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Heavy metal Contamination and Ecological Risk Assessment of soil around open landfill and dump site in Lafia metropolis and its potential impact on environment and urban community.

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ABSTRACT
The study was aimed at determining the status of heavy metal Contamination and Ecological Risk Assessment of soil around open landfill and dump site in Lafia metropolis and its potential impact on environment and urban community. Soil samples were collected from different landfill and dumpsites in Lafia metropolis at the depth of 0 – 30 cm. The analysis for heavy metal was conducted using Atomic Absorption Spectrometer (AAS). The result of heavy metals across sampling sites in Lafia indicated the mean order of heavy metal concentration as Zn>Fe>Al>Mn>Pb>Cu>Ni>Se>As>Hg respectively. The levels of concentration of these metals varied across soil sampling points. The pollution indices such as Contamination factor (CF), Pollution load index (PLI), Contamination degree (Cd), Potential contamination index (Cp), potential ecological risk index (RI) were used for the metal enrichment and contamination status. The CF, Cd, Cp, PLI and RI value of the present work indicating that the soils of these sites are not polluted by heavy metals. The mean order of heavy metal concentration in plant samples are Fe>Zn>Mn >AL> Pb >Cu>Cr>Ni >As>Hg respectively. The result showed a wide range of values in the various elements measured. The heavy metal (Fe and Zn) contents in the plants were higher compared to other metals in all the sites. The concentration of some metal was relatively high in the maize plant, but they 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. The correlation analysis indicates significant negative correlation in soil and significantly and positively in plant of metals. 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 or properly managed by recycling in order to minimize future pollution problems.
Keywords*: Heavy metal, Solid waste, dumping site, soil pollution, adjacent community.*

INTRODUCTION

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 (NylesandRay, 1999)

The quality of soil can be adversely affected by the over-concentration of waste released from agriculture, industry, municipality and individual household (Soffianian et al., 2014).

The disposal of domestic, commercial and industrial garbage in the environment is a problem that continues to grow with human civilization and no method so far is completely safe (Ogu and Ogwo, 2014).These waste deteriorate the quality of soil and influence environmental sustainability. In Nigeria today, urban centres are experiencing an increased rate of environmental deterioration with refuse dumped in open landfill within the urban centres (Olowookere et al., 2018). Rapid increase in volume and types of solid and hazardous waste as a result of continuous economic growth, urbanization and industrialization, is becoming a serious problem for national and local governments to ensure effective and sustainable management of waste (UNEP, 2009).

In the urban areas, especially with the rapid population growth presents serious challenge to the authorities, so much that wastes from various household are disposed off in uncontrolled dumpsites polluting the soil, water body and air (Srivastava, 2012; Bello et al., 2016)

Nasarawa state is one of the last State created by the military Government in 1996 and Lafia been its capital has witnessed remarkable expansion, growth and developmental activities such as building, road construction, deforestation and many other anthropogenic activities (Ibrahim and Umar, 2008). The city has now become the first order town in the state. This sudden increase in the population creates problems in waste management in Lafia metropolis. This rapid population growth overwhelms the capacity of the municipal authorities to provide the basic management services. As a result, most of the waste, generated from the household which is often mixed with human and animal excreta, is dumped indiscriminately in the streets and undeveloped plots within the urban centres constituting environmental hazard to the community. Recently in Lafia privates individuals have set up some waste management company to collect waste from household but still waste are seen growing in the various dumpsites and landfill in the city. Also due to unplanned communities settlement in these cities waste generation kept on increasing annually in the open dumping sites and landfill. Due to improper waste disposal and management systems most people in the areas are facing serious negative environmental impacts (Ejaz et al., 2010).

These municipal refuse dumps contribute to the increase in heavy metal concentration in soil and underground water (Uba *et al.,* 2007) may have effects on the host soils, crops and human health (Smith *et al.,* 1996; Nyle and Ray 1999). Thus, the environmental impacts of municipal refuse are greatly influenced by their heavy metal contents.

