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Soil Properties in the Vicinity of Discharge Spent Motor Oil in Ohiya Automobile Mechanic Village Umuahia, Abia State

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Abstract

The environmental problem caused as a result of indiscriminate discharge of spent motor oil has been proving to be hazardous to human and other life forms. The study assessed the impact of utilized motor oil on soil physicochemical component in Ohiya motor servicing village in Southeastern Nigeria. Auger-boring instrument was used to collect soil samples at 0-15cm (top soil) and 15-30cm (sub soil). The top soil samples collected from the five workshops were homogenized in a bucket and a composite sample was drawn. Same process was repeated for the sub soil samples collected from the five workshops and a control sample was collected 2 kilometers away from the study area. Soil samples were analyzed for heavy metal by means of Atomic Absorption Spectrophotometer (AAS), Soil pH, particle size distribution, cation exchange capacity (CEC), total available nitrogen, total available phosphorous, exchangeable bases (Mg, Ca, K, and Na), carbon content and organic matter were also determined. The result of the study shows that the heavy metals concentrations in the contaminated sample were high in comparison with the control sample. The concentration of Pb, Zn, Fe, Cd, and Cu in the contaminated soil decreases with the soil depth. pH range of the contaminated soil was between 4.74±0.04 (top soil) and 5.02±0.07 (sub soil) which was lower when compared to the control sample 6.09±0.07 (top soil) and 6.11±0.21 (sub soil). Organic carbon, organic matter, P, N, Mg, Na, and Ca in the contaminated soils was high compared to the control. The study concluded that improper disposal of spent motor oil in the study area influenced the soil physicochemical properties and elevated the soil heavy metal content thereby causing heavy metal pollution.

1. Introduction

Pollution of the environment with hydrocarbon has been known as one of the most severe prevalent issues particularly when linked with unintended spill of oil on large-scale. As motor oil is utilized in car, it gets various added substances, for example, iron, steel, copper, zinc, lead, barium, cadmium, sulfur, earth and debris from motor wear [1]. When the utilized oil is drained off a motor, it is not, at this point clean since it is mixed with foreign materials, e.g. dirt particles, and different synthetic compounds during motor activity; accordingly, the greasing oil is termed utilized/used engine oil. Utilized engine oil removal can be more ecosystem harming than raw petroleum contamination due to the added substances and contaminants therein [2]. These added substances may cause both acute and chronic impact if permitted to enter the ecosystem through soil or conduits

[3]. Spent motor oil has become progressively regular wellspring of soil pollution in numerous metropolitan regions most particularly as it can't be changed into helpful auxiliary use. At the point, this contaminant (such as heavy metals) causes higher danger of harmfulness and soil infertility when indiscriminately deposed in the soils. Consequently, this presents a threat to the soil condition and properties [4].

Presence of heavy metals in the soil as a consequence of human activities tends to be more itinerant thus bioavailable than pedogenic, or lithogenic ones [5]. Heavy metals are harmful as they tend to bioaccumulate, thereby resulting in the increase of contaminants after some time when compared to their concentration in natural ecosystem [6].
Recent findings on hydrocarbon contamination on soil had revealed that the oil makes the soil conditions undesirable for plants and influences the soil composition [7]. Oil discharged into the ecosystem affect numerous flora and fauna contained in the oil affected environment. Protracted contact to high concentration of hydrocarbon could result in liver or kidney infection, feasible harm to the bone marrow and increased malignant growth [8, 9, 10, 11].
With expanding number of car specialist workshop in Umuahia and the expanding number of vehicles being fixed or serviced at these auto-mechanic workshops, it can in this manner be built up that the amount of spent motor oil from vehicles in Umuahia is on the increase.
This study was carried out to provide baseline data on the impacts of spent motor oil contamination on the physicochemical properties and heavy metal concentration of soil in the study area.

