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Occurrence, Toxicology and Health Risk Assessment of Heavy Metals from Topsoil of School Playgrounds at Delta State

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Abstract – The present study was conducted to evaluate the possible occurrence and toxicological health risk impacts of heavy metals on topsoil in ten selected school playgrounds located in Delta State. The results of the Atomic Absorption Spectroscopy analysis revealed the concentrations of the heavy metals present in various schools in the decreasing trend as follows; Cu>Pb>Cr>Cd>Hg>As. Multivariate pollution indices were further deployed to ascertain the degree of contamination, sources, accumulation and health impacts of the metals. The result of the index of geoaccumulation (I_{geo}) recorded values lesser than 1 in all the sites, which suggests an acceptable standard value. On the other hand, the results of the contamination factor and pollution load index had higher values when compared with the baseline, indicating higher levels of site contamination. The enrichment factors of all the metals were greater than 1 except Hg which indicates that the pollutants were mainly of anthropogenic sources. The levels of average daily oral intake of the metals were slightly above their respective oral reference doses. However, the non-cancer hazard quotient and total hazard index indicated that no significant health risks is posed from the current levels of the metal deposits on the topsoil as the values were still below 1, which is an acceptable standard.

Keywords – ***Heavy Metals, Health Risks, Soil, Contamination, Geoaccumulation Index, Pollution Load Index.***

I. INTRODUCTION

Heavy metals are metalloids with relatively high atomic weights which are considered toxic even at low concentrations. Environmental contamination by heavy metals has become a major concern in recent years due to their potential to bioaccumulate in biosystems viz a viz contaminated air, soil and water. [1][2][3] (Kosolapov et al, 2004; Alloway, 1995 and Nriagu, 1989). Heavy metals are major contaminants of the soils. They are unable to undergo chemical and microbial degradation and as such have the tendency to persist in the environment for too long. [4] (Adriano, 2003). Sharp rise in Urbanization, anthropogenic activities and large scale industrial presence are responsible for the deposition of these heavy metals on soil surfaces. These metals found their way to the soil and atmosphere from activities relating to disposal of metal wastes, fertilizer applications, pesticides, coal combustion residues, crude oil spillage, abandoned automobiles, petrochemical spillages, electronics, electroplating and tanneries [5][6](Khan et al, 2008; Zhang et al 2010). The toxic effects of heavy metals have also been extended to the soil microbes where they exert a devastating damage to soil microorganisms, hence decreasing their population and activities. [7] (Ashraf and Ali 2007). They have also been reported to inhibit various crucial plant processes such as cell division, light and water absorption. Usually, these heavy metals are absorbed by the plants and subsequently accumulate in the food chain posing serious threat to human health. The introduction of heavy metals in the food chain happens when plants absorbed them in soils where they are present. Subsequent consumption of food crops from plants which have been polluted by these metals is one major way by which humans gets exposed. The consumption of heavy metal contaminated food can cause serious health issues ranging from cerebrovascular infarction, cancers to central nervous system damages. In aquatic environment, heavy metals can persist for a long time because they cannot undergo bacterial degradation where they in turn induces serious oxidative stress in aquatic animals. [8] (Woo et al, 2009) However, some of the heavy metals are essential to maintain proper human metabolism. Heavy metals are needed in small quantities by living organism for several metabolic and growth processes. Metals such as Zn, Fe are highly recommended for human daily intakes, while some other heavy metals such as Pb, Cd, As, Hg, have unknown biological significance and are toxic to human health on ingestion even at lower concentrations [9]. (Duruibe et al, 2009). The body is unable to metabolized heavy metal and as such accumulates in soft tissues where they pose health threats to humans [10]. (Sobha et al, 2007) Most of the commonly found heavy metals at polluted sites are chromium (Cr), lead (Pb), arsenic (As), copper (Cu), mercury (Hg), zinc (Zn), cadmium (Cd), and nickel (Ni) (GWRTAC). Most of the heavy metals released into the environment by anthropogenic sources are largely deposited on top layer of soils. Soil pH and temperature also greatly influence the accumulation and availability of these heavy metals on soils [11] (Shakery et al, 2010). Precipitation, complexation, ion exchange are several factors that also affects the distribution of heavy metals in the environment [12](Silveriia et al 2003). In this present study, the occurrence and health risk impacts of heavy metals found in some selected school playgrounds in Delta State metropolis was evaluated.

II. Materials And Methods

2.1 STUDY AREAS

Ten (10) schools located at Delta State Nigeria were used for this study. Soil samples were collected in two parts, representing the test and control samples. The test soil samples were collected at the different playgrounds while the control soil samples were collected 100m away from the playgrounds. The schools used for this study include:

- Infant Jesus Academy (IJA)
- Master care International school (MCI)
- Government Model Secondary School (GMS)
- Kings and Queens Christian School (KQCS)
- Marble Hill School (MHS)
- Edulyn School (ES)
- High Merit Mixed Secondary School (HMMS)
- Eagle Height International School (EHIS)
- Unique International School (UIS)
- Our Lady's High School (OLH)

2.2 SAMPLE COLLECTION AND PREPARATION

The soil sample was collected during the dry season from various topsoil of school playgrounds using a digger from 0-15cm layer and was transported into a clean plastic container. After a handy separation of debris from the soil samples, they were assembled to the laboratory for further use. The soil sample collected from various school playgrounds were dried at ambient temperature for three days, ground and a 2mm stainless mesh was used to sieve.

2.3 SOIL SAMPLE ANALYSIS

A matrix containing 15 ml of $HClO_4$, H_2SO4 and HNO_3 in the ratio of 1:1:5 was transferred into a beaker containing 1g of the soil sample and was stirred and placed on a heating mantle maintaining a temperature of 80^0C until a clear solution was obtained. The mixture was allowed to cool at ambient temperature and made up to 30 ml of 2% $HNO_3$and filtered. The concentrations of As, Cd, Cu, Cr, Pb and Hg were obtained using AAS.

2.4 GEOACCUMULATION INDEX (IGEO)

This index is used in quantifying the extent or degree of contamination of heavy metals in the environment in both aquifers and terrestrial compartments. [13] [14] (Muller, 1969; Sekabira et al, 2010) The mathematical expression below is used to evaluate the geoaccumulation index (Igeo)

$$I_{geo} = \mathrm{Log}_2 \frac{C_n}{1.5B_n}$$

Where, C_n stands for the concentration of heavy metal present in the school playgrounds. B_n stands for standard background value of element n. The factor 1.5 is used for the possible variations of the background data due to lithological variations. I-geo was classified into seven classes: ≤ 0 is unpolluted, 0-1 is slightly polluted, 1-2 is moderately polluted; 2-3 is moderately severely polluted; 3-4 is severely polluted, 4-5 is severely extremely polluted, > 5 is extremely polluted [13] (Muller, 1969).

