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Comparative Study of Heavy Metals Accumulation in Soils of Solid Waste Dumpsites and Automobile Workshops in Uyo

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Abstract: **This study was undertaken to compare the effects of heavy metals accumulation on soils from Solid Waste Dumpsites (SWD) and Automobile Workshops (AMW) within Uyo metropolis. Flame atomic absorption spectrometry was used to test the concentrations of mercury, Hg; zinc, Zn; copper, Cu; cadmium, Cd; lead, Pb, nickel, Ni; aluminium, Al; Arsenic, As; Manganese, Mn and Chromium, Cr in soils, while electrometric method was used to determine soil pH. Three representative samples were collected for each depth range (0-1.5m, 1.5-3m and 3-4.5m) from both sites. The mean concentration of heavy metals from AMW occurred in the order Zn>Cd>Mn>Pb>Ni>Fe>Cu>Al>Cr>As while for the SWD, Fe>Cd>Cu>Zn>Mn>Pb>As>Al>Ni>Cr. The mean concentrations of the major contaminants when compared to WHO standards (WHO: AMW, SWD) are Cd (0.0030mg/l: 0.1111mg, 0.2748mg/l), Pb (0.01mg/l: 0.0824mg/l, 0.1003mg/l) and Zn (0.1mg/l: 0.151mg/l, 0.1409mg/l). There were trace amounts of Cr, Cu, Mn, Ni and Al at both sites whereas, excess As occurred at the SWD. AMW had average pH level of 4.18 and SWD, 7.36.**

Keywords: **Chemical and physical properties of soil, Heavy metals, environmental health, Solid wastes, Automobile wastes.**

I. INTRODUCTION

In its natural state, soil contains an optimum amount of heavy metals to support lives. Due to man's quest for knowledge and industrialization, soils are exposed to contamination. Soils may be contaminated by the accumulations of heavy metals beyond the natural threshold through anthropogenic activities [1]. These activities involve the dumping of waste from point sources; from industries and waste treatment plants or from non-point sources; agricultural waste, spillage from petrochemical industries and surface runoff. These waste are burdened with heavy metals such as, mercury, Hg; zinc, Zn; copper, Cu; cadmium, Cd; lead, Pb and nickel, Ni [2]. Heavy metals are elements with atomic densities greater than $5.0 g/cm^3$ and is toxic at low concentrations [3]. He further stated the usefulness of heavy metals in manufacturing industries. Cr is used in metal alloys and pigments for paints, cement and paper; in small amounts Ni can be used in steel; Cd compounds are used in rechargeable Ni-Cd batteries and as stabilizers in polyvinyl chloride; Zn is used in paint and wood preservatives; Pd in insulating cables and plumbing

Within Uyo metropolis, leachates from Solid Waste Dumpsites (SWD) and Automobile Workshops (AMW) constitute a major source of heavy metal pollution. Due to population explosion and urbanization, a high degree of solid wastes generation is inevitable. Waste at these sites are treated or reduced by burning and natural digestion. No engineered treatment system has been in effect. By-products of aerobic digestion from these dumpsites release heavy metals into the soil, thus, affecting its physical and chemical properties [4], contaminating ground-water and air quality. These are harmful to soil organisms, plants, animals and humans. These metals are mostly non-biodegradable and can bio-accumulate [5]. In excess concentrations, Zn has an adverse effect on soil micro-organisms, Cr can lead to allergic dermatitis in humans, high dose of Cu can cause kidney damage, Cd causes bone disease and Pd affects the gastrointestinal tract.

[6] reported high values of Zn, Pb and Cr in the soils within chemical and metallurgical industrial areas of Kumasi, Ghana. [7] opined to this with relative to municipal solid waste in China. With Ain-El-Hamman, Algeria as case study, [8] also agreed that municipal solid waste discharges excess amount of heavy metal to the soil but it also enhances its organic

matter content. For Perungudi, India, [9] reported mg/kg level of heavy metals in municipal solid waste and µg/L in leachates from the same sampling area. They attributed it to the pH, flowrate and complexing agent. Mechanic workshops within Akure metropolis of Nigeria are anthropogenic sources with high Fe and Zn concentrations [10].

