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Determination of some Potentially Toxic Elements in Indoor Dust Particles from Selected Medical Laboratories in Kano Metropolis

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ABSTRACT

Indoor dust particles act as a medium for toxic elements accumulation. The risk of exposure to metal contaminated dust particles is of great concern. In this research, some potentially toxic elements (PTEs) in indoor dust samples from selected laboratories in Kano metropolis were examined. The samples were collected from different locations (doors, windows, reagent-shelves, fans, and air conditioners filters) to produce a composite representative sample. The samples were analyzed for Si, Co, Mn, As, Ni, Cr, Pb, Cd, Cu, and Zn using a Microwave Plasma Atomic Emission Spectroscopy (MP-AES). Results obtained revealed that the levels of these elements determined in the dust samples were significantly different at ($P<0.001$). The levels of the elements Zn, Cd, Pb, Cr, As, Cu, Ni, Co and Mn in the various samples analyzed were all below the permissible limit established by World Health Organization (WHO). However, all the laboratories had high concentration of Si. This study may provide baseline data for monitoring and/or controlling air pollution in the laboratory premises.

Keywords: Indoor dust, Medical laboratories, MP-AES, PTEs

INTRODUCTION

Potentially toxic elements are naturally occurring, ubiquitous substances in the human environment originated from the weathering of parent materials. Human activities like mineral resources development, industrial emissions, metal processing and smelting, fertilizer and pesticides applications, atmospheric transportation and sewage irrigation, potentially toxic elements have substantially accumulated in the global environment in recent years, particularly in soil and sediment environments. With the rapid development of industrialization and urbanization over the past few decades, significant environmental problems have dramatically increased in cities, especially megacities (Kung *et al.*, 2011).

Urban dust is considered a good indicator of environmental pollution in urban environments due to its composition and characteristics (Han and Vallyathan, 2003). Toxic elements are ubiquitous pollutants in urban dust, and the concentrations of such elements in urban dust have been elevated worldwide in view of the increase in urban populations and intensity of anthropogenic activities (Taiwo *et al*., 2017).

Dust composition has a potential effect on human health. Urban surfaces receive toxic element deposits from sources such as vehicular emissions, industrial discharges, domestic heating, waste incineration and other anthropogenic activities through atmospheric transport and local activities (Chen *et al.*, 2013).

Both outdoor and indoor dust particles have different compositions and are likely to pose health problems through direct inhalation (principally the finest particle of sizes <10 µm) and unintentional consumption due to hand-to-mouth contact by children (Sock *et al*., 2016). Consumption of poorly washed fruits and vegetables are also ingestion routes of contaminated dust (Zhou *et al.*, 2003). The potentially toxic elements are usually non-degradable and their homeostasis mechanism is not well understood. Thus, elevated levels of these elements are a potential threat to life. They may accumulate in the fatty tissues of the human body and affect the central nervous system (Cosma *et al.*, 1992). They may also disrupt the normal functioning of the body's internal organs and sometimes act as cofactors in other diseases (Tong and Lam, 2000). Contaminated dust particles in the environment may find their way into laboratory buildings possibly through wind action (Aschner and Michael, 2005).

Currently, there are no substantial reports or records of researches carried out on the levels of potentially toxic elements in dust particles from laboratories in Kano metropolis. It has therefore become necessary to determine the levels of such elements in order to assess the possibility of health implications and to provide baseline data for

monitoring and/or controlling air pollution in the laboratory premises.

MATERIALS AND METHODS

Reagents

All the reagents used were of analytical grade chemicals. De-ionized water was used throughout to avoid interferences by other ions. All plastic containers and glassware used were thoroughly washed with detergent solution, rinsed with tap water and soaked in 10% (v/v) HNO_3 overnight. They were then rinsed with deionized water and dried in an oven prior to use.

Sampling Areas

Sampling areas covered in this study include Court Road (LC), Hospital (LH) in Tarauni Local Government Area and Zoo Road (LZ) in Kano Municipal (Figure 1).