2.5 CONTAMINATION FACTOR (C^if)

Contamination factor (CF) is utilized in measuring the degree of the heavy metal contamination as it relates the established baseline values of the metal and the mean crustal composition of the metal. Contamination factor was evaluated using the below mathematical expression.

$$C^i f = \frac{C_n}{B_n}$$

C_n represents the concentration of heavy metals present in the school playgrounds. B_n stands for standard background value of element n. C^if values are classified into four categories: < 1implies low contamination factor, 1-3implies moderate contamination factor, 3-6 implies considerable contamination factor and > 6 implies very high contamination factor [15] (Håkanson, 1980)

2.6 ESTIMATION OF ENRICHMENT FACTOR (EF)

The enrichment factor is a parameter used to ascertain the origin of the heavy metals. It is evaluated using the relationship below:

$$EF = \frac{Heavy\ elements\ in\ the\ soil\ at\ the\ school\ playground}{Heavy\ elements\ in\ the\ soil\ at\ control\ site}$$

The EF values < 1 or close to unity indicate a natural source or crusted origin and a possible mobilization or depletion of metals, whereas >1suggests that the element is of anthropogenic origin [16] (Zsefer *et al.,* 1996). Five further contamination categories are generally recognized on the basis of the enrichment factor: < 2 implies depletion to mineral enrichment, 2-5 implies moderate enrichment; 5-20 implies significant enrichment; 20-40 implies very high enrichment >40 implies extremely high enrichment [17] (Sutherland, 2000).

2.7 POLLUTION LOAD INDEX (PLI)

The PLI is obtained as a concentration factor of each heavy metal with respect to the background value in the soil. The PLI is used to estimate the heavy metal contamination status and the necessary action that should be taken. The pollution load index (PLI) was proposed by [18] Thomilson *et al.,* 1980 for detecting pollution which permits a comparison of pollution levels between sites and at different times. The PLI value of > 1 is polluted, whereas <1 indicates no pollution. Pollution load index (PLI) is calculated using the equation:

$$PLI = n\surd\ (CF1 \times CF2 \times CF3 \times \ldots\ldots..CFn)$$

Where CF represents the contamination factor and n represents number of metals. The sum of contamination factors for all elements examined represents the contamination degree (C_{deg}) of the environment and four classes are recognized. < 8 low degree of contamination 8-16 moderate degree of contamination 16-32 considerable degree of contamination ≥32 very high degree of contamination [15] (Håkanson *et al.,* 1980).

2.8 HEALTH RISK ASSESSMENT

For the assessment of health risks through ingestion of the top soils at the individual school playgrounds by children, the daily intake of metal (DIM) (that estimates the total dose entering the human body through oral ingestion of contaminated soil), and systemic toxicity or non-carcinogenic hazard for each metal were calculated using the following equations:

$$\text{Daily oral intake of soil (DI) (mg/kg/day)} = \frac{\text{C} \times \text{IR} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

Where C represents concentration of the metal in the school playground soils (mg/kg), IR represents ingestion rate (mg/kg), EF represents exposure frequency (day/year), ED = exposure period (year), AT represents average time for non-carcinogens and BW = body weight (kg) [19] (Lack and Stuart-Taylor, 1997). This gives the total dose entering the human body through oral ingestion of contaminated soil. The systemic toxicity or non-carcinogenic hazard for a single element is expressed as the hazard quotient:

$$Non - cancer\ Hazard\ Quotient\ (HQ) = \frac{ID\langle kg|mg|day\rangle}{ORfd}$$

Where DI represents the daily oral intake of soil ORfd represents is oral reference dose for the element. In the case where ORfd is not available for a particular metal, the ORfc (oral reference concentration) is utilized. Total chronic hazard index which is the summation of all the individual hazard quotients is represented as below:

$$\text{Total Chronic Hazard Index (THI)} = \sum_{n=1}^{n} HQ$$

The greater is the value of HQ and THI above 1, the greater is the level of concern since the accepted standard is 1.0 at which there will be no significant health hazard [20] (Grzetic and Ghariani, 2008). The probability of experiencing long-term health hazard effects increases with the increasing THI value [21] (Wang *et al.*, 2012)

III. STATISTICAL ANALYSIS

The experiment was carried out in triplicates and data analyzed using Statistical Package for Social Sciences (SPSS), incident 21.0 software. The results were expressed as mean± standard deviation, the comparison for significance between the control and the experimental group was analyzed using analysis of variance (ANOVA) and the significance level was calculated at 95% confidence level ($p<0.05$).

IV. Results

Table 1: Mean value of Heavy Metals at Different School Study Sites at Delta state

