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Ecological Risk Assessment of Heavy Metals in Soil of Lagos State University, Epe, Lagos State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Soil contaminated with heavy metals poses an ecological risk especially to public health. The aim of this work is to assess the ecological risk of heavy metals in soil of Lagos State University (LASU), Epe, Lagos State, Nigeria. Soil samples were collected from 8 different points in LASU which were stored in various polythene bags labeled SS1 – SS8. A control sample was taken 1 km away from LASU and was labeled SC9. All the sampling locations were identified using handheld Global Positioning System (GPS) for the purpose of universal identification. The soil samples were analysed for nickel (Ni), lead (Pb), copper (Cu), Zinc (Zn), chromium (Cr), cadmium (Cd) and Iron (Fe) using Atomic Absorption Spectrophotometer. Enrichment factor (*EF*), potential ecological risk (E_i) and ecological risk index (R_I) were carried out using the data from the analysis. The results revealed that all the *EF* values were less than 2 except that of lead in SS1. The E_i values were less than 40 except that of lead in SS1. Moreover R_I values of all the soil samples investigated were less than 150. It was obvious from this work that the soil of LASU, Epe, Lagos State, were not enriched with heavy metals and have a low potential ecological risk.

Keywords: Assessment; ecological; heavy metals; Lagos State University and risk.

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1. INTRODUCTION

Soil is an irreplaceable resource which sustains life on the planet, challenged by food and energy demands of an increasing population [1]. Soil pollution is the presence of toxic chemicals in soil in sufficient concentrations to pose a risk to human health and ecosystem. It is a health risk as it increases one's chance of developing a disease. The sources of soil pollution include agricultural, industrial, urban, sewer, sludge, mining and smelting, biological, acid rain and nuclear resource. Soil pollution constitutes a critical issue to be addressed if the life qualities of presence and future generations are to be secured [1].

Many researchers have assessed the potential risk of contaminants in soil [2-19]. Jiang et al. [7] assessed the potential ecological risk and trend of soil heavy metals pollution around coal gangue dump in Jilin Province of China. The assessment revealed that pollution degrees descended in the order Cd $\succ$ Zn $\succ$ Pb $\succ$ Cu $\succ$ Cr. Salami and Susu [10] evaluated comprehensively the contaminants in soil within the vicinity of the three Soluos dumpsites in Igando area of Lagos State, Nigeria. The evaluation showed that the soils within the vicinity of the dumpsites were polluted with heavy metals. Odunlami and Salami [9] worked on soil contamination status in approved mechanic villages in Lagos State, Nigeria. The work indicated that the soils of mechanic villages investigated have been polluted.

Owoso et al. [14] investigated heavy metal contamination of soil and groundwater by artisanal activities in Lagos metropolis, Nigeria. The investigation showed a very high degree of contamination of soil and groundwater which was an indication of serious anthropogenic pollution from artisanal activities at the location. Gworek et al. [20] carried out ecological assessment for land contaminated by petrochemical industry. The assessment pointed out that the soils assessed were uncontaminated. Fatai et al. [15] examined sources and pattern of heavy metal concentration in urban road dusk, Lagos metropolis. The examination identified anthropogenic activities as the major source of metal pollution in the studied road dusk. Olatunji and Afolabi [18] assessed the lead contamination of soil, sediments and road dusts of the city of Lagos, Nigeria. The assessment revealed the presence of lead in the environment which was from anthropogenic sources. The lead was held in reactive geochemical phases which potend a great risk to the environment and public health. Fakayode and Onianwa, [16] carried out heavy metal contamination of soil and bioaccumulation I Guinea grass around Ikeja industrial estate, Lagos State, Nigria. The work showed that the level of metals in the soils and plants around the estate were found to be significantly higher than the background concentrations obtained at the remote control sites

