Research Article

Evaluations of Estimated Daily Dose Intake of Toxic Metals in Commonly Used Building Materials and Its Health Impacts on the Society in Lagos, South West Nigeria

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ABSTRACT

Toxic metals are persistent in our environment, and building materials are not left over from the contaminations of these metals. These toxic metals posed great treat to human health. Some of these heavy metals such as lead have been identified as a potential human carcinogen, causing lung cancer. This study is on commonly used building materials and identifications of selected toxic metals present therein and its health implications to our society. Thus the commonly used building materials of interest are: Asbestos, Red Bricks, Plasters of Paris (POP) and Paints from major manufacturers. The samples of these building materials were collected from point of sales and toxic metals such as: Pb, Zn, Cu and Co were identified and quantified. Using Atomic Absorption Spectrophotometer (AAS) model S4 series, Model (GBC 906) (USA) for the analysis of the samples. The Estimated Daily Dose Intake (EDDI) of the detected toxic metals was computed. EDDI from POP due to Pb, Cu and Zn are 1.390×10^{-5}, 1.812×10^{-6} and 1.482×10^{-5} mg/Kg/day respectively. For the paints, EDDI from paints are for Pb, Cu and Co are 9.900×10^{-5}, -1.156×10^{-5} and 3.990×10^{-5} mg/kg/day respectively. However; in red bricks the EDDI obtained are Pb, Cu and Zn are 1.844×10^{-5}, 8.711×10^{-6}, and 3.159×10^{-5} mg/kg/day respectively. The EDDI from the Asbestos due to Cu was 1.578×10^{-6} and 4.061×10^{-5} mg/kg/day. EDDI in POP are as follows Pb, Cu and Zn, 1.396×10^{-5}, 2.990×10^{-5} and 9.519×10^{-6} mg/kg/day respectively. The ICRP have a set minimum permissible daily dose for each of the heavy metals however, from the results so obtained in this study shows that the Pb EDDI in Paints is 1.567×10^{-4} mg/kg/day.

Keywords: Toxic Metals; Building Materials, Daily Dose Intake; Cancer; Radiation Exposure

Introduction

Metallic elements are of particular toxicological importance. Many metallic elements play an essential role in the function of living organisms; they constitute a nutritional requirement and fulfill a physiological role. However, overabundance of the essential trace elements and particularly their substitution by non-essential ones, such as Co, Pb, Cr, Ni, Zn, Cu etc., can cause toxicity symptoms or death. Most human exposure to heavy metals is from both the natural sources and man-made sources. Man-made sources (such as: agrochemicals (fertilizers, fungicides etc), industrial waste, plume from industries and automobile, and waste from the locality) of heavy metals (e.g. Co, Pb, Cr, Ni, Zn, Cu) released into our environment have been identified by various research works. Heavy Metal pollution from man-made sources can easily create local conditions of elevated metal presence, which could lead to disastrous effects; and thus affects several individuals worldwide posing a serious threat to the health of millions of people. The environmental impact of heavy metals contaminations has been largely documented around the world [1]. The presence of radionuclides in the environment is partially due to natural processes and anthropogenic sources [2, 3], but is mostly the result of accumulated industrial wastes [4, 5]. Heavy metal contaminated building materials could aggravate human health risk when inhale or ingested into human body. In addition to building materials health risks, there is also risk of potential levels of heavy metals entering the food chain via absorption by crops from contaminated soil and water. Also ingestions of radioactive heavy metals by cattle grazing on contaminated soil and plants may aggravate human health risk when beefs from these cattle find their way to market. Several numbers of research works have suggested that there is higher probability that heavy metals contaminations in building materials may accumulate in humans, either directly or indirectly by inhalation, ingestion as a result of hand-to mouth activity or via dermal contact absorption [6, 7]. Children can easily ingest soils or dusts particles from building materials unintentionally since they spend most of their time outdoors 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 [8].

