EFFECTS OF SPENT OIL POLLUTION ON THE MICROFLORA AND PHYSICOCHEMICAL PROPERTIES OF RECEIVING SOIL AND WATER

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Abstract
The effect of spent engine oil on soil and water samples from mechanic workshops in Owo, Ondo - State was investigated using standard techniques. The pH of the polluted water (5.39) and soil (4.21) was lower than that of the unpolluted water (7.08) and soil (7.01) samples. The temperature of the polluted soil was higher than that of the unpolluted soil whereas, that of the water sample was comparable. There were higher levels of organic matter and organic carbon in the polluted soil compared to the unpolluted soil sample. The polluted soil sample had lower nitrogen, phosphorus, and moisture. Moreover, the polluted soil had a water retention capacity of 0% while the unpolluted soil had 24% retention. There was no remarkable difference in the total dissolved solids, temperature, and total hardness of the polluted and unpolluted water samples. However, there was a significantly higher level of heavy metals in the polluted soil (Ni 0.9, Zn 2.8, Pb 4.01) and water (Ni 0.08, Zn 0.32, Pb 0.11) compared to the unpolluted soil and water samples. The microbial load ranged from 1.2× 10^5cfu/g (polluted soil) to 22 × 10^5cfu/g (unpolluted soil) while that of water ranged from 1.3 × 10^2cfu/ml (unpolluted) to 9.1 × 10^2cfu/ml (polluted). Staphylococci were absent in the polluted soil and water. These results suggest that crude oil has a deleterious effect on the physic-chemical and microflora properties of soil and water analyzed.
Keywords: Effect, Pollution, Spent oil Pollution, Microflora and Physiochemical properties, Soil, Water

Introduction

The disposal of spent engine oil waste into gutters, water drains, open vacant plots and farms is a common practice in Nigeria especially by motor mechanics. This oil, also called spent lubricant or waste engine oil, is usually obtained after servicing and draining from automobile and generator engines (Adesodun, 2004) and much of this oil is poured into the soil.There are relatively large amounts of hydrocarbons in the used oil, including highly toxic polycyclic aromatic hydrocarbons (Adeoye*et al.*, 2005).

Also, most heavy metals such as V, Pb, Al, Ni, and Fe, which were below detection in unused lubricating oil, have been reported by Adedokun and Ataga (2007) to give high values (ppm) in used oil. These heavy metals may be retained in soils in the form of oxides, hydroxides, carbonates, exchangeable cations, and/or bound to organic matter in the soil. Nevertheless, this is dependent on the local environmental conditions and on the kind of soil constituents present in the soil-water system.

Ekundayo *et al.* (1989) have shown that a marked change in properties occurs in soils polluted with petroleum hydrocarbons, affecting the physical, chemical and microbiological properties of the soil. Oil pollution of soil leads to build up of essential (organic C, P, Ca, Mg) and non-essential (Mg, Pb, Zn, Fe, Co, Cu) elements in soil and the eventual translocation in plant tissues (Adewole *et al.*, 2008).

Although some heavy metals at low concentrations are essential micronutrients for plants, at high concentrations they may cause metabolic disorders and growth inhibition for most of the plant species (Agbogidi*et al.*, 2009).Spent oil sometimes referred to as waste engine oil is produced by automobile mechanic shops and mechanical or electrical engine repairers' shops (Agbogidi and Enujeke, 2012) after servicing the vehicles' engines, generating sets, and other types of engines. It has dark brown to a black colour and it is harmful to the soil environment (Adedokun and Ataga, 2007). This is because it contains a mixture of different chemicals including low to high molecular weight (C15-C21) compounds, lubricants, additives and decomposition products, and heavy metals which are harmful to the soil and human health (Duffus, 2002).

According to Ekundayo *et al.* (1989), a marked change in properties occurs in the physical, chemical, and microbiological properties of soils contaminated with lubricant oil. Oil displaces air and water leading to anaerobic conditions (Atlas, 1977

The presence of spent lubricant oil in the soil increases bulk density and decreases water holding-capacity and aeration propensity (Kayode*et al.*, 2009). These conditions generally cause unsatisfactory seed germination, growth, and yield in soil contaminated with spent engine oil waste. For instance, Odjegba and Sadiq (2002) reported low yield and decreased growth of plants grown in spent lubricant oil-contaminated soil. In most cities and towns in Nigeria, some farmers or residents grow vegetables, maize and other crops around the mechanic villages or sink borehole without considering the health risks involved.

Researchers such as Wang *et al.* (2000), Odjegba and Sadiq (2002), Agbogidi et al., (2006) and Okonokhua*et al.* (2007) had worked on the effect of spent lubricant oil contamination on crop yield. Thus, this study was aimed at determining the effect of spilled oil on the receiving soil and water.

