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# OCCURRENCE AND DISTRIBUTION OF HEAVY METALS IN INDOOR SETTLED PARTICLES IN LAGOS METROPOLIS, NIGERIA

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**Abstract**
*The increased application of technology, industrialization and growing population has resulted in the emission of wastes such as heavy metals that pollute the environment. The occurrence and distribution of heavy metals such as cadmium (Cd), copper (Cu), chromium (Cr), iron (Fe), manganese (Mn), lead (Pb), nickel (Ni) and zinc (Zn) in settled particles (indoor) collected from selected residential in Lagos metropolis over a two- year period (February, 2007 – July, 2008) was therefore investigated. The measurements of heavy metals contents were performed using Atomic Absorption Spectroscopy (AAS). The results showed widespread heavy metals contamination especially Fe and Zn, which were present as the highest concentration while Cd was the lowest in the settled particles (dust). The order of occurrence of heavy metals in settled particles (dust) collected indoor in 2007 and 2008 respectively were as follows, Fe > Zn > Pb > Cu > Cr > Mn > Ni > Cd and Fe > Zn > Mn > Pb > Cr > Cu > Ni > Cd. The outcome of this study implied that dust represent major source of heavy metals around dwelling places in the Lagos metropolis and therefore should be monitored. Additionally, data from this study could stand as a reference point for subsequent monitoring.*

**Key Words:** *Heavy metals, Settled particle, Indoor, Dust, Lagos metropolis, Dwelling*

## Introduction

The application of technology to explore and exploit natural resources inadvertently resulted in the release of varied types and amounts of industrial wastes into the environment. These industrial wastes are complex admixtures of several classes of pollutant such as hydrocarbons and heavy metals (Oyewo and Don-Pedro, 2002). Rapid economic growth via industrialization has contributed immensely to the heavy metal load in the environment (Abdul, 2011; Chin *et al*., 2012). Heavy metals are toxic at relatively low concentrations (Falusi and Olanipekun, 2007; Raymond and Felix, 2011), bioaccumulate (Chukwu, 1991; Otitoloju and Don-Pedro, 2002 and 2004) and persist in the environment long after the source of emission has been removed thus an important sources of pollution (DeVagi and Arfiziah, 2009). Anthropogenic activities (mining and industrialization)



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have increased the natural heavy metals constituents of the earth's crust (Adriano, 2001; Mohamed and Elsayed, 2007). Heavy metals in the atmosphere come in contact with air particles such as settled particles (dust) (Shinggu *et al*., 2007) that pollute the environment and penetrate living cells resulting in a number of chronic toxic effect (Kan, 2011; Sham *et al*., 2011 and Umme *et al*., 2011). Classical cases of heavy metal toxicities include *Minamata* (Kurland, 1960), Niigata disease (Gary *et al*., 2007), "Quiet baby" syndrome caused by mercury (Al – Damluji, 1976), *Itai - Itai* caused by cadmium (Jun-ichi, 2006). These have been known to contribute immersely to decline in human population. At present in Nigeria, there is relatively scanty documented data available on the occurrence and distribution of heavy metals in settled particles indoor environment within dwelling places in the Lagos metropolis. Settled particles are significant environmental media from which information about the concentration, distribution and fate of contaminants present in the surface environment could be obtained. Higher concentrations of Pb, Zn, Cr, Ni, Cd and Cu have been detected in urban households dust (Anna *et al*., 2008; Dan'Azumi and Bichi, 2010) a situation of growing concern. Moreover high toxicity even at low concentrations has been observed (Marcovecchio *et al*., 2007). This is further enhanced because of daily exposure of individuals who spend significant amount of time in houses, day care centres, schools, offices, markets and dwelling places. It is for this reason that settled particles were used for monitoring heavy metal pollution in the environment. This study was designed to provide information on heavy metals occurrence and distribution patterns in settled particles sources in selected areas of the Lagos metropolis indoors precisely in places where people spend considerable period of time. This will provide documented environmental data on heavy metals background as a fill-up on environmental studies.

