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Heavy Metals Content in Classroom Dust of Some Public Primary Schools in Metropolitan Lagos, Nigeria

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Abstract: This aim of the study is to determine the levels of heavy metals (Pb, Cr, Cd and Mn) in 40 dust samples obtained from the classrooms of some public primary schools in Lagos State, Nigeria. Children are more susceptible to the adverse health effects of heavy metal pollution due to their small body size, developing nervous system, high absorption rate and behavioral pattern present during childhood. Exposure to heavy metalladen dustis considered to be a significant contributor. To assess the extent of pollution by heavy metals, classroom dust samples were obtained from 40 selected schools in Lagos, Nigeria. The samples were subjected to aqua regia microwave digestion and analysed using graphite furnace atomic absorption spectrophotometer.The results showed that the classroom dusts contained Pb_{HD} 23.89±16.39, Pb_{LD} 22.77±9.21; Cr_{HD} 10.53±5.08, Cr_{LD}6.17±2.47; Cd_{HD}0.09±0.12, Cd_{LD}0.09±0.10 μg/g, respectively. Interestingly, the highest concentration of lead (82.51 μg/g) was found in a classroom far removed from any commercial or industrial activites, Ajeromi-Ifelodun high density area while Ikeja, a more industrialized area has lower concentration of the metal. The values obtained in this study are lower than expected but it is still a source of concern since children are exposed to this environment daily and for appreciable period of time.

Key words: Children, classroom, dust, heavy metal, cancer, Lagos

INTRODUCTION

On a daily basis, numerous human activities, including municipal, industrial, commercial and agricultural operations, release a variety of toxic and potentially toxic pollutants into the environment (Nriagu, 1979; Nriagu and Pacyna, 1988). Within the urban environment, where these activities are especially intense, emissions of both metal and organic pollutants are often vastly accelerated, inevitably rendering the urban environment particularly susceptible to environmental degradation and contamination (Nriagu, 1988; Kreimer, 1992; Thornton, 1993). One of the crucial properties of the metals that differentiate them from other toxic pollutants is that they are non-biodegradable and also accumulate in the environment.

Dust is the material that has largely been ignored as a significant source of trace metal contamination in the urban environment. In recent times, however, studies of heavy metals pollution via dust especially in the urban environment have focused largely on road deposited dust De Miguel *et al*. (1997), Bhargava *et al*. (2003), Banerjee (2003), Turer (2005), Yongming *et al*. (2006), Ahmed and Ishiga (2006), Shinggu *et al*. (2010) and Lu *et al*. (2009). Soil particle directly or indirectly transform into house dust and can be ingested by adults and children through unintentional hand-mouth contact, geophagia or dust inhalation (Mielke and Reagan, 1998; White *et al*., 1998). A study by Lanphear *et al*. (1996) conducted among children in Rochester (New York, USA) indicates that dust lead content explains most of the variance in blood lead levels.

Dust makes a significant contribution to the pollution in the urban environment and consists of vehicle exhaust, sinking particles in air, house dust, soil dust and aerosols that are carried by air and water. Many studies on street dust have focused on elemental concentrations and source identification (Ericson and Mishra, 1990; Fergussion and Kim, 1991; Higgs *et al*., 1997).

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The direct health impacts of trace metal contamination of the urban environment are usually difficult to assess due to the complexity of the medical factors involved. Nonetheless, it is generally accepted that children represent the most sensitive group to trace metal contamination (Watt *et al*., 1993; Nriagu *et al*., 1996; Shen *et al*., 1996).The health effects of toxic metals in dust when inhaled can inflame, sensitize and even scar the lungs and tissue. The pollutants may enter the numerous tiny air sacs deep inside the lungs and also blood stream thereby affecting several other organs than lungs (Gbadebo and Bankole, 2007). The carcinogenic potential of Cd as well as the mechanisms underlying carcinogenesis following exposure to Cd has been studiedusing in vitro cell culture and in vivo animal models. Exposure of cells to Cd result in their transformation. Administration of Cd in animals result in tumors of multiple organs/tissues. Also, a causal relationship has been noticed between exposure to Cd and the incidence of lung cancer in human. It has been demonstrated that Cd induces cancer by multiple mechanism and the most important among are aberrant genes expression, inhibition of DNA damage repair, induction of oxidative stress, and inhibition of apostopsis (Joseph, 2009).

