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The Effect of Spent Engine Oil Discharge on Soil Properties in an Automobile Mechanic Village in Nekede, Imo State, Nigeria

Uchendu, Udochukwuka Ifeanyi[1] and Ogwo, Patrick Agwu[2]
[1]Environmental Management Unit, Dept of Forestry and Environmental Management
[2]Dept. Of Environmental Management &Toxicology, Michael Okpara University of Agriculture, Umudike, Nigeria

Abstract: *The study investigated the concentration of heavy metal in soil around Nekede automobile mechanic village in Southeastern Nigeria. Sample plots were established in a randomized method along a transect at 100m interval for five (5) different locations within the study area, these sample point were constantly receiving spent engine oil (SEO) and were labeled treatment SA, SB, SC, SD, SE. A composite soil sample was drawn from depths of 0 – 15cm and 15 – 30cm for each of the five treatments. These were air dried, passed through a 2mm sieve and properly labeled for laboratory analysis. Soil samples were then analysed for heavy metal (Pb) using Atomic Absorption Spectrophotometer (AAS). Two (2) soil samples were collected at each sample point and two (2) soil samples CF and CG were also collected 2 km away from the study area in an undisturbed forest as control. Soil pH, cation exchange capacity (CEC) and particle size distribution were also determined. Results showed that the concentrations of Pb from soil samples were random across sample point. The concentration of Pb in the contaminated soil at a depth of 0 – 15cm (topsoil) varies, the highest value was observed at SD (482.2mg/kg) and the lowest value at SE (146.8mg/kg). At the depth of 15 - 30cm (subsoil) concentration of Pb is highest at SB (397.6mg/kg) and lowest at SC (140.1mg/kg). The mean concentration of Pb in the contaminated soil sample has its highest concentration at SB (382.9mg/kg) and lowest at SC (157.8mg/kg). The level of Pb in the control site was lower (CF, 46.5mg/kg and CG, 11.8mg/kg) when compared to the various concentrations of the contaminated soil. pH range was between 5.43 and 6.79. CEC varied across the sample area and showed no variation within the control site. The highest value was observed at CF and CG (3.65cmol/kg) respectively while the lowest value was observed at SA (2.15cmol/kg). The % sand distribution varied across the sample point and showed a higher distribution in the study area than % clay and % silt, the soil texture (sandy loam) was not significantly affected by the SEO. The study concluded that improper disposal of SEO in the study area elevated the soil Pb content thereby causing Lead pollution.*

Keywords: *Spent Engine Oil (SEO), Lead Pollution, Soil properties, auto-mechanic village*

I. Introduction

As engine oil is used in automobile, it picks up a number of additional compounds from engine wear. These include iron, steel, copper, zinc, lead, barium, cadmium, sulfur, dirt and ash. Because of the additives and contaminants, used motor 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 effect if they are allowed to enter the environment through water ways or soil (Anoliefo and Vwioko, 2001). Once engine oil is drained off an engine, it is no longer clean because it has picked up materials, dirt particles, and other chemicals during engine operation, thus such lubricating oil is now classified as SEO.

The increase in the number of vehicles in Nigeria has necessitated a higher production and use of SEO. This has subsequently given rise to the generation of large quantities of SEO, at the time of servicing the vehicles. This SEO 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. This practice of disposal is a continuous exercise, except when the SEO is collected by unregistered and unregulated vendors.

