Determination of heavy metals (Pb, Cu and Cd) in dust from selected households in Kano city, Nigeria

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ABSTRACT
The levels of lead, copper and cadmium were determined in household dust samples collected from selected houses in Kano city, using Atomic Absorption Spectrophotometry (AAS). A total of 18 samples were collected, 3 samples at 6 different zones. The mean and standard deviation of cadmium in the dust samples from the selected households range from (22.434±3.552)mg/kg – (32.622±7.063)mg/kg while the mean and standard deviation of copper range from (5.560±0.000)mg/kg- (11.300±0.000)mg/kg and then followed by lead with a mean and standard deviation ranging from (2.886±0.000)mg/kg-(8.658±0.000)mg/kg. The results indicate that the level of cadmium is higher than copper and lead. The high concentration of the heavy metals could be associated with several factors such as internal combustion engines which produce airborne lead particles, industrial activities, paint and paint chips and automobile emissions which pose serious threats to both adults and young children in households.

Keywords: Household dust, heavy metals, digestion, atomic absorption spectrophotometer

1. Introduction

Dust can be defined as matter or particulate in the form of fine powder, lying on the ground or on the surface of objects or blown about by wind (Adekola and Dosumu, 2001). Dust is described as a solid matter composed of soil, anthropogenic metallic constituents and biogenic materials (Ferreira-Baptista and De Miguel, 2005). In a typical household, dust consists mainly of things such as dead insect parts, flakes of skin, food particles, and shreds of fabric (Jeremy, 2013). Dust can enter an indoor environment in several ways such as infiltration from outdoor sources and internally from smoking, incense burning, buildings and furniture materials, consumer products and occupant activities (Al-Rahji and Seaward, 1996; Turner and Simmonds, 2006). Settled dust is present in the indoor environment as a composite of particulate matter derived from interior and exterior sources (Butte and Heinzow, 2002). Indoor dust is present in the indoor environment as a composite of particulate matter derived from interior and exterior sources. Indoor dust is a repository for environmental pollutants such as heavy metals that may accumulate indoors and is an important pathway of exposure to metal for humans. There is an increasing concern about heavy metals contamination in indoor environment since most people spend a great extent of their time indoors (Klepeis *et al*., 2001; Sharpe, 2004).

Outdoor dust contains particulate matter (PM), which can be inorganic, organic, or a mixture of both types. Among the inorganic elements present in particulate matter (PM), heavy metals and other toxic elements, which rise from different environmental sources, are an important group to be considered. Some of these elements, e.g., Fe, Ca, Mn etc are mainly linked to the earth's crust or re-suspended soil (Rashed, 2008). Heavy metals are those having densities greater than 5g/cm^3 (Ademoroti, 1996). The term heavy metals refer to any metallic chemical element that has a relatively high density and is toxic or poisonous at low concentrations (Skoog *et al*., 1991). The main aim of this research work is to determine the levels of heavy metals in dusts obtained from selected households in Kano city. The aim of this research work is to determine the levels of heavy metals in dusts obtained from selected households in Kano city. Meanwhile the specific objective is to compare the estimated metal levels in the household dusts with result of other literatures and to make recommendation on the risk of the exposure.

2. Literature Review

Most of the air pollution studies have revealed a strong association between urban dust concentrations and deaths from respiratory diseases (Byrne, 1998; Hammer et al., 1992). Study made by Fergusson and Kim (1991) shows that metal loading for Pb, Cu and Cd in house dust correlates strongly with the dustiness of the house and this in turn relates strongly to the amount of carpet wear. In a recent study conducted by the U.K. Department of Environment Expert Panel on Air Quality Standard, it was concluded that particulate pollution hazards are most likely to exert their effect on mortality by accelerating death in people who are already ill. The elderly and babies are also susceptible to high risk as dust particles readily penetrate buildings through doors and windows, and cracks in building structures (Byrne, 1998). Toxic house dust is a particular menace to small children who play on floors, crawl on carpets and regularly put their fingers in their mouths.

Some authors (Thornton, 1991; Tong and Lang, 1998) have established that the major mechanism by which children staying indoors are exposed to lead (Pb) and other heavy metals arise from infiltrated vehicle and industrial emissions and also from eroding paint surfaces. Furthermore, (Tong and Lang, 1998) also found from their investigation that indoor dust is one of the major pathways of childhood exposure to heavy metals. A number of studies have suggested that there is a possibility that metals in the indoor dust can accumulate in human, either directly or indirectly by inhalation, ingestion as a result of hand-to-mouth activity or via dermal contact absorption (Al-Rahji and Seaward, 1996; Molhave *et al*., 2000).

