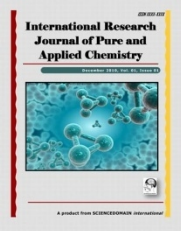

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Determination of Concentrations of Heavy Metals in Municipal Dumpsite Soil and Plants at Oke-ogi, Iree, Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author OOO and designed and managed the analyses of the study. Author DO wrote the first draft of the manuscript. Author AOH managed the literature searches, and performed the statistical analysis. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

The study examined the concentration of heavy metals [Cd, Co. Cu, Pb, Ni, Mn, Pb and Zn) in dumpsite soil and waterleaf [*Talinum triangulare*) growing wildly on Oke-ogi dumpsite, Osun state, Nigeria. Soil samples from different layers [0-15cm, 15-30 cm and 30-45 cm) were collected in triplicate and analysed using Atomic Absorption Spectrophotometer. Pb had the highest mean ± SD 91.67±13.80 mgkg^{-1}followed by Zn, which is 20.85±4.80 mgkg^{-1}. Mean concentration of Pb and Zn in the soil of the control site is significantly lower than [Pb, 10.67±2.08 mgkg^{-1}) and [Zn, 2.58±0.38 mgkg^{-1}) respectively. Concentration of Pb in both the dumpsite soil and plant in excess of allowable limit. Concentration of Co in the dumpsite soil [0.02 – 0.72 mgkg^{-1}). Fe is the most abundant element in the vegetable with a mean value of 186 mgkg^{-1} followed by Zn [8.63 mgkg^{-1}). Heavy metal concentrations followed the order of Pb>Zn>Mn>Cu>Cd>Co in the both the control and dumpsite soils most of which falls below the critical permissible concentration level, their persistence in these soils of the dumpsite may lead to increase

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uptake by plants. Transfer factor for Cd and Mn were 1, while others values are below 1. Elevated heavy metal concentrations at dumpsite need to be properly addressed given the fact, that inorganic waste are being dumped by the people. This can be done if the sitting of dumpsite is regulated, minimizing waste and remediation techniques, such as bioremediation that have shown potential for their ability to degrade and detoxify certain contaminants.

Keywords: Dumpsites; heavy metal; health risk; soil contamination; solid waste; transfer factor; Oke-Ogi.

1. INTRODUCTION

Waste is generated universally and is a direct consequence of such human activities. Odewunmi [1] observed that waste generation is a concomitant aspect of living; it cannot be avoided but can only be managed. Many part of Nigeria today including Iree, Osun state is fast urbanizing due to increasing economic growth and population increase [2-3]. One of the biggest challenges facing the government is provision of a healthy and clean environment to the populace especially in the context of waste management [4]. Major urban centres are faced with the daunting problems of clearing heaps of solid wastes and the possible effects on the health, quality of environment and the urban landscape [2,5]. Waste management is one of such areas that require special attention to plan and manage in view of the increase in waste generation taking place within the urban milieu. Unprecedented growth of towns and cities have posed lots of challenges to urban planner, managers and decision makers on issues of proper urban development and management. Inappropriately sited open dumps are characteristic of major cities, endangering public health by encouraging the spread of odours and diseases, uncontrolled recycling of contaminated goods and pollution of soil and water sources [6-7]. This is important given the complex problems such as new emerging waste streams, contamination with micropollutants, heavy metals, organic pollutants as well as environmental challenges of waste handling and treatment among others [8-9].

Wastes on dumpsite generally contain toxic metals, which are of concern and pose dangers to people in contact with the contaminated soils and plants. The chemical compositions of the solid waste materials often lead to changes in soil physical and chemical characteristics [10] due to contaminations. One of the most serious contaminant groups is the heavy metals [11-12]. Ideriah et al. [13] reported that types of wastes, topography, run-off and level of scavenging influence concentrations of heavy metals in soil around waste dumpsites. Majority of the dumpsites in Nigeria have consumable plants such as waterleaf, *Amaranthus spp*., bitter leaf and other food crops growing on their soils [14-15]. Heavy metals such as cadmium, lead, nickel, cobalt and zinc in dumpsite soils are of concern primarily because of their potential to harm soil organisms, plants, animals and human beings [16]. These metals are very harmful because of their non-biodegradable nature, long biological half-lives and their potential to accumulate in different body parts [17]. Contamination of vegetables and other foodstuffs by heavy metals is a major concern, as these foodstuffs are important components of human diet especially on the issue of food safety and quality assurance [18-19]. Heavy metals enter the body system when these plants are directly or indirectly consumed and bioaccumulate over a period of time [20-21]. These findings demonstrate the severe risks associated with municipal dumpsites. This indicates that there is an urgent need to conduct studies into heavy metal contamination near urban dumpsites to ascertain their toxic levels and recommend better management options for sustainable development. This study determined the concentration of heavy metals at Oke-ogi dumpsite in Iree, Osun state, Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

Iree is one of the fast growing towns in Osun State, Nigeria. It is located on Latitude 7º55´ N and Longitude 4º43´E (Fig. 1), situated Osogbo-Illa-Orangun road, about 30 km from Osogbo the state capital and 8 kilometres from Ikirun another major town in the state. Iree has a hilly terrain, which make it a beautiful attraction to tourists.

