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CONCENTRATIONS OF HEAVY METAL AND PHYSICOCHEMICAL CHANGES OF SPENT ENGINE OIL TREATED SOIL WITH POULTRY MANURE AFTER *Sida acuta* BURM.F. GROWTH

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ABSTRACT
Concentrations of heavy metal and physicochemical changes of spent engine oil treated soil and poultry manure after sida acuta growth was the aim of the study. 400 g poultry manure and 3600 g of the soil was measured into a sack bag. Then, spent engine oil was added to at different concentrations: control (0 mL), 1 % (40 mL), 3 % (120 mL) and 5 % (220 mL) v/w oil-in-soil and permitted to stand for seven days in the sack bags before transplanting. The soil after 12 weeks was collected and subjected to physical, chemical and heavy metal analysis. The results gotten showed that the heavy metal content of the spent engine oil, clay and sand of the treated soil, organic carbon, organic matter, exchangeable acidity, base saturation, manganese, copper, chromium and cadmium of the treated soil sample was significantly different (p<0.05) relative to the control soil sample. Also, the remediation showed low heavy metal content of experimental soil, stilt of the treated soil sample, pH, phosphorus, nitrogen, magnesium, potassium, electrical conductivity, calcium, zinc, mercury and iron of the treated soil sample was significantly different (p<0.05) relative to the control soil sample. There was no significant difference (p> 0.05) in sodium of the treated soil sample relative to the control soil sample while the lead of the treated soil sample was not detected relative to the control soil sample. Based on the results above, it could be concluded that S. acuta had the latent for phytoremediation of spent engine oil polluted soil and be considered for phytoremediation for such.

KEYWORDS: *Base Saturation, Exchangeable Acidity, Iron, Manganese and Mercury*

INTRODUCTION
Pollution of soil with petroleum derivatives was previously considered to be a problem of petroleum producing or processing countries only (Anoliefo and Vwioko, 2001). But day to day, it is becoming a global problem, consequently posing a startling challenge to the non-producing countries as well (Anoliefo and Vwioko, 2001). This is because of manifold surge in the number of automobiles, coupled with oil spillage in agricultural lands (Anoliefo and Vwioko, 2001). Most of the automobile mechanics dispose of the petroleum derived waste either directly into open soil or into water bodies and irrigation canals which ultimately reach agricultural plant (Anoliefo and Vwioko, 2001).

Spent engine oil is produced when new mineral-based crankcase is subjected to high temperature, high mechanical strain (Anoliefo and Edegai, 2000). As engine oil is used in automobile, it picks up several additional compounds from engine wear which include iron, steel, copper, zinc, lead, barium, cadmium, sulfur, dirt and ash (Dauda and Obi, 2000). Because of the additives and contaminants, spent engine oil disposal can be more environmentally damaging than crude oil pollution (Abioye *et al*., 2012). These additives and contaminants may cause both short- and long-term effects if they enter the environment through water ways or soil (Anoliefo and Vwioko, 2001). Also, chemical additives such as amines, phenols, benzenes, Ca, Zn, Pb, Ba, Mn, P and S are dangerous to living organisms (Smith, *et.al*., 2006). The increase in the number of vehicles in Nigeria has necessitated a higher production and use of spent engine oil (Anoliefo and Vwioko, 2001). The spent engine oil is considered as ordinary waste by majority of the workers of the automobile mechanic workshops in Nigeria, who dispose this oil by dumping on surface soil (Anoliefo and Vwioko, 2001). The contamination of the natural environment by petroleum-derived substances contributes to the degradation of land (Odjegba and Sadiq, 2002). However, Organic manures as well as plants have over time been used to improve soil fertility (Nwankwo, 2014, Ijah *et al*., 2008; Onuh *et al.*, 2008). Their use in promoting plant growth in crude oil polluted Nigerians soils has also been well documented (Ogboghodo *et al.*, 2005; Amadi and Uebari, 1992). Obasi *et al*., (2013), showed that organic manure supplements modified the physical, chemical, and biological properties of crude oil polluted soils and improved their nutritional status for enhanced agronomic performances.