		IJA	MCI	GMS	KQCS	MHS	ES	HMMHS	EHIS	UIS	OLH
Pb	Test	7.13±0.25	5.94±0.21	8.33±0.03	6.26±0.12	8.10±0.40	9.32±0.18	10.67±0.46	9.74±0.13	11.53±0.44	10.32±0.83
	Control	6.52±0.15	4.73±0.32	6.52±0.42	5.67±0.51	7.72±0.73	5.42±0.17	6.15±0.27	4.72±0.20	4.91±0.74	3.84±0.01
	Std	8.58±0.28	8.58±0.28	8.58±0.28	8.58±0.28	8.58±0.28	8.58±0.28	8.58±0.28	8.58±0.28	8.58±0.28	8.58±0.28
Hg	Test	0.36±0.02	0.08±0.00	0.1±0.03	0.07±0.21	0.25±0.0.01	0.09±0.02	0.31±0.05	0.41±0.03	0.46±0.08	0.40±0.05
	Control	0.09±0.01	0.1±0.03	0.3±0.02	0.04±0.01	0.33±0.04	0.02±0.01	0.05±0.02	0.02±0.01	0.58±0.05	0.52±0.03
	Std	0.47±0.35	0.47±0.35	0.47±0.35	0.47±0.35	0.47±0.35	0.47±0.35	0.47±0.35	0.47±0.35	0.47±0.35	0.47±0.35
Cr	Test	3.63±0.13	2.65±0.34	5.74±12	6.34±0.43	4.75±0.13	6.71±0.21	7.31±0.23	7.62±0.31	9.31±-0.16	8.23±0.35
	Control	1.23±0.12	0.83±0.12	1.21±0.21	2.34±0.41	0.48±0.11	3.20±0.13	5.43±0.14	4.37±0.41	6.01±0.42	5.91±0.23
	Std	5.13±0.24	5.13±0.24	5.13±0.24	5.13±0.24	5.13±0.24	5.13±0.24	5.13±0.24	5.13±0.24	5.13±0.24	5.13±0.24
Cd	Test	0.65±0.36	0.63±0.08	0.51±0.7	0.66±0.09	0.48±0.05	0.74±0.13	0.77±0.04	0.79±0.04	0.81±0.20	0.85±0.03
	Control	0.65±0.14	0.78±0.15	0.82±0.07	0.72±0.034	0.54±0.14	0.63±0.15	0.63±0.13	0.59±0.21	0.61±0.25	0.49±0.10
	Std	0.57±0.06	0.57±0.06	0.57±0.06	0.57±0.06	0.57±0.06	0.57±0.06	0.57±0.06	0.57±0.06	0.57±0.06	0.57±0.06
As	Test	0.07±0.03	0.04±0.02	0.62±0.25	0.05±0.23	0.03±0.02	0.31±0.21	0.23±0.11	0.16±0.32	0.29±0.32	0.41±0.21
	Control	0.04±0.02	0.05±0.02	0.32±0.03	0.02±0.01	0.04±0.03	0.26±0.05	0.31±0.23	0.03±0.02	0.40±0.21	0.23±0.16
	Std	0.05±0.03	0.05±0.03	0.05±0.03	0.05±0.03	0.05±0.03	0.05±0.03	0.05±0.03	0.05±0.03	0.05±0.03	0.05±0.03
Cu	Test	9.57±0.12	11.53±0.17	10.72±0.16	13.71±0.3	11.82±0.12	14.62±0.31	12.71±0.37	15.61±0.14	13.68±0.23	10.34±0.16
	Control	7.01±0.27	6.93±0.13	7.05±0.17	8.25±0.41	5.32±0.17	8.53±0.35	7.32±0.54	6.54±0.27	8.86±0.32	4.24±0.21
	Std	11.12±0.23	11.12±0.23	11.12±0.23	11.12±0.23	11.12±0.23	11.12±0.23	11.12±0.23	11.12±0.23	11.12±0.23	11.12±0.23

Values are expressed as mean ± standard deviation. Significant level of mean was determined at 95% confidence level ($p<0.05$)

