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Research Article

Assessment of Heavy Metal Pollution Levels in Soils of Keffi, Landfill and Solid Waste Dumpsite and Its Ecological Risk

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Abstract: This study was carried out to quantitatively assess the heavy metal pollution level of soils collected from different landfill and solid waste dumpsite in keffi metropolis of Nasarawa State, Nigeria. Soil samples were collected from different landfill and dumpsites in Keffi metropolis at the depth of 0-30 cm. A total of 5 random samples per location and composited to obtain a laboratory sample. The collected soil sample were allowed to dry under normal temperature within soil sample preparation room of Department of Agronomy Nasarawa State University Shabu Lafia Campus. The analysis for heavy metal was conducted using Atomic Absorption Spectrometer (AAS). The levels of concentration these metals varied across soil among sampling point. The mean order of heavy metal concentration in Keffi is Zn>Fe>Mn>Pb>Al>Cu>Se>Ni>As>Hg respectively. The pollution indices such as Contamination factor (CF), Pollution load index (PLI), Contamination degree (Cd), Potential contamination index (Cp) and potential ecological risk index (RI) were used for the metal enrichment and contamination status was also calculated. The CF, Cd, Cp, PLI and RI values of the studied metals indicated that the study area does not posed risk to local environments. The concentration of heavy metal indicated that the study area does not posed high risk to local community but the odour from the land fill and dumping site pollute the air which causes respiratory problems. Hence, this open landfill should be closed from use in future and or properly managed by recycling in order to minimize future pollution problems. The mean order of heavy metal concentration in plant samples is Fe>Zn>Mn>AL>Pb>Cu>Cr>Ni >As>Hg respectively. The heavy metal (Fe and Zn) contents in the plants were higher compared to other metals analysed. The concentration of some metal was relatively high in the maize plant, but there were all below the WHO permissible limit except for Zn metal. The transfer factor (Tf) revealed that plants grown on dumpsite and landfill soils absorbed and accumulates heavy metals. The highest transfer factor value was obtained in Fe, followed by Cu, Pb, Zn, Al, Mn, Ni and As respectively.
Keywords: Heavy metal, Solid waste, dumping site, soil pollution, adjacent community.

1.0 Introduction

Soil is a precious natural resource upon which economic activity like agriculture and existence of life depend. The soil is a primary recipient of solid wastes disposal (Nyles and Ray, 1999). The disposal of domestic, commercial and industrial waste constitutes a major problem in many big cities and urban settlements. Waste disposal are done indiscriminately in cities with materials disposed off at locations that are unlawful and where it could result in environmental or health hazards to humans and animals (Olayiwola *et al.*, 2017). This is due to increase in population resulting from economic development in these cities (Harrison and Maduabuchi, 2019).

Keffi`s proximity to the Federal Capital Territory (FCT), has witnessed remarkable expansion and growth in recent years. This rapid population growth overwhelms the capacity of the municipal authorities to provide the basic management services (Agunwamba, 1998). Increased growth of anthropogenic activities, especially in urban centres, is one of the main sources of toxic substances in the soil (Getachew and Habtamu, 2015). These municipal refuse dumps contributes to the increase in heavy metal concentration in soil and underground water (Uba *et al.*, 2007), which may have effects on the host soils, crops, animal and human health (Smith *et al.*, 1996; Nyle and Ray, 1999). Also according to Fonseca *et al.*, (2011) the release and disposal of heavy metals from anthropogenic activities have been responsible for the increasing concentrations of these contaminants in soil environments. Thus, the environmental impacts of municipal refuse are greatly influenced by their heavy metal contents.

Heavy metals constitute heterogeneous group of elements widely varied in their chemical properties and biological functions. The term “heavy metals” defined as those metals, which have specific weights more than 5g cm^{-3} (Holleman and Wiverd, 1985). Heavy metals are kept under environmental pollutant category due to their toxic effects in plants, human and food. Some of the heavy metals such as Arsenic (As), Cadmium (Cd), Lead (Pb), Mercury (Hg) are cumulative poison. These heavy metals are persistence, accumulate and not metabolized in other intermediate compounds and do not easily degraded in environment. These metals are accumulating in food chain through uptake at primary producer level (plant) and then through consumption at consumer level.

The presence of heavy metals in the environment is considered to be important due to their toxicity at certain concentrations, translocation through food chains and non-biodegradability which is responsible for their accumulation in the biosphere (Awofolu, 2005; Hammed *et al.*, 2017). The effects of heavy metals depend on their bioavailability and they have been extensively studied for their consequences on human and animal health (Malomo *et al.*, 2013; Ekmekyapar *et al.*, 2012), but there is no record of any information on the heavy metals contents of soils and plants in this area. The aim of this work is to assess the heavy metal contamination in soils and maize plant grown on landfill and dump site around the city.