Bundy *et al*. (2002), observed that contamination of soil by oil is a widespread environmental problem that often requires cleaning up of the contaminated sites. Phytoremediation is one of the several recent technologies for effective clean-up of the polluted soils, which requires the *in-situ* use of plants and their associated microorganisms to degrade, contain or render harmless contaminants in the soil (Joner *et al.,* 2004). Oyelola *et al*. (2009) opined that for remediating some of heavy metals polluted sites, phytoremediation is well-thought-out an advanced, cost-effective and eco-friendly well-suited result. Effective phytoremediation of the polluted soil with fibrous root structure of great rhizoplane surface area is a benefit for establishing active microbial inhabitants (White *et al.,* 2000).

Sida acuta, common name is wireweed, a species of flowering plant in the mallow family, *Malvaceae* (United States Department of Agriculture (USDA), 2015). It is believed to have originated in Central America but has a pantropical distribution and is considered a weed in some area (Parsons and Eric, 2001). Wireweed is a much branched, perennial plant producing a somewhat woody stems 1-2 m tall from rootstock (DeFillipps *et al.,* 2009). The plant is harvested from the wild as a local source of medicine and fiber (DeFillipps *et al.,* 2009). The plant contains the alkaloid crytolepine, which shows hypotensive and antimicrobial actions. (Manadhar, 2002). The Bark is a good source of fibre (Safford, 1995). It does appear to do best in disturbed habitats. There are, however, paucity of documented information on the effect of oil on the physical, microbial effects on soil and growth of seeds. It is against this background that a study as this has been embarked on. Therefore, the aim of the study was concentrations of heavy metal and physicochemical changes of spent engine oil treated soil and poultry manure after *sida acuta* growth.

MATERIALS AND METHOD

Collection of soil and plant samples

This study was done in the screen house of the Department of Plant Science and Biotechnology, Michael Okpara University of Agriculture, Umudike. Umudike is located within Longitude 07°34′ E, Latitude 05°29′ N and at an elevation of 122 m above sea level (National Root Crop Research Institute Umudike, 2015). Plant samples were collected from the surroundings of Michael Okpara University of Agriculture, Umudike. Samples of spent engine oil was collected from motor mechanics shops around Michael Okpara University of Agriculture, Umudike. Soil samples were collected at the depth of 0 – 15 cm in crop farms around Michael Okpara University of Agriculture, Umudike.

Experimemtal Design

The research design of this experiment was completely randomized designed with only one factor (spent engine oil). 400 g of poultry manure was constant to amount of soil needed (3600 g) which amounts to 10 % of 4000 g. While the spent engine oil was varied in 1 %, 3 % and 5 % to the soil and poultry manure content. Control samples had zero levels of spent engine. Each sample was replicated three times. Soil samples were sieved with 2 mm sieve and was mixed in the following way: Negative control (0 g of Poultry manure, 4000 g farm soil), Positive control (400 g of poultry manure, 3600 g of farm soil and zero millilitres of SEO), 1 % (400 g of poultry manure, 3600 g of farm soil and 40 millilitres of SEO), 3 % (400 g of poultry manure, 3600 g of farm soil and 120 millilitres of SEO), 5 % (400 g of poultry manure, 3600 g of farm soil and 220 millilitres of SEO). The treatment samples were permitted to stand for seven days. Subsequently, three de-leafed plants obtained with the roots and of same heights were transplanted in each sack bags filled with the above-mentioned treatment. At the end of 12 weeks of transplanting, the plants were removed, the soil were then taken to the laboratory for physical, and chemical constituent evaluation.

Soil porosity

The macro and the micro-pores were the two types of pore size measured. The samples used for the determination of saturated hydraulic conductivity were also used to determined the macro-porosity of the samples (W_{sat}) and the weight after 24 hrs of mounting on the tension table at 60 cm tension (W_{60}) by the volume of the core (Vc) then multiplying by100%.

$$\text{Macro-porosity} = \frac{W_{sat} - W_{60}}{Vc} \times 100\%$$

Also in the same sample, micro-porosity was determined by dividing the difference between the weight of sample after 24 hrs of mounting on the tension table at 60 cm tension (W_{60}) and the weight of oven dried sample at 105^0 C for 48 hrs (W_0) by the volume of the core (V_c),then multiplied by 100%.

$$\text{Micro} - \text{porosity} = \frac{W_{60} - W_o}{V_c} \times 100$$

Soil pH

Soil pH was determined with the use of pH indicator (meter). Apparaus used were test tube, pH meter, weighing balance, spatula, beaker. Five (5) g of the soil samples were weighed into 5 g of distilled water in a test tube and vigorously stirred. The pH was obtained using pH indicator and read after 3 secs. It was cross matched with the colour scale.

