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Lubricant Automobile Oil: Effect on Chemical and Heavy Metal Status of Soil in Rivers State, South-South, Nigeria

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Abstract:

A study was conducted at the department of crop and soil science teaching farm, University of Port Harcourt to examine the effect of lubricant automobile oil on some soil chemical properties and heavy metals status of the soil. Composite soil samples were collected randomly at a depth of 0-20cm from the back of the department. The soil was placed in a 10kg bucket, spent lubricant oil collected from Ozuoba automobile mechanic workshop was used to contaminate the soils at 0 (control), 2, 4, and 6% w/v. Okra (Abelmoschus esculentus) a dominant vegetable crop in Nigeria was used as test crop. Three okra seeds were planted two weeks after contamination and later thinned to two. The experiment was replicated thrice and the design is completely randomized. Result of the study revealed that the soil pH, % total nitrogen, % total organic carbon and total hydrocarbon content of the spent lubricant contaminated soil significantly ($P<0.05$) increased over control samples. The contents of these parameters increased as the level of contamination increased. On the other hand, the concentrations of available phosphorus, soluble potassium and exchangeable cations (calcium and magnesium) were significantly ($P<0.05$) lower in contaminated soil than in control. Increase in percentage of spent oil lubricant decreases the concentrations of these elements. The concentration of the three heavy metals (Zn, Pb and) investigated were significantly higher in lubricant oil contaminated soil than control samples. The higher the increase in % lubricant oil, the higher the concentration of the three heavy metals studied. Generally, the study showed that spent lubricant oil had negative (adverse) effects on some soil chemical properties which may indirectly affect the plant that uptake these nutrients from the soil.

Key Words: Lubricant engine oil, chemical properties, heavy metals status and THC

Introduction:

Spent automobile oils are used mineral obtained from the engine of vehicles when the oil is changed (Stephen et al., 2013). It is one of the most common pollutants of the environment especially in Nigeria where they are obtained after draining the engine oil sump during servicing and lubricating oil replacement (Iren and Ediene, 2017).

Used lubricant or waste oil has been reported to contain relatively high hydrocarbon, including injurious polycyclic aromatic hydrocarbon, heavy metals such as lead (Pb), Aluminum (Al), nickel (Ni), and iron (Fe) (Whisman et al., 1974, Wang et al., 2000).

Spent oil (Waste oil) contains amines, phenol, benzene and mixtures of various petroleum products such as hydrocarbons, chlorinated biphenyls, chloro-dibenzofurans and heavy metals caused by the wear and tear of engine parts, aromatic aliphatic hydrocarbons, nitrogen and Sulphur compounds and heavy metals such as manganese (Mn), Al, chromium (Cr), Pb, Ni, silicon (Si), Fe, and vanadium (Va) are found in large quantity in spent oil (John Bosco et al., 2020, Nwachukwu et al., 2020, Mohd et al., 2011).

Spent oil pollutes the environment when it is disposed improperly through automobile crank case and oil seal leakages. It is formed as a result of change in viscosity, additives and oxidation caused by the breakdown of the additives due to combustion properties and accumulations of metals such as magnesium (Mg), Zn, Pb, Cu, cadmium (Cd) from the wear and tear of engine during running (Ayandele et al., 2018, Adeleye et al., 2018)..

Disposal of spent oil in gutter, water drain, vacant plots and farm land is a common practice in Nigeria (Okonokhua et al 2007). Spent lubricating oil contains heavy metal which are transported with time to agricultural plants, as the plants are consumed by man, they cause bioaccumulation of heavy metals thus causing harm to human health such as cellular and tissue damage, infertility, neurotoxic effect on children and others (Damek-Proprawa, 2013, Jarup et al., 2013).

Presence of waste lubricant oil in soil adversely affects the growth and development, maturity and yield of plants including the chemical, physical and biological properties of the soil on which the plant grow. Kayode et al., (2009) reported an increase in soil acidity and soil organic matter as the quantity of spent oil contamination increased in soil, while the total nitrogen, phosphorus and exchangeable cations (Ca, Mg and Na) content of the soil reduces as the volume of oil in soil increases.

The heavy metal toxicity results in weak plant growth, chlorosis, yield depression, reduced nutrient disorder in plant metabolism and inability to fix nitrogen in leguminous plant (Guala et al., 2010). Okra a text crop in this study is a common staple vegetable crop in Africa, especially Nigeria where it is as one of the most popular vegetable crops consumed by the population.

The study is aimed at assessing the effect of lubricant automobile oil on soil chemical properties and heavy metal status of soil.

