IJSRM
INTERNATIONAL JOURNAL OF SCIENCE AND RESEARCH METHODOLOGY
An Official Publication of Human Journals

Human Journals
Research Article
December 2016 Vol.:5, Issue:2

Risk Assessment of Sediment of Aforemu River, Oye Ekiti, Nigeria

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INTERNATIONAL JOURNAL OF SCIENCE AND RESEARCH METHODOLOGY
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Submission: 7 December 2016
Accepted: 12 December 2016
Published: 25 December 2016

HUMAN JOURNALS
www.ijsrm.humanjournals.com

Keywords: Heavy metals, geoaccumulation index, potential, ecological, index

ABSTRACT

In this paper, the pollution properties of Pb, Cr, Cu, Zn, Cd, and Ni in river sediments were studied. The results indicate varying degree of contamination with respect to their location in this order of *5>4>1>2>3*. The concentrations of Pb, Cr, Cu, Zn, and Ni in the soil were low, so their potential ecological risks were far lower than other heavy metals and exerted no potential harm to environment except Cd which is of great concern.

1.0 INTRODUCTION

Heavy metals are regarded as serious pollutants of sediment because of their toxicity and environmental persistence[1]. They can be migrated from the soil to other ecosystem components, such as groundwater, sediment and plants, thus affecting human health through drinking water and food chain. Health problems can be developed as a result of excessive dietary accumulation of heavy metals in human body[2].

There are various sources of heavy metals; some originates from anthropogenic activities like draining of sewerage, dumping of hospital wastes and recreational activities. Conversely, metals also occur in small amounts in nature and may enter into aquatic system through leaching of rocks, airborne dust, forest fires and vegetation[3].

Elements like Pb, Cd, Cr and Ni, are said to be non-biodegradable thus, persist everywhere in the environment and have the ability to be deposited in various body organs which poses a great threat to the human health[4]. Several researches[5] have shown that food plants, growing in heavy metal contaminated soils have higher concentrations of heavy metals than those grown in uncontaminated soil[5]. It has been reported that serious health problems have developed as a result of high accumulation of heavy metals such as Cd, and Pb in the human body[6]. Despite Zn and Cu being essential elements in the diet, high concentration in food plants is of great concern because they are toxic to humans and animals[7]. Therefore, this study focuses on level and risk of the heavy metals in the sediment of Aforemu River, oye Ekiti, Nigeria.

2.0 MATERIALS AND METHODS

2.1 Sample collection and preparation

Oye Ekiti is a town and headquarters of Oye Local government area in Ekiti state, western Nigeria. It has geographical coordinates of 7°8′00″N and 5°33′00″E. The major occupation of the inhabitant is farming.

A total of 25 sediment samples were collected from a depth of approximately 12cm at 5 different locations along Aforemu River stored in previously acid washed clean polyethylene container, which was thoroughly mixed. The samples were oven dried at 50^0C until a constant weight is achieved. Then, these samples were pulverized and sieved through 0.8mm mesh and stored in polyethylene bag for further analysis.

2.2 Determination of total heavy metal in soil

Dried and powdered samples of 1.2 g were digested with mixture of HCl-HNO_3-HF-$HClO_4$. Pb, Cr, Cu, Zn, Cd, and Ni in the digest were determined using 210 VGP (Buck Scientific) atomic absorption spectrophotometer. The detection limit of the atomic absorption spectrophotometer used is 0.01.

2.3 Assessment method

(1) Geo-accumulation index (I_{geo})

The contamination levels of heavy metals in soils were assessed by geo-accumulation index ($_{Igeo}$).

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

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 [muller].

Table1: Geo-accumulation index classes[8]

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

(2) 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)[8].

$$C_f^i = C_s^i / C_n^i, \quad C_d = \sum_i^m C_f^i$$

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.

Table 2: Descriptive classes of contamination factor[9]

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 3: Degree of contamination[9]

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

(3) **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.

