Research Article

Risk Assessment of Heavy Metals in Dumpsite soil of Ijero Ekiti, Nigeria

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Abstract

The term heavy metals are generally defined as metals with relatively high densities, atomic weights or numbers. The determination of the heavy metals in soils, dusts, plants and sediments are very essential in monitoring environmental pollution. The purpose of study was to assess the heavy metals (Ni, Pb, Cu, Zn, Cd and Cr) pollution in dumpsite soil. The results indicated that the soil was moderately polluted by Pb, Cu and Cd (Igeo = 2.63, 2.92 and 2.74) respectively. Potential ecological risk index results indicated that Cd is at very high potential ecological risk and should be of great concern to the inhabitant and government agencies.

Keywords: Heavy metals, Geo-accumulation index, Pollution, Potential ecological risk pollution

Introduction

Among the series of environmental problems besieging urban centre, solid waste stands out as a serious hazard in Ekiti metropolis. The rapid population explosion, industrialization and continuous change in consumption pattern have compounded solid waste challenges in the area million metric tons of hazardous wastes are generated each year. The components and constituents of urban waste are hazardous and devastating. The hazardous nature of the waste is a serious threat to soil quality, health, water and the entire ecosystem, Ozone destruction, climate change increase due to pollution. A visit to the dump site will actually validate the thoughts.

The determination of the heavy metals in soils, dusts, plants and sediments are very important in monitoring environmental pollution. The contribution of heavy metals to environmental pollution from industrial, agricultural and mining processes besides automobile emission, have been the main subject of many studies and research in recent years.

The term "heavy metals" refers to any metallic element that has a relatively high density and is toxic or poisonous even at low concentration.[1] "Heavy metals" is a general collective term, which applies to the group of metals and metalloids with atomic density greater than 4 g/cm^3 , or 5 times or more, greater than water.[2-7]

Heavy metals can be found gene rally at trace levels in soil and vegetation, and living organisms, the need for microelements of these metals. However, these have a toxic effect on organisms at high content levels. Heavy metals toxicity has an inhibitory effect on plant growth, enzymatic activity, stoma function, photosynthesis activity and accumulation of other nutrient elements, and also damages the root system.[8,9] However, being a heavy metal has little to do with density but concerns chemical properties.

A pollutant is any substance in the environment, which causes objectionable effects, impairing the welfare of the

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environment, reducing the quality of life and may eventually cause death. Such a substance has to be present in the environment beyond a set or tolerance limit, which could be either a desirable or acceptable limit.[10]

Soil is a dynamic resource that supports plant life. It is made up of different sized mineral particles (sand, silt, and clay), organic matter, and numerous species of living organisms. Thus, soil has biological, chemical, and physical properties, some of which are dynamic and can change in response to how the soil is managed.[11-13] Mabogunje AL observes that ineffective solid waste management is caused by the poor attention being paid to physical planning in Nigeria cities.[14] As a consequence, the relic of pre-industrial urbanization in these cities such as narrow, irregular and unplanned lanes and alleys hamper the efficient collection and disposal of solid waste in the cities.

Urbinato D maintained that Pollution is the introduction of contaminants into an environment that causes instability, disorder, harm or discomfort to the ecosystem i.e. physical systems or living organisms.[15] Pollution can take the form of chemical substances or energy, such as solid waste, noise, heat, or light.

Materials and Methods

Study Area

Ijero dumpsite was selected as the study area, because it is one of the largest dumpsite in Ekiti State and is located at Ijero Local Government area of Ekiti State, Nigeria. The study area is located on 7°49’ N and 5°5’ E.

Sample Collection and Analysis

10 soil samples (three replicates) were collected at surface level (0-10cm in depth) were collected from various locations. Samples at each point were collected randomly and combined to form composite samples. Coning and quartering method of sampling were then used to obtain a representative sample. The resulted samples were air dried and sieved into course and fine fractions. Well mixed samples of 2 g each were taken in 250 mL glass beakers and digested with 8 mL of aqua regia on a sand bath for 2 hours11. After evaporation to near dryness the samples were dissolved with 10 mL of 2% nitric acid, filtered and then diluted to 50 mL with distilled water. Leachates from all samples were stored in plastic containers and kept in fridge (4°C) until metal analysis, using Atomic Absorption Spectrophotomer (AAS) Buck Scientific (model 210VGP) using air acetylene flame at the optimal wavelengths of each metal. Standards used to calibrate the AAS were obtained as commercial BDH stock metal solutions from which working standards were prepared by appropriate dilution. Blank samples (sample containing all reagents except the soil sample) were carried through all methods, analyzed and subtracted from the sample. This was done to check reagent and environmental interferences.