The total intakes and uptakes of lead expected from all sources are 29.5 and 12.5 mg/d, respectively, for children and 63.7 and 6.7 mg/d, respectively, for adults in urban areas [9]. The relative contribution of water to average intake is estimated to be 9.8% and 11.3% for children and adults, respectively. Lead can be absorbed by the body through inhalation, ingestion, dermal contact (mainly as a result of occupational exposure), or transfer via the placenta. In adults, approximately 10% of ingested lead is absorbed into the body. Young children absorb from 40% to 53% of lead ingested from food. Once lead is absorbed, it enters either a" rapid turnover" biological pool with distribution to the soft tissues (blood, liver, lung, spleen, kidney, and bone marrow) or a "slow turnover" pool with distribution mainly to the skeleton [10]. The symptoms of acute lead poisoning are headache, irritability, abdominal pain and various symptoms related to the nervous system. Lead encephalopathy is characterized by sleeplessness and restlessness. The various health effects of heavy metal contaminations in human metabolic system vary from one heavy metal to another and the amount of bioaccumulations of these metals. Highly poisonous arsenic is widely distributed in nature and occurs in the form of inorganic or organic compounds. Uranium occurs in the mammalian body in soluble form only as tetravalent uranium or hexavalent uranium in uranyl complexes. Both hexavalent and tetravalent uranium form complexes with carbonate ions and proteins in the body. Oxidation of tetravalent uranium to hexavalent uranium is likely to occur in the organism. Absorption of uranium salts may occur by inhalation or by ingestion; 95% of uranium retained in the body is deposited in bone. Excretion is mainly via the kidney. As all uranium isotopes are radioactive, the hazards of a high intake of uranium are twofold: chemical toxicity and radiological damage. There is no evidence that uranium has any metabolic function in the mammalian organism. The acute oral lethal dose of cadmium for humans has not been established; it has been estimated to be several hundred milligrams [11]. Doses low as 15 – 30 mg from acidic foodstuffs stored in cadmium-lined containers have resulted in acute gastroenteritis [12]. The consumption of fluids containing 13–15 mg of cadmium per liter by humans has caused vomiting and gastrointestinal cramps. Acute cadmium poisoning has occurred following exposure to fumes during the melting or pouring of cadmium metal [12]. Dose limits for radiation exposure, from artificial sources, for the public have been issued by the International Commission on Radiological Protection (ICRP), and have been set at 1 mSv per year.

Materials and Methods

In Lagos south-west of Nigeria, most of the building materials were mostly imported with few locally made ones. There are several building material sales points, but the major markets; apart from the local manufacturer can be located in Mushin, Idi-Magbo area and Oshodi. Therefore, these locations were selected randomly for the sample collections. For the Red Bricks we have to contact the major red bricks maker locally in their respective locations around within the South-west of Nigeria.

Samples of the selected building materials of interest were collected; and were transferred into sterile sample bottles, labeled and kept for digestion. Digestion of samples was done using aqua-regia solution. Each sample weighing 1g, each of wet samples was transferred into a beaker of 100ml high pressure vessel. Agua-ragia of ratio 1ml of HNO_3 and 3ml HCL was added to the sample in the beaker cleaned with 10% HNO_3 and rinsed with deionized water. The mixture was heated to $100°C$ on a hot plate until the solute dissolved completely. A brownish poisonous gas is released during the process. The solution is heated until it gets to a 5 ml point on the beaker. The solution is allowed to cool. The solutions were filtered through Whitman No.1 filter papers into a pre-cleaned beaker to remove the particulates in the solution. The solution is then transferred into a 50 ml volumetric flask and diluted with distilled water to make up different concentration. The concentrations of the selected heavy metals were determined by atomic absorption spectrometry (AAS) with detection limit of 0.001ppm. The values of the heavy metal concentrations in the samples were calculated on dry weights. Measurement was performed for each of the triplicates of building material samples. The accuracy of the instrumental methods and the precision of the results of the sample were checked by performing the measurement in triplicate. The average mean concentration of each sample was calculated by using appropriate graph.

Results

The results obtained were analyzed for each of the different heavy metals in the selected building materials. The motivation for the selection of these building materials was due to the fact that they are commonly used in and around Lagos Metropolis. The Asbestos are used commonly as a roofing plates and both internally and externally in majority of the buildings (residential, offices and work places) in Lagos where majority of the citizens spend most of their times every day. Mean Pb estimated daily dose intake (EDDI) from the two types of Asbestos are 4.562 x10^{-7} mg/kg/day and 5.141x10^{-5}; Cu the mean EDDI was detected as 1.578 x10^{-5} and 4.061 x10^{-5} mg/kg/day and the mean EDDI obtained or Zn is 2.185 x10^{-4} mg/kg/day respectively. The Zn mean EDDI is the highest in the Asbestos while the Pb mean EDDI is the lowest in this material. However, the comparisons between EDDI in each of the heavy metals in the Asbestos have been obtained.

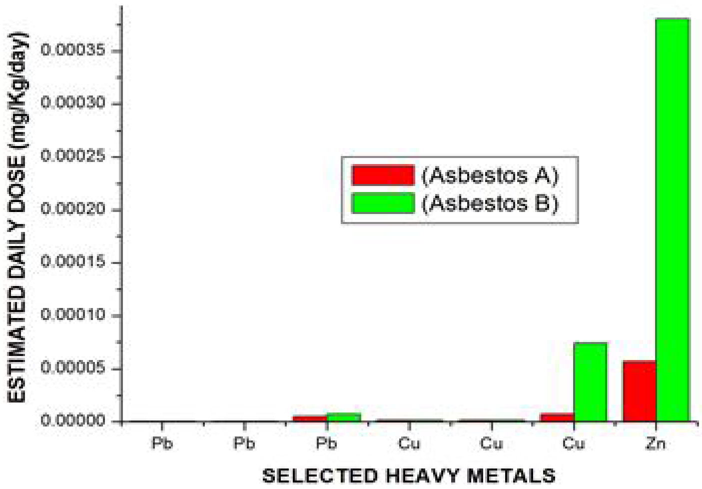

Figure 1: Estimated daily dose from Asbestos of different make

Figure 1 shows the results as obtained for the Asbestos. Asbestos type B have EDDI of about 3.805 x10^{-4} mg/kg/day from the Zn while type A EDDI is 5.657 x10^{-7} mg/kg/day. The Cu daily dose intake of type B is of about 7.401 x10^{-5} mg/kg/day. The Pb daily dose level is very low compared to that of the other heavy metals.