Nekede Mechanic Village was selected as the study area. It was established in 1975 by the Imo State Government of Nigeria, went into full operation in 1984 and has been in use with constant growth since then. Udebuani et al (2010) reported that the quantity of SEO generated in this area is estimated at about an average of four thousand seven hundred and ten (4710) litres per week. The study area covers an area of about 3600m^2 with a population of about five thousand workers. These workers are mainly motor mechanics which constitute about 60% of the total workforce and includes panel-beaters, welders, automobile electricians, painters, automobile upholstery workers, automobile spare part dealers, vulcanizers and blacksmiths. Complimentary service workers found in the area include confectionaries, commercial phone call service operators, textile dealers, audio and video cassette retailers etc. Most of these artisans and vendors belong to the informal sector of the economy. They neither pay tax, nor register with the government. Their level of education ranges between first school leaving certificate and the senior secondary school certificate, this partly explains the difficulty of controlling their method of disposal of SEO in the area. With increasing number of automobile mechanic workshop from about 25 in 1985 to about 160 in 2007 and many more workshops under construction as evident at the Nekede Mechanic Village and the increasing number of vehicles being serviced or repaired at these mechanic workshop from an average of 3 vehicles per workshop per day in 1985 to an average of 10 vehicles per workshop per day in 2007, it can therefore be established that the amount of SEO from vehicles in Nigeria in general and Owerri in particular is on a steady increase.

These findings have provided a stimulus for studies of known and suspected areas of SEO contamination. It is therefore necessary to assess the extent of heavy metal contamination resulting from the dumping of SEO. Such information provides a perspective when considering what level of heavy metals in soil will be defined as hazardous and would suggest the extent of remediation needed. This study therefore attempts to assess the effect of SEO on receiving soil with particular interest on the level of heavy metal (Pb) contamination on these soils.

II. Materials And Method

The study area, Nekede mechanic Village was selected because it is one of the largest functioning mechanic villages in Southeastern Nigeria. The study area geographically falls under Owerri West L.G.A, which ranges longitudinally between $7^0$03' and $7^0$05'E and $5^0$26' and $5^0$35'N in latitude. The climatic condition of the area has its parameter as; temperature range of 21^0C and 27^0C, relative humidity ranges between 60 – 80%. The area lies within the sub-equatorial, sub-humid region with March to October as rainy season and November to February as dry season. Annual average rainfall is about 1500mm with a monthly average of 30mm. The study area has its drainage source as Otamiri River running from Egbu and Nwaorie River running from Akwakuma. These two river meets at Owerri suburb and drain through Nekede, Ihiagwa and empties into the Imo River.

Sampling design, collection and preparation

Contaminated soil samples were collected using a Dutch soil auger in a randomized method along a transect at 100m interval for five (5) different locations within the study area, these sample points were constantly receiving spent engine oil and were labeled samples SA, SB, SC, SD, SE. At each of these sampling location, auger-boring instrument were used to bore holes of depths 0 – 15cm depth (top soil) and subsoil 15 – 30cm. Two (2) samples were collected 2km away from the study area as control and were labeled CF and CG, they were not receiving SEO or any other type of contaminant (undisturbed forest). The samples were homogenized in a clean plastic bucket and a composite sample was drawn from each. This process was repeated for all the experimental units. All the composite samples were air dried and allowed to pass through a 2 mm sieve, which were then poured into polythene bags, labeled adequately and transported to the laboratory immediately for analyses. A total of 14 soil samples were analyzed from the study area.

The sieved soil samples less than 2mm diameter were then taken to the laboratory and analyzed for particle size, soil pH, CEC and digested for heavy metals analyses. Three grammes of 2mm sieved air dried soil were weighed into a digestion tube (50ml in volume) and 1 ml of HNO_3 and 10 ml of HCl (aqua regia of ratio 1:2) were added to the samples. The content was heated on a digestion block in fume cupboard to dryness at 120°C (Ademoroti, 1996). The residue was allowed to cool and leached with 5ml of 2M HCl, placed inside the centrifuge machine for 10 minutes at 4500rpm at 120°C for 1 hour, then increased to 250°C for I hour and allowed to cool before making it to volume with ultra-pure water. The extract was then poured into a set of vials for the determination of Pb using a Buck 205 model Atomic Absorption Spectrophotometer (AAS). Soil pH was determined in 1:1 soil to water ratio using a pH meter according to modified method of Mclean (1982). The particle size analysis was carried out using the hydrometer method and extrapolating on the texture triangle (USDA, 1951). The exchangeable acidity of the sample was determined using INKCL extracting solution by titration, while the exchangeable base was extracted with neutral normal ammonium acetate solution. Exchangeable Calcium and Magnesium were determined using absorption spectrometer (AAS) while Sodium and Potassium was determined using flame photometer. 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 (IITA, 1979)

