International Journal of Advances in Engineering and Management (IJAEM)
Volume 3, Issue 8 Aug 2021, pp: 1324-1330 www.ijaem.net ISSN: 2395-5252

Potentially Toxic Elements Concentrations and Pollution Indexing in Classroom dusts ofPrimary Schools in Abeokuta Metropolis, Southwestern, Nigeria

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Submitted: 10-08-2021 Revised: 22-08-2021 Accepted: 25-08-2021

ABSTRACT
Heavy metals are known to have a negative impact on human health especially children through oralingestion. This study therefore seeks to determine the presence and level of potentially toxic pollutants elements in primary schools classroom dust selected from Abeokuta North and Abeokuta South Local Government, Ogun State, Nigeria. Dust samples were obtained from classrooms of the ten selected schools across the location. The samples were digested and analyzed for heavy metals using microwave plasma atomic emission spectrophotometer (MP-AES). The result showed that the dusts contains cadmium (0.36 – 1.23 mg/kg), chromium (3.77 - 11.27 mg/kg), copper (2.57 – 12.57 mg/kg), lead (6.9 – 41.73 mg/kg), nickel (1.30 to 6.37 mg/kg), and zinc (14.27 – 106 mg/kg) across the locations. The geoaccumulation factor showed that all the locations were not polluted with all the metals analysed except cadmium and lead. Also, theenrichmentfactorsshowedsuggest that all metals are deficiently to minimally enriched except cadmium that found to be moderately enriched in dusts from Ebenezer African Primary School, Bashorun Primary School 1, Owu Methodist Primary School and KudiratAbiola Primary school. It was also revealedthat no pollution of all classroom dust samples by chromium, copper, lead and nickel but cadmium and zinc. This study showed that heavy metals are widely distributed in our surroundings especially in urban areas.

Keywords: classroom dusts, metals, Abeokuta

I. INTRODUCTION

Potential health risks associated with toxic metal pollution have necessitated the importance of monitoring their levels in the environment. Dust from the urban area has been reported to contain toxic organic and inorganic pollutants such as heavy metals[1]. The presence of trace metals in urban dust may be a result of various mobile and stationary sources such as vehicle exhaust, sinking particles in air, house dust, soil dust, and aerosols that are carried by air and water. Therefore, during dust transportation, pollutants such as trace metals may form part of the street dust as they are blown by wind[2].Dust-laden air may deposit trace metals on food, drink, and surfaces of indoor appliances and this may often result in carcinogenic or non-carcinogenic health risk to residents, especially children. Ingestion of dusts appeared to be the main route of exposure to dust particles and consequently pose a higher health risk. Inhalation and dermal uptake are the other pathways in which trace metals can enter into the human systems[3].

Levels of trace metals in the environment are of major concern due to their nonbiodegradable and toxic nature especially if accumulated at levels higher than those required in the body. Accumulation of trace metals in human tissues and other organs of the body can have adverse effect on the central nervous system acting as cofactors, stimulants, and promoters of other diseases and might likely result in trace metal related diseases later in life. Pupils from high schools can easily ingest dust from classrooms or playing grounds and may adversely affect their retention ability[2]. Several studies have pointed to factors such as small and overcrowded classrooms, location of industries, vibrant outdoor activities of students during school recess, endemic dusty environment, and infrequent washing of hands as factors that may increase the likelihood of hand contamination and hand-to-mouth transfer of some trace elements among school children [4]. It needs to be emphasized that the socioecological conditions in many urban schools in Nigeria may increase the risk of dust exposure as some of the factors listed above are predominant features of some of these schools[5]. Despite the aforementioned factors, some schools environment in urban areas has not received the attention and public concern that it deserves in terms of managing and reducing the level of risk that may arise as a result of pollutants from dust.

Few countries currently have guidelines and procedures for dealing with this risk associated with pollution from either industries or vehicular emissions. The present study therefore investigates the concentration and composition of toxicelements in dust collected from some selected primary school classrooms and also to determine the degree of contamination by employing pollution assessment tools such as geoaccumulation index, enrichment factor and contamination factor.

II. EXPERIMENTATION

Classroom dust samples were collected from 10 primary schools in Abeokuta North and South local government areas of Ogun State. About 2-4 samples was pooled together to have a representative sample for each primary school. The samples were collected between June and August, 2018 through the use of sweeping brooms and were sealed in polyethylene bags, labelled and then transported to laboratory for digestion. Classrooms facing the direction of wind blow and where windows were often opened were selected for classrooms dust samples collection. All samples were air dried for at least one week and then sieved with an appropriate mesh sieve to ensure that all ranges of dust particles passed through, which also remove refuse and small stones. The samples were then grounded with mortal and pestle and transferred into a Zip-lock bag for further analysis.

