EFFECT OF SOLID WASTE GENERATION ON SOIL QUALITY DYNAMICS

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**ABSTRACT**

*The consequences of solid waste on soil quality were carried out by collecting Soil samples taken in triplicate from different soil layers (0-15cm, 15-30cm, and 30-45cm) and analyzed to determine the effect of solid waste on the physical and chemical parameters of the soil surrounding the research area, to ascertain the level of heavy metals in the soil and to compare values with the National Environmental Standards and Regulation Enforcement Agency and the World Health Organization recommended standards. The elemental composition of selected heavy metals from the dumpsite was done using an atomic absorption spectrophotometer. The mean values of soil pH ranged from 5.50 - 4.72 in the dumpsite and 7.51 -6.99 in the control site in all three soil depths (0-15, 15-30, 30-45em) this indicates that the soil at the dump site was moderately acidic at 5.50 (0-15cm soil depth) and very strongly acidic at 4.72 (30-45cm soil depth), while that of the control was almost neutral at 6.77 (0-15 soil depth) and slightly alkaline at 7.51 (30-45 soil depth). The organic matter level of the soil varied significantly (P=0.05), with the topsoil (0-15cm) having the highest concentration. The topsoil organic matter at the dumpsite soil was 14.72%, compared to 17.55% at the control site. This study found that the concentration of heavy metals such as cadmium, cobalt, copper, lead, manganese, nickel, and zinc in the dumpsite was substantially greater (p 0.05) than in the control site.*

Keywords: Heavy Metal, Health Hazards, Soil Quality, Solid Waste, Management, Pollution.

**INTRODUCTION**

In developing nations, the challenges related to managing solid waste are more severe compared to developed countries, as outlined by Zerbock in 2003. These challenges encompass limited financial resources, inadequate planning, a lack of transportation for waste disposal, insufficient waste management infrastructure, and improper waste collection techniques (Zerbock, 2003). The waste management issue is further complicated by rapid population growth and urbanization, resulting in a significant increase in the volume of generated waste (Zerbock, 2003). Waste management also involves strategies for waste prevention and reduction and requires the involvement of various stakeholders (Aziegbe, 2007). Improper handling and disposal of solid waste in developing nations pose significant threats, often overlooked, that contribute to high mortality rates. The improper management of solid waste jeopardizes the well-being of both humans and ecosystems. Nevertheless, municipal solid waste can be repurposed as fertilizer and natural manure for agricultural purposes (Zerbock, 2003). Responsible waste management enhances environmental quality, supports sustainable use of solid waste resources, and promotes economic production. It encompasses a range of activities such as waste collection, transportation, processing, recycling, disposal, on-site handling, storage, treatment, and waste monitoring (Zerbock, 2003). Waste management challenges are a pressing issue in African developing countries, especially Nigeria. These issues encompass a range of concerns, including threats to human health, as well as pollution of the air, water, and land, among other issues. It's essential to assess the primary obstacles hindering effective solid waste management, particularly in an emerging economy like Nigeria (Abila and Kantola 2013). The area of interest was the hostel area, which is located at Michael Okpara University of Agriculture, Umudike, Umuahia, the capital of Abia State. The Umuahia-Ikot Ekpene Federal Road, which connects the state capitals of Abia, Akwa-Ibom, and Cross River, is the primary road going to the hostel., Akwa-Ibom, and Cross River. Due to the growing population of students, several hostels have emerged around the area. This population growth has led to indiscriminate waste disposal in front of the hostels. Consequently, the study area is of particular interest to the researcher, as it will enable the collection of soil specimens taken from the landfill and thorough characterization of solid waste. This will help determine the effect of disposal of solid waste on soil quality. Challenges of solid waste management have appeared as a significant developmental hurdle, especially in the vicinity of hostels in Umudike Local Government Area of Abia State. Addressing this challenge should not be the sole responsibility of government authorities or waste management agencies; it also calls for the active involvement of corporate entities and individuals in finding a sustainable solution. This is because poor waste management has the potential to result in the loss of valuable human resources and subsequently impact the productivity of the local community. The purpose of this study is to investigate the impact of solid waste on soil quality in Hope's Villa Hostel, located in Umudike, Abia State. The study aims to achieve the following objectives: First, analyze the physical and chemical properties of the soil surrounding the waste dumpsite in Hope's Villa Hostel, Umudike. Second, examine the composition of the waste dumped in the vicinity of Hope's Villa Hostel, Umudike. Lastly, compare the findings with established standards to gauge the extent of the issue.

**MATERIAL AND METHOD**

The project was carried out at the Hostel area of the Michael Okpara University of Agriculture, Umudike in Abia State (Fig 1), the Hope’s villa hostel was used as a case study. The Umuahia-Ikot Ekpene Federal Road, which connects the capital cities of Abia, Akwa-Ibom, and Cross River States, is the primary access route to the hostel.



