Physicochemical Characterization of Farmland Affected by Automobile Wastes in Relation to Heavy Metal.

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Abstract: Selected properties of automobile waste and non-automobile waste (control) affected soils and its relation with some heavy metals were investigated in this study. Sampling site was delimited at each area by free survey technique and soil samples collected at the surface (0-20cm) and subsurface (20-40, 40-60cm) depth. Results of the study showed decreased Ca, k, Mg and CEC levels as well as increased Na content of the automobile waste affected soil compared to the control. Both soils were acidic in nature and their heavy metal contents decreased with depth. Higher levels of heavy metals above critical limits in automobile soils using standard were observed .Soil contents of $P0_4^-$, $N0_3^-$ and sodium adsorption ratio (SAR) were within tolerable limits in both soils. The results indicate that automobile wastes had adverse effect on the nutrient level and fertility status of the studied soil.
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Keywords: *Heavy metal, nutrient level, fertility status, automobile soil, critical limits.*

1.Introduction

Abakaliki is the capital of Ebonyi State and a major food producing area of Nigeria. The area is endowed with natural resources including good weather and fertile land for agriculture. Heavy metals are naturally present in soil (Ojanuga *et al.* 1996) but anthropogenic activities have resulted in high concentration in the environment (He *et al.* 2004). The metal is non-essential element to human and has a toxic potential for all biological systems if present in a large quantity.

The invention of automobile as a means of transportation and haulage led to the emergence of automobile servicing centres popularly called “mechanic village”. These automobile servicing centres are sources of automobile waste-mostly fossil fuel products – in urban and peri-urban areas of Ebonyi State. Onweremadu *et al.* (2007) reported that these wastes accumulate and deteriorate nearby farmlands causing non-point source pollution. But little has been done in terms of evaluating the damage done by automobile wastes on agricultural farmlands. This study compares the physicochemical parameters and heavy metal contents of automobile waste with non-automobile waste affected farmland in Abakaliki. The result will give an insight to the level of damage that automobile waste disposal has done to the fertility and nutrient status of the area regarded as food basket of the nation.

2. Materials and Methods

2.1. Study area:

The study area, Abakaliki is located in Ebonyi State in the southern part of Nigeria. Abakaliki is the capital city of Ebonyi State and lies between latitude 06^o04^1N and longitude 08^o65^1E in the derived savannah zone of the southern-agroecological zone of Nigeria. Soils of the area are products from successive deposit from Asu River of crutaceous age belonging to the order ultisol and classified as Typic Haplustult, (FDALR, 1985). The area experiences bimodal pattern of rainfall i.e. April-July and September – early November with short spell in August – normally called “august break”. The area has an average annual rainfall range of 1700 – 2000mm and mean annual temperature ranging from 27^oC – 31^oC. Farming is a major economic activity even in urban areas where patches of subsistence farms are found.

2.2 Field Studies;

Field sampling was conducted using a free survey technique involving target sampling of soils from two sites viz automobile waste affected farmland (automobiles soil) and non-automobile waste affected farmland (control). On each area three profile pits were dug and soil samples collected at the surface (0-20cm), subsurface[1] (20-40cm) and subsurface[2] (40-60cm). These soil samples were air dried, sieved using 2mm sieve and stored in plastic bags for analysis. Similarly, cores were used to collect undisturbed samples for bulk density determination.

2.3 Analysis

Particle size distribution was determined by hydrometer method according to the procedure of Gee and Or (2002). Bulk density was measured by Core method (Grossman and Keinch, 2002). The P^H was determined using 1:2.5 soil- liquid ratio (Thomas, 1996). Exchangeable cations (EC) were first extracted by the ammonium acetate extraction method (Jackson, 1962). Then sodium (Na) and potassuim (K) were determined using flame photometry while calcium (Ca) and magnesium (mg) were determined by the Versenate method as described by Jackson (1962). Exchangeable acidity was determined by the titration method using phenolphthalein as indicator organic carbon was analysed by the wet combustion method of Walkley and Black (1934). Available phosphorus was determined by Olsen method (Emeteryd, 1989) while total Nitrogen was determined by Kjeldahl Digestion with Keltec Auto 1030 system (Tecaton, Hoganas, Sweeden).

Nitrates and phosphates were determined by phenol sulphuric acid and ascorbic acid molybednum blue methods, respectively, using UV visible spectrophotometer.