Materials and Method

Sample Collection: Soil samples were collected randomly at a mechanic village in Owo from 0 – 15cm depth into sterile wide-mouthed screw cap bottles because oil penetration to the soil is very slow and hardly exceeded 13.5cm.

Physicochemical Analysis: properties likethe pH, temperature, water retention capacity, transparency, colour, total dissolved solids (TDS), hardness, organic matter, C, N, P, and moisture were determined using the method described by APHA (2005).

Determination of minerals and heavy metals
The minerals and heavy metals present in the samples were assayed using the Atomic Absorbance Spectrophotometer (AAS) method.

Microbial Analysis
Samples of the pond water were serially diluted in ten folds. Total viable heterotrophic aerobic plate counts were determined by plating in duplicate, using pour plate technique. Molten Nutrient agar, Mannitol salt agar and Potato Dextrose agar at 45 ^{0}C were poured into the Petri dishes containing 1mL of the appropriate dilution for the isolation of the total heterotrophic bacteria, Staphylococci group and fungi respectively. They were swirled to mix and colony counts were taken after incubating the plates at 35 ºC for 24 hours (Akinnibosun*et al*., 2020).

Results and Discussion
The results of the physicochemical properties of the soil and water samples are presented in Table 1. The results showed that there was a considerable difference in the pH of the polluted unpolluted soil and water samples with the polluted samples having lower pH signifying that spent oil might be responsible for the high H^+ ion concentration in the samples, soil pH is a major factor influencing the availability of elements in the soil for plant uptake.

The temperature of the polluted soil (26.1) was higher than that of the unpolluted sample(25.2) and this suggests that the oil might be able to trap heat in the soil which may not be good for plant development as it may place a lot of stress on their roots causing excessive loss of water and withering of the plant. Previous studies on spent oil pollution in the soil had revealed that the oil makes the soil conditions unsatisfactory for plants (Alloway, 1990) and affects the soil's physical and chemical compositions.

Table1: Physico-chemical Characteristics of soil and water polluted with spent oil

Parameters	UPS	PS	UPW	PW
pH	7.01±0.01^{c}	4.21±0.02^{a}	7.08±0.05^{c}	5.39±0.06^{b}
Temperature	25.20±0.58^{a}	26.1±0.56^{a}	26.2±0.15^{a}	29.1±1.20^{b}
Transparency	NA	NA	29.1±1.52^{b}	27.2±1.00^{a}
Colour	Brown	Black	Colourless	Light brown
TDS	NA	NA	245.03±6.72^{a}	251.45±8.01^{a}
Total Hardness	NA	NA	38.07±2.15^{a}	52.05±4.05^{b}
Water Retention capacity (%)	24.00±0.00^{b}	0±0.00^{a}	NA	NA
Moisture (%)	0.78±0.03^{b}	0.42±0.00^{a}	NA	NA
% Organic matter	3.82±0.07^{a}	8.18±025^{b}	NA	NA
Organic C	2.18±0.01^{a}	6.24±0.81^{b}	NA	NA
N (%)	0.25±0.00^{b}	0.11±0.00^{a}	NA	NA
P (mg/Kg)	22.82±1.03^{b}	12.14±0.56^{a}	NA	NA

NA= not applicable, UPS = unpolluted soil, PS = polluted soil, UPW = unpolluted water, PW = polluted water; Values are Mean±SEM and those followed by * across rows are significantly different at P<0.05

The presence of spent lubricating oil had been reported to have considerable adverse effects on the physical and chemical properties of the soil. While the water retention capacity of the control soil sample was 24%, the polluted soil had 0%. This indicates that polluted soil may not be able to hold water which is of grave consequence to agricultural practices. Moreover, the low moisture content of the polluted soil sample may be linked to the inability of the soil to hold water passing through it, since soil aeration increases with an increase in daily watering (Anikwe and Nwobodo, 2002). Thus, soil from the control sample may have better aeration than that from spent lubricating oil- polluted soil.

