Chapter 18

Health Risk Assessment of Heavy Metals on Primary School Learners from Dust and Soil within School Premises in Lagos State, Nigeria

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Additional information is available at the end of the chapter

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Abstract

This chapter is aimed at evaluating learner's health risk based on the concentration of toxic metals (Pb, Cr, Cd and Mn) in soil/dust from playgrounds/classrooms in selected primary schools in Lagos State. Samples were divided into four groups based on the density of the locations. Concentration of toxic metals in samples were determined by Graphite Furnace Atomic Absorption Spectrophotometer (GFA-EX7) technique after microwave digestion. The result showed that some of the heavy metals in the soil were higher than permissible limits set by DPR, FEPA and WHO. The soil/dust were contaminated with Cr, Cd and Pb but Mn was within permissible limit. Due to exposure to playground soil and classroom dust, hazardous index (HI) for non-carcinogenic/carcinogenic risk in children was estimated. HI value indicated that the heavy metal pollution may pose no obvious non-cancer health risk to children learning in such schools. However, children via ingestion pathway are exposed to the greatest carcinogenic risk followed by the inhalation pathway. The cancer risk for learners was found to be 3.2×10^{-2} (1 in 31 individuals). Hence, there is need for local environmental authorities to be warned about the potential health risks caused by heavy metals in playground/classroom.

Keywords: classroom, health risk, hazard index, heavy metals, Lagos State, playgrounds

1. Introduction

Lagos State is the most crowded city in Nigeria, the second quickest developing city in Africa, and the seventh in the world [1]. The rapid development of industrialization and urbanization in recent decades has resulted in the high emissions of both metal and organic pollutants, inevitably rendering the environment especially defenseless to ecological degradation and pollution [2–4]. Heavy metals are nondegradable and accumulate in the environment with no known homeostasis mechanism for their removal [5]. High level of heavy metals may affect human health by hindering normal functioning of organs/systems such as liver, kidney, central nervous system, bones, among others or acting as cofactors in other diseases [5, 6]. A few metals are fundamental to life and assume key parts as wellsprings of vitamins, and minerals in the working of body organs. All living organisms require different measures of metals but at higher concentrations, it becomes toxic [7]. Upon absorption by the body, heavy metals keep on accumulating in vital organs like the brain, liver, bones, and kidneys, for years or decades causing serious health consequences [8].

Substantial metals like copper (Cu), cobalt (Co), and zinc (Zn) are basically required for typical body development and elements of living beings, while the high groupings of different metals like cadmium (Cd), chromium (Cr), manganese (Mn), and lead (Pb) are considered profoundly dangerous for human and aquatic life [9]. A measure of Cr is required for typical body capacities; while its high fixations may cause poisonous quality, including liver and kidney issues and genotoxic cancer-causing agent [10–12]. By and large, high concentrations of Mn and Cu in drinking water can cause mental illnesses, for example, Alzheimer and Manganism [12], which mostly affects the intellectual functions of 10-year-old children [13]. Pb is additionally an exceptionally dangerous and cancer-causing metal and may cause perpetual wellbeing dangers, including migraine, crabbiness, stomach torment, nerve harms, kidney harm, circulatory strain, lung tumor, stomach growth, and gliomas [14–16]. As the children are most susceptible to Pb toxicity, their introduction to large amounts of Pb cause serious wellbeing complexities, for example, behavioral unsettling influences, memory disintegration, and decreased capacity to comprehend as well as anemia for long-term exposure [16]. Pb likewise initiates renal tumors and disturbs the normal functioning of kidneys, joints, reproductive, and nervous systems [17].

Soils and dust have become a very good diagnostic tool of environmental conditions that influence human health [18]. Chemical composition of soil and dust has been conducted in many studies during the last 10 years. Special attention has been devoted to studies on urban parking playgrounds and on road deposited dust [19–25]. Soil particles directly or indirectly transform into house dust, and can be ingested by adults and children through various means [26]. Dermal contact, ingestion, and inhalation are the fundamental route of exposure to toxic metals in urban environment [26, 27]. Probability of exposure to unfavorable impacts of soil ingestion is higher children than adults [26]. Children fundamentally interact with soil and clean in classrooms and play areas. Children could ingest a lot of harmful metals from soil, dust, and air [27]. Because of their low resilience to poisons and hand-to-mouth pathways, the wellbeing hazard is high in this populace [28, 29]. Hence, the control of conceivably destructive substances in soil is of high significance and must be kept at low levels in the areas frequented by children [30].