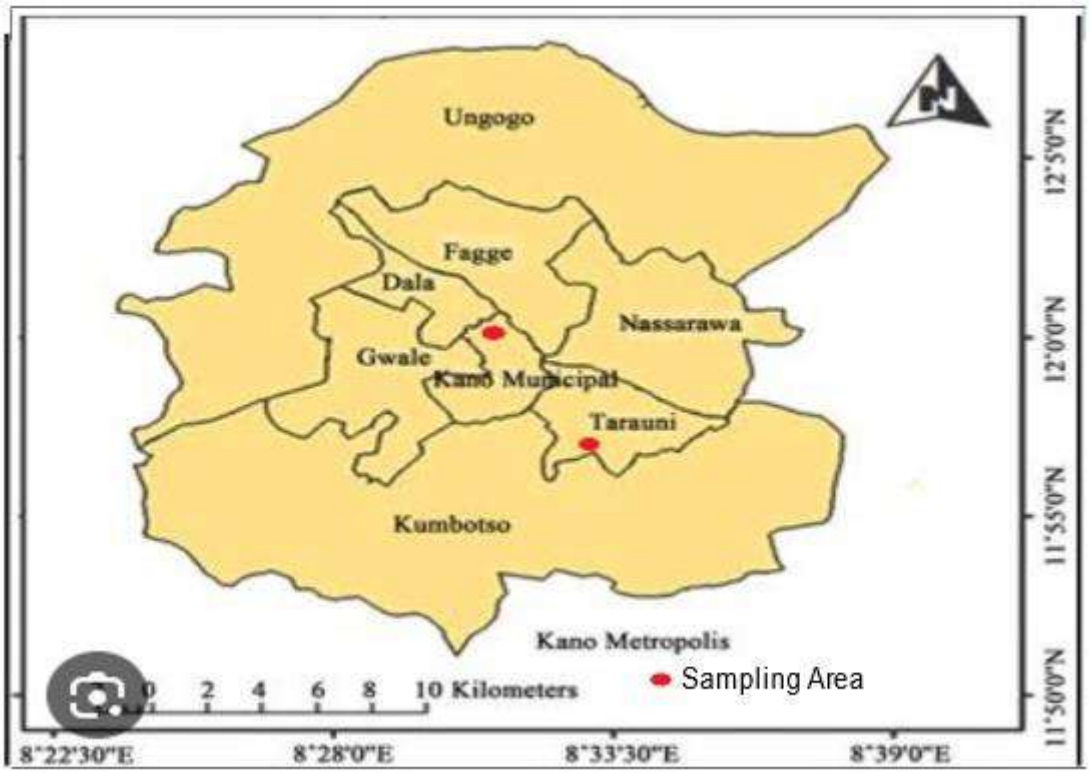

Figure 1: Map of Kano Metropolis indicating the Sampling Sites

Sample Collection

Airborne dust samples were collected by trapping using a foam filter from all the sampling locations during a period of three (3) months. The trapped dust particles were detached from the filters onto a paper and transferred into sample bottles in which it was kept at room temperature prior to analysis.

Sample Preparation

Samples were prepared for analysis using advanced microwave digestion system, Model: EHOS EASY. Two hundred milligrams (200 mg) of each sample were weighed and transferred into 90 cm^3 microwave digestion vessel. A mixture of concentrated nitric acid, hydrogen peroxide and perchloric acid (7:2:1) was added to the sample and the temperature of the system ramped from ambient temperature to 200°C through 20 min and held for 20 min. After digestion, it was allowed to cool to approximately 50°C before handling. The product was transferred into 50 cm^3 volumetric flask and the volume adjusted to mark with deionized water. The solution was finally taken for analysis.

Instrumentation

All measurements were performed using Agilent 4120 MP-AES. (Microwave Plasma-Atomic Emission Spectrophotometer) at the center for Dryland Agriculture (CDA), Bayero University, Kano.

RESULTS AND DISCUSSION

Table 1 shows the results obtained in the dust samples collected from the selected laboratories (LZ, LC and LH). The concentration of Zn in the various laboratories analyzed ranged from 0.12±0.11 mg/kg to 0.79±0.14 mg/kg. The highest concentration emerged from LC while the lowest was observed in LZ. The sources of Zn vary from paints, roofing materials, and some laboratory equipment (DPR, 2002). Zinc is classified as an essential metal. However, exposure to very high concentration of Zn or its deficiency may enhance

susceptibility to carcinogens. The level of Zn in this study was less than the permissible limit for Zn in Nigeria which is 140 mg/kg (DPR, 2002). Zn concentration is similar to that reported in a study by Perihan *et al. (*2012).