## Materials and Methods

### *Description of Study Area*

The Lagos metropolis lies within the South-Western Nigeria, located on longitude 3°10′36″-3°35′′08″E and latitude 6°20′32″- 6°40′15″N. It occupies an area of about 3,475.1 square kilometres, with an estimated population of 15.7 million inhabitants (Oyegoke *et al*., 2012). About 80% of this population resides in metropolitan Lagos making the state; the most urbanized in Nigeria. Lagos metropolis is a place of high commercial activities thus experience high traffic density comparatively. The Lagos metropolis was selected on the basis of traffic load, population density and anthropogenic activities (fig.1). Temperature ranges from 26 – 33$^{o}$C.

### *Sample Locations*

The Lagos metropolis was divided into four zones based on population density per square kilometer. The zones were areas of low density (Ikoyi/Akoka Campus), medium density (Isolo), and high density (Ajegunle). Within each zone, three houses, one market place, one school premise and one office sampling stations were established making a total of six stations per zone. These stations were randomly picked per zone. The global Positioning system was used to measure the Longitude and Latitude of the sampling locations (fig. 1 and table 1).

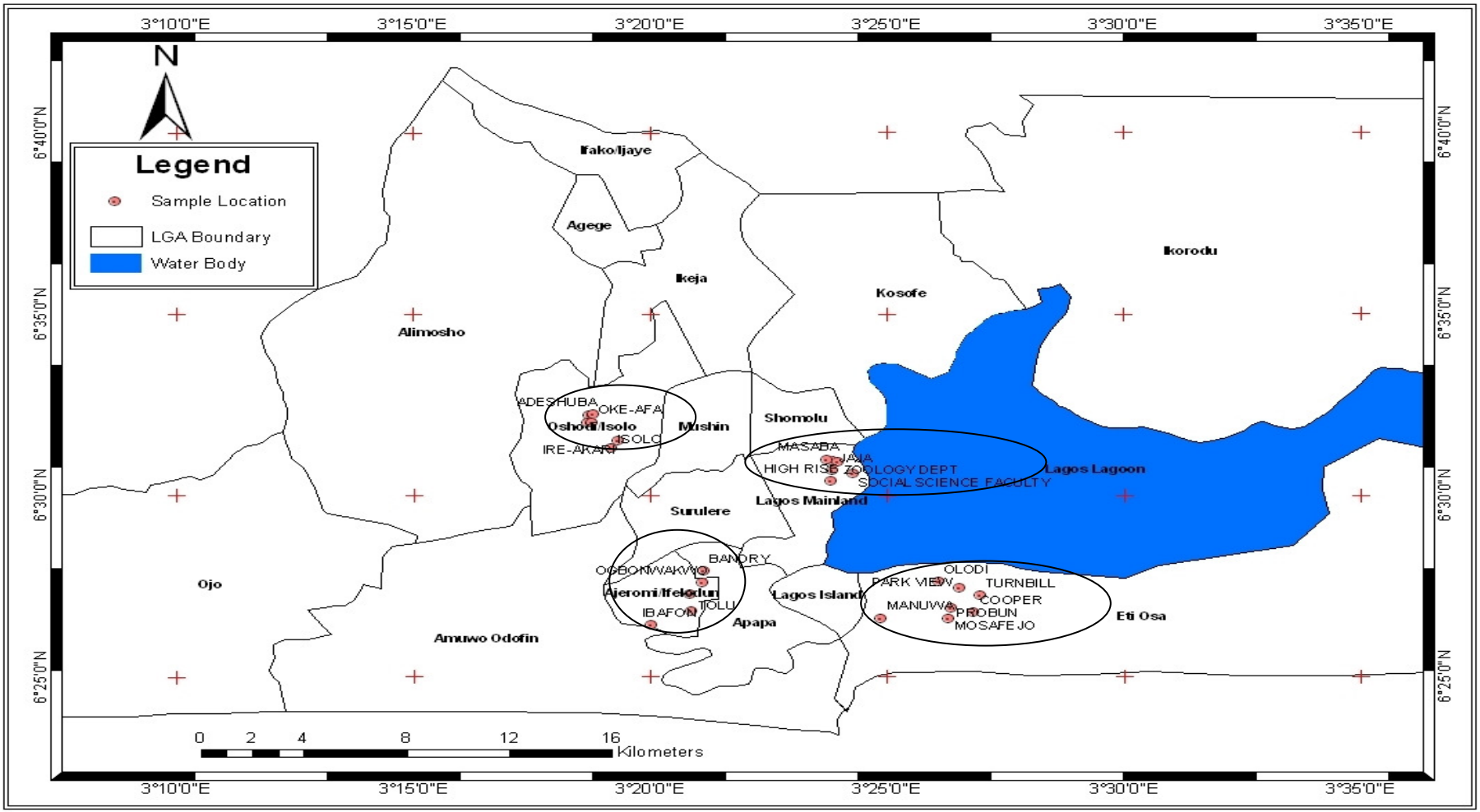


Figure 1: Map of Lagos metropolis showing the sampled zone

Table 1: Sampling stations and their coordinates

| ZONES | LOCATION/ DENSITY | SAMPLING STATION | COORDINATES | LOCATION |
|---|---|---|---|---|
| 1 | AJEGUNLE (HIGH ) | 1 | N06$^0$ 27 ′92”E003$^0$ 21′128” | BOUNDARY |
| | | 2 | N06$^0$ 27 ′631”E003$^0$ 26′099” | OLODI |
| | | 3 | N06$^0$ 26 ′431”E003$^0$ 20′013” | IBAFON |
| | | 4 | N06$^0$ 27 ′276”E003$^0$ 20′828” | NOSAMU |
| | | 5 | N06$^0$ 27 ′597”E003$^0$ 21′107” | OGBONWAKWO |
| | | 6 | N06$^0$ 26 ′822”E003$^0$ 20′873” | TOLU |
| II | AKOKA/UNILAG (LOW) | 7 | N06$^0$ 33 ′730”E003$^0$ 24′185” | SOCIAL SCIENCE |
| | | 8 | N06$^0$ 30′57.8”E003$^0$23′50.6” | ZOOLOGY DEARTMENT |
