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Effects of used engine oil polluted-soil on seeds' germination and seedlings' growth characteristics of some tropical crops

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Abstract— *The ability of Phaselous vulgaris, Zea mays L., Solanum lycopersium and Sorghum saccharatum to germinate and grow in unpolluted soils, 1% w/w and 2% w/w used engine oil polluted soils were investigated. Twenty (20) seeds of each plant species were sown in the various polluted and unpolluted soils and germination were monitored for 7 days, and subsequent growth for 7 weeks. The numbers of germinated seeds were counted daily from the 2nd to the 7th day, and percentage germination recorded. Plants' growth parameters (shoot heights and leaf area) of the seedlings were assayed and recorded on the 3rd, 5th and 7th week. Percentage germination varied for the various plant seeds.* S. saccharatum *had the best germination in polluted and unpolluted soil with 100%, 95% and 90% germination as against the least germination 100%, 65% and 25% observed in S. lycopersium in unpolluted, 1% w/w polluted and 2% w/w polluted soils, respectively. In terms of growth, P.* vulgaris *had the best performance in unpolluted and polluted soils with mean shoot heights of 47.8 cm, 41.3 cm and 28.4 cm as against S.* lycopersium *with mean shoot heights of 10.8 cm, 5.8 cm and 3.6 cm in unpolluted, 1% w/w and 2% w/w polluted soils, respectively at the end of the study. The results of this study showed that used engine oil inhibited the germination of these seeds in a dose depended manner, and that inhibition of seeds' germination does not connote inhibition of subsequent growth. This highlights the need to prevent agricultural soil pollution with used engine oil.*

Keywords— ***Petroleum hydrocarbon pollution, plants' growth inhibition, seed germination, Used engine oil pollution.***

I. INTRODUCTION

Used engine oil (UEO) is a brown/black liquid mixture of heavy metal contaminants (zinc, lead, and chromium that come from engine parts as they wear down), low to high molecular weight aliphatic and aromatic hydrocarbons, polychlorinated biphenyls, chlorodibenzofurans, lubricative additives and decomposition products [1]. UEO are usually improperly disposed after oil changing operations.

The oil which is not recycled in Nigeria is spilled by mechanics into runoff water drains and open farm lands [2], thereby polluting both soil and water bodies. Contamination of soil by UEO creates an unsatisfactory condition for life in the soil. This result from poor aeration it causes in the soil by displacement of air from the spaces between soil particles, immobilization of soil nutrients, loss of water-holding capacity, and lowering of soil pH. These leads to chlorosis of plant leaves, dehydration of plants and retardation of plant growth [3].

This study is aimed at ascertaining the effects of used engine oil polluted-soil on germination and early growth characteristics of some tropical crops commonly grown in Nigeria. These plants are beans *(Phaselous vulgaris),* maize *(Zea mays L.),* tomatoes *(Solanum lycopersium*) and guinea corn *(Sorghum saccharatum*).

II. MATERIALS AND METHODS

Sample collection

The soil sample used for this study was collected from a fallow farm land at the Federal University of Technology, Owerri. Surface soil (0-20 cm) was collected using a shovel, and was bulked to form composite sample. Used engine oil (UEO) was collected from the mechanic village Nekede in Owerri town, the oil was collected with a chemically clean aluminum pan and ran into a ten liter plastic container immediately after draining from vehicle engine. The seeds of the four different plant species were purchased from Ekeonunwa market in Owerri.

Soil pollution and experimental setup

The UEO was dissolved in acetone, and mixed with 10% of the total soil. The UEO laddered soil was then added to the bulk of the soil and mixed to obtain the final concentrations of 1% (10 g/kg) and 2% (20 g/kg) UEO in soil. The mixed UEO enriched soil was then stirred several times for two days to remove the acetone [4]. The soil samples were then moistened with tap water to bring the soil's moisture level to about 80% of its water holding

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capacity and allowed to undergo weathering for four weeks.

