African Scientist Vol. 17, No. 2 June 30, 2016
Printed in Nigeria

1595-6881/2016 $10.00 + 0.00

http://www.niseb.org/afs

AFS 2016015/17202

Physicochemical analysis of automobile waste oil on soil quality in Benin City, Nigeria

N.O Erhunmwunse[1*], M.O. Ainerua[2], E.E. Ewere[3] and I.B. Ogboghodo[4]

[1-3]Laboratory for Ecotoxicology and Environmental Forensics, Department of Animal and Environmental Biology, [4]Department of Microbiology, Faculty of Life Sciences, University of Benin, P.M.B 1154, Benin City, Nigeria.

***Corresponding Author's Email:** nosakhare.erhunmwunse@uniben.edu donsazy@yahoo.co.uk,

(Received February 22, 2015; Accepted in revised form April 19, 2016)

ABSTRACT: Sustainable use of soil on which agriculture depends is absolutely necessary for agricultural productivity. Soil samples were collected from two auto-mechanic workshops sited at Technical College Road (Station A) and Textile Mill Road (Station B) while the control was at EDPA Housing Estate, all in Benin City with the aid of a split soil core sampler at a depth of 0 – 10cm. The Physicochemical parameters of the samples were analysed using standard methods and revealed pH mean value of 7.27 at station A and 6.83 at station B respectively. The total petroleum hydrocarbon (THC) had mean value of 61.93 at station A and 66.73 mg kg^{-1} and these concentrations were relatively high and represent elevated concentrations above background levels found in unpolluted soils. Generally, the concentration of heavy metals in the examined site A and B followed the same order: Fe >Zn > Mn > Pb > Cr > Cd > Ni>V and exceeded the permissible limits of WHO and NESREA. To effectively control issues related to soil contamination with engine oil, it has been suggested that the concept of environmentally friendly automobile mechanic village be established for the disposal or otherwise recycling of used motor engine oil.

Keywords: Automobile, oil spill impact, soil quality, Nigeria

Introduction

Soil is the most valuable component of the farming ecosystem and environmental sustainability largely depends on proper soil maintenance. It is a primary recipient by design or accident of a myriad of products and chemicals used in modern society (Mbah *et al.,* 2009). Sustainable use of this natural resource on which agriculture depends is absolutely necessary for agricultural productivity. The disposal of spent engine oil (SEO) into gutters, water drains, open vacant plots and farms is a common practice in Nigeria especially by motor mechanics (Anoliefo and Vwioko, 2001). Substantial volumes of soil have been contaminated by used oil in many countries of the world, especially industrialized nations. Large amounts of used engine oil are liberated into the environment when the oil from motor cars, motor-bikes, generators is changed and disposed into gutters, water drains, open vacant plots and farmlands, a common practice by motor and generator mechanics (Odjegba and Sadiq, 2002). Various contaminants such as used engine oil and heavy metals have been found to alter soil biochemistry, which includes alteration in soil microbial properties: pH, O_2 and nutrient availability (Atuanya, 1987; Brookes, 1995 and Odjegba and Sadiq, 2002).

Disposal of spent engine oil in the big cities in Nigeria has been persistently problematic since many automobile mechanics dispose these oils indiscriminately either in gutters or open lands. This practice adversely affects plants, microbes and aquatic lives (Nwoko *et al*., 2007; Adenipekun *et al*., 2008), because of the large amount of hydrocarbons and highly toxic polycyclic aromatic hydrocarbons contained in the oils (Vwioko and Fashemi, 2005). Edebiri and Nwaokwale (1981), reported that metals present in spent lubricating oil are not necessarily the same as those present in the unused lubricant. Whisman *et al.* (1974) observed that most heavy metals such as vanadium, lead, aluminium, nickel and iron, which were below detection levels in unused lubricating oil, were present in high levels in used oil. These high amounts of heavy metals in spent engine oil may be one cause of the retarded growth and chlorosis of leaves of plants growing in oil polluted soils (Udo and Fayemi, 1975). Idugboe *et al,* (2014) reported the presence of heavy