Where,

CEC = Cation Exchange Capacity

TEB = Total Exchangeable Bases, (K^+, Na^+, Ca^{2+}, Mg^{2+})

TEA = Total Exchangeable Acidity

III. Results

Result shows the mean values of physico-chemical properties in soil at various sample point SA, SB, SC, SD, SE and control CF and CG. There was no significant difference in the soil pH within the contaminated soil and control. However, pH range was between 5.43 and 6.79. Soil pH is a major factor influencing the availability of elements in the soil for plant uptake (Marschner, 1995). Many metal cations are more soluble and available in the soil solution at low pH (below 5.5) including Cd, Cu, Hg, Ni, Pb, and Zn (McBride, 1994) the retention of metals to soil organic matter is also weaker at low pH, resulting in more available metal in the soil solution for root absorption. CEC varied across the sample area and showed no variation in the control site. The % sand distribution varied across the sample point and showed a higher distribution in the study area than % clay and % silt, the soil texture (sandy loam) was not significantly affected by the SEO (Table 1).

Table 1: Spatial Variation on the Distribution of Physico-Chemical Properties in Soil at the study area

Treatment	soil pH	CEC (cmol/kg)	Particle size (%)			Textural class
			Sand	Silk	Clay	
SA	6.39	2.15	89.65	5.75	4.55	Sandy loam
SB	6.79	3.00	90.05	4.95	5.00	Sandy loam
SC	6.39	2.23	85.50	7.10	7.10	Sandy loam
SD	5.94	2.80	90.55	5.27	4.67	Sandy loam
SE	6.55	2.95	80.20	7.90	11.90	Sandy loam
CF	5.43	3.65	82.25	7.65	10.10	Sandy loam
CG	6.04	3.65	89.15	5.00	5.85	Sandy loam

The concentration of Pb in soil in the study area is presented in Table 2. The concentration of Pb in the contaminated soil at a depth of 0 – 15cm (topsoil) varies, the highest value was observed at SD (482.2mg/kg) and the lowest value at SE (146.8mg/kg). At the depth of 15 - 30cm (subsoil), concentration of Pb was highest at SB (397.6mg/kg) and lowest at SC (140.1mg/kg). The mean concentration of Pb in the contaminated soil sample area has its highest concentration at SB (382.9mg/kg) and lowest at SC (157.8mg/kg). The level of Pb in the control site was lower (CF, 46.5mg/kg and CG, 11.8mg/kg) when compared to the various concentrations for the contaminated soil.

Table 2: Spatial Variation on the Distribution of Pb in Soil at the study area

Treatment	Lead (Pb) concentration in soil (mg/kg)		
	Topsoil (0-15cm)	Subsoil (15-30cm)	Mean Value
SA	218.3	150.6	184.5
SB	368.2	397.6	382.9
SC	175.4	140.1	157.8
SD	82.2	226.6	354.4
SE	146.8	174.5	160.7
CF	46.5	10.2	28.4
CG	11.8	3.5	7.65

IV. Discussion

Lead In Soil

The assessment of the concentration of Pb in the study area showed significant differences between treatments at different sampling point. Pb concentration did not follow any pattern across the sample points. The highest value of Pb (482.2mg/kg) observed at SB was higher than 312.0mg/kg of Pb found at Ile-Ife Southwestern Nigeria (Adewole and Aboyeji, 2014) and lower than 649mg/kg found at Okigwe mechanic village Southeastern Nigeria (Nwachukwu et al 2010), The range of value 100 – 400mg/kg for Pb by the US EPA above which toxicity is considered to be possible were exceeded in the top soil.