2. Methodology

2.1.Study Area

The soil samples were collected from Ohiya mechanic village one of the largest functioning mechanic villages in Umuahia, Abia State. Ohiya lies on latitude 05°28'N and longitude 07°26'E. Ohiya has a mean annual rainfall of 2133 mm dispersed within eight months of rainy season (March to October) with peak period in July and September. The temperature range between 21°C and 30°C with relative humidity of 60-70%. The main food crops grown by farmers include cassava, maize, yam, vegetables as fluted pumpkin, bitter leaf, okra; cash crops such as oil palm fruits, groundnuts among others.

2.2.Sample Collection

Soil samples were collected from five various locations within the study area. These selected sites were polluted with spent engine oil for a long time (more than 10 years). The samples were collected using hand-held auger-boring instrument from a depth of 0-15cm (top soil) and 15-30 cm (sub soil). The top soil samples collected from the five workshops were homogenized in a bucket and a composite sample was drawn. Same process was repeated for the sub soil samples collected from the five workshops and a control sample was collected 2 kilometers away from the study area. The samples were poured into a polythene bag container which was then transported to the lab for analysis.

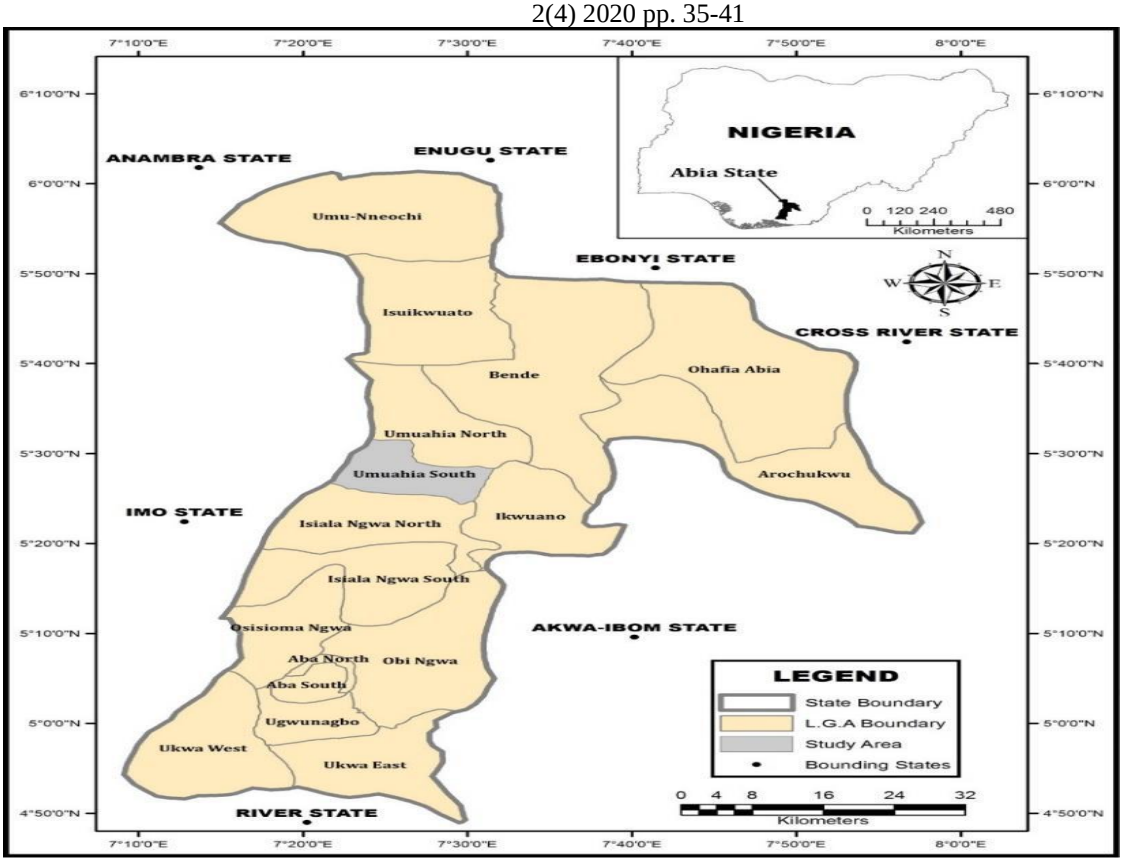

Figure 1: Abia State showing Umuahia South (Source: GIS Lab., Department of Geography, University of Nigeria, Nsukka (2018))