2.0 Materials and Methods

2.1 Description of Experimental Location

The study was conducted in Keffi metropolis of Nasarawa State. Keffi L.G.A is located in North Central Nigeria between latitudes $8^0\, 51^1$ and $8^0\, 53^1$ North of the equator and longitudes $7^0\, 50^1$ and $7^0\, 51^1$ East of the Greenwich meridian. Keffi is located about 128km away from Lafia, the Nasarawa State Capital and about 57km away from Abuja, the Federal Capital Territory of Nigeria. Keffi is the smallest L.G.A in the whole of Nasarawa State with a total land area of approximately $140km^2$. The 2006 population census puts the population of Keffi L.G.A at 92,664 persons (Keffi, 2012 and National Bureau of Statistics (NBS), 2006). The area has a population density of 661 persons/km^2. In recent time the population of Keffi town would have been more than the figure above due to increase in the number of settlements. The area is characterized by a tropical sub-humid climate with two distinctive seasons (wet and dry (Binbol, 2007 and Lyam, 2000). The wet season starts from late April and ends in October.

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Annual rainfall of the area ranges between 1100mm to about 2000mm and about 90% of the rain falls between May and September with the wettest months being July and August. Temperatures are generally high in Keffi especially during the day, partly because of its location in the tropical sub-humid climate (Binbol, 2007). Average monthly temperatures ranges between 26.8^{0}C and 27.9^{0}C, with the hottest month being March/April and the coldest month being December/January (Lyam, 2000). Unlike the other elements, wind velocity in this region is relatively steady (Binbol, 2007). The vegetation lies in the Guinea Savanna a derivative of the tropical deciduous forest and is characterized with interspersed of thick, grassland, savannah trees, and fringing woodland or gallery forests along the valleys. The topography of the land is slightly undulating (high to low) and the geology consist mostly of the Basement complex; Migmatite–Gneisses associated with the older granites. The older granites are mainly biotite granites (Obaje *et al.*, 2007). The predominant soil parent materials in the area are derived from the cretaceous sandstone, siltstone, shale and ironstone of the Precambrian to Cambrian (Samaila and Ezeaku, 2007).

2.2 Sample Collection

Samples were collected from Keffi L G A area of the State in the month of June, 2019. Table 1 shows the latitude and longitude of the sampling locations of the study area.

Table 1. The latitude and longitude of the sampling locations of the study area.

S/N	City/town	Latitude (N)	Longitude (E)	Location
1	Keffi	08^o 50.682’	007^o 54.200’	High court area
2	Keffi	08^o 49.168’	007^o 52.508’	Gauta
3	Keffi	08^o 49.996’	007^o 53.131’	Stadium Area
4	Keffi	08^o 50.638’	007^o 53.089’	Kofankokona
5	Keffi	08^o 51.138’	007^o 52.603’	Yankokora
6	Keffi	08^o 50.692’	007^o 52.339’	Gindin-dutse
7	Keffi	08^o 49.469’	007^o 51.811’	El Kabir estate Area
8	Keffi	08^o 50.339	007^o 55.537	Old Barrack

Soil samples from the landfills and dumping sites were collected in June, 2019 from all the locations in Keffi local government areas. Soil samples were collected at a depth 0 -30cm in five points from each site and mixed together to form a composite sample using a metalic soil probe. Global Positioning System (GPS), for Sample points (Table 1) location, masking tape, writing materials, polythene bags and malex were sample collections equipments used. Soil samples were taken at a depth of 0- 30 cm were quickly packed in air tight polythene bags and label before taken to the laboratory for sample preparation and analysis.

