ISSN 2348-1218 (print)
International Journal of Interdisciplinary Research and Innovations ISSN 2348-1226 (online)
Vol. 7, Issue 2, pp: (222-225), Month: April - June 2019, Available at: www.researchpublish.com

Heavy Metal Geo-Accumulation Index in the Soil of Agricultural Areas of Kaduna Metropolis, Nigeria

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Abstract: **The objective of this study is to determine the level of cadmium and lead in soil where vegetable samples are grown in irrigated farmland of Kaduna metropolis. Twenty sampling sites were selected with one control site. The result of geo-accumulation index (Igeo) in soil showed that most of the samples were practically unpolluted while samples from RGS, KWO and URM are moderately polluted with respect Zn, Pb and Fe. Samples from KKR, KWO and DKA are moderately to strongly polluted with Pb and sample from TDW is also moderately to strongly polluted with Cu whereas soil samples from BNW is strongly polluted in relation to Cu contamination. Infact soil samples collected from irrigated farmlands of Kaduna has its geo-accumulation index where it revealed that most of the samples were unpolluted whereas many were moderately polluted by the analyzed heavy metals**

Keywords: **Heavy Metals, Soil, Atomic Absorption Spectrophotometer, Kaduna Metropolis, Nigeria.**

I. INTRODUCTION

Contaminated soils with heavy metals can potentially lead to the uptake and accumulation of these metals in the edible plant parts causing risk to human and animal health [1, 2]. Contamination and subsequent pollution of the environment by heavy metals have become global concern due to their sources, widespread distribution and multiple effects on the ecosystem [3]. Soil contaminations by heavy metal are also caused by sources of agricultural origin, sewage, sludges fertilizers liming materials and pesticides [4]. The movement of trace metals and metalloids between the soil, plant, water and even atmosphere is part of a complex and intricately interrelated biogeochemical cycling processes in nature and is affected by several factors that are both natural and anthropogenic [5]. Unlike organic waste, heavy metals are non-biodegradable and they can be accumulated in living tissues, causing various diseases and disorders, therefore, they must be removed before discharge [6]. Heavy metals contamination may occur due to irrigation with contaminated water, the addition of fertilizers, metal based pesticides, industrial emissions, transportation, harvesting process and storage. Advancement in technology has lead to high levels of industrialization leading to the discharge of effluent bearing heavy metals into our environment. The geo-accumulation index (Igeo) has been used since late 1960s and has been employed in European trace metal studies originally used for bottom sediments, it has been successfully applied to the measurement of soil pollution [7-10]. Infact geo accumulation index (Igeo) approach was used to quantify the degree of anthropogenic contamination in soil and stream sediment. Hence, this research work was aimed at evaluating the degree of heavy metal contamination with respect to geo accumulation index of the soil of agricultural areas of Kaduna metropolis.

II. MATERIALS AND METHODS

2.1 Sample Collection and Preparation

Soil samples were randomly collected from twenty one (21) different irrigation site of the farmlands of the Kaduna metropolis where they were irrigated with water from the river or pond which are sometimes contaminated. A sample was also collected from Rigachikun which is a control site where less activities were taken place. These samples were then stored in polythene bags and taken to the laboratory and dried in an oven at 100^{0}C. The dried samples were ground with mortar and pestle and sieved with 2mm sieve.

2.2 Description of the Sampling Sites

Soil samples for heavy metal determination were collected from twenty one (21) irrigation sites of the Kaduna metropolis. These sites were Kabala (KBL), Danmani (DMN), Rigasa (RGS), Barnawa (BNW), Makera (MKR), Kakuri (KKR), Badiko (BDK) Nasarawa (NAS, Malali (MAL), Kudende (KUD), Kinkinau (KKN), Kawo (KWO), Unguwan Rimi (URM), Unguwan Sanusi (UNS), Tudun Wada (TDW), Doka (DKA), Unguwan Dosa (UDS), Kabala Costain (CTA), Kurmin Mashi (KMS) and Abakpa (ABK). In this research work soil sample from Rigachikun (RCK) irrigation site was taken as control site.

2.3 Method of Analysis

20 g of the finely ground soil samples was mixed with 60 cm^3 (5:5:1) $H_2SO_4/HNO_3/HCl$ acid mixtures and the content were refluxed for 12 hours. The sample was washed with 1M HNO_3 and 100 cm^3 of deionized water was also added and centrifuged. The elements (Cd, Fe, Zn, Cu & Pb) were determined using bulk scientific VPG 210 model atomic absorption spectrophotometer (AAS).

The geo accumulation index of heavy metal in the soil samples was calculated using the formula

$$\mathrm{Igeo} = \log_2\left[\frac{C_n}{1.5B_n}\right]$$

where C_n is the measured concentration of the analysed metal in the soil and B_n is the geochemical background concentration of the metal. Factor 1.5 is the background matrix correction factor due to lithogenic effect. That is, it detect a little bit of the anthropogenic activities in the soil.