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School playgrounds and classrooms are places specifically designed to allow children to play, keep them happy, and develop their learning abilities [31]. They are designed to enhance the inter-relationships among kids, provide enjoyment and recreation, and develop physical fitness and flexibility. Present day, playing grounds are all the more frequently furnished with metal made sandbox, wilderness exercise center, carousel, slide, and different materials that can upgrade recreational exercises [31]. Safety, particularly on playgrounds, relates to prevention of injuries, but less attention on the heavy metals health risk. The health risk is associated with exposure to toxicants. Human Exposure to Soil Pollutants (HESP) model is often used to survey dangers of exposures to carcinogenic and non-carcinogenic sources and is only in view of information from soil contamination [32]. The risk assessment for heavy metals is estimated by comparing the daily oral intake of heavy metals to the normal standard daily oral intake. The target hazard quotient (HQ), which according to USEPA [32], is the proportion of the estimated exposure to a contaminant, the measurement at which no unfavorable impact occurs, is the current method for non-cancer risk assessment. If the proportion is estimated above 1, then potential well-being impacts are conceivable.

Although direct exposure forms the basis of human health risk assessments, it is not discussed as widely in the literature as the first pathway (indirect exposure) [33–35]. Studies have, in any case, demonstrated that open-air exercises where people come into contact with metal-contaminated soil could also represent an important exposure pathway for intake of heavy metals for humans, particularly children [33–35]. The aim of this chapter was to evaluate risk assessment to children's health based on the content of toxic metals in soil from playgrounds and classroom dust in selected primary schools in Lagos State. This study included the investigation of several toxic metals such as Pb, Mn, and Cr in surface soil and dust samples from playgrounds and classrooms of some selected primary schools in Lagos State. Therefore, the concentration of heavy metals and risk assessment were assessed in this chapter, to ascertain the potential health risks children are subjected to, in playgrounds and classrooms at selected schools in Lagos State.

1.1. Study area

Lagos State (**Figure 1**) represents the most urbanized state in Nigeria with about 300 industries on 12 industrial estates, representing more than 60% of all industries activities in the country. It is the smallest state in Nigeria, yet it has the second biggest populace of more than 9 million [1]. The rate of populace development is around 275,000 people for every annum with a populace thickness of 2594 people for each km^2. Lagos State primary schools list was acquired from the Lagos State Primary School Education Board (SPEB), Maryland. Two schools were selected in each of the 20 local government areas (namely Agege, Ajeromi-Ifelodun, Apapa, Alimosho, Amuwo-Odofin, Badagry, Eti-Osa, Epe, Ifako-Ijaye, Ikeja, Ojo, Oshodi-Isolo, Surulere, Mushin, Shomolu, Lagos Mainland, Lagos Island, Kosofe, Ikorodu, and Ibeju-Lekki), one in highly populated area and the other in the low-density area. One of the two primary schools selected was from the planned areas (low traffic density areas, government reserved areas or residential estates) and the other from the unplanned area (high traffic density, commercial, or industrial areas).