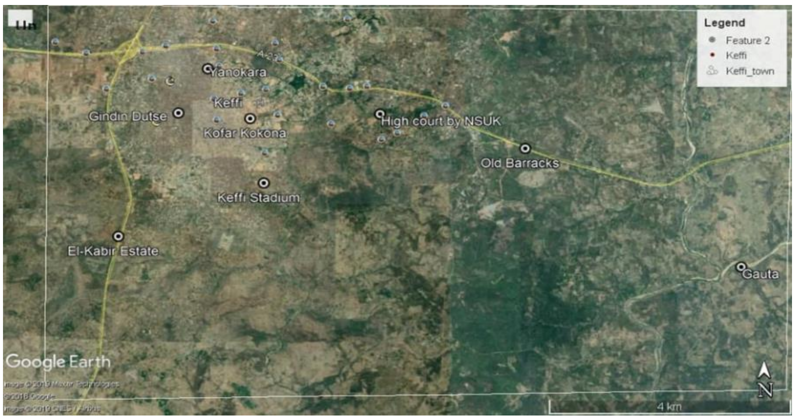

Plate 1. Google earth map showing the study locations

Plate 2. Showing some landfills and dumpsite in Keffi

2.3 Sample Preparation

The collected soil samples were air dried in the soil laboratory of the Nasarawa State University, faculty of Agriculture for a week and then grinded, passed through a 2mm sieve to remove stones, plant roots in order to have uniform soil particle size. The sieved sample was stored in labelled plastic cans for analysis. A sub sample of 50g from each sample were transferred to digestion vessels with 7.5 ml of HCl and 2.5 ml of concentrated HNO_3 (3:1 HCl:HNO_3). The total concentrations of CO, Pb, Ni, Mn, Cr and Cd in filtrates were then determined using a Flame Atomic Absorption Spectrometer (model PG990, PG Instruments Ltd, United Kingdom) using air acetylene flame. Also the plant materials were put in an envelope and oven dried at temperature of 65^0C for two days. The oven dried material was crushed and 0.5g was put into the crucible and then ashed. Dispensed with 15ml of aqua regia solution inside the crucible and raised the solution into the centrifuge tube. The centrifuge tube was cover and shakes for 5minutes and then centrifuge for 10mins. The supernatant was transferred into glass vials for reading in the AAS.

2.4 Assessment of the contamination

To assess the degree of pollution of this heavy metal requires that the pollutant metal concentrations are compared with an unpolluted reference material (geochemical background values). Absence of established background values of metal concentrations in the two sites necessitated the use of the reference material. The reference material represents a benchmark to which the metal concentrations in the polluted samples are compared and measured. Literature indicates that many authors have used the average sandstone, shale values or the average crustal abundance data as reference base lines.

In this study, some methods of pollution assessment of metals were conducted, the potential contamination index (CP), contamination factor (CF), pollution load index (PLI) and Hakanson potential ecological risk index (Hakanson, 1980).

2.5 Contamination factor (CF)

The level of metal contamination was calculated using the contamination factor (CF). CF is the ratio between the metal content in the soil sample to the background value of the metal (Turekian and Wedepohl, 1961). It is used as an effective tool for monitoring the pollution over a period of time and it is calculated as follows

CF = Ci /Cb background ……. 1

Ci = heavy metal concentration in sample

Cb = the preindustrial reference value for the substance

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Hakanson (1980), categorises levels contamination is soil: CF<1 indicates low contamination; 1<CF<3 is moderate contamination; 3<CF<6 is considerable contamination; and CF>6 is very high contamination.

2.6 Contamination Degree

The degree of contamination (CD) was also used to determine the contamination status of soil in the study area. The formula for Degree of contamination is stated below;

$$Cd = \sum_{i=1}^{i=n} CF \quad \text{...2}$$

Cd = Summation of all the contamination factor (CF)

The Cd is aimed at providing a measure of the degree of overall contamination in surface layers in a particular sampling site. Hakanson (1980) proposed the classification of the degree of contamination in sediments as:

Cd<6 Low degree of contamination
6<Cd<12 Moderate degree of contamination
12<Cd<24 Considerable degree of contamination
Cd> 24 High degree of contamination

2.7 Potential contamination index (Cp)

The potential contamination index can be calculated by the following method.

$$Cp = \frac{(\text{Metal})\ \text{Sample Max}}{(\text{Metal})\ \text{Background}} \quad \text{...3}$$

Where (Metal) sample Max is the maximum concentration of a metal in soil, and (Metal) Background is the average value of the same metal in a background level. Cp values were interpreted as suggested by Dauvalter and Rognerud (2001), where Cp<1 indicates low contamination; 1<Cp<3 is moderate contamination; and Cp>3 is severe contamination.

2.8 Pollution load index (PLI)

The Pollution load index (PLI) represents the number of times by which the heavy metal concentrations in the sediment exceeded the background concentration, and give a summative indication of the overall level of heavy metal toxicity in a particular sample and is determined as the nth root of the product of nCF. PLI for the soil samples was determined by the equation below, as proposed by Tomilson *et al.*, (1980).

$$PLI = (CFn \times CFn \times CFn \times CFn \times CFn \times CFn)1/n. \quad \text{..................................4}$$

Where CFn is the CF value of metal n. It gives simple and comparative means for assessing the heavy metal pollution level in the soil sample. The PLI values are interpreted into two levels as polluted (PLI>1) and unpolluted (PLI<1), (Chen *et al.*, 2005).