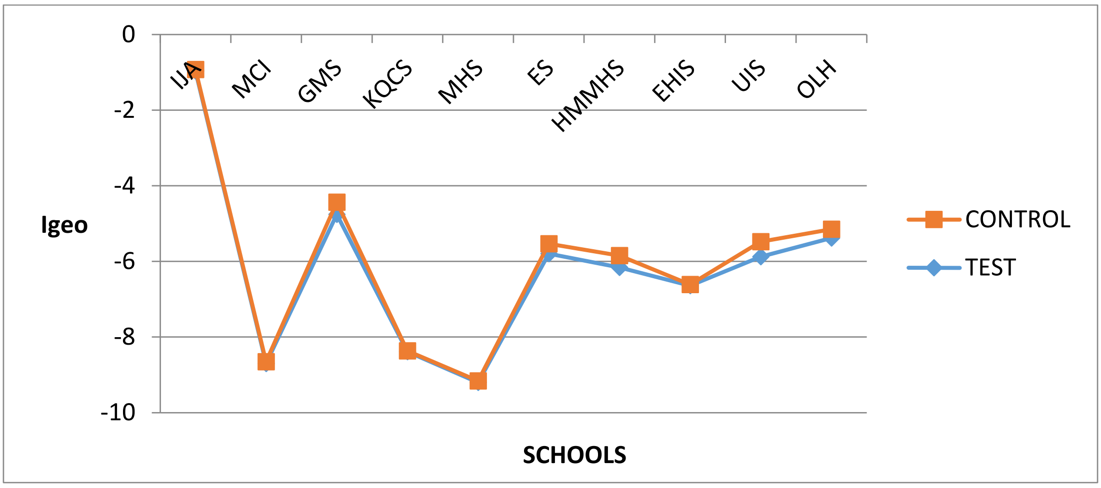

Fig. 1: Index of Geoaccumulation of Arsenic in school playgrounds at Delta state

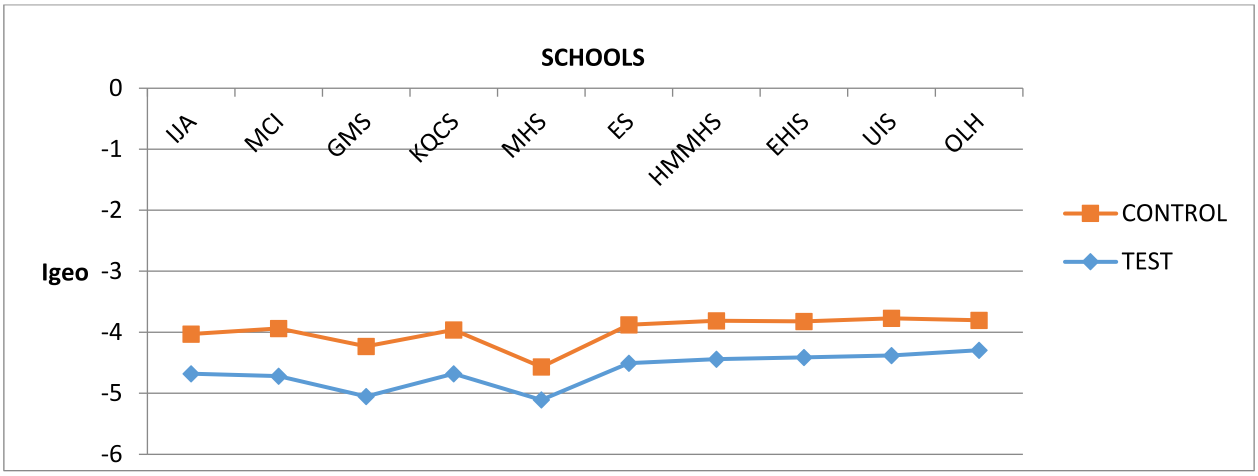

Fig. 2: Index of Geoaccumulation of Cadmium in school playgrounds at Delta State

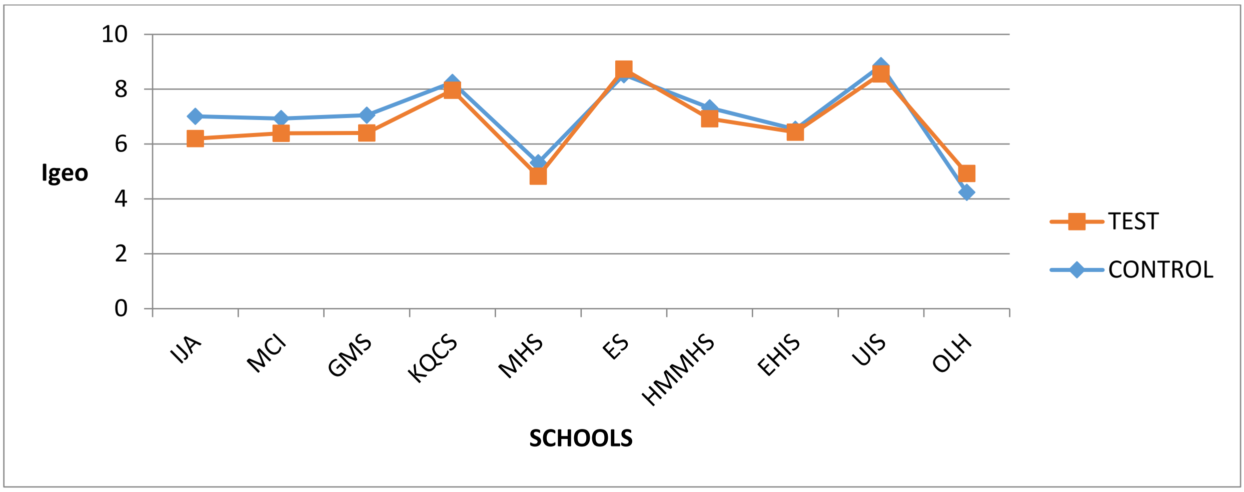

Fig. 3: Index of Geoaccumulation of Copper in school playgrounds at Delta State

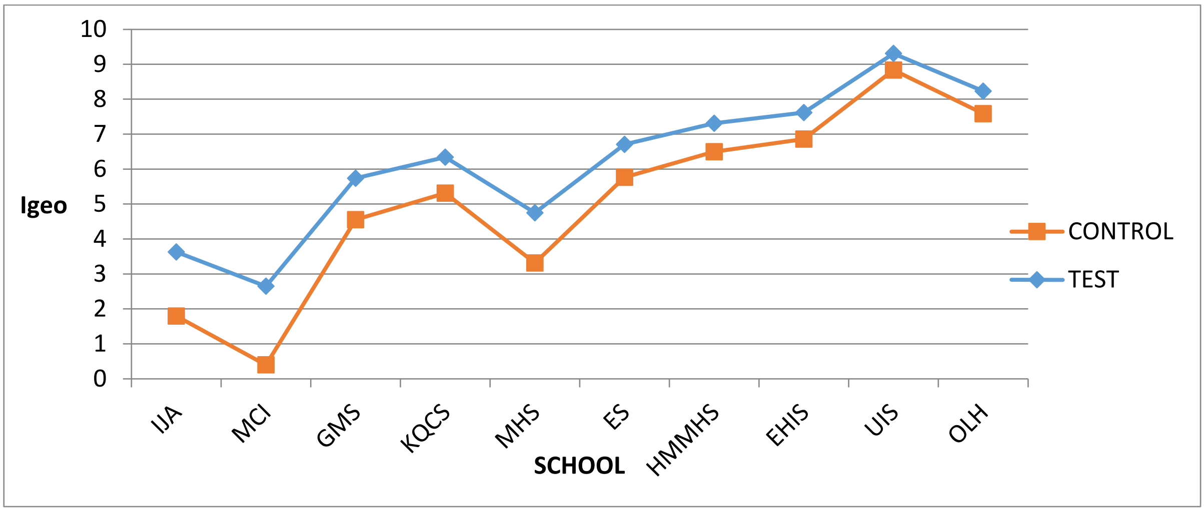

Fig. 4: Index of Geoaccumulation of Chromium in school playgrounds at Delta State