Phosphorus Content

This was determined by the Bray and Kutz (1945) method with the use of absorption spectrophotometer. One (1) g scoop of soil and 10.00 ml of extractant were mixed together for 5 min. This was further shaken to give a blue colour. The intensity of the blue colour filtrate development was treated with ammonium molybdate-hydrochloric acid solution and aminonaphthol-sulfonic acid solution. The colour was measured using an absorption spectrophotometer at 640 nm. The result was calculated in ppm.

Potassium Content

Apparatus used were test tube, colour scale, beaker, and spatula. A test tube was placed into cavity of the thermoformed lining and filled with 0.7 % nitric acid. Potassium test sticks were removed as required and then the container was resealed immediately. A test stick was dipped into the solution to be tested so that the reaction zone was completely moist. Excess liquid was shaken off. A test stick was placed into the test tube which was filled with 0.7 % nitric acid and then left for 1 min. The test tube was removed and compared with the color scale. In the presence of potassium, the test paper turned yellow to orange red.

Total Organic Carbon

Total organic carbon was determined by the Walkey and Black (1934) wet dichromate oxidation method.

Total Nitrogen

Total nitrogen was measured by the macro Kjedahi digestion procedure as described by Bremner (1965).

Cation Exchange Capacity

Cation exchange capacity was determined by the ammonium acetate displacement method as described by Chapman (1965).

Analysis of Heavy Metals

Bio-available or soluble concentration of heavy metal was determined by Aqua Regia method (Chen and Ma, 2001). Conventional aqua regia digestion was performed in 250 ml glass beakers covered with watch glasses. A well-mixed sample of 0.5000 g was digested in 12 ml of aqua regia on a hotplate for 3 hrs at 110°C. After evaporation to near dryness, the sample was diluted with 20 ml of 2 % (v/v with H_2O) nitric acid and transferred into a 100 ml volumetric flask after filtering through Whatman no. 42 filter paper and diluted to 100 ml with DDW. The filtrates were analyzed for Zinc (Zn), Mercury (Hg), Manganese (Mn), Iron (Fe), Lead (Pb), Copper (Cu), Chromium (Cr) and Cadmium (Cd) using atomic absorption spectrophotometer. The values were compared with the widely used normal and critical levels of total concentration of heavy metal for the contaminant limit (c), p index was calculated as the ratio between the heavy metal content in the soil and the toxicity criteria (the tolerable levels).

Data Analysis

Data collected was subjected to descriptive statistics to obtain the means and standard deviations. T-test analysis was used to compare the difference in the heavy metal properties of soil and spent engine oil. Means of the laboratory analysis were subjected to analysis of variance (ANOVA). Statistically significant means at 5 % probability were separated using Ducan multiple range test (DMRT). All the test was done using statistical package for social sciences (SPSS) version 26.

RESULTS

Heavy metal content of experimental soil and spent engine oil is presented in Table 1. From the result, Zn in the soil was 0.025 mg/kg while that of spent engine oil was 9.310 mg/kg. Hg in the soil was 0.025 mg/kg while that of spent engine oil was 7.250 mg/kg. Mn in the soil was 0.615 mg/kg while that of spent engine oil was 33.725 mg/kg. Fe was in the soil was 0.465 mg/kg while that of spent engine oil was 14.885 mg/kg. Pb in the soil was 0.000 mg/kg while that of spent engine oil was 119.300 mg/kg. Cu in the soil was 0.000 mg/kg while that of spent engine oil was 10.825 mg/kg. Cr in the soil was 0.035 mg/kg while that of spent engine oil was 17.270 mg/kg. Cd in the soil was 0.045 mg/kg while that of spent engine oil was 14.360 mg/kg. There was significant difference (P≤0.05) in the concentration all the heavy metals in soil and that of spent engine oil.