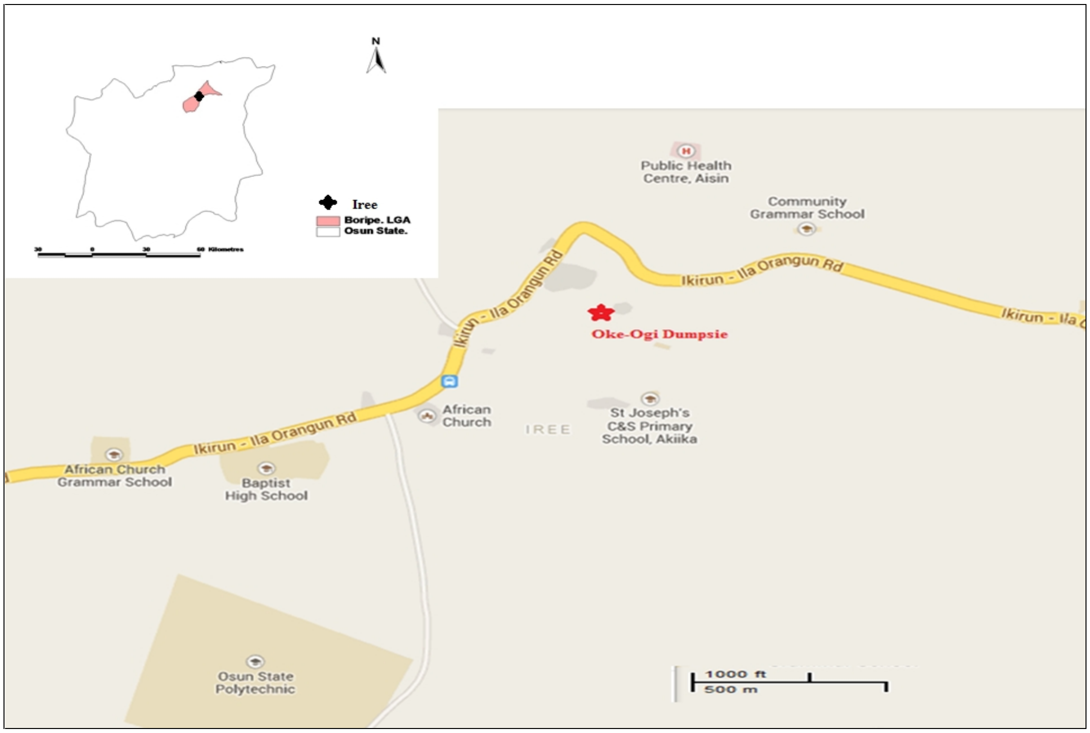

Fig. 1. Iree town in Boripe LGA, Osun State, Nigeria

The town experiences the tropical wet and dry climate with a lengthy wet season and a short dry season. The raining season runs from March through October with a short spell of dryness in August (August break) while the dry seasons (harmattan) is between the months of November and February. Mean annual temperature is about 28.5ºC that is relatively constant throughout the year. In the last three decades, the town have witnessed tremendous growth in population and infrastructural developments with several small-scale and cottage industries coming up. Establishment of schools and expansion of commerce have all contributed to the rise in the volume waste generated. As the volume of waste increase, so also the composition of the waste changes given rise to more toxic compounds in the dumpsite.

2.2 Sample Collection and Preparation

Sampling was conducted in April 2009 at the Oke-ogi dumpsite in Iree, Osun state, Nigeria. Dumpsite soil samples were randomly and separately collected from four different parts of the dumpsite located on the outskirt of the town. A stainless steel sampling auger was used to collect soil samples at 0-15cm, 15-30cm, and 30-45cm depths at each sampling site. An uncontaminated site about 250m away from the dumpsite was used as control site. The samples were pulled together as composite samples and then placed into appropriately labelled polyethylene bags, and taken to the laboratory for analysis. The samples were air-dried at room temperature and sieved through a 0.850mm nylon sieve to remove coarse fragments. The soil samples were then ground mechanically with an agate pestle and mortar and sieved to obtain <2mm fraction. Thirty grams sub-sample was drawn from the bulk [< 2 mm fraction) and reground to obtain <200µm fraction. Samples of waterleaf (*Talinum triangulare*) growing on the dumpsite were collected at the same point where soils were sampled. The vegetable samples were washed in three sequential ways and were then air dried, weighed and placed in a dehydrator at approximately 80ºC for 48 hours. Moisture and water droplets remaining in the dried samples were removed with the help of blotting papers after which the samples were milled to fine powdery form using agate pestle and mortar and pelletized by CAVER model manual palletizing machine.

