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Heavy Metal Content and Physicochemical Properties of Municipal Solid Waste Dump Soils in Owerri Imo State

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ABSTRACT: *A study was carried out in Owerri municipal, the regional capital of Imo State to characterize the heavy metal content and physicochemical properties of waste dump sites for more than 15 years. Soil samples were collected from two different locations (Otamiri hilltop dumpsite and Otamiri Gully dumpsites) with control samples collected ten meters away from the dumpsites. The samples were collected at three depths (0-20cm, 20-40cm and 40-60cm) from each of the sites with three replicates making a total of 27 samples. Samples were taken for laboratory analyses for properties such as heavy metals (Ld, Fe, cu), chemical properties (organic carbon and Nitrogen pH CEC and EA) and physical properties (As, BD Ksat Particle size). Results show that the wastes dump sites showed variability in soil properties with depth the soils of the non-dump site at varying depth are classified as slightly acidic of high aggregate stability (76%). Comparison of the two sites indicated higher values in the soils properties for samples collected from gulley dumpsite than those collected from hill top. Heavy metal content were generally higher at deeper depths (40-60cm) and the hill top waste dump site had higher values compared to the gulley dump site only at shallow depth (0-40cm). Statistically, there was a significant ($p<0.05$) difference in heavy metal content, exchangeable cations and soil pH as well as and BD and AS between two sites Generally, the solid wastes increased the values for soil pH, CEC, heavy metals, aggregate stability, organic matter and total nitrogen when compared to adjacent uncontaminated soil. This is attributable to the decomposition and mineralization of the biodegradable solid wastes in the sites leading to release of minerals as well as basic cations into the soil which caused increases in soil physicochemical properties.*

Keywords: Municipal solid waste, Owerri metropolis, heavy metal, soil pH, aggregate stability

I. INTRODUCTION

Solid wastes other than hazardous and radioactive materials are often referred to as municipal solid waste (MSW). According to Nyangabobo and Hamya, 1980, municipal solid waste are useless unwanted materials discharged as a result of human activity which commonly may be solids, semi solids or liquids in containers thrown out of houses, commercials or industrial premises. They are commonly called trash or garbage and include wastes such as durable goods, e.g. tires, furniture; non durable goods, e.g. newspapers, plastics wrap; and other wastes, e.g. yard waste, food etc. this category waste generally refers to common household wastes, as well as office and retail wastes but excludes industrial, hazardous and construction wastes. MSW varies in composition which may be influenced by many factors such as culture affluence, location and its management depends on the characteristic of the solid waste including the gross composition, moisture contents, average particle size, chemical composition and density. The United States environmental protection Agency defined solid waste as “any useless, unwanted or discarded material with insufficient liquid content to be free flowing”. The non-free flowing or sticky nature of the solid waste gives rise to the accumulation of solid wastes on some habitable parts of the earth surface, places with accumulated solid wastes are called refuse dumps but a designed place for dumping of refuse is known as dump site. Soils intensively affected by human activities might present special features such as mixed horizons, foreign materials and thin topsoil (Civeira and Lavado, 2006). Normally these soils are poor in organic matter and fertility with reductions in their most important physical properties, such as structural stability and water retention. Eventually, these characteristics have detrimental effects on the soil by either affecting plant growth or submitting the particular environment to erosion processes (Vetterlein and Hiittl, 1999; Scharenbroch *et al* , 2005). Several waste dumpsites are located at various parts of Owerri municipal and some of these sites are indiscriminately located at stream valleys; open fields water canals and in abandoned borrow pits. Studies by Ezeigbo (1989), Egboka and Umah (1985) show that there is an unconfined water waste aquifer underlying most of Owerri and environs, upon which all the divers depend for their various water needs.

Many management techniques of waste disposal abound but the most favorite techniques used in Owerri municipal, probably because of its low cost, is the disposal on land or in holes made in the earth. Modifications of these have popularized in Landfills, pit latrines and deep-well injections among others. One critical issue in all the management techniques is how to keep the harmful effects of waste away from man. A major concern in waste dumping either above or below the earth’s surface is the safety of the ground water in the area. In areas of shallow water table and abundant rainfall the danger is greater since waste contaminated water reaches the aquifer easily. The resulting contamination can spread as far as the ground water can reach, sometimes through the entire aquifer. When an entire aquifer is polluted, the health of millions becomes endangered. Many designs have been employed in the construction of landfills with the main purpose being to fortify the walls, the bottoms of the pits and cover the top from contaminating the atmosphere. The bottom and the walls, however, are the contacts that conduct waste leachates into ground water (Allen, 2001). O’Swallwan (1995) observed that no matter the degree of structuring or engineering a landfill site receives, that only the natural local geology and hydrogeology of the site can guarantee its efficiency. Therefor the objective of his study is; to access the effect of soil waste dump on heavy metal content and compare it with those of adjacent land, and assess the effects of municipal solid waste on some selected physiochemical properties of the soil at varying depths.