The digested samples were used to measure the individual metal concentrations in the dust using a microwave plasma atomic emission spectrophotometer (MP-AES). Blanks were also made going through the same procedure but without the samples. Standard solutions of the heavy metals of interest (Sigma–Aldrich) were prepared and analyzed to obtain calibration curves. The analyte metals (Cu, Cr, Ni, Pb, Zn, and Cd) were identified with the accurate detection of absorbance of standards.

Determination of Geoaccumulation Index

Geo-accumulation Index (Igeo), which was proposed to assess the degree of pollution in aquatic sediments by Müller in 1969 [6], can also be used to the assessment of soil pollution. I_{geo} is computed by the following equation:

$I_{geo} = Log_2(C_n/1.5B_n)$

where, C_n is the measured concentration of the examined metal (n) in the soil, B_n is the geochemical background concentration of the metal (n), and factor 1.5 is the background matrix correction factor due to lithogenic effects. I_{geo} was classified into seven grades ranging from unpolluted to extremely polluted: $I_{geo} \leq 0$ (grade 0), unpolluted; $0<I_{geo} \leq 1$(grade 1), slightly polluted; $1<I_{geo} \leq 2$ (grade 2), moderately polluted; $2<I_{geo} \leq 3$ (grade 3), moderately severely polluted; $3<I_{geo} \leq 4$ (grade 4), severely polluted; $4<I_{geo} \leq 5$ (grade 5), severely extremely polluted; $I_{geo}>5$ (grade 6), extremely polluted.

Determination of Enrichment Factors

In order to evaluate the anthropogenic environmental status of the elements examined, the Enrichment Coefficient was used[7]. The Enrichment factor {EF} in given as:

EF= {(Me/Fe-sample)} / {Me/Fe-background)}

Where Me are examined metal content in the examined environment and reference environment respectively while Feis reference element (iron) in the examined environment and reference environment respectively. According to Famuyiwa et.al 2019 [8], Enrichment factor is classified as follows as follows:

i. Deficiency to minimal enrichment for values below 2,
ii. Moderate enrichment for values from 2 to 5,
iii. Significant enrichment for values from 5 to 20,
iv. Very high enrichment for values from 20 to 40,
v. Extremely high enrichment for values above 40.

Determination of Contamination Index

The contamination/pollution index (C/P) of the three most abundant metals in the soil dusts was calculated as recommended by Lacatusu (2000) [8], thus:

$$\text{Contamination index} = \frac{\text{Conc. of the metal in the soil}}{\text{Target value of metals}}$$

Where, the contamination factor CF < 1 refers to no contamination; 1≤ CF < 3 means slight contamination; 3 ≤ CF ≤6 indicates considerable contamination and CF > 6 indicates very high contamination.

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III. RESULTS AND DISCUSSION

The result of the heavy metals present in the classroom dusts in Abeokuta metropolis showed that heavy metals were present in the dusts samples at varying concentrations as shown in Figure 1. The mean concentration of cadmium was found to be within the range 0.36 – 1.23 mg/kg at the sites with mean concentration of 0.625 mg/kg. This is below the maximum permissible limit of 10 mg/kg stated in Canadian Environmental Quality Guidelines by (Canadian Council of ministers of the environment (CCME, 1999)[9], for cadmium in soil. The highest concentration was found to be in Ebenezer African Primary School, ItaEko while A.N.L.G Primary School, Olomore was found to have the least concentration of cadmium. The concentrations found in this study are lower than of dust samples reported by other literature like 1.54 – 2.85 mg/kg reported by Mafuyaiet al., 2015 [10], and 5.93 mg/kg reported by Mohamed and Abdel-Majid (2016)[11]. Cadmium is the by-product in the production of zinc and lead and the pyro metallurgy production of zinc is the most important anthropogenic source to the environment and combination with other metals[12]. Cadmium has been observed in road dust due to its presence in automobile fuel and in the soil. Therefore, inhalation exposure to cadmium can occur from road dust. After inhalation, the absorption of cadmiumcompounds may vary greatly depending upon the particle sizes and their solubility [13].