A study by Kumpiene et al., (2011) has suggested that industry and city traffic, top soil and building materials, especially during renovation, are among the sources of heavy metals in preschools. Indoor air quality in preschools has received wide interest in recent studies due to the possible impact of air pollutants on preschool children (Wichman et al., 2010; Kang et al., 2011). Furthermore, several studies also indicated the influence of indoor pollutants on the academic performance and mental stability of the children in question (Mendell and Heath 2005; Mohai et al., 2011).

The assessment of the level of heavy metals in indoor dust is important as small children, especially those in the crawling stage, are highly exposed to indoor dusts (Adekola and Dosumu, 2001). Young children, especially toddlers, can easily ingest soils or indoor dusts unintentionally since they spend most of their time indoors and much of this time is spent in contact with floors, engaging in mouthing of hands, toys and other objects or the consumption of food contaminated by hands (Mohd Tahir, 2007; Adekola and Dosumu, 2001). The high risk of exposure of small children as well as adults even though to a small extent, to indoor dusts or fine particles has prompted this study.

3. Materials and Methods

In the preparation of the reagents, chemicals of analytical grade purity and distilled water were used. All glass wares were cleaned by immersion in 70% nitric acid overnight and were washed with detergent before rinsing with distilled water.

Sampling

Sampling was carried out between the first, second and third week of November, 2014. The dust samples were collected from selected households in the following six zones in Kano city; Challawa, Brigade, Bakin zuwo road, Gadon Kaya, Sabon Gari and Kabuga. The indoor dust samples were all taken by early morning sweeping of the houses using new brooms and parkers. Samples were collected in the central floor area away from the walls. Samples collected daily during each week were pooled together to form a composite sample. At least two composite sample was collected for each location.

Sample Treatment

About 10g of dried samples were pulverized to uniform size and the fraction with particles of diameter 0-0.2mm was retained for analysis.

Sample Analysis

About 1.5g of pulverized sample was digested in a mixture of hot concentrated perchloric acid (4ml), nitric acid (25ml) and sulphuric acid (2ml) (IITA, 1979). The content was thoroughly mixed and digested on BIBBY hot plate and heated gently at low temperature of 55^0C. Heating continued until white dense fume observed. The solution was allowed to cool and 40ml of distilled water was added to it. It was further boiled for about 1 minute at a moderate temperature of 55^0C. The solution was allowed to cool finally and was filtered into a 100ml volumetric flask and made up to the mark with doubly distilled water. The digested sample was kept inside the 120ml plastic bottle with cover and put in the fridge. The re-productivity of the digestion procedure was checked by analyzing the samples in triplicate. Concentration of metals was determined using an atomic absorption spectrophotometer (Pye Unicam Model 2900). All results are presented as milligram of metal per kg of dry matter of sample (Adekola and Dosumu, 2001).

Apparatus/Equipment

Weighing balance
Measuring cylinder ($10cm^3$ and $100cm^3$)
Plastic bottles ($120cm^3$)
Beaker ($250cm^3$)
Volumetric flask ($100cm^3$ and $1000cm^3$)
Cornical flask
Sieve (0-0.2mm)
Filter paper
Glass funnel
Porcelain mortar and pestle
Hot plate
Atomic absorption spectrophotometer (AAS)
Spatula

Reagents

1M Nitric acid
0.1M Nitric acid
Perchloric acid
Sulphuric acid
Distilled water

Instrumentation

Heavy metal concentration was determined by flame atomic absorption spectroscopy on an ALPHA 4 model Atomic Absorption Spectrophotometer (AAS). The result of each sample was the mean of three sequential readings. The instrumentation has two correction modes; the deuterium background correction (D_2) AND Variable Giant Pulse correction (VGP). Standard element pye unicam hollow cathode lamps were used as line series. Air acetylene was used as fuel.

Procedure

A chromium cathode lamp was placed in the machine and all parameters were set. Individual solutions from the blank, standard and sample were aspirated and their absorbance readings recorded respectively. The procedure was repeated using different lamps and samples. Average reading of both standards and samples were corrected from the blank readings. A calibration curve was plotted for the standards. The concentration of each element under investigation in mg/dm^3 was determined from the calibration curve of its standard.

