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INVESTIGATIONS OF SOME HEAVY METALS IN SOILS AROUND REFUSE DUMPSITES, SAGBAMA LOCAL GOVERNMENTAREA, BAYELSA STATE, NIGERIA

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Abstract
The concentrations of some heavy metals in dumpsite soil collected from eight different locations in the Sagbama Local Government Area of Bayelsa State, Nigeria, were ascertained through AAS and standard analytical methods. The heavy metal concentrations obtained in the samples were in the following pattern: nickel, chromium, zinc, copper, lead, and cadmium. The heavy metal concentration values in dumpsite soil samples ranged from 7.698 to 8.865 for Pb, from 6.154 to 8.154 for Cr, from 5.787 to 7.586 for Cu, from 1.053 to 1.528 for Cd, from 4.231 to 6.167 for Zn, and from 5.76 to 8.60 for Ni. The standards given by the World Health Organization (WHO) and the National Environmental Standard Regulation and Enforcement Agency (NESREA)were used in the comparison of these results and also with the work done by other researchers. These results were within or lower than the permissible limits of WHO and NESREA, except Cd. The result also indicated pollution with heavy metals in the soil in the following order: Chromium>Lead> Nickel>Cadmium. This research indicated that the environment is not at risk because the heavy metals studied had very low concentrations. It was suggested, amongst others, that the dumpsites should be put under strict supervision and public awareness made of the negative effects on health from exposure to heavy metal contamination in the soil. Also, the environment should be safeguarded for microorganisms and people living in the area who depend on it for their livelihood by curbing all anthropogenic activities that heighten the metal pollution of the soil.

Keywords: Heavy Metals, Soils, Refuse Dumpsites, Sagbama Local Government Area, Bayelsa State

Introduction

The growth of population in Bayelsa State over the years has resulted in a rise in human activities leading to refuse production. Refuse or waste is profitable if it is properly recycled, but it could be very dangerous and life-threatening if not properly managed. It has the power to pollute the land, the water, and the air (Bishop, 2000).A typical refuse dump consists of organic wastes such as poultry litter, waste clothing and paper, wood waste and furniture, corn cob and chaff, vegetable residues, leftover foods hair weavon etc, electrical and electronic waste refrigerators, damaged phones and accessories, damaged computers and accessories, damaged fans and electric irons, waste bulbs and sockets and sundry wastes such as pharmaceuticals, paint products and containers (Nduka &Orisakwe, 2010). These dumps add large quantities of heavy metals to the soil. Surface water that runs from such refuse dumpsites eventually builds up the heavy metal content of the aquatic ecosystem when it enters the ground waters (Osakwe, 2011). Contaminated soils with heavy metals constitute a major problem for plant nutrition and the food chain, and they can also be hazardous to health. Since the protection of both terrestrial and aquatic ecosystems from contamination as a result of anthropogenic activities is a global concern, monitoring the concentration, phase association and mobility of metals in the environment which has a lot of human activities is very important. Like other urban centres, where the demand for suitable land for development exceeds the availability, such contaminated sites may be used in the future for residential, industrial, recreational, or educational purposes. If these locations are built up and used without remediation, they can become hazardous to the people who live there. Monitoring the concentrations of heavy metals in the soil is important since knowledge of the heavy metal levels in the soil gives vital information regarding their sources, distribution and degree of pollution (Odefemi et al., 2007).

The most common heavy metals found at contaminated sites, in order of abundance are Pb, Cr, As, Zn, Cd, Cu, and Hg (USEPA. 2001). These metals can decrease crop productivity because of their risk of bioaccumulation and biomagnification in the food chain. They can also contaminate the groundwater. The simple chemical, environmental, and health-related knowledge and the effects of these heavy metals are important in knowing their characterization and biological availability. The chemical form and speciation of a heavy metal is what determine its fate and transport in the soil. When heavy metals enter the soil, they are initially quickly absorbed by fast reactions, which are followed by slow adsorption reactions which take days, and years, they are, thereafter distributed in various forms with different bioavailability, mobility, and toxicity. (Wuana & Okiemen. 2011).