Weathering was by incubation in a green house with approximately 12 h daylight with intermittent moistening with tap water.

Twelve planting pots of approximately 8 cm diameter, each containing 1 kg of soil sample each were set up as follows:

i. Unpolluted soil samples - Four pots
ii. Polluted soil samples (1%) - Four pots
iii. Polluted soil samples (2%) - Four pots

Determination of % germination and plants' growth parameters

Twenty seeds each of the four different plant species (*Z. mays* L., *P. vulgaris*, *S. lycopersium* and *S. saccharatum)* were sown respectively in different unpolluted pots, 1% w/w polluted soil pots and 2% w/w polluted soil pots. The pots were kept in green house and watered three times a week using tap water. Germination in each pot was monitored and number of germinated seeds recorded daily for 7 days. On the 7th day, the germinated seedlings were thinned down to four, and subsequently, plants' growth parameters (shoot heights and leaf area) were determined at the 3rd, 5th, and 7th week of the study.

Germination Indices

The germination indices below were determined as follows:

Final germination percentage (FGP)

FGP = (No. of germinated seeds after 7days/No. of seeds tested) x 100

Germination index

Germination index = % Germination in treatment/ % Germination in control

Energy of germination (EG)

Energy of germination (EG) on Day 4 = % germination 4 days after planting (4DAP) relative to the number of seeds tested.

Measurement of plants' height

Plant's shoot height was determined by measuring from the shoot base to the apical tip using a meter rule. These were determined at the 3rd, 5th and 7th WAP.

Determination of plants' leaf area

The plants' leaf area was determined by calculating the product of its length and width taking at their broadest portions [5]. These were determined at the 3rd, 5th and 7th WAP.

III. RESULTS

Table.1: Z. mays L. seeds' germination in polluted and unpolluted soil (%).

% Oil in soil	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
0%(control)	0	65	100	100	100	100
1%	0	0	0	70	75	75
2%	0	0	0	65	65	65

Table.2: P. vulgaris seeds' germination in polluted and unpolluted soils (%).

% Oil in soil	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
0%(control)	0	15	100	100	100	100
1%	0	0	25	60	60	65
2%	0	0	0	15	35	40

Table.3: S. lycopersium seeds' germination in polluted and unpolluted soil (%).

% Oil in soil	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
0%(control)	0	35	100	100	100	100
1%	0	0	0	40	45	65
2%	0	0	0	10	25	25

Table.4: S. saccharatum seeds' germination in polluted and unpolluted soil (%).

% Oil in soil	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
0%(control)	25	85	100	100	100	100
1%	20	80	85	95	95	95
2%	0	10	35	60	85	90

The percentage seed germination of the four different plant species namely *Z. mays L.*, *P. vulgaris*, *S. lycopersium* and *S. saccharatum* were shown in Tables 1 to 4. The results revealed that percentage seed germination were higher in unpolluted soil samples (100% from day 4) than in polluted soil samples, and it decreased with the increase in the concentration of used engine oil in soil. *S. saccharatum* had the best germination response in unpolluted and polluted soil samples with 100%, 95% and 90% germination respectively in 0%, 1% and 2% w/w oil in soil, followed by *Z. mays L*. with 100%, 75% and 65%, while the least percentage germination was observed in *S. lycopersium* with 100%, 65% and 25% germination respectively in 0%, 1% and 2% w/w oil in soil at the end of the 7 days incubation.

Table.5: Final germination percentages (FGP) of plants' seeds in unpolluted and polluted soil.

% Oil in soil	*Z. mays L.*	*P. vulgaris*	*S. lycopersium*	*S. saccharatum*
0%(control)	100	100	100	100
1%	75	65	65	95
2%	65	40	25	90

The results of the final germination percentages of the test crops (Table 5) show that all the crops had 100% final germination in unpolluted soil. The final germination percentages of the crops decreased as the concentration of oil in soil increased from 0% to 2%. *S. saccharatum* had best final germination percentages with 100%, 95% and 90% in unpolluted soil (0%), 1% w/w and 2% w/w oil in soil respectively. The least FGP was observed in *S. lycopersium* with 100%, 65% and 25% in unpolluted soil, 1% w/w and 2% w/w oil in soil respectively.