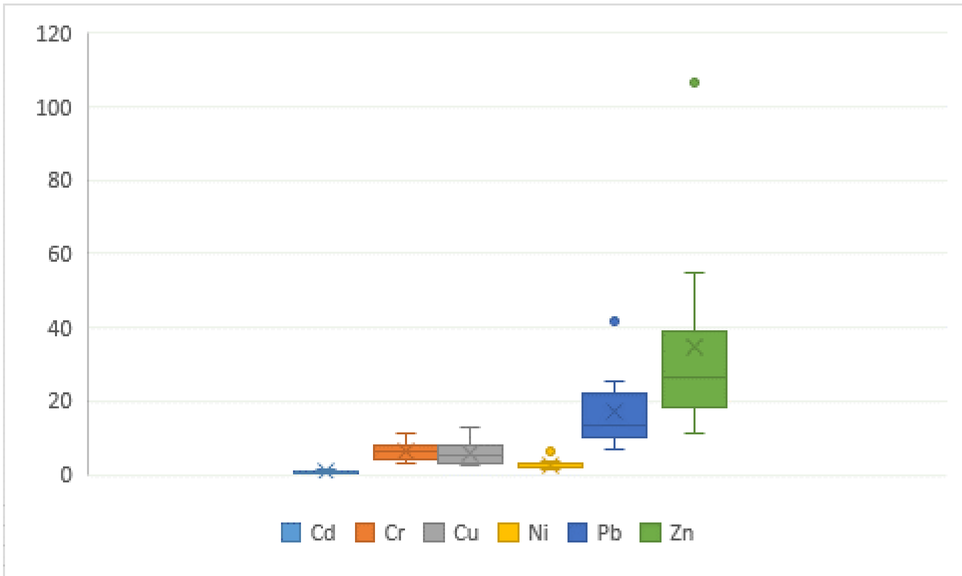

Figure 1: Box plot showing metal concentrations in the classroom dusts

The mean chromium level in the classroom dusts ranged from 3.77 - 11.27 mg/kg with average concentration of 6.27 mg/kg. This was below the maximum permissible limit of 64 mg/kg stated in CCME, 1999 [9], for chromium in soil. However, the mean concentration of chromium for the classroom dust samples were lower than for dust samples reported at the city of Bahrain (7.34 mg/Kg)[14]. Also, it is lower than 1.13 - 2.79 mg/kg reported by Mafuyaiet al., (2015)[10]. Chromium is one of those heavy metals whose concentration steadily increases due to industrial growth especially the development of chemical and tanning industries. The presence of chromium in the classroom dusts might be as a result of deposition of chromium containing substances[15].

As observed for Cd and Cr, Cu measurements (ranged from 2.57 – 12.57 mg/kg) in the dust samples did not exceed the maximum permissible limit of 63 mg/kg stated in Canadian Environmental Quality Guidelines [9].Copper ranged from 2.57 – 12.57 mg/kg with mean value of 5.94 mg/kg. This was below the maximum permissible limit of 63 mg/kg for copper in soil. The Cu values in the current study are lower than the average value reported by Fabis, 1987 (100 mg/kg). This is much lower than 24.5 – 72.0 mg/kg reported by Mafuyaiet al., (2015) [10], for roadside dust and 22.2 mg/Kg reported by Olanrewajuet al., (2015) [5], for class room dust.

Exposure to chromium (Cr) can lead to allergic dermatitis in humans, bleeding of the gastrointestinal tract, cancer of the respiratory tract and ulcers of the skin. It also causes damages to the mucus membrane, liver and kidney [16], [17].Nickel measurements ranged from 1.23 – 3.88 mg/kg and were below the maximum permissible limit of 50mg/kg (CCME 1999). The sources of nickel in classroom dusts may be due to corrosion of vehicular parts around the school[15]. Nickel can result in lung, liver and kidney damage. In high quantities Ni can also cause cancer, respiratory failure, birth defects, allergies, dermatitis, eczema, nervous system and heart failure[17].Lead and Zn measurementsranged from 6.9 – 41.73 mg/kg and 14.27 – 106 mg/kg respectively in the dusts samples. These values are below Canadian maximum permissible limit of 140 mg/kg (Pb) and 200 mg/kg (Zn) respectively (CCME, 1999). Lead values from this current stuy were found to be lower thanprevious studies such as that of 90-210 mg/kg for Michigan[18] and 98-136.1mg/kg for Osogbo[19].

The exposure to lead substances should be minimized becausePb accumulates in the body organs (i.e, brain) and this may lead to poisoning (plumbism) or even death. The presence of Pb may also affect the gastrointestinal tract, kidneys, and the central nervous system. For instance, children exposed to Pb suffer from impaired development, lower intelligent quotient (IQ), shortened attention span, hyperactivity and mental deterioration. Those at substantial risk are the children under the age of six[20]. In the case of adults, there is decreased reaction time, loss of memory, nausea, insomnia, anorexia, weakness of the joints, failures of reproduction, irritation and producing tumour are all caused by exposure to lead[16].