| | | 9 | N06$^0$ 30′55.9”E003$^0$23′57.7” | STAFF SCHOOL |
| | | 10 | N06$^0$31′58.0”E003$^0$23′51.7” | JAJA |
| | | 11 | N06$^0$31 ′00.3”E003$^0$23′43.5” | MASABA |
| | | 12 | N06$^0$30 ′24.5”E003$^0$23′49.1” | HIGH RISE |
| III | IKOYI (LOW) | 13 | N06$^0$ 26 ′899”E003$^0$ 26′340” | PROBUN |
| | | 14 | N06$^0$ 26 ′616”E003$^0$ 24′865” | MANUWA |
| | | 15 | N06$^0$ 26′606”E003$^0$ 26′291” | MOSAFEJO |
| | | 16 | N06$^0$ 27 ′254”E003$^0$ 26′956” | TURNBILL |
| | | 17 | N06$^0$ 27 ′451”E003$^0$ 26′521” | PARK VIEW |
| | | 18 | N06$^0$ 26 ′776”E003$^0$ 26′820” | COOPER |
| IV | ISOLO (MEDIUM) | 19 | N06$^0$ 31 ′31”E003$^0$ 19′18” | ISOLO |
| | | 20 | N0632 ′12.7”E003$^0$ 18′41.9” | PROSPERITY |
| | | 21 | N06$^0$31 ′31.8”E003$^0$19′19.6” | IRE-AKARI |
| | | 22 | N06$^0$32 ′14.4”E003$^0$18′48.1” | ADESHUBA |
| | | 23 | N06$^0$32 ′00.8”E003$^0$18′41.7” | OLUADEBAYO |
| | | 24 | N06$^0$32 ′01.4”E003$^0$18′46.3” | OKE-AFA |

***Sampling Schedule***

The sampling period was between two years (February, 2007 to July, 2008); this was to reflect the two major seasons (dry and rainy seasons) in Nigeria. The sampling schedules were as follows:

Dry season sampling, 17 - 23 February 2007

Wet season sampling, 16 - 22 July 2007

Dry season sampling, 17 - 23 February 2008

Wet season sampling, 16 – 22 July 2008

***Collection of Settled Particles (Dust) Samples***

Settled particles samples from the twenty four (24) sampling stations (indoor) were collected in triplicates using a new broom to sweep and a clean plastic dust pan to pack the samples. The collected settled particles were transferred into polyethene bags and labeled. A subsample of the settled particles was collected from the original sample and transferred into polyethene bags and labeled. All samples were stored in a dry place until analyzed.

***Digestion of Samples for Atomic Absorption Spectrophotometry (AAS)***

Sieved dust samples (1g) were digested according to the method adopted by Agemian and Chau (1976) as well as Bryan and Langston (1992).