Sodium adsorption ration (SAR) was computed as

$$SAR = \frac{Na^+}{\sqrt{(Ca^{2+} + Mg^{2+})^{1/2}}}$$

where SAR = Sodium adsorption ratio, Na^+, Ca^{2+} and Mg^{2+} = concentrations of sodium, calcium and magnesium, respectively.

Total Iron(Fe), copper(Cu), lead(pb), zinc(Zn) and cadmium(cd) were measured by Sp 1900 pye Unican Recording flame atomic absorption spectrophotometer at their respective wavelengths after wet digestion with a mixture of HCL and $HN0_3$.

2.4 Data Analysis:

Linear regression analysis was performed on soil data and heavy metal using SAS computer software (SAS, Institute 2001).

3. Results and Discussions

Soil properties at various depths in automobile and control soil are shown in Table1. Bulk density was lower in the automobile soil than the control. Total porosity decreased by 3% in control compared to automobile soil. Exchangeable bases (Ca^{2+}, Mg^{2+} and K^+) were higher in the control than in the automobile soil in all the depths. The table show higher content of Na in automobile soil compared to the control. There were higher values of total organic carbon in automobile soil. Available P was also higher at various depths in the automobile soil. Organic carbon content may have influenced the distribution pattern of available phosphorus which is associated with low solubility. The table also showed higher values of soil P^H in automobile soil compared to control.

The observed soil P^H ranged between 5.69±0.01 – 6.2±0.01 in automobile soil and 6.59±0.01 – 6.59±.0.01 in the control soil. The soils are all acidic which may not be attributed to automobile waste since the control is equally acidic. The acidity is typical of the soils of the southern part of Nigeria and is ascribed to the excessive precipitation which lead to leaching loses of most of the cations in the soil (James and Wild, 1975). According to Ngobori *et al* 2007, these cations are replaced by hydrogen ion (H^+). The observed p^H range at the top soils according to Cheng (1997) is quite suitable for K availability. The low ca content of automobile soil will cause poor stem growth and decolouration of crops and thus low yield (Nwilo and Badojo, 2005). Similarly, the observed low k values at the top (0-20cm) and other depths of the automobile soils are less than the critical value ($0.2mgha^{-1}$) of K for crop production (Adenye *et al.* 2002) and will retard plant growth, cause poor stem development according to Atubi and Onokala (2006) and wilting (Brady and Weil, 1999). Slight increase in Na was observed in the top (0-20cm) of the automobile soil with value of 0.12±0.1 in contrast to 0.1±0.01 in top (0-20cm) control. This suggests that automobile deposits increase soil Na content. High Na content in soil is not an index for effective crop productivity according to Adams and Ellis (1960). The higher values of soil carbon in automobile soil could be attributed to regular supply of automobile wastes, most of which are of fossil origin. The reverse was the case in the control soil where there were lower values of organic carbon components which Foth (1984) attributed to cultivation and pronounced activities of soil organisms. Observed CEC values in both soils were less than 20 $mgkg^{-1}$ and is considered insufficient for soil fertility and crop growth (Green land and Hayes (1978) and will have statistically significant effect on crop yield and land productivity.

Similarly the low values of cation exchange capacity and available phosphorus observed in the control soil compared to the automobile soil could be as a result of exchangeable cation and P – uptake by crops in the control soil.

The heavy metal (Mg/l) contents of the automobile and control soil are shown in Table2.

Table1. Physicochemical Properties of the automobile Waste and Control Soils

	Automobile	Waste		Control		
Parameter	0-20cm	20-40cm	40-60cm	0-20cm	20-40cm	40-60cm
Bulk density gcm^{-3}	1.6±0.01	-	-	1.64±0.01	-	-
Total Porosity (%)	39	-	-	38	-	-
P^H	5.69±0.01	5.80±0.01	6.2±0.01	6.52±0.01	6.59±0.01	6.49±0.01
OC	1.24±0.01	0.77±0.01	0.41±0.01	0.74±0.01	0.63±0.01	0.38±0.01
Avail.P $Mgkg^{-1}$	56±0.7	46±0.7	40±0.7	48±0.7	46±0.8	30±0.1
Na $Cmolkg^{-1}$	0.12±0.1	0.10±0.01	0.10± 0.01	0.10±0.01	0.10± 0.01	0.9 ±0.1
Ca “	2.4±0.8	1.8±0.06	1.8± 0.06	8.0±0.9	7.6±0.1	10±0.7
K “	0.09±0.01	0.09± 0.01	0.09± 0.01	0.21±0.01	0.11±0.01	0.1±0.01
Mg “	0.4±0.04	0.3±0.07	1.2±0.1	1.04±0.01	1.2±0.1	1.2± 0.1
Total N	0.056±0	0.07±0.01	0.07± 0.01	0.10±0.01	0.07±0.01	0.08±0.01
CEC	18±0.9	10±1.0	9±0.4	14±0.4	8±0.9	8±1.0

CEC = Cation exchange capacity, OC = Organic Carbon.