**Fig 1. Geographical Map of Nigeria Showing the Study Area**

**Source: GIS LAB Department of Geography, University of Nigeria Nsukka**

**Collection of Soil Samples**

Soil samples were gathered around Hope's Villa Hostel in Umudike from three distinct locations of the solid waste dump located in front of the hostel. These samples were obtained randomly and separately. Soil samples were collected for the experiment using soil auger at three different depths: 0-15cm, 15-30cm, and 30-45cm, at each sampling site within the solid waste dump. To serve as a control site, an uncontaminated location situated approximately 100 meters away from Hope's Villa Hostel dumpsite was selected. The samples were combined to create composite samples, carefully labelled, sealed in polypropylene bags, and then brought to the lab for further analysis.

**Determination of Soil Characteristics of the Samples**

Samples of soil were taken from the trash dump site at three distinct depths: 0–15 cm, 15–30 cm, and 30–45 cm. Samples collected were sealed in airtight polythene bags to maintain their moisture and volatile matter content. Upon arrival at the laboratory, the soil samples were air-dried, and any lumps in the air-dried samples were subsequently crushed using a porcelain mortar. Standard methods were employed to sieve the soil samples through a 2mm sieve. The soil samples were later subjected to analysis for parameters including electrical conductivity (EC), pH, and organic matter (OM).

**Determination of pH of the soil samples**

Using an electronic JENWAY glass electrode pH meter (Model 3510), the pH of the soil was determined. A beaker was filled with 100ml of water, and 20 grams of weighed soil samples were added. The mixture was let to stand for 30 minutes while stirring. The electrode was placed into the soil-water suspension in the beaker, and the pH value was ascertained using the pH meter's automated display.

**Determination of Soil Electrical Conductivity (EC)**

Soil-to-water (1:5) suspension was created by adding 50ml of deionized water to a beaker containing 10g of air-dried soil. It was agitated for one hour at a speed of fifteen revolutions per minute (rpm). To determine the cell constant, the conductivity meter was calibrated using a KCl reference solution and the soil electric conductivity was done using standard procedures.

**Determination of Soil Organic matter**

**This was done** using an auto-titrator, an expanding scale pH/mV meter, and standard procedures..

**Sample Preparation and Chemical Analysis**

The American Public Health Association's (Bakirdere *et al*., 2015) standard was followed in doing this.

Percentage of organic carbon$=\frac{(B-T)×0.5×0.003×1.33}{weight of samle}×\frac{100}{1}$…………………equation (1)

Where;

B- stands for blank concentration value,

T- for sample concentration value,

F- for correction factor = 1.33, and 0.5N for ferrous ammonium sulfate concentration. The sample weight (0.5g) is the weight of the soil that has been air-dried.

Percentage of clay= corrected hydrometer reading at

$=\frac{5hrs,48mins}{weight of soil taken}×100$ … Equation (2)

Percentage of silt= concentrated hydrometer reading at

 $=\frac{40secs}{weight of soil taken}×100 $… Equation (3)

Percentage of sand = 100% - Percentage of silt - Percentage of clay ………….……………………………..equation (4)

**Determination of Heavy Metal Concentration in Soil**

Soil samples (2.0g) were weighed, and 50 ml of nitric acid (HNO3) and 50 ml of perchloric acid (HClO4) were included in each soil sample. These samples were then digested at 200°C for 1 hour using a digestion chamber. After digestion, the soil samples were left to cool at room temperature. After cooling, 50ml of distilled was included in each of the soil samples, and the soil sample was swirled, ensuring thorough mixing of the digested extract. Whatman No. 1 filter paper was used to filter the mixture into a 100ml volumetric flask to obtain both the extract and residue.

The concentration of the following elements; cadmium (Cd), lead (Pb), copper (Cu), iron (Fe), and zinc (Zn) in the digested samples was determined using an Atomic Absorption Spectrophotometer.

**Assessment of Heavy Metal Contamination**

**Determination of pollution load index**

In the assessment of heavy metal contamination in the soils at the various sampling site at the waste dumpsite, the geoaccumulation Index (I*geo*) Equation 5 was used. (Muller, 1969) This method of assessment compares the heavy metal concentrations at the dumpsite relative to the background levels in the soil

I*geo* =log2 $\frac{(C\_{n})}{(1.5B\_{n})}$……………………………………………….( Equation 5)

where: I geo the geoaccumulation index; Cn is the heavy metal concentration in the underlying waste soil; Bn is the reference value of the heavy metal; and 1.5 is the reference matrix correction factor. Classification of geoaccumulation index of heavy metal was adapted from Lu et al. (2009) which is given by: 0< uncontaminated (class 0); 0-1= uncontaminated to moderately contaminated (class 1); 1-2 = moderately contaminated (class 2); 2-3 = moderately to strongly contaminated (class 3); 3-4 = strongly contaminated (class 4); 4-5 = strongly to extremely contaminated (class 5); >5 = extremely contaminated (class 6)

**Contamination Factor Cfi and Potential Ecological Risk (PERI)**

The ecological risk of a given heavy metal is computed using the $E\_{r}^{i}$ and the element’s reference value. It is obtained as follows:

$E\_{r}^{i}$= $T\_{r}^{i}$ x$C\_{r}^{i}$……………………………………………..(Equation 6)

$T \_{r}^{i}$ Represents the toxic response factor and $C\_{r}^{i}$ Contamination factor.