2.3 Sample Treatment and Data Analysis

The soil samples were by wet ashing while, the plant materials were digested using the dry ashing method, which is suitable for samples that have high organic matter content. Ten grams of the soil sample was weighed into 100ml digestion bottle. Twenty millilitres of concentrated nitric acid was added and boiled gently on a hot plate until the volume of the nitric acid had been reduced to about 5ml. Twenty millilitres of de-ionised H_2O was added and boiled gently again until volume was reduced to about 10ml. The suspension was allowed to cool down, filtered through a Whatman No. 1 filter paper, and then washed with de-ionised H_2O. It was then transferred into a 50ml graduated flask and made up to mark by de-ionised H_2O. The concentrations of heavy metals in all the samples were determined using atomic absorption spectrophotometer [22]. Sol pH was determined with an electronic JENWAY glass electrode pH meter (Model 3510), while particle size of soil samples was determined using the hydrometer method. Soil organic matter (OM) was digested with $H_2SO_4/K_2Cr_2O_7$.and determined with phenanthroline titration. Total nitrogen (TN) was determined by micro-Kjeldahl digestion followed by steam distillation. Total phosphate (TP) was determined colorimetrically by the molybdenum blue method. The chemicals used throughout the experiments were analar grade. Containers were cleansed with hot nitric acid and then rinsed with double distilled water before use while the glass beakers and containers were kept and stored in dilute solution of nitric acid to eliminate any possible contamination.

2.4 Statistical Analysis

All statistical analyses were performed using SPSS 17 for Windows (SPSS Inc., USA). One-way (ANOVA) was carried out to compare the difference of means from various sampling. Pearson’s correlation coefficients of heavy metal elements in dumpsite soil and vegetables (*Talinum triangulare*). The level of significance was set at P=.05 [two-tailed). In order to quantify the relative differences in bioavailability of metals to plants or to identify the efficiency of a plant species to accumulate a given heavy metal, Transfer factor (TF) is the ratio of the concentration of heavy metal in a plant to the concentration of heavy metal in soil. Transfer factor (TF) was computed for the heavy metals based on the formula:

$$Ps\left(\mu g\,g^{-1}\right) \Big/ St\left(\mu g\,g^{-1}\right)$$

where Ps is the plant metal content (Pg) originating from the soil dry weight (g) and St is the total metal contents in the soil [23].

3. RESULTS AND DISCUSSION

3.1 Soil pH, Particle Size Distribution, OM, TN and TP

The soil pH, particle size distribution, OM, TN and TP are presented in Figs. 2-5. Soil pH ranged from 4.73 to 5.45 and averaged 5.0 for the dumpsite soil which indicated that the soil in the three layer were acidic in nature. For the control site, the soil pH ranged from 6.97 to 7.54, with an average of 7.24 showing slightly alkaline nature of the soil (Fig. 2).

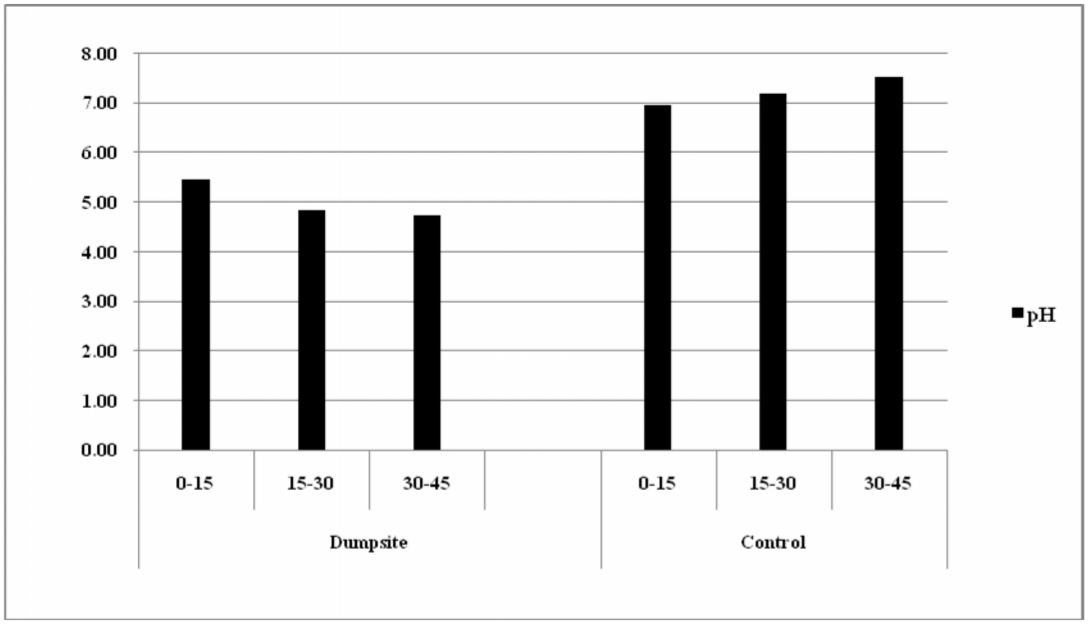

Fig. 2. Soil pH in the Oke-ogi dumpsite and the control site

The results showed that the soils were predominantly sandy with the top-layer (0–15cm) containing higher percentage of sand for both the dumpsite and control site (Fig. 3).