***Determination of Heavy Metals in Samples (Settled particles)***

All digestates obtained from settled particles were filtered through Whatman No.1 filter paper and made up to the mark in appropriate volumetric flasks (50cm$^3$

for water samples and 100cm$^3$ for settled particles samples). The heavy metal content were then determined using AAS (Perkin Elmer, Analyst 200 AAS). The absorbances of test samples were compared to absorbance of standard solutions using an Alpha-4 Cathode on AAS.

***Statistical Analysis***

Results were expressed as Mean ± SEM. Statistical significant ($P < 0.05$) difference based on Duncan multiple range test at 0.05 was determined using one way analysis of variance (ANOVA). All data were analyzed using Statistical Package for the Social Science 16.0 for windows (SPSS 16.0 Inc., Chicago, U.S.A).

***Quality Assurance***

The reliability of the results was confirmed by taking appropriate quality assurance and procedure. The containers, brooms and plastic packers used were properly cleaned and sterilized. Reagent blank determinations were used to correct the instrument readings and repeated calibration of analytical equipment was done. Deionised water was used throughout the study to prevent volatile species from contaminating the sample solution. Samples were properly preserved and labelled to avoid mix up. All samples were carefully handled to avoid contamination.

**Results**

Indoor heavy metals analysis of samples collected from the four different zones in 2007 and 2008, showed that Cd, Cr, Cu, Fe, Mn, Ni, Pb and Zn were detected.

In 2007 indoor settled particles analysis (fig. 2a), showed that zones 2 (1.12 $\mu gg^{-1}$) and 3 (0.11$\mu gg^{-1}$) had the highest and lowest level of Cd significantly ($P<0.05$) different from the other zones respectively. The highest level of Cu (zone 2; 122.84$\mu gg^{-1}$) and Zn (zone 1; 182.01 $\mu gg^{-1}$) were significantly ($P<0.05$) different amongst the zones whereas the lowest levels were detected in zone 3 (18.04; 122.40 $\mu gg^{-1}$) correspondingly. Zones 3 and 1 had the highest and lowest Cr concentrations of (75.04 $\mu gg^{-1}$) and (30.37 $\mu gg^{-1}$) respectively significantly ($P<0.05$) different compared to the other zones. Ni level was highest in zone 2 (43.10 $\mu gg^{-1}$) significantly ($P<0.05$) different from the other zones whereas, it was lowest in zone 3 (12.13 $\mu gg^{-1}$) not significantly ($P>0.05$) different from zone 1 and 4. Pb levels was highest in zone 2 (133.63 $\mu gg^{-1}$), significantly ($P<0.05$) different from the other zones whereas, the lowest level was detected in zone 3 (92.06 $\mu gg^{-1}$) but was not significantly ($P>0.05$) different from zone 1 but different from zone 4. In addition, Fe level was significantly ($P<0.05$) higher in zone 2 (3076.01 $\mu gg^{-1}$) than the other zones while it lowest in zone 4 (2719.19 $\mu gg^{-1}$) not significantly ($P>0.05$) different from zone 1. Mn was highest in zone 2 (51.45 $\mu gg^{-1}$) which not significant ($P > 0.05$) different between zone 1 and 3. The indoor prevalence in 2007 was Fe >Zn>Pb>Cu>Cr>Mn>Ni>Cd while in terms of occurrence amongst the zones, the order was zone 2>3>1> 4 (fig. 2a).

