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Investigation of Heavy Metal Content on Dumpsites Soil and Vegetables Grown: A case study of Ilesha metropolis, Nigeria

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ABSTRACT

The research evaluated the levels of heavy metals (Mn, Cr, Pb, Cd, and Fe) in two dumpsites and control in Ilesha metropolis, Nigeria. Specific soil properties and the level of metals in dumpsites soil samples and vegetables were also considered. Standard techniques were employed in the appraisal and atomic absorption spectrophotometer (Buck Scientific model 210) for the metal concentration analysis. The level of each metal was detected low in the control site compared to the dumpsites which prove that there had been the anthropogenic contribution of heavy metal through the disposal of wastes containing or made of heavy metals. The metal concentration ranges between 0.25 mg/Kg (Cadmium of control) to 82,313 mg/Kg (Iron of IMD dumpsite). The vegetable (Talinum triangulare) that was common to the dumpsites and control accumulated minimal concentrations of the metals. In fact, vegetable in the two dumpsites and control had Cr, Cd, and Pb occurring below the detection limit. All the concentrations of metals studied in soil and vegetable were found to be lower than the maximum permissible limit of heavy metal in soil and vegetable stated by the World Health Organisation (WHO) which implies that the vegetables are presently safe for human consumption. The higher concentration of metals in dumpsite and their vegetables more than the control site shows that there is gradual pollution of heavy metals in the vegetable and implies that there is a need to avoid consuming vegetable grown on these sites and discourage the use of the sites for any form farming activities.

Key words: *Heavy metals, Dumpsites, Vegetables, Ilesha.*

1.0 INTRODUCTION

Waste generation is one of the consequences of advancement in technology. This invariably led to environmental pollution, particularly in the developing countries where major strides towards improved processing of wastes and disposal practices have not been made. Also, the increasing influence in the more technologically developed countries, more municipal solid wastes and waste waters are being produced and these need treatment and proper disposal [1]. There is no doubt that a healthy environment has a high correlation with good human health [2].

The disposal of materials that contains heavy metals in open dumpsites are of concern and pose dangers to people in contact with the soil and plants of these sites in which they are disposed. In Nigeria, leachates from refuse dumpsites constitute a source of heavy metal pollution to both soil and aquatic environments [3]. In some cases, wastes are dumped recklessly with no regards to the environmental implications, while in some dumpsites, wastes are burnt in the open and ashes abandoned at the sites. The concentrations of heavy metals in soil around waste dumpsites are influenced by types of wastes, topography, run-off and level of scavenging [4 , 5]. Once heavy metals are deposited in the soil, they are not degraded and persist in the environment for a long time causing serious environmental pollution [6].

There is a growing concern about the possibility of soil contamination resulting in the introduction of elements in food chains through uptake by plants and thereby affecting food safety [7]. They accumulate in soil and plants having a negative influence on physiological activities of plants such as photosynthesis, gaseous exchange and nutrient absorption which result in plant growth reduction and dry matter accumulation [8]. Although the rate of metal uptake by plants could be influenced by factors such as metal species, plants species, etc. [9].

As it is in most cases, soils in municipal waste dumpsites commonly serve as fertile ground for the cultivation of a variety of fruit and leafy vegetables, with little regard to the probable health hazards the heavy metal content of such soils may pose [9] . Most dumpsite soils in Nigeria are extensively used for cultivating varieties of edible vegetables and plant-based foodstuff without proper routine assessment of the associated health and ecological [1 0] .

Toxic metals may be absorbed by vegetables through several processes and finally enter the food chain at high concentrations capable of causing a serious health risk to consumers. Some metals, such as Mn, Cu, Zn, Mo and Ni, are essential or beneficial micronutrients for microorganisms, plants and animals. Their absence may cause deficiency diseases but at high concentrations all have strong toxic effects and pose an environmental threat. Some heavy metals such as Cd and Pb have been known to have no known biological importance. Their toxicity can damage or reduce mental and central nervous function, lower energy levels, and damage to blood composition, lungs, kidneys, liver and other vital organs. Long term exposure may result in slowly progressing physical, muscular, and neurological degenerative processes that cause muscular dystrophy, and multiple [1 1] .