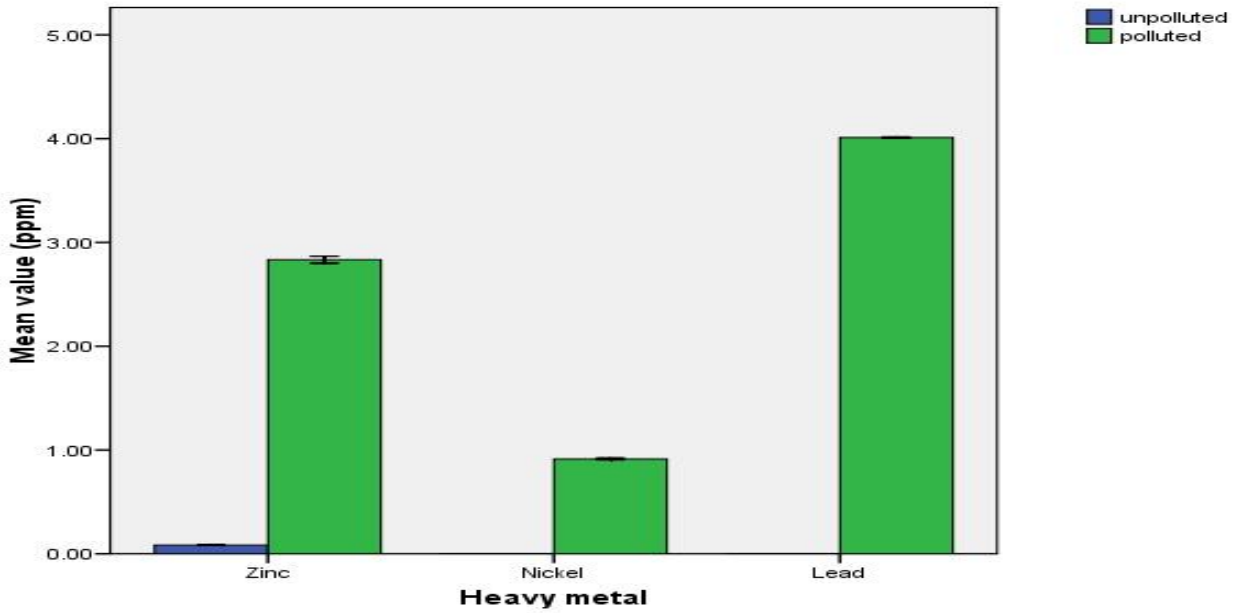

Figure1: Effect of spent engine oil waste on the heavy metal accumulation in soil

The observed increase in the soil acidity and increased organic matter and carbon contents in the polluted soil were probably due to the addition of carbon already present in the spent lubricating oil to carbon already present in the soil. It may also be linked to the aromatic and aliphatic hydrocarbons in the oil while the lower nitrogen and phosphorus content in the soil suggests that the presence of oil might be responsible for the loss of these vital nutrients probably due to various reactions between the oil matrix in the soil. The reduced phosphorus in the oil contaminated soils compared to the control agrees with the findings of Ogboghodo *et al.*, (2004)

