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Assessment of Heavy Metals Contamination in Soil from Farmlands within Adumpsite in Rumuagholu, Rivers State, Nigeria

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Abstract Soils samples were collected from operational farmlands at the vicinity of the Rumuagholu dumpsite for a period of three months. The soil samples were prepared for heavy metals analysis following standard procedures. Then they were analyzed using atomic absorption spectrophotometer. The results obtained showed that the mean values of the metals were; Pb (1.71±0.75 mg/Kg), Cd (0.21±0.19mg/Kg), Cr (2.59±0.59mg/Kg), Cu (1.75±0.34 mg/Kg) and Ni (2.06±0.62 mg/Kg). The result showed that the concentrations of all the metals were below the DPR target and intervention values. Contamination factor analysis of the results of the heavy metals showed that the soils are not contaminated with any of the metals in all the stations examined except Cd at station 1, which showed signs of slight pollution. Pollution load index (PLI), contamination degree (CD) and modified contamination degree (mCD) analysis of the heavy metals in the soil at the different farm stations showed that the soils were not contaminated. geochemical index (I-geo) analysis showed non contamination of the soils with heavy metals. The observed concentrations of heavy metals in the soil of the dumpsite farms showed that although waste is being discharged at the dumpsite, it might not have contributed much to the levels of the heavy metals.

Keywords Dumpsite, heavy metals, contamination, soil, farmlands, Rumuagholu

Introduction

The need for survival and better living has culminated in the continuous emergence of urban centres and settlement all over the world. The rapid growth of urban city centres is accompanied with several an*thro*pogenic activities in the form of industrialization and economic development [1]. In the event of productions arising from these activities, there is the issue of waste generation and disposal which gave rise to designated sites by government where these wastes can be disposed [2-3]. However, the dumping of refuse at these sites (dumpsites) do not follow any laid down rules and regulations on the nature of wastes to be dumped. Therefore, wastes that contain heavy metals and other toxic chemicals, which have originated from homes and industries are easily dumped at these dumpsites [4-5].

Anthropogenic inputs have negative consequences on the geochemical concentrations of ionic species (heavy metals and nutrients) in the soil environment and also have deteriorating effect on the soil composition [6]. Soil contamination due to anthropogenic activities has been observed in abattoirs [7], metal production sites, roadsides [8-9], dumpsites [2, 10] and mechanic workshops [11-12].

The presence of heavy metals in any environment, especially at very high concentrations is not acceptable for both plants and animals [13], this based on the given reality that they are toxic to both man and the environment [14].

Any plant that is grown within the area of accumulated heavy metals has the capacity to take them up [13], which when consumed is transferred to the consumer.

The belief that soils within the proximity of dumpsites are fertile and fortified with relevant plant nutrients and organic manure has led to the establishment of small farms (especially vegetables) within dumpsite areas. This is based on the ignorance in most cases of the farmers on the implied aftermath effects that can possible result from the consumption of such plants. Therefore, this research work was undertaken to assess the concentrations of selected heavy metals in soils from selected farmlands situated within the vicinity of a dumpsite at Rumuagholu, Port Harcourt, Rivers State, Nigeria.

Materials and Methods

Three sample points on three farmlands separated from each other at a distance of 1-1.5 Km were chosen. Within these positions three samples were taken and a composite sample formed for each of the points sampling was done. The farmlands chosen for the experiment were around the circumference of the dumpsite. A separate soil sample was taken from a farmland that is 3 Km away from the dumpsite as control. Sampling of soil was done with soil auger for three months. The depth of sampling was between 0-20 cm into the soil. The composite soil samples were put into cellophane bags and then transported to the laboratory for further treatment. Sampling was done for three months and the mean value only was recorded for each of the stations and control. The final mean was taken with the exclusion of the concentration of the control value

In the laboratory, the soil samples were allowed to air dry freely without exposure to sunlight or heating. This was allowed for s period of three weeks before constant weight was observed in all the samples. Thereafter, the samples were carefully sorted to remove pieces of wood, vegetables and stones and then homogenized in a mortar with pestle. The homogenates were sieved to obtain a fine powder and then stored in well corked and labeled glass containers.