metal (Fe, Zn,Mn, Pb, Cu, Cd, Cr, Ni) in soils of three auto-mechanic village and were above WHO and NESREA limit set for the concentration of the metals in soil. Inuwa et al. (2007) assessed some trace metals in soils around the major industrial areas of North-western, Nigeria and found out that industrial areas were relatively higher in concentration of tested metals (Pb, Cd, Cr and Ni) than areas without industries. This research project is aimed at assessing the environmental impact on soil quality caused by waste engine oil from mechanic workshops in Benin-City.

Materials and Methods

Sample Collection, Samples Preparation and Analysis

Soil samples polluted with oil were collected with aid of Split soil core sampler (Auger) from two auto-mechanic workshops sited at Technical school road (6° 22' 57.4"N 5° 37' 9.8"E) and Textile mill road both in Benin-City (6° 21' 35.4"N 5° 36' 31.9"E) and were designated as workshop A and B. The control soil was obtained from BDPA Housing Estate, in Ugbowo, Benin-City (6° 23' 54.4"N 5° 36' 08.3"E). Three different sampling sites were established. Soil samples were collected in sterile polythene bags using a split soil core sampler to a depth of 0 – 5cm and were immediately transported to the laboratory for analyses.

Results

The results obtained for the various physicochemical parameters are shown in Table1. The results obtained from the analysis indicated that the pH had mean value of 7.27 in station A and 6.83 in station B, while the control was 6.5. The EC had mean value of 582 in station A and 890 in station B while the control was 402. The THC had mean value of 61.93 in station A and 66.73 mg/kg in station B while the control had value of 5.60 indicating an increase in total hydrocarbon content in the polluted sites. The mean value of Org.C was 3.58 in station A and 2.5 in station B while the control was 0.55 which indicates an increase in organic carbon as a result of pollution.

The level of organic carbon in sample A was relatively greater with a 3.58 % value compared to sample B which had lower organic carbon level of 2.5 %.. This indicates that soil samples A was highly polluted than soil samples B. Electrochemical conductivity (EC) analysis of both samples A and B had values of 582µS/cm and 890µS/cm respectively and fell within the range reported by Ugoh and Moneke (2011) on engine oil contaminated soil samples with 200µS/cm to 1300 µS/cm. Total nitrogen in sample A was observed to be 0.55 % and was higher than the value obtained in sample B (0.38 %) while the exchangeable acidity was at a level of 0.3 meq/100g of soil in both soil samples A and B from the mechanic workshops.

The percentage of clay, silt and sand in soil samples A was 6.40 %, 2.30 % and 91.30 % respectively. The results indicated that soil sample A had greater proportion of sand and lowest proportion of clay. Clay, silt and sand analysis of soil samples B had 6.23 %, 2.40 % and 91.37 % respectively. There were no significant differences ($p>0.05$) in the values obtained for parameters such a sodium, potassium, calcium, magnesium, chloride, available phosphorus, ammonium nitrate, nitrite, nitrate, sulphate in both polluted soil samples A and B (Table 1) respectively. The concentration of heavy metals in the examined site A and B followed the same order: Fe >Zn > Mn > Pb > Cr > Cd > Ni>V. Total hydrocarbon content for soil samples A and B was observed to be 61.93 and 66.73 mg kg^{-1} respectively.