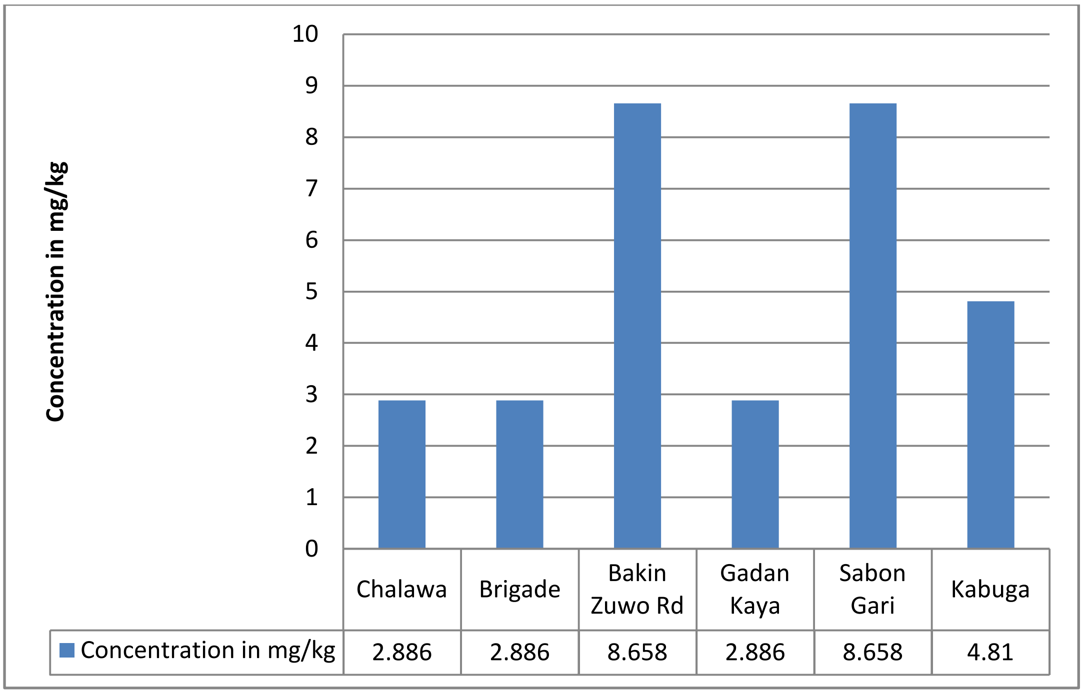
4. RESULTS AND DISCUSSION

The results of this analysis are discussed using the concentration charts for the heavy metals in household dusts. Their mean concentrations and standard deviations were used to assess their levels in the household dust.

Lead

The concentration chart for lead in household dust is as shown in Figure 1

Figure 1: Chart showing the concentration of led in the sampled zones.



Source: Author's computation

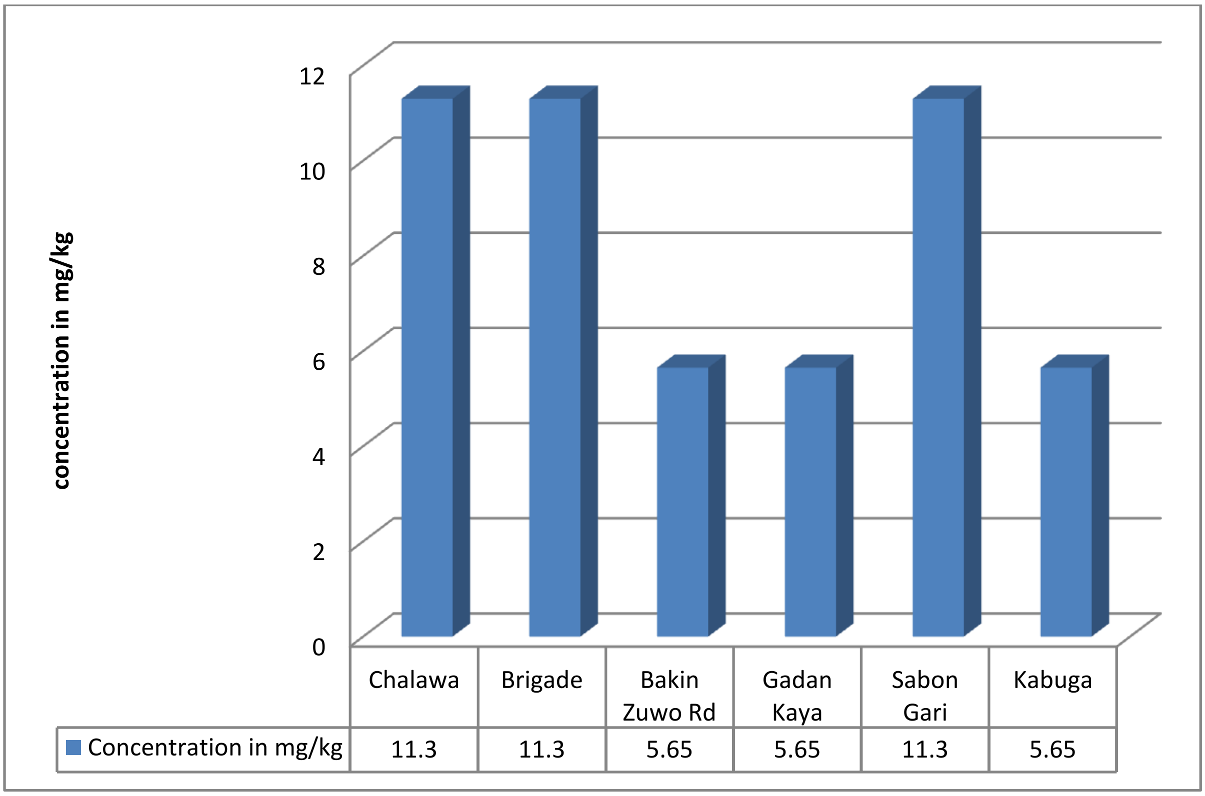
From the results shown in Fig 1, the mean concentration of lead ranges between 2.886mg/kg – 8.658mg/kg. The lowest mean value of 2.886mg/kg were obtained at Challawa, Brigade and Gadon Kaya while the highest value of 8.658mg/kg were obtained at Bakin zuwo road