Table 1: Heavy metal content of experimental soil and spent engine oil

Heavy metals	**Samples**	**Mean**	**STD**	**SEM**	**Sig. (2tailed)**	**FAO/WHO$_{PL}$**
Zn (mg/kg)	Soil	0.025	0.021	0.015	0.000***	50
	Engine Oil	9.310	0.042	0.030		
Hg (mg/kg)	Soil	0.025	0.007	0.005	0.000***	270.00
	Engine Oil	7.250	0.156	0.110		
Mn (mg/kg)	Soil	0.615	0.007	0.005	0.000***	-
	Engine Oil	33.725	0.035	0.025		
Fe (mg/kg)	Soil	0.465	0.007	0.005	0.000***	425.5
	Engine Oil	14.885	0.106	0.075		
Pb (mg/kg)	Soil	0.000	0.000	0.000	0.000***	85
	Engine Oil	119.300	0.127	0.090		
Cu (mg/kg)	Soil	0.115	0.007	0.005	0.000***	36
	Engine Oil	10.825	0.247	0.175		
Cr (mg/kg)	Soil	0.035	0.007	0.005	0.000***	100
	Engine Oil	17.270	0.127	0.090		
Cd (mg/kg)	Soil	0.045	0.007	0.005	0.000***	85
	Engine Oil	14.360	0.283	0.200		

* (p≤0.05), ** (p≤0.01), *** (p≤0.001), NS (not significant) (p>0.0

Particle size composition of soil treated with spent engine oil and poultry manure before vegetation is presented in Table 2. From the result, sand ranges from 55.20±0.00 % of the negative control sample to 79.81±0.01 % of the 5 % sample. Treatment effect was significant (P≤0.05) to the variations in mean. Silt ranges from 11.41±0.01 % of the 5 % sample to 22.00±0.00 % of the negative control sample. Treatment effect was significant (P≤0.05) to the variations in mean. Clay ranges from 4.51±0.01 % of the 1 % sample to 23.80±1.41 % of the negative control sample. Treatment effect was significant (P≤0.05) to the variations in mean.

Table 2: Particle size composition of soil treated with spent engine oil and poultry manure before vegetation

Samples		**Parameters**	
	Sand (%)	**Silt (%)**	**Clay (%)**
Po control	77.81±0.01[c]	15.41±0.01[c]	6.81±0.01[b]
Ne control	55.20±0.00[a]	22.00±0.00[d]	23.80±1.41[d]
1 %	81.81±0.01[e]	13.41±0.01[b]	4.51±0.01[a]
3 %	75.81±0.01[b]	15.41±0.01[c]	8.89±0.01[c]
5 %	79.81±0.01[d]	11.41±0.01[a]	8.81±0.01[c]
Total	74.08±10.17	15.52±3.75	10.56±7.19
P≤0.05	0.000***	0.000***	0.000***

* (p≤0.05), ** (p≤0.01), *** (p≤0.001), NS (not significant) (p>0.05). Means ± standard deviation with different superscript alphabets are significantly different at alpha 0.05.

The Chemical composition of experimental soil treated with spent engine oil and poultry manure is presented in Table 3a. From the result, pH ranges from 4.55±0.07 of the negative control sample to 6.91±0.01 of the1 % and 5 % sample. Treatment effect was significant (P≤0.05) to the variations in mean. Phosphorus (P) ranges from 44.28±0.01 mg/kg of the 3 % sample to 128.55±6.68 mg/kg of the negative control sample. Treatment effect was significant (P≤0.05) to the variations in mean. Nitrogen (N) ranges from 0.12±0.01 % of the 3 % sample to 0.29±0.01 % of the negative control sample. Treatment effect was significant (P≤0.05) to the variations in mean. Organic Carbon (OC) ranges from 1.52±0.01 % of the positive control sample to 3.70±0.01 % of the 5 % sample. Treatment effect was significant (P≤0.05) to the variations in mean. Organic Matter (OM) ranges from 2.62±0.01 % of the positive control sample to 6.37±0.01 of the 5 % sample. Treatment effect was significant (P≤0.05) to the variations in mean. Calcium (Ca) ranges from 5.11±0.31 cmol/kg of the negative control sample to 13.01±0.01 cmol/kg of the 5 % sample. Treatment effect was significant (P≤0.05) to the variations in mean.