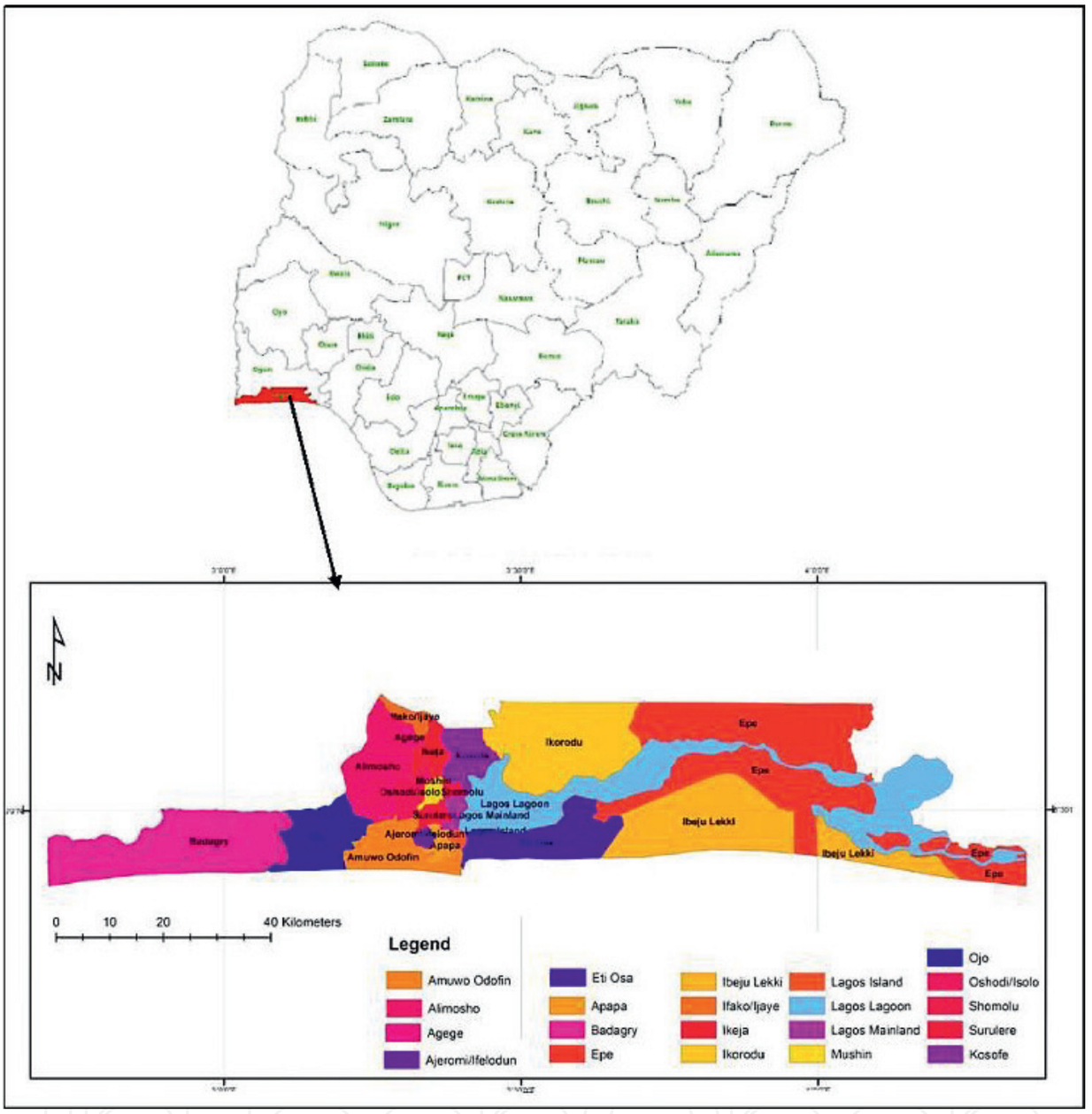

Figure 1. Lagos State map showing local government areas.

2. Methodology

2.1. Sampling and analysis

Samples were collected in two primary schools in each of the 20 local government areas of Lagos State. The schools were selected based on the proximity of the school to major roads and where possible, nearness to industrial activities. A point was picked aimlessly in the play area and entrance and a squared framework of around 2 km side was drawn from the spot. In the vicinity of four and five discrete soil samples were gathered from each of the grid. The number of samples from each site was determined based on the circumstances existing at that

site, i.e., high foot traffic (entrance), spots where the children frequently play during recess (playgrounds). A total of 80 topsoil samples were obtained. Plastic parker and brush were used to collect the surface soil. Composite samples were obtained by mixing all the subsamples to form one single sample (about 2 kg of soil), which was used for chemical analysis. Particulates such as grass, leaves, polythene bags, and papers present in soil samples were removed after gentle shaking to remove the soil attached around them. All soil samples were air-dried and sieved to 2 mm using a stainless-steel sieve and stored in plastic vials until analyzed.

In the classrooms, 40 dusts samples were gathered in the nursery classes (kids in the age scope of 2–4 years of age are more inclined to pica propensities). Dusts were gathered from window ledges, bookshelves, corners in the classrooms, and so forth. Around 3–5 tests were gathered and were blended to frame one composite sample. The soil and dust samples were air-dried and sieved to <2 mm using a stainless-steel sieve and stored in plastic vials until analyzed.

2.2. Sample preparation

The samples were air-dried in the laboratory for 24 h (laboratory dust was avoided). Larger grits and dirt were removed from the dried-dust samples before being homogenized with mortar and pestle. The collected samples were packed and kept in a sealed polythene prior analysis.

2.3. Glassware, reagents, and standards

All glassware and plastic products were first washed with high-grade laboratory cleanser, flushed with deionized water, and then 10% nitric acid was added overnight and rinsed with the deionized water. All solutions and dilutions were performed with double deionized water (18.2 M cm) obtained from Simplicity water purification system. All chemicals utilized through the examination were analytical grade chemicals. There was no further cleaning for purification of all reagents and adjustment benchmarks were provided by Merck Pty Ltd. South Africa. The analysis was carried out in triplicate to obtain the mean value.

2.4. Microwave-assisted digestion

Davidson et al. [36] method for determination of pseudototal metal concentration was adopted. This digestion method is enhanced by extracting most of the potentially mobile fractions but leaves the more resistant silicates undissolved. Approximately, 1 g of the sample and 20 mL of acid were heated at temperature of 180°C and pressure of 120 psi for 10 min. Then, the digested samples were filtered through Whatman No. 125 filter paper into 100 mL volumetric flasks. The digestion vessels were then rinsed with distilled water and filtered into the flasks. Each filtrate was made up to the mark with further distilled water, to give a final sample solution containing 20% (v/v) aqua regia.

2.5. Instrumentation calibration and measurement

1000 μg/mL standard stock solutions of Pb, Cr, Cd, and Mn were prepared from 1000 mg/L certified standard solutions (Merck Ltd., South Africa). The stock solutions were acidified with nitric acid and used for calibration. Calibration solutions concentrations of 5, 10, 20, 30, 40, 50, and 60 ppb (μg/mL) were prepared, respectively, for Pb, Cr, and Cd, while 1, 1.5, 2,

2.5, 3, 3.5, and 4 μg/mL (ppb) were prepared for Mn. A Shimadzu AA-6300 Graphite Furnace Atomic Absorption Spectrophotometer (GFA-EX7) fitted with an Autosampler (ASC)-6100 was used for determination of the heavy metals. The GFAAS was equipped with Cr, Cd, Pb, and Mn hollow cathode lamps (Varian cathode lamps and photon cathode lamps) and were employed for the measurement of the absorbance.