Table 4: Descriptive table for Ecological Risk factor (E_r)[9]

Classes	Indications
E_r^i≤40	low potential ecological risk
40≤ E_r^i<80	moderate potential ecological risk
80≤ E_r^i<160	considerable potential ecological risk
160≤ E_r^i<320	high potential ecological risk
E_r^i≥320	very high ecological risk

(4) 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 index (I_r)[9]

Classes	Indications
I_r<150, low ecological risk	low ecological risk
150≤ I_r<300	moderate ecological risk
300≤ I_r<600	considerable ecological risk
I_r>600	very high ecological risk

3.0 RESULTS

Muller Descriptive Tables 1 is used to categorize the average values of *I*geo for each metal and their pollution levels. To further determine the environmental pollution and the ecological damage of heavy metals in the soil, potential ecological risk index method proposed by HAKANSON[9] was employed and the descriptive Table 2-5 was used to categorize them.

Geo-accumulation Index (Igeo)

The I_{geo} values were calculated by the heavy metals (Cu, Ni, Zn, Cr, Cd, Pb) average concentrations in soil samples. The average values of *I*geo for each metal and their pollution levels are shows that they are uncontaminated-moderate. The assessment results were in the following trend: Cd>Cr>Cu>Pb.>Zn>Ni

Table 6: Result for Contamination factor (C_f) and degree of contamination (C_d) in the sediment

			C_f				
Location	Cr	Ni	Pb	Zn	Cd	Cu	C_d
1	0.10	0.97	1.52	0.50	4.34	0.10	7.53
2	0.11	0.81	1.92	0.51	4.20	0.13	7.68
3	0.09	0.75	2.12	0.55	3.92	0.14	7.58
4	0.13	0.86	1.66	0.44	4.40	0.12	7.61
5	0.12	0.88	2.03	0.49	4.64	0.14	8.30
Average	0.11	0.85	1.85	0.50	4.30	0.13	

Contamination factor and degree of contamination, descriptive table 3.0 and 4.0 are used to categorize them. Cd is greater than 3 and less than 6 which indicated that it is considerably contaminated while Pb is greater than 1 and less than 3 which indicated moderate contamination. Cr, Ni, Zn and Cu were less than 1 which indicated low contamination.

The results observed from Table 6, the contamination degrees of location *1,2,3* and *4* were less than 8 which indicated that they were within low degree of contamination. The contamination degree of location 5 is greater than 8 but less than 16 which indicated moderate degree of contamination. The average contamination degree of all soil samples was 8.45, which suggested that they were within moderate degree of contamination. The order of contamination degree of each sampling area was5>2>*4>3>1*.

Table 7: Result for Ecological Risk factor(E_r) and Potential Ecological Risk index (I_r) in the sediment

			E_r				
Location	Cr	Ni	Pb	Zn	Cd	Cu	I_r
1	0.20	4.85	7.60	0.50	130.20	0.50	143.85
2	0.22	4.05	9.60	0.51	126.00	0.65	141.03
3	0.20	3.75	10.60	0.55	117.60	0.70	133.40
4	0.26	4.30	8.30	0.44	132.00	0.60	145.90
5	0.24	4.40	10.15	0.49	139.20	0.70	155.18
Average	0.22	4.27	9.25	0.50	129.0	0.63	

According to Table 7, the potential ecological risk factor of Cr, Ni, Pb, Zn and Cu were much less than 40, indicating low ecological risk. The potential ecological risk factor of Cd was greater than 80 and less than 160, indicating considerable potential ecological risk. The order of the potential ecological risk factor of heavy metals was Cd>Pb>Ni>Cu>Cr. The potential ecological risk index for each location was in the order of *5>4> 1>2*>3. In addition, the potential ecological risk index for location *1, 2, 3, and 4* was less than 150, indicating that the potential ecological risk was low. Among them, the I_r value of location 5 was greater than 150, indicating moderate potential ecological risk index.

The concentrations of Cr, Ni, Pb, Zn, Cd, and Cu in the sediment were low, so their potential ecological risks were far lower than other heavy metals and exerted no potential harm to environment except Cd which is of great concern.

4.0 CONCLUSION

The *Igeo* values suggest that the soil samples were uncontaminated-moderate with the heavy metals. The assessment results show that the contamination degree from considerable to low in soil which is Cd>Pb>Ni>Zn>Cu>Cr.

The potential ecological risk index for each location is in the order of 5>4>1>2>3. The order of the potential ecological risk factor of heavy metals is Cd>Pb>Ni>Cu>Zn>Cr.

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