Table 1: Concentrations (mg/kg) of Potentially Toxic Metals in the Selected Laboratories

Metal	LZ	LC	LH
Zn	0.12±0.11	0.79±0.14	0.79±0.04
Cd	0.18±0.03	0.26±0.04	0.42±0.09
Si	24.85±0.50	5.70±0.22	2.47±0.02
Cu	3.37±0.03	0.64±0.03	0.71±0.03
Ni	0.50±0.01	0.18±0.01	0.10±0.01
As	1.06±0.14	0.60±0.05	0.07±0.04
Co	2.06±0.14	1.04±0.27	0.46±0.05
Pb	3.10±0.15	0.59±0.09	0.73±0.03
Mn	3.79±0.07	3.42±0.05	0.90±0.00
Cr	0.36±0.00	0.22±0.01	0.10±0.01

Key: LZ = Laboratory from Zoo Road; LC= Laboratory from Court Road; LH= Laboratory from Hospital Road.

Cadmium ranged from 0.18±0.03 mg/kg to 0.42±0.09 mg/kg, the highest concentration emerged from LH while the lowest from LZ. Cadmium is a toxic heavy metal that can be found in various laboratory materials and equipment. Some potential sources of cadmium in a laboratory include laboratory glassware, batteries, solder, pigments and dyes, and chemical reagents. It is important to properly handle and dispose of laboratory materials that may contain cadmium to minimize exposure and potential health risks. The concentration of cadmium here is less than 0.8 mg/kg which is the permissible safe limit for Cd in Nigeria (DPR, 2002).

Silicon ranged from 2.47±0.02 mg/kg to 24.85±0.50 mg/kg, LZ has the highest concentration while LH emerged with the lowest. Silicon deposits in dust are received from sources such as vehicular emission, industrial discharges, domestic heating and waste incineration (Omoyemi *et al.*, 2022). There are no official limits for silicon in dust and soil in the Nigerian environment. In a similar study, Rebecca *et al*. (2010) reported that silica exposure remains a serious threat for nearly two million U.S construction workers.

The levels of copper ranged from 0.64±0.03 mg/kg to 3.37±0.03 mg/kg, the highest concentration was in LZ while the lowest in LC. Cu in this study is below permissible limit of 36 mg/kg (DPR, 2002). The average concentration of copper from this study is similar to the level reported in a study carried out in Ondo state, Nigeria by Omoyemi *et al*. (2022).

Nickel has concentration range between 0.10±0.01 mg/kg and 0.50±0.01 mg/kg, the highest concentration was from LZ while the lowest was from LH. The major source of Ni in laboratories is the outdoor contaminated particulate matter (Hassan, 2012). The concentration of Ni in this study is less than the permissible limit of 35 mg/kg established by DPR (2002), but similar to the study carried out in Niger Delta, Nigeria by Abdolkazem (2016).

Arsenic revealed a concentration range of 0.07±0.04 mg/kg to 1.06±0.12 mg/kg with the highest concentration emerging from LZ and the lowest from LH. Arsenic is associated with several diseases including cancers of skin, lung, urinary bladder, kidney and liver (Ardashiri and Hashem, 2017). Arsenic concentrations analyzed were below WHO (2001) permissible limit of 20 mg/kg. This is similar to a study carried out in peri-urban of Ora-eri, South Eastern Nigeria by Ebuka (2022).

Cobalt ranged from 0.46±0.05 mg/kg to 2.06±0.14 mg/kg, the highest concentration emerged from LZ while the lowest from LH. There are no official limits for cobalt in dust and soil in the Nigeria environment but a prolong exposure to Co results in asthma, pneumonia, eye effects and cardiac problems. Similar study by Olujimi *et al*. (2015) showed higher concentration of cobalt.

The levels of lead (Pb) ranged from 0.59±0.09 mg/kg to 3.10±0.15 mg/kg with the highest concentration emerging from LZ and the lowest from LC. The concentration of Pb in this study is much lower than the permissible limit of 85 mg/kg (DPR, 2002). Pb may have accumulated in laboratories dusts due to paints or laboratory equipment used. Young people, especially children are mostly at higher risk on exposure to lead even at low levels as this can cause serious learning disabilities, seizures, or even death (WHO 2010). The results of Pb levels obtained in this study are similar to the results reported in a study carried out by Ahmadu and Egbodion (2013).