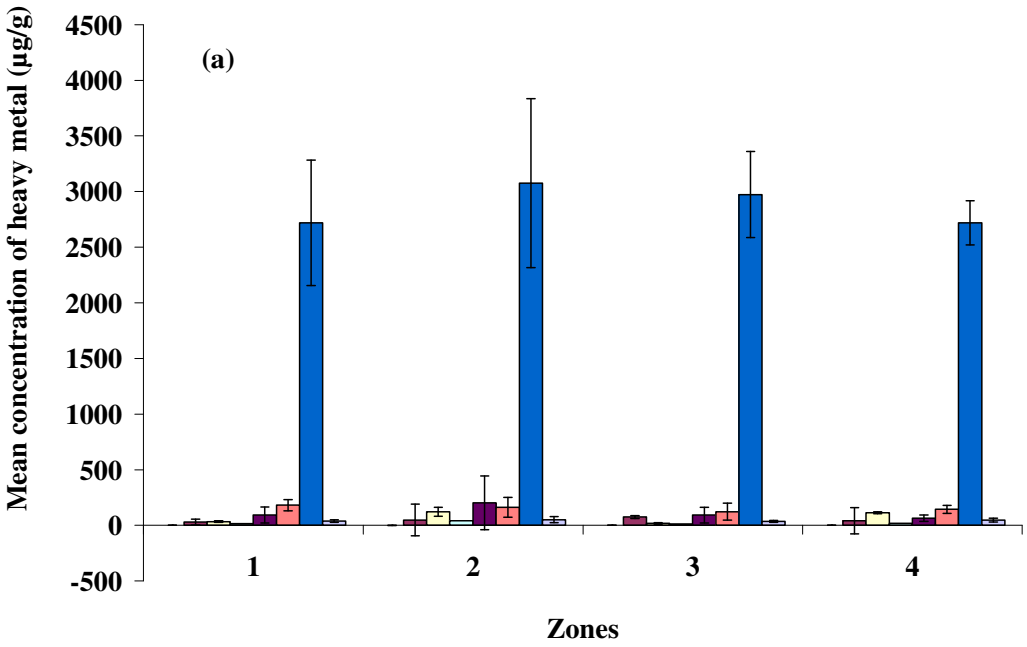


Fig. 2a: Distribution of heavy metals in settled particles (dust) collected from indoor of different zones in 2007

In 2008 (fig. 2b) high Cd level was detected in zone 1 (1.29 $\mu gg^{-1}$) significantly (P<0.05) different from zones 2 and 3 but lowest in zone 3 (0.29 $\mu gg^{-1}$). The highest and lowest level of Cr were in zone 3 (60.73 $\mu gg^{-1}$) and zone 1 (8.86 $\mu gg^{-1}$) respectively significantly (P<0.05) different from the other zones. Cu level was highest in zone 2 (58.64 µgg-1) significantly (P<0.05) different from the other zones but lowest in zone 4 (10.40 $\mu gg^{-1}$) not significantly (P>0.05) different from zone 3. Ni level was highest in zone 4 (18.74$\mu gg^{-1}$) significantly (P<0.05) different from the other zones but lowest in zone 2 (3.61 $\mu gg^{-1}$) not significantly (P>0.05) different from zone 1 and 3. The highest Pb level was in zone 3 (48.69 $\mu gg^{-1}$) not significantly (P>0.05) different from zone 2 and 4 but significantly (P<0.05) different from zone 1 (13.62 $\mu gg^{-1}$) which had the lowest level. Zn level was highest in zone 3 (227.56 $\mu gg^{-1}$) significantly (P<0.05) different from the other zones but lowest in zone 1 (138.13 $\mu gg^{-1}$). Fe level was highest in zone 2 (3076.01 $\mu gg^{-1}$) which was significantly (P<0.05) different from other zones but lowest in zone 4 (2719.19 $\mu gg^{-1}$). Highest level of Mn was highest in zone 3 (116.63 $\mu gg^{-1}$) significantly (P < 0.05) different from the other zones but lowest in zone 1 (88.12 $\mu gg^{-1}$). The order heavy metals prevalence indoor in 2008, was Fe>Zn>Mn>Pb>Cr>Cu>Ni> Cd while the mean occurrence across the zones was: zone 2>3>4 > 1 (Fig. 2b). Furthermore, there was drastic reduction in the concentrations of Cd, Cr, Cu, Pb and Fe in 2008 whereas Zn and Mn concentrations increased in 2008 compared to 2007.

