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Remediation of Spent Engine Oil Polluted Soil using *Glycine Max* (L.) (Soybean) and *Vigna Unguiculata* (L.) (Cowpea)

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Keywords: remediation; soil nutrient; soybean; cowpea.

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Abstract- Spent engine oil is synthetic oil that contains impurities or loss of major properties thus affecting its unique purpose. In this study, an experiment was carried out at the contaminated site of Federal College of Forestry; Ibadan to investigate the remediation of spent engine oil polluted soil using soybean and cowpea. The treatments are soybean planted on polluted soil (T1), cowpea planted on nonpolluted soil (T2), cowpea planted on polluted soil (T3), soybean planted on nonpolluted soil (T4). The treatments were arranged in a complete randomized design (CRD) and replicated four times. The soil analysis before and after harvesting was carried out. The growth parameters measured for the legumes were plant height (cm), stem girth (cm), number of leaves, and number of branches. The result of this study shows that the overall growth performance of the two legumes reduced significantly ($p<0.05$) due to the presence of spent engine oil in the soil, which introduced heavy metals above critical level into the soil. At six weeks after planting (6 WAP), the number of leaves and number of branches was significantly reduced in soybean and cowpea polluted soil when compared with the control. The stem girth of soybean (1.37 cm) was significantly reduced ($p<0.05$) more than cowpea (1.94 cm) in polluted soil while the plant height of cowpea (14.86 cm) was significantly reduced more than soybean (18.59 cm). For both pre-planting and post-planting chemical properties analysis, it was observed that the level of Cd, Cr, Pb, and Ni in the pre-planting analysis reduced significantly in the post-planting chemical properties. This shows that both soybean and cowpea exhibited significant remediating ability. However, the level of Cr, Pb, and Ni in the soil cropped by soybean was higher than cowpea and level of Cr, Cd, Pb in soybean plant was higher than that of cowpea, respectively. It can be concluded that soybean is a good crop legume to remediate spent engine oil polluted soil due to its high remediating ability and is recommended that farmers should take considerable measures of cleaning up their polluted farmland with the use of leguminous crops such as soybean.

Keywords: *remediation; soil nutrient; soybean; cowpea.*

I. Introduction

Soil pollution is the presence of xenobiotic (human-made) chemicals or other alteration in the natural soil environment. It is typically caused by industrial activity, agricultural chemicals, or improper disposal of waste, and the most common chemicals involved are petroleum hydrocarbons, polynuclear aromatic hydrocarbons (such as naphthalene and benzopyrene), solvent, pesticides, lead and other heavy metals (Alloway, 1990). The degree of soil pollution correlates with the degree of industrialization and intensity of chemical usage in that environment. The danger of toxic metals is aggravated by their almost indefinite persistence in the environment (Garbisu *et al*. 2001). Pollution of the biosphere with toxic metals has accelerated dramatically since the beginning of the industrial revolution (Memon *et al*. 2000). Spent motor oil, also called used lubricating oil, is obtained after servicing. The disposal of spent oil into gutters, water drains, open vacant plots, and farms in Nigeria is a common occurrence, and this is mostly done by automatics and allied artisans with workshops on roadsides and open places. (Agbogidi, 2011) reported that spent oil is the commonest soil contaminant in the rural areas of Nigeria where agriculture/farming forms the mainstay of the rural inhabitants. The used oil may contain some toxic materials, including heavy metals that could affect growth, yield, and general performance of plants (Agbogidi and Egbuchua, 2010). The contamination of the natural environment by petroleum-derived substances contributes to the degradation of land (Shcwab, 1999). The most important and common symptoms observed in the plants contaminated with oil and its by-products include the degradation of chlorophyll, alterations in the stomata mechanisms and reduction in photosynthesis and respiration, increase in the production of stress-related phytohormone, accumulation of toxic substances or their by-products in vegetal tissue (Baker, 1970), decrease in size and less production of biomass (Ayotamuno *et al.* 2004). In response to a growing need to address environmental and soil contamination which would affect the growth of the plant, phytoremediation has been developed to treat contaminated soil (Riser-Robert, 1998).