Qi et al. [21] studied the heavy metals contamination and ecological risk assessment of the agricultural soil in Shanxi Province, China. The study demonstrated that Cd and Hg had higher levels of ecological risk for agricultural soil in Shanxi Province of China. Broomandi *et al*. [22] worked on critical review of soil contamination in areas impacted by military activities. The work showed that heavy metals have been found in elevated concentrations in many military impacted zones. Ugwu and Ofomah, [19] assessed the health risk of students' exposure to some potentially toxic metals in classroom dust in Southeast, Nigeria. The assessment proved that there was carcinogenic risk for ingestion of dust. Continuous assessment of potential ecological risk of soil is very crucial in order to secure quality of life. However the potential ecological risk of soil of Lagos State University, Epe, Lagos State which was a formal military barrack is very scarce in the literature. Therefore the aim of this work is to assess the ecological risk of heavy metals in soil of (LASU), Epe, Lagos State, Nigeria with a view of establishing level of risk poses by the soil. This assessment can be used by relevant authorities in making decisions concerning the management of the soil which justifies this work.

1.1 Study Area

LASU Epe, Lagos State is on coordinate 6.588^{o}N and 3.9896^{o}E (http://en.m.wikipedia.org). It was formally used as a military barrack before 1996. The campus became a full fledge academic campus in 1996. The campus is a large tract of land that runs into thousands of acreage. At present, LASU campus houses school of agriculture and faculty of engineering which comprises the following departments: chemical, mechanical, civil, electronic and computer and aerospace engineering. It also houses directorate which runs pre-degree programme. There are accommodation for students and staff of the university. The campus is beautifully set in the coasts valley landscape of Epe and happens to be one of few places with sea cliffs in Nigeria

[23]. The campus is surrounded by vast of land use for agricultural purpose by the villagers.

2. METHODOLOGY

2.1 Sampling Location

8 different sampling points were selected within LASU Epe campus, labeled 1 – 8, for collection of soil samples. 1 location was also chosen 1 km away from the campus, labeled 9, where control sample was taken. All the sampling points were coordinated using handheld Global Positioning System (GPS) (Etrex 12 Garmin model) for the purpose of universal identification of the sampling points. The specifications of the sampling points are presented in Table 1.

2.2 Sampling of Soil and Analysis

Soil samples were collected from points 1 – 8 during the month of October, 2020 from surface layer (0 – 20 cm) soil of LASU Epe with the aid of stainless auger. The soil samples were stored in different polythene bags and were labeled SS1 – SS8. The same was done at point 9 and the sample was labeled SC9. The auger was washed with distilled water each time it was used for collection of sample before using it again. All the soil samples were quickly transferred to laboratory for analysis. The method of Salami and Susu [10] was adopted with a little modification. The soil samples were first air dried overnight in an oven at 32^{o}C. The dried samples were mechanically ground and sieved through 200 mesh size sieve to remove large debris, gravel sized materials and plant roots. 5 g of each sieved samples was placed in an Erlenmeyer flask and 2.5 ml of extracting solution (0.05N HCl + 0.24 H_2SO_4) was added after which the mixture was placed in a mechanical shaker for 20 minutes as compared to 15 minutes used by Salami and Susu [10]. The resulting solution was filtered through whatmann filter paper into a 50 ml volumetric flask and diluted to 50 ml with the extracting solution. The treated samples were analysed for the following heavy metals: Ni, Pb, Cu, Zn, Cr and Cd using Atomic Absorption Spectrophotometer (Model 210 VGP) made by Buck Scientific.

2.3 Enrichment Factors and Ecological Risk Index

The EF were determined using the model shown in Equation (1).

$$EF = \frac{\left(\frac{C_i}{Fe}\right)_{sample}}{\left(\frac{C_b}{Fe}\right)_{background}} \quad (1)$$

Where C_i is the concentration of heavy metal of interest in the sample, C_b is the concentration of heavy metal of interest in the background, $\left(\frac{C_i}{Fe}\right)_{sample}$ is the ratio of concentration of heavy metal of interest in the sample to concentration of iron in the sample and $\left(\frac{C_b}{Fe}\right)_{background}$ is the ration of the concentration of heavy metal of interest in the background to concentration of iron in the background.