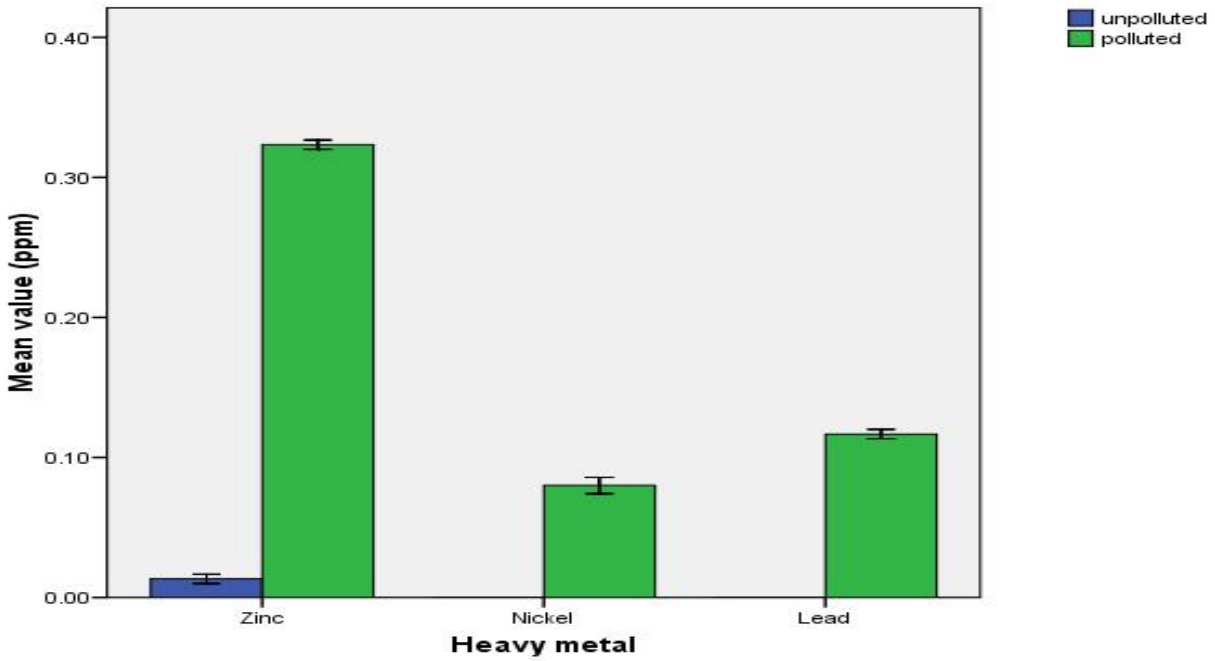

Figure2: Effect of spent engine oil waste on heavy metal accumulation in water

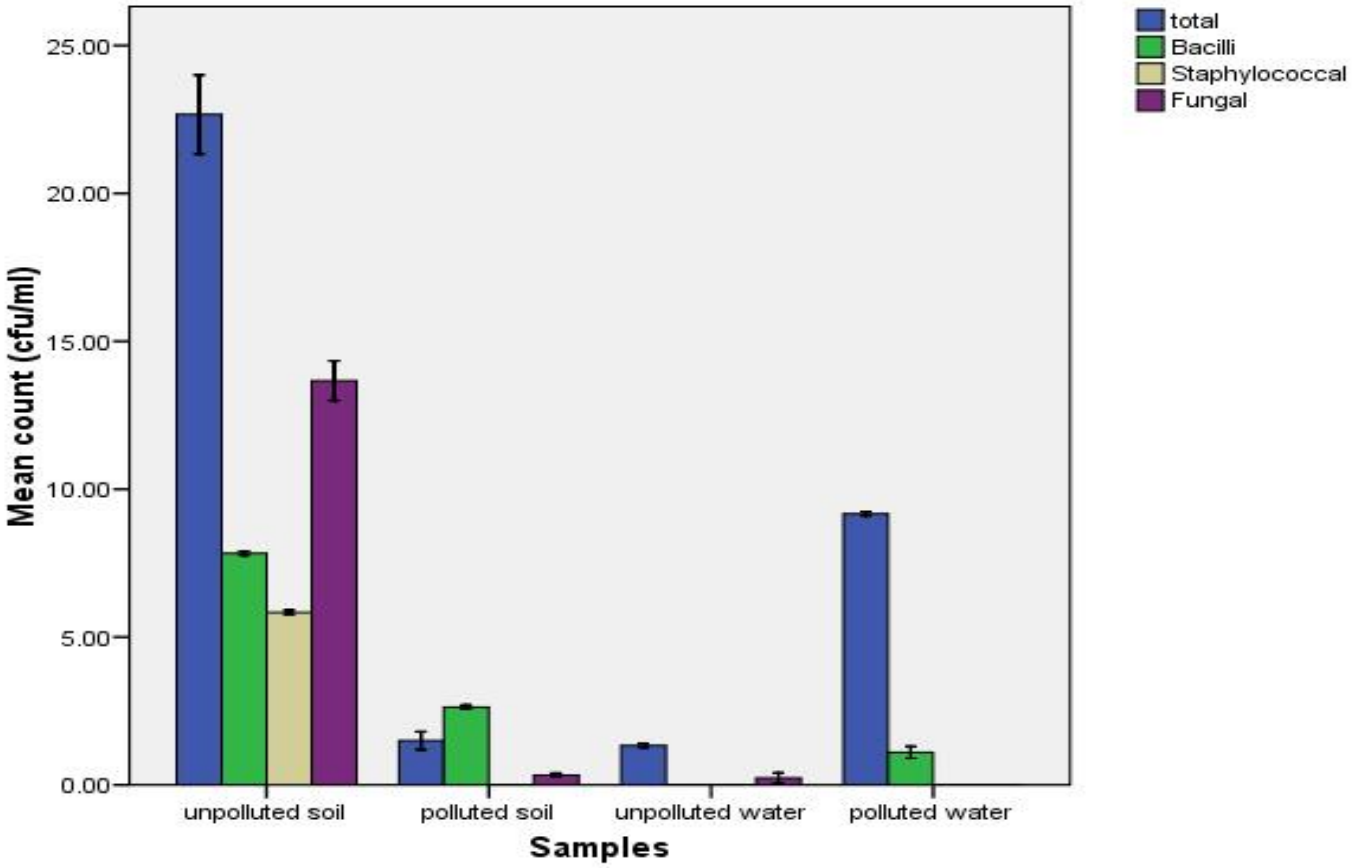

Figure 3: Effect of spent engine oil wastage on the polluted soil and water microbial population