Phytoremediation is the use of plants and their associated rhizosphere microorganisms to remove degrade or immobilize various contaminants from polluted soil (Singh *et al.* 2003). Phytoremediation is, on average, ten-fold cheaper than engineering-based remediation methods such as soil excavation, soil washing, or burning or pump and treat systems (Glass, 1999). Plants have a range of potential mechanisms at

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the cellular level that might be involved in the detoxification and tolerance to heavy metal stress. These all appear to be involved primarily in avoiding the buildup of toxic concentration at sensitive sites within the cell, thus preventing the damaging effects (Hall, 2002).

Legume is a plant in the family Fabaceae or the fruit or seed of such a plant. Legumes are notable in that most of them have symbiotic nitrogen-fixing bacteria in a structure called root nodules (Smil, 2000). Legumes are important for nitrogen cycling in the environment and agriculture due to the ability of nitrogen-fixation by rhizobia. Legume species can form a symbiosis with various beneficial micro-organisms, arbuscular mycorrhizal fungi, and plant growth-promoting bacteria. These plant microbe associations implications imply plant growth, nutrition, and disease. The symbiosis of the legume and micro-organisms provides nutrient for the plant, stimulates plant growth, exerts an anti-stress effect on the plant, improves soil fertility, and restore ecosystem biodiversity and function (Postgate, 1998). Legumes species vary significantly in the ability to accumulate metals from contaminated soils, as a balance between the uptake of essential metals ions to maintain growth and development and the ability to protect sensitive cellular activity and structure from excessive levels of essential and non-essential metals is required (Garbisu and Alkorta, 2001). Even though legumes are grown in Nigeria, little has been known about the phytoremediation of polluted soil using different legumes. The objective of the study was to evaluate the phytoremediation potentials of two legumes (*Glycine max and Vigna unguiculata*) by comparing their growth response on soils polluted by the spent engine oil.

II. Materials and Methods

The experiment was conducted at the Federal College of Forestry Jericho Hill, (latitude 7°26'N and longitude 8°36'E) Ibadan, Oyo State, Nigeria. The annual rainfall 1500 mm with a bimodal pattern and has a minimum temperature of 21.9°C and a maximum temperature of 35.5°C with an average relative humidity of about 74.55%. Spent engine oil was collected from a mechanic shop and used to pollute the soil at the rate of 0.25L of oil to 4kg soil. The polluted soil were potted. Two leguminous crops, *Glycine max* (soybean) and V*igna unguiculata* (cowpea), were planted at a depth of 4cm. The experimental design was complete randomized design (CRD) replicated four times.

a) *Data collection*

Three plants from mid-row of the experimental units were randomly selected and used for the data collection on plant height (cm), number of leaves, number of branches, stem girth (cm) at 2, 3, 4, 5, 6, 7 weeks after planting (WAP).

b) *Data analysis*

Data collected was analyzed statistically using Genstat Statistical Software package and was subjected to Analysis of variance. Means were separated using Least significantly difference (LSD) at 5% level of significance.