There is no significant difference in the particle size distribution for both the dumpsite and control site soils. Clay content is however higher in the control site soil, and this increases down the profile. Organic matter (OM) content of the soil varies significantly (P=0.05) with higher content in the top soil (0-15cm). Soil organic matter for the top soil for the dumpsite soil was 14.78% compared to 17.81% for the control site (Fig. 4).

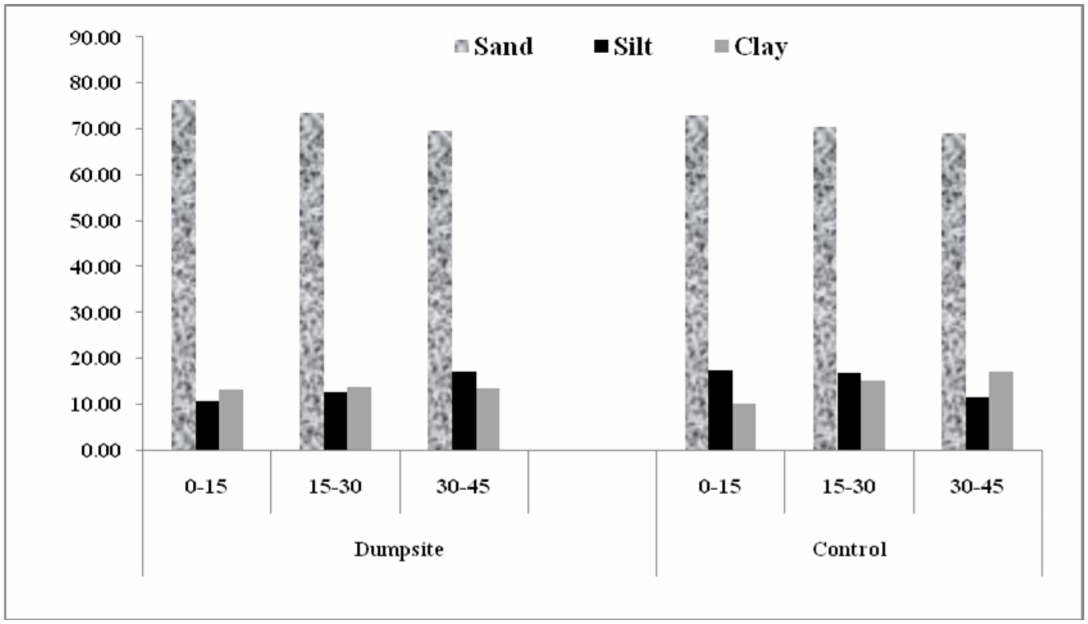

Fig. 3. Particle size distribution of the soils of Oke0ogi dumpsite and control site