The R_I was calculated with the aid of the model presented in Equation (2).

$$R_I = \sum_{i=1}^{n} E_i \quad (2)$$

Where E_i is the monomial potential ecological risk factor. The monomial potential ecological risk factors were evaluated using the model proposed by Hakanson [24] shown in Equation (3).

$$E_i = T_i\left(\frac{C_i}{C_b}\right) \quad (3)$$

Where T_i is the toxic response factor of a particular heavy metal.

3. RESULTS AND DISCUSSION

The specifications of the coordinates where soil samples were taken is presented in Table 1 while the concentrations of heavy metals in the soil of LASU, Epe, Lagos State is shown in Table 2.

The concentrations of lead in the soil investigated varied between 0.21 and 12.6 mg/kg with the exception of SS8 having a concentration less than 0.001 mg/kg. The concentrations of copper in the soil ranged between 1.48 and 6.47 mg/kg while that of the zinc varied between 1.56 and 11.87 mg/kg. The concentrations of iron in the soil examined ranges between 32. 98 and 135.59 mg/kg. The work of Olatunde et al. [17] revealed that children were exposure to some heavy metals in soil and dust from playground and classrooms in selected primary schools in Lagos State, Nigeria, via ingestion pathway which was of greatest carcinogenic risk. . Heavy metals have been chosen for assessment in this study because of their effects in public health. This work only considered heavy metals however a comprehensive investigation of the soil should be carried out in future work.

The EF values of soil of LASU are presented in Table 3. Iron was used as a normalization element in the calculation of enrichment factor because it distribution has no relation with other heavy metals according to Deely and Fergusson (1994). Iron has a high natural concentration (Abrahim and Parker, 2008) which was also the case in this study as clearly shown in Table 2. This was also the reason why iron was used as the normalization element. In Table 3, the enrichment factor values for lead and copper varied between 0.20 and 10.02 and between 0.56 and 1.04 respectively while that of zinc ranged between 0.59 and 1.31. EF provides accurate assessment of heavy metals accumulation from anthropogenic sources [25,26] which was why it was carried out in this study.

Table 1. Specification of the sampling locations for soil samples

S/N	Coordinates		Sampling location	Identification code of samples	Sampling elevation
	Easting	Northing			
1	004°00.080’	06°35.106’	Minimart	1	6
2	004°00.030’	06°35.107’	Students’ hostel	2	11
3	003°59.837’	06°35.333’	Downhill farm	3	2
4	003°59.727’	06°35.356’	Mechanical workshop	4	59
5	004°00.057’	06°35.582’	School of Agriculture	5	92
6	003°59.850’	06°35.659’	Uphill quarter	6	134
7	003°59.880’	06°35.551’	Classroom uphill	7	158
8	003°59.531’	06°35.462’	Junior staff quarter	8	224
9	003°59.327’	06°35.301’	Outside LASU	9	93

Table 2. Concentrations of heavy metals in the soil of Lagos State University, Epe, Lagos State

S/N	Sample code	Parameters (mg/kg)						
		Ni	Pb	Cu	Zn	Cr	Cd	Fe
1	SS1	≺0.001	12.60	3.55	8.93	≺0.001	≺0.001	115.37
2	SS2	≺0.001	0.42	1.48	1.56	≺0.001	≺0.001	32.98
3	SS3	≺0.001	5.21	6.47	10.20	≺0.001	≺0.001	135.59
4	SS4	≺0.001	0.21	2.49	6.92	≺0.001	≺0.001	95.83
5	SS5	≺0.001	0.80	2.93	4.64	≺0.001	≺0.001	114.91
6	SS6	≺0.001	2.95	4.86	6.89	≺0.001	≺0.001	118.17
7	SS7	≺0.001	2.58	3.51	11.87	≺0.001	≺0.001	133.73
8	SS8	≺0.001	≺0.001	2.76	4.74	≺0.001	≺0.001	89.99
9	SC9	≺0.001	1.29	5.38	8.01	≺0.001	≺0.001	117.84