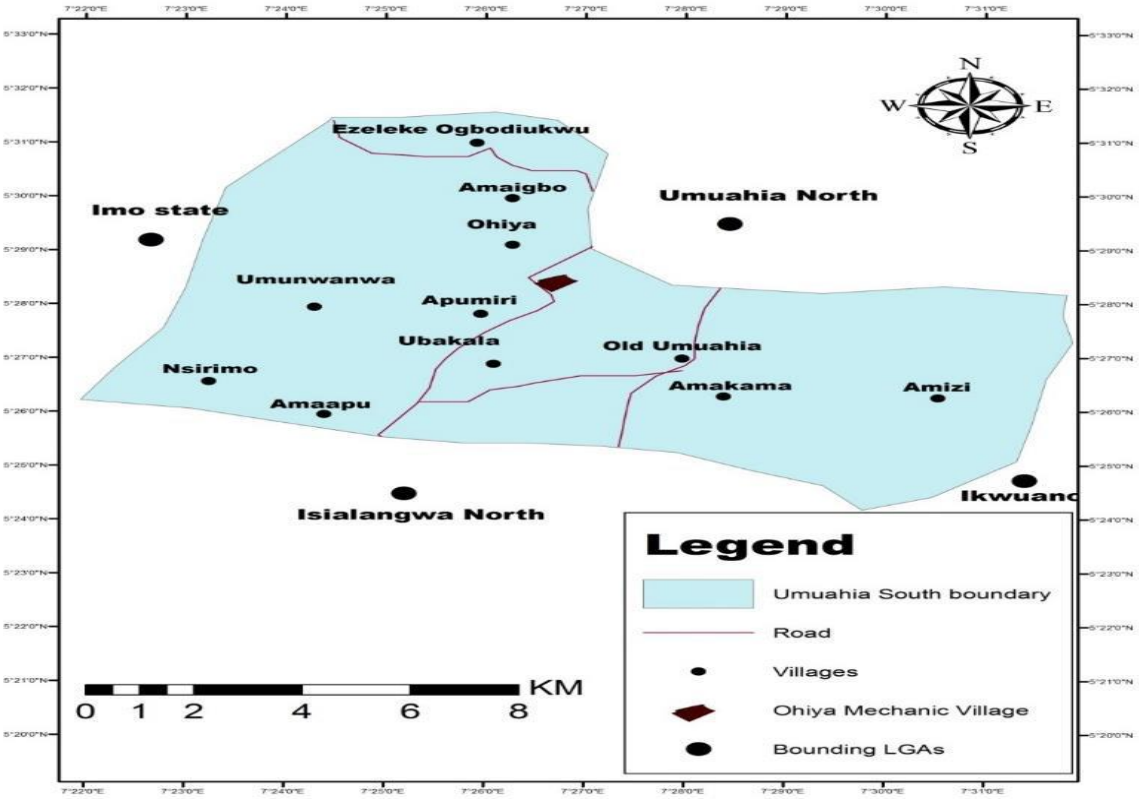

Figure 2: Map of Umuahia South LGA showing Ohiya mechanic village (Source: GIS Lab., Department of Geography, University of Nigeria, Nsukka (2018))