The $T\_{r}^{i}$ of Pb, Cd, Zn, Cu, Mn, Co and Ni is 5, 30, 1, 5, 1,5, and 6, respectively (Chai, 2017) and Suresh et al.., (2012)

The $E\_{r}^{i}$ values, according to Hakanson [32], “are classifed into five degrees of ecological risk. These are $E\_{r}^{i}$ < 40, low potential, ecological risk; $E\_{r}^{i}$ 40 < 80, moderate potential ecological risk; $E\_{r}^{i}$ 80 < 160, considerable potential ecological risk;$ E\_{r}^{i}$ 160 < 320, high potential ecological risk; and $E\_{r}^{i}$ ≥ 320, very high ecological risk.

Contamination factor $C\_{r}^{i}$ is obtained from:

Cf = $\frac{C\_{heavy metal}}{C\_{Backgroud value}}$ ………………………………………(Equation 7)

Where C heavy metal and C background represent the concentration and background concentration of the heavy metal, respectively. Cf are characterized as follows (Hakanson,1980): Cf < 1, low contamination factor indicating low contamination of the soil with the examined substance; 1$\leq $ Cf< 3, moderate contamination factor, 3$\leq $ Cf< 6, Considerable contamination factor, 6≥Cf very high contamination factor.

**Statistical Analysis**

SPSS 17 for Windows (SPSS Inc., USA) was used for all statistical analyses. To compare mean differences among different sampling points, one-way ANOVA was used. Pearson's correlation coefficients were calculated for heavy metal components in dumpsite soil. P=0.05 (two-tailed) was chosen as the criterion of significance.

**Results and Discussion**

The soil physicochemical properties such as pH, electrical conductivity (EC), organic matter concentration, and particle size. Heavy metals like zinc (Zn), cadmium (Cd), iron (Fe), lead (Pb), and copper (Cu), are known to influence metal interactions and dynamics in the soil matrix.

**Table 1: The physicochemical properties of different soil sample depths in Dumpsite**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Soil depth (cm) | Soil pH | O.M (%) | E.C (ds/m) | Sandy | Silt | Clay |
| Dumpsite  |  |  |  |  |  |  |
| 0-15 | 5.50 | 14.72 | 0.162 | 70.80 | 10.00 | 10.21 |
| 15-30 | 4.92 | 10.05 | 0.170 | 70.61 | 10.43 | 10.34 |
| 30-45 | 4.72 | 7.10 | 0.192 | 60.89 | 10.62 | 10.51 |
| Control site  |  |  |  |  |  |  |
| 0-15 | 6.99 | 17.53 | 0.108 | 70.12 | 10.76 | 10.88 |
| 15-30 | 7.20 | 2.60 | 0.240 | 60.84 | 10.71 | 10.59 |
| 30-45 | 7.51 | 0.48 | 0.372 | 60.50 | 10.30 | 10.98 |

**Source: Author’s Fieldwork data 2023**

According to the data in Table 1, the average soil pH levels varied between 4.72 and 5.50 in the dumpsite and between 6.99 and 7.51 in the control site across all three soil depths (0-15 cm, 15-30cm and 30-45cm). This result implies a moderately acidic content of 5.50 (0-15cm depth) and very strongly acidic at 4.72 (30-45cm depth) soil in the dumpsite, whereas the control site had a neutral pH of 6.77 (0-15cm depth) and slightly alkaline pH at 7.51 (30-45cm depth). pH in natural soil is influenced by the mineral composition of the parent material and the weathering processes it undergoes.

The organic matter (OM) The soil content varied significantly (P=0.05) with higher content observed in topsoil dept of (0-15cm). The topsoil in the dumpsite had 14.72% organic matter, whereas the control site had 17.55%. The electrical conductivity of both control and dumpsite soils ranged from 0.162 to 0.192 to 0.108 and 0.372, indicating that the dumpsite soil had lower electrical conductivity compared to the control site.

Table 1 shows sandy soil mean value both in dumpsite soil and control site, there was no significant difference in their particle size distribution. The clay content ranged from 10.51 to 10.21 in the dumpsite and 10.98 to 10.88 in the control site, while the silt content ranged from 10.62 to 10.00 in the dumpsite and 10.30 to 10.76 in the control soil. The sandy soil observed in the study area ranged from 60.89 to 70.80 in the dumpsite and from 60.50 to 70.12 in the control site. Notably, the silt content in the control site soil was higher, and it increased with depth. Particle size distribution categorizes the soils as sandy or loamy and falls under a textural classification.