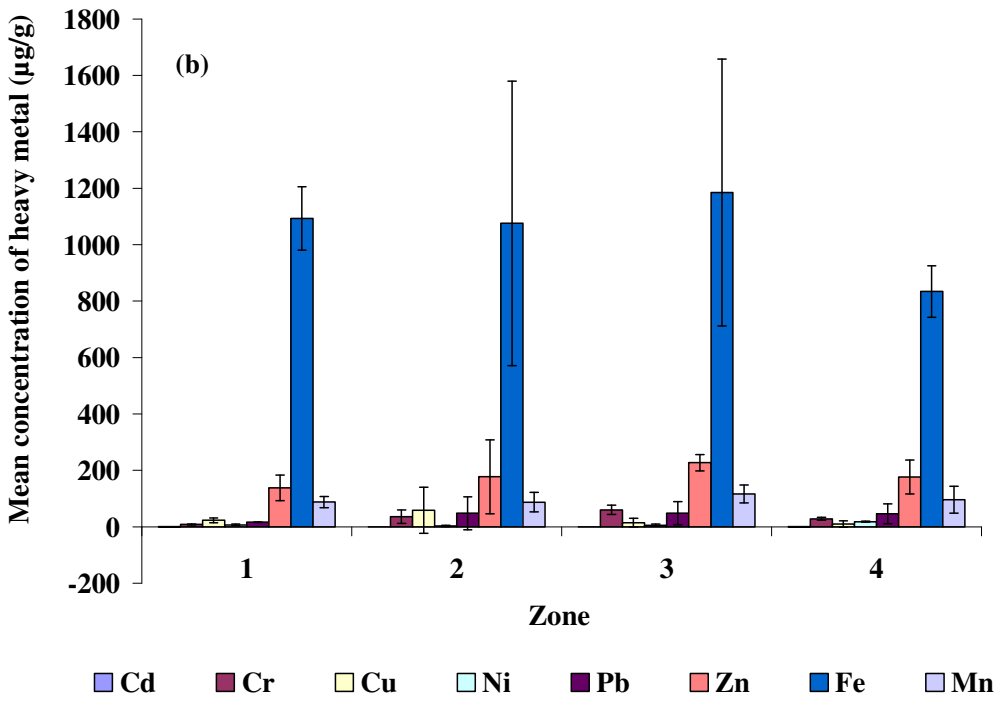


Fig. 2b: Distribution of heavy metals in settled particles (dust) collected from indoor of different zones in 2008

## Discussion

The present study has established the occurrence and abundance of various heavy metals such as Cd, Cr, Cu, Fe, Mn, Ni, Pb and Zn detected in settled particles (dust) collected from indoor areas of designated zones of the Lagos metropolis, between 2007 and 2008 field survey. This is in agreement with the findings of Otitoloju and Don-Pedro (2002 and 2004, Norhayati *et al*. (2007) and Anna *et al*. (2008). Higher levels of heavy metals occurrence and variation indoor compared to outdoor corroborates with the findings of Abdul-Wahaba and Yaghib (2006), Gemenetzis *et al*. (2006), Manno *et al*. (2006). This could probably be due to dust infiltration from outdoor which stick to particles, other materials and make their way indoor. Additionally, the wide spread of heavy metals contamination in the environment were in agreement with Norhayati *et al*. (2007); Shinggu *et al*. (2007). However previous research has shown the occurrence of elevated concentrations of Zn (2012 mg $kg^{-1}$), Pb (101.88 mg $kg^{-1}$) and Cd (28.38 mg $kg^{-1}$) in elementary schools environs in Mexico (Diana *et al*., 2007). The high level of indoor Cd observed in zone 2 during the 2007 sampling period could be from sources such as carpet wear, galvanized iron roofs and red/orange/yellow coloured carpets which were present at sampled sites while the lowest Cd level observed in zones 3 could probably be attributed to increased distance from point pollution, this is in agreement with the findings of Tong and Lang (1998); Adekola and Dosumu (2001).

The elevated Zn level in zone 1 could be attributed to the sites of samples which were close to the road with high traffic load, corrosion of galvanized automobile parts as well as the wear and tear of tyres. Dust from tyres is a significant source of zinc in the urban environment. The other sources of Zn indoor could have been generated from products made from rubber, fillers in linoleum and paints (Al-Khashman, 2004; Nor *et al*., 2012) and galvanized iron roofs. Elevated level of Cu could probably be due to intrusion from the external surroundings as a result of high traffic movement that was experienced in zone 2 (a sample site located in UNILAG campus). Another probable contributive source could be from vacuum cleaners employed in interior cleaning and fan.

The highest Ni level in zone 2 corroborates with the research of Nor *et al*. (2012) on Ni levels (1.50 to 32.70 $mgkg^{-1}$) in residential building. A probable source could be emission from automobile, brake dust, bearing metals and fallout from paint walls (Adekola and Dosumu, 2001).