2.6. Risk assessment

The measured total heavy metals from the analysis were used to assess the health risk of the metal on children. The mean heavy metals concentrations were used to estimate intake at different pathways using standard USEPA's exposure equations [37, 38]. Children could be exposed to contaminants from soil via three different pathways that include oral intake ($I_{ingestion}$), inhalation intake ($I_{inhalation}$), and through skin exposure (I_{dermal}) [38]. Based on this fact, cancer/noncancer risk assessment in this study was estimated. For intake estimation via each exposure pathways, the following equations were used.

$$\text{Intake}_{\text{ingestion}} = \frac{C\ X\ IngR\ X\ EF\ X\ ED}{BW\ X\ AT}\ X\ 10^{-6} \tag{1}$$

where C—concentration of a contaminant in soil (mg/kg), IngR—ingestion rate of soil (mg/day), EF—exposure frequency (days/year), ED—exposure duration (years), BW—average body weight (kg), and AT—average time (days) = ED*365

$$\text{Intake}_{\text{inhalation}} = \frac{C\ X\ InhR\ X\ EF\ X\ ED}{PEF\ X\ BW\ X\ AT} \tag{2}$$

where InhR—inhalation rate (m^3/day) and PEF—particle emission factor (m^3/kg).

$$\text{Intake}_{\text{dermal}} = \frac{C\ X\ SA\ X\ SAF\ X\ ABS\ X\ EF\ X\ ED}{BW\ X\ AT}\ X\ 10^{-6} \tag{3}$$

where SA—surface area of the skin that contacts the soil (cm^2), SAF—skin adherence factor for soil (mg/cm^2), and ABS—dermal absorption factor (chemical specific) = 0.001 (for all metals).

After the three exposure pathways were calculated, hazard quotient (HQ) and HI based on cancer/non-cancer toxic risk were calculated as follows [38]:

$$\text{HQ} = \frac{Intake}{RfD} \tag{4}$$

$$\text{HI}_{ex}\,\text{P} = \sum HQexP \tag{5}$$

where exP are different exposure pathways, respectively. Reference dose (RfD) (mg/kg/day) is an estimated value of the daily exposure, maximum permissible risk, to the human population, including sensitive subgroups (children) during a lifetime. **Tables 1** and **2** show the exposure parameters, reference doses, and cancer slope factors used for the health risk assessment for standard residential exposure scenario through different exposure pathways.

Parameter	Unit	Child	References
Body weight (*BW*)	kg	15	[39]
Exposure frequency (*EF*)	days/year	360	[38]
Exposure duration (*ED*)	years	6	[40]
Ingestion rate (*IR*)	mg/day	200	[41, 42]
Inhalation rate (*IRair*)	m^3/day	7.6	[43]
Skin surface area (*SA*)	cm^2	2800	[40]
Soil adherence factor (S*AF*)	mg/cm^2	0.2	[40]
Dermal Absorption factor (*ABS*)	none	0.001	[38–40, 43, 44]
Particulate emission factor (*PEF*)	m^3/kg	1.36×10^9	[38, 39]
Average time (*AT*)	days		[39]
For carcinogens		365 × 70	[39]
For non-carcinogens		365 × ED	[39]

Table 1. Exposure parameters used for the health risk assessment through different exposure pathways for soil.

Heavy metal	$RfD_{ingestion}$	RfD_{dermal}	$RfD_{Inhalation}$	$exP_{ingestion}$	exP_{dermal}	$exP_{Inhalation}$	Ref.
Pb	3.50E−03	5.25E-04	3.50E-03	8.50E−03	—	4.20E−02	[39, 45]
Cr	3.00E−03	3.00E−03	3.00E−05	5.00E−01	—	4.10E+01	[39, 46]
Cd	1.00E-03	1.00E-03	5.70E-05	6.30E+00	—	6.30E+00	[39, 45]
Mn	1.40E-1	1.40E-1	—	—	—	—	[39, 46]

Table 2. Reference doses (***RfD***) in (mg/kg-day) and cancer slope factors (exP) for the different heavy metals.

3. Results and discussion

3.1. Concentrations of heavy metals in soil from classrooms and playgrounds

Descriptive statistics of the four groups of schools are shown in **Table 3**. Average concentrations of heavy metals in mg/kg from playgrounds and classrooms in selected primary schools in Lagos State were used to calculate average daily intakes for carcinogenic/non-carcinogenic risk assessment. The results presented showed the average concentrations of heavy metals in classrooms and playgrounds varied significantly and decreased in the order from Group 1 > Group 3 > Group 2 > Group 4 for Pb; Group 4 > Group 3 > Group 1 > Group 2 for Cr; Group 2 > Group 1 > Group 3 = Group 4 for Cd and Group 2 > Group 3 > Group 1 = Group 4 for Mn in the samples. This implies that the heavy metals are distributed irrespective of the locality either in high or low-density playgrounds/classrooms. The results show the magnitude of the heavy metals in the classrooms and playgrounds decreases in the following order:

		GROUP 1	GROUP 2	GROUP 3	GROUP 4
Pb (μg/g)	Min	23.04	24.30	24.96	8.33
	Max	79.01	37.05	41.91	41.91
	Mean + SD	35.17 ± 16.54	30.08 ± 5.35	30.75 ± 6.72	24.21 ± 12.05
	Range	23.04–79.01	24.30–37.05	24.96–41.91	8.33–41.91
Cr (μg/g)	Min	3.25	0.05	6.66	11.42
	Max	16.93	14.52	19.15	20.24
	Mean + SD	11.88 ± 4.50	6.08 ± 4.63	14.58 ± 4.33	15.73 ± 2.87
	Range	3.25–16.93	0.05–14.52	6.66–19.15	11.42–20.24
Cd (μg/g)	Min	1.05	0.90	ND	ND
	Max	1.63	3.10	ND	ND
	Mean + SD	1.28 ± 0.31	1.90 ± 1.07	ND	ND
	Range	1.05–1.63	0.90–3.10	ND	ND
Mn (μg/g)	Min	ND	1.18	1.18	ND
	Max	ND	1.87	1.18	ND
	Mean + SD	ND	1.47 ± 0.36	1.18 ± .00	ND
	Range	ND	1.18–1.87	1.18	ND

Group 1—High density playground; Group 2—Low-density playground; Group 3—High density classroom, and Group 4—Low-density classroom, ND—Not detected.

Table 3. Statistical parameter for the distribution of Pb, Cr, Cd, and Mn in classroom dusts and playgrounds from selected schools in Lagos State.

Pb > Cr > Cd > Mn. The high concentrations of Pb and Cr in the samples could be attributed to the paint chippings peeling off to settle on the classrooms floors as dust [30]. A study from Wright et al. [47] show that chipping house paint is a critical determinant of high blood lead levels more than 10 μg/L found in 70% of children aged 6–35 months. It has been accounted for that emulsion and gloss sorts of paints, which are produced and sold in Nigeria contained considerable levels of lead [48].

Higher concentrations of investigated metals could be due to proximity of the schools to traffic roads and some industrial locations. Lagos State has been under high urbanization in the past few decades. In this chapter, there were no specific pollution sources of toxic metals [30]; hence, the toxic metal contamination of the soils from the classrooms and playgrounds was most likely from continuous urbanization and development, which can influence human health in the contaminated area. It is important to emphasize that Lagos State with her increasing population is known to have very intensive and heavy traffic [30]. The high Pb concentration of the soil could be ascribed to vehicular discharges and metal plating and greasing up oils. It could likewise be because of harsh surfaces of the streets which increment the wearing of tires and run-offs from the roadsides [48]. Lead contamination in urban soil

	Pb	Cr	Cd	Mn
DPR(μg/g)	0.05	0.03	0.01	—
FEPA(μg/g)	0.05	0.03	0.01	—
WHO (μg/g)	0.05	0.02	0.005	5

Table 4. DPR [50], FEPA [51], and WHO [52] permissible limits.

has been ascribed to ignition of fuel that contains tetraethyl lead as anti-knock agent [48, 49]. Compared with recommended maximum allowable limits for Nigeria and WHO as shown in **Table 4**, Pb, Cr, and Cd concentrations were found to be higher than the permissible limits, and hence the classrooms and playgrounds soils were contaminated, and the learners were at high risk. These highest levels of Pb and Cr could possibly be the cause of alleged sickness in children suffering from diarrheal diseases and chest pains. The high concentrations of heavy metals could be because of the nearness of the schools and playgrounds to bus stops, auto workshops, nearby industries, gas stations in addition to paints chippings as reported in the city of Ibadan [53].

3.2. Health risk of heavy metals for children

The mean values of the heavy metals were higher than permissible limits by DPR, FEPA, and WHO, which make the soils/dusts contaminated except for Mn (**Table 4**). The obtained results of non-carcinogenic health risk on children, based on metal concentrations in playgrounds and classrooms soils and exposure by three different pathways (ingestion, inhalation, and dermal) are shown in **Table 5**. When HQ and HI values are less than one, there is no obvious risk to the population, but if these values exceed one, there may be concern for potential non-carcinogenic effects [38]. The results showed that the major path of children exposure to playgrounds soils and classroom dust that may have adverse effect on their health by Pb, Cr, Cd, and Mn is ingestion, followed by dermal exposure (**Figure 2**). Contribution of inhalation exposure to the HQ and HI is the smallest (**Figure 2**). This finding supports other studies to establish the ingestion pathway as the major contributor to HI, particularly for children [6, 17, 28, 31].