Aim and Objectives of the Study

The aim and objectives of this research work were to ascertain the concentrations of some heavy metals in soils around refuse dumpsites in Sagbama Local Government Area, Bayelsa State.

The specific objectives of this research work are to:

1. assess the concentrations of selected heavy metals (Nickel, Copper, Cadmium, Zinc, Chromium, Lead) in the soil samples.
2. evaluate the contamination and pollution state of the soil samples about each metal.
3. calculate the ecological risk of metals in the soil samples.

Materials and Methods

Sagbama L.G.A. is found in Bayelsa state, Nigeria. The Local Government Area comprises several towns and villages such as Adagbabiri, Bulou-Orua, Sagbama, Tungbo, Ofoni, Elemebiri, Ebedebiri, Toru-Orua, etc. The estimated population of the Local Government Area is 241,603 inhabitants according to the 2006 census. The LGA spans an area measuring 945 square kilometres and with a temperature averaging 25 degrees Celsius. The Local Government Area is covered with water with the LGA hosting the Focardos River and other tributaries of the River Niger. Sagbama LGA is host to part of the Bayelsa National Forest with the area being heavily forested. The LGA experience high humidity and heavy rainfall for a major part of the year and has two major seasons, the rainy and dry seasons which are characteristics of the equatorial climate. The LGA experience an annual rainfall amounting to 2673.8mm and a mean temperature of 32.8 ^{0}C and is also marked by a tropical equatorial climate.

The soil samples were collected from eight (8) locations. That is two locations each from Sagbama, Adagbabiri, Tungbo, and Toru-Orua. The samples were collected around refuse dumpsites in each town. The collected soil samples were placed in clean polythene sacks, labelled and moved to the laboratory for Atomic Absorption Spectroscopic analysis.

Soil samples (0.5g) werecarefully placed into a digestion tube, 15 ml aqua regia (three**:** one Hydrochloric acid**:** Trioxonitrate (iv) acid) was added**,** the mixture was swirled vigorouslyfor the sample to be wet and it was thereafter kept overnight. The tube was heated the next day at a temperature of 50°C for 30 minutes, thereafter the temperature was raised to 120 °C for 2 hr. The digest was cooled and filtered via filter paper and made up to 25 ml with 0.25 mol/L Trioxonitrate (iv) acid (Radojevic & Bashkin, 1999). The sample solution was thereafter analysed for Nickel, Copper, Cadmium, Zinc, Chromium, and Leadusing an air-acetylene Atomic Adsorption Spectrophotometer(AAS).

Results

Table 1: Mean concentrations of heavy metals in Refuse Dumpsites

SAMPLE PROPERTIES(mg/kg)	SAGBAMA	ADAGBABIRI	TUNGBO	TORU-ORUA	WHO (2011)	NESREA (2009)
Lead	7.73±0.04	7.57±0.06	8.57±c40.01	8.83±0.05	85	164
Chromium	6.16±0.02	8.39±0.34	7.48±0.08	6.76±0.01	100	100
Copper	5.83±0.06	6.81±0.08	7.51±0.03	7.47±0.16	36	100
Cadmium	1.11±0.08	1.47±0.08	1.51±0.01	1.21±0.06	0.8	3
Zinc	4.42±0.14	5.09±0.01	6.17±0.00	4.29±0.09	-	421
Nickel	6.80±0.05	7.87±0.14	8.55±0.07	5.81±0.07	35	70

Source: Okegye and Gajere, (2015)