Table.6: Germination index of Zea mays L. within 7 days of seed sowing.

% Oil	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
0%(control)	0	0	0	0	0	0
1%	0	0	0	0.70	0.75	0.75
2%	0	0	0	0.65	0.65	0.65

Table.7: Germination index of P. vulgaris within 7 days of seed sowing

% Oil	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
0%(control)	0	0	0	0	0	0
1%	0	0	0.25	0.6	0.6	0.65
2%	0	0	0	0.15	0.35	0.4

Table.8: Germination index of S. lycopersium within 7 days of seed sowing.

% Oil	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
0%(control)	0	0	0	0	0	0
1%	0	0	0	0.4	0.45	0.65
2%	0	0	0	0.1	0.25	

Table.9: Germination index of S. saccharatum within 7 days of seed sowing.

% Oil	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
0%(control)	0	0	0	0	0	0
1%	0.8	0.94	0.85	0.95	0.95	0.95
2%	0	0.11	0.35	0.6	0.85	0.9

The results of the germination index of *Z. mays L., P. vulgaris, S. lycopersium* and *S. saccharatum* are shown in Tables 6 to 9. From the results, *S. saccharatum* had the highest germination index with 0.95 in 1% w/w and 0.9 in 2% w/w oil in soil at the end of the 7 days incubation, followed by *Z. mays* L. with 0.75 in 1% w/w and 0.65 in 2% w/w oil in soil. The least germination index was observed in *S. lycopersium* with 0.65 in 1% w/w and 0.25 in 2% w/w oil in soil at the end of 7 days incubation.

Table.10: Energy of germination of Z. mays L., P. vulgaris, S. lycpersium and S. saccharatum seeds in unpolluted and polluted soil on day 4 of planting.

% Oil	*Z. mays L.*	*P. vulgaris*	*S. lycopersium*	*S. saccharatum*
0%(control)	5	5	5	5
1%	0	1.25	0	4.25
2%	0	0	0	1.4

The result of the energy of germination of these test crops (Table 10) revealed that unpolluted soil (0%) gave the highest energy of germination for all the crops tested. This decreased as the concentration of oil in soil increased from 1% to 2% in all the crops tested.

Table.11: Average shoot heights and percentage seedling height reduction of Z. mays L. seedling in unpolluted and polluted soil.

	3WAP		5WAP		7WAP	
% Oil	SH(cm)	% SHR	SH(cm)	% SHR	SH(cm)	%SHR
0%(control)	38.8	0%	43.1	0%	45.5	0%
1%	30.8	25.97	33.5	28.65	35.3	28.89
2%	28	38.57	26.4	63.25	30.4	49.67

Key: WAP-Week after Planting; SH- Shoot Height; SHR- Seedling Height Reduction

Table.12: Average leaf area and percentage leaf area reduction of Z. mays L. seedling in unpolluted and polluted soil.

	3WAP		5WAP		7WAP	
% Oil	LA (cm^2)	%LAR	LA (cm^2)	%LAR	LA (cm^2)	%LAR
0%(control)	22.8	0	32	0	37.8	0
1%	11.5	98.26	22.2	44.14	22.5	68
2%	6.2	267.74	15.1	111.92	15.2	148.68

Key: WAP-Week after Planting; LA- Leaf Area; LAR- Leaf Area Reduction

Table.13: Average shoot heights and percentage seedling height reduction of P. vulgaris seedling in unpolluted and polluted soil.

	3WAP		5WAP		7WAP	
% Oil	SH(cm)	%SHR	SH(cm)	%SHR	SH(cm)	%SHR
0%(control)	38.8	0%	47.3	0%	47.8	0%
1%	35.3	9.92	39.8	18.8	41.3	15.7
2%	25.1	54.6	28.1	68.3	28.4	68.3

Key: WAP-Week after Planting; SH- Shoot Height; SHR- Seedling Height Reduction

Table.14: Average leaf area and percentage leaf area reduction of P. vulgaris seedling in unpolluted and polluted soil.