**Table 2: The mean concentrations of heavy metals in the dumpsite and the control site (mgkg-1)**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  Soil Depth | Cadmium | Cobalt | Copper | Lead | Manganese | Nickel | Zinc |
| 0-15 | 2.31$\pm $0.27 | 1.07$\pm $0.84 | 3.24$\pm $0.92 | 81.50$\pm $17.67 | 3.72$\pm $1.58 | 1.63$\pm $0.41 | 34.10$\pm $18.22 |
| 15-30 | 2.16$\pm $0.94 | 0.35$\pm $0.03 | 2.65$\pm $0.28 | 62.00$\pm 16.97$ | 3.25$\pm $0.21 | 1.81$\pm $0.43 | 28.49$\pm $18.22 |
| 30-45 | 1.23$\pm $0.04 | 0.04$\pm $0.00 | 1.57$\pm $0.03 | 26.29$\pm $4.65 | 2.80$\pm $0.14 | 1.07$\pm $0.03 | 17.80$\pm $14.70 |
|  |
| 0-15 | 1.01$\pm $0.09 | 0.005$\pm $0.007 | 1.51$\pm $0.71 | 0.13$\pm $0.06 | 2.65$\pm $1.25 | 0.59$\pm $0.91 | 15.27$\pm $8.54 |
| 15-30 | 0.00$\pm $0.00 | 0.03$\pm $0.02 | 0.50$\pm $0.14 | 5.35$\pm $1.12 | 1.11$\pm $0.31 | 0.00$\pm $0.00 | 22.90$\pm $12.02 |
| 30-45 | 0.00$\pm $0.00 | 0.03$\pm $0.02 | 0.25$\pm $0.12 | 2.67$\pm $1.40 | 0.54$\pm $0.36 | 0.00$\pm 0.00$ | 5.70$\pm 6.38$ |

**Source: Field work data from lab analysis 2023**

The data presented in Table 2 from the analysis of heavy metals concentration in soil samples show that the average cobalt concentration in the soil can be attributed to the improper disposal of cobalt-containing waste, such as condemned oil, in the vicinity of Hope's Villa Hostel Waste Dumpsite in Umudike. Elevated cobalt (Co) levels in soil can harm human health by increasing the risk of cancer and causing symptoms such as vomiting, nausea, visual problems, heart problems, and thyroid damage (Lenntech Water Treatment, 2009).

Copper (Cu) concentrations in soil vary from 2 to 100 mg/kg (Ebong *et al.,* 2008), but in this investigation, the measured concentrations varied from 1.62 to 2.84 mg/kg in the dumpsite and 0.26 to 1.51 mg/kg in the control site, as shown in Table 2. Notably, according to Kabata-Pendias (2013), these values are within the threshold range for soil (50-250 mg/kg). Copper is an essential metal that is involved in the creation of molecules such as haemoglobin, elastin, and collagen, as well as iron and catecholamine metabolism (Bartnikas, 2012).

In their study on the long-term impacts of municipal waste disposal on soil characteristics and agricultural production in Abakiliki, a city in southeastern Nigeria, Anikwe and Nwobodo (2011) found significant levels of heavy metals such as lead (Pb), iron (Fe), copper (Cu), and zinc (Zn). Because of the concentration of human activities associated with urban living, urban soils, such as those found in dumpsites, frequently receive higher amounts of contamination (Bartnikas, 2012). Heavy metal concentrations in soil are regulated by biological and geochemical processes, as well as human activities such as agriculture, industry, and waste disposal (Zauyah *et al.,* 2004).

The results from this study can only be effectively discussed when compared to control values and established standards from other sources.

**Table 3: Heavy metal concentrations at the dumpsite and the control site comparing FEPA and WHO standards**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Heavy Metal | Dumpsite Site (mg/kg) | Control Site (mg/kg) | FEPA Guidelines for Heavy Metal Threshold Values in Soils (mg/kg)  | WHO Standards for heavy metals concentration in the soil (mg/kg) |
| Lead | 26.29-81.50 | 2.54-0.13 | 1.6 | 15-25 |
| Cadmium | 1.23-2.31 | 0.00-1.01 | 0.01 | 0-30 |
| Zinc | 17.80-34-10 | 5.70-15.27 | 300-400 | 20-300 |
| Copper | 2.49-3.24 | 0.75-1.51 | 70-80 | 0-140 |
| Manganese | 2.80-3.71 | 0.54-2.65 | 0.050 | 200-900 |
| Cobalt | 0.49-1.07 | 0.004-0.05 | 0.05 | - |
| Nickel | 1.07-1.63 | 0.00-0.59 | 0.1 | 0-100 |

**Source: Field work data from lab analysis 2023**

The findings shown in Table 3 show that the concentrations of heavy metals in the soil from the Hope's Villa Hostel waste dumpsite in Umudike and the control site, except lead, cadmium, cobalt, and nickel, generally fell within the allowable limits set by the guidelines of the World Health Organization (WHO) and the Federal Environmental Protection Agency (FEPA). Lead levels above the FEPA and WHO recommended limits of 1.6 mg/kg and 15–25 mg/kg for soil heavy metal concentrations, with levels ranging from 26.29 to 81.50 mg/kg in the dumpsite and 2.54 to 0.13 mg/kg in the control site.