This study aimed at assessing the heavy metals contents in soil of two dumpsites and vegetables grown around them (Sabo market dumpsites and Ijesha Muslim grammar school dumpsite in Ilesha) and one control site at Kajola in Ilesha. It is expected that results obtained from the study will widen our knowledge on the environmental risks associated with solid waste dumps and vegetables grown around dumpsites.

2.0 MATERIAL AND METHODS

2.1 Study Area

The first dumpsite is located in Sabo market, Iyemogun (Figure 1) of Ilesha on Latitude 7^0 36.083 N and Longitude 4^0 45.300 E. This dumpsite is physically located at the boundary of a big market in Ilesha. It serves as the major dumpsite for the market but because of its size, it has gradually become a major dumping site for many residential too. The age of this dumpsite was dated to be over 20 years. As a regularly practice by the market management administrators, the dumpsite is burnt once in a month. The second dumpsite is located in Ijesha Muslim Grammar School (Figure 2), Ilesha on Latitude 7^0 35^1 57.7932 N and Longitude 4^o 45^1 19.6092 E. This dumpsite is located within the school compound but close to the major road. The absence of a fence to confine the school dumpsite has made its constituent range from the school wastes to nearby household wastes. Its age was dated to be less than 3 years. A reference sample was taken outside these areas, in an area considered not under the direct influence of dumpsites or any other anthropogenic influence. In all of the sites, *Talinum triangulare* (water leaf) vegetable is the most grown and widely consumed by residents around.

2.2 Sample collection and preparation: Twelve sampling spots at different distance of 50 m from each other were mapped out for soil samples collection within the sampling sites, using clean stainless steel shovel from 0-15 cm depth. A soil sample to serve as control was also collected. The collected dried soil samples were thoroughly mixed in clean plastic bucket to obtain a representative sample, crushed, air dried and sieved with 2 mm mesh before stored in labeled polythene bags prior to analysis. The vegetable plant species from each sample site were uprooted washed with distilled water to eliminate air-borne pollutants, sliced and dried to eliminate excess moisture. These vegetables samples were weighed and oven-dried at 60°C to constant weight. Each oven-dried sample was ground in a mortar until it could pass through a 0.18 mm sieve. The samples were then stored in a clean, dry, stoppered glass container before analysis.

Figure 1: Dumpsite at Sabo market

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Figure 2: Ijesha Muslim Grammar School

2.3 Determination of Soil P [H]

The pH of the samples was recorded using Corning pH meter, by introducing the meter probe into the prepared samples solution [12].

2.4 Organic Matter Determination

The soil samples were ground to pass through 0.5mm sieve after which they were weighed in duplicate and transferred to 250 mL Erlenmeyer flasks. Exactly 10 mL of 1M potassium dichromate was pipette into each flask and swirled gently to disperse the soil followed by addition of 20 mL of concentrated, tetraoxosulphate (IV) acid. The flask was swirled gently until soil and reagents were thoroughly mixed. The mixture was then allowed to stand for 30 minutes on a glass plate to allow for the oxidation of potassium dichromate to chromic acid. Distilled water (100 mL) was added then 34 drops of ferroin indicator, after which the mixture was titrated with 0.5 M ferrous sulphate solution. A blank titration was similarly carried [13]. The percentage organic carbon is given by the following equation:

$$(M_1e_1K_2Cr_20_7 - M_2e_2FeSO_4) \text{ x } 0.0031 \text{ x}100 \text{ x } F / \text{Mass (g) of air dried soil} \quad \text{-------------- (1)}$$

F= correction factor (1.33), M_1 = mole of K2Cr2O7, e_1= volume of K2Cr2O7 M_2 = mole of FeSO4, e_2 = volume of FeSO4.