Heavy metal poisoning is not uncommon in children and can seriously impair normal development (Nriagu *et al*., 1997). Ingestion of dust and soil is widely regarded as the key pathway for childhood exposure to lead based paint, leaded gasoline and other metals and metalloids derived from vehicular traffic and local industrial sources (Thornton *et al*., 1994; Rasmussen *et al*., 2001). The potential for exposure to contaminants via this source is greater for children because they are more likely to ingest more soil than adult as a result of behavioral pattern present during childhood. Inadvertent soil ingestion among children may occur through the mouthing of objects or hands. The toxicological effects are further aggravated by the unique physiology of children, the sensitivity of their developing vital organs, and different chemical forms of metals involved (Hrudey *et al*., 1996).

Previous studies in Nigeria have shown that 70% of children aged 6 to35 months had blood lead levels greater than 10 μg/dL (Pfitzner *et al*., 2006) and that flaking house paint was an important determinant of this (Wright *et al*., 2005). It has been shown that emulsion and gloss types of paints currently manufactured and sold in Nigeria contained substantial levels of lead (Adebamowo *et al*., 2006).

However, much attention has not been paid to the problem of heavy metal contamination in classrooms. There is a lack of information on classroom dust and consequently; there are no regulations, and guidelines for heavy metal contamination in classrooms. If dust laden