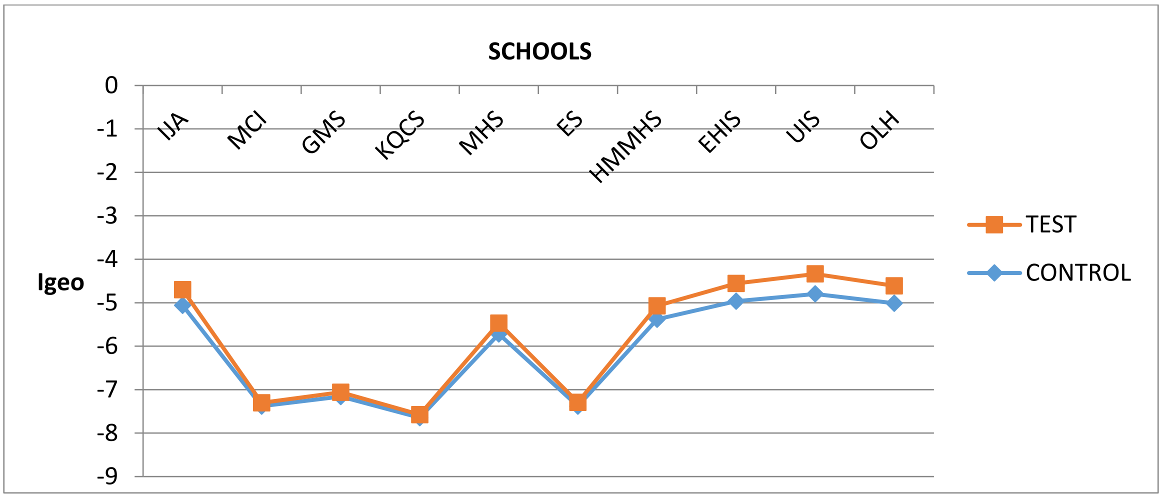

Fig. 5: Index of Geoaccumulation of Mercury in school playgrounds at Delta State

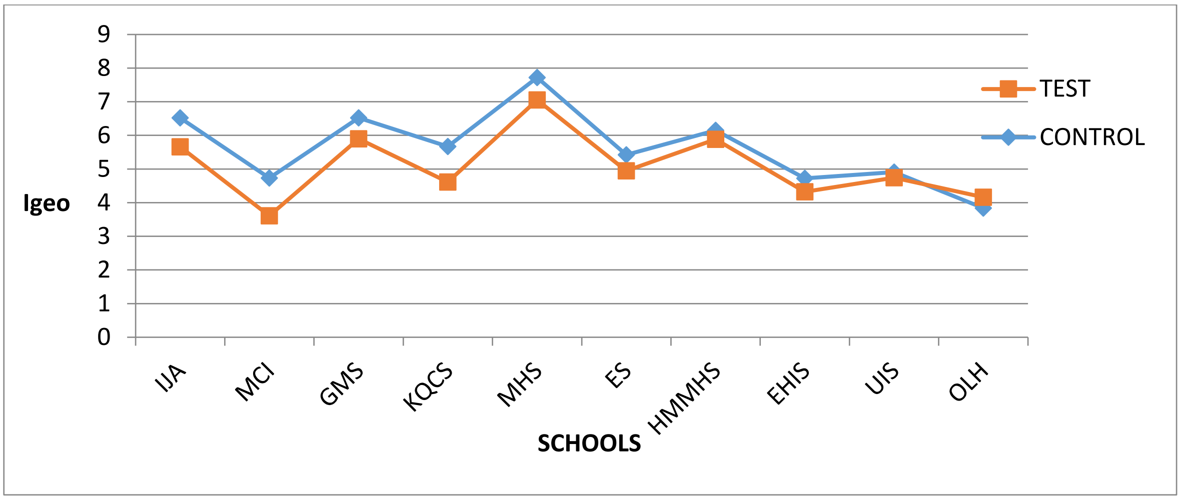

Fig. 6: Index of Geoaccumulation of Lead in school playgrounds at Delta State

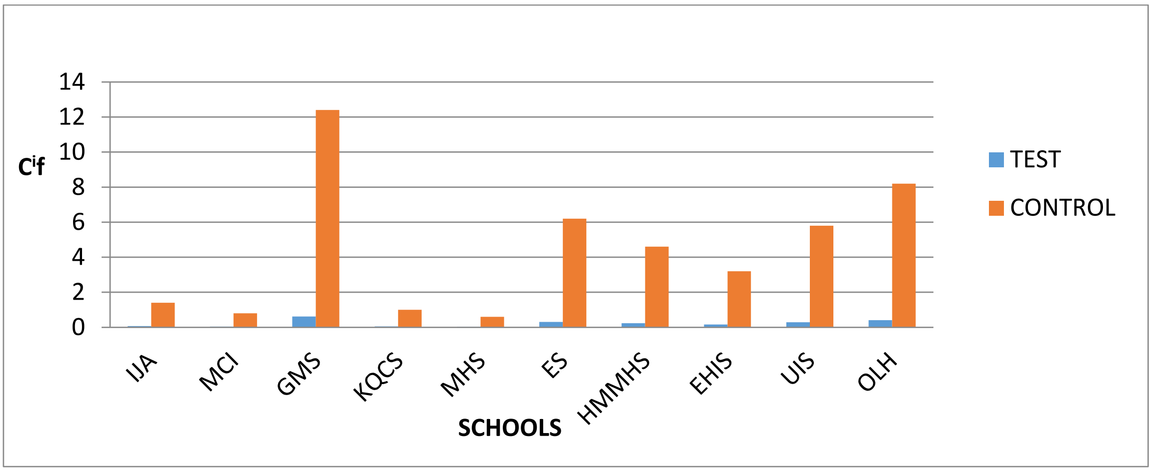

Fig. 7: Contamination Factor of Arsenic in school playgrounds at Delta State

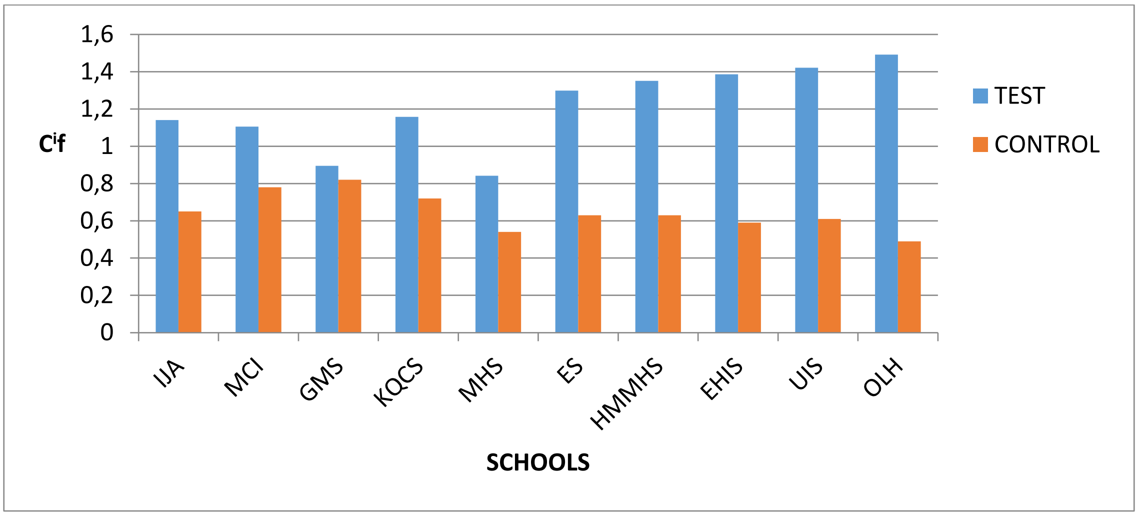

Fig. 8: Contamination Factor of cadmium in school playgrounds at Asaba-Delta state