Table 1 shows a summary of the mean concentrations for heavy metals in dumpsite soils in Sagbama, Adagbabiri, Tungbo and Toru-Orua sampling locations. The result shows that Pb has a mean value of 7.73±0.04 in Sagbama, 7.57±0.06 in Adagbabiri, 8.57±0.01 in Tungbo, 8.83±0.05 in Toru-Orua and 3.19±0.00 as the control. The result also shows that Cr has a mean value of 6.16±0.02 in Sagbama, 8.39±0.34 in Adagbabiri, 7.48±0.08 in Tungbo, 6.76±0.01 in Toru-Orua and 1.41±0.00as the control. It further indicated that Cu has a mean value of 5.83±0.06 in Sagbama, 6.81±0.08 in Adagbabiri, 7.51±0.03 in Tungbo, 7.47±0.16 in Toru-Orua and 2.57±0.00as the cool. It also shows that Cd has a mean value of 1.11±0.08 in Sagbama, 1.47±0.08 in Adagbabiri, 1.51±0.01 in Tungbo, 1.21±0.06 in Toru-Orua and 1.06±0.00as the control. The result also shows that Zn has a mean value of 4.42±0.14 in Sagbama, 5.09±0.01 in Adagbabiri, 6.17±0.00 in Tungbo, 4.29±0.09 in Toru-Orua and 2.65±0.00as the control. Moreso, it outlined that Ni has a mean value of 6.80±0.05 in Sagbama, 7.87±0.14 in Adagbabiri, 8.55±0.07 in Tungbo, 5.81±0.07in Toru-Orua and 1.50±0.00as the control. The statistical analysis shows a p-value less than 0.05 therefore there is a significant difference in the heavy metal concentrations of soilsamong sampling locations.

Table 2; Significance of intervals of contamination/pollution index (C/PI) C/PI Significance

<0.1 Very slight contamination

0.10-0.25 Slight contamination

0.26-0.5 Moderate contamination

0.51-0.75 Severe contamination

0.75-1.00 Very severe contamination

1.1-2.0 Slight pollution

2.1-4.0 Moderate pollution

4.1-8.0 Severe pollution

8.1-16.0 Very severe pollution

>16.0 Excessive pollution

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Table 3:Summary of contamination and pollution index of heavy metals in soil.

	Sagbama	Adagbabiri	Tungbo	Toru-Orua	Control
Heavy metals	HPI	HPI	HPI	HPI	HPI
Pb	13.39	12.94	15.77	16.50	0.54
Cr	0.42	0.60	0.52	0.47	0.03
Cu	0.00	0.00	0.00	0.00	0.00
Cd	23.00	31.20	32.11	25.28	21.86
Zn	0.00	0.00	0.00	0.00	0.00
Ni	3.27	3.81	4.15	2.77	0.60
HPI <total>	40.08	48.54	52.55	45.02	23.04

HPI=Heavy Metal Pollution Index.

Contamination and pollution index

The contamination and pollution index of metals in dumpsite soil samples ranges from 0.54 to 15.77 for Pb, 0.03 to 0.60 for Cr, 21.86, to 32.11 for Cd, 0.00 for Cu, 0.00 for Zn and 0.60 to 4.15 for Ni. The contamination/pollution index for Pb ranged from severe contamination to excessive pollution, for Cr, it ranged from slight contamination to severe pollution, for Cd it ranged from very severe contamination to excessive pollution, for Cu and Zn it was zero contamination/pollution, and for Ni, it ranges from severe contamination to severe pollution.

Table 4:Summary ofecological risk assessment of heavy metals in soils.

	Sagbama	Adagbabiri	Tungbo	Toru-Orua	Control
Heavy metals	ER	ER	ER	ER	ER
Pb	2.06	2.11	1.86	1.81	3.36
Cr	6.87	5.04	5.66	6.26	35.39
Cu	0.88	0.75	0.68	0.69	0.47
Cd	0.95	0.72	0.70	0.88	0.61
Zn	3.00	2.60	2.15	3.09	6.63
Ni	1.10	0.95	0.88	1.29	1.13
RI<total>	14.87	12.18	11.93	14.01	47.60

RI=Risk Index, ER=Ecological Risk, RI<150=low risk

Ecological Risk Assessment of Metals in dumpsites soils

The ecology risk of metals in soils is shown in Table 3.

