4.00±0.00^{c}	8.00±0.00^{d}
150	0.00±0.00^{a}	1.00±0.00^{e}	3.00±0.00^{f}	5.00±0.00^{bc}	5.00±1.41
200	0.00±0.00^{a}	1.00±0.00^{e}	3.00±1.41^{f}	5.00±0.00^{bc}	7.00±1.41^{d}
250	0.00±0.00^{a}	1.00±0.00^{e}	3.00±0.00^{f}	4.00±0.00^{e}	6.00±0.00^{d}
300	0.00±0.00^{a}	1.00±0.00^{e}	4.00±1.41^{f}	6.00±2.83^{bc}	6.00±0.00^{d}
FLSD(0.05)	**3.100**	**2.511**	**3.527**	**2.770**	**1.990**

Note: Values are mean ± Standard deviation in triplicates. Mean values with similar Superscripts are not significant

Effect of Used Engine Oil on the Germination of pepper

The effect of used engine oil on the germination of pepper is presented in Table 1b. There was a significantly ($P<0.05$) highest rate of germination of 96.67%, in the control (0 mL) compared to all the treatments, indicating optimal conditions with no oil contamination. This was followed by the plants

in the 100mL contaminated soil although, no significant difference (P>0.05) was observed compared to 200mL contaminated soil. The result further shows that, as engine oil concentration increases, the percentage of seed germination decreases, implying that, used engine oil has a toxic effect on seed viability and early growth.

Table 1b: Effect of Used Engine oil contamination on the mean % Germination of pepper

Concentration (mL/v)	% Seed germination
0	96.67 ± 5.77
100	76.67 ± 5.77[a]
150	40.00 ± 10.00[b]
200	63.33 ± 5.77[a]
250	50.00 ± 17.32[b]
300	46.67 ± 15.28[b]
FLSD (0.05)	**15.000**

Effect of different levels of used engine oil contaminated soil on the growth parameters of Pepper Seedlings

The result in Table 2 presents the effect of different levels of used engine oil contamination on the growth parameters of pepper seedlings namely height, width, and number of leaves. The control group (0 mL/v) shows the highest height (~7.06 cm), standing out clearly above all other treatments, from 100 mL/v upwards, plant height drops significantly (P<0.05) and remains relatively constant between ~2.9 to 3.15 cm .A sharp reduction of the parameters was observed from 0 to 100 mL/v, indicating that even low levels of used engine oil significantly stunt vertical growth again, the control group leads with the widest stem (1.17 cm).More so, stem width drops steeply at 100 mL/v to ~0.37 cm and continues declining with increasing concentration, at 300 mL/v, it recorded its lowest value (~0.23 cm) which was a clear indicator of stress and stunted development due to contamination. The number of leaves also drops from the control (5.57) to about 3.33–3.67 in all contaminated treatments, unlike height and width, the number of leaves remains fairly stable across 150 to 300 mL/v. Though reduced, the variation isn't as sharp, suggesting that leaf production is less sensitive to oil concentration than height or width

Table2 Effect of different levels of used engine oil contaminated soil on the growth parameters of Pepper Seedlings

Concentration (mL/v)	Height (cm)	Width (cm)	Number of Leaves
0 (Control)	**7.06±0.49**	**1.17±0.23**	**5.57±0.68**
100	3.10±0.25[ab]	0.37±0.05[b]	3.33±0.48
150	3.15±0.19[a]	0.37±0.05[b]	3.67±0.48[b]
200	3.10±0.51[ab]	0.37±0.05[b]	3.67±0.48[b]
250	3.03±0.42[ab]	0.30±0.00	3.67±0.48[b]
300	2.90±0.44[b]	0.23±0.05	3.67±0.48[b]
FLSD (0.05)	**0.112**	**0.771**	**2.111**

Note: Values are mean ± Standard deviation in triplicates. Mean values with similar Superscripts are not significant

The result of the contaminated soil has a higher pH (**8.6**) compared to the uncontaminated (**7.3**), indicating that ,used engine oil increases the pH of the soil to alkalinity, likely due to the presence of hydrocarbons and heavy metals. Both soil samples had phosphorus below detection limit, which could mean that oil contamination suppresses P availability or microbial activity needed to release. Magnesium (Mg) levels were slightly lower in contaminated soil (11.85 vs. 12.06 mg/L), but not drastically different indicating minor depletion due to contamination. Potassium (K) levels were also very close (8.09 vs. 8.11 mg/L), suggesting that used oil may not significantly affect potassium retention. Sodium (Na**)** was slightly lower in contaminated soil (21.40 vs. 21.67 mg/L), showing minimal impact. Organic carbon was reduced in contaminated soil (0.018 vs. 0.022), suggesting that oil contamination may suppress microbial decomposition or alter organic matter dynamics (Table3).