Heavy metals though occur naturally in the ecosystem with large variations in concentrations, but rarely at toxic levels. Anthropogenic activities usually create wastes which constitute sources of heavy metals and have introduced some of these heavy metals into the ecosystem (Oluyemi, et al, 2008). These heavy metals are considered serious pollutants because they are toxic and non-degradable. 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 have been extensively studied for their consequences on human and animal health. Therefore, there is need for continuous monitoring of the level of heavy metals in landfills, dumping site as well as its immediate impacts on the soil biota, humans and the ecosystem generally in order to keep a check on the environment and provide literature for future research works in this area. Heavy metals such as Cd, Ni, As, Pb pose a number of hazards to humans. These metals are also potent carcinogenic and mutagenic.

In recent time, many researchers are investigating into the effect of heavy metals, deposition, bioaccumulation, and health risk to both human and animals but in Lafia only few or no literatures are available. The main aim of this research was to determine the heavy metals concentration found in soils of the landfills, dump sites and crop(maize) grown on these landfills and to establish toxicity level and its effects on human and animals.

Materials and Methods

Description of experimental location

The study was conducted in Lafia metropolis. Lafia lie between latitude 8^0 25' 40" to 8^0 34' 15"N and longitude 8^0 24'25"to 8^0 38'19"E and 290 meters elevation above the sea level, in the Guinea Savannah region North Central of Nigeria (Nuhu and Ahmed, 2013). Lafia is the largest town in Nasarawa State with population of 330, 712 (NPC, 2006). Due to influx of people in recent time the population of Lafia city might have double or close to double since 2006.An average of seven (7) months of rainfall constituting the wet season commence from the month of April and last till October, with an average annual rainfall of about 456mm, the highest annual rainfall of 168.3mm is recorded in the month of August which decreases from north to south. Annual average temperature ranges between 31.8°C to 21.6°C, with an average of 26.8° C, (NIMET, Lafia 2017) Iafia is located in the savannah grasslands of the north central (Achohwora, 1986 and Ariyo, 1987). The soil is highly porous due to the coarse and friable nature which allows free flow of water and other substances in solution.

Sample collection

Samples were collected in Lafia 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	Lafia	08° 30.079'	008° 31.756'	Low cost
2	Lafia	08° 29.834'	008° 31.885'	Kaura street
3	Lafia	08° 29.254'	008° 31.295'	Angwajaba
4	Lafia	08° 29.291'	008° 30.967'	Angwadoka
5	Lafia	08° 29.097'	008° 29.638'	Doma road
6	Lafia	08° 28.993'	008° 32.597'	Gimare Rd by Ridi Coy
7	Lafia	08° 32.382'	008° 31.946'	Ombi 1 by poly
8	Lafia	08° 30.289'	008° 30.433'	Tudungwandara
9	Lafia	08° 31.535'	008° 30.466'	Angwanungu
10	Lafia	08° 30.155'	008° 30.698'	Behind Govt college

Soil samples from the landfills and dumping sites were collected in June, 2019 from all the locations in table 1. 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. Soil samples were quickly packed in air tight polythene bags and label before taken to the laboratory for sample preparation and analysis. Plant samples were collected from some of the locations where they are grown for home use or commercial purposes.

Sample Preparation

The soil samples were air dried in the soil laboratory of the Nasarawa State University, faculty of Agriculture for a week and then ground, passed through a 2mm sieve to remove stones, plant roots in order to have uniform soil particle size. The sieved sample is 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 Cu, 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^{o}c for two days. The oven dried material was crushed and 0.5g was put into the crucible and then ashed. Dispensed 15ml of aqua regia solution inside the crucible and raised the solution into the centrifuge tube. Cover the centrifuge tube and shake for 5minutes and then centrifuge for 10mins. The supernatant was transferred into glass vials for reading in the AAS.