In this study, the ingestion had HI values less than 1 for all the observed heavy metals in all the groups. The summation of the total HI-value is approximately 0.4, which is less than one and ingestion pathway is a major contributor though there is no health effect (**Table 5**). Although, samples (classroom dusts and playground soils) were contaminated with Pb, Cd, and Cr but there is no obvious non-cancer health risk to the children. The high concentrations of indicated heavy metal pollution may pose a non-cancer health risk to children learning in such schools. This could be attributed to the short-term exposure duration (ED) of 6 years as recommended by USEPA health assessment model deployed in the study. The results also indicate that children via ingestion pathway could be exposed to potential possibility of non-carcinogenic risk followed by the inhalation pathway if considered at long-term exposure duration.

		GROUP 1	GROUP 2	GROUP 3	GROUP 4
Pb	Intake(ingestion)	4.63E-04	3.96E-04	4.04E-04	3.18E-04
	Intake(inhalation)	1.29E-08	1.11E-08	1.13E-08	8.90E-09
	Intake(dermal)	1.30E-06	1.11E-06	1.13E-06	8.91E-07
	Total Intake	**4.64E-04**	**3.97E-04**	**4.06E-04**	**3.19E-04**
	HQ(ingestion)	1.32E-01	1.13E-01	1.16E-01	9.10E-02
	HQ(inhalation)	2.46E-05	2.11E-05	2.15E-05	1.69E-05
	HQ(dermal)	3.70E-04	3.16E-04	3.24E-04	2.55E-04
	Total HQ	**1.33E-01**	**1.13E-01**	**1.16E-01**	**9.12E-02**
	HI(ingestion)	1.12E-03	9.61E-04	9.82E-04	7.73E-04
	HI(inhalation)	1.03E-06	8.84E-07	9.04E-07	7.12E-07
	HI(dermal)	—	—	—	—
	Total HI	**1.12E-03**	**9.62E-04**	**9.83E-04**	**7.74E-04**
Cr	Intake(ingestion)	1.56E-04	8.00E-05	1.92E-04	2.07E-04
	Intake(inhalation)	4.37E-09	2.23E-09	5.36E-09	5.78E-09
	Intake(dermal)	4.37E-07	2.24E-07	5.37E-07	5.79E-07
	Total Intake	**1.57E-04**	**8.02E-05**	**1.92E-04**	**2.07E-04**
	HQ(ingestion)	5.21E-02	2.67E-02	6.39E-02	6.90E-02
	HQ(inhalation)	1.46E-06	7.45E-07	1.79E-06	1.93E-06
	HQ(dermal)	1.46E-02	7.46E-03	1.79E-02	1.93E-02
	Total HQ	**6.67E-02**	**3.41E-02**	**8.18E-02**	**8.83E-02**
	HI(ingestion)	2.60E-02	1.33E-02	3.20E-02	3.45E-02
	HI(inhalation)	5.97E-05	3.05E-05	7.32E-05	7.90E-05
	HI(dermal)	—	—	—	—
	Total HI	**2.61E-02**	**1.34E-02**	**3.20E-02**	**3.46E-02**
Cd	Intake(ingestion)	1.68E-05	2.50E-05	—	—
	Intake(inhalation)	4.70E-10	6.98E-10	—	—
	Intake(dermal)	4.71E-08	7.00E-08	—	—
	Total Intake	**1.69E-05**	**2.51E-05**	**—**	**—**
	HQ(ingestion)	1.68E-02	2.50E-02	—	—
	HQ(inhalation)	8.25E-06	1.22E-05	—	—
	HQ(dermal)	4.71E-05	7.00E-05	—	—
	Total HQ	**1.69E-02**	**2.51E-02**	**—**	**—**
	HI(ingestion)	1.06E-01	1.57E-01	—	—
	HI(inhalation)	5.20E-05	7.72E-05	—	—
	HI(dermal)	—	—	—	—
	Total HI	**1.06E-01**	**1.57E-01**	**—**	**—**

		GROUP 1	GROUP 2	GROUP 3	GROUP 4
Mn	Intake(ingestion)	—	1.93E-05	1.55E-05	—
	Intake(inhalation)	—	5.40E-10	4.34E-10	—
	Intake(dermal)	—	5.41E-08	4.34E-08	—
	Total Intake	**—**	**1.94E-05**	**1.56E-05**	**—**
	HQ(ingestion)	—	1.38E-04	1.11E-04	—
	HQ(inhalation)	—	—	—	—
	HQ(dermal)	—	3.87E-07	3.10E-07	—
	Total HQ	**—**	**1.38E-04**	**1.11E-04**	**—**

Table 5. Noncarcinogenic risk for children in soil/dust from the classrooms and playgrounds.