The zinc concentration ranges for both sites (17.80-34.10 mg/kg in the dumpsite and 5.70-15.27 mg/kg in the control site) were within the FEPA and WHO permissible ranges for soil heavy metals, which are 300-400 mg/kg and 20-300 mg/kg, respectively. The heavy metal levels in the soil at the control location were generally within the FEPA and WHO acceptable limits. Notably, heavy metal concentrations in the dumpsite soil were substantially greater than in the control site.

Cadmium (Cd), a heavy metal, was found in all soil depths throughout the dump site. The soil analyzed from 0-15cm depth had the greatest mean cadmium level, with a value of 2.3 mg/kg. Cadmium concentrations in soil depths ranged from 1.23 to 2.31 in the dumpsite and 0.00 to 1.01 in the control site. These readings were lower than the mean value reported by Ukpong *et al*.,(2013) for waste dumpsites in Uyo city, Akwa Ibom State (4.6 mg/kg), but they were within the range reported by Raymond et al., 2012 for several hazardous metals in waste dump soils in Makurdi, North-central Nigeria. The average cadmium level in the dumpsite soil was within the WHO guideline range of 0-30 mg/kg, indicating the presence of a considerable proportion of cadmium-containing trash at the dumpsite, most likely attributable to human activity.

Lead (Pb), as shown in Table 3, the mean levels of lead in soil depths ranged from 26.29 to 81.50 mg/kg at the dumpsite and from 2.54 to 0.13 mg/kg at the control site. These results were greater than those reported by Amos-tuatua *et al*., 2014 for a municipal open waste dumpsite in Yenagoa, Nigeria (14.75 to 16.14 mg/kg), but lower than those reported by Oladunni *et al*., 2013, for heavy metal contamination near an electronic trash dumpsite. The mean lead readings in the dumpsite soil surpassed the WHO recommended range of 15-25 mg/kg, indicating that lead-containing wastes were present in significant quantities at the dumpsite. Lead concentrations in the environment are frequently linked to its use as an antiknock ingredient in gasoline, ceramics, solders, lead pipes, paint, glasses, and plastics. Lead is hazardous in low quantities and has no recognized function in biological processes. The mean value of lead recorded by Ukpong et al., 2013 (89 mg/kg) for waste dumpsites in Uyo metropolis, Akwa Ibom State, was similar to the range observed in this study but lower than the mean concentration of lead in the soil at an Ibadan dumpsite reported by Aluko et al., 2013, which ranged from 1.34 to 1.69 mg/kg. Interestingly, in this study, the mean values declined from topsoil (0-15cm) to subsoil (30-45cm) in both the dumpsite and the control site. In summary, while the majority of heavy metal concentrations in the dumpsite soil were within acceptable limits, lead and cadmium concentrations exceeded these limits, indicating a significant presence of these contaminants at the dumpsite, most likely as a result of human activities and poor waste disposal practices.

The mean levels of zinc (Zn) throughout all soil depths in the dumpsite ranged from 17.80 to 34.10 mg/kg, while they ranged from 5.70 to 15.27 mg/kg at the control site (see Table). The zinc levels in the dumpsite's soil depths were substantially greater than in the control site. The World Health Organization (WHO) recommends an acceptable range for soil zinc concentrations of 20-300 mg/kg, which is consistent with the findings of this study. In contrast, Aluko et al. (2003) found lower zinc contents in Ibadan dumpsite soils, ranging from 1.42 to 2.42 mg/kg. Yahaya *et al.* (2009), on the other hand, found greater zinc concentrations (56.31-92.50 mg/kg) in the soil of an Abattoir dumpsite in Nigeria. This shows that the principal sources of zinc in the environment may be the wear and tear of motor vehicle tyre rubber as a result of poor road conditions, as well as lubrication lubricants containing zinc as part of various additives. Furthermore, discarded construction debris and some malfunctioning electrical equipment might lead to elevated zinc levels in the environment (Monechot *et al.,* 2014).

The dumpsite's mean manganese (Mn) values ranged from 2.80 to 3.71 mg/kg, which was significantly greater than the control site's range of 0.54 to 2.65 mg/kg (Table 3). According to WHO, the permitted limits for manganese (Mn) in soil vary from 200 to 900 mg/kg (Monechot et al., 2014), which are higher than the amounts identified in this study. Manganese (Mn) is likely present in the dumpsite due to manganese-containing garbage, which could have a deleterious impact on soil qualities (Monechot et al., 2014). In comparison to this study, Yahaya *et al*., (2009) found greater quantities of manganese (Mn) (263.01 to 608.11 mg/kg) in the soil of an Abattoir dumpsite in Nigeria.