2.3.Soil Sample Analysis

The sieved soil samples less than 2mm diameter were taken to the laboratory and analyzed for soil pH, total nitrogen, total phosphorous, determination of exchangeable bases, determination of total organic carbon., organic matter and CEC and digested for heavy metals analyses. The method of [12] was used to determine the particle size and soil texture. A glass electrode pH meter was used to measure the soil pH according to modified method of [13]. Kjel-dahl method was used to determine the total nitrogen content [14]. Bray 1 method was used to determine the available phosphorous [15]. Organic Carbon was determined using the adapted [16]. The exchangeable acidity of the sample was determined using INKCL extracting solution by titration, while the exchangeable base was extracted using the leachate extracted with 1M ammonium acetate solution. Atomic absorption spectrometry (AAS) was used to determine the exchangeable Calcium and Magnesium determined while flame emission was used to determine sodium and potassium. The total exchangeable base was determined by the summation of all bases (Ca, Mg, K and Na). The cation exchange capacity was determined by the summation method:

CEC = TEB + TEA (1) [17]
Where, CEC = Cation Exchange Capacity
TEB = Total Exchangeable Bases, (K^+, Na^+, Ca^{2+} $Mg^{2+)}$
TEA = Total Exchangeable Acidity.
Heavy metal analysis was done wet digestion method on Atomic Absorption Spectra (AAS) [18].

3. Result and Discussion

3.1 Effects of Spent Engine Oil Discharge on the Soil Properties

The particle size distribution of the soil shows that the soil texture of the contaminated top soil sample is sand loamy (SL) and that of the sub soil is clay loamy (CL) while that of the control sample top soil and sub soil are sand loamy (SL) and clay loamy (CL) respectively (Table 1).This indicates that the contaminated top soils are coarse with a high sand content giving prevailing textural class of loamy sand.

The soil pH of the contaminated samples ranged from 4.74±0.04 (very strongly acid) in top soil to 5.02±0.07 in sub soil (strongly acid) as seen in Table 1 while soil pH of the control samples ranged from6.02±0.07 (moderate acidic) in top soil to 6.11±0.21(weak acidic) in sub soil. The value of the pH obtain from the soil sample of the study area were lower (4.74 to 5.02) when compared to the pH value (5.43 to 6.79) in Nekede mechanic workshop in Imo State by [1]. The low pH range of the polluted soil may be linked to higher concentration of particulates from spent motor oil. These particulates would normally settle on the top soil, and hence, affects its acidity. It could also be as a result of the basic cation (Ca^{2+}, Mg^{2+}, K^{2+}, Na^{2+}) being leached away by rain water resulting to the replacement of many of these basic cations by hydrogen ion, (H^+) from carbonic acid (H_2CO_3) formed from water and dissolved CO_2. The low pH may also be as a result of increased mineralization of spent motor oil by the organisms in the soil, resulting in accumulation of acidic metabolites [19].

The available phosphorus of the used engine oil polluted soil was higher when compared with the control sample at different depth of sample collection. This contradicts the findings of [6] who reported high phosphorous values in uncontaminated site than in used engine oil polluted site but in conformity with the result of [20] who reported high Phosphorous values in crude oil polluted soils than the non-contaminated site.

Table 1: Effects of spent engine oil discharge on physicochemical properties of the soil

Sample	% Sand	% Silt	% Clay	Texture	pH (H_2O)	P Mg/Kg	% N	% OC	% OM	Ca	Mg	K	Na	EA Cmol Kg^{-1}	ECEC	% BS
0-15cm	54.20±0.10	25.53±0.47	20.20±0.10	SL	4.74±0.04	39.66±0.11	0.33±0.03	3.56±0.03	6.13±0.04	6.52±0.19	2.89±0.09	0.17±0.01	0.42±0.02	1.39±0.03	11.38±0.02	87.79±0.00
15-30cm	42.14±0.04	19.58±0.21	38.41±0.27	CL	5.02±0.07	16.77±0.10	0.26±0.02	3.26±0.04	5.66±0.10	6.04±0.06	2.52±0.17	0.22±0.02	0.46±0.03	3.13±0.01	12.34±0.04	74.38±0.00
Control 0-15cm	78.36±0.25	9.26±0.15	12.19±0.10	SL	6.09±0.07	25.69±0.26	0.17±0.06	1.14±0.03	1.97±0.02	3.98±0.07	1.65±0.05	0.12±0.02	0.15±0.03	0.86±0.10	6.72±0.04	85.97±0.00
15-30cm	62.21±0.01	8.45±0.11	32.34±0.24	CL	6.11±0.21	15.71±0.11	0.16±0.03	1.12±0.12	1.95±0.01	3.79±0.05	1.61±0.03	0.13±0.01	0.18±0.02	2.29±0.01	8.00±0.00	71.24±0.00