2.5 Determination of heavy metals

Triplicate samples of 1.0 g of the sieved soil samples were digested with 25 mL of a mixture of hydrochloric acid (HCl) and trioxonitrate (v)acid (HNO3) in the ratio of three to one parts by volume respectively at 120ºC on a water bath in a fume cupboard. The solution was heated to dryness and the residue was re-dissolved in 5mL of 2.0 M HClO. On cooling, the digest was filtered into a 50.0 ml volumetric flask and made up to the mark with distilled water [14]. Exactly 8 ml of HN03 were added to 0.5 g of samples and left to stand overnight. The solution was then heated for one hour at 120°C on hot plate with several additions of 4 mL H202. After heating, cooled and filtered. The filtrate was made up to 50 ml with distilled water [15]. Blanks were prepared to check for background contamination by the reagents used.

2.6 Metal analysis: The digest samples were analyzed for heavy metals (Mn, Cr, Cd, Pb, and Fe) using atomic absorption spectrophotometer (AAS Buck Scientific model 210) in Ibadan, Oyo, Nigeria. The instrument setting and operational conditions were done in accordance with the manufacturers' specifications.

2.7 Statistical analysis: Mean concentrations of heavy metals in soil and vegetable were analysed using Statistical Programme for Social Sciences (SPSS) and Excel computer packages.

3.0 RESULTS AND DISCUSSION

Table 3.1 shows the result of the pH and organic matter of the soils samples. The Sabo market dumpsite, Ijesha Muslim grammar school dumpsite and the control site represented are represented by SMD, IMD and CNT respectively.

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Table 3.1: Physiochemical property of the soil samples

Sites	SMD	IMD	CNT
pH	9.70 ± 0.00	8.70 ± 0.00	8.00 ± 0.00
%Organic matter	2.55 ± 0.05	2.81 ± 0.12	0.1 ± 0.00

From the above pH ranges, it shows that all the soils are alkaline which is in agreement with a research reported by [16] on refuse dumpsites in Akure. The mean pH values of studied soils were greater than the value obtained on the control site. This higher value of the pH may be as a result of mineral build-up by wastes on the dumpsite. The higher pH dumpsite against its control site is similar to the pH reported by [17] on Oke-Ese dumpsite, Ilesha. It has been reported that most soils within the pH range of 6.0-9.0 have metals that are not always in the free form, hence not likely to be bioavailable [18]. The pH of all the soil samples investigated are within this range therefore, the metals investigated in this study possibly may not be bioavailable to the plant until when favourable conditions like acidic precipitation prevailed on the soil. pH plays significant role in solute concentration and in sorption and desorption of contaminants in soil [19].

The soil organic matter enhances the usefulness of soils for agricultural purpose. It supplies essential nutrients and functions as source of food to microbes and thereby helps to enhance and control their activities [20]. The percentage organic matter of all the sites was found to be higher than the percentage organic matter of the control site. The higher percentage of organic matter recorded may have resulted from the decomposition and composting processes of the organic wastes such as food wastes etc. as a result of their location close to market and school. The result from this research is lower than the 7.62 to 8.60 % organic matter reported by [17] for Oke-Ese dumpsite in Ilesha This shows positive indication that the soil are fertile and likely to support healthy growth of vegetable which may attract attention of farmers to the locations. [21] reported that the organic matter content of soil contributes to the increase in the availability of mineral elements, nutrition to living organisms and acts as a buffer aqueous solution to maintain a neutral pH.

The concentration of heavy metals in soil samples is presented in Table 3.2. Results above obtained showed that soils from the study sites have higher metal concentrations than their corresponding metals level at the control site. This is in agreement with the results obtained from similar studies by [17] on a dumpsite in Ilesha and it could be attributed to the availability of metal containing wastes at dumpsites which have eventually leached into the underlying soils. The metal concentrations of the selected heavy metals (Mn, Cd, Cr, Pb and Fe) were compared with World Health Organization (WHO) standards and all found to be lower than the WHO maximum permissible limit.