Materials and Methods:

The study was carried out at the department of crop and soil science research farm, University of Port Harcourt. The site is located at latitude 4^0 54' 29" N and longitude 6^0 54' 58" E of the equator, the elevation is 16M above sea level. The mean annual rainfall ranges from 3000 to 4500mm (FAO, 1984). The rainy season starts from April to October while dry season is from November to March. The temperature varies from 22^0C to 31^0C (FDRD, 1981). The relative humidity is between 35 to 90% depending on the period of the year.

Soil Sample Collection:

Composite soil samples were randomly collected from the back of crop and soil science department at a depth of 0-20cm. The soil was placed on a 10kg perforated plastic bucket. Spent lubricating engine oil collected from Choba mechanic workshop were placed on each bucket at a rate of 0, 2, 4 and 6% w/v. The control (0) soil sample was taken at 100 meters away from the location. The spent oil was evenly worked into the soil with hand trowel.

Okra (Abelmoschus esculentus) seeds of two different varieties obtained from Agricultural Development Program (ADP) Rumuodomaya farm in Obio/Akpor Local Government Area were planted in the soil. Three seeds were sown two weeks after contamination in each of the buckets and later thinned to two after germination.

The soils were watered with 200mls of water from a watering can three times per week. Growing weeds were handpicked as the need arises and the experiment was left for a period of 56 days (8 weeks). The design was a 2 × 4 completely randomized design (CRD) replicated thrice bringing it to a total of 24 buckets.

Collection of Soil Samples for Laboratory Analysis:

Composite soil samples were collected from each of the buckets with hand trowel. They were crushed with hands and left to air dry at room temperature in the laboratory. The dried samples were pulverized with mortar and pestle, sieved in 2mm mesh screen, bagged in polythene bag awaiting laboratory analysis. The soil chemical parameters analyzed are:

The soil pH was analyzed in soil water ratio using pH meter (Tel and Hargarty, 1984), Nitrogen was determined using Kjedahl method of Bremner and Mulvaney, 1982). Phosphorus was analyzed Bray-2 method (Page et al., 1982). Potassium was determined using flame photometer (Ohiri and Ano, 1985), Exchangeable calcium and magnesium using titration method (Mbah, 2004), Total organic carbon by the method of Walkley and Black (Nelson and Sommer, 1982).

Total hydrocarbon content was estimated using the method of Odu et al., (1985) while the soil sample for heavy metals (Pb, Zn and Ni) were extracted by wet digestion method of Benton, (2001). The data generated were subjected to statistical analysis using Analysis of variance (ANOVA), the differences assessed with least significant difference (LSD) post hoc test.

Results and Discussion:

Results of the study on soil chemical properties are as presented in table 1 below. The result showed that pH of the soil decreases from 4.76±0.01[a] in control (0) sample to 4.48±05[c] in soil contaminated with 6% level of spent oil. The significant ($P<0.05$) reduction observed in control over contaminated implies that spent oil contamination of soil decreases the pH of the soil. This observation agrees with the report of (Chukwumati and Kamalu, 2021 and Njoku et al, 2011) who reported a decrease in soil pH in soil contaminated with automobile lubricant over control. The pH of the soil decreases with increase in level of contamination. Generally, the soil studied was strongly acidic; these finding tallies with the work of (Kayode et al., 2009) who reported an increase in soil acidity as the quantity of lubricant automobiles oil increased in the soil.

Percentage total nitrogen and organic carbon in the soil decreases from 0.85±0.02[a] and 9.01±0.05[a] in soil contaminated with 6% spent oil to 0.08±0.07[c] and 3.32±0.12[c] in control samples for percent total nitrogen and organic carbon respectively. The result showed that spent oil significantly ($P<0.05$) increased percent nitrogen and organic carbon.

Table 1: Effect of spent oil on soil chemical properties.

Contamination %	pH (H_2O)	%N	P (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	K (mg/kg)
0%	4.76±0.00[a]	0.08±0.07[c]	35.54±3.73[a]	12.50±0.25[a]	20.21±4.05[a]	10.03±0.12[a]
2%	4.61±0.00[b]	0.13±0.02[bc]	23.61±7.65[b]	7.20±3.05[b]	12.05±08.12[b]	7.12±2.82[bc]
4%	4.57 0.04[bc]	0.45±0.014[b]	18.78±5.14[bc]	3.25±1.51[bc]	8.00±42.07[bc]	3.08±15.02[b]
6%	4.48±0.05[c]	0.85±0.02[a]	14.14±2.81[c]	2.15±0.82[c]	6.13±31.08[c]	1.25±8.17[c]

Values with the same superscripts on the same column are not significantly different.

The percent total nitrogen and organic carbon increased as the level of contamination increases. This report agrees with the studies of (Nwite and Alu, 2015 and Kayode et al., 2009). This is in contrast to the studies of (Agbogidi et al., 2007, Wyszykowski and Zukowska, 2008) who reported a decrease in nitrogen and organic carbon component of soil in spent oil contaminated soil.