III. Results And Discussion

The analysis in Table 1 further confirms this assertion and also reveals that the soils are moderate in zinc, high in potassium, and phosphorous. Organic carbon and total nitrogen content of the soil were 69.77 and 5.87g kg,$^{-1}$ respectively, which is above the critical range (Adeoye and Agboola, 1985), nearly neutral pH. The extractable Mn and Fe contents of the soil are high, with 141.00 mg kg^{-1} and 151 mg kg^{-1}, respectively. The soil bulk density was 1.2 g cm^{-3}, with sandy loam texture. Saturated hydraulic conductivity value of 12.64cm hr^{-1} indicated a well-drained soil suitable for the production of the legumes. These physical properties were adequate for crop production (Agbede *et al.,* 2011). The heavy metals in the polluted soil were; lead (Pb) (13.40 mg kg^{-1}), chromium (Cr) (59.85 mg kg^{-1}), cadmium (Cd) (0.70 mg kg^{-1}) and nickel (Ni) (9.30 mg kg^{-1}). According to the (WHO, /2005) moderate level recommendation, Ni (1.5 mg kg^{-1}), Pb (10 mg kg^{-1}), Cr (1.5 mg kg^{-1}), and Cd (0.3 mg kg^{-1}), this shows that the level of heavy metals in the soil was high. High level of heavy metals causes deficiency of available nutrients needed to maintain growth at apical regions of the crops: there is negative effect which could be due to impermeability effect of petroleum hydrocarbons or immobilization of nutrients mainly nitrogen or inhibitory effect of some polycyclic aromatic compounds as a result of high level of heavy metals (Ogbuehi and Ezeibekwe, 2010).

The post-planting soil and plant chemical analysis were presented in table 2. it shows that the level of Cr (18.0 mg kg^{-1}), Pb (10.4 mg kg^{-1}) and Ni (0.38 mg kg^{-1}) in the soil cropped to soybean was higher than that of the soil cropped to cowpea respectively of Cr (13.50 mg kg^{-1}), Pb (8.3 mg kg^{-1}) and Ni (0.32 mg kg^{-1}) while the level of Cd (0.17 mg kg^{-1}) in cowpea was higher than that of soybean Cd (0.13 mg kg^{-1}). These agree with the finding of Adenipekun *et al*. (2008), which says that crops differ in their response to the pollutant. It was observed that the low level of Cd, Cr, Pb, Ni in soil cropped to cowpea was due to the ability of cowpea to extract the heavy metals than soybean. This agrees with the finding of Fitter and Stickland (1991), which says that the root morphological traits such as the pattern of root density, maximum depth, and specific root length help in the extraction of heavy metals in soil.

Global Journal of Science Frontier Research (H) Volume XX Issue I Version I 44 Year 2020

It was also observed that the level of Cr (1.10 mg kg^{-1}), Pb (1.25 mg kg^{-1}) and Ni (0.28 mg kg^{-1}) in soybean plant was higher than that of cowpea plant Cr (0.98 mg kg^{-1}), Pb (1.00 mg kg^{-1}) and Ni (0.25 mg kg^{-1}) respectively while the range of Cadmium (Cd) in both plants is the same. The level of Cr, Cd, Pb and Ni of both legumes was observed to be above critical level for human consumption when compared to World Health Organization recommendation Cd (0.1 - 0.3 mg kg^{-1}), Pb (0.5 - 0.8 mg kg^{-1}), Ni (0.1 - 0.2 mg kg^{-1}) and Cr (0.2 - 0.5 mg kg^{-1}) respectively (W.H.O, 2005).

a) Effect of Remediation of Spent Oil Polluted Soil on Number of Branches using Soybean and Cowpea

The effect of remediation of spent oil-polluted soil on a number of branches using soybean and cowpea was presented in table 3. The data shows that significant differences ($p<0.05$) exist between polluted and nonpolluted soil in the number of branches of the plant. At six weeks after planting, the number of branches reduced by spent engine oil pollution. This reduction in number of branches may be due to the limitation of nutrients uptake necessary for the production of branches occasioned by a high level of pollutants. This agrees with findings of (Agbogidi *et al*. 2010) who reported that oil contamination also reduces the soil fertility by causing immobilization of nutrients by microbes such immobilization of nutrients leads to difficulty in the uptake of nutrients in oil-contaminated soil which will be difficult despite the presence of such nutrients in the soil.

b) Effect of Remediation of Spent Oil Polluted Soil on Plant Height using Soybean and Cowpea