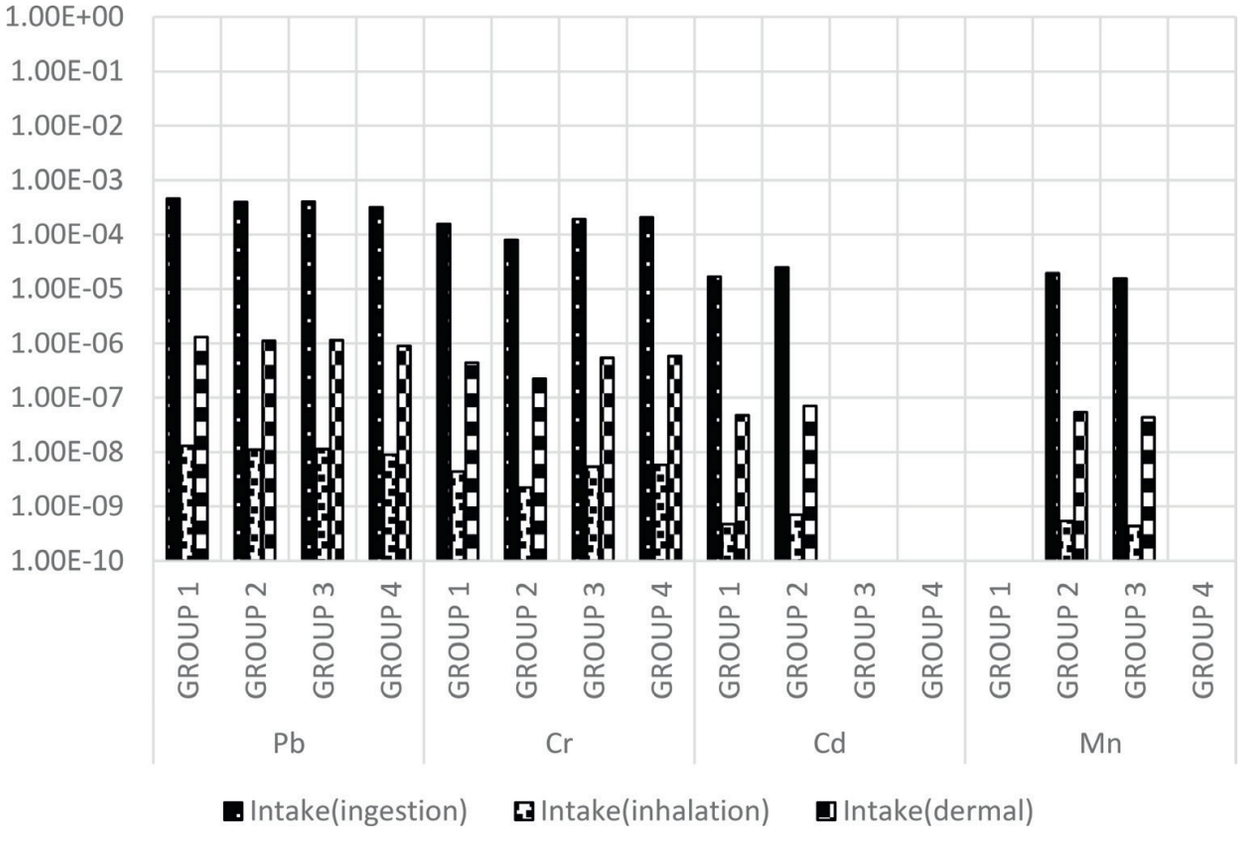

Figure 2. Heavy metal intake (three pathways) values for children in selected school in Lagos State.

Literature shows that the daily ingestion rates of soil by children were calculated to vary between 39 and 270 mg/day [54]. Monitoring of Pb content in soil is of great necessity owing to the adverse effect on the children's central nervous system [55]. Numerous neurological and formative issue might be seen in children' populace because of a long time of exposure and ingestion of specific amount of Pb from contaminated soil; the potential wellbeing dangers

incorporate iron deficiency, kidney harm, colic, muscle shortcoming, and cerebrum harm [56]. Ingestion of small Pb from dust may be harmful for blood, development, behavior, and intellectual functioning, as well [56]. Hence, children are more at risk particularly in both high- and low-density classrooms/playgrounds.

The excess lifetime cancer risks for children are calculated from the mean concentrations of individual heavy metals in classrooms and playgrounds for the pathways using Eqs. (4) and (5). **Table 6** presented the calculated carcinogenic risk values for Pb, Cr, Cd, and Mn. Cr and Cd was found to be highest contributor to the cancer risk. The US Environmental Protection Agency considers adequate for administrative purposes a malignancy hazard point of confinement of 1×10^{-6} to 10^{-4} [32]. The summation of cancer risk for learners was found to be