(Lufaloy nursery and primary school) and Sabon gari. The result is comparable with the works reported by (Adekola and Dosumu, 2001; Rashed, 2008) with metal concentrations ranging from 2.340 – 10.170mg/kg and 4.72 – 16.59mg/kg. The presence of lead could be attributed to the high emission in homes from internal combustion engines like generating sets of which some airborne lead particles find their way indoor. Other sources could be lead painted metals, battery wastes, paints and paint chips which flake from indoor walls of homes. These pose serious health threats such as anaemia, brain damage, slurred speech, restlessness, miscarriage in pregnant women, infertility in men and heart diseases in children and adult (Agbo, 1997; Brown and Lemay, 1983).

Copper

The concentration chart of copper in household dust is shown in fig. 2

Figure 2: Chart showing the concentration of copper in the sampled zones.



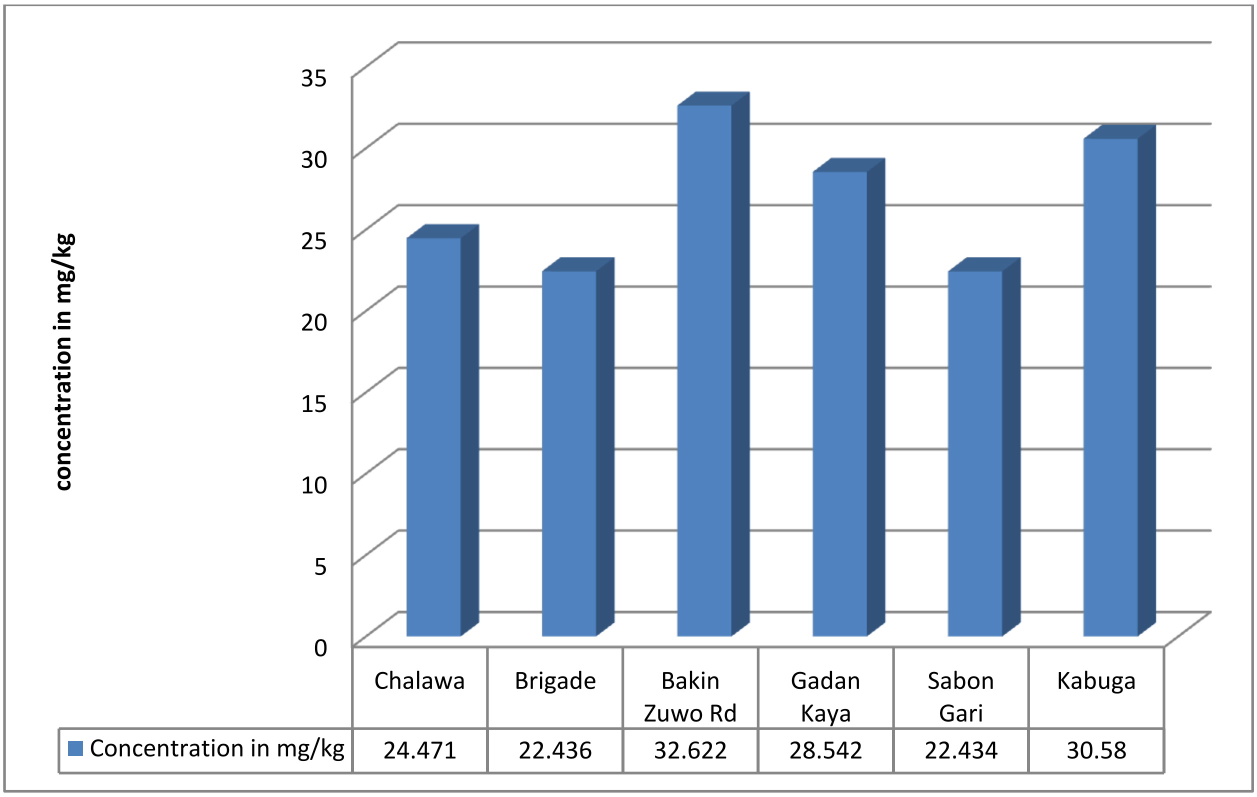
Source: Author’s computation

From the result in fig 2, the mean concentration of copper ranges from between 5.650mg/kg – 11.300mg/kg. The lowest mean value of 5.650mg/kg were obtained at Challawa, Brigade and Gadon kaya while the highest value of 11.300mg/kg were obtained at Bakin zuwo road and Sabon gari. These results are similar with the works reported by (Wahab *et al*., 2012) with metal concentrations ranging from 2.20 – 14.00mg/kg and very low compared with the works reported by (Adekola and Dosumu, 2001) with metal concentrations ranging from 0.190 – 1.990mg/kg. The presence of copper could be as a result of exposure to high levels of copper plated utensils, copper wires used in homes which can result in adverse health effects like antisocial and hyperactive behavior, learning difficulties and infections in children (Wilson, 2007).

Cadmium

The concentration chart for cadmium in household dust is as shown in fig. 3

Figure 3: chart showing the concentration of cadmium in the sampled zones.



Source: author's computation