Table 2: Distribution of heavy metals ($Mgkg-^1$) studied soils (mean values)

	Heavy Metals				
Depth cm	Cu	Zn	Pb	Fe	Cd
0-20^a	2±0.2	2.04±0.01	38.2±0.04	0.09±0.01	2.0±0.2
20-40^a	1.8±0.001	1.69±0.01	29.3±0.04	0.07±0.001	1.82±0.01
40-60^a	0.91±0.004	1.2±0.004	17.4±0.001	0.045±0.001	0.51±0.04
0-20^x	0.06±0.001	0.22±0.01	1.32±0.01	0.008±0.01	0.021±0
20-40^x	0.002±0	0.16±0.004	1.21±0.01	0.006±0.01	0.008±0.01
40-60^x	0.001±0	0.04±0.01	0.27±0.01	0.004±0.001	0.002±0.01

a= automobile soil , x = control soil

The table showed highest concentration of heavy metals at the top (0-20cm) soil compared to subsoils (20 -40cm, 40 -60cm) in both soils. Heavy metal concentration at the top (0-20cm) of the automobile soil were 2±0.2(cu), 2.04±0.01(zn), 38.2±0.04(pd), 0.09±0.01(fe) and 2.0±0.2(cd) and 0.06±0.001(cu), 0.22±0.01(zn), 1.32±0.01(pb) 0.008±0.01(fe) and 0.021±0(cd) for the top horizons of the control. The heavy metal (cu, zn, fe, pb and cd) value observed at the top (0-20cm) horizons of the automobile soil exceeded the FAO (1976) and WHO (2003) maximum permissible limits of les than 0.2, 2, 5.4, 5 and 0.81 mg/l, respectively. Table 2 also showed higher concentration of heavy metals in the automobile soil compared to the control. This implies that repeated disposal of automobile waste may increase heavy metal load of the affected soil. Generally, the concentration of these heavy metals declined with depth in both soil. Higher concentration of heavy metals on top soils suggests that most arable plants may get these heavy metals by interception and mass flow while tree crops may suffer deficiencies due to inadequacy in the deeper horizons. The high concentration of heavy metals at the to (0-20cm) soil is line with the observations of Nyanagabobo and Hamya (1986) and Elbassam *et al.* (1979) who reported that top soils are better indicators of heavy metal burden than subsoils.

The contents of nitrate ($N0_3^-$), phosphate ($P0_4^-$) and sodium adsorption ratio (SAR) of the automobile and control soils are shown in table 3.

Table 3: Sodium Adsorption Ratio (SAR), Nitrate ($N0_3^-$) and Phosphate ($P0_4^-$) content of the soil

	Automobile soil			Control		
Parameter	0-20cm	20-40cm	40-60cm	0-20cm	20-40cm	40-60cm
SAR	0.083	0.068	0.54	0.108	0.102	0.100
NO_3^-	3.24	0.818	0.338	6.68	6.48	2.79
PO_4^-	0.026	0.018	0.011	0.008	0.005	0.003

Higher levels of $N0_3$ were observed in the control relative to the waste affected soil. However observed $N0_3^-$ and PO_4 values at all depths in the soil were lower than the FAO critical limits of 6.9 and 8.6 mg/l, respectively. Similarly, SAR values were within tolerance limits of 4 and 8 – 18 for sensitive fruits and field crops respectively (Stewart and Meek 1977) in both soils.

4.0 Conclusion:

Results from this study showed decreased levels of available cations in automobile waste affected soil. It also showed higher levels of heavy metals on top surface (0-20cm) of automobile waste affected and control soils. These heavy metals decrease with depth in both affected and control soils. The values of heavy metals in affected soils were higher than limits. These values suggest a high degree of bioavailability and toxicity. Therefore, there is need for further studies on the uptake and tolerance limits of these heavy metals by crops growing in automobile waste affected farmland.