Table 3a: Chemical composition of experimental soil treated with spent engine oil and poultry manure

Samples	Parameters					
	pH	**P (mg/kg)**	**N (%)**	**OC (%)**	**OM (%)**	**Ca (cmol/kg^{-1})**
Po control	6.81±0.01^{b}	62.29±0.01^{c}	0.16±0.01^{b}	1.52±0.01^{a}	2.62±0.01^{a}	12.81±0.01^{c}
Ne control	4.55±0.07^{a}	28.55±6.68^{d}	0.29±0.01^{d}	2.43±0.02^{b}	4.18±0.*04^{b}	5.11±0.31^{a}
1 %	6.91±0.01^{c}	54.03±0.01^{b}	0.17±0.01^{c}	2.61±0.01^{c}	4.49±0.01^{c}	10.61±0.01^{b}
3 %	6.81±0.01^{b}	44.28±0.01^{a}	0.12±0.01^{a}	2.69±0.01^{d}	4.63±0.01^{d}	12.81±0.01^{c}
5 %	6.91±0.01^{c}	69.89±0.01^{c}	0.15±0.01^{b}	3.70±0.01^{e}	6.37±0.01^{e}	13.01±0.01^{c}
Total	6.39±0.97	71.80±31.31	0.18±0.06	2.59±0.73	4.45±1.26	10.87±3.17
P≤0.05	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***

*(p≤0.05), ** (p≤0.01), *** (p≤0.001), NS (not significant) (p>0.05). Means ± standard deviation with different superscript alphabet are significantly different at alpha 0.05.

The Chemical composition of experimental soil treated with spent engine oil and poultry manure is presented in Table 3b. From the result, magnesium (Mg) ranges from 4.09±0.25 cmol/kg^{-1} of the negative control sample to 9.41±0.01 cmol/kg^{-1} of the 5 % sample. Treatment effect was significant (P≤0.05) to the variations in mean. Potassium (K) ranges from 0.12±0.01 cmol/kg^{-1} of the 3 % sample to 0.36±0.00 cmol/kg^{-1} of the negative control sample. Treatment effect was significant (P≤0.05) to the variations in mean. Sodium (Na) ranges from 0.01±0.01 cmol/kg^{-1} of the all the samples except negative control sample which had 0.23±0.03 cmol/kg^{-1}. Treatment effect was significant (P≤0.05) to the variations in mean. Exchangeable acidity (EA) ranges from 0.73±0.01 cmol/kg^{-1} of the 3 % and 1 % sample to 0.97±0.01 cmol/kg^{-1} of the 5 % sample. Treatment effect was significant (P≤0.05) to the variations in mean. Effective cation exchange capacity (ECEC) ranges from 11.19±0.66 cmol/kg^{-1} of the negative control sample to 23.64±0.01 cmol/kg^{-1} of the 5 % sample. Treatment effect was significant (P≤0.05) to the variations in mean. Base saturation (BS) ranges from 87.48±0.23 % of the negative control sample to 96.44±0.01 % of the 3 % sample. Treatment effect was significant (P≤0.05) to the variations in mean.

Table 3b: Chemical composition of experimental soil treated with spent engine oil and poultry manure

	Mg (cmol/ksg^{-1})	K (cmo/kg $^{-1}$)	Na (cmol/kg^{-1})	EA (cmol/kg^{-1})	ECEC (cmol/kg^{-1})	BS (%)
Po control	6.81±0.01^{c}	0.16±0.01^{b}	0.01±0.00	0.81±0.01^{b}	20.67±0.01^{c}	96.15±0.01^{c}
Ne control	4.09±0.25^{a}	0.36±0.00^{c}	0.23±0.03	1.40±0.06^{d}	11.19±0.66^{a}	87.48±0.23^{a}
1 %	7.01±0.01^{c}	0.13±0.01^{a}	0.01±0.00	0.73±0.01^{a}	18.54±0.01^{b}	96.15±0.01^{b}
3 %	6.41±0.01^{b}	0.12±0.01^{a}	0.01±0.00	0.73±0.01^{a}	20.12±0.01^{c}	96.44±0.01^{b}
5 %	9.41±0.01^{d}	0.16±0.01^{b}	0.01±0.00	0.97±0.01^{c}	23.64±0.01^{d}	95.93±0.01^{b}
Total	6.74±1.79	0.19±0.09	0.08±0.11	0.92±0.27	18.83±4.39	94.43±3.67
P≤0.05	0.000***	0.000***	0.165 ^{NS}	0.000***	0.000***	0.000***

*(p≤0.05), ** (p≤0.01), *** (p≤0.001), NS (not significant) (p>0.05). Means ± standard deviation with different superscript alphabet is significantly different at alpha 0.05.