II. MATERIALS AND METHODS SITE DESCRIPTION

This study was carried out in Owerri municipal, the regional capital of Imo State. It is located on latitude 5^0N to 6^0N and longitude 6^0 to 7^0 34^1E. It experiences two distinct climate seasons; namely dry seasons (October-March) and wet (April-September) seasons. A period of cold, dry, dusty winds known as "Harmattan" occurs from (December-February) annually. Owerri has a mean temperature range between 24^0 to 34^0C with a relative humidity of 70% in dry months and 90% in wet months with a projected 2010 population of 610,211 people (NPC, 2007) unevenly distributed over a total land area of 50,885km^2, its residents are mainly traders, civil servants, artisans and blue collar workers in small-scale industries (Bakeries, food processing, medical laboratories, printing etc), a well developed network of major roads, access roads and streets also exist in the town.

The waste dump sites had been under used for more than 15 years, with a surface area of approximately six hectares. Nearly ten tons of wastes are dumped here each day, waste components include metals, (beverages, cans, ferrous materials etc.), used papers, rags, plastics and organic materials (food remnants, decaying leaves, fruits and vegetables etc) car batteries etc.

III. SAMPLE COLLECTION

Soil samples were collected from two different locations of the dumpsites namely Otamiri hilltop dumpsite and Otamiri Gully dumpsites both situated at Owerri-Aba road in Owerri municipality. Control sample were also collected at 10 meters away from the dumpsites. The samples were collected at intervals of 0-20, 20-40, 40-60cm from each of the sites with three replicates making a total of 27 samples. Samples were taken for laboratory analyses after picking out bulky materials and sieving with 5mm mesh.

IV. DETERMINATION OF HEAVY METAL CONTENT

This was determined using the digestive method of A.O.A.C (1975). 1g of dried and homogenized soil obtained from each samples were weighed into a 100ml beaker and 10ml of nitric acid was added and the mixture was reacted. The heating continued, followed by the addition of 10ml of HNO_3, 3ml of $HClO_4$ at intervals. $HClO_4$ was added and the solution filtered and diluted with water to 50ml mark. Standard solution of Lead (Pb), Zinc (Zn) and Iron (Fe) were prepared. The concentrations of the heavy metals were determined by using atomic absorption spectrophotometer. Other properties analysed include particle size analysis determined using the hydrometer method of Bouyoucous (1951), aggregate stability was determined using the mean weight diameter method as described by Kemper and Chepil, (1965) and soil pH was measured electrometrically with a glass electrode pH meter in KCL using a soil: liquid suspension ratio of 1:2:5 as modified by Jones (2001). Total nitrogen was determined by the method of Bremmer and Malvaney (1992), while organic matter was determined using dichromate wet oxidation method (Walkley and Black, 1934) the organic carbon was calculated as: % organic carbon in soil

$$= \frac{(MeK_2Cr_2O_7 - MeFeSO_4) \times 0.003 \times 100 \times 1.33(F)}{\text{Gram of air dry soil}}$$

Where; F = Correction factor

Me = Normality of solution x 1ml of solution used.

Exchangeable cations were extracted using ammonium acetate method, potassium, sodium were determined on a flame photometer while calcium and magnesium were determined by titrating with EDTA (Chapman, 1965).

V. STATISTICAL ANALYSIS

Soil data were subjected to analysis of variance using 2×3×3 factorial in RCBD and significant treatment means were separated by F_{LSD} 0.05.

VI. RESULTS AND DISCUSSIONS

Analysis of soils collected from site ten meters away from the wastes dump sites (Table1) showed variability in soil properties with depth, while soil pH, O.M and total nitrogen values decreased with increase in depth, CEC, and some heavy metals values were inconsistent across the sampling depth. However, the soils of the non dump site at varying depth are classified as slightly acidic of high aggregate stability (76%).