With the rapid development strides Uyo is experiencing, there is an economic boom. Therefore, land and agricultural products are becoming less affordable. Residents now resort to establishing ventures like eateries, relaxation centres and residential quarters within the numerous AMW (mechanic village). Boreholes are sited haphazardly and agricultural activities on dumpsites are now prevalent. The negative effects imposed by heavy metals on the soil will have a damaging effect on the environment. The objective of this study is to compare the effects of heavy metals on the soils within the AMW and SWD. The World Health Organization (WHO) standard is used to measure how healthy these sites are.

II. MATERIALS AND METHOD

A. Study Area

This study was carried out in Uyo, the capital of Akwa Ibom state. Samples were collected at the SWD along Uyo village road and at the auto-mechanic village in Abak road, Uyo. The study area is located between latitudes $4^0 32^0$ and $5^0 33^0$ North and longitudes $7^0 25^0$ and $8^0 25^0$ East. It is 1m above mean sea level and located within the lowland coastal plains of Nigeria with average annual rainfall and temperature of 2466.6mm and 26.4^0c respectively. Rainfall is more concentrated between the months of April and October.

B. Sample Collection

Soil samples from both sites were randomly collected with the use of hand auger at 0-1.5m, 1.5-3m and 3-4.5m depths. Three samples were collected for each depth. It was ensured that the hand auger maintained a vertical position while in use. Samples were stored in sample bags, labelled immediately and taken to the Akwa Ibom State Science and Technology Laboratory, Uyo.

C. Sample Preparation and Laboratory Tests

Samples collected were thoroughly mixed in a clean stainless steel pan to obtain a representative sample. These samples were then crushed and sieved through a 2mm sieve to obtain fine particles. Soil samples were then preserved using refrigerator in order to prevent the loss of heavy metals. Flame Atomic Absorption Spectrometry (FAAS) was used to analyze the following; Cu, Pb, Zn, Ni, Hg, Cr, Manganese (Mn), Cd, Arsenic (As) and Aluminium (Al) while the electrometric method was used in determining the pH values of soil samples.

FAAS was carried out by the method found in [11] and [12] while the pH level determination followed the methodology of Wilbur and Anderson (1948). The electrometric method is readily preferred because it factors in the inhibitory effects of indicators.

III. RESULTS AND DISCUSSION

A. Description of Soil Properties

Results from laboratory analysis of the samples collected at different depths from AMW and SWD are presented in Tables 1 and 2. It is observed that, the presence of Zn and Fe is more prominent at all depths at AMW and SWD respectively. This is followed closely by Cd at both sites.

Table 1: Laboratory Analysis Results of Heavy Metal Concentrations for AMW

		Concentrations (mg/l) at different depths		
S/N	**Parameters**	**0-1.5m**	**1.5-3m**	**3-4.5m**
1	Cd	0.1111	0.1000	0.1173
2	Cr	0.0016	0.0015	0.0019
3	Pb	0.0824	0.0826	0.0799
4	Zn	0.1510	0.1533	0.1510
5	Cu	0.0232	0.0234	0.0233
6	Fe	0.0523	0.0500	0.0523
7	Mn	0.1034	0.1027	0.1034
8	Ni	0.0712	0.0700	0.0715
9	As	< 0.0001	< 0.0001	< 0.0001
10	Al	0.0019	0.0016	0.0020

At a depth of 3-4.5m, the soil tends to host more concentrations of these heavy metals. It could be attributed to the type of waste, a high flowrate and more soil interstices at shallow depths. Therefore, the middle strata serves as a transition zone where the waste moves to accumulate at greater depths.

Table 2: Laboratory Analysis Results of Heavy Metal Concentration for SWD

		Concentrations (mg/l) at different depths		
S/N	**Parameters**	**0-1.5m**	**1.5-3m**	**3-4.5m**
1	Cd	0.2891	0.2625	0.2845
2	Cr	0.0064	0.0050	0.0100
3	Pb	0.0998	0.0500	0.1173
4	Zn	0.1362	0.1280	0.1493
5	Cu	0.1781	0.1645	0.1620
6	Fe	0.3101	0.3000	0.3273
7	Mn	0.1024	0.1163	0.1117
8	Ni	0.0054	0.0118	0.0125
9	As	0.0602	0.0634	0.0670
10	Al	0.0381	0.0365	0.0284

The mean concentrations of these heavy metals from both sites is presented in Figure 1. They are compared to the standards stipulated by WHO. It is noted in Figure 1 that, the mean concentration of heavy metals from AMW occur in the order Zn>Cd>Mn>Pb>Ni>Fe>Cu>Al>Cr>As. This agrees with the work of [6]. At the AMW, the mean concentration of Cd, Pd, Zn and Ni was 0.1111mg/l, 0.0824mg/l, 0.1510mg/l and 0.0712mg/l respectively. These values exceed WHO thresholds, therefore, this site is polluted by these metals.