The ecological risk of the metals in dumpsite soils is in the following pattern: Copper < Cadmium <Nickel < Zinc < Lead < Chromium. The potential ecological risk of metals was in the low ecological categories (i.e. <150). The RI values of these soil samples range from 0.66 to 13.34.The highest values were recorded at Toru-Orua and the lowest values were recorded at Tungbo sampling locations. The ecological risk index (RI) for Pb ranges from 3.25 to 6.85, for Cr, it ranges from 11.83 to 30.00, for Cd it ranges from1.03 from 2.00, for Cu it ranges from 0.66 to 1.13, for Zn it ranges from 2.19 to 5.00 and for Ni it ranges from 1.07 to 5.00. Below are the heavy metal risk index (Low ecological risk of metals (RI value < 150), moderate ecological risk of metals (> 150 < 300), and strong ecological risk of metals (RI value ≥ 300 > 600). From Table 3 above the potential ecological risk of the metals in the soil samples is in the low risk level.

Discussion

Lead

Lead had concentrations in the research work, ranging from 7.698 to 8.865, with a mean value of 8.83 ± 0.05. The values of lead were recorded in the highest and lowest levels at Toru-Orua 2 and Sagbama 1 sampling locations respectively. Pb values observedin the research work are at a higher level than those recorded by Nwajei et al. (2007) with values of 0.00 -1.00, Osakwe, (2011) with values of 1.36 – 3.76, Adelekan and Alawode, (2011) with values of 0.00 – 1.00 and Odukoya et al. (2011) with values of 0.00 – 49mg/kg. However, Pb values recorded for the research work had been observed to be of lower values than those recorded by Amadi, (2011) with concentrations of 45.0 – 625, Ogbemudia and Mbong, (2013) with concentrations values of 16.1 – 17.8, Adefemi and Awokunmi, et al; (2009) with concentration values of 63.6 -418 respectively.

Chromium

Chromium concentrations recorded in this study ranged from 6.154 to 8.154mg/kg. with a mean value of 8.39 ± 0.034mg/kg. The highest and lowest concentrations of Cr were obtained at Sagbama 1 and Adagbabiri 2 sampling locations respectively. Chromium concentrations recorded for this research work had been observed to be lower than the standards permitted by WHO, (2011) and NESREA, (2009) concentrations values of 100mg/kg respectively. The concentrations of Cr recorded for the study can be compared to the ones recorded by the following. Amadi, (2010) reported chromium concentrations ranging from 1.56 -5.28mgkg/, Adefemi and Awokunmi, (2009) with concentrations of 5.55-22.2mg/kg. The concentrations of Cr recorded from Nwajei et al. (2007) and Adeleke and Alawode, (2011) with concentrations ranging from 0.00-0.96mg/kg and 0.00-0.96mg/kg are of lower values than the ones recorded in the study.

Copper

Copper was detected at concentrations ranging from 5.787 to 7.586 with a mean value of 7.47±0.76. The recorded highest concentrations of copper were at Toru-Orua 2 and the lowest at Sagbama 1 sampling locations respectively. The Cu concentrations observed in this research work are seen to be within the WHO, (2011) target and intervention values of 36 and 190mg/Kg and also within or lower than the NESREA, (2009) acceptable values of 100mg/kg. The concentrations of Cu in the soil samples ofthe research work can be compared to the following recorded by Amadi et al; (2011) observed value of 5.2 to 58.6mg/kg, Iwegbue (2011) recorded range of 2.5 to 82.1mg/kg, Adefemi and Awokunmi, (2009) reported values of 3.64 to 67.8mg/kg, and Akpoveta et al. (2009) observed values of 14.3 to 34.2mg/kg.