Manganese ranged between 0.90±0.00 mg/kg and 3.79±0.07 mg/kg. LZ has the highest concentration while LH has the lowest. The concentration of Mn is below the permissible limit of 66.1 mg/kg (DPR, 2002). Manganese concentration in the present study is less than the manganese concentration in Jeddah Saudi Arabia (8.2 mg/kg) reported by Mansour *et al*. (2019).

Chromium ranged from 0.10±0.01 mg/kg to 0.36±0.00 mg/kg, the highest concentration emerged from LZ while the lowest from LH. Cr

concentration in this study is lower than the permissible safe limit (100 mg/kg) established by DPR (2002). Prolonged exposure of staff to Cr in the laboratory can result to health problems such as cardiac, renal, hepatic, blood and brain disorders (Gupta *et al*., 2013). Chromium concentrations in the present work were much lower than the values recorded from previous studies reported by Ardashiri and Hashem (2017) with average of 49 mg/kg and Iwegue *et al*. (2019) with average of 27.1 mg/kg.

Statistical interpretation of results using ANOVA showed that there was significant difference at (P=<0.001) in all the sampling sites analyzed.

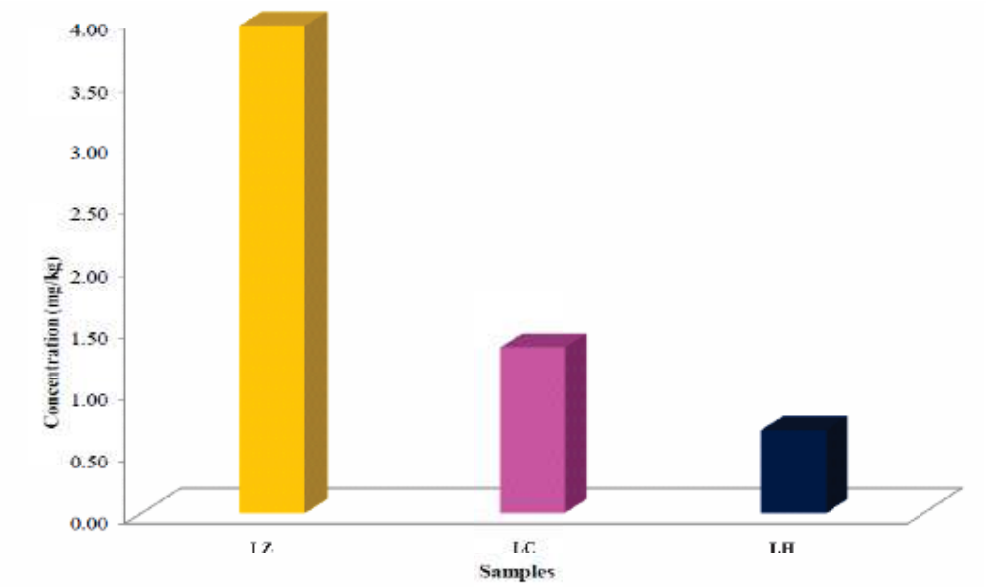

Figure 2: Overall Mean Concentration of Potentially Toxic Elements in the Selected Laboratories

Figure 2 showed that the overall mean concentration of the potentially toxic elements considered in this study is in the order LZ > LC > LH. One possibility for the high levels of elements in dust from LZ was probably due to introduction of already contaminated soil particles into the laboratory from outside through various building openings where there are constant and rampant anthropogenic activities taking place around the laboratory compared to other sampling sites. Contaminated dust can pose health risks if inhaled, as it can irritate the lungs and cause respiratory problems (Kim *et al.*, 2015). Therefore, it is important to take appropriate precautions to minimize exposure to such contaminated dust in laboratories. This can be achieved by wearing appropriate personal protective equipment, such as masks and respirators, and implementing measures to control dust generation and dispersion (Kim *et al.*, 2015).

CONCLUSION

Determination of some potentially toxic elements (zinc, silicon, cadmium, copper, cobalt, lead arsenic, manganese, nickel, and chromium) in indoor dust particles from selected laboratories in Kano metropolis was carried out. Results indicated that laboratory from Zoo Road (LZ) has the highest overall mean concentration of the elements possibility due introduction of already contaminated soil particles into the laboratory from outside where there are constant and rampant anthropogenic activities taking place around the laboratory compared to the other sampling sites. Despite the fact that all the concentrations of the elements determined did not exceed the permissible limits indicating no hazard, the study has provided a baseline data for the levels of such toxic metals and can serve as a basis for pollution monitoring and/or control in the laboratory premises.

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