The highest level of Pb in zone 2, may probably be due to the house age with leaded paint interior and the ability of the deteriorated walls of the interior, windows, distorted doors, carpets and crevices in floor to trap heavy metals like Pb (Lindern *et al*., 2003; Rasmussen *et al*., 2011). Mn detected in zone 2 could have originated from infiltration of outdoor air, smoking, indoor cooking and activities such as cleaning, dusting, and vacuuming. In terms of prominence, lowest Cd level from all zones was consistent with findings of Adekola and Dosumu (2001) on heavy metal determination in household dust from Ilorin city in Nigeria. However, Mohamed (2008) recorded the prevalence of heavy metal in outdoor fallen dust in Aswan city as Fe > Mn > Pb > Cd. Furthermore, the elevated level of Cd in zone 1 in 2008 indoor compared to 2007 could probably be an indication of increased Cd transport from outdoor to indoor. This could also have been generated from anthropogenic activities such as cooking with coal that is a common practice in the sampled zone because of its availability and affordability. Overall, elevated Cd concentrations indoor dust has been reported by Matthew *et al*. (2012) in La Oroya Antigua. The elevated Cu level in zone 2 could be attributed to dusty carpets, proximity to road and road traffic (Madany and Crump, 1993). The highest concentration of Ni and Cr could be attributed to outdoor dust, the use of Cr and Ni plated household products and tobacco smoke that is highly probable if anyone of the occupants smoke tobacco.
The elevated indoor Pb detected was not surprising because most of the samples were collected from smoking homes and the interior was painted with leaded paints (Morawska and Salthammer, 2003). Moreover, Pb is a common pollutant in urban areas due to automobile emission (Chattopadhyay *et al*., 2003).

The detection of Zn in higher levels in zone 3 is in agreement with the findings of Rasmussen *et al*. (2001). This could be explained based on infiltrations of outdoor pollutants such as automobiles, lubricating oil or the burning of incense to dispel insects, rubber carpets underlay and smoking (Morawska and Salthammer, 2003). Elevated concentrations of Fe and Mn

observed indoors in zone 2 and 3 respectively have also been reported by Zacco *et al.* (2009) and Yang (2012). According to Tong and Lang (1998) indoor dust is one of the major pathways of childhood exposure to heavy metals. This study revealed the importance of settled particles (dust) as one of the important sources of heavy metals exposure to man and therefore justify the emphasis in this study for evaluation of occurrence and distribution of heavy metals in places where people spend considerable period of time.

Additionally the high concentration of Fe detected indoor in 2008 irrespective of the sampled zones probably suggests that the area could have similar Fe inputs since most of the sampled sites were near road side. The detection of Fe in indoor dust has been reported by Rasmussen *et al*. (2001). Furthermore, the drastic reduction in the concentrations of Cd, Cr, Cu, Pb and Fe in 2008 might have resulted from climatic alterations that could have contributed to decreased concentrations of these metals contrary to the increased concentrations of Zn and Mn concentrations in 2008 when compared to 2007.

The detection of significantly high concentrations of varied heavy metals in all the sampled zones implied that settled particles (dust) is a complex mixture of multiple source contributions which includes; anthropogenic materials such as automobile / truck exhaust particles, lubricating oil residues, tirewear particles, weathered street surface particles, brake lining wear particles, and natural biogenic materials such as leaves and other plant matter that can be pulverized by the passing traffic or exhaust emissions (Nasr *et al*., 2003 and Emanuela *et al*., 2006).

Suspended particle matter in air and its deposition in dwelling places is one of the fastest growing types of environmental pollution. The fallout of atmospheric particles is an important factor when considering the fate and effects of heavy metal pollution on human health. The toxicological risks of heavy metals that are associated with settled particles that are potentially inhaled by humans have much uncertainty, mainly due to poor knowledge and awareness. Therefore, it is important to provide baseline information on heavy metals concentrations in settled particles for future environmental monitoring studies in selected areas of Lagos metropolis.

## Conclusion

The implication of this monitoring study and those of similar studies mentioned earlier have now provided a fair amount of basic environmental data, on the heavy metals levels indoor dust within the designated areas of the Lagos metropolis re – emphasizing the importance of metal sources such as settled particles in the overall exposure routes around living dwellings. Further studies will be carried out to monitor the present levels of these heavy metals in the selected areas.

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