Table 3. Enrichment factor values of soil of Lagos State University, Epe, Lagos State

S/N	Sample code	Parameters		
		Pb	Cu	Zn
1	SS1	10.20	0.67	1.14
2	SS2	1.17	0.98	0.70
3	SS3	3.53	1.04	1.11
4	SS4	0.20	0.57	1.06
5	SS5	0.64	0.56	0.59
6	SS6	2.29	0.90	0.86
7	SS7	1.77	0.57	1.31
8	SS8	-	0.67	0.77

Table 4. Potential ecological risk factors and ecological risk index values of soil of Lagos State University, Epe, Lagos State

S/N	Sample code	Ecological risk factor			R_I
		Pb	Cu	Zn	
1	SS1	48.48	3.30	1.11	53.25
2	SS2	1.63	1.37	0.19	3.19
3	SS3	20.19	6.01	1.27	27.47
4	SS4	0.81	2.31	0.86	3.98
5	SS5	3.10	2.72	0.58	6.40
6	SS6	11.43	4.52	0.86	16.81
7	SS7	10	3.26	1.48	14.74
8	SS8	-	2.57	0.59	3.16

Pekey [27] used the following EF values in his work; EF $\prec 2$ indicates no enrichment, EF = 2 – 3 is minor enrichment, EF = 3 – 5 is moderate enrichment, EF = 5 – 10 means moderately severe enrichment, EF = 10 – 25 is severe enrichment, EF = 25 – 50 is very severe enrichment and EF $\succ$ 50 is extremely severe enrichment. The terminologies were adopted in this work. In Table 3, all the enrichment factor values were less than 2 except that of Pb in SS1. This was a clear indication that the soils of LASU were not enriched with heavy metals. EF less than 2 means the element in the soil is originated predominantly from lithogenous materials while an EF value greater than 2 indicates the element is of anthropogenic origin [28]. It can be said that the origin of heavy metals in the soil of LASU were from lithogenous materials.

The potential ecological risk factor and ecological risk index values of soil of LASU are shown in Table 4. T_i used for the calculation of potential ecological factors was as follows: Pb (5), Cu (5) and Zn (1). The terminologies used to describe potential ecological risk factor by Hakanson (1980) were also adopted in this work. $E_i \prec 40$ indicates low potential ecological risk, $40 \leq E_i \prec 80$ is moderate potential ecological risk, $80 \leq E_i \prec 160$ means considerable potential ecological risk, $160 \leq E_i \prec 320$ indicates high potential ecological risk and $E_i \geq 320$ is very high ecological risk. In Table 4, all the potential ecological risk factor values were less than 40 except Pb in SS1 which was 48.84. This clearly showed that the soils of LASU, EPE, Lagos State have low potential ecological risk.

The ecological risk index is a comprehensive index used to assess heavy metals in soil. The terminologies used for describing the ecological risk index are as follows [24]: $R_I \prec 150$ indicates low ecological risk, $150 \leq R_I \prec 300$ means moderate ecological risk, $300 \leq R_I \prec 600$ indicates considerable ecological risk and $R_I \geq 600$ means very high ecological risk. All the ecological risk indexes in Table 4 were below 150 which mean the soils of LASU, Epe, Lagso State were of low ecological risk. It was obvious that the soils of LASU, Epe, were of low ecological risk of contamination and low ecological risk to public health which is a departure from the work of Broomandi et al. [22] which indicated that military activities did impact on the areas of activities zones.

4. CONCLUSION

The ecological risk of heavy metals in soil of LASU, Epe, Lagos State, has been assessed. The enrichment factor values of the soil investigated were less than 2 which indicated the soils were not enriched with heavy metals and the heavy metals in the soil were from lithogenic materials. The potential ecological risk factor values were less than 40 which showed that the soils examined were of low potential ecological risk. The ecological risk index values of soils investigated were less than 150 which revealed the soils were low ecological risk. It was concluded that the soils of LASU, Epe, Lagos State pose low ecological risk of contamination and low ecological risk to public health.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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