Total nitrogen in the contaminated soil was higher than the control sample. However, [6] reported higher values in unpolluted site than in polluted site whereas [20] reported higher total N values in soil contaminated with crude oil than in the non-contaminated site. The higher value in total nitrogen is linked to increased atmospheric nitrogen fixation during the oil debasement process [21].

The result from the study shows that the organic matter (OM) and carbon content in the contaminated soil was higher than that of the control sample. This contradicts the findings of [6] who reported higher organic carbon content in unpolluted site than in spent motor oil polluted site but in agreement with the findings of [20] who reported higher organic carbon values in crude oil polluted soils than the non-contaminated site. This also agrees with the findings of [22] when examining the effect of spent engine oil on soil properties and growth of maize (Zea mays). This could be linked to the spent motor oil contamination in the soil samples. Crude oil, from which motor oil is produced, contains other elements other than hydrogen and carbon such element includes; nitrogen, oxygen and sulphur [23].

3.2 Effects of Spent Engine Oil Discharge on Heavy Metal Concentrations

The heavy metals concentration as influenced by utilized motor oil discharge is shown in Table 2. The heavy metals concentration in the contaminated soil was high compared to that of the control sample. Previous studies showed that soil within or around source of pollutants had high heavy metals concentration [24, 25, 26, 27].

Table 2: Effects of spent motor oil on heavy metal concentrations in the soil

Soil sample	Pb(lead)	Zn(zinc)	Fe(iron)	Cd(cadmium)	Cu(copper)
Contaminated sample					
Top soil(0-15cm)	12.40±0.667	17.23±0.049	15.23±0.021	9.32±0.035	9.61±0.014
Sub soil(15-30cm)	10.31±0.014	15.22±0.028	13.12±0.035	6.79±0±.014	5.77±0.028
Control sample					
Top soil (0-15cm)	0.150±0.014	0.263±0.035	0.121±0.000	0.020±0.000	
Sub soil(15-30cm)	0.142±0.022	0.224±0.013	0.119±0.000	0.018±0.011	0.029±0.000 0.025±0.000

Unlike the control sample, the high concentrations of heavy metals in the contaminated soil sample may be linked to leaching of the heavy metals (Cd, Pb, Cu and Cr) from the large volume of waste motor oil. The heavy metals concentration generally decreases with soil depth. This is linked to presence of organic matter since metals are bound to topsoil by organic matter [28] consequently reducing the leaching of heavy metals into the lower depths [29]. Organic matter residue from effluent oil and oil spills adds organic matter and carbon to the soil [30].

4.Conclusion

The study concluded that improper discarding of spent motor oil in the study area influences the soil physicochemical properties and elevated the soil heavy metal content thereby causing heavy metal pollution. Proper disposal of spent motor oil should be encouraged to evade heavy metals toxicity as majority of heavy metals pollutes underground waters via leaching which in turn makes the water unsafe for human consumption.

Based on these findings, programme like collection of spent oil should be introduced by government at all level (Local, State and Federal) to halt disposal of spent motor oil on soil. If feasible, collected spent oil should be sent to automobile oil manufactures for recycling. The populace, especially people who openly engage in activities generating spent motor oil should be enlightened via seminar or workshops. Phytoremediation should be encouraged by planting plant in the contaminated area that can degrade the complex compound that makes up the spent motor oil.

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