Table 3: Effect different level of used engine oil contamination on physicochemical properties of soil

Samples	Weights (gram)	Textural Class	pH	P(mg)	Mg(mg/l)	K(mg/l)	Na(mg/l)	Organic carbon
C.S	1.0371	Loamy-clay	8.6	BD	11.85	8.09	21.40	0.018
US	1.0436	Loamy-clay	7.3	BD	12.06	8.11	21.67	0.022

Keys: C.S = Contaminated soil, U.S = Uncontaminated soil, BD = Below detection limit, P= Phosphorus, Na= Sodium, Mg= Magnesium, K= Potassium

Discussion

The influence of used engine oil on soil properties and plant growth, specifically pepper (*Capsicum* spp.) plants, is a critical area of research due to its implications for agricultural productivity and environmental health (Amuah, *et al.*, 2024). This study examined the impact of different concentrations of used engine oil on the physicochemical properties of soil and the subsequent effects on seed germination and early seedling growth of pepper plants. The results of this study showcased the detrimental effects of oil contamination on both soil quality and plant development.

Impact on Seed Germination and Seedling Emergence

The germination and early establishment of pepper seeds were markedly influenced by soil contamination levels, as the seed emergence was significantly hindered at higher concentrations of used engine oil, most especially at a concentration of 100 ml, no seeds had emerged by day 4, and only three seeds had emerged by day 20. In contrast, the control group exhibited full emergence (10 seeds) by day 20. Azorji *et al.,(* 2021) also reported that, used engine oil exerts toxic effects on seed viability and germination, likely due to the presence of hydrocarbons and heavy metals that interfere with seed metabolic processes.

Effect on Seedling Growth Parameters

The growth in height of pepper seedlings was significantly reduced in contaminated soils compared to the control by the second week. Rashid *et al.,* (2023) suggests that soil contamination severely restricts seedling elongation, likely due to impaired nutrient uptake and increased phytotoxicity

The stem width of pepper plants also demonstrated a reduction in contaminated soils as compared to the control group. This reduction indicates stunted growth, which can be attributed to the toxic effects of used engine oil on cellular processes and structural development (Salam *et al.,* 2017).

The number of leaves, an essential indicator of plant health and photosynthetic capacity, was similarly affected. The control plants had significantly higher ($P<0.05$) number of leaves in week two, whereas those in contaminated soils had fewer leaves, with the highest contamination. Fewer leaves imply reduced photosynthetic capacity and overall vigor, further illustrating the adverse impact of oil contamination on plant growth (Azorji *et al.,* 2021).

Effect on Soil Physicochemical Properties

The contamination of soil with used engine oil altered several key physicochemical properties. The soil pH in contaminated samples increased to 8.6 compared to 7.3 in uncontaminated soil, indicating a shift towards alkalinity. This alkalinisation can significantly affect nutrient solubility and availability, potentially disrupting plant nutrient uptake and microbial activity. Moreover, the organic carbon content decreased in contaminated soils relative to uncontaminated soils, suggesting that used engine oil might interfere with the decomposition of organic matter and the overall soil organic carbon cycle. Such alterations can lead to a decline in soil fertility and structure, further hindering plant growth and soil health as similarly reported by Msimbira and Smith, (2020).

Conclusion

This study provides clear evidence that, used engine oil contamination adversely affects both the physicochemical properties of soil and the growth parameters of pepper (*Capsicum* spp.) plants. Increased soil pH and decreased organic carbon content highlight the negative impact on soil health, potentially leading to long-term degradation of soil quality. The significant reduction in seed germination rates and seedling growth parameters (height, width, and number of leaves) underscores the phytotoxicity of used engine oil, which disrupts normal plant physiological processes. These findings emphasize the need for stringent measures to prevent soil contamination and for remediation strategies to restore affected soils.

Recommendations

1. Implementing soil remediation techniques such as bioremediation with oil-degrading microbes or phytoremediation with tolerant plant species is essential to mitigate the adverse effects of used engine oil contamination. These methods can help restore soil health and functionality.
2. Continuous monitoring of soil health parameters, including pH, nutrient levels, and organic carbon content, is crucial in areas prone to contamination. This will aid in the early detection of contamination and the implementation of timely remediation measures.

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