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Heavy metal burdens of public primary school children related to playground soils and classroom dusts in Ibadan North-West local government area, Nigeria

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ABSTRACT

Information about heavy metal burden of children in Nigeria related to playground soils and classroom dusts is lacking. Playground soil, classroom dust, blood and spot urine samples (n = 253) were collected from 6 urban and 2 semi-rural public schools in Ibadan North-West, Nigeria. Samples were analysed for Pb, Cu, Zn, Fe and Mn. Mean blood Pb levels in urban area (male, 41.66 ± 8.78 μg/dl vs. female, 40.64 ± 5.46 μg/dl) were twice as high as those in semi-rural area (male, 19.71 ± 3.73 μg/dl vs. female, 20.65 ± 2.26 μg/dl). Concentrations of Pb, Cu, Zn, and Fe in soil and dust samples in the urban schools were between 2- to 4-fold greater than that of semi-rural schools. No correlation was observed between blood and dust metals. A positive correlation (r = 0.168, p = 0.008) was observed between blood Pb and playground soil Pb. Pb burden in the children might be from their schools' playgrounds and other yet unidentified sources.

1. Introduction

The environment contains diverse impurities and contaminants which are by-products of both human and industrial activities (FAO, 2002). The levels of these impurities vary from one part of the environment to another. Heavy metals form the bulk of these impurities and comprise essential metals like iron, manganese, copper, zinc and non-essential and toxic metals like arsenic, cadmium, lead, mercury, etc. (Moore and McHyres, 1997). While metals such as copper, zinc and iron function at very low concentrations as components of enzymes, structural proteins and pigments and in maintaining ionic balance of cells (Kosolapov et al., 2004), others like arsenic, lead, cadmium and mercury have no known physiological function and are toxic, affecting several organ systems in the body (Ademuyiwa et al., 2009; Afolabi et al., 2015; Zevenhoven and Kilpinen, 2001).

Exposure routes that have been identified for the entry of heavy metals into the body include food, air water and soil (Goyer, 1991). When the metals are deposited in soil from anthropogenic sources, they do not biodegrade or decay and are not rapidly absorbed by plants. Thus, they remain in the soil at elevated levels. Heavy metals deposited in soil can enter the human body through two pathways: (i) soil-crop-human body (indirect exposure) and (ii) soil-human body (direct exposure). The first pathway includes intake of heavy metals through foods while the direct exposure includes incidental ingestion of soil, inhalation of particulates emitted from soil or industrial and agricultural pollutants and dermal contact with soil (Goyer, 1991).

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) (Dooyema et al., 2012; Su et al., 2014; Wang et al., 2010). Studies have however shown that outdoor activities where individuals come into contact with metal-contaminated soil could also represent an important exposure pathway for intake of heavy metals for humans, particularly children (Dooyema et al., 2012; Su et al., 2014; Wang et al., 2010). When children play outdoors, metal-contaminated dust can get on

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hands, clothes, toys and food. Putting these items in the mouth can lead to ingestion of the metals. Children can also breathe metal dust or metal-contaminated dirt stirred up by the wind or by outdoor play activities. During dry periods, dust from bare patches of contaminated soil can readily become airborne, increasing the chance of being inhaled. Also airborne metal dust and metal contaminated dirt can settle on play clothes and shoes and can be taken into homes, further increasing exposure (Dooyema et al., 2012).

Various studies have found an association between blood lead and soil and dust lead (Dooyema et al., 2012; King et al., 2015; Wang et al., 2010; Zahran et al., 2012). Other studies have also found an association between time spent outdoors and children putting soil or dirt in their mouths and elevated blood lead levels (Zahran et al., 2012; Zimova et al., 2001). Information about heavy metal burden of children in Nigeria related to play ground soils and classroom dusts compared to economically advanced countries is lacking. Since children's health status is an important predictor of the levels of environmental stressors that pose threats to human health, this study was undertaken to determine heavy metal burdens of some public primary school children in Ibadan North West Local Government area of Ibadan in Nigeria and these were then related to the concentrations of the metals in their playground soils and classroom dusts.

2. Subjects and methods

2.1. Subjects and study area

The city of Ibadan (7°2316N, 3°5347E), is the capital of Oyo State. It is located in southwestern Nigeria at an altitude of 255 m above sea level. It is about 120 km away from Lagos, the commercial capital of Nigeria. It is the third largest metropolitan area by population in Nigeria after Lagos and Kano with a population of over 3 million. A few manufacturing concerns are located in the city.