Heavy metal composition of the experimental soil treated with spent engine oil and poultry manure after growth is presented in Table 4. From the result, Zinc ranges from 0.00±0.00 mg/kg of positive control sample to 0.31±0.01 mg/kg of 5 % sample. Treatment effect was significant ($P \leq 0.05$) to the variations in mean. Mercury ranges from 0.00±0.00 mg/kg of all the samples except 0.03±0.01 mg/kg of negative control sample. Treatment effect was significant ($P \leq 0.05$) to the variations in mean. Manganese ranges from 0.00±0.00 mg/kg of positive control sample to 5.35±0.01 mg/kg of 5 % sample. Treatment effect was significant ($P \leq 0.05$) to the variations in mean. Iron ranges from 0.37±0.01 mg/kg of positive control sample to 5.67±0.01 mg/kg of 5 % sample. Treatment effect was significant ($P \leq 0.05$) to the variations in mean. Lead was not detected in all the soil samples. Copper ranges from 0.12±0.01 mg/kg of negative control sample to 4.53±0.01 mg/kg of 5 % sample. Treatment effect was significant ($P \leq 0.05$) to the variations in mean. Chromium ranges from 0.04±0.01 mg/kg of negative control sample to 0.51±0.01 mg/kg of 5 % sample. Treatment effect was significant ($P \leq 0.05$) to the variations in mean. Cadmium ranges from 0.05±0.01 mg/kg of negative control sample to 0.63±0.01 mg/kg of 5 % sample. Treatment effect was significant ($P \leq 0.05$) to the variations in mean.

	Zn (mg/kg)	Hg (mg/kg)	Mn (mg/kg)	Fe (mg/kg)	Pb (mg/kg)	Cu (mg/kg)	Cr (mg/kg)	Cd(mg/kg)
Po control	$0.00±0.00^{a}$	$0.00±0.00^{a}$	$0.00±0.00^{a}$	$0.37±0.01^{a}$	ND	$1.03±0.01^{d}$	$0.05±0.01^{a}$	$0.07±0.01^{b}$
Ne control	$0.03±0.02^{a}$	$0.03±0.01^{b}$	$0.62±0.01^{c}$	$0.47±0.01^{c}$	ND	$0.12±0.01^{a}$	$0.04±0.01^{a}$	$0.05±0.01^{b}$
1 %	$0.00±0.00^{a}$	$0.00±0.00^{a}$	$0.53±0.01^{b}$	$0.49±0.01^{c}$	ND	$0.45±0.01^{b}$	$0.13±0.01^{b}$	$0.19±0.01^{c}$
3 %	$0.27±0.01^{b}$	$0.00±0.00^{a}$	$2.21±0.01^{d}$	$0.44±0.00^{b}$	ND	$0.57±0.01^{c}$	$0.11±0.01^{b}$	$0.25±0.01^{d}$
5 %	$0.31±0.01^{c}$	$0.00±0.00^{a}$	$5.35±0.01^{d}$	$5.67±0.01^{e}$	ND	$4.53±0.01^{e}$	$0.51±0.01^{c}$	$0.63±0.01^{e}$
Total	0.12±0.14	0.01±0.01	1.74±2.05	1.48±2.20		1.34±1.71	0.16±0.18	0.23±0.22
P≤0.05	0.000***	0.002**	0.000***	0.000***	-	0.000***	0.000***	0.000***
WHO/FAO	50.00	270.00	-	425.50	85.00	36.00	100.00	85.00

Table 4: Heavy metal composition of the experimental soil treated with spent engine oil and poultry manure after growth
* (p≤0.05), ** (p≤0.01), *** (p≤0.001), NS (not significant) (p>0.05), ND (Not Detected) Means ± standard deviation with different superscript alphabet are significantly different at alpha 0.05. Po (positive), Ne (Negative).