Two (2g) grams each of the fine soil samples were weighed and put into digestion containers placed in a steam bath for digestion. A mixture of three concentrated acids (H_2SO_4, HCl and HNO_3) in the ratio 2:3:5 were added to the soil sample. Added also was 20 ml of water and then heated to obtained a slightly yellow or clear colour. The digested samples were then filtered with whatman filter paper. The filtrates were made up to 50 ml with deionize water and collected in 60 ml plastic vials and properly labelled and stored at a temperature of 4 ^{o}C in a freezer before analysis.

Heavy metals analysis of the samples were done using Atomic Absorption Spectrophotometer (AAS). The results obtained were subjected to statistical analysis and analysis of variance to determine differences in the mean values between stations and control. Furthermore, the results were tested with some pollution indices (contamination factor, pollution index, contamination degree and modified contamination degree) to examine the status of heavy metals contamination resulting from the dumpsite and the obtained values interpreted based on the interval of pollution or contamination proposed by the original equation proposers.

Results and Discussion

The results of the concentrations of the heavy metals in the farmlands within the dumpsite are shown in Table 1. The levels of Pb in the soil samples varied from 0.94±0.02 - 2.72±0.21 mg/Kg with a mean value of 1.71±0.75 mg/Kg. The highest level of Pb in soil was recorded in farmland 2. The levels of Pb in soil were below the DPR recommended value ofmg/Kg.

The levels of Pb observed in the study locations were higher than the value observed in the control soil sample, which was 0.011±0.00 mg/Kg. The observed higher concentrations at the dumpsite farmland soils suggests that with time the heavy metals can accumulate to a toxic level [15]. Furthermore, the results for Pb reported in this study were observed to be lower than those reported by Okorosaye & Igwe [16], whose values ranged from 3.42 ± 0.27 - 7.69 ± 0.45 mg/Kg at abandoned solid waste dumpsite in Port Harcourt, Nigeria and higher than those of Radwan and Salema [17], in a dumpsite elsewhere in Egypt.

The levels of Cdin the soil samples varied from 0.04±0.01 - 0.47±0.22 mg/Kg, with a mean value of 0.21±0.19 mg/Kg. the observed concentrations of Cd in the dumpsite soil is lower than the DPR value of 0.8 mg/Kg. The values obtained in the soil from the dumpsite farmlands were higher than that of the control where Cd values were undetected. The highest concentration of Cd was observed in farmland 2, which was 0.472 mg/Kg. In a similar study, Hammed *et al.,* [18] reported low levels of Cd (<1.0mg/Kg) in Ibadan, Oyo State. On the other hand, Okorosaye & Igwe [16] reported higher values of Cd (0.43±0.09 to 1.82±0.12mg/Kg) in Port Harcourt, Rivers State.

The levels of Chromium observed in studied soil in the selected farmlands ranged from 1.81±0.69 - 3.25±1.25 mg/Kg, with a mean value of 2.59±0.59 mg/Kg. the highest value was observed in farmland 2. The concentration of the control soil sample from a distant farmland was 0.18±0.11mg/Kg. The mean concentration of Cr in soil was observed to be lower than the maximum permissible limit set by DPR. This suggests that the higher concentrations at the dumpsite farmlands were as a result of the leaching of Cr-containing wastes present in the dumpsite. Sources of chromium might be due to wastes from household chemicals and cleaners, diesel engines, utilizing anti-corrosive agents, rubber, candles and matches.

Olubunmi *et al*. [19] recorded Cr levels of 7.90 mg/Kg in Ado-Ekiti which were higher than the values of the present work. Also, Marcus *et al*. [2],observed values of Cr in soils contaminated from leachates from dumpsite in the range of 5.67±0.02 - 11.22±2.04 mg/Kg, which were higher than the values obtained in this dumpsite. However, the values of Cr observed in soil within abattoir environment [7] were within the range of values observed in the present work.