Table 2 and 3 shows the physicochemical properties of soil collected from the solid waste dump sites at varying depths. These results indicate that solid wastes had a significant effect on all the soil properties, these effects varied significantly ($P < 0.05$) with depth. Generally, the solid wastes increased the values for soil pH, CEC, heavy metals, aggregate stability, organic matter and total nitrogen when compared to adjacent uncontaminated soil. This is attributable to the decomposition and mineralization of the biodegradable solid wastes in the sites leading to release of minerals as well as basic cations into the soil which caused increases in soil physicochemical properties.

Comparison of the two sites indicated higher values in the soils properties for samples collected from gulley dumpsite than those collected from hill top. Heavy metal content of the sampled soils (Figs.1, 2,and 3) indicated that the metals were generally higher at deeper depths (40-60cm) and the hill top waste dump site had higher values compared to the gulley dump site only at shallow depth (0-40cm). Statistically, there was a significant difference between two sites and increases in the values of soil properties analyzed for the valley dumpsite compared to that of hill top could be explained from differences in the topography of sites such that most materials are moved from the hill top to the valley by erosion.

VII. SUMMARY AND CONCLUSION

The concentration of heavy metals, total nitrogen, organic matter, soil pH, and cation exchange capacity were observed to be higher in soils at dumpsite compared to those obtained in adjacent soils 10 meters away. This implies that the municipal solid waste dumpsite have a significant impact on the environment. From this study, the municipal solid waste impacted or decreased the soil pH, OM and CEC down the depth, while heavy metals deposit increased down the depth. Also, the soil properties studied had higher values in the soils collected from valley dump site than those collected from hill top.

Table1: Properties of Soil Collected From An Uncontaminated Site At Different Depths

Soil Parameters	Soil Depths		
	0-20	**20-40**	**40-60**
Particle Size Distribution			
% Sand	80.0	71.40	68.00
% Silt	2.90	3.60	4.20
% Clay	17.10	25.00	27.80
pH (H_2O)	6.34	6.26	6.14
Organic Matter Content (%)	1.24	0.90	0.78
Total Nitrogen (%)	0.098	0.058	0.47
Cation exchange Capacity ($Cmol.kg^{-1}$)	3.86	3.72	3.96
Heavy Metals			
Zinc	0.03	0.02	0.02
Iron	0.36	0.20	1.00
Lead	0.04	0.07	0.02
Aggregate stability (%MWD)	80.40	53.10	73.70

Table 2: Effect of Solid Waste on Some Properties of Soil Collected at the Valley Dumpsite at varying depths

Soil Parameters	Soil Depths			L.S.D(0.05)
	0-20	**20-40**	**40-60**	
Particle Size Distribution				
% Sand	75.40	72.50	70.02	-
% Silt	3.30	5.60	6.50	-
% Clay	21.30	21.90	23.48	-
pH (H_2O)	7.04	6.58	6.39	0.461
Organic Matter Content (%)	2.26	1.47	0.98	0.180
Total Nitrogen (%)	0.23	0.17	0.09	0.039
Cation exchange Capacity ($Cmol.kg^{-1}$)	5.05	4.64	4.88	0.461
Heavy Metals				
Zinc	0.03	0.12	0.09	0.038
Iron	0.30	1.80	0.70	0.278
Lead	0.22	0.23	1.12	0.091
Aggregate stability (%MWD)	85.5	7.3	82.2	7.968

Table 3: Effect of Municipal Solid Waste on some Properties of Soil collected at the Hilltop Dumpsite.

Soil Parameters	Soil Depths			L.S.D(0.05)
	0-20	**20-40**	**40-60**	
Particle Size Distribution				
% Sand	74.8	69.4	64.2	-
% Silt	2.6	2.8	4.6	-
% Clay	22.6	27.8	31.2	-
pH (H_2O)	7.37	7.22	6.80	0.46
Organic Matter Content (%)	1.84	1.20	1.08	0.18
Total Nitrogen (%)	0.19	0.09	0.06	0.04
Cation exchange Capacity ($Cmol.kg^{-1}$)	4.12	3.88	3.79	0.46
Heavy Metals				
Zinc	0.01	0.26	0.40	0.04
Iron	1.30	0.30	1.20	0.28
Lead	0.46	0.32	0.93	0.10
Aggregate stability (%MWD)	40	25.2	35.9	7.97