DISCUSSION

The study findings showed that soil from farmlands in Umudike had very low heavy metal (Zn, Hg, Mn, Fe, Pb, Cu, Cr, and Cd) concentrations when compared to the soil concentrations of heavy metal in raw spent engine oil which were higher. Hence, the significant variation ($P \leq 0.05$) existing between the soil heavy metal and spent engine oil. This may be as a result of spent engine oil contaminations of the soil with toxic heavy metals. This result was confirmed by Kashif *et al*. (2018), who compared fresh and unused engine oil with spent engine and concluded that higher Pb, Cu, Cr, Ni and Fe values were found in spent engine oil which is a threat to the environment due to presence of hazardous substances. Also, the findings from this work conformed to the work done Ifediora and Okwunodolu (2018), who conveyed that the concentrations of the heavy metals in the contaminated soils increased with the increased concentrations of the waste engine oil.

Higher sand levels, lower silt and clay were observed in the treated soil than the original soil from farmland. The physical parameters of the soil were significantly ($P \leq 0.05$) higher than the spent engine oil treated samples. This may be as a result of sieving of the soil, introduction of spent engine oil and poultry manure. The result is not in agreement with the report of Nwite *et al*. (2016), who stated that physical properties of soil after kerosene oil contamination and poultry manure amendment had no significant ($P>0.05$) treatment effect on bulk density of kerosene oil contaminated soil. Also, Mbah *et al*. (2009), Nwite (2013) and Ogbohodo *et al*. (2001) reported similar findings on hydrocarbon oil contamination of soil. They observed that the treatment loosened soil compaction and increased its total porosity, improved aggregate stability as well as moisture content of soil.

Hydrogen ion concentration of the treated soil samples and the poultry manure (negative control) had low acidity. This could be as a result of low acidity of spent engine oil and the poultry manure. Ifediora *et. al.,* (2023), made an opposing observation of higher acidic hydrogen ion concentrations of the treated soil samples and the poultry manure (negative control).

Also, spent engine oil treated soil and the positive control had higher organic matter, organic carbon, Ca, and Mg. This could be as a result of carbon reach nature of spent engine oil and poultry manure. The report by Nwite *et al*. (2016), which were higher OC, OM, Mg, and Ca in hydrocarbon polluted soil agreed with this result of the study. However, lower concentrations of Nitrogen, phosphorus and potassium (NPK) were recorded for 1 % and 3 % spent engine oil treated samples which may be as a result of NPK rich nature of spent engine oil and poultry manure. This agrees with the discovery of Osaigbovo *et al*. (2012) who reported increased levels of nitrogen, phosphorus and potassium (NPK) in soil treated with spent engine oil and amended with fertilizer.

Increased amount of heavy metal was observed in samples with 5 % spent engine oil. This may be as a result that the spent engine oil possesses the potential to cause soil heavy metal toxicity. This was confirmed by Ifediora *et. al.,* (2023), in their study on the heavy metal concentrations and physicochemical changes of soil treated with spent engine oil and organic manure (poultry) after 12 weeks of growing *Cyperus compressus* L.

in which they stated that increased value of spent engine oil percentage to soil, lead to increased heavy metals. Also, it was observed that *S. acuta* completely remediated Pb in the soil. Hence, Pb was not detected in the soil but was in high concentration in the spent engine oil analysis this may be the capacity of plant sample to phytoremediate the polluted soil sample. Ifediora *et al.* (2023), made similar detection with *C. compressus* which completely remediated Pb in waste engine polluted soil.

CONCLUSION

The study exhibited that spent engine oil pollution unfavorably disturbs soil fertility and physicochemical properties. Adding of organic amendments, such as poultry waste to the contaminated soil proved to modify the physicochemical properties of spent engine oil pollution soils and improved their nutritional status. *Sida acuta*, has shown great potential in the degradation of spent engine oil. Poultry manure augmentation of soil was significantly advantageous in creating the ideal surroundings for the plants to grow and microbial activities to thrive, thereby making phytoremediation a success. This confirmation the possibilities of *S. acuta* in phytoremediation spent engine oil with organic amendments.

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