2.9 Potential ecological risk index

Hakanson (1980) proposed a method for the potential ecological risk index (RI) to assess the characteristics and environmental behaviour of heavy metal contaminants in soils. The main function of this index is to indicate the contaminant agents and where contamination studies

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should be prioritized .CF is the contamination factor, and Tri is the toxic response factor, representing the potential hazard of heavy metal contamination by indicating the toxicity of particular heavy metals and the environmental sensitivity to contamination. The standard toxic response factor proposed by Hakanson (1980), As, Ni, Pb, Cu and Zn have toxic response factors of 10, 5, 5, 5 and 1 respectively.

Eri = Tr i × CF……………………………………………………….….5

where *Tri* is the toxic-response factor for a given substance and *Cf* is the contamination factor.

$$RI = \sum_{i=1}^{n} Er$$

This is used to describe the risk factors and RI was suggested by Hakanson (1980), where: <40 indicate a low potential ecological risk; 40<Er<80 is a moderate ecological risk; 80<Er<160 is a considerable ecological risk; 160<Er<320 is a high ecological risk and Er> 320 is a very high ecological risk. RI<95 indicates a low potential ecological risk; 95<RI<190 is a moderate ecological risk; 190<RI<380 is a considerable ecological risk and RI > 380 is a very high ecological risk.

2.10 Transfer Factor (TF)

Transfer factor was calculated as a ratio of heavy metals concentration in the extracts of soils and vegetables.

PCF **=** Cplant/Csoil (Ciu *et al.*, 2005)

Where C plant and C soil represent heavy metal concentration in extracts of maize plant and soils on dry weight basis, respectively.

2.11 Data analysis

For all the parameters tested, comparisons of means were analysed statistically using SPSS statistic package. The relationships between the heavy metals were established using the Pearson Correlation index. All statistical analyses were performed using SPSS 16.

3.0 Results

3.1 Heavy metal concentration (mg/kg^{-1}) in soil of Keffi landfill and dumping sites

The results of the chemical analysis of heavy metal concentration in keffi landfill and dumping sites are presented in table 2, alongside with the potential contamination index (CP). The ranges of the heavy metal concentration in mg/kg in soil are as follow: Pb (0.57–2.1630, mean 0.8804), Zn (2.51–7.7730, mean 5.4498), Cd (-0.51–0.2740, mean -0.4756), Cu (0.17-0.8250, mean 0.3620), Cr (-0.12–0.015, mean- 0.0531), Fe (1.584–4.0830, mean 2.8180), Mn (0.5730–2.0270, mean 1.2746), Ni 0.01–0.2190, mean 0.1238), Se 0.02–0.3610, mean 0.1549), Al 90.06–1.1950, mean 0.8639), As (-0.02- 0.0580, mean 0.2340), Hg (0.0000). The mean order of heavy metal concentration is Zn>Fe>Mn >Pb>Al>Cu>Se>Ni >As>Hg in the study area.

The mean concentrations of heavy metals vary per sample in all the sampling location and this may be due to the nature of the composition of this anthropogenic waste in the sites. These results indicate that the concentrations of heavy metals in the soils investigated are not

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yet an environmental concern neither do they pose any ecological hazards arising from their concentration. The Cp values of heavy metals shows less than one (1) indicating that the soils are low contamination.

Table 2. Heavy metal concentration (mg/kg^{-1}) in soil of Keffi landfill and dumping sites

	Pd	Zn	Cu	Fe	Mn	Ni	Sn	Al	As	Hg
Stadium	0.5730	4.0760	0.2460	4.0830	0.5730	0.0470	0.0430	0.6030	0.0130	0.000
El–Kabir Estate	0.6370	2.5740	0.2550	4.0690	2.0270	0.1400	0.2210	0.7960	0.0580	0.0010
Grindi Dutse	0.8060	7.5530	0.5270	3.2620	1.1800	0.1980	0.2770	0.8240	0.0310	0.0010
Gauta	0.7270	4.6350	0.3070	2.2800	1.5640	0.0940	0.3610	0.9060	0.0330	0.0010
Yankokara	0.8820	7.7730	0.8250	2.1870	1.1550	0.1150	0.1390	1.0050	0.0210	0.0010
Highcourt Zone	0.5730	7.3730	0.1810	2.6560	1.6340	0.1630	0.0170	1.1950	0.0210	0.0000
Keffi–Kokona	0.6820	5.2920	0.1700	2.4230	1.1330	0.0140	0.0960	0.8860	0.0350	0.0000
Old Barracks	2.1630	4.3820	0.3850	1.5840	0.9310	0.2190	0.0850	0.6960	ND	0.0000
Mean	0.8804	5.4498	0.3620	2.8280	1.2746	0.1238	0.1549	0.8639	0.0234	0.0005
Minimum value	0.57	2.51	0.17	1.58	0.570	0.01	0.02	0.60	ND	0.000
Maximum Value	2.1630	7.7730	0.8250	4.0830	2.02.70	0.2190	0.3610	1.1950	0.0580	0.0010
Back Ground Value	70	110	50	47200	110	27	3	88000	7	0.25
Cp	0.0309	0.0706	0.0165	0.000086	0.0184	0.0081	0.1203	0.000013	0.0083	0.0040
ND = not detected										

3.2 The results of Contamination factor (CF), Pollution load index (PLI) and Contamination Degree (Cd) of Keffi landfill and dumping sites

The results of Contamination factor (CF), Pollution load index (PLI) and Contamination Degree (Cd) of Keffi landfill and dumping sites are presented in Table 3.