Assessment Methods

Geo accumulation Index (I_{geo})

The contamination levels of heavy metals in soils were assessed by geo accumulation index (I_{geo}).[16]

$$I_{geo} = \log_2[C_n/(1.5B_n)]$$

Where C_n is the measured concentration of heavy metal n in the soils, B_n the geochemical background concentration of metal n, and 1.5 is the background matrix correction factor due to lithogenic effects.

Table 1.Standard Regulatory Limit/Background Levels of Metals in Soil[17]

Metals	Concentration (mg/kg)
Cd	0.5
Pb	10
Zn	90
Cr	100
Ni	40
Fe	38,000
Cu	30
Co	8

Table 2.Geo-accumulation Index Classes[18]

Classes	Ranges	Indications
0	Igeo<0	Practically uncontaminated
1	0<igeo<1	Uncontaminated- moderate
2	1<igeo<2	Moderately uncontaminated
3	2<igeo<3	Moderately-heavily contaminated
4	3<igeo<4	Heavily contaminated
5	4<igeo<5	Heavily- extremely contaminated

Contaminant Factor and Degree of Contamination

Assessment of soil contamination is performed by the contamination factor (C_f^i) and degree of contamination (C_d).[19]

Where C_s^i is the content of metal I, and C_n^i is the reference value, baseline level, or national criteria of metal i.

$$C_f^i = \frac{C_s^i}{C_n^i}, \quad C_d = \sum_i^m C_f^i$$

Table 3.Descriptive Classes of Contamination Factor[19]

Classes	Indications
$C_f<1$	Low contamination
$1<c_f<3$	Moderate contamination
$3<c_f<6$	Considerably contaminated
$6<c_f$	Very high contaminated

Table 4.Degree of Contamination[19]

Classes	Indications
$C_d<8$	Low degree of contamination
$8\leq c_d<16$	Moderate degree of contamination
$16\leq c_d<32$	Considerable degree of contamination
$32\leq c_d$	Very high degree of contaminated

Ecological Risk Factor

An ecological risk factor (E_r^i) to quantitatively express the potential ecological risk of a given contaminant also suggested by Hakanson is:

$$E_r^i = T_r^i C_f^i$$

The toxic-response factor T_r^i of heavy metals i are:

$T_r^{Zn} = 1$; $T_r^{Pb} = 5$; $T_r^{Cd} = 30$; $T_r^{Cu} = 5$; $T_r^{Ni} = 5$; $T_r^{Cr} = 2$

Ecological Risk Index (I_r)

$$I_r = \sum_i^n E_r^i = \sum_i^n T_r^i C_f^i = \sum_i^n T_r^i C_s^i / C_n^i$$

Table 5.Descriptive Table for Ecological Risk Factor (E_r)[19]

Classes	Indications
$E_r^i\leq40$	Low potential ecological risk
$40\leq E_r^i<80$	Moderate potential ecological risk
$80\leq E_r^i<160$	Considerable potential ecological risk
$160\leq E_r^i<320$	High potential ecological risk
$E_r^i\geq320$	Very high ecological risk

Table 6.Descriptive Table for Ecological Risk Index (I_r)[19]

Classes	Indications
$I_r<150$, low ecological risk	Low ecological risk
$150\leq I_r<300$	Moderate ecological risk
$300\leq I_r<600$	Considerable ecological risk
$I_r>600$	Very high ecological risk

Table 7.Average Values of I_{geo} for Each Metal

Heavy metal	Igeo	Pollution level
Ni	-2.38	Practically uncontaminated
Pb	2.63	Moderately heavily contaminated
Cu	2.92	Moderately heavily contaminated
Zn	-0.13	Practically uncontaminated
Cd	2.74	Moderately heavily contaminated
Cr	-0.23	Practically uncontaminated