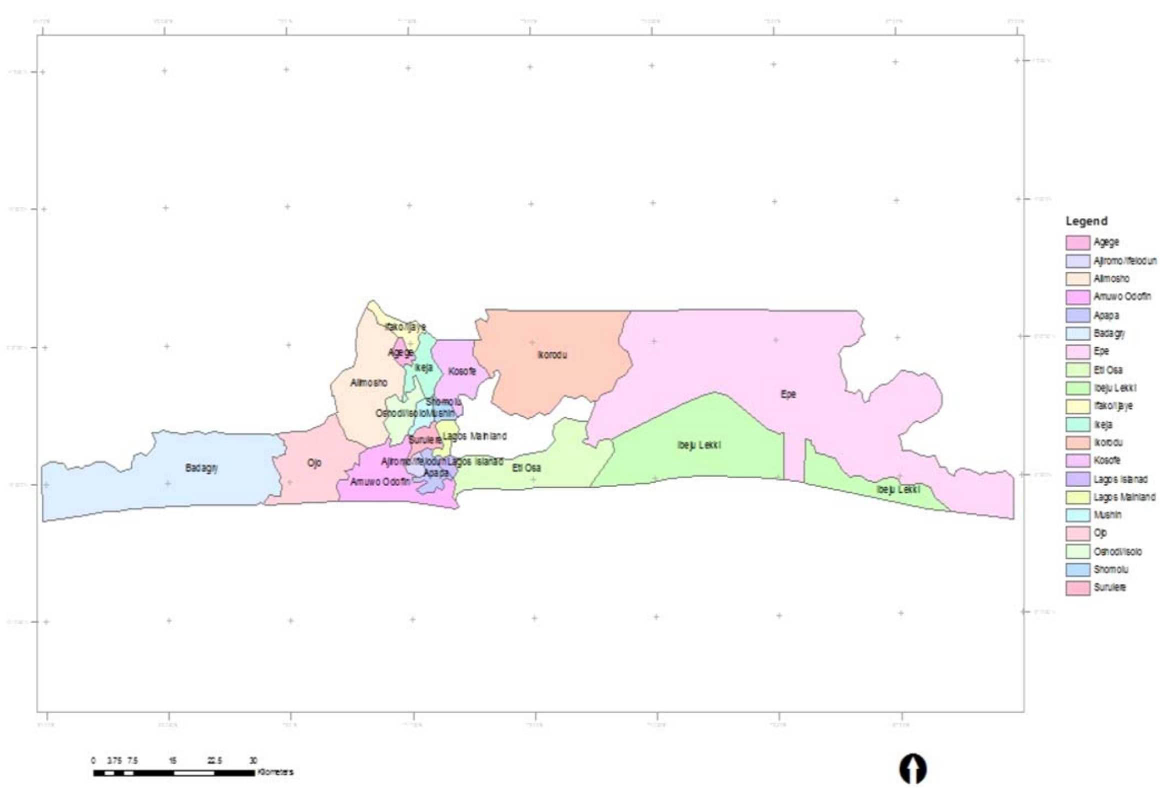

Fig. 1: Lagos Sate Map Showing Local Government Areas

with heavy metals provides a critical link in the exposure pathway for young children, contaminated classroom dust can undoubtedly pose a potential hazard to the health of young school children. To provide a healthy city environment and protect young lives from heavy metal contaminants, it is important to have a thorough understanding of the extent of heavy metal pollutantsin classrooms. This aim of this study therefore, is to determine the levels of heavy metals (Pb, Cr, Cd and Mn) in 40 dust samples obtained from the classrooms of some public primary schools in Lagos State.

METHODOLOGY

Study area: Lagos state (Fig. 1), represents the most urbanized area in Nigeria with its almost 300 industries on 12 industrial estates, representing of over 60% of all industrial activities in Nigeria. It is the smallest state in Nigeria, yet it has the second largest population of over 9 million, Federal Republic of Nigeria official gazette (2007). The rate of population growth is about 275,000 persons per annum with a population density of 2,594 persons per km^2. A list of primary schools in Lagos State was obtained from the Lagos State Primary School Education Board (SPEB), Maryland. Two schools were selected in each of the 20 local government areas, one in highly populated area and the other in the low density area. All the schools are located in residential areas. The schools were selected based on the nearness of the school to major roads and where possible, nearness to industrial activities. The dust samples were collected in the classrooms of 40 selected schools in Lagos state, Nigeria during the dry season (between October and February).

Sampling: Samples were collected in two primary schools in each of the 20 local government areas of Lagos State.In the classrooms, 40 dusts samples were collected in the nursery classes (children in the age range of 2-4years old are more prone to pica tendencies). Dusts were collected from window sills, bookshelves, corners in the classrooms etc. About 3-5 samples were collected and were mixed to form one composite sample.

Sample pre-treatment: The samples were air-dried in the laboratory for 24 h (care was taken to prevent contamination from laboratory dusts). Larger grits and dirt were removed from the dried dust samples before being homogenized with mortar and pestle. The collected samples were kept in sealed polythene vials for subsequent analysis.

Glassware/reagents: All laboratory glassware and plastic wares were first washed with high grade laboratory soap, rinsed with deionised water and soaked in 10% nitric acid (overnight), then rinsed again with double deionised water. All reagents used in this work were of analytical grade quality and the acids used for pseudototal digestions were supplied by Merck Pty Ltd. South Africa. All solutions and dilutions were performed with double deionised water (18.2 M cm) obtained from Simplicity water purification system.

Microwave-assisted aqua regia digestion: Pseudo-total metal content was determined by digestion with aqua regia using the method of Davidson *et al*. (1998). This digestion method is favoured because it provides the pseudo-total metal concentration since it extracts most of the potentially mobile fractions, but leaves the more resistant silicates undissolved. Vessels containing 1 g of the sample and 20 mL of acid were heated at temperature of 180^{o}C and pressure of 120 psi for 10 min. Digests were filtered through Whatman No.125 filter paper into 100 mL volumetric flasks. The digestion vessels were then rinsed with distilled water. The washings were also 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.

Instrumentation for total metal determination: 1000 μg/mL standard stock solutions of Cd, Pb, Cr and Mn were prepared from 1000 mg/L certified standard solutions (supplied by Merck Ltd South Africa). The stock solutions were acidified with nitric acid and were used for calibration. Standard calibration solutions concentrations of 5, 10, 20, 30, 40, 50 and 60 ppb (μg/mL) were prepared respectively for Pb and Cr while 1, 1.5, 2, 2.5, 3, 3.5 and 4 μg/mL (ppb) were prepared for Cd and Mn. Intermediate standards and reagent solution were stored in polythene bottles.

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 Cd, Cr, Pb and Mn hollow cathode lamps (Varian cathode lamps and photron cathode lamps) and were employed for the measurement of the absorbance.