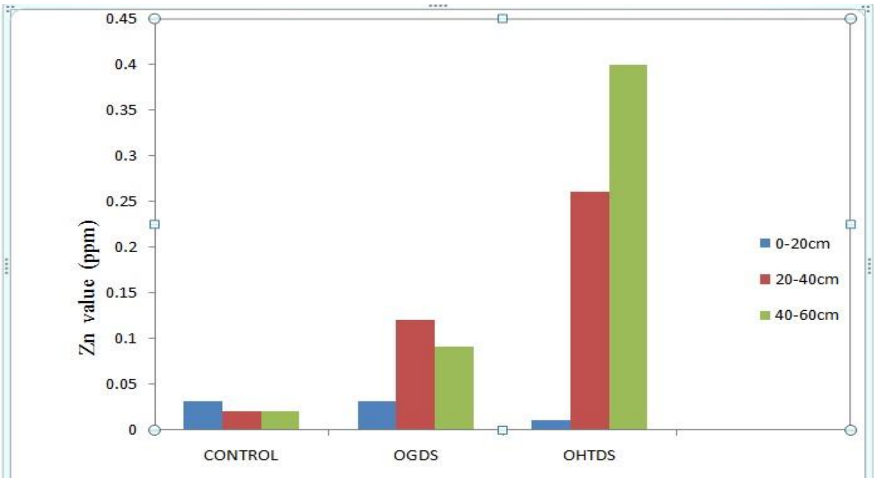

Fig. 1 : EFFECT OF MUNICIPAL SOLID WASTE ON AVAILABLE ZINC (PPM) AT VARIOUS DEPTH.

OGDS – OTAMIRI GULLY DUMP SITE

OHTDS – OTAMIRI HILL TOP DUMP SITE

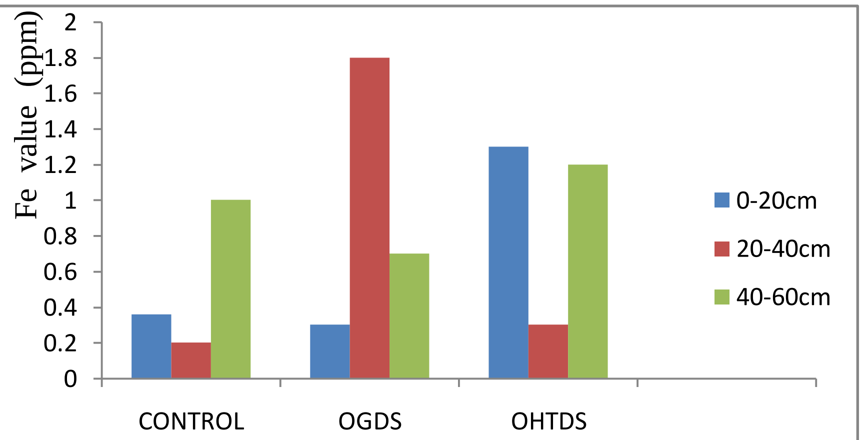

Fig. 2: EFFECT OF MUNICIPAL SOLID WASTE ON AVAILABLE IRON (ppm) AT VARIOUS DEPTHS

OGDS – OTAMIRI GULLY DUMP SITE
OHTDS – OTAMIRI HILL TOP DUMP SITE

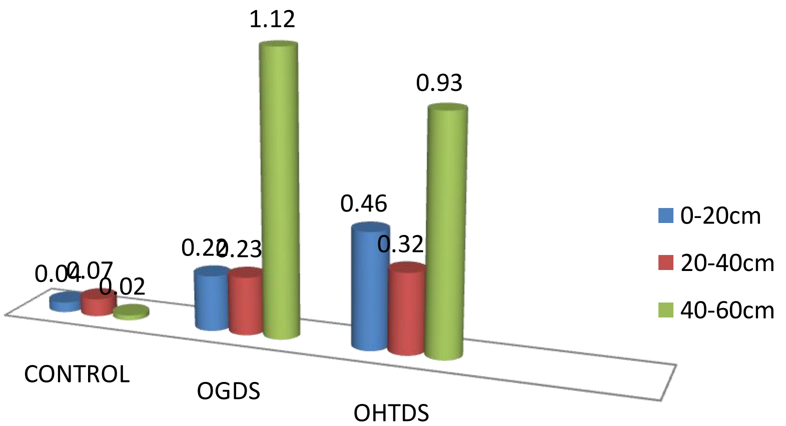

Fig.3 : EFFECT OF MUNICIPAL SOLID WASTE ON LEAD (Ppm) AT VARIOUS DEPTHS

OGDS – OTAMIRI GULLY DUMP SITE
OHTDS – OTAMIRI HILL TOP DUMP SITE

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