It is further noted in Figure 1 that, the mean concentration of heavy metals from SWD occur in the order Fe>Cd>Cu>Zn>Mn>Pb>As>Al>Ni>Cr. With mean concentrations of 0.2748mg/l, 0.1003mg/l, 0.1409mg/l and 0.0672mg/l for Cd, Pd, Zn and As respectively at the SWD, these metals exceed the WHO standards. While the mean concentration of Fe at SWD equates that of WHO, there are trace amounts of Cr, Cu, Mn and Al at both sites. Mean concentration of Cr was 1.6µg/l and 7.9µg/l at the AMW and SWD respectively.

Cd is a by-product of Pb and Zn refining. It might also be introduced into the soil via automobile rechargeable batteries and corrosion resistance coatings of automobile parts at the AMW. Zn is deposited into the soil by disposing zinc contaminated sludge and waste burning at the SWD. Soldering rods, bearings and car batteries used in AMW are notorious for their Pb contents. Excess Pb at the AMW can also be attributed to Pb-containing premium motor spirit. This study supports the results of [14] and [13] that, Pb is a major contaminant at AMW and SWD.

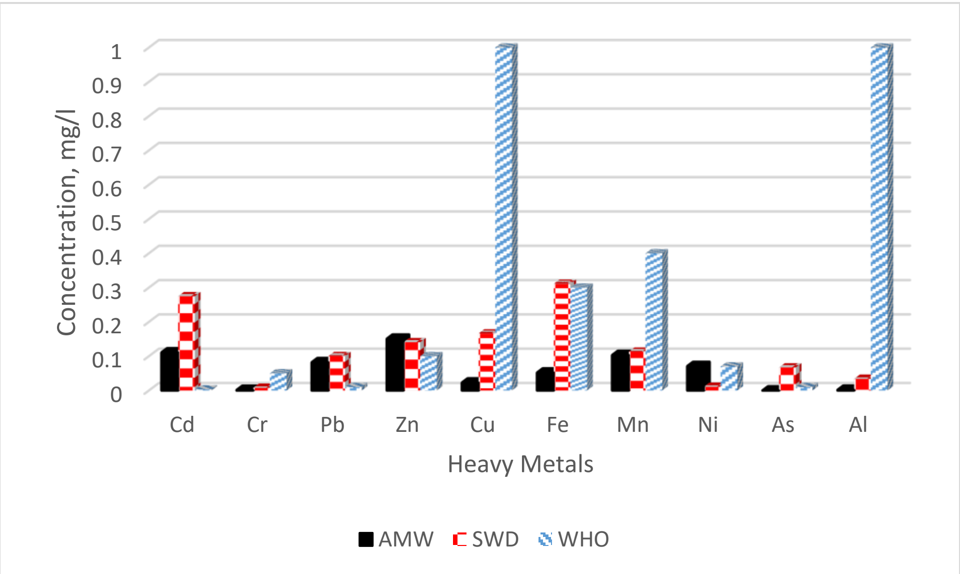

Figure 1: Comparing the Mean Concentrations of Heavy Metals at AMW and SWD with WHO Standard.

In Table 3, it could be seen that, the average pH level of soils from AMW and SWD were 4.18 (acidic) and 7.36 (neutral-alkaline) respectively. High soil pH encourages metal retention and lower solubility of heavy metals in soils [15]. Low pH values may not support plant growth.

Table 3: pH Values for the AMW and SWD

	pH Values	
Sample Depth	**AMW**	**SWD**
0-1.5m	4.00	7.58
1.5-3m	4.25	7.50
3-4.5m	4.30	7.00

IV. CONCLUSION

Results from this study indicate that, waste from AMW and SWD contaminates the soil by depositing excess amounts of Cd, Pd and Zn when compared to WHO standards. As and Ni were in trace amounts at the AMW and SWD respectively. These heavy metals pose serious hazards to environmental health.

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