III. RESULTS AND DISCUSSION

Table 1 shows the degree of heavy metal pollution in terms of seven contamination classes based on the increasing numerical value of the index as follows: [9-10]

Table 1: classification of Geo accumulation index (Igeo) and intensity of pollution

Igeo value	Igeo Class	Intensity of pollution
<0	1	Practically unpolluted
> 0=1	2	Unpolluted to moderately polluted
> 1=2	3	Moderately polluted
>2 – 3	4	Moderately to strongly polluted
> 3- 4	5	Strongly polluted
> 4 – 5	6	Strongly to very strongly polluted
> 5	7	Very strongly polluted

Table 2.0 shows geo accumulation index (Igeo) for Fe, Cu, Zn, Cd and Pb for the irrigated soil of Kaduna metropolis. The Igeo for cadmium in the soil samples collected were less than zero (< 0) indicating practically unpolluted except samples from BNW (0.17), KUD (0.13) and UDS (0.34) were all greater than zero (> 0) predicting unpolluted to moderately polluted. For Zinc, it was found that geo accumulation index were all greater than zero (> 0) suggesting unpolluted to moderately polluted with exception of samples from KMS (-0.22), ABS (-0.03), and BDK (-0.10) which were practically unpolluted since they have Igeo values less than zero. At the same time samples from RGS (1.36) and URM (1.27) have Igeo values greater than 1 indicating moderately polluted.

Table 2: Geo accumulation Index (Igeo) of Soil Samples

SAMPLING SITES	ELEMENTS				
	Cd	Zn	Cu	Pb	Fe
KBL	-0.55	0.31	-0.72	-0.40	-0.46
DMN	-0.95	0.26	-0.01	-0.47	0.46
RGS	-5.62	1.36	-0.73	1.26	1.65
BNW	0.17	0.39	3.02	-5.93	1.65
MKR	-0.02	0.65	0.65	-0.24	0.41

SAMPLING SITES	ELEMENTS				
	Cd	Zn	Cu	Pb	Fe
KKR	-1.44	0.99	1.70	2.73	1.56
BDK	-0.64	-0.10	-0.22	-1.34	0.49
NAS	-0.15	0.26	0.50	-0.24	0.41
MAL	-0.66	0.06	-0.38	-0.54	-1.38
KUD	0.13	0.64	0.59	-2.42	0.54
KKN	-0.35	0.17	0.26	-0.67	0.13
KWO	-1.87	0.87	1.93	2.85	1.65
URM	ND	1.27	0.06	1.58	1.68
UNS	-5.91	0.92	0.63	0.80	1.65
TDW	-3.31	0.65	2.20	-0.09	1.62
DKA	-0.66	0.19	1.46	2.46	1.19
UDS	0.34	0.04	-0.07	-0.59	-1.02
CTA	-1.17	0.09	-0.41	-1.12	-0.15
KMS	-0.43	-0.22	0.03	-1.08	0.28
ABK	-0.75	-0.03	-0.59	-0.67	-0.74

Copper analysis revealed that geo accumulation index for most of the soil samples ranged from practically unpolluted to moderately polluted with exception of samples from KKR (1.70), KWO (1.93) and DKA (1.46) being greater than 1, therefore moderately polluted so also samples from BNW (3.02) and TDW (2.20) are moderately to strongly polluted as shown in Table 2. The geo accumulation index for lead samples in irrigated soil were all less than zero (< 0) proving to be practically unpolluted while few are moderately polluted since there geo accumulation index is greater than 1 (>1), that is RGS (1.26) and URM (1.56). Samples from KKR (2.73), KWO (2.85) and DKA (2.46) were greater than 2 (>2) indicating moderately to strongly polluted while UNS (0.80) less than zero (< 0) is practically polluted. For iron, it was observed that many samples have Igeo values less than zero (< 0) indicating practically unpolluted whereas some have values ranges from 1.19 to 1.68 being greater than 1 (> 1) predicting the soil to be moderately polluted. Other samples recorded values greater than zero (> 0) suggesting unpolluted to moderately polluted soil.

IV. CONCLUSION

The results of geo accumulation index (Igeo) based on its classification into seven categories revealed that most of the samples were practically unpolluted while samples from RGS, KWO and URM are moderately polluted with respect Zn, Pb and Fe. Samples from KKR, KWO and DKA are moderately to strongly polluted with Pb and sample from TDW is also moderately to strongly polluted with Cu whereas soil samples from BNW is strongly polluted in relation to Cu contamination. The soil samples collected from irrigated farmlands of Kaduna and analysed for heavy metals and hence its geo accumulation index and revealed that most of the samples were unpolluted whereas many were moderately polluted by studied heavy metals as indicated by Igeo values. Therefore this might affect the agricultural product as at the time of this study.

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