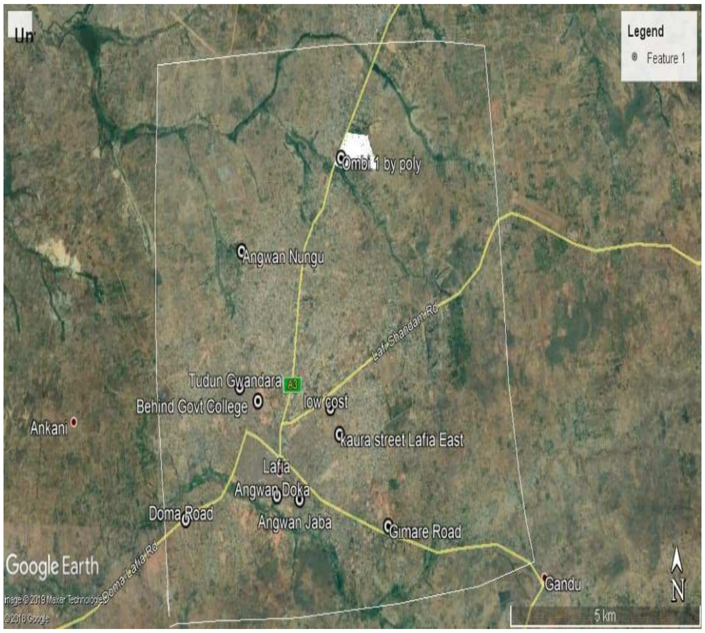

Plate 1. Showing lafia location where samples were collected

Plate 2: a and b Showing landfills and dumpsite, a. landfill in Lafia, b. landfill with maize grown on it in Lafia

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 for Lafia necessitates 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 carried out, the potential contamination index (CP), contamination factor (CF), pollution load index (PLI) and Hakanson potential ecological risk index (Hakanson 1980).

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 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

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.

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;

$$Cd = \sum_{i=1}^{i=n} CF \qquad \text{……2}$$

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

Potential contamination index (Cp)

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

$$Cp = \frac{(\text{Metal})_{\text{sample Max}}}{(\text{Metal})_{\text{Background}}} \qquad \text{……3}$$

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.

Pollution load index (PLI)
The Pollution load index (PLI) represents the number of times by which the heavy metal concentrations in the soil 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×CFn×CFn×CFn×CFn×CFn)1⁄n. …………………………4

Where CF_n 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)

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 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<320is a high ecological risk and Er> 320 is a very high ecological risk.
RI<95 indicates a low potential ecological risk; 95<RI<190is a moderate ecological risk; 190<RI<380 is a considerable ecological risk and RI > 380 is a very high ecological risk.

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.

RESULTS

Heavy metal concentrations
The results of the chemical analysis of heavy metal concentration in lafia landfill and dumping sites are presented in Table 2, alongside with the potential contamination index (CP).The concentration of heavy metal range from 0.14 – 1.049mg/kg-1 for Pb, with mean value of

0.5188mg/kg and the highest value of 1.0440mg/kg was in Gimare dumping site. The concentration of Zn range from 2.94 – 11.822 mg/kg with mean of 6.172mg/kg, the highest value of 11.8220mg/kg was obtained in Ombi 1 poly. The concentration of other heavy metals ranges are Cu (0.150 – 0.3690 mg/kg), Fe (1.430 – 7.4500mg/kg), Mn (0.4720 – 1.6120 mg/kg), Ni (0.01 – 0.3290 mg/kg), Se (-0.085 – 0.2400mg/kg), Al (0.5180 – 2.0040 mg/kg), As (0.00 – 0.0770 mg/kg), Hg (0.000 –0.0010mg/kg) respectively. The mean order of heavy metal concentration is Zn>Fe>Al>Mn>Pb>Cu>Ni>Se>As>Hg>Cd>Cr in the study area.
Table 2 also reports the potential contamination index (Cp) of soil samples of the study area. 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 lafia landfill and dumping sites