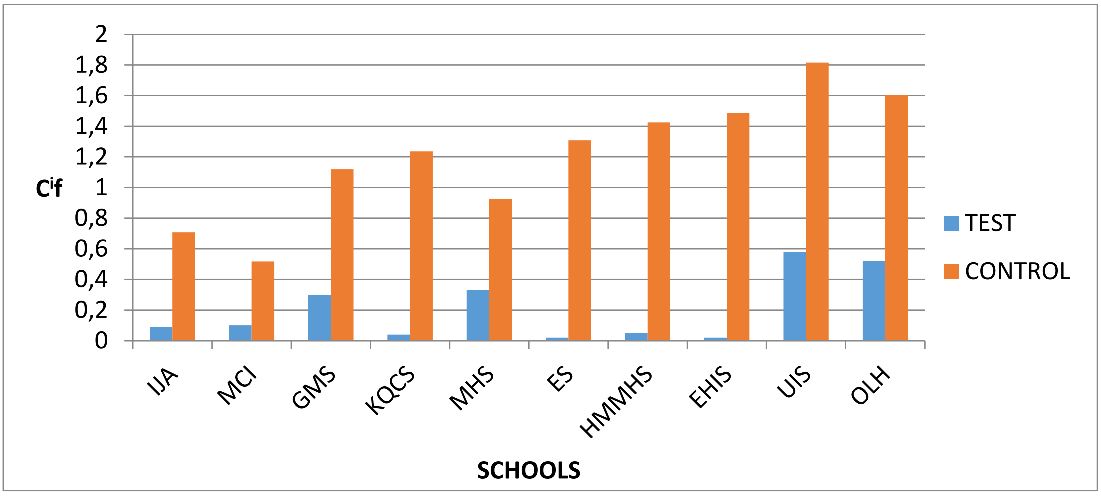

Fig. 9: Contamination Factor of Chromium in school playgrounds at Delta State

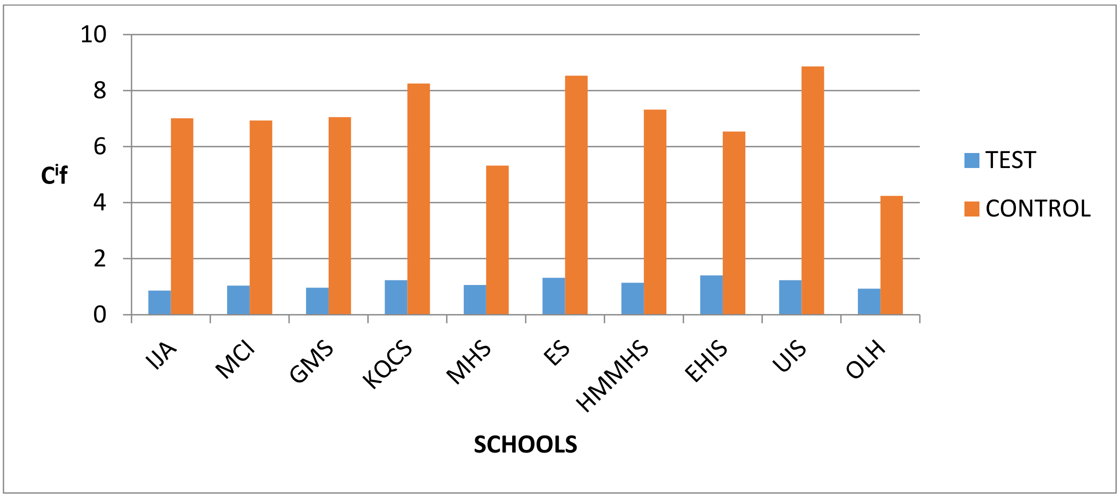

Fig. 10: Contamination Factor of Copper in school playgrounds at Delta State

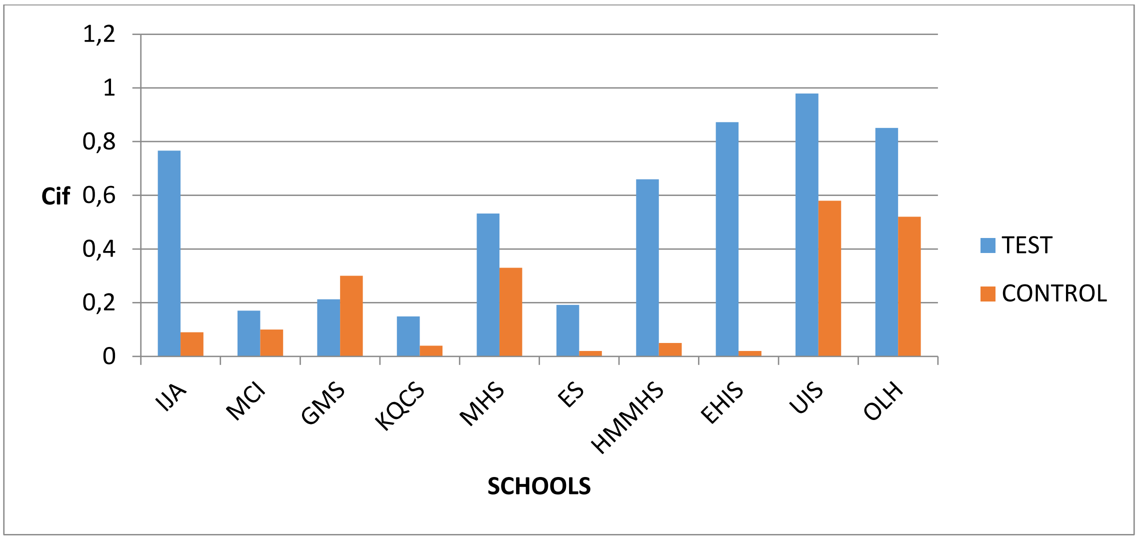

Fig. 11: Contamination Factor of Mercury in school playgrounds at Delta State

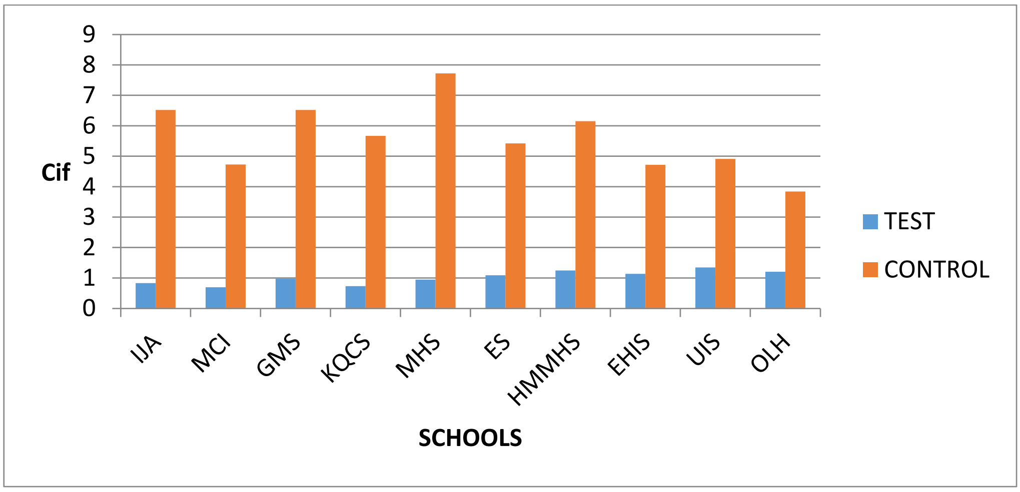

Fig. 12: Contamination Factor of Lead in school playgrounds at Delta State

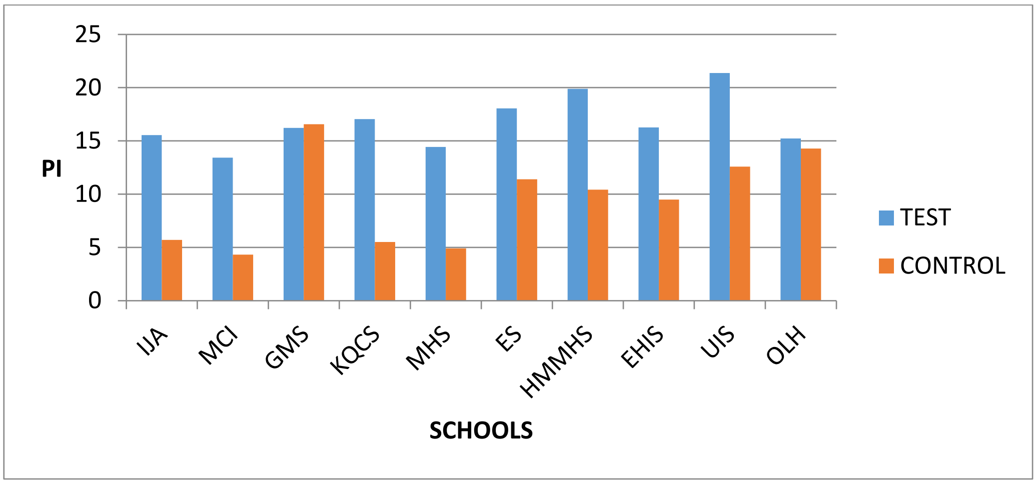

Fig. 13: Pollution Load Index of school Playgrounds in Delta State

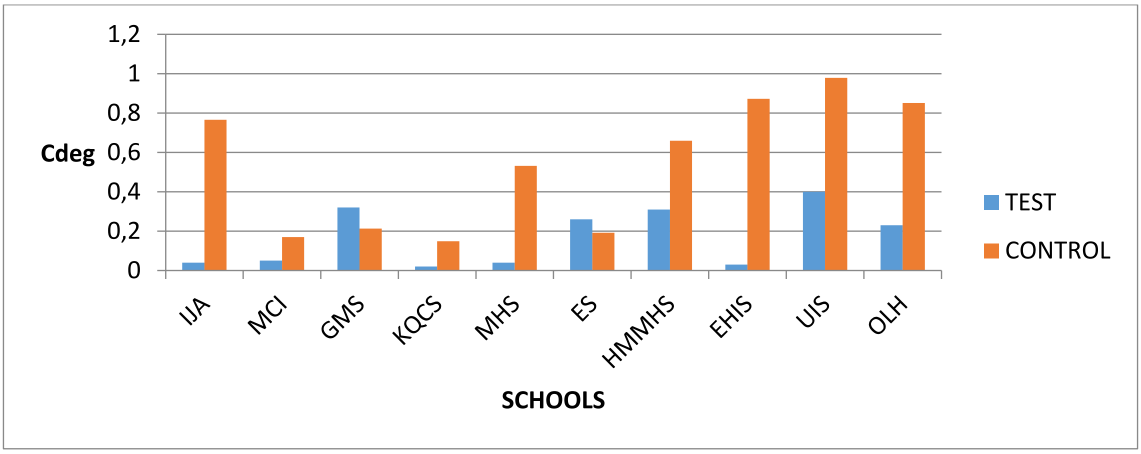

Fig. 14: Degree of Contamination of Heavy Metals at school playgrounds in Delta state

Table 2: Enrichment factor of heavy metals at school playgrounds at Delta State

Heavy Metals	IJA	MCI	GMS	KQCS	MHS	ES	HMMHS	EHIS	UIS	OLH
Cd	1	0.807692	0.621951	0.916667	0.888889	1.174603	1.222222	1.338983	1.327869	1.734694
As	1.75	0.8	1.9375	2.5	0.75	1.192308	0.741935	5.333333	0.725	1.782609
Cu	1.365193	1.663781	1.520567	1.661818	2.221805	1.713951	1.736339	2.38685	1.544018	2.438679
Pb	1.093558	1.255814	1.277607	1.104056	1.049223	1.719557	1.734959	2.063559	2.348269	2.6875