It can be observed from Fig 3 that the result for the mean concentration of cadmium ranges between 22.434mg/kg – 32.622mg/kg. The lowest mean value of 22.434mg/kg was obtained at Sabon gari while the highest value of 32.622mg/kg was obtained Bakin zuwo road due to closeness to industries. These results are however very low compared with those reported by (Rashed, 2008; Adekola and Dosumu, 2001) with concentrations ranging from 0.175 – 0.722mg/kg and 0.001 – 0.380mg/kg respectively. Cadmium is nephrologically toxic, carcinogenic and has the ability to damage the blood vessel system (Ewers *et al*., 1993). Cadmium exposures are associated with kidney damage, bone damage and lung cancer (Rashed).

Conclusion and Recommendations

Determination of lead, copper and cadmium was conducted. The variation in concentration is observed from the result. It is evident from the results and discussion that the level of heavy metals in the household dusts depend on factors such as site location i.e. closeness of houses to industries, roads, automobile emissions, ventilation and the intensity of human activities within the localities. However, the levels observed in public buildings such as primary school in Bakin zuwo road, Bayero University, Kano (Kabuga) and in most of the houses located within the town like in Sabon gari indicate that the floor dusts pose a serious health risk to younger children, especially those in the crawling age. The present study shows that the levels of Pb in floor dust in Kano city are however lower than those reported for some cities in the developed countries (Solomon and Hartford, 1976; Tong and Lang, 1998). This tends to confirm an automobile origin of lead, cadmium and copper in urban dusts as these metals occur in indoor dusts.

Infants, young children (especially those less than five years of age) absorb 4-5 times as much heavy metals as adults (apart from pregnant women). Hence parents are adviced to be more watchful of their children on levels of exposure to heavy metals by preventing them from exposure of heavy metals in homes. A good housekeeping practice such as frequent wet mopping and good maintenance of ventilation system by closing those windows that are facing major roads should be taken into consideration in order to avoid or minimize children exposure to contaminated dust by heavy metals in the households. Further work is recommended to analyze tissue samples of both adult and children in the various homes sampled to establish the level of exposure to the heavy metals investigated.

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