Location	Pb	Zn	Cu	Fe	Mn	Ni	Sn	Al	As	Hg
Low cost	0.138	2.9360	0.460	3.6200	2.9150	0.0870	0.1370	1.3340	0.0770	ND
Kaura Street	0.5120	5.2170	0.3690	0.1870	1.3460	0.1350	0.0820	0.7610	0.0370	ND
AngwanJaba	0.3440	4.6220	0.2110	7.4500	1.6120	0.0220	0.0870	1.2720	0.0660	0.0010
Angwan Doka	0.4720	9.4960	0.3330	2.9040	0.9190	0.0780	0.1270	0.7190	0.0580	0.0010
Doma Road	0.1610	5.4600	0.2550	4.9720	0.4720	0.02070	ND	1.2200	0.0470	0.0010
Gimare road	1.0440	7.6390	0.3650	3.4920	0.5100	0.1080	ND	2.0040	0.0400	ND
Ombi I by Poly	0.5040	11.8220	0.1870	1.5280	0.8830	0.2090	0.0180	0.5180	0.0700	0.0010
TudunGwandara	06820	5.2920	0.1700	2.4320	1.1330	0.0140	0.0960	0.7400	0.0460	0.0010
AngwanNungu	0.1380	5.0780	0.1890	1.4280	0.7040	0.1330	0.2400	1.3480	ND	0.0000
Govt. College	0.5600	4.1280	0.1260	2.2320	0.9380	0.3290	0.0560	1.4890	0.0360	0.0000
Mean	0.5188	6.1721	0.2441	3.3236	1.1438	0.1320	0.0680	1.1405	0.0470	0.0050
Minimum value	0.14	2.94	0.15	1.43	0.47	0.01	0.01	0.52	0.00	0.00
Maximum Value	1.0490	11.8220	.3690	7.4500	1.6120	0.3290	.2400	2.0040	.0770	0.0010
Back Value	70	110	50	47200	110	27	3	88000	7	0.25
CP	0.0149	0.1074	0.0073	0.00157	0.0146	0.01218	0.080	0.000027	0.011	0.004

ND not detected

Contamination factor (CF)

The results of Contamination factor (CF), Pollution load index (PLI) and Contamination Degree (Cd) of Lafia landfill and dumping sites are presented in Table 3. From the table the calculated value of contamination factor (Cf) are generally low for all the heavy metal analysed. The calculated value ranges for the metals are: Pb (0.002 – 0.0145), Zn (0.027 – 0.108), Cu (0.003 – 0.067), Mn (0.004 – 0.05), Ni (0.001 – 0.012), Se (0.006 – 0.08), As (0.001 – 0.011) respectively. Also from table 3 the contamination degree (Cd) of soil samples from the site were low and the calculated values were lower than 6 and therefore indicating low degree of contamination. The Pollution load index (PLI) was calculated per site, the value range from 0.013 in Doma road to 0.032 in Agwan doka. The value in all the site is less one indicating that the area is unpolluted (PLI<1).The PLI can provide some understanding to the public of the area about the quality of a component of their environment, and indicates the trend over time and area. In addition, it also provides valuable information and advice for the policy and decision makers on the pollution level of an area.

The result of the potential ecological risk due to heavy metal pollution in lafia is summarized in Table 4.The result in all the location were very low. The highest values of Er specific to metals are: Pb (0.08) at Gimare road, Zn (0.12) at Ombi 1 poly, Cu (0.34) at Agwan doka, Ni (0.06) at Govt. College and As (0.11) at low cost. The heavy metals in all the location show no risk of pollution in the soil sample. Also potential ecological risk index of all metals were less than 95 indicates low potential ecological risk index (RI). Therefore soils of the present study area showed low potential ecological risk.