The result in table 2 indicates wide variation between Pb contaminated soil samples SA, SB, SC, SD, SE, and control soil sample CF and CG with frequency range across all sample points as 375.25mg/kg and frequency range for contaminated soil sample as 222.2mg/kg. This variation indicates that certain places in Nekede mechanic village are receiving more spent oil than some others. The high concentration of lead in the sub soil may be as a result of Tetra Ethyl Lead (TEL), a Pb compound normally found in SEO. The TEL easily moves down the soil profile, facilitated by the coarse textured (high permeable) sandy soil of Nekede mechanic village. The high concentration of Pb in the sub soil may also be as a result of the conversion of non-polar Pb compounds to aqueous Pb as it passes through clay soil or liners in the soil profile. The main compartments for Pb in the soil are the soil solution, the absorption surfaces of the clay-humus exchange complex, precipitated forms, secondary iron and manganese oxide and Alkaline earth carbonates, the soil humus are silicate lattices. The pH of the soil, which is subject to short-term variation, has an effect on the absorption of lead by the soil particles. At near neutral pH values, proved the highest absorption of lead. In general heavy metal cation such as that of Pb are most mobile under acidic conditions and increasing the pH by liming (addition of Ca and Mg compound) usually reduces their bioavailability. The concentration of Pb in soil in dry season is significantly higher than concentration of metals in wet season. This is in agreement with the findings of Yahaya et al. (2009). This might be due to the run off effect that is capable of removing heavy metals from the site and the effect of rainfall which may facilitate the dilution of soil solution during the wet season and intense evaporation in the dry season makes soil solution more concentrated.

Soil pH, Particle Size Distribution and CEC

Analysis of soil sample showed high sand content with percentage of sand ranging between 80.20% to 90.55% as shown in table 1; the high proportion of sand in the soil sample can be attributed to the parent materials. The soil is derived from coastal plain sands of southern Nigeria and as such has high sand content.

The pH of the soil samples is predominantly acidic. The highest value was observed at SB (6.79) and lowest value at CF (5.43). This could be as a result of the leaching away by rainwater of the basic cation (Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}) and replacement of many of these basic cation by hydrogen ion, H^{+} from carbonic acid (H_2C0_3) formed from water and dissolved carbon dioxide. Soil pH usually increases with depth in humid areas where bases are leached down the soil profile and decrease with depth in arid environments where evaporation causes salts to accumulate in the surface horizon.

The CEC which is an indication of the relative ability of K, Na, Ca and Mg to displace other cation was observed to be low, the highest value was observed at CF and CG (3.65cmol/kg) respectively while the lowest value was observed at SA (2.15cmol/kg). Sand generally has low CEC values of 1–5cmol/kg, compared to other soil. This is because the coarse textured soil (sand) is commonly lower in both clay and humus content. Likewise, a clay soil dominated by the 1.1 type silicate clay and iron and aluminum oxide will have a much lower cation exchange capacity than will one with a similar humus content dominated by smectite clay. The CEC of most soil increases with pH. At very low pH values, the CEC is generally low. The low value of CEC in the soil samples implies low fertility of the contaminated soil.

V. Conclusion

The result from this study shows that pH values of the contaminated soil around Nekede mechanic village are predominantly acidic. The research also shows that CEC is relatively low which implies low fertility of the soil. Particle size analysis shows that the soil is predominantly sandy. The soil in the study area shows varying level of Pb contamination, the highest concentration of lead in the study area exceeded the permissible level (limits). Based on these findings, a well coordinated waste oil collection programme should be initiated by the government in partnership with the private sector, to minimize disposal of waste oil on soil. The collected waste oil should be sent to motor oil manufactures for recycling and re-injection into the production stream. Health, Safety and Environmental workshops and seminars should be organized for the populace, especially for enlightenment of people who directly engage in activities generating SEO. There should be periodic monitoring of the contaminated areas to ascertain that pollution do not exceed permissible limits. Certain plants found in the environment which are capable of decomposing the organic constituents of SEO should be planted within the contaminated areas to help break down the complex molecules of SEO (phytoremediation).

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