	3WAP		5WAP		7WAP	
% Oil	LA(cm^2)	% LAR	LA(cm^2)	%LAR	LA(cm^2)	% LAR
0%(control)	12.4	0	35.4	0	40.1	0
1%	7.6	63.2	21.2	67.0	24.9	61.0
2%	3.2	287.5	13.9	154.7	16.1	149.1

Key: WAP-Week after Planting; LA- Leaf Area; LAR- Leaf Area Reduction

Table.15: Average shoot heights and percentage seedling height reduction of S. lycopersium seedling in unpolluted and polluted soil.

	3WAP		5WAP		7WAP	
% Oil	SH (cm)	%SHR	SH(cm)	%SHR	SH(cm)	%SHR
0%(control)	8.1	0	10.8	0	10.8	0

1%	3.1	161.29	5.8	86.20	5.8	86.20
2%	2.4	273.5	3.5	208.57	3.6	200

Key: WAP-Week after Planting; SH- Shoot Height; SHR- Seedling Height Reduction

Table.16: Average leaf area and percentage leaf area reduction of S. lycopersium seedling in unpolluted and polluted soil.

	3WAP		5WAP		7WAP	
% Oil	LA(cm^2)	% LAR	LA(cm^2)	% LAR	LA(cm^2)	% LAR
0%(control)	0.5	0	1.8	0	2	0
1%	0.1	400	0.7	157.14	0.7	185.71
2%	0.05	900	0.2	800	0.29	589.65

Key: WAP-Week after Planting; LA- Leaf Area; LAR- Leaf Area Reduction

Table.17: Average shoot heights and percentage height reduction of S. saccharatum seedling in unpolluted and polluted soil.

	3WAP		5WAP		7WAP	
Oil %	SH(cm)	%SHR	SH(cm)	%SHR	SH(cm)	%SHR
0%(control)	41.8	0	45.1	0	45.1	0
1%	21.3	96.24	27.1	66.42	27.9	61.64
2%	19	120	21.5	109.76	22	105

Key: WAP-Week after Planting; SH- Shoot Height; SHR- Seedling Height Reduction

Table.18: Average leaf area and percentage leaf area reduction of S. saccharatum seedling in unpolluted and polluted soil.

	3WAP		5WAP		7WAP	
% Oil	LA(cm^2)	%LAR	LA(cm^2)	%LAR	LA(cm^2)	%LAR
0%(control)	14	0	27.2	0	27.3	0
1%	2.2	536.36	8.8	209.09	10.6	157.54
2%	1.4	900	6	353.33	5.8	370.68

Key: WAP-Week after Planting; LA- Leaf Area; LAR- Leaf Area Reduction

The results of the shoot heights and percentage seedling height reduction, leaf area and percentage leaf area reduction of *Z. mays L*., *P. vulgaris*, *S. lycopersium* and *S. saccharatum* are shown in (Table 11-18). The result show that shoot heights and leaf area of these crops were higher in unpolluted soil than in polluted soil, and they decreased with the increase in the concentration of used engine oil. *P. vulgaris* had the best shoot heights with 47.8 cm, 41.3 cm and 28.4 cm and leaf area with 40.1 cm^2, 24.9 cm^2 and 16.1 cm^2 in unpolluted soil (0% w/w), 1% w/w and 2% w/w used engine oil in soil respectively at end of the study, as against *S. lycopersium* with shoot heights of 10.8 cm, 5.8 cm and 3.6 cm and leaf area of 2 cm^2, 0.7 cm^2 and 0.29 cm^2 in unpolluted soil (0% w/w), 1% w/w and 2% w/w used engine oil in soil respectively at the end of the study. The percentage seedling reduction and percentage leaf area reduction tend to increase as the concentration of oil increased from 1% to 2%.