Analysis of the data: Statistical data analysis of the research was done using SPSS version 12.0. Analysis of variance was used to test significant difference among the mean concentrations of the heavy metals in the samples from the high and low population density areas. Mean of the three extraction results were calculated as well as the Standard Deviation (SD) of the concentration of metals.

RESULTS AND DISCUSSION

The concentrations of heavy metals in classroom dust samples from selected schools in local government areas of Lagos state are presented in Table 1 while the mean, maximum, minimum and ranges are presented in Table 2.The result of this study shows Pb, Cr and Cd were detected in the classroom dust samples investigated, the only exception is Mn which was not found in the dust

Table 1: Concentrations of metals in classroom dustsamples from selected schools in local government areas of Lagos state

	Pb (µg/g)		Cr (µg/g)		Cd (µg/g)		Mn (µg/g)	
Local government areas	HD	LD	HD	LD	HD	LD	HD	LD
Mainland	29.52±1.30	13.56±0.14	12.56±3.14	ND	ND	0.01±0.01	ND	ND
IfakoIjaiye	31.67±0.52	15.38±0.41	11.38±1.49	8.28±0.05	0.00±0.00	0.04±0.02	ND	ND
Badagry	12.34±0.00	27.67±0.78	ND	ND	0.04±0.02	0.00±0.00	ND	ND
IbejuLekki	16.64±0.02	12.95±0.27	4.21±0.14	ND	0.02±0.01	0.01±0.00	ND	ND
Epe	36.91±0.59	26.47±0.07	7.15±0.25	6.78±0.08	0.15±0.01	0.00±0.00	ND	ND
Kosofe	17.07±0.55	25.56±0.14	ND	ND	0.10±0.00	ND	ND	ND
Alimosho	16.80±0.04	24.05±0.85	ND	ND	0.01±0.01	0.02±0.00	ND	ND
Shomolu	20.33±0.91	37.34±0.46	ND	ND	ND	ND	ND	ND
AmuwoOdofin	23.85±0.23	23.60±0.46	ND	ND	0.12±0.01	0.13±0.01	ND	ND
Surulere	22.35±0.08	14.80±0.08	ND	ND	0.01±0.00	0.01±0.00	ND	ND
Apapa	19.91±0.82	30.22±0.53	ND	ND	0.05±0.00	0.18±0.01	ND	ND
Eti-Osa	0.06±0.03	16.60±0.48	ND	ND	0.07±0.02	0.10±0.00	ND	ND
Mushin	26.66±0.53	34.39±0.21	ND	ND	0.08±0.00	0.13±0.00	ND	ND
Ojo	2.52±0.15	10.34±0.16	ND	ND	0.04±0.00	0.06±0.00	ND	ND
OshodiIsolo	24.70±0.16	22.79±0.06	ND	ND	0.13±0.00	0.10±0.00	ND	ND
AjeromiIfelodun	82.51±0.91	39.18±1.82	ND	ND	0.13±0.00	ND	ND	ND
Lagos Island	22.43±0.76	3.62±0.79	ND	ND	0.20±0.01	0.15±0.00	ND	ND
Ikorodu1	8.36±0.12	14.60±0.32	ND	ND	0.01±0.00	0.06±0.00	ND	ND
Agege	24.47±0.48	23.18±0.29	ND	ND	0.01±0.00	0.06±0.00	ND	ND
Ikeja2	8.77±1.05	ND	17.37±1.30	3.45±0.04	0.50±0.00	0.40±0.00	ND	ND

Table 2: Basic statistical parameter for the distribution of Pb, Cr, Cd and Mn in classroom dusts from selected schools in Lagos state

		Mean Conc.	Max	Min	Range
Pb	HD	23.89±16.38	82.51±0.91	0.06±0.03	82.45
	LD	22.77±9.21	39.18±1.82	3.62±0.79	39.74
Cr	HD	10.53±5.08	17.37±1.30	4.21±0.14	41.99
	LD	6.17±2.47	8.28±0.05	3.45±0.04	30.44
Cd	HD	0.09±0.12	0.50±0.00	0.01±0.00	0.52
	LD	0.09±0.10	0.40±0.00	0.01±0.00	0.42
Mn	HD	ND	ND	ND	ND
	LD	ND	ND	ND	ND

Max: Maximum; Min: Minimum

Table 3: Comparison of heavy metal concentration in street dust from some popular cities of the world with values from classroom dust in Lagos state