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References

1. Adams, R.S., Ellis, E. (1960). Some Chemical and Physical changes in soil brought by unsaturation with natural gas. Journ. Soil Sci. Am. 24: 41 – 44.
2. Adenye, E.A., V.o. clued, L.O. Adehusuji., S.o. oleyiwola, (2002). Fertilizer use and management practices for crops in Nigeria. Federal Min. of Agric and Rural Dev. Abuja.
3. Atubi, A.O., P.C Onokala. (2006). The socio-economic effects of oil spillage on agriculture in Niger Delta. J. Envirn. Stud., 2:50-56.
4. Brady, N.C., R.R. Well (1999). The nature and properties of soils. 12th Edn., Prentice-Hall Inc., New Jersey, USA.
5. Chenq, B.T (1997): Soil organic matter as soil nutrient in the soil organic matter studies Venna, 1:21-30.
6. El-Bassam, M., Tietjen, C., Esser, J. (1979). Long-term studies on application of urban wastes on heavy metal inputs and crop ecology. Intern. Conf. Manag. and contr. Heavy metals in Environment. London J: 1-4.

7. Emteryd, O. (1989). Chemical and Physical analysis of inorganic nutrients in plant, soil, water and air. Swed. Univ. Agric. Sci. Dept site Res. Stencil, 10:8-23.

8. FAO. Food and Agricultural Organization (1976). Soil Survey Investigations for Irrigation Soil Bull; Rome.

9. Federal Department of Agricultural Land Resources (FDALR) (1985). The recconaisance soil survey of Anambra State soil report 1985. Federal Department of Agric and Lad Res. Lagos-Nigeria.

10. Foth, H.D., (1984). Fundamentals of soil science 7th Edn. John Wiley and Sons, New York, 435.

11. Gee, G.W. Or, P. (2002). Particle size analysis. In. Dane D.H., Topp G.C. (Eds). Methods of soil Analysis. Part 4: physical methods. Soil Sci. Am Book Series No5, ASA and SSSA, Madison, W1. p. 255-293.

12. Grossman, R, B., Riensah, T. G (2002). Bulk density and linear Extensibility. In: Dane, J.A., Topp. G.C (Eds). Methods of soil Analysis Part 4: physical methods. Soil Sci. Am Book Series No.5, ASA and SSSA, Madison, W1 p. 202-228.

13. He., Z.L. Zhang, M.L., Calvert, D.V., Stoffella., P.J., Yang, X.E., Yu, S. (2004). Transport of Heavy metals in surface runoff from vegetation and citrus fields. Soil. Ser. Soil. Am. J. 68:1662-1669.

14. Jackson, M.C. (1962). Soil Chemical Analysis 1st Edn. Prentice Hall. Eaglewood Cliffs, New Jersey, USA.

15. James, M.J., Wild A. (1975). Soils of West Africa Savanna. Tech. Commun. 55: 210-218.

16. Ngobiri, C.N., A.A. Ayuk., I.I Awuoso, (2007). Differential degradation of hydrocarbon fractions during bioremediation of crude of polluted sites in Niger Delta area. J. Chem. Soc. Nig., 32: 151-158.

17. Nyanagabobo, J.T., Hanya; J.W (1986). The decomposition of lend, cadmium, zinc and copper from motor traffic on Bracharia erimi and soil along a major Bombo road in kampula city. Int. Journ. Env. Studies 27:115-119.

18. Nwilo., C., O.T. Badajo, (2005). Management of oil spill along the Nigeria coastal areas. 1st Edn. Univ. of Lagos Pres, Nigeria.

19. Ojanuga A.G., Lekwa, G., Okusami., T.A. (1996) Distribution, classification and potentials of wetland soils of Nigeria. Monograph No2, Soil Sci. Soc. of Nig. 1-24.

20. Onweremadu., E.U., E.T. Eshiet., G.E. Osuji. (2007) Temporal Variability of selected heavy metals in automobile soils. Inc. J. Environ. Sci. Tech. (4)1:35-41.

21. SAS Institute (2001). SAS user's Guide Statistics Version 8.2.

22. Stewart, B.A., Meek, B.O. (1977) solube salt considerations with wastes in the tropic-systems. J.K. and D.L. Rimmers, Eds. Oxford. pp 40-55.

23. Thomas G.W. (1996). Soil PH and soil acidity. In methods of soil Analysis part 3. chemical methods. SSSA Book Series No.5. SSA and ASA, Madision, W.I. P. 475-490.

24. Walkley A., I.A. Black (1934). Determination of Organic carbon n soils. Soil Sci. 37: 27-38.

25. WHO (World Health Organization) (2003) Guidelines for drinking water quality. (3rd Edn.). WHO Gener, Rome.

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