Discussion

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) and support the findings in this study (pH level in soil sample A 7.27 and B 6.83.) as Fe, Zn, Mn, Pb, Cr, Cd, Ni and V were all found in both Mechanic workshop . 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 (Martínez et al. 2003). Results obtained from physico-chemical analysis revealed that the these results were similar to pH ranged of 6.3 to 6.9 reported by Ugoh and Moneke (2011). Electrical conductivity was higher in station B than station A. This finding was higher than the studies done by Akpoveta *et al*. (2010) for automobile dumpsites at Agbor and Abraka, Nigeria and Idugboe et al., (2014) for automobile dump sites at Uwelu and Evbareke Spare part market both in Benin City. According to Idugboe *et al*. (2014) mechanic village whose soil are heavily contaminated may eventually leached into the underlying soils and hence leads to an increase in the concentration of some ions such as sodium, calcium, aluminium and hydrogen in the soils. Although the resultant organic carbon from this study were lower than the one obtained from Idugboe *et al*. (2014), however the high levels of organic carbon in the soils of the sampled auto-mechanic villages indicated the possible presence of Organic matter content which normally increases following the addition of carbonaceous substances as was the case in this study due to the presence of used oil and other carbonated

fluid in the auto-mechanic villages and according to Osuji et al., (2006a) this might cause an increase in the presence of soil microorganisms which are in the business of breaking down organic compounds in soils (Idugboe et al. 2014).

The result of the analysed heavy metals showed concentrations in the soil samples higher in the auto-mechanic workshops than the control. According to Nwachukwu et al., (2010) and Idugboe et al. (2014) engine oil and other transmission fluids collect heavy metals such as lead, cadmium, zinc, iron and copper when an automobile engine is running and they remain in the used oil. When it is discharged, it increases the concentration of heavy metals in soils and maybe responsible for the higher concentration in the auto-mechanic village soils than the control which is not exposed to high volume of waste engine oil.

The results of Fe found in this study were far lower than value range of 1746.4 to 2839.4mg/kg reported in soils in the vicinity of automobile spare parts market and oil field in Nigeria (Iwegbue et al. 2006a) and Haliru et al.(2014) who reported a range value of 89-310mg/kg. The variation in concentration level of Zinc (Station A-B) in these two auto-mechanic soils showed the impact of pollution from anthropogenic activities rather the lithogenic one. The main source of Zn in these soils be from attrition of motor vehicles, metal fabrication works and lubricating oil found as additives as Zn dithiophosphates (Haliru et al. 2014).

Table 1: Physicochemical analysis of soil samples from auto-mechanic workshops in Benin-City

Parameter	Soil samples (Mean ± S.D)			P-value
	Control(Sand)	A(Sand)	B(Sand)	
pH	6.5	7.27±0.47	6.83±0.47	0.2655
EC (µS/cm)	402	582±252.49	890±893.18	0.0024
Org. C	0.55	3.58±0.72	2.5±1.44	0.8523
T.N	0.08	0.55±0.11	0.38±0.23	0.0487
EA	0.4	0.33±0.06	0.3±0.26	0.0457
Na	0.54	0.53±0.10	0.50±0.06	0.0628
K	0.19	0.24±0.08	0.23±0.02	0.0369
Ca	5.40	1.45±0.48	4.34±3.07	0.2583
Mg	1.48	0.40±0.07	1.48±1.10	0.2655
Cl	31.2	49.6±14.40	49.0±26.25	0.0024
Av. P	4.17	15.0±2.76	20.8±10.66	0.0822
NH_4N	3.16	5.56±3.81	4.30±4.02	0.0604
NO_2	3.71	2.81±0.06	1.66±0.34	0.4296
NO_3	5.99	4.54±0.10	2.67±0.54	0.0990
SO_4	3.75	9.58±6.17	14.41±8.36	0.0819
Clay	6.6	6.40±0.70	6.23±0.35	0.0017
Silt	1.5	2.30±0.87	2.40±0.44	0.9223
Sand	91.9	91.30±1.57	91.37±0.76	1.27E-08
Fe	103.3	845.93±145.10	750.30±74.12	0.0727
Mn	28.2	67.60±7.30	71.87±61.10	0.0179
Zn	53.9	221.43±130.89	157.1±10.58	0.0436
Cu	5.99	31.30±12.42	32.30±14.97	0.0700
Cr	7.11	44.53±1.07	40.63±4.27	0.0729
Cd	2.59	30.47±11.32	34.53±19.16	0.1107
Pb	4.24	61.00±1.47	60.30±2.57	0.1016
Ni	1.55	18.23±6.77	20.67±2.57	0.1299
V	1.19	14.04±5.20	15.87±1.95	0.1467
THC(mg/kg)	5.60	61.93±17.54	66.73±21.47	0.0950