The result also showed a significant (P<0.05) decrease in the content of phosphorus, potassium and exchangeable cations (Mg and Ca) between the control samples and the contaminated; implying that contamination of the soil with spent oil decreases the content of these essential elements in the soil which automatically affect negatively the growth, performance and yield of the plants.

The contents of phosphorus (P), potassium (k), calcium(Ca)and magnesium (Mg) decreased as the level of contamination increases. This is in agreement with the work of Okonokhua et al., (2007) who in their study on maize plant reported a decrease in the content of Mg and P as the level of spent oil contamination increased.

Generally, the study showed that spent engine oil had adverse (negative) effects on the properties of the soil and the plant that uptake these nutrients.

Heavy Metal Contents:

The result for heavy metal content of the soil is presented in table 2 below. The result of the study showed that the contents of zinc, lead and nickel increases from 8.28 ± 0.91^c for Zn, 17.23 ± 4.07^c for Pb and 0.21 ± 0.12^c for Ni in control samples to 20.00 ± 0.77^a for Zn, 36.15 ± 13.40^a for Pb and 0.70 ± 0.29^a for Ni in soil contaminated with lubricant engine oil.

The result showed that the three heavy metals (Zn, Pb and Ni) investigated in the study were significantly (P<0.05) higher in spent engine oil contaminated soil over control samples. The higher the level of contamination, the greater the content of the heavy metals (Zn, Pb and Ni). The report confirms the findings (Nwite and Alu, 2015, Uquatan et al., 2017) who noted an increase in heavy metals (Mn, Cd, Fe and Pb) content in oil polluted soils and crops. The increase, Okonokhua et al., (2007) asserted increases with an increase in the level of contamination with spent oil.

Table 2: Effect of Spent Lubricant oil on Heavy metal, Total organic carbon and Total hydrocarbon content of the Soil

Contamination %	Zinc (mg/kg)	Lead (mg/kg)	Nickel (mg/kg)	% TOC	THC (mg/kg)
0%	8.28 ± 0.91^c	17.23 ± 4.07^c	0.21 ± 0.12^c	3.32 ± 0.12^c	14.10 ± 2.14^d
2%	14.30 ± 0.26^b	25.20 ± 3.66^b	0.33 ± 0.32^{bc}	5.25 ± 1.48^{bc}	627.5 ± 06.3^c
4%	16.20 ± 1.27^b	32.01 ± 0.31^{ab}	0.44 ± 0.13^b	7.08 ± 1.05^b	938.25 ± 5.73^b
6%	20.00 ± 0.77^a	36.15 ± 13.40^a	0.70 ± 0.29^a	9.01 ± 0.05^a	1423 ± 26.01^a

Values with the same superscripts on the same column are not significantly different.

These heavy metals are in most cases uptake by plants which are later consumed by man, they then bioaccumulate and cause adverse effect on human health such as cellular and tissue damage, infertility, neurotoxic effect on children etc (Jarup et al., 2013, Damek-Proprawa, 2013).

Apart from its effect on human, the heavy metals also influence the survival and reproductive activities and damage to plant metabolism, their growth and genetic variations (Deng et al., 2007, Hasan et al., 2009, Xie et al., 2016).

Total Hydrocarbon Content:

The result of the Total Hydrocarbon Content of the soil varies from 10.91 ± 15.20^d in control sample to 14.23 ± 0.031^a as presented in table 2 above. The result revealed a significant (P<0.05) increase in THC in contaminated samples over control. THC in the studied area increases with increase in spent oil contamination. This agrees with the studies of (Nwite Alu, 2015) who inferred that total hydrocarbon content of the soil increased with spent oil polluted soil while Phosphorus exchangeable cations are reduced.

Andem et al., (2019) reported that Polycyclic Aromatic Hydrocarbon (PAH) a major contaminant of soil in spent oil contamination is dangerous to plants, animals and man. This was confirmed by (Adeoye et al., 2005) who observed in their study that hydrocarbon is responsible for reduced soil quality and reduction in crop yield.

Conclusion and Recommendation:

Findings from the study showed that spent lubricant oil negatively affected some soil chemical properties as the concentration of some major essential nutrients such as phosphorus, potassium, calcium and magnesium used by plants were reduced. More so, the increase in concentrations of total hydrocarbon contents and heavy metal (Zn, Pb and Ni) as observed from the study may become a major pollutant to the entire ecosystem thus posing a problem to the food chain and underground water.
Therefore, indiscriminate disposal of spent lubricant oil should be avoided and farmers should be discouraged from cultivating their crops and vegetable from spent oil disposed sites.

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