		GROUP 1	**GROUP 2**	**GROUP 3**	**GROUP 4**
Pb	Intake(ingestion)	3.96E-05	3.39E-05	3.47E-05	2.73E-05
	Intake(inhalation)	1.11E-09	9.47E-10	9.68E-10	7.63E-10
	Intake(dermal)	1.11E-07	9.49E-08	9.71E-08	7.64E-08
	Total Intake	**3.98E-05**	**3.40E-05**	**3.48E-05**	**2.74E-05**
	HQ(ingestion)	1.13E-02	9.69E-03	9.90E-03	7.80E-03
	HQ(inhalation)	2.11E-06	1.80E-06	1.84E-06	1.45E-06
	HQ(dermal)	3.17E-05	2.71E-05	2.77E-05	2.18E-05
	Total HQ	**1.14E-02**	**9.72E-03**	**9.93E-03**	**7.82E-03**
	HI(ingestion)	9.63E-05	8.23E-05	8.42E-05	6.63E-05
	HI(inhalation)	8.86E-08	7.58E-08	7.75E-08	6.10E-08
	HI(dermal)	—	—	—	—
	Total HI	**9.64E-05**	**8.24E-05**	**8.43E-05**	**6.63E-05**
Cr	Intake(ingestion)	1.34E-05	6.85E-06	1.64E-05	1.77E-05
	Intake(inhalation)	3.74E-10	1.91E-10	4.59E-10	4.95E-10
	Intake(dermal)	3.75E-08	1.92E-08	4.60E-08	4.96E-08
	Total intake	**1.34E-05**	**6.87E-06**	**1.65E-05**	**1.78E-05**
	HQ(ingestion)	4.46E-03	2.28E-03	5.48E-03	5.91E-03
	HQ(inhalation)	1.25E-07	6.38E-08	1.53E-07	1.65E-07
	HQ(dermal)	1.25E-03	6.40E-04	1.53E-03	1.65E-03
	Total HQ	**5.71E-03**	**2.92E-03**	**7.01E-03**	**7.57E-03**
	HI(ingestion)	2.23E-03	1.14E-03	2.74E-03	2.96E-03
	HI(inhalation)	5.11E-06	2.62E-06	6.28E-06	6.77E-06
	HI(dermal)	—	—	—	—
	Total HI	**2.24E-03**	**1.14E-03**	**2.75E-03**	**2.96E-03**

		GROUP 1	GROUP 2	GROUP 3	GROUP 4
Cd	Intake(ingestion)	1.44E-06	2.14E-06	—	—
	Intake(inhalation)	4.03E-11	5.98E-11	—	—
	Intake(dermal)	4.04E-09	6.00E-09	—	—
	Total intake	**1.45E-06**	**2.15E-06**	**—**	**—**
	HQ(ingestion)	1.44E-03	2.14E-03	—	—
	HQ(inhalation)	7.07E-07	1.05E-06	—	—
	HQ(dermal)	4.04E-06	6.00E-06	—	—
	Total HQ	**1.45E-03**	**2.15E-03**	**—**	**—**
	HI(ingestion)	9.09E-03	1.35E-02	—	—
	HI(inhalation)	4.46E-06	6.61E-06	—	—
	HI(dermal)	—	—	—	—
	Total HI	**9.09E-03**	**1.35E-02**	**—**	**—**
Mn	Intake(ingestion)	—	1.66E-06	1.33E-06	—
	Intake(inhalation)	—	4.63E-11	3.72E-11	—
	Intake(dermal)	—	4.64E-09	3.72E-09	—
	Total intake	**—**	**1.66E-06**	**1.33E-06**	**—**
	HQ(ingestion)	—	1.18E-05	9.50E-06	—
	HQ(inhalation)	—	—	—	—
	HQ(dermal)	—	3.31E-08	2.66E-08	—
	Total HQ	**—**	**1.19E-05**	**9.53E-06**	**—**

Table 6. Carcinogenic (three exposure pathways) risk for children in soil and dust from the classrooms and playgrounds.

3.2×10^{-2} (1 in 31 individuals), which is higher than the acceptable values. Be that as it may, ingestion pathway is by all accounts the significant contributor to overabundance lifetime cancer risk, then inhalation pathway. **Tables 5** and **6** show the difference in the exposure duration, which results to the no obvious non-cancer risk (exposure duration of 6 years) and potential cancer risk (exposure duration of 70 years) of the learners in the selected schools. Therefore, there is a need to take necessary action to decontaminate the sites in order to protect children's health. This approach may be helpful in decision-making process in every growing city in the world like Lagos State.

4. Conclusion

Heavy metals concentrations (Pb, Cr, Cd, and Mn) were determined from the playgrounds and classrooms of selected primary schools in Lagos State. The concentrations of the metals

detected in classrooms dust and playgrounds soils were higher than recommended permissible limits by DPR, FEPA, and WHO except for Mn. The high concentrations of the heavy metals could be because of the proximity of the schools to bus stops, auto workshops, nearby industries, gas stations in addition to paints chippings. The results showed that the major path of children exposure to playgrounds soil and classroom dust is ingestion, followed by dermal exposure. HI value indicated heavy metal pollution that may pose no obvious non-cancer health risk to children learning in such schools. This is possibly due to the short exposure duration of 6 years. The results also indicate that children via ingestion pathway contributes most to carcinogenic risk followed by the inhalation pathway owing to longer exposure duration of 70 years. The cancer risk for learners was found to be 3.2×10^{-2} (1 in 31 individuals), which is higher than the acceptable values of 1×10^{-6} to 10^{-4}. The results will provide the direct evidence needed by local environmental authorities and school managers to warn learners about the potential health risks caused by heavy metals in playgrounds and classrooms dust.

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