KEY: EC = Electrical conductivity, Org. C= Organic Carbon, T.N= Total Nitrogen, EA = Exchangeable acidity, Av. P = Available phosphorus, THC= Total hydrocarbon content, S.D = Standard deviation.

The mean value of Pb concentration recorded at soil sample A and B with mean value of 60s mg/kg were found to be comparatively higher than the mean values of Pb concentration of 34.32, 1.11±0.28, 10.0 and 8.5, 0.84±0.05 mg/kg reported by (Liang et al, 2011; Osakwe, 2013; Bichi and Bello, 2013; Majolagbe et al, 2014) and lower than 243-126,000 mg.kg-1 in soils from the premises of a battery manufacturing plant reported by Adie and Osibanjo (2009). The results of heavy metal concentration levels in soil sample A and B revealed that the soil contains substantially high level of heavy metals (Cu, Cr, Cd, Ni and V) due to auto-mechanic activities. The levels of occurrences of these metals were higher than the report of Idugboe et al. (2014) but far higher than WHO and NESREA limits for soil and could cause great damage to sensitive environments and soil microorganisms.

Conclusions and Recommendations

To effectively control issues related to soil contamination with engine oil, Nwachukwu *et al.* (2010) has suggested that the concept of environmentally friendly automobile mechanic village should be established for the disposal or otherwise recycling of used motor engine oil, a process that can be structured with the major petroleum marketers, whereby gas stations could periodically collect all used oil stored in mechanic villages and the mechanics are obliged to store the used oil in plastic barrels rather than the present attitude of spilling on the ground. Mechanic villages should be properly planned and mechanics are to operate under a defined code of practice. Continuous education and training should be provided to the mechanics, emphasizing on the environmental implications of their poor occupational waste management. Code of practice and specific regulations guiding the establishment and the operation of mechanic villages must be in place and accordingly enforced.

References

Adenipekun CO, Kassim LQ: Effect of spent engine oil on some growth parameters and moisture content of *Celosia argentea* L. Nig J Bot 19(2): 318-324. 2006.

Adie GU, Osibanjo O: Assessment of soil pollution by slag froman automobile battery manufacturing plant in Nigeria. Afr J Environ Sci Technol 3(9): 239-250. 2009.

Akpovata OV, Osakwe SA, Okoh BE, Otuya BO. Physico-chemical Characteristics and Levels of Some Heavy Metals in Soils around Metal Scrap Dumps in some parts of Delta State, Nigeria. J Appl Sci Environ Manage 14(4): 57-60. 2010.

Anoliefo GO, Vwioko DE: Tolerance of *Chromolaena odorata* grown in soil contamination with spent lubrication oil. J Trop Biosci 1:20-24. 2001.

Atuanya EJ: Effect of oil pollution on physical and chemical properties of soil: a case study of waste oil contaminated delta soil in Bendel State, Nigeria. J Appl Sci 55: 155-176. 1987.

Bichi MH, Bello UF: Heavy Metal Pollution in Surface and Ground Waters Used for Irrigation along River Tatsawarki in the Kano, Nigeria. J Eng (IOSRJEN) 3:1-9. 2013.

Brookes PC: The use of microbial parameters in monitoring soil pollution by heavy metals. Biol Fert Soil 19: 269-279. 1995.

Edebiri RA Nwaokwale E: Control of Pollution from internal combustion engine used lubricant, Warri, Bendel State, Nigeria: Petroleum Training Institute. pp.71-75. 1981.