Table 8.Contamination Factors and Contamination Degree Values

		C_f						
Location	**Item**	**Ni**	**Pb**	**Cu**	**Zn**	**Cd**	**Cr**	**C_d**
	Min	0.12	10.2	13.4	2.2	5.0	0.10	31.02
A	Max	0.16	15.1	15.8	2.8	7.5	0.17	41.53
	Average	0.19	12.2	14.69	2.4	6.7	0.12	36.30
	Min	0.13	4.30	7.07	0.52	3.50	0.08	15.60
B	Max	0.73	12.3	14.0	2.31	8.0	0.14	37.48
	Average	0.36	8.10	10.6	1.57	5.80	0.10	26.53
	Min	0.15	8.40	8.20	0.50	8.50	0.07	25.82
C	Max	0.29	22.30	17.7	12.4	29.6	0.15	82.44
	Average	0.23	13.2	11.8	0.81	15.9	0.10	42.04
	Min	0.20	0.55	0.48	0.34	0.50	0.07	2.14
D	Max	0.53	17.8	16.8	1.29	32.0	0.21	68.63
	Average	0.37	6.90	8.38	0.67	11.7	0.12	28.14
Average		0.29	10.10	11.38	1.36	10.0	0.11	33.25

Table 9.Ecological Risk Factors and Potential Ecological Risk Index

	E_r						
Location	**Ni**	**Pb**	**Cu**	**Zn**	**Cd**	**Cr**	**I_r**
A	0.95	61.0	73.45	2.40	201	0.24	339.04
B	1.80	40.5	53.0	1.57	174	0.20	271.07
C	1.15	66.0	59.0	0.81	477	0.20	604.16
D	1.85	34.5	41.9	0.67	351	0.24	430.16
Average	1.19	50.5	56.84	1.36	300.8	0.22	411.11

Results and Discussion

The I_{geo} values were calculated by the heavy metals (Ni, Pb, Cu, Zn, Cd, Cr) average concentrations in soil samples. According to Muller Descriptive tables 2, the average values of Igeo for each metal and their pollution levels are shown in Table 7 indicated that the soils of the study area can be categorized as follows: unpolluted with Ni, Cr and Zn, moderately heavily contaminated with Pb, Cu and Cd. The assessment results were in the following trend: Cu>Cd>Pb>Zn>Cr>Ni.

To further determine the environmental pollution and the ecological damage of heavy metals in the dumpsite soil, potential ecological risk index method proposed by Hakanson L was employed and the descriptive Table 3-6 was used to categorize them.[19]

The contamination factors of Ni, Pb, Cu, Zn, Cd and Cr and their contamination degree values of samples are shown in Table 8. Contamination factors of Pb, Cd, Zn, Cu and Ni varied in the range of 0.12-0.73, 0.55-22.3, 0.48-17.7, 0.34-12.4 and 0.50-32.0, with average values of 0.29, 10.10, 11.38, 1.36, 10.0 and 0.11 respectively.

The contamination factors of heavy metals were ranked in the order of Cu>Pb>Cd>Zn>Ni>Cr. Cu, Pb and Cd were in a state of very high contamination, Zn was in a state of moderate contamination. Ni and Cr are in a state of low contamination.

The degree of contamination varied from 2.14 to 82.44, with a mean of 33.25. This shows that averagely they fall within very high degree of contamination.

According to Table 9, the potential ecological risk factor of Ni, Zn, and Cr were much less than 40, indicating low ecological risk. The potential ecological risk factor of Pb, Cu was greater than 40 and less than 80, indicating moderate potential ecological risk. The potential ecological risk factor of Cd was 160 but less than 320 indicating high potential ecological risk. The order of the potential ecological risk factor of heavy metals was Cd>Cu>Pb>Zn>Ni>Cr. The potential ecological risk index for each sampling area was in the order of C>D>A>B. In addition, the potential ecological risk index for sampling areas A and D was greater than 300 but less than 600, indicating that the potential ecological risk was considerable. Among them, the I_r value of sampling area C was greater than 600, indicating very high potential ecological risk should be paid close attention to.

The average potential ecological risk index of in the studying area was greater than 300 but less than 600, which indicated that the ecological risk was considerable.

Conclusion

The I_{geo} value suggests that the soil samples were uncontaminated with Ni and Zn, moderately to heavily contaminated with Pb, Cu and Cd. The assessment results show that the contamination degree from strong to weak in soil is Cu>Cd>Pb>Zn>Ni.

The potential ecological risk index for each sampling area is in the order of C>D>A>B. The order of the potential ecological risk factor of heavy metals is Cd>Cu>Pb>Zn>Ni>Cr. Soils are engaging in a high potential ecological risk by pollution of Cd and should be given rise to widespread concerns.

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