The calculated values of contamination factor (Cf) are generally low for all the heavy metal analysed from the sites. The calculated value ranges for the metals are: Pb (0.0082–0.0309), Zn (0.0229– 0.0670), Cu (0.0034–0.0165), Mn (0.0052–0.0184), Ni (0.0005–0.0184), Se (0.0056– 0.1203), As (0.0003–0.0104) respectively. These show the variation of contamination factor in all the locations.

The values were lower than 6 and therefore indicating low degree of contamination. Also the values obtained for Contamination Degree (Cd) were: Pb (0.1006), Zn (0.3963), Cu (0.0473), Mn (0.0926) Ni (0.0366) Se (0.4128), As (0.0325) respectively. The contamination degree (Cd) of soil samples from the all the sites were low and the calculated values were lower than 6, therefore indicating low degree of contamination. The pollution load index (PLI) values ranged from 0.010-0.029, with mean value of 0.020. PLI value of all soil samples is less than one this means the area is not polluted. The study further shows that all the metals are below pollution concerns.

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Table 3. Contamination factor (CF), Pollution load index (PLI) and Contamination Degree (Cd) of Keffi open landfill and dumping sites

	Pd	Zn	Cu	Mn	Ni	Se	As	PLI
Stadium	0.0082	0.0371	0.0049	0.0052	0.0017	0.0143	0.0104	0.010
El-Kabir Estate	0.0091	0.0229	0.0051	0.0184	0.0052	0.0737	0.0083	0.020
Grindin Dutse	0.0115	0.0687	0.0105	0.0107	0.0073	0.0923	0.0044	0.029
Gauta	0.0104	0.0421	0.0061	0.0142	0.0035	0.1203	0.0047	0.029
Yankokara	0.0126	0.0706	0.0165	0.0105	0.0043	0.0463	0.0003	0.023
Highcourt Zone	0.0082	0.0670	0.0036	0.0149	0.0060	0.0056	0.0017	0.015
Keffi – Kokona	0.0097	0.0481	0.0034	0.0103	0.0005	0.0320	0.0050	0.015
Old Barracks	0.0309	0.0398	0.0077	0.0084	0.0081	0.0283		0.021
Average	0.0126	0.0495	0.0059	0.0115	0.0045	0.0045	0.00406	0.020
C_d	0.1006	0.3963	0.0473	0.0926	0.0366	0.4128	0.0325	

3.3 The results of the potential ecological risk (Er) factor and potential ecological risk index (RI) due to heavy metal pollution in Keffi study area.

The results of the potential ecological risk (Er) factor and potential ecological risk index (RI) due to heavy metal pollution in Keffi study area is presented in table 4. The result in all the locations were very low, the highest values of Er specific to metals are: Pb (0.16) at Old barrack, Zn (0.07) in three locations, Cu (0.09) at Yankokara, Ni (0.04) at Gindi Dutse, As (0.10) at Stadium. The heavy metals in all the location show no risk of pollution in the soil sample. Also, potential ecological risk index of all metals was less than 95 indicates low potential ecological risk index (RI). Therefore, soils of the study area showed low potential ecological risk. The study further shows that all the metals are below pollution concerns to both human and animals.

Table 4. Potential ecological risk (Er) factor and potential ecological risk index (RI) values of heavy metals in soils sample of Keffi.

Location	(Er) Pb	(Er) Zn	(Er) Cu	(Er) Ni	(Er) As
Stadium Area	0.04	0.04	0.03	0.01	0.10
El-Kabir Estate	0.05	0.02	0.03	0.03	0.08
Gindi Dutse	0.06	0.07	0.06	0.04	0.04
Gauta	0.05	0.04	0.03	0.02	0.05
Yankokara	0.07	0.07	0.09	0.02	-
High court Area	0.04	0.07	0.02	0.03	0.02
Keffi – Kokona	0.05	0.05	0.02	0.01	0.05
Old Barrack	0.16	0.04	0.04	0.04	-
Ecological Risk index (RI)	0.52	0.37	0.32	0.20	0.34