Hg	4	0.8	0.333333	1.75	0.757576	4.5	6.2	20.5	0.793103	0.769231
Cr	2.95122	3.192771	4.743802	2.709402	9.895833	2.096875	1.346225	1.743707	1.549085	1.392555

Table 3: Daily oral intake of heavy metals at school playgrounds at Delta State

Heavy metals	IJA $\times10^{-6}$	MCI $\times10^{-6}$	GMS $\times10^{-6}$	KQCS $\times10^{-6}$	MHS $\times10^{-6}$	ES $\times10^{-6}$	HMMHS $\times10^{-6}$	EHIS $\times10^{-6}$	UIS $\times10^{-6}$	OLH $\times10^{-6}$	Reference (mg/kg/day)
Cd	8.310502	8.054795	6.520548	8.438356	6.136986	9.4611872	9.844749	10.10046	10.35616	10.86758	1×10^{-3}(ORfD)
As	0.894977	0.511416	7.926941	0.639269	0.383562	3.9634703	2.940639	2.045662	3.707763	5.242009	3×10-4(ORfD)
Cu	122.3562	147.4155	137.0594	175.2877	151.1233	896498400	162.5023	199.5799	174.9041	132.2009	4×10^{-3}(ORfD)
Pb	91.15982	75.94521	106.5023	80.03653	103.5616	119.15982	136.4201	124.5297	147.4155	131.9452	3.5×10^{-3}(ORfD)
Hg	12.78539	1.022831	1.278539	0.894977	3.196347	1.1506849	3.96347	5.242009	5.881279	5.114155	4×10^{-5}(ORfC)
Cr	46.41096	33.88128	73.38813	81.05936	60.73059	85.789954	93.46119	97.42466	119.032	105.2237	1×10^{-2}(ORfD)

Table 4: Non Cancer Hazard Quotient and Total Hazard Index of Heavy Metals at School Playgrounds in Delta State