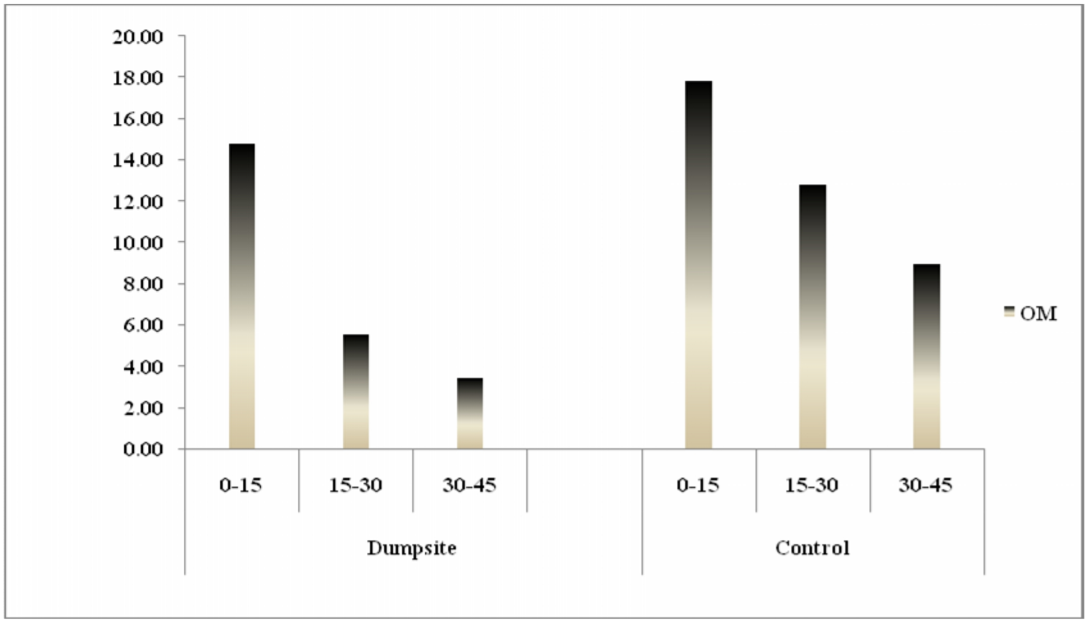

Fig. 4. Organic matter content of Oke-ogi dumpsite soil and control site

Total nitrogen (TN) and total phosphorous (TP) in the different layer of the soils are shown in Fig. 5 below. TN varies from 0.45g/kg to 0.99gkg^{-1} in the dumpsite compared to 1.00 g/kgto

1.30gkg^{-1} in the control site. The topsoil (0-15cm) significantly have higher TN contents which is similar to that of the TP (Fig. 5). Soil properties such as pH, texture, and organic matter have been shown to influence the solubility of heavy metals [24].

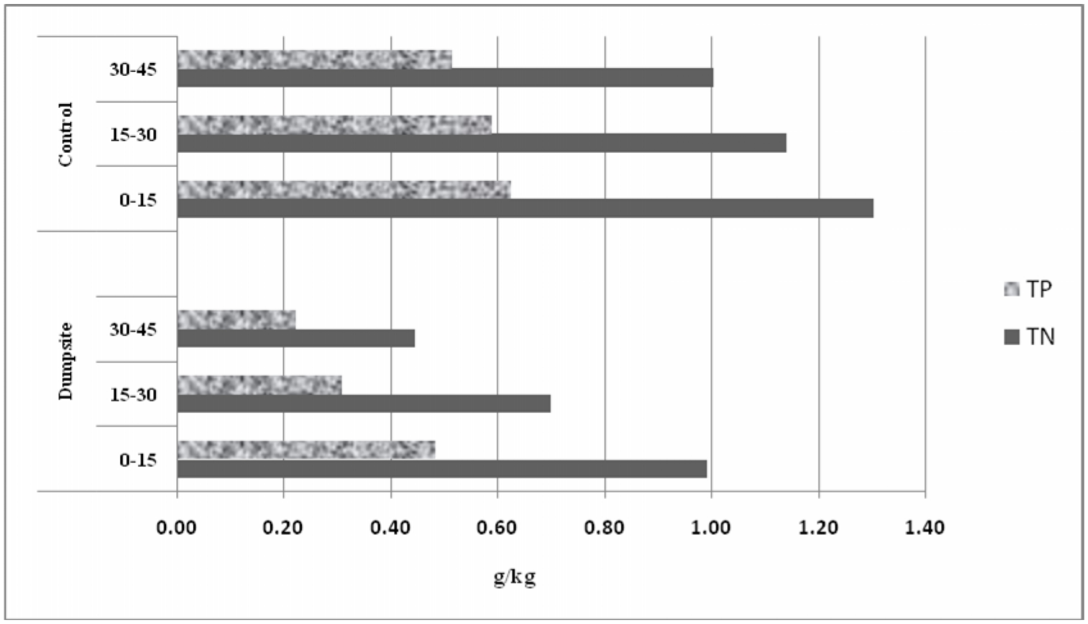

Fig. 5. TN and TP in Oke-ogi dumpsite soil and control site

3.2 Heavy Metals in the Soils

Heavy metals concentrations in soil are associated with biological and geochemical cycles and are influenced by anthropogenic activities such as agricultural practices, industrial activities and waste disposal methods [25]. In this study there are significant differences (P=0.05) in the concentrations of heavy metals in the soils collected from the dumpsite relative to the control site. The topsoil (0–15cm) heavy metal levels in the soil varied from 1.05±0.06mgkg-1for the control site to 2.58±0.89mgkg^{-1} in the dumpsite soil (Table 1). The mean values of all heavy metals decrease down the soil profile for both the dumpsite soil and the control site. Of all the metals, Pb had the highest mean ± SD 91.67±13.80mgkg^{-1} followed by Zn, which is 20.85±4.80mgkg^{-1}. Mean concentration of Pb and Zn in the soil of the control site is significantly lower than (Pb, 10.67±2.08mgkg^{-1}) and (Zn, 2.58±0.38mgkg^{-1}) respectively. The concentration of heavy metals in the soils for this study is considerably lower compared to the Pb level of 2467mgkg^{-1} reported by Nduka et al. [26] in a study of soil samples of refuse dumps in Awka (Anambra State, Nigeria). Although little is known about the toxicity of Zn in humans [26], it has been reported that Zn interferes with Cu metabolism [27-28]. Furthermore, Salgueiro et al. [29] stated that an acute oral Zn dose may results in symptoms such as tachycardia, vascular shock, dyspeptic nausea, vomiting, diarrhoea, pancreatitis and damage of hepatic parenchyma.