City	Cd	Cr	Mn	Pb	Reference
Calcutta	-	54.0	-	536.0	Chatterjjee and Banerjee, 1999
Islamabad	-	-	-	104.0	Faiz *et al*., 2009
N. Zealand	-	103.0	-	1223.0	Fergusson and Kim, 1991
Amman	-	-	-	236.0	Al-Khashman 2007
Oslo	-	-	830	180	De Miguel *et al*., 1997
Ottawa	-	-	431.5	39.1	Rasmussen *et al*., 2001
Hong Kong	-	-	594.0	120.0	Yeung *et al*., 2003
Shanghai	-	159.3	-	294.9	Shi *et al*., 2008
Luanda	-	26.0	-	315.0	Ordóñez *et al*., 2003
Ketu-south district, Ghana	-	744.02	564.42	22.89	Addo *et al*., 2012
Classroom dust, Lagos	0.098.35		ND	23.33	Present study

samples.The concentrations of heavy metals in this study is compared with reported values from some other cities in the world (Table 3). The results indicated that the metals have lower concentrations than reported from other cities. This should be expected since most of the cities are more industrialized than Lagos (Table 3). On the other hand Pb concentration in this study was found to be in close range with reported data from neighbouring African city, Ketu, Ghana (Addo *et al*., 2012). The very low level for Pb in the present study was attributed to the fact that leaded gasoline which is an important input of Pb pollution in urban soil has been banned in Nigeria and most of the Industries in Lagos City have shut down due to down turn in the Economy. Interestingly, the amount of the metals detected in classrooms dust are higher than the values for street dust obtained from residential area in metropolitan city of Kathmandu, Nepal (Tamrakar and Shakya, 2011). Pb has the highest concentrations of all the metals investigated. The high concentration of Pb is indicative of it being the primary anthropogenically derived contaminant heavy metal in the soils.

Lead in classroom dust: The Pb concentrations in the dust were fairly uniform for all the classrooms studied except for one isolated sample obtained from Ajeromi-Ifelodun high density area 82.51 µg/g. The high levels found for this site and in some other areas such as Epe local government area may be as a result of paint chippings because some of the schools' buildings were very old causing the paints to peel and settle on the classroom floor as dusts. Wright *et al*., 2005, had shown in a previous study carried out in Nigeria that flaking house paint is an important determinant of high blood lead levels greater than 10 µg/L found in 70% of children aged 6 to35 months. It has been reported that emulsion and gloss types of paints currently manufactured and sold in Nigeria contained substantial levels of lead (Adebamowo *et al*., 2006).

Values higher than the mean (Table 2) was found in the classroom dust of the school close to Ikeja industrial estate. The influence of the prevailing winds can cause quantities of Pb-bearing soil particles from the Industries to be deposited around the playgrounds entrances and subsequently transported into the classrooms. Others such as high density Mainland, Ifako Ijaiye, Epe, Badagry and low density Apapa, Shomolu, Mushin local government areas with concentrations greater than the mean (Table 2) may be as a result of the nearness of the schools to bus stops, auto workshops, gas stations in addition to paints chippings as reported in the city of Ibadan by Onianwa *et al*. (2003).

Chromium in classroom dust: The concentrations of Cr were lower than what obtains for Pb in classroom dusts. Cr was not detected in most classroom dust and the highest concentration for Cr (17.37 µg/g) was found for sample collected from a classroom close to Ikeja Industrial area. Activities of the nearby industries might be responsible for the values reported.

Cadmium in classroom dust: The concentrations of Cd for all the classrooms investigated were within the range of the average concentration in the earth's crust which is about 0.2 µg/g (Lalor, 2008). The Cd concentrations do not therefore give cause for concern. Manganese was not detected in all the classroom dusts studied.

CONCLUSION

The result of this study showthat Pb, Cr and Cd were detected in the classroom dust samples investigated, the only exception is Mn which was not found.The amounts of the metals detected in classroom dust are lower than some reported values for street dust in some popular cities of the world. Results indicate that the metal pollutants in classroom dusts could significantly contribute to the heavy metal burden in the children since the classroom is an immediate environment of children where they spend appreciable amount of their time.

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