Heavy metals	IJA	MCI	GMS	KQCS	MHS	ES	HMMHS	EHIS	UIS	OLH
Cd×10^{-1}	8.310502	8.054795	6.520548	8.438356	6.136986	9.461187	9.844749	10.10046	10.35616	10.86758
As×10^{-2}	0.894977	0.511416	7.926941	0.639269	0.383562	3.96347	2.940639	2.045662	3.707763	5.242009
Cu×10^{-3}	122.3562	147.4155	137.0594	175.2877	151.1233	8.96E+08	162.5023	199.5799	174.9041	132.2009
Pb×10^{-3}	91.15982	75.94521	106.5023	80.03653	103.5616	119.1598	136.4201	124.5297	147.4155	131.9452
Hg×10^{-2}	12.78539	1.022831	1.278539	0.894977	3.196347	1.150685	3.96347	5.242009	5.881279	5.114155
Cr×10^{-3}	46.41096	33.88128	73.38813	81.05936	60.73059	85.78995	93.46119	97.42466	119.032	105.2237
Cd×10^{-2}	8.310502	8.054795	6.520548	8.438356	6.136986	9.461187	9.844749	10.10046	10.35616	10.86758
THQ×10^{-3}	281.9178	266.8311	332.6758	346.3562	325.1324	8.96E+08	409.1324	438.9224	461.2968	390.5936

V. Discussions

The results of the heavy metal concentrations on topsoil of the ten study sites are represented on table 1. The concentrations of lead (Pb) were the highest in all schools playground when compared with the control and baseline values. UIS school playground recorded the highest level of Pb on its topsoil. The mean test values of Pb slightly exceeded the baseline values in EIS, HMMHS, EHIS, UIS and OCH school topsoil. Pb test values ranged from (5.94±0.21) to (11.53±0.44), the elevated levels of Pb recorded in the five aforementioned school could be attributed to the crude oil and hydrocarbon production and processing activities by numerous petrochemical industries in Warri area where these schools are located. Crude oil production in this region is occasioned by recurrent oil spillages in the which introduce various heavy metals on the soils, because they are non-biodegradable, they have the ability to persist for a long time in the environment. Similarly, industrial activities from paint manufacturing companies from Asaba and Onitsha environs are possible depositors of Pb in the environment. Also, deteriorated paint peelings from the school buildings may fall off to the playgrounds. Pb is toxic to humans even at low concentrations [22](Kazemipour et al, 2008). Pb has been implicated in the disruption of developing embryo, inhibition of hemoglobin production and damage to the central and peripheral nervous system. [23](Odum et al, 2000). In a study conducted by Justice et al on the heavy metals on top soils in some marts located in Port- Harcourt, Rivers state. It revealed a higher concentration of Pb on the mart soils. The test concentrations of mercury (Hg) ranged from 0.08±0.00 to 0.46±0.08 and were higher when compared with the control samples in all the sites except MCI, GMS, MHS, UIS and OLH. The levels of Hg were highest in UIS than in other sites. The deposition of Hg on the sites would have resulted from coal combustion around the school environment. Manometers along gas and oil pipelines are known to release substantial amount of Hg to the environment. Exposure to Hg has been associated with kidney damage [24](Jones and Jarvis, 1981). Copper (Cu) records the highest test values among all other metals. The test values were seen to be higher when compared with the control samples but exceeded the baseline values. Cu is an important micro element required in human diet, however, acute toxicity of Cu cause severe mucosal irritation, anemia, capillary damage, renal and hepatic damage. Arsenic (As), test values are within the baseline values with the exception of IJA and GMS, but were lower when compared with the control in all the sites. There were slightly elevated values of Cadmium Cd) in ES, HMMHS, EHIS, UIS and OLH school top soils compared to the control. The presence of cadmium on the soils could have possibly resulted from the use of fertilizers, detergents, acid rains and other anthropogenic activities such as disposal of industrial wastes, sewages. [25](Harrson, 2001). Industries that utilize cadmium compounds for the production of batteries, plastics pigments are possible sources of Cd in the environment. Quantitative indices were used to evaluate the degree of contamination and its trend on the top soil. The result of the index of geoaccumulation was represented in Fig.1-6. The Igeo decreasing trend on the study sites are as follows; Cu>Pb>Cr>Cd>Hg>As. The Igeo values for the metals in all the sites were less than 0.00 except lead and copper with 0.32 and 0.68 respectively. Igeo values less than 0.00 is considered unpolluted and values 0< I-geo ≤1 is considered slightly polluted, as classified by [26] (Nriagu, 1996). The results of the contamination factor (C^if) obtained from the understudied sites are represented in fig xxx, Arsenic had the highest value of C^if (44.2) only Hg recorded a moderate contamination with a Cif value lesser than 6. According to the classification, C^if values greater than or equal to 6 (CF≥6) is described as a high contamination factor. The results of the enrichment factor are presented in Table 2. The results, Cd, As and Cr, values were less than 2. EF<2 represents deficiency to minimal enrichment, Hg was less than 1 which indicates a background concentration which could have possibly contaminated the soil from a natural source. Cu and Pb had EF values greater than 1 which signifies that their deposition were of an anthropogenic source. The pollution index (PLI), as developed by [18](Thomilson et al, 1980) is used in evaluating the extent of the pollution by the metals. The results of the PLI are presented on Fig 13. The PLI values were greater than 1 which implies serious deterioration of the site. The decreasing trend of pollution load index are as follows; Pb>Cu>As>Cd>Cr>Hg. The results of the daily oral intake of the metals at the various school playgrounds are presented in Table 3. Cu recorded the highest level of oral ingestion. All the metals had a higher intake values when compared with their respective oral reference doses (Orfd). Similarly, the results of the non-cancer hazard quotient and total hazard index are presented in Table 4. The result suggests that there is no potential carcinogenic risk associated with an eventual ingestion of the metals currently in the study sites. The THI and HQ values at the sites were less than 1. This is an acceptable standard which dos not pose any serious health concern.

VI. Conclusion

The present study assessed the occurrence and possible health risks posed by heavy metals sampled on the topsoil of ten selected school playgrounds in Asaba and Warri regions of delta state. The study revealed the presence of Cu, Pb, Cr, Cd, As, Hg on the soils. Mathematical matrix was carefully used to evaluate the extent of contamination which revealed that the soils were highly contaminated by the metals and anthropogenic activities were largely responsible for the deposition of the metals. Therefore, it is imperative that strict environmental monitoring and regulations should be put in place by various environmental and health stakeholders and possible remediation strategies deployed in the schools to ameliorate the current situation.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this paper.

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