The effect of remediation of spent oil-polluted soil on plant height using soybean and cowpea result were presented in table 4. The data shows that significant differences ($p<0.05$) exist between polluted and nonpolluted soil in the plant height of the plant. The plant height was significantly reduced by a high level of pollution, and it was observed that the plant height of cowpea was adversely affected compared to soybean. This could be attributed to a deficiency in the availability of nutrients needed to maintain physiological processes involved in plant growth occasioned by nutrient stress due to influence of spent engine oil. This observation was in line with (Ogbuehi and Ezeibekwe, 2010), who reported that crude oil causes a deficiency of the availability of nutrients needed to maintain growth at apical regions of the crops.

c) Effect of Remediation of Spent Oil Polluted Soil on Number of Leaves using Soybean and Cowpea

The effect of remediation of spent oil-polluted soil on a number of leaves using soybean and cowpea was presented in table 5. It shows that significant differences ($p<0.05$) exist between polluted and nonpolluted soil in the number of leaves of the plant. Also, it was observed that the number of leaves of soybean was more adversely affected compared to cowpea. This could be inferred as having caused by a reduction in available macro elements needed for the production of leaves. This agrees with the findings of (Jung, 2008); it could be due to the presence of heavy metals and polycyclic aromatic compounds found in spent engine oil, which could cause distort within the plant tissues.

d) Effect of Remediation of Spent Oil Polluted Soil on Stem Girth using Soybean and Cowpea

The effect of remediation of spent oil-polluted soil on stem girth using soybean and cowpea was presented in table 6. It shows that a significant differences ($p<0.05$) exist between polluted and nonpolluted soil in the stem girth of the plant. There is a significant difference ($p<0.05$) exist between polluted and nonpolluted soils in the stem girth of the plants. It was also observed that the stem girth of soybean was significantly reduced when compared to that of cowpea. According to (Edem *et al*., 2009) the poor growth was due to metals which were present in high toxic levels and partially to the inability of the plants in the polluted medium to absorb the nutrient from the soil possibly due to poor insulation and poor functioning of vascular (phloem and xylem tissues) bundles.

IV. Conclusion

The result showed that the spent engine oil hurts the growth of cowpea (*Vigna unguiculata*) and soybean (*Glycine max*). It was be observed from the result that the plant height, stem girth, number of leaves and number of branches were significantly ($p<0.05$) reduced due to the presence of spent engine oil which contains some heavy metals (Cd, Cr, Ni, Pb) which can cause a significant reduction in the growth performance of plant in the spent engine oil soil when compared to control. For both pre-planting and post-planting chemical properties analysis, it was observed that the level of Cd, Cr, Pb, and Ni in the pre-planting analysis reduced significantly in the post-planting chemical properties. This shows that both soybean and cowpea exhibited significant remediating ability. However, the level of Cr, Pb, and Ni in the soil cropped by soybean was higher than cowpea and level of Cr, Cd, Pb in soybean plant was higher than that of cowpea respectively, but the level Cd, Cr, Pb, and Ni in both plant is above the World Health Organization critical level recommendation.

Therefore, it can be concluded that cowpea is a good crop legume to remediate spent engine oil polluted soil due to its high remediating ability and easy availability of the crop seed in the market. It is recommended that there is a need for the government to enact a strict law and educate the citizenry on indiscriminate disposal of this pollutant (spent engine oil) on farmlands to ensure optimal growth of plant and crop safe for human consumption.

Farmers should also take considerable measures of cleaning up of their farmland with the use of leguminous crops such as cowpea to remediate their spent engine oil-polluted soil.

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Table 1: Soil Physical and Chemical Properties