Cadmium

The concentrations of Cadmium had been observed to have values ranging from 1.053 to 1.528mg/kg with a mean value of 1.33±0.08mg/kg. The highest and lowest concentrations of Cd were recorded at Adagbabiri 2 and Sagbama 1 sampling locations respectively. The WHO, (2011) target value of 0.8mg/kg was higher than the Cadmium concentrations obtained in the study but was lower than the intervention standard at 12mg/kg. The concentrations were also within the NESREA, (2009) values of 3mg/kg. Various concentrations of Cadmium in dumpsite soils have been reported in the literature, Ogbemudia and Mbong, (2013) reported concentrations of Cd ranging from 3.7 to 4.40mg/kg. The concentrations of Cd in the study can be compared to the ones recorded by Oviasoge et al. (2009) concentration of 0.00 to 2.91 for dumpsites in Akure, Nwajei et al. (2007) concentrations of 0.40 to 1.60 in the soil around refuse dumpsites in Onitsha. Higher concentrations of Cadmium have been reported in the literature. An instance is Amusan et al. (2005) who reportedly obtained a concentration of Cd which ranged from 17.0 to 47.06mg/kg in soils of dumpsites at Obafemi Awolowo University, Ile-Ife. Ogboma et al. (2009) also reported concentrations of Cd of 1.28 to 21.31mg/kg.

Zinc

Zinc concentrations recorded in the samples of the dumpsite are in the range of 4.231 to 6.167mg/kg with a mean of 4.99 ± 0.01mg/kg. The highest and lowest concentrations were obtained at Tungbo 2 and Toru-Orua 1 sampling locations. Zn concentrations of the study were however within acceptable limits set by NESREA, (2009) of 421mg/kg. Zinc concentrations of the study can be compared to the ones recorded by Iwegbue et al. (2011) at concentrations ranging from 4.64 to 40.6mg/kg and Ogbemudia and Mbong (2013) with concentrations of 16.4 to 24.4 mg/kg. The concentrations of Zn recorded by Amusan et al. (2005) with concentrations of 63.2 to 10.2.11mg/k at Ile Ife and Amadi (2011) with concentrations ranging from 68 to 290mg/kg are however of higher values than the ones observed in the study.

Nickel

The concentrations of Nickel in this study from samples of the dumpsite are in the range of 5.76 to 8.60/mg/kg and mean values of 7.26 ± 0.07mg/kg. The highest and lowest concentrations were observed at Tungbo 1 and Toru-Orua, 1 sampling locations. The concentrations observed during the research work are lower or within allowed standard values set by the World Health Organization, (2011) and NESREA, (2009) of concentrations of 35mg/kg and 70mg/kg. The concentration of Ni recorded by Adefemi and Awokunmi, (2009) and Akpoveta et al. (2010) with concentrations of 0.00 to 2.36 and 4.48 to 5.10mg/kg were of lower values than the ones observed in this research work. Ni values in the research work were however higher in values than those recorded from Chengo et al. (2013) and Adelekan and Alomode (2011) with concentrations of 402-584mg/kg and 4.35 to 49.8mg/kg.

Conclusion

The concentrations of some heavy metals in soils in refuse dumpsites in the Sagbama local government area (Sagbama, Adagbabiri, Tungbo and Toru-Orua) of Bayelsa State were carried out. The results indicated heavy metal contamination ofsoils around refuse dumpsites was in this pattern Chromium >Lead> Nickel>Cadmium. This research work indicated that the environment is not at risk because the heavy metals studied had very low concentrations.

Recommendations

1. It was suggested amongst others that the dumpsites should be put under strict supervision and public awareness made of the negative effects on health by exposure to heavy metal contaminations in the soil.
2. Also, the environment should be safeguarded for micro-organisms and people living in the area who depend on it for their livelihood by curbing all anthropogenic activities that heighten the metal pollution of the soil.

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