Table: 3 Contamination factor (CF), Pollution load index (PLI) and Contamination Degree (Cd) of Lafia landfill and dumping sites

Location	**Pb**	**Zn**	**Cu**	**Mn**	**Ni**	**Se**	**As**	**PLI**
Low cost	0.0019	0.0266	0.0029	0.0265	0.0032	0.0457	0.0110	0.0168
Kaura Street	0.0073	0.0477	0.0073	0.0122	0.0050	0.0273	0.0053	0.0160
AngwanJaba	0.0049	0.0420	0.0042	0.0146	0.0010	0.0290	0.0010	0.0138
Angwan Doka	0.0067	0.0862	0.0666	0.0084	0.0029	0.0423	0.0082	0.0316
Doma Road	0.0023	0.0496	0.0051	0.0043	0.0077	ND	0.0067	0.0126
Gumare	0.0149	0.0694	0.0073	0.0046	0.0040	ND	0.0057	0.0169
Ombi by Poly	0.0072	0.1075	0.0037	0.0080	0.0077	0.0060	0.0100	0.0214
TudunGwandara	0.0097	0.0481	0.0034	0.0103	0.0010	0.0330	0.0066	0.0159
AngwanNungu	0.0020	0.0461	0.0038	0.0064	0.0049	0.0800	ND	0.0239
Govt. College	0.0080	0.0375	0.0043	0.0085	0.0122	0.0187	0.0051	0.0135
Average	0.00659	0.05607	0.01086	0.01038	0.00489	0.02367	0.00602	0.01824
Cd	0.0649	0.5607	0.1086	0.1038	0.0489	0.2367	0.0602	

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

Location	**(Er)Pb**	**(Er)Zn**	**(Er)Cu**	**(Er)Ni**	**(Er)As**
Low cost	0.05	0.03	0.02	0.02	0.11
Kaura Street	0.04	0.05	0.04	0.03	0.05
AgwanJaba	0.03	0.04	0.02	0.01	0.01
Agwan Doka	0.04	0.09	0.34	0.02	0.08
Doma Road	0.01	0.05	0.03	0.02	0.07
Gumare	0.08	0.07	0.04	0.02	0.07
Ombi by Poly	0.04	0.12	0.02	0.04	0.10
TudunGwandara	0.05	0.05	0.02	0.01	0.07
AgwanNungu	0.01	0.05	0.02	0.03	-
Govt. College	0.04	0.04	0.02	0.06	0.03
Ecological Risk index(RI)	0.35	0.58	0.58	0.26	0.59

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 in most urban settlement. The mean concentration of lead, copper, zinc, chromium, nickel, iron, manganese, aluminium, Arsenic and Mercury in the plant samples from the study sites are 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 high metal contents of dumpsite and landfill soils which are taking up by the plants grown on them. Concentration of Pb in the plant samples from the sites ranged from 0.297 – 0.805mg/kg with mean of 0.5652mg/kg. The concentration of Zn ranges from 2.216 – 8.475mg/kg with mean of 4.504mg/kg. The concentration range of other heavy metals are as follows; Cu (0.202 – 1.00 mg/kg), Cr (0.042 – 0.847 mg/kg), Fe (18.618 – 58.843 mg/kg), Mn (0.56 – 6.289 mg/kg), Ni

(0.049 – 0.221 mg/kg), Al (0.904 – 2.090 mg/kg), As (0.011 – 0.034 mg/kg) and Hg (0.001 – 0.004 mg/kg). Their mean values are as follows; 0.456, 0.365, 34.844, 1.838, 0.128, 1.368, 0.018 and 0.001 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

Site	Pb	Zn	Cu	Cr	Fe	Mn	Ni	Al	As	Hg
Gi mare	0.571	3.635	0.310	0.303	24.631	0.700	0.080	1.853	0.014	0.001
Ombi (1) Poly	0.727	3.811	0.344	0.336	25.815	0.811	0.221	1.554	0.017	0.000
Doma road	0.297	2.216	0.202	0.042	20.927	0.561	0.049	1.216	0.021	0.000
Angwa Nungu	0.534	6.831	0.507	0.427	32.131	1.468	0.074	2.090	0.018	0.001
Mean	0.5652	4.504	0.455	0.364	34.844	1.838	0.128	1.368	0.0184	0.011
Minimum	0.30	2.22	0.20	0.04	18.62	0.56	0.05	0.90	0.01	0.00
Maximum	0.80	8.45	1.00	0.85	58.84	6.29	0.22	2.09	0.03	0.00