3.4 Concentration of heavy metals in plant samples

Maize (*Zea mays*) is one of the essential constituents of the human diet and staple food in Nigeria. Maize was chosen to test heavy metal contamination because it is commonly planted in most of the dump site and landfill of most cities. The mean concentration of lead, copper, zinc, chromium, nickel, iron, manganese, aluminium, Arsenic and Mercury in the plant samples from the dump sites and landfill is presented in table 5. The result showed a wide range of values in the various elements measured. It was observed that plants grown in waste dumpsite and landfill soils recorded high level of heavy metals in maize plant. This may be attributed to the fact that maize plant has high affinity in taking up these metals and also associated with increases in the bioavailability of these metals. Concentration of Pb in the plant samples from the sites ranged from 0.430–0.805mg/kg with mean of 0.648mg/kg. The concentration of Zn ranges from 2.953–8.475mg/kg with mean of 4.934mg/kg.

The concentration range of other heavy metals are as follows; Cu (0.348–1.00 mg/kg), Cr (0.084– 0.847 mg/kg), Fe (18.618–58.843 mg/kg), Mn (0.969–6.289 mg/kg), Ni (0.099–0.201 mg/kg), Al (0.904–1.319 mg/kg), As (0.011–0.034 mg/kg) and Hg (0.001–0.004 mg/kg). Their mean values are as follows; 0.571, 0.453, 43.812, 2.793, 0.151, 1.058, 0.019 and 0.002 respectively. The highest concentrations were observed in Fe, Zn, Mn and Al while the lowest was in Hg.

Table 5. Concentration of heavy metals in maize (*Zea mays*) plant sample mg/kg

Location: Keffi										
Site	**Pb**	**Zn**	**Cu**	**Cr**	**Fe**	**Mn**	**Ni**	**Al**	**As**	**Hg**
El- Kabir Est.	0.554	8.475	1.00	0.847	54.900	6.289	0.182	1.063	0.013	0.001
Old barrack	0.804	4.898	0.548	0.549	42.888	1.805	0.201	1.319	0.019	0.001
Gauta	0.805	2.953	0.348	0.330	58.843	2.108	0.099	0.904	0.034	0.001
Yankokara	0.430	3.488	0.388	0.084	18.618	0.969	0.122	0.947	0.011	0.004
Mean	0.648	4.934	0.571	0.453	43.812	2.793	0.151	1.058	0.019	0.002
Minimum	0.43	2.95	0.34	0.08	18.62	0.96	0.09	0.90	0.011	0.001
Maximum	0.80	8.47	1.00	0.85	58.84	6.290	0.201	1.319	0.034	0.004

3.5 Transfer Factor (Tf) of Individual Metal to maize plant

The transfer factor which is defined as the ratio of the concentration of metals in plants to the total concentration in the soil is presented in table 6. Transfer factor shows the proportion of heavy metals in the soil taken up by plants. The soil-to-plant transfer factor is a way of indicating human exposure to heavy metals through the food chain.

The transfer factor for all the heavy metals Pb, Zn, Cu, Fe, Mn, Ni, Al and As ranged from 0.372-1.107, 0.448–3.922, 0.470–3.922, 8.513–27.808, 0.838–3.103, 0.917–1.300, 0.942–1.895 and 0.224–1.030 mg/kg respectively. The highest transfer factor value was obtained in Fe, followed by Cu, Pb, Zn, Al, Mn, Ni and As respectively.

Table 6. Transfer Factor of Individual Metal to maize plant

Site	**Pb**	**Zn**	**Cu**	**Fe**	**Mn**	**Ni**	**Al**	**As**
El- Kabir Est.	0.869	3.371	3.922	13.492	3.103	1.300	1.335	0.224
Old barrack	0.372	1.118	1.423	27.075	1.939	0.917	1.895	-
Gauta	1.107	0.637	1.133	27.808	1.347	1.053	0.998	1.030
Yankokara	0.487	0.448	0.470	8.513	0.838	1.061	0.942	0.524

4.0 Discussion

4.1 Heavy metal concentration of soils at the different landfill and dumping sites in Keffi.

The mean concentrations of heavy metals vary per sample in all the sampling location and this may be due to the nature of the composition of the materials in the sites (Getachew and

Habtamu, 2015). The results, obtained from the landfill and dumpsites soils recorded low concentration of heavy metal and this could be attributed to the porous and sandy nature of soils in the study area which do not permit accumulation of this heavy metals, this agrees with (Horowitz, 1991; Mohiuddin *et al.*, 2009) who report that heavy metal concentration showed a general increase in soil with clay minerals and a decrease in the sand in soils. Also Kabata-Pendias (2011) reported that soils with a high proportion of sand have a minimal ability to hold metal ions. In a similar work carried out by Akomolafe and Lawal (2019) in specific polluted sites in Lafia urban centre give low concentration of heavy metals analysed. These metals do not stay in the landfills for long as they find their way to groundwater bodies through leaching (Amadi *et al*., 2019).