Nickel (Ni) mean values ranged from 1.07 to 1.63 mg/kg in soil samples collected from the dumpsite, whereas nickel was only identified in the 0-15cm soil level in the control, ranging from 0.00 to 0.59 mg/kg (Table 3). The WHO acceptable limit for nickel (Ni) in soil is 0 to 100 mg/kg (Monechot et al., 2014), which corresponds to the amounts identified in this investigation. The increase in nickel content in dumpsite soil samples compared to the control site indicates the presence of nickel-containing garbage at the dumpsite. The nickel (Ni) contents observed for dumpsite soil in this investigation were lower than those found by Yahaya et al. (2009) (36.21-107.13 mg/kg) and also lower than the mean value obtained by Ukpong *et al*. (2013) (7.0 mg/kg) for garbage dumpsites in Uyo, Akwa Ibom State. According to Oladunni *et al*., (2013), the presence of nickel (Ni) can be ascribed to several types of electronic trash, specifically Ni-Cd batteries and cathode ray tubes.

 The mean levels of cobalt (Co) in soil depths ranged from 0.49 to 1.07 mg/kg in dumpsite soil and from 0.75 to 1.51 mg/kg in control soil (Table 3). The mean cobalt content in this investigation was within the same range as that found by Olayinka *et al*., (2014) for heavy metal concentrations in municipal dumpsite soil and plants at Oke-Ogi, Iree, Nigeria (0.02 to 0.72 mg/kg). It was, however, lower than the values observed in similar investigations by Awokunmi *et al*., (2010), which varied between 105-810 mg/kg, and also those of Yahaya et al. (2009) (13.21-30.02 mg/kg) for heavy metal concentrations in an Abattoir dumpsite soil in Nigeria. The cobalt concentrations in the soil are most likely due to the indiscriminate disposal of cobalt-containing garbage at the dumpsite. High cobalt (Co) uptake can cause cancer and symptoms such as vomiting, nausea, visual issues, heart problems, and thyroid damage (Lenntech Water Treatment, 2009).

Cu (copper), Table 3 shows that the mean copper (Cu) values in the soil depths ranged from 2.49 to 3.24 mg/kg in the dumpsite soil and from 0.75 to 51 mg/kg in the control soil. Copper levels were substantially greater in each of the soil depths within the dumpsite than in the control site. According to Ebong et al. (2008), the usual natural range for copper (Cu) concentration in soil is between 2-100 mg/kg. The mean copper concentration in this study was within the range reported by Raymond et al. (2012) (2.70-10.86 mg/kg) for some toxic metals in waste dump soils in Makurdi, North-Central, Nigeria, and also within the range provided by Olayinka et al. (2014) (1.71 to 3.30 mg/kg) for heavy metal concentrations in Oke-Ogi, Iree, Nigeria. However, it was lower than the values reported by Yahaya et al. (2009) for heavy metal contents in an Abattoir dumping site soil in Nigeria (59.32-96.13 mg/kg).

**Table 4: The degree of metal enrichment based on Geo-accumulation (Igeo) classification.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Metals (Dumpsite) | Measured conc. Of metals in the study area | The average continental shale. (Hakanson 1980) | Igeoaccumulation values | Igeo class | Igeo index of enrichment |
| Cadmium  *Igeo* | 2.31 | 0.3 | 2.94 | 2 | Moderately polluted  |
| Cobalt  *Igeo* | 1.07 | 19 | 0.10 | 1 | Unpolluted to moderately polluted |
| Copper  *Igeo* | 3.24 | 45 | 1.70 | 2 | Moderately polluted |
| Lead  *Igeo* | 81.5 | 20 | 6.35 | 6 | Extremely polluted |
| Manganese  *Igeo* | 3.72 | 850 | 1.90 | 1 | Unpolluted to moderately polluted |
| Nickel  *Igeo* | 1.63 | 68 | -5.38 | 0 | Unpolluted  |
| Zinc *Igeo* | 34.1 | 95 | -1.48 | 0 | Unpolluted |
|  |  |  |  |  |  |
| Metals ( Control site) |  |  |  |  |  |
| Cadmium *Igeo* | 2.16 | 0.3 | 2.85 | 2 | Moderately polluted |
| Cobalt  *Igeo* | 0.35 | 19 | -5.76 | 0 | Unpolluted |
| Copper  *Igeo* | 2.65 | 45 | -4.09 | 0 | Unpolluted |
| Lead  *Igeo* | 62 | 20 | 1.63 | 2 | Moderately polluted |
| Manganese  *Igeo* | 3.25 | 850 | -8.03 | 0 | Unpolluted |
| Nickel  *Igeo* | 1.81 | 68 | -5.23 | 0 | Unpolluted |
| Zinc  *Igeo* | 28.49 | 95 | -1.74 | 0 | Unpolluted |