Haliru HA, Ling LP, Selaman OS: Environmental Burden of Heavy Metal Contamination Levels in Soil from Sewage Irrigation Area of Geriyo Catchment, Nigeria. Civil Environ Res 6(10):118-124. 2014.

Idugboe, SO, Tawari-Fufeyin P, Midonu AA. Soil pollution in two auto-mechanic villages in Benin City, Nigeria. J Environ Sci Toxic Food Technol 8(1):9-14. 2014.

Inuwa M, Abdulrahman FW, Birnin Yauri UA, Ibrahim SA: Analytical Assessment of Some Trace Metals in Soils Around the Major Industrial Areas of North-western Nigeria. Trends Appl Sci Res 2: 515-521. 2007.

Iwegbue CMA, Egobueze FE Opuene K: Preliminary assessment of heavy metals in soils of an oil field in the Niger Delta, Nigeria. International J Environ Sci Technol 3(2):167 – 172. 2006a.

Liang J, Chen C, Song X, Han Y, Liang Z. 2011. Assessment of Heavy Metal Pollution in Soil and Plants from Dunhua Sewage Irrigation Area. Int J Electrochem Sci 6: 5314 – 5324. 2011.

Mojolagbe AO, Yusuf KA, Duru, AE: Trace metals characterization in environmental media: A case study of cement production area Ewekoro, southwest, Nigeria. Amer J Environ Protect 3(2):83 – 89. 2014.

Marschner H: Mineral nutrition of higher plants (2nd ed.). New York, Academic Press, 889p. 1995.

Martinez L, Cavagnaro P, Masuelli R, Rodrignez J: Evaluation of diversity among Argentine grapevine (*Vitis vinifera* L.) varieties using morphological data and AFLP markers. Electron J Biotechnol 6(3):244-253. 2003.

McBride MB: Environmental chemistry of soils. New York, Oxford University Press, 406p. 1994.

Mbah CN, Nwite JN, Nweke IA: Amelioration of spent oil contaminated ultisol with organic wastes and its effect on soil properties and Maize *(Zea mays)* yield. World J Agric Sci 5(2): 163-168. 2009.

Nwachukwu MA, Feng H, Alinnor J: Assessment of heavy metal pollution in soil and their implications within and around mechanic villages. Intern J Environ Sci Technol 7(2): 347-358. 2010.

Nwoko CO, Okeke PN, Agwu OO, Akpan IE: Performance of *Phaseolus vulgaris* L. in a soil contaminated with spent engine oil. Afr J Biotechnol 6(16): 1922-1925. 2007.

Odjegba VJ, Sadiq AO: Effect of spent engine oil on the growth parameters, chlorophyll and protein levels of *Amaranthus hybridus*. The Environmentalist 22: 23-28.2002.

Osakwe SA: Pollution Status of Soils and Vegetation around Busy Motor Parks in Selected Areas of Delta State, Nigeria. J Appl Chem 4(2):05 – 12. 2013.

Osuji LC, Iniobong DI, Ojinnaka CM: Preliminary investigation of Mgbede-20 oil-polluted site in Niger Delta, Nigeria. Chem Biodivers 3: 568-577. 2006a.

Udo EJ, Fayemi AA: The effect of oil pollution of soil on germination, growth and nutrient uptake of Corn. J Environ Qual 5: 537 – 540. 1975.

Ugoh SC, Moneke LU: Isolation of bacteria from engine oil contaminated soils in automechanic workshops in Gwagwalada, Abuja, FCT-Nigeria. Academ Arena 3(5): 28-33.2011.

Vwioko DE., Fashemi SD: Growth response of *Ricinus communis* L. (Castor oil) in spent lubricating oil polluted soil. J Appl Sci Environ Manage 9(2): 73-79.2005.

Whisman ML, Geotzinger JW, Cotton FO: Waste lubricating oil research. In: An Investigation of Several Re-refining Methods. Bureau of Miner, Bartlesville Energy Research Centre. 352p. 1974.