Table3.2: Heavy metal concentration in soil samples

Sites	SMD (mg/Kg)	IMD (mg/Kg)	CNT (mg/Kg)	WHO MPL (mg/Kg)
Mn	520±11.85	274.67±2.08	120.83±0.76	2000
Cr	22.85±0.77	37.03±0.69	21.25±0.17	100
Cd	1.10±0.08	0.85±0.05	0.25±0.00	3
Pb	27.03±0.45	10.38±1.33	0.5±0.00	100
Fe	8221.33±51.733	7152.50±146.82	6362.83±49.50	50000

Manganese is found naturally in the most soil as it is one of the most essential mineral for life [22]. The result from this study is similar to the result from [23] on distribution and enrichment of heavy metals in soils from waste dump sites within Imoru and environments, southwest Nigeria. All the concentration of manganese values was found to be lower than the World Health Organization standard for manganese in soil. The mean concentration of chromium in studied soil ranges from 22.85 mg/kg to 37.03 mg/kg higher than the mean value of 21.25 mg/Kg at the control site. This implies that the high concentrations at the dumpsite are the result of the dumping of Cr-containing waste. Sources of chromium might be due to wastes from household chemicals and cleaners, diesel engines utilizing anti-corrosive agents, rubber, candles and matches etc. Anthropogenic input of Cr comes from solid wastes, where approximately 30% of Cr originates from plastics, packaging materials and lead-chromium batteries [24]. The values of Cr obtained in this study were lower than the 900 – 2000 mg/kg reported by [25] at selected dumpsites in Ado – Ekiti the south west of Nigeria. The highest percentage of cadmium, Lead and iron was noted in SMD. Even though it was higher, still yet lower than the maximum permissible limit. Among all the metal studied in this research, the concentrations of Fe has the highest values throughout the sites. Although many researchers have earlier

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reported the high concentration of iron in Nigeria soil [26] but the concentrations discovered in this study are much higher than the literature reports.

Table 3.3 shows the mean concentrations of metals in the vegetables around on the dumpsites. Throughout the sites, only manganese and iron were absorbed by the plants at a very significant concentration. The factors affecting the amount of metal absorbed by a plant are (i) the concentration and speciation of the metal in the soil solution (ii) the movement of the metal from the bulk soil to the root surface (iii) the transport of the metal form the root surface into the root, and (iv) its translocation from the root to the shoot [27, 28].

One or more of these controlling factors may have been responsible for the wide variation in the concentration and pattern of uptake observed for the various metals in the vegetable plants. The measure of concentration of these metals in the vegetables reflected their corresponding concentrations in the soil. Thus agreed with what some authors have noted, that plant uptake of metal from soil is largely determined by the concentration of the metal in the soil matrix [28]. The manganese and iron that have a significant concentration were more than the control site which means there is a likelihood of anthropogenic input on the vegetable from the dumpsite. They were below the maximum permissible level which implies that they are safe for consumption although continuous build up could make the unsafe for consumption.

Table 3.3 Heavy metal concentration in vegetables

Metals	SMD (mg/Kg)	IMD (mg/Kg)	CNT (mg/Kg)	WHO MPL (mg/Kg)
Mn	48.00 ± 0.89	77.06 ± 2.24	32.61 ± 1.40	500
Fe	210.28 ± 6.0	335.83 ± 5.48	153.89 ± 2.26	425
Cr	ND	ND	ND	2.3
Cd	ND	ND	ND	0.10
Pb	ND	ND	ND	0.30

ND: Not detected

4.0 CONCLUSION

This research has shown that there is heavy metal pollution on dumpsites site soil which is resulting effect of heavy metal containing wastes that are improperly disposed there. Buildups of heavy metal on these dumpsites have leached to the nearest place of uptake by vegetables and other plants around them. Although, the soil and vegetable studied were found to be safe for now but there are concerns for the gradual and continuous buildup which has started and indicated in the obvious difference of the dumpsites and control site metal concentration. This study shows that continuous cultivation of consumable vegetables in or around dumpsites is highly risks to human and also it is necessary to take measures both to stop cultivating vegetables and to conduct pubic talk on the risks associated with dumpsite.

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