The concentration of nickel ranged from 1.30 to 6.37 mg/kg, with mean concentration of 2.47 mg/kg. It is important to note that the composite classroom dust collected from Ebenezer African Primary school, ItaEko was consistently higher than other samples for Cd, Cu, Pb and Zn. These metals are usually called ‘’typical urban metals’’[21]. The probable reason why this sample was higher in metal concentration than others may be attributed to the fact that, it is located along a major busy road in Abeokuta metropolis. Soils and dusts collected along traffic corridors and in near proximity to industrial emissions have been noted to have higher concentrations of metals[7].

The calculated geoaccumulation (I_{geo}) values are presented Figure 2. The result shows that all the classroom dusts were found to be unpolluted by chromium, copper, nickel and zinc. However, Ebenezer African Primary School, ItaEko was found to be moderately polluted by lead and cadmium. Other classroom dusts were found to be slightly contaminated by cadmium except A.N.L.G Primary school, Olomore and C.A.C Nursery and Primary School, Totoro. Also, aside Ebenezer African Primary School, ItaEko, other classroom dusts were not polluted by lead except Methodist Primary School 1, Sapon which was slightly polluted by lead.

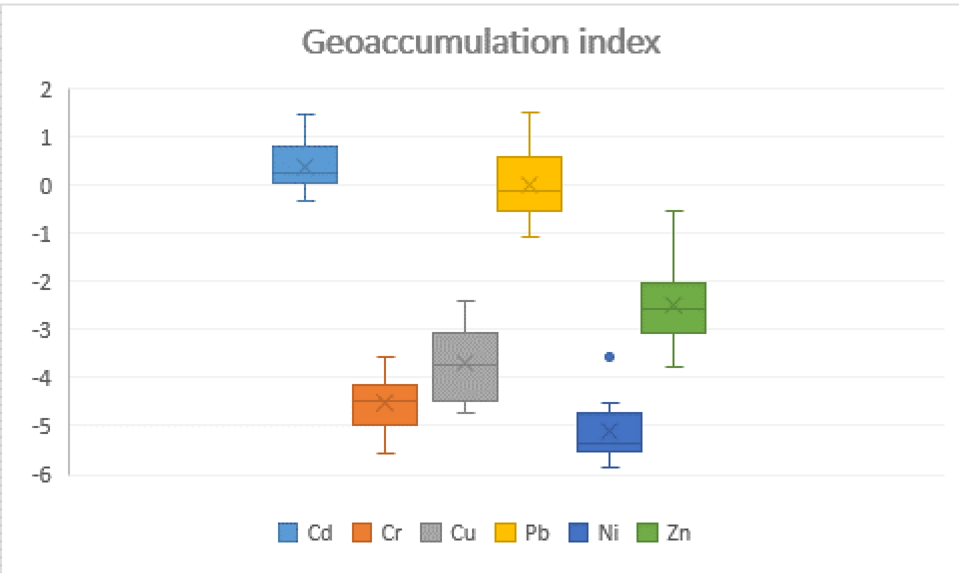

Figure 2: Box plots showing geoaccumulation index of metals

The values obtained for the enrichment factor of the various metals in the classroom dusts sampled sites is presented in Figure 3. These results suggest that all metals are deficiently to minimally

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enriched except cadmium that found to be moderately enriched in dusts from Ebenezer African Primary School, Bashorun Primary School 1, Owu Methodist Primary School and KudiratAbiola Primary school. These results are contrary to those previously reported by Mmolawaet al. (2010)[22].