The concentrations of Lead (Pb) in Keffi soil sample ranged from 0.57 to 2.163 mg/kg with a mean of 0.880 mg/kg. The mean concentration of Pb is less than the FAO (2001) permissible limit of 50.0 mg/kg for soils. This is in agreement with (Mohiuddin *et al.*, 2009) who considered Pb to be easily moved by urban run-off water and leaching. The main sources of Pb pollution in urban waste are from gasoline, fuel and other sources in urban area (Mukai *et al*., 1994). Pb being one of the heavy metal that do not have any beneficial effect on organisms is regarded as very harmful to both plants and animals. Zn concentration has more spread compared to the other metals analysed in Keffi landfill and solid waste dump sites. The mean concentration of zinc (Zn) ranged from (2.51–7.77) mg/kg with a mean value of 5.45 mg/kg. The maximum mean concentration of Zn recorded in Keffi is (7.77mg/kg). The values were below the WHO/FAO (2001) permissible limit of 300.00 mg/kg for soils therefore the soil in these areas were not polluted by Zn. Zinc as a metal is essential for human health and animal (Alysson and Fabio, 2014), and it shortages may cause certain birth defects (Wuana and Okieimen, 2011). The main sources of Zn is from brake linings because of their heat conducting properties and as such released during mechanical abrasion of vehicles, and also from engine oil combustion and tyres of motor vehicle (Ogundele, *et al.*, 2015).

The level of copper (Cu) in all the landfill and dumping sites soils ranged from (0.17–0.825mg/kg). The toxic levels were below the WHO/FAO (2001) permissible limit of 100 mg/kg for soils. Iron (Fe), detected in soil samples from all the locations but concentration were level below the permissible limit. The maximum concentration of Fe was (4.08 mg/kg) next to Zn (7.77mg/kg) in all the sites. Iron is an abundant nutrient element required by plants and humans and its toxicity is not common in human and animals. Iron has high affinity for soil organic matter, perhaps this may accounts for it high value observed in the samples. The results of the extraction of Manganese in the samples of soils of the landfill and dumpsites ranged from (0.57–2.027 mg/kg, with mean of 1.274mg/kg). The concentration of this metal in all soils was within the tolerable limits (100–300 $mgkg^{-1}$ set by USEPA (1986).

Nickel (Ni) is one of the trace metals that occurs in the environment only at very low levels and is essential in small doses, but it may become dangerous when the maximum tolerable amounts are exceeded (Sreekanth *et al*., 2013). While its deficiency may results in liver disorder (Fosu-Mensah *et al.*, 2017). The mean concentrations of Ni recorded at the various sites were below the WHO/FAO (2001) permissible limit of 50 mg/kg for soils. The mean concentration of Selicon at the sites ranged from 0.02–0.361mg/kg in soil samples with a mean value of (0.155 mg/kg). The mean concentrations of Selicon obtained in all the samples were below FAO/WHO (1984) permissible value for Selicon. The concentration of Arsenic (As) recorded in soils ranged from 0.00–0.058 mg/kg with mean value of (0. 023 mg/kg). The mean concentrations of As in all the sites were below the WHO/FAO (2001) permissible limit of 20.00 mg/kg for soils. The mean concentration of Mercury (Hg) was the least abundant metal recorded from the sites. The mean concentration of mercury recorded at the different sites was below the WHO/FAO (2001) limit of 2.00 mg/kg for soils. The low concentration of Hg may be attributed to the fact that Hg easily evaporates into organo-mercury forms (Fosu-Mensah *et al.,* 2017).

5.2 Concentration of heavy metals in plant samples

Plant uptake of heavy metals from soil occur flow of water into the roots and through active transport crossing the plasma membrane of roots epidermal cells (Kim *et al.,* 2003; Ekmekyapar *et al.,* 2012). Also, the removal of heavy metals may be through filtration, absorption, and cation exchange, as well as through plant induced chemical changes in the rhizosphere (Lu *et al.,* 2015). According to Ekmekyapar (*et al.,* 2012), higher levels of heavy metals accumulate more in the roots of maize plant (*Zea mays)* compared to other parts. The concentration of Fe obtained from the maize plant was high in all the samples. This is because Fe is a common element in plants and humans and it has a relatively high levels in food (Malomo *et al.,* 2013). The safety limit of Fe is as high as 300 mg/kg, Nkansah *et al.,* (2010). A deleterious effect of daily intakes is between 25-75 mg and is unlikely in healthy persons (Ozkutlu *et al.,* 2011).