The levels of Cu in the soil varied from 1.35 ±0.33 - 2.19±1.01 mg/Kg in the examined farmlands at the dumpsite. The mean value of Cu was observed to be 1.75±0.34 mg/Kg. the highest value was observed in farmland 2. The value observed at the control farmland was 0.42±0.12 mg/Kg. The level of Cu in soil of this study was observed to be higher than those reported by Hammed *et al*. [18], in Ibadan, Oyo State, whose values were in the range of 0.34–0.91 mg/Kg) and those of Uka *et al*. [20], in Abakaliki metropolis South eastern Nigeria, where values were in the range of 0.02– 0.07 mg/Kg.

Cu is an indispensable nutrient that is assimilated into a number of metalloenzymes for human metabolic activities. ATSDR, [21] observed symptoms associated with Cu deficiency in humans to include hypochronic anaemia, osteoporosis etc. The levels of Cu in soil and vegetable were below the DPR of 45 mg/Kg value in soil.

The levels of Ni in the soil varied from 1.42±0.08 - 2.90±0.96 mg/Kg, with a mean value of 2.06±0.62 mg/Kg. Concentration of Ni in the control farmland soil observed was 0.26±0.03 mg/Kg. There was reported higher levels of Ni in the range of 13.02 – 35.23 mg/Kg in Nairobi Kenya, which was higher than the values reported in this work. The values of Ni reported in dumpsite soil by Marcus *et al*., [2] were in the range of 7.81±0.78 - 18.29±3.00 mg/Kg, which were also higher than the values of the present work, but the values of Edori and Kpee [7] in abattoir soil were almost within range observed in this work.

Table 1: Concentrations of heavy metals in farmland soils from Rumuagholu dumpsite

Heavy Metals (mg/Kg)	Farmland Stations				Mean ± SD	DPR (2002)
	Control	1	2	3		Value
Pb	0.011±0.00	1.47±0.03	2.72±0.21	0.94± 0.02	1.71±0.75	85
Cd	ND	0.47±0.22	0.04±0.01	0.11±0.02	0.21±0.19	0.8
Cr	0.18±0.11	2.71±0.42	3.25±1.25	1.81±0.69	2.59±0.59	100
Cu	0.42±0.12	1.35 ±0.33	2.19±1.01	1.72±0.53	1.75±0.34	45
Ni	0.26±0.03	1.88±0.36	2.90±0.96	1.42±0.08	2.06±0.62	35

The contamination factor (CF), pollution load index (PLI), contamination degree (CD) and modified contamination degree (mCD) results of the heavy metals are shown in Table 2. The contamination fact of Pb varied from 0.01 – 0.03 within dumpsite farmland soils. The values showed that the soils were not contaminated with Pb when compared with the proposed chart for intervals of contamination [22]. The contamination factor for Pb in the present work is lower than the values in roadside soils in Botswana [23], also lower than those of Naveedullah *et al*. [24], in farmlands soils of Siling Basin at water break point in Zhejiang Region, China and Omotoso and Ojo (2015), in soil disposed to flood along River Niger at Jebba, central Nigeria [24].

The values of contamination factor observed for Cd varied from 0.05 – 0.59. The values showed that dumpsite soil in farmland 1 is in a state of severe contamination with Cd, farmland soil 2 is not contaminated with Cd and farmland soil 3 is slightly contaminated with Cd. The contamination factor for Cd in the dumpsite soils were lower than the values observed in soils collected from industrial area in South Western Nigeria [25] and also those of Ghazaryan *et al*. [26], in soils where Cu and Mo are mined in Agarak, Armenia.The contamination index values of Cr in the farmlands ranged from 0.02 – 0.03. these values showed that the soil were not contaminated with Cr. The contamination factor values observed in the present work is lower than those of Naveedullah *et al*. [24], in farmland soils elsewhere in China, also lower than the observed values in soils from a mine area in Agarak, Armenia [26] and those of Perunović *et al*., [27], in a contaminated soil collected from Kremna Basin, Serbia.