Parameters	Polluted Soil	Non Polluted Soil	W.H.O Moderate Level Recommendation
pH (H_2O)	5.7	6.1	
Organic carbon (g kg^{-1})	69.77	27.4	
Total Nitrogen (g kg^{-1})	5.86	1.74	
Available Phosphorous (mg kg^{-1})	16.38	6.04	
Exchangeable cation (cmol kg^{-1})			
Ca	9.08	10.11	
Mg	2.32	1.70	
K	0.32	0.28	
Na	0.61	0.39	
Extractable micro nutrients (mg kg^{-1})			
Mn	141.00	109.70	
Fe	151.00	122.20	
Cu	27.20	3.92	
Zn	27.20	12.18	
Exchangeable Acidity (cmol kg^{-1})	1.5	1.5	
Heavy metals (mg kg^{-1})			
Pb	13.4		10
Cd	0.70		0.3
Cr	59.85		1.5
Ni	9.30		1.5
Particle size distribution (g kg^{-1})			
Sand	660.0		
Silt	174.0		
Clay	166.0		
Textural class	Sandy loam		
Bulk density (g cm^{-3})	1.2		
Saturated Hydraulic Conductivity (cm hr^{-1})	12.64		

Table 2: Post-Planting Soil and Plant Chemical Properties

Samples	Cadmium(Cd)	Chromium(Cr)	Lead (Pb)	Nickel (Ni)
	←	(mg kg^{-1})	←	
Soil cropped to soybean	0.13	18.00	10.4	0.38
Soil cropped to cowpea	0.12	13.50	8.3	0.32
Soybean plant	0.02	1.10	1.25	0.28
Cowpea plant	0.02	0.98	1.00	0.25
W.H.O moderate level for plant	0.1- 0.3	0.2- 0.5	0.5- 0.8	0.1-0.2

Table 3: Effect of Remediation of Spent Oil Polluted Soil on Number of Branches using Soybean and Cowpea

Treatment	Weeks After Planting					
	1	2	3	4	5	6
Soybean + pollution	0.00	0.92	2.25	3.08	4.33	5.58
Cowpea	0.25	2.1	4.83	9.17	15.83	24.58
Cowpea + pollution	0.00	0.92	1.50	2.92	4.42	5.42
Soybean	0.00	1.75	3.50	5.25	8.25	10.92
LSD	0.19*	0.35**	0.58**	1.31**	2.09**	3.18**

ns = not significantly different *=$P \leq 0.05$ **= $P \leq 0.01$

Table 4: Effect of Remediation of Spent Oil Polluted Soil on Plant Height using Soybean and Cowpea

Treatment	Weeks After Planting (Cm)					
	1	2	3	4	5	6
Soybean + pollution	5.94	9.04	11.44	12.47	16.01	18.59
Cowpea	10.46	12.54	14.75	15.18	23.14	26.02
Cowpea + pollution	7.35	8.38	9.46	10.58	12.52	14.86
Soybean	7.49	11.57	14.80	16.94	24.70	30.26
LSD	1.23**	1.47**	1.79**	2.04**	2.34**	3.19**

*ns = not significantly different *=P≤ 0.05 **= P ≤ 0.01*

Table 5: Effect of Remediation of Spent Oil Polluted Soil on Number of Leaves using Soybean and Cowpea

Treatment	Weeks After Planting (Cm)					
	1	2	3	4	5	6
Soybean + pollution	5.94	9.04	11.44	12.47	16.01	18.59
Cowpea	10.46	12.54	14.75	15.18	23.14	26.02
Cowpea + pollution	7.35	8.38	9.46	10.58	12.52	14.86
Soybean	7.49	11.57	14.80	16.94	24.70	30.26
LSD	1.23**	1.47**	1.79**	2.04**	2.34**	3.19**

*ns = not significantly different *=P≤ 0.05 **= P ≤ 0.01*

Table 6: Effect of Remediation of Spent Oil Polluted Soil on Stem Girth using Soybean and Cowpea

Treatment	Weeks After Planting (Cm)					
	1	2	3	4	5	6
Soybean + pollution	0.78	0.90	1.05	1.14	1.19	1.37
Cowpea	1.27	1.43	2.06	2.56	3.72	3.21
Cowpea + pollution	1.056	1.11	1.28	1.41	1.73	1.94
Soybean	0.97	1.10	1.26	1.44	1.68	1.84
LSD	0.12**	0.10**	0.17**	0.21**	0.31**	0.24**

*ns = not significantly different *=P ≤ 0.05 **= P ≤ 0.01*