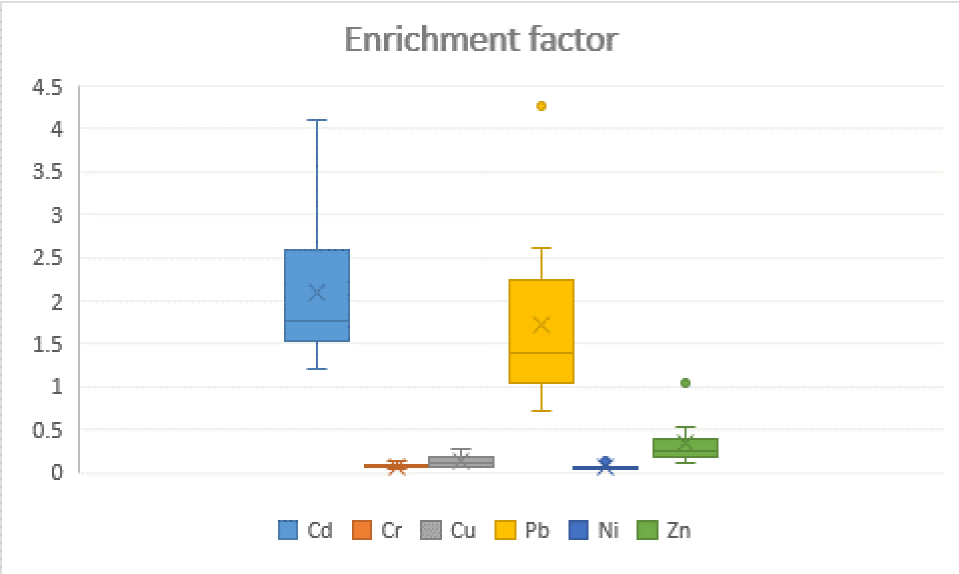

Figure 3: Box plots showing enrichment factor of metals

The contamination factor of the various metals in the classroom dust samples is presented in figure 4. This study shows that no pollution of all classroom dust samples by chromium, copper, lead and nickel. Also, zinc was found at non-polluted level in all the classroom dusts except in Ebenezer African Primary School and Bashorun Primary School 1 which were slightly polluted by zinc. Cadmium slightly contaminated all the classroom dusts except in Ebenezer African Primary School, A.N.L.G Primary school, C.A.C Nursery and Primary School and Lisabi Primary school which were not polluted by cadmium.

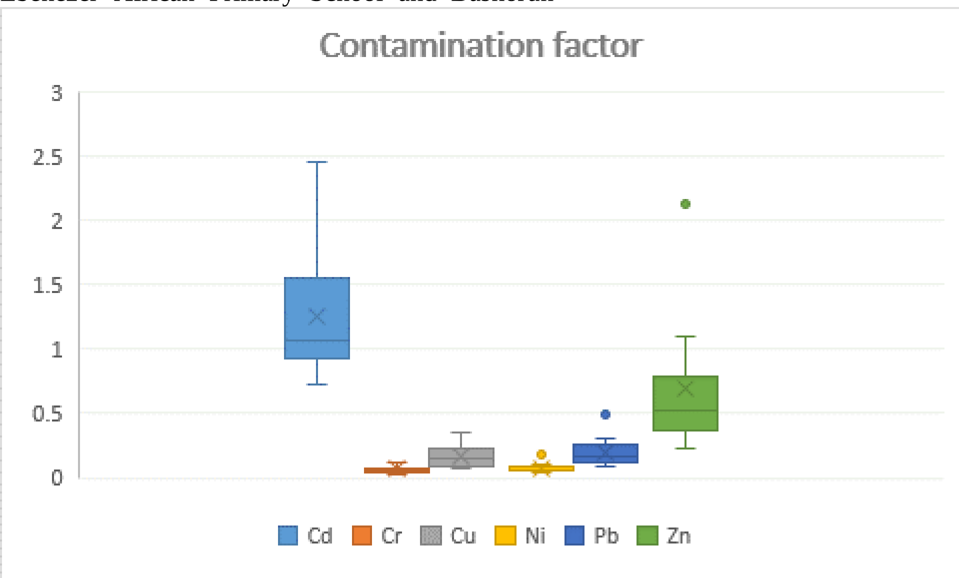

Figure 4: Box plots showing Contamination factor of metals

IV. CONCLUSION

This study has provided data on levels of heavy metals in dust from classrooms in selected primary schools in Abeokuta metropolis. The results showed that the dusts contain heavy metals at varying concentrations. The dusts showed the presence of cadmium, chromium, copper, lead, nickel and zinc. The mean concentrations of all these metals were found to be below the maximum permissible limits stated in Canadian Environmental Quality Guidelines by (Canadian Council of ministers of the environment (CCME) for heavy metals in dust.

Generally, it can be concluded that few places (classrooms) were slightly polluted by cadmium and lead. This could be as a result of deposition of lead and cadmium contain substances into the environment by the populace or there commercial activities like automechanic workshops that could lead to the release of lead and cadmium containing materials like batteries to the environment or nearness to traffic activities. Moreover, the children in the school might be exposed to toxic level of the metals if proper alleviation mechanism is not put in place.Public awareness should be made on the toxicity of heavy metals and proper method of its usage and deposition should be expressed. Environmental agencies should play their roles as expected so as to minimize the presence of heavy metals in our surrounding by doing routine check. Health risk analysis of the heavy metals should be made in further researches while other heavy metals are also put into consideration.

Funding

Authors are grateful to the Tertiary Education Trust Fund (TETFUND), Abuja, Nigeria (AST&D 2018 intervention) for supporting the execution of this research work.

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