The values recorded for Pb were higher than the allowable limits for soils in most of the countries [30]. The level of Cd detected in the soil varied from 1.05mgkg^{-1}in the 0-15cm layer in the control site to 2.58mgkg^{-1} in the dumpsite soil. Pb and Cd normally do not accumulate in the topsoil but, anthropogenic activities such as dumping of wastes can increase their concentration in the soil [31]. Anthropogenic contribution to cadmium and lead contamination of the environment can therefore be significantly more than natural input [12]. While cadmium is not considered as an essential element for human being, its toxic effects together with lead are recognized [32]. The half-life of cadmium in human body is between one and four decades [33], which makes it to be able to accumulate in vital organs such as the liver, lungs and kidneys thus causing damages. Concentration of Co in the dumpsite soil (0.02–0.72mgkg^{-1}) for this study generally lower than values obtained in similar studies such as Awokunmi et al. [34] that ranged between 105–810mgkg^{-1}.

Table 1. Descriptive statistics of heavy metals in the dumpsite and control site soil (mgkg^{-1})

	Dumpsite						
	Cadmium	**Cobalt**	**Copper**	**Lead**	**Manganese**	**Nickel**	**Zinc**
0-15 cm							
Mean	2.58±0.89	0.72±0.12	3.30±0.25	91.67±13.80	4.28±1.10	2.91±0.60	20.85±4.80
Range	1.56	0.22	0.49	26.00	2.20	1.20	9.50
Minimum	1.56	0.59	3.07	76.00	3.19	2.34	16.50
Maximum	3.12	0.81	3.56	102.00	5.39	3.54	26.00
15-30 cm							
Mean	2.25±0.21	0.42±0.03	2.58±0.19	60±14.42	3.20±0.13	1.91±0.45	12.78±3.30
Range	0.41	0.06	0.37	28.00	0.26	0.89	6.30
Minimum	2.07	0.39	2.41	48.00	3.08	1.45	10.20
Maximum	2.48	0.45	2.78	76.00	3.34	2.34	16.50
30-45 cm							
Mean	1.18±0.02	0.02±0.01	1.71±0.08	23±3.61	2.77±0.12	1.07±0.03	7.53±0.43
Range	0.04	0.01	0.15	7.00	0.23	0.05	0.78
Minimum	1.16	0.02	1.65	20.00	2.67	1.05	7.24
Maximum	1.20	0.03	1.80	27.00	2.90	1.10	8.02
	Control						
0-15 cm							
Mean	1.05±0.06	0.07±0.01	1.56±0.29	10.67±2.08	2.06±0.42	1.12±0.07	2.58±0.38
Range	0.11	0.02	0.58	4.00	0.78	0.14	0.68
Minimum	0.98	0.06	1.27	9.00	1.76	1.06	2.34
Maximum	1.09	0.08	1.85	13.00	2.54	1.20	3.02
15-30 cm							
Mean	0.0±0.00	0.03±0.02	0.45±0.09	6.13±0.81	1.17±0.25	0±0.00	2.05±0.09
Range	0.00	0.03	0.18	1.60	0.47	0.00	0.18
Minimum	0.00	0.02	0.38	5.40	0.98	0.00	1.95
Maximum	0.00	0.05	0.56	7.00	1.45	0.00	2.13
30-45 cm							
Mean	0.00±0.00	0.02±0.02	0.27±0.09	3.19±1.03	0.61±0.28	0.00±0.00	1.42±0.23
Range	0.00	0.03	0.17	1.82	0.55	0.00	0.45
Minimum	0.00	0.01	0.17	2.00	0.32	0.00	1.21
Maximum	0.00	0.04	0.34	3.82	0.87	0.00	1.66