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 0.546 -3.689, 0.475 – 1.345, 0.792 – 2.683, 4.206 – 22.500, 0.119 – 2.468, 0.237 – 1.057, 0.924 – 3.000 and 0.243 – 0.446 mg/kg respectively. The highest transfer factor value was obtained in Fe, followed by Pb, Al, Cu, Mn, Zn, Ni and As respectively.

Table 6: Transfer Factor of Individual Metal to maize plant

Site	Pb	Zn	Cu	Fe	Mn	Ni	Al	As
Gimare	0.546	0.475	0.849	7.053	1.373	0.741	0.924	0.350
Ombi (1) Poly	1.442	0.322	1.839	16.894	0.918	1.057	3.000	0.243
Doma road	1.811	0.406	0.792	4.204	0.119	0.237	0.997	0.446
AngwaNungu	3.689	1.345	2.683	22.500	2.468	0.556	1.550	nd

Correlations Matrix

Pearson correlation analysis was performed between all the variables (metal). The level of significance ($p \leq 0.05$ and $p \leq 0.01$) of multi-element correlation for plant samples was determined and the results are given in Table 7. The listed r values indicated the high degree of positive, except few metals with negative correlations. The significant linear relation between various pairs of metals, reflect their simultaneous release and from identical source. The inter-metallic correlation coefficients in the plant samples with $p < 0.05$ from the site were: Zn-Cu,Cu-Cr, Zn-Cr, Cu-Mn, Cr-Mn, Fe-Mn, Pb-Fe, Zn-Mn and Pb-Ni.

Table 7: Correlation coefficient matrix for the metals in plant of the dump site and landfill in the study area

	Pb	Zn	Cu	Cr	Fe	Mn	Ni	Al	As	Hg
Pb	1									
Zn	-0.034	1								
Cu	0.070	0.869**	1							
Cr	0.290	0.843**	0.850**	1						
Fe	0.513*	0.364	0.492*	0.743**	1					
Mn	0.253	0.559**	0.802**	0.757**	0.788**	1				
Ni	0.411*	0.313	0.208	0.336	0.115	0.068	1			
Al	-0.083	0.402	0.121	0.235	-0.105	-0.180	0.252	1		
As	0.200	-0.320	-0.321	-0.095	0.228	-0.095	0.342	0.266	1	
Hg	-0.040	0.073	0.211	-0.058	0.153	0.258	0.035	-0.222	-0.314	1

DISCUSION

Heavy metal concentration of soils at the different landfill and dumping sites in lafia

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). Generally, the result showed that soils from the landfill and dumpsites recorded low concentration of heavy metal and this could be attributed to the nature of soil which encourages leaching of these metal into the underlying soil(Ukpong*et al.,* 2013; Olayiwola et al., 2017). The sandy nature of soils in the study area do not allow accumulation of this metals, this agrees with (Horowitz, 1991; Mohiuddin *et al.,* 2009) that trace metal concentration showed a general increase in clay minerals content and a decrease in the sand content in the soils. In a similar work carried out by Akomolafe and Lawal(2019) in specific polluted sites in Lafia give low concentration of heavy metals analysed. These metals do not stay in the landfills and dumpsites; they find their way to groundwater bodies through leaching (Amadi *et al*., 2019).

The concentrations of lead (Pb) in soil samples analysed ranged from 0.14 to 1.044 mg/kg with a mean value of 0.519 mg/kg in lafia. The mean concentration of Pb in Lafia was less than the FAO (2001) permissible limit of 50.0 mg/kg for soils. The low concentration of Pb may be due to leaching and run-off water. 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. It behaves like calcium in body and accumulates in bone, liver, kidney and other tissues in animals. The toxic limit in the blood is (> 500 µg/L Blood), with recommended Safe intake of 20 - 280 µg/day adult and 10 - 275 µg/day children (Veterinary World, 2008).