There was a marked difference in the heavy metals present in the polluted soil compared with the unpolluted sample. The higher level of heavy metals like lead, nickel, and Zinc may be due to the presence of oil in the soil and they may bio accumulate in plants grown on such soil. This implies that soils retain heavy metals in spent engine oil waste even during drainage. This behaviour may result from certain mechanisms such as chelation and sorption by soil (Asadu*et al.*, 2008). Anoliefo and Vwioko (2001) reported that there is a bonding relationship between contaminants and soil surfaces due to sorption forces. The contaminant solutes in solution become attached to the surface of the soil (solids) particles through mechanisms, which seem to satisfy the forces of attraction from the soil

solids (surfaces) (Enwezor*et al.*, 1989). The heavy metals, being positively charged, are electrostatically attracted to the negative charges on the clay particles (Black and Hartge, 1986).

Organic complexation of metals may also occur when the solid state humic material binds metals into a ring-typed structure (ligand molecule) most commonly a chelate (Ekundayo *et al.*, 2001). Metals present in spent lubricants can accumulate in plants and affect metabolic processes. It may also damage plants as a result of the increase in temperature due to the dark nature of contaminated soils. It was observed in this study that the contaminated soils were darker than the control, and dark soils absorb more heat than light ones

Enwezor *et al.* (1989) reported that some black coal mining wastes and dark-colour oil shale residues reached temperatures of 65-70^{0}C, which are lethal to many plants that would otherwise grow in those soils. Soils polluted with waste-oil result in the soil remaining unsuitable for crop growth and depending on the degree of contamination, type of soil, and soil environment, the soil may remain unsuitable for crop growth for months or years until the oil is degraded to tolerable levels (FDALR , 1985).

There were a significantly lower number of microorganisms in the polluted soil and water compared with the unpolluted samples. This suggests that the oil may possess inhibitory effects on the microorganisms. Whereas Staphylococcus species were found on unpolluted samples, they were not found in polluted soil.

Also, Bacillus species and Fungal species were lower in the polluted soil and this may negatively affect soil fertility as most organisms involved in the decomposition of dead organic matter may have been wiped off by the oil poisoning (Ohiri and Ano, 1985). However, the little Bacillus and Fungal groups present in the polluted soil may be able to degrade the oil complexes. Therefore they may be identified and tested for this property as it may go a long way in aiding the cleaning of oil polluted soil with environmentally friendly methods.

There were no significant differences in the physic-chemical parameters measured in water samples suggesting that the water might not be affected by the oil. However, there were higher level of heavy metals in the water which though very low may still pose serious health implications to the users.

The results obtained in this study revealed that spent lubricating oil may alter the physical and chemical properties of the soil. It may also destroy the soil structural classes and as well as leads to increased bulk density of the soil, which can reduce root penetrations of crops and subsequently impedes nutrient uptake from the soil (Onwuka*et al.*, 2012).

Previous reports by Rasaiah *et al.* (1990) revealed that crude oil readily penetrates the pore spaces of terrestrial vegetation on land following any spill with heavier friction, which may block the pores of the soil particles. Spent lubricating oil had been found to reduce the phosphorus, nitrogen, calcium, and magnesium contents of soil. The low phosphorus and nitrogen and high carbon obtained in this study agreed with the results of Wang *et al* (2002).

Visual observations showed that soil that has been polluted with spent oil treatment reduced water infiltration and percolation in the soil. This may result in water accumulating in small pools while air-drying of the impacted soils may take a relatively longer time. This observation is in harmony with earlier reports of Unegbu *et al* (2012) who noted that oil in soil has deleterious effects on the biological, chemical and physical properties of the soil depending on the dose, type of the oil and other factors. This suggests that spent oil may affect agriculture practices on the affected soil as reported earlier by Anoliefo and Vwioko (2001) in a study of the effect of spent oil on groundnut seed germination where all the seeds of the groundnut sown in the uncontaminated soils germinated on the 4th day after sowing while significant reductions were however, observed in the germination percentage of Arachishypogaea seeds sown in soils contaminated with the spent oil. This finding supports the reports of Agbogidi (2009).

Conclusion and Recommendations

This study has shown that spent oil in soil significantly affects soil physico-chemical properties, increases the level of heavy metals in both the polluted water and soil, and greatly reduced the microflora of the soil. From the foregoing, it is, therefore, recommended that public awareness should be intensified in the

study area, on the detrimental effects of spent engine oil waste pollution and its indiscriminate disposal should be discouraged. Strict laws should be made to guide against indiscriminate disposal while the existing laws on pollution should be reviewed to be made more effective and complementary to the present trend. Also, there should be effective implementation of the laws on pollution.

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