Concentrations of cobalt in the soil are attributed to indiscriminate disposal of cobalt containing wastes on the dumpsites. High uptake of Co can be carcinogenic and causes vomiting, nausea, vision problems, heart ailments and thyroid damage [35]. While the natural range of concentration of Cu in soil is 2-100 mgkg^{-1} [36], the concentration in this study ranged between 1.71 to 3.30mgkg-1 and 0.27 to 1.56mgkg^{-1} for dumpsite and control site in the present study (Table 2). These values are however within soil critical range (50-250mgkg^{-1}) as given by Kabata-Pendias and Pendias [37]. Copper is an essential element that plays important roles in iron and catecholamine metabolism, free radical scavenging, and in the synthesis of hemoglobin, elastin and collagen [38]. Anikwe and Nwobodo [39] reported high level of heavy metals (Pb, Fe, Cu and Zn) in their study of the long term effects of municipal waste disposal on soil properties and productivity of sites used for urban agriculture in Abakaliki, South Eastern part of Nigeria. Urban soils such as that of the dumpsite receive loads of contaminants that are usually greater than in the surrounding areas due to the concentration of anthropogenic activities of urban settlements [38,40]. Basically heavy metal concentrations followed the order of Pb>Zn>Mn>Cu>Cd>Co in the both the control and dumpsite soils. High concentrations of heavy metals obtained at the Oke-ogi dumpsite showed that concentrations of the metals in dumpsite soils is not dependent on the age of the dumpsite but on the source and composition of the waste disposed on the in the area [13]. Though these heavy metal concentrations falls below the critical permissible concentration level, their persistence in these soils of the dumpsite may lead to increase uptake by plants, though their transfer ratio differ from crop to crop [41].

Table 2. One-way ANOVA of heavy metal contents in dumpsite soil

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	4870.25	6.00	811.71	4.24	0.003	2.37
Within Groups	6702.95	35.00	191.51			
Total	11573.21	41.00				

Analysis of variance (ANOVA, $p<0.05$) showed that there were significant differences in heavy metals concentration in the dumpsite.

3.3 Heavy Metals in Plant

Accumulation of metals in edible vegetables poses a great threat to human health especially to local communities that collect vegetables such as waterleaf freely growing on dumpsites. For this reason the International and national regulations on food quality have lowered the maximum permissible levels of toxic metals in food items due to an increased awareness of the risk, these metals pose to food chain contamination [42]. Waterleaf (*Talinum triangulare*) is a leafy vegetable commonly grown in many parts of Nigeria and is also found growing widely on most municipal dumpsites. Concentration of Pb ranged from 3.65 to 4.11mgkg^{-1} and Cd from 2.12 to 3.09mgkg^{-1}. Cadmium is a highly mobile metal, easily absorbed by the plants through root surface and moves to wood tissue and transfers to upper parts of plants [28] growing on dumpsites. Metal accumulation in the vegetables taken from the Oke-ogi dumpsite varies significantly from one element to the other (Table 3). Zn is the most abundant element in the vegetable with a mean value of 8.63 mgkg^{-1} followed by Mn (4.28mgkg^{-1}).

Concentration of Co is almost below detection limit, with mean of 0.01±0.003mgkg^{-1}. The mean concentration of Cu in the vegetable sampled was 2.53mgkg^{-1} relative to 3.30mgkg^{-1} found in the topsoil of the contaminated soil. Xiong and Wang [42] found that Cu concentration in the plant shoots was significantly influenced by Cu concentration in soil and increased markedly with an increase in the soil Cu concentration. Several other studies have reported uptake of heavy metals including Cu and Pb by vegetables e.g. water leaf (*Talinum triangulare*) and *Amaranthus* species from soils of contaminated sites such as refuse dumpsites and animal waste dumpsites [43]. Uwah et al. [44] observed heavy metal values ranging from 0.04±0.01 and 0.09±0.01µgg^{-1} for Cd, to 90.50±2.22 and 93.50±2.58µg g^{-1} for Cr, in Alau dam and Gongulon respectively in Maiduguri, Nigeria. Vegetables can absorb metals from polluted soils as well as from deposits on the parts of the vegetables exposed to the air from polluted environments [19]. Ademoroti [45] have shown that vegetable growing on contaminated soils accumulate considerable amount of heavy metal in roots and leaves. The uptake and bioaccumulation of heavy metals in vegetables is influenced by many factors such as atmospheric depositions, climate, the concentrations of heavy metals in soils, the nature of soil and the degree of maturity of the plants at the time of the harvest [46-47].

Table 3. Descriptive statistics of the metal concentration in vegetable growing on the Oke-ogi dumpsite

	Cd	Co	Cu	Pb	Mn	Ni	Zn
Mean	2.58	0.01	2.53	3.61	4.28	2.14	8.63
Median	2.54	0.01	2.59	3.65	4.03	2.23	8.67
Standard Deviation	0.49	0.00	0.52	0.52	0.67	0.45	0.52
Range	0.97	0.01	1.03	1.04	1.26	0.89	1.03
Minimum	2.12	0.00	1.98	3.07	3.78	1.65	8.10
Maximum	3.09	0.01	3.01	4.11	5.04	2.54	9.13