The values of contamination factor observed for Cu varied from 0.03 – 0.05 in the farmlands. These values showed that the soils were not contaminated with Cu. The observed contamination levels of Cu in the dumpsite soil in the present work do not agree with the observation of other others in a similar environment [23], whose values were in the range of severe contamination to mild pollution of soil with Cu and also those of Omotoso and Ojo [28], whose contamination factor values for Cu in soil within flooding areas of Jebba, Nigeria were at the level of very high pollution and those of Kolawole *et al*. [25], in soils from manufacturing area elsewhere in the south-western part of Nigeria, where the level of occurrence of Cu in the soil have risen to the level of severe pollution.

The values of contamination factor observed for Ni varied from 0.05 – 0.08 in the farmland soils, which is an indications of non-contamination with Ni. The index of contamination exhibited by Ni in the farmland soil were lower than the values of other authors in different contaminated soil environments [23, 26]. Mmolawa *et al*. [23], examined the contamination status of heavy metals in soils collected along major roadside areas in Botswana and observed that the status of Ni fell within the range of slight pollution to moderate pollution. Ghazaryan *et al*. [26], analyzed the contamination status of individual metals in a metal smelting industry and observed that Ni value was in the range of moderate pollution.

The pollution index of the farmland soils varied from 0.75 – 0.94. based on the categories of intervals of pollution or contamination, the observed values from the different farmland fall within the category of severe contamination with heavy metals in stations 2 and 3 to very severe contamination with heavy metals in station 1. The pollution index observed in the present study were lower than those of Ghazaryan *et al*. [26], whose intervals of contamination/pollution were observed in the range of slight pollution and also lower than the values observed in soil from Kremna Basin in Serbia, where the values ranged from mild contamination to slight pollution [27].

The contamination degree values for the farmlands in the dumpsites varied from 0.24 - 0.72. based on the intervals of contamination levels proposed by Hakanson [29], all the observed values fall into non contamination with heavy metals. This observation disagrees with the observation of Omotoso and Ojo [28], who observed contamination degree range between low contamination degree to moderate contamination degree in flood plain soils in Jebba, Nigeria, and also lower than the values Perunović *et al* [27], where the contamination status was significant degree of contamination. The modified contamination degree results from the farmland stations in the dumpsite varied from 0.05 – 0.14. these values indicated nil degree of contamination.

Table 2: Contamination Factor, Pollution Load Index, Contamination Degree and Modified Contamination Degree of Heavy metals in Farmland at Rumuagholu Dumpsite

Heavy Metals	**Contamination Factor**		
	1	**2**	**3**
Pb	0.02	0.03	0.01
Cd	0.59	0.05	0.12
Cr	0.03	0.03	0.02
Cu	0.03	0.05	0.04
Ni	0.05	0.08	0.06
PLI	0.94	0.75	0.76
CD	0.72	0.24	0.25
mCD	0.14	0.05	0.05

The geochemical or geo-accumulation index of the soil samples from the dumpsite farmsare shown in Table 3. The values of Pb in the farmland stations varied from 0.002 – 0.006, which indicated uncontamination with Pb. This suggested that anthropogenic influence on Pb input may be null or minimal and that the source of Pd may have resulted from natural effects. The values for Cd fall with the range of 0.010 – 0.120, Cr values fall within the range of 0.004 – 0.0-06, Cu values fall within the range of 0.006 – 0.010, and Ni values ranged from 0.010 – 0.016. All the categories of the examined metals in the present work indicated human non-interference of heavy metals input to slight contamination by human activities when compared with the proposed values for comparison by Muller [30].

Table 3: Geochemical Index of Heavy metals in Farmland at Rumuagholu Dumpsite

Heavy Metals	**Geochemical Index**		
	1	**2**	**3**
Pb	0.004	0.006	0.002
Cd	0.120	0.010	0.024
Cr	0.006	0.006	0.004
Cu	0.006	0.010	0.008
Ni	0.010	0.016	0.012

Conclusion

Soil is one of the most important resource for human beings. This is because its importance in agricultural productivity. Heavy metals are one of the natural constituents of the soil, but its quantity can be dangerous to humans. The concentrations of heavy metal examined in the soil at the farmlands showed that the occurrence is more of natural than anthropogenic. Although, human input sources are not implicated in this assessment, yet there should proper vigilance and protection of the nature of waste to be disposed so as to prevent upsurge of heavy metals presence in these areas, which have negative consequences later.

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