Subjects were primary school children (age 2–15 years) and were drawn from 8 public primary schools (6 urban and 2 semi-urban) located in Ibadan Northwest Local Government Area of the city. Parents of all children received oral and written information about the study. Those that accepted that their children should participate in the study signed a consent form. A total of 253 children participated in the study and were made up of male (n = 72) and female (n = 181) pupils of the schools from kindergarten to primary 6.

Study protocol was approved by the Postgraduate Committees of Biochemistry and Chemistry Departments of Federal University of Agriculture, Abeokuta, Nigeria as well as the State Universal Basic Education Board (SUBEB) of Oyo State, Nigeria. Fig. 1 depicts the study protocol, sample size for each subgroup as well as the analytical set up.

2.2. Sample collection and processing

Venous blood samples were collected from the children on their school premises each day after an overnight fast into pre-cooled heparinised tubes. Spot urine samples were also collected into pre-cooled acid-washed universal urine bottles. Samples were stored at 4 °C before being transferred to the laboratory for further processing.

Soil samples collected from 10 different portions of each school's play-ground were mixed to obtain a composite. Dust samples were also collected from the classrooms of subjects who participated in the study. Both soil and dust samples were dried to constant weight. Soil samples were thereafter pulverized. Samples were then sieved with appropriate meshes (0.5 mm for soil and 0.25 mm for dust).

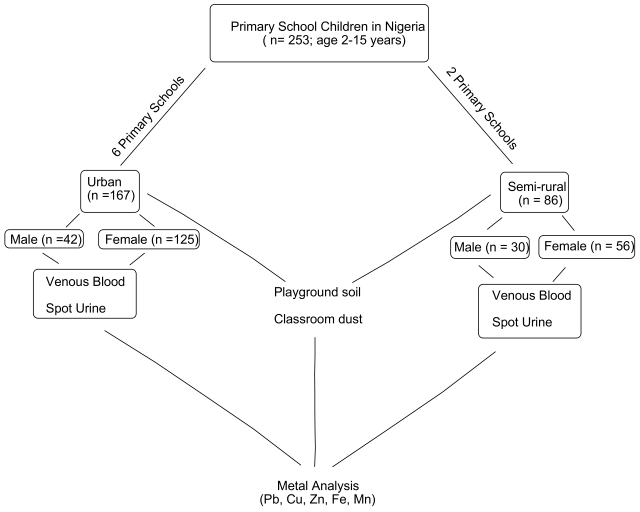

Fig 1. Schematic representation of study design.

2.3. Analytical procedures

Blood samples were digested with concentrated nitric acid as described earlier (Ademuyiwa et al., 2005a). Briefly, to 1 mL blood in acid-washed conical flasks was added 5 mL of concentrated nitric acid and left overnight to pre-digest the samples. An additional 5 mL of the acid was added the following day and samples were heated at 90 °C on a sand bath until mixture was clear. After cooling, digests were transferred into acid-washed 10 mL volumetric flasks and made up to mark with distilled water.

Soil and dust samples were digested in nitric acid over a water bath according to the method of Ozkan et al. (1980). To 5 g of either soil or dust samples in acid-washed conical flasks were added 10 mL of nitric acid and left overnight. The following day, an additional 40 mL of the nitric acid was added and conical flasks placed in a shaking water bath maintained at 100 °C for 3 h. Digests were allowed to cool, then filtered into 100 mL standard flasks and made up to mark with distilled water. One blank and one certified reference (Spex Multielement Standard, Spex Industries Inc., Edison, New Jersey, USA) as well as samples spiked with known concentrations of the reference material were included in each batch of the digestion. Urine samples were acidified with 5% nitric acid and analysed directly without further treatment. All digests were stored at 4 °C until analysed.

The concentrations of Pb, Cu, Zn, Fe and Mn in all the samples were determined by atomic absorption spectrophotometry (Buck Scientific AAS Model 210, Connecticut, USA). Calibration curves were obtained using 6 points with the certified standard. After each analytical run (usually 20 samples), calibration curves were obtained again to check for linearity and replication. A mean recovery rate of >95% was obtained for each element after two determinations.

2.4. Statistical analysis

Data are expressed as mean ± SEM and $p < 0.05$ was considered significant. The significance of the differences for soil and dust metals was assessed by the Student T-test while Kruskas-Wallis Test was used to assess blood and urinary metal concentrations. Relationships among the parameters were assessed by Spearman's correlations. Principal Component Analysis (PCA) was also applied to the data for further multivariate analysis.