The values obtained for heavy metals in vegetable in this study were low when compared to similar studies such as Okoronkwo et al. [41] who reported Pb level as 105.37±45.37mgkg^{-1} and 111.51±17.78mgkg^{-1} in the leaves of cocoyam and cassava respectively. Furthermore, Akan et al., [48] reported concentrations metals in vegetable samples ranging from 0.23 to 3.43mgkg^{-1}; 0.23 to 3.45mgkg^{-1}; 0.25 to 4.56mgkg^{-1} 0.87 to 8.34mgkg$^{-1;}$ 0.34 to 5.44mgkg^{-1} and 0.21 to 3.22mgkg^{-1} for Mn, Fe, Pb, Zn, Cd and Cu respectively; for agricultural areas of Biu, North Eastern Nigeria. High concentrations of heavy metal in the vegetable leaves are mostly due the composition of waste in the dumpsite, which have changed due to increasing population and consumption pattern. Much of toxic metals such as Cd and Pb get into the human body by direct ingestion of vegetables or other plants that absorbs metals from contaminated soils [16]. The result from this study revealed that Pb concentration in the waterleaf is higher than the WHO limit, while mean concentration of 8.63mgkg^{-1} for Zn is lower that the WHO limit. This agreed with Odai et al. [49] who reported that concentration levels of heavy metals such as cadmium, lead, copper and zinc in vegetables grown on urban waste dumpsites in Kumasi, Ghana. The levels of the two most toxic heavy metals were far higher in the vegetables than the WHO/FAO recommended values and the transfer factors of these two metals were also the highest suggesting that consumption of vegetables grown on such sites could be dangerous to human health. High level of metals can be harmful to plants and indirectly poison humans and animals that consume the vegetable. Studies have reported that continuous intake of heavy metal in vegetables and other foodstuffs can lead to alteration of humans and animals healthiness state. Turkdogan et al. [50] noted that the carcinogenic effects generated by continuous consumption of fruits and vegetables loaded with heavy metals such as Cd, Pb or even Cu and Zn are well known. It is hypothesised that there are significant differences in the levels of individual heavy metal concentration in the dumpsite soils and the plants growing on the dumpsite.

3.4 Transfer Factor

According to Lokeshwari and Chandrappa [51] the transfer factors were based on the root uptake of the metals and discount the foliar absorption of atmospheric metal deposits. Transfer factors for heavy metals from soils to vegetables in this study are presented in Table 4. Highest TF values were obtained for Cd, Mn, Cu and Ni in that order. TF for Cd and Mn were 1, while others values are below 1. Overall TF values of Pb and Co were 0.04 and

0.01 respectively, while those of Cd, Mn Cu, and Ni were quite high and significant corroborating the findings that accumulation of Cd, Cu and Zn are more in plants [44].

Table 4. Transfer factor [TF] for the metals in soil to the vegetable at Oke-ogi dumpsite

Cd	Co	Cu	Pb	Mn	Ni	Zn
1.00	0.01	0.77	0.04	1.00	0.74	0.41

3.5 Relationship between the Heavy Metals in *Talinum triangulare*

Pearson's correlation coefficient revealed a strong correlation between the heavy metal concentration in the dumpsite soil and the concentrations in *Talinum triangulare*. A correlation analysis between heavy metal concentrations in the topsoil at the dumpsite with the vegetable growing on the dumpsite revealed significant positive correlation (*P*=0.05) existed for all the metals. High positive correlations of Cd, Co. Cu, Pb and Ni were observed Indicating that they are being influenced by similar anthropogenic sources (Table 5).

Table 5. Soil-Vegetable heavy metals correlation matrix

	Cd	Co	Cu	Pb	Mn	Ni	Zn
Cd	1.00						
Co	1.00	1.00					
Cu	1.00	1.00	1.00				
Pb	1.00	1.00	1.00	1.00			
Mn	-0.69	-0.70	-0.67	-0.71	1.00		
Ni	1.00	1.00	1.00	1.00	-0.68	1.00	
Zn	1.00	1.00	1.00	1.00	-0.70	1.00	1.00

4. CONCLUSION

Concentration of Pb in the dumpsite soil was higher than the allowable limit, while Zn and others were low or within the range allowed. All heavy metals investigated in dumpsite soil were found in concentrations higher than the control site. Metal accumulation in the vegetables taken from the Oke-ogi dumpsite varies significantly from one element to the other. Zn is the most abundant element in the vegetable with a mean value of 8.63mgkg^{-1} followed by Mn (4.28mgkg^{-1}). High concentrations of heavy metal in the vegetable leaves are mostly due the composition of waste in the dumpsite, which have changed due to increasing population and consumption pattern. The transfer factor (TF) of the metals showed significant accumulation of Cd, Cu and Zn in the vegetable. This suggested that consumption of vegetables grown on such sites could be dangerous to human health. Elevated heavy metal concentration dumpsite need to be properly addressed given the fact that the people are dumping inorganic waste. To deal with heavy metal contamination and decrease their dietary toxicity of micro-organism-based remediation techniques, such as bioremediation that have shown potential for their ability to degrade and detoxify certain contaminants should be adopted.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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