The concentration of Zn in maize plant stock from the sites varied between 2.953–8.475mg/kg WHO (1996) permissible limit is 0.60mg/kg in plants. The result is at par with what was obtained by Akomolafe and Lawal (2019). The concentration is very high compared to its permissible limit. Though zinc in little concentration may be essential for human health (Alysson and Fabio, 2014) but excess could be toxic resulting in health problems. The level of lead in the maize plant samples from the sites varied from 0.430–0.805mg/kg compared to the permissible limit for plants recommended by WHO (1996) which is 2 mg/kg. The concentration therefore is below the health hazard limit and this depicts the environment is polluted. This result also agree with Opaluwa *et al.,* (2012) who reported similar low result of lead concentration in some plants in Lafia urban solid waste dump site.

The concentration of Chromium (Cr) ranged from (0.084–0.847 mg/kg) in the maize plant stock from all the sites. The concentration of chromium in plant from the sites was less than the permissible limit of 1.30 mg/kg recommended by WHO (1996). Chromium is not required by plant for it growth and it has low rate of uptake by the plant shoot (Ogundele *et al.,* 2015).

The concentration of Copper in plant stock ranged between (0.348–1.00 mg/kg). The permissible limit according to WHO standard (1996) is 10 mg/kg so the concentration of copper in the entire site is less than the WHO standard. The result also corroborate with the finding of Opaluwa *et al.,* (2012). The concentration of Nicle (Ni) ranged from (0.099–0.201 mg/kg) in the maize plant stock across the sampling site. The permissible limit by WHO (1996) is 10mg/kg, the concentration values were all less than the permissible limit. Nicle is absorbed easily and rapid by plant and it is also an essential trace element for human and animal health (Ogundele *et al.,* 2015). The concentration of Arsenic ranged from (0.011–0.034 mg/kg) in the sampling points across the sites. The mean (0.018 mg/kg) levels of arsenic in the maize plant samples was less than the recommended value of 0.1 mg/kg as reported by Shaheen *et al.,* (2016). Arsenic is associated with skin damage, increased risk of cancer, and problems with circulatory system (Scragg, 2006). The body only requires arsenic level of 0.015 mg/kg body weight (FAO/WHO, 2005).

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5.3 Transfer Factor (TF) of Individual Metal to maize plant

Plants are known to take up and accumulate trace metals from contaminated soil (Olayiwola *et al.,* 2017). Plant uptake is largely influenced by the bioavailability of metals, which is determined by both external (soil-associated) and internal (plant-associated) factors (Lu *et al.,* 2015). This result indicates that metal with high values are easily absorbed by maize plant compared to the metal with low values.

According to Omolara *et al.,* (2019), maize (*Zea mays L.*) proves to be heavy metal tolerant and has high metal accumulating ability. Although the values of these metals are within normal range for plants, however continual consumption may lead to accumulation and adverse health implication (Opabunmi, and Umar, 2010).

Conclusion

Soils are most important in many ecosystems as dynamic natural body and fundamental resource upon which economic activity like agriculture and existence of life depend. The soil is a primary recipient of solid wastes disposal and great geochemical reservoir for contaminants. Soils being important constituent of the human biosphere, any harmful change to this segment of the environment seriously affects the overall quality of human life. Agricultural products growing on soils with high heavy metal concentrations are represented by metal accumulations at levels harmful to human and animal health as well as to the microbial environment. The state of heavy metal pollution in the soils and plant collected from Keffi urban centre was analysed in all the samples to determining their status and potential impact on environment. The results indicated that there was considerable concentration of these heavy metals in both soil and plants in the study area. However, the pollution indices measured for enrichment and contamination status, such as Contamination factor (CF), Pollution load index (PLI), Contamination degree (Cd), Potential contamination index (Cp), potential ecological risk index (RI), does not posed risk to local environments. Though the concentration of heavy metal indicated that the study area does not posed high risk to local community, but the odour from the land fill and dumping site pollute the air which may cause some respiratory problems. Hence, this open landfill should be closed from use in future and or properly managed by recycling in order to minimize future pollution problems.

Recommendations

- ✓ The concentration of heavy metal indicated that the study area does not posed high risk to local community but the odour from the land fill and dumping site pollute the air which causes respiratory problems. Hence, this open landfill should be closed from use in future and or properly managed by recycling in order to minimize future pollution and health hazard.
- ✓ Effective legislation. Guidelines and detection of the areas where there are higher levels of heavy metals are necessary. Failure to control the exposure will result in severe complications in the future due to adverse effects imposed by heavy metals.
- ✓ Monitoring the exposure and probably interventions for reducing additional exposure to heavy metals in the environment and in humans can become momentous steps towards prevention.
- ✓ National and International Cooperation is vital for framing appropriate tactics to prevent heavy metals toxicity.

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Conflicts of interest

The authors declare no conflicts of interest.

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