IV. DISCUSSION

Indiscriminate disposal of used engine oil has been found to be harmful for living organisms and vegetation. The adverse effects on plant growth may range from morphological aberrations, reduction in biomass to stomatal abnormalities [6].

In this study, the percentage seed germination results revealed that seeds' germination were higher in unpolluted soil samples than in polluted soil samples and it decreased with the increase in the concentration of used engine oil in soil. This could be as a result of the fact that the used engine oil components were toxic to the seeds, thereby inhibiting their complete germination in polluted soil samples. Wang *et al.* [1] and Adam and Duncan [7] suggested that the failure of seeds to germinate in the presence of hydrocarbon contaminants could be as a result of formation of polar compounds dissolved in water that could penetrate the seed coat, exerting polar narcosis. Used engine oil may also have prevented uptake of nutrient, water and oxygen required for seed germination. This finding is in accordance with the findings of Agbogidi and Ilondu [8] in which the inhibitory effect of spent engine oil on germination and seedling growth of *M. oleifera* was found to be dose dependent. Of the tested seeds, *S. saccharatum* had the best germination in used engine oil-polluted soil, followed by *Z. mays L*. The least percentage germination was observed in *S. lycopersium*.

This shows that the response of the seeds to the toxicity of the UEO differs.

The results of the final germination percentage, germination index and energy of germination of these test crops seeds shows that FGP also decreased in a dose dependent manner in all the seeds tested. *S. saccharatum* had the best FGP, followed by *Z. mays L*., while the least was observed in *S. lycopersium*. The germination index of these crops seeds also decreased as the oil concentration increased. *S. saccharatum* had the highest germination index, while the least was obtained in *S. lycopersium*. The energy of germination of these crops revealed that the highest energy of germination was obtained in unpolluted soil (0% w/w) and it also decreased in a dose dependent manner. These results show that used engine oil contaminant is inhibitory to seed germination. It also shows that different plant species reacted differently in the midst of this pollutant. This is in line with the work of Wiltse *et al*. [9] that reported that the potential to tolerate polluted soils differs among plants species and even among varieties.

The effect of the contaminant on the seedlings' growth parameters (shoot heights, percentage seedling height reduction, leaf area and percentage leaf area reduction) of the test crops revealed that the mean plant shoot height and mean leaf area of the crops decreased with the increase in the concentration of used engine oil . The mean heights of the unpolluted controls were greater than those of the plants grown in 1% w/w and 2% w/w used engine oil in soil in all the different plant species. This could be due to the absence of oil in the control which made the soil conducive for the growth of the plant crops. These findings agree with the work of Ekpo *et al*. [10] and Kayode *et al.* [11] on *Glycine max*, *Vigna uniguiculata* and *Z. mays L.*, and the findings of Adenipekun [12] that used engine oil affect plant height, stem girth, moisture content, leaf area and number of leaves in *Celosia argentea.* In this study the higher percentage seedling height reduction and percentage leaf area reduction observed as the concentration of oil increased in soil shows that the seedling heights and leaf area tend to reduce more as the concentration of used engine oil increased from 1% w/w to 2% w/w oil in soil. From the seedlings' growth indics *P. vulgaris* had the best growth response in the presence of the UEO pollutant. Nwoko *et al*. [13] also observed that *P. vulgaris* thrives well in the presence of this contaminant. Seedling growth was found to be adverse for *S. lycopersium*.

The results show that inhibition of germination does not necessarily lead to inhibition of growth. This was seen in *P. vulgaris* whose percentage germination on used engine oil polluted soil was reduced, but its seedlings had the best growth response in the presence of the contaminant.

V. CONCLUSION

Used engine oil polluted-soils are unsuitable for germination and growth of plants, hence there is need to enlighten the public on the hazards of indiscriminate disposal of this pollutant into environmental media. This will go a long way in ensuring human and environmental health, improved crop propagation and safety, and food security.

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