The mean concentration of zinc (Zn) ranged from 2.94 – 11.822 mg/kg with a mean value of 6.17 mg/kg. The maximum mean concentration of Zn recorded in both Lafia was (11.82 mg/kg). This value is below the WHO/FAO (2001) permissible limit of 300.00 mg/kg for soils, therefore the soil in this area was not polluted with Zn. Zinc as a trace element is essential for human and animal health (Alysson and Fabio, 2014) and it shortages may cause birth defects (Wuana and Okieimen, 2011). The consequence is that Zn from these landfills and dumping sites found their way into the ground water through leaching and run off which increase the acidity of waters (Raymond and Felix, 2011), and can contaminate groundwater. The recommended intake/ Safe intake for animal is 15 µg/day (Veterinary World, 2008). 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 (0.15 – 0.369 mg/kg) in Lafia with mean value of (0.244 mg/kg) respectively. The toxic levels were below the WHO/FAO (2001) permissible limit of 100 mg/kg for soils.

The mean concentration of iron is (7.45 mg/kg) and was next to Zn (11.822 mg/kg) which have the maximum value. The Fe values detected in soil samples from all the locations are at lower concentration level below the permissible limit. Iron is an abundant nutrient element required by plants, animals and humans and its toxicity is not common. The high value compared to others may be because of its ability to form bound with soil organic matter.

Mn, the results of the extraction of Mn in the samples of soils of the landfill and dumpsites ranged from (0.47 – 1.612 mg/kg, mean of 1.144mg/kg). The concentration of these metals in all the sites was within the tolerable limits (100 – 300 $mgkg^{-1}$ set by USEPA (1986).

Ni, Nickel is an element that occurs in the environment only at very low levels and is essential in small doses, but it can be dangerous when the maximum tolerable amounts are exceeded (Sreekanth *et al*., 2013). The mean value of Ni is (0.132 mg/kg) and is below the WHO/FAO (2001) permissible limit of 50 mg/kg for soils.

The mean concentration of Se at the sites ranged from 0.018 – 0.240 mg/kg. The mean concentrations of Se obtained in the sites were below FAO/WHO (1984) permissible value for Se. Arsenic (As) has mean value of (0.470 mg/kg) and is 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 in the entire site. 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). When animal consumed high mercury in vegetation the animal will suffer from alopecia, neuropathy, visual and gastrointestinal tract disorder.

Concentration of heavy metals in plant samples

Plant uptake of heavy metals from soil occurs either passively with the mass flow of water into the roots or 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 in the roots of maize (*Zea mays)* than the leaves. Maize plants are also known as plants with high growth rate as well as high biomass are associated with increases in the bioavailability of these metals (Marques *et al.,* 2009).

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 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). Deleterious effects of daily intakes between 25-75 mg are unlikely in healthy persons (Ozkutlu *et al*., 2011).

The concentration of Zn in maize plant stock from the sites varied between 2.216 – 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 0.297 – 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 (0.042 – 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 (0.202 – 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 Opaluwa *et al.* (2012). The concentration of Nickel (Ni) ranged from (0.049 – 0.221 mg/kg) in the maize plant stock across the sampling site in both cities. The permissible limit by WHO (1996) is 10mg/kg, the concentration values were all less than the permissible limit. Nickel 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 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 of 0.015 mg/kg body weight (FAO/WHO, 2005).

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

The most adverse effect of heavy metals is that they can be introduced into the food chain and threaten human health. 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 soil was analysed in lafia city of Nasarawa State of Nigeria to determining their status and potential impact on environment and urban community. The results indicated that there was considerable concentration of these heavy metals in soil of 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 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.

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.

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