**Key:** 0< *Igeo*  <1, class 1= unpolluted to moderately polluted, 1 ≤ *Igeo* ≤ 2, class 2= Moderately polluted, 2 ≤ *Igeo* ≤ 3, class 3= Moderately to strongly polluted

3 ≤ *Igeo* ≤ 4, class 4= Strongly polluted, 4 ≤ *Igeo* ≤ 5, class 5= Strongly to extremely polluted, *Igeo* > 6, class 6= Extremely polluted

**Geoaccumulation index(Igeo)**

According to, Geoaccumulation index (I**geo**) from both the dumpsite soil and the control area, the dumpsite site was unpolluted with Ni, Zn. I*geo* for Mg and Co showed Unpolluted to moderately polluted, cu and cd showed moderate pollution, while Pb showed extremely polluted in the study site. In the control all metals indicated unpolluted except for Pb and Cd that showed moderate level of pollution.

**Table 5: Assessment of metals based on Contamination Factor Cfi and Potential Ecological Risk (PERI)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Significant elements from the dumpsite soil samples  | Cfi | Tri | PERI values | GRADE OF ECOLOGICAL RISK INDEX |
| Lead | 1.16-0.37 | 5 | 1.88-5.82 | *PERI<40-Low potential ecological risk*  |
| Cadmium | 2.31-1.23 | 30 | 36.90-69.30 | *PERI 40<80 moderate potential ecological risk*  |
| Zinc | 0.19-0.10 | 1 | 0.10-0.19 | *PERI<40Low potential ecological risk*  |
| Copper | 0.06-0.03 | 5 | 0.16-0.32 | *PERI<40 Low potential ecological risk*  |
| Manganese | 0.00 | 1 | 0.00-0.00 | *PERI<40-Low potential ecological risk*  |
| Cobalt | 0.05-0.00 | 5 | 0.01-0.27 | *PERI<40-Low potential ecological risk*  |
| Nickel | 0.02-0.01 | 6 | 0.09-0.14 | *PERI<40-Low potential ecological risk*  |
| Significant elements from the control site  |  |  |  |  |
| Lead | 0.00 | 5 | 0.01-0.00 | *PERI<40--Low potential ecological risk*  |
| Cadmium | 1.01 | 30 | 0.00-30.30 | *PERI<40-Low potential ecological risk*  |
| Zinc | 0.08-0.03 | 1 | 0.03-0.15 | *PERI<40-Low potential ecological risk*  |
| Copper | 0.03 | 5 | 0.19-0.01 | *PERI<40-Low potential ecological risk*  |
| Manganese | 0.00 | 1 | 0.00 | *PERI<40-Low potential ecological risk*  |
| Cobalt | 0.00 | 5 | 0.00-0.05 | *PERI<40-Low potential ecological risk*  |
| Nickel | 0.00 | 6 | 0.03-0.09 | *PERI<40-Low potential ecological risk*  |

**Key:** < 40, low potential, ecological risk; 40 < 80, moderate potential ecological risk; 80 < 160, considerable potential ecological risk; 160 < 320, high potential ecological risk; and ≥ 320, very high ecological risk.

**Potential ecological risks:**

Potential ecological risks of the metals were calculated using the formula: ErF = Tri × CFi, with results presented in Table 5 the Mean potential ecological risks are ranked as Cd > Pb > Zn > Ni > Cu > Mn>Co>Ni. The Ei values for all metals in the dumpsite except for cd are all <40 , indicating low potential ecological risk while cd is 40<80, indicating moderate potential ecological risk. In the control site all the metals were <40-, indicating Low potential ecological risk.

**CONCLUSION**

This study revealed significantly higher concentrations of heavy metals such as lead, manganese, zinc, cadmium, cobalt, copper, and nickel, (p < 0.05) in the soil. These findings confirm that solid waste disposal, especially generated by students, is causing a decline in soil quality. This has led to the accumulation of heavy metals, an increase in soil pH, an increase in organic matter content and a decrease in electrical conductivity around the waste dumpsite

**Recommendation**

Based on the findings of the study, the following recommendations are proposed: Adoption of Effective Solid Waste Management Techniques: Implementing suitable solid waste management practices is crucial. There should be an emphasis on educating students about the solid waste management hierarchy to promote practices beyond mere waste disposal.

Public Awareness Programs: Michael Okpara University of Agriculture, Umudike, should organize regular public awareness programs to educate and reorient students about their environmental responsibilities. These campaigns should focus on bringing about significant changes in students' attitudes and perceptions towards solid waste management. By increasing awareness, it is anticipated that student behaviors and habits related to proper solid waste management will improve.

 **Conflict of Interests**

 This study recorded no conflicts of interest.

**REFERENCE**

Abila, B., and Kantola, J., (2013) Municipal Solid Waste Management Problems in Nigeria: Evolving Knowledge Management Solution World Academy of Science, Engineering and Technology International Journal of Environmental, Chemical, Ecological, Geological and Geophysical Engineering, 7(6), 20-13

Aluko. O. O. Sridha. M. K.C. and Oluwande, P. A. (2003). “Characterization of Leachates from a Municipal Solid Waste Landfill site in Ibadan, Nigeria” Journal Environmental. Health Research. Vol., 2 Issue 1.

Anikwe. M.A.N. and Nwobodo, K.C.A. (2011). Long term effect of municipal waste disposal on soil properties and productivity of sites used for urban agriculture in Abakaliki. Nigeria. Bio resources Technology.

Awokunmi E.E, Asaolu S.S, and Ipinmoroti K.O. (2010). Effect of leaching on heavy metals concentration of soil in some dumpsites. African Journal of Environmental Science and Technology. 4(8):495-499.

Aziegbe, F.I. (2007). Seasonality and environmental impact status of polyethylene (cellophane) generation and disposal in Benin City, Nigeria Journal of Human Ecology. 22(2): 141-147.

Bakirdere, S., Yaroglu, T., Tmk, N., Demiroz, M., Kemal Fidan, A., Maruldah, O., and Karaca, A. (2015). Determination of As, Cd, and Pb in tap water and bottled water samples by using an optimized GFAAS system with Pd-Mg and Ni as matrix modifiers. Journal of Spectroscopy. Article ID 824817, p7.

 Chai L, Li H, Yang Z et al (2017) Heavy metals and metalloids in the surface sediments of the Xiangjiang River, Hunan, China: distribution, contamination, and ecological risk assessment. Environ Sci Pollut Res 24:874–885 39.

Ebong G. A., Akpan, M. M., and Mkpene V. N. (2008). Heavy metal content of municipal and rural dump site soils and rate of accumulation by Carica papaya and Talinum triangulare in Uyo Nigeria. Electronic Journal of Chemistry. 5(2): 281-290.

Hakanson L (1980) Ecological risk index for aquatic pollution control A sedimentological approach. Water Resour 14:975–1001

Kabata-Pendias, A., Pendias H. (2012). Trace Elements in the Soil and Plants. International Research Journal of Environmental Science. 3:11-16.

Lenntech Water Treatment. (2009). Chemical properties, health and environmental effects of cobalt. Lenntech Water Treatment and Purification Holding B.V. Available at www. lenntech. com/periodic/elements/co.html

Lu, X ., Wang, L.,  Lei, K .,  Huang, J and Zhai, Y .(2009) Contamination assessment of copper, lead, zinc, manganese and nickel in street dust of Baoji, NW China. J. Hazard. Mater., 161 (2-3), pp. 1058-1062

Monechot, W.O., Eno-Obong, S.N., and Onyekachi, C.l. (2014). Heavy metal characteristics of soils at the municipal solid waste dumpsite at Uyo metropolis Akwa Ibom State, South-South Nigeria. Material research 6:7.

Muller G.(1969), Index of geoaccumulation in sediments of the Rhine River, Geojournal 2 (1969) 108–118

Oladunni, B.O., Tejumade, A., and Otolorin, A. (2013) Heavy metals contamination of water, soils and plant around an electronic waste dumpsite. Poland journal of environmental study. 22(5): 1431-1439.

Olayinka O. Olufunmilayo, I., Adedeji, H., Oludare, I. and Dada Oluwatoyin, (2014). Determination of Concentrations of Heavy Metals in Municipal Dumpsite Soil and Plants at Oke-ogi, Iree, Nigeria. International Research Journal of Pure & Applied Chemistry 4(6): 656-669.

Suresh G, Sutharsan P, Ramasamy V, Venkatachalapathy R (2012) Assessment of spatial distribution and potential ecological risk of the heavy metals in relation to granulometric contents of Veeranam lake sediments, India. Ecotoxicol Environ Saf 84:117–124

Ukpong E.C. Antigha. R.E. Moses E.O (2013). Assessment of heavy metal content in soils in plant around waste dumpsite in Uyo metropolis Akwa Ibom State. International journal of engineering in science. 2(7):75-86.

World Health Organization (2008). West African dumping convention. Ghana. The first and second decades.

Yahaya, M. I., Mohammad. S. and Abdullahi. B. K. (2009). Seasonal Variations of Heavy Metals Concentration in Abattoir dumping site soil in Nigeria. Journal of Applied Science, Environment and Management. 13(4)9-13.

Zauyah. S., Juliana, B., Noorhafizah, R., Fauzah, C.I., and Rosenami, A.B. (2004). Concentration and speciation of heavy metals in some cultivated and uncultivated ultisols and inceptisols in Peninsular Malaysia, Super-Soil 3rd Australian New Zealand Soils Conference, University of Sydney, Australia

Zerbock, O. (2003). Urban Solid Waste Management: Waste Reduction in Developing Nations. [(w ww.cee.mtu.edu)](http://www.cee.mtu.edu/). Accessed on 18th July,2009.