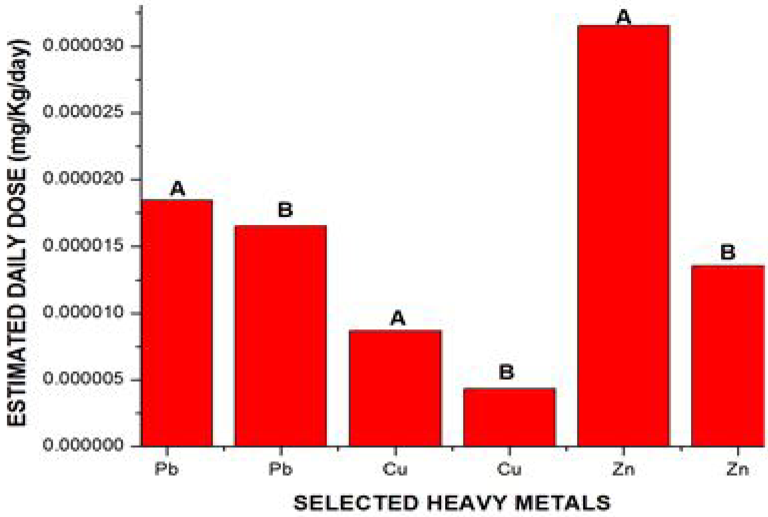

Figure 2: EDDI from Red Bricks of producer A and B

Red bricks samples were collected from the two major Red bricks (S and B) producers in Lagos and the mean EDDI have been obtained as follows from producer A for Pb, Cu and Zn 1.844 x10^{-5}, 8.711 x10^{-6}, 3.159 x10^{-5}mg/kg/day respectively while for producer B 1.651 x10^{-5}, 4.325 x10^{-6} and 1.359 x10^{-9} mg/kg/day for Pb, Cu and Zn respectively.

The estimated daily dose intake have been computed and compared from these producers. The EDDI obtained from the two Red bricks producers is has illustrated in Fig 2, the producer A contains the highest EDDI from Pb, Cu and Zn which are 1.844 x10^{-4}, 8.711 x10^{-6} and 3.156 x10^{-5} mg/kg/day respectively while that obtained from producer B Red bricks are 1.651x10^{-5}, 4.325x10^{-6} and 1.358 x10^{-5} mg/kg/day for Pb, Cu and Zn respectively as shown in Figure 2.

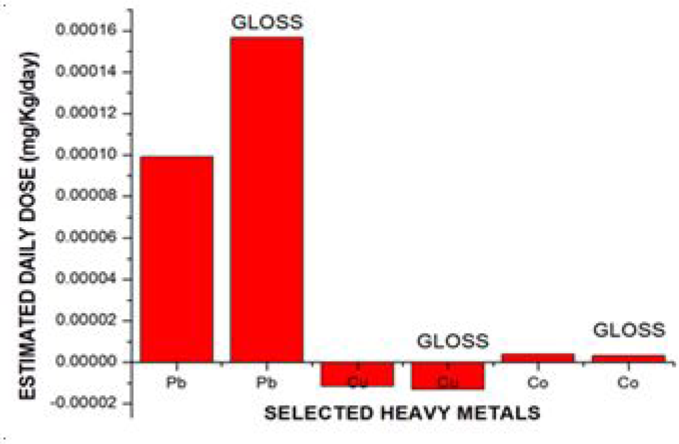

Figure 3: EDDI obtained from the two major types of paints produced

There were many paints producers in Lagos but paints samples were collected from the two major paints producers in Lagos for both the commercial and residential uses and these paint samples grouped according to the producers as S or B. However, the paints used in this research study are Gloss and Emulsion paints that are commonly used. The EDDI from producer B obtained are as follows for Pb, Cu and Co are 9.900 x10^{-5}, -1.156 x10^{-5} and 3.990 x10^{-6} mg/kg/day respectively. While for the second producer S, obtained mean EDDI were for Pb, Cu and Co are 3.044 x10^{-5}, -7.116 x10^{-6} and 3.331 x10^{-6} mg/kg/day. From the producer B, Gloss has the highest EDDI in Pb while both Emulsion and Gloss have the lowest EDDI from both Gloss and Emulsion from the producer B of the paints. Cu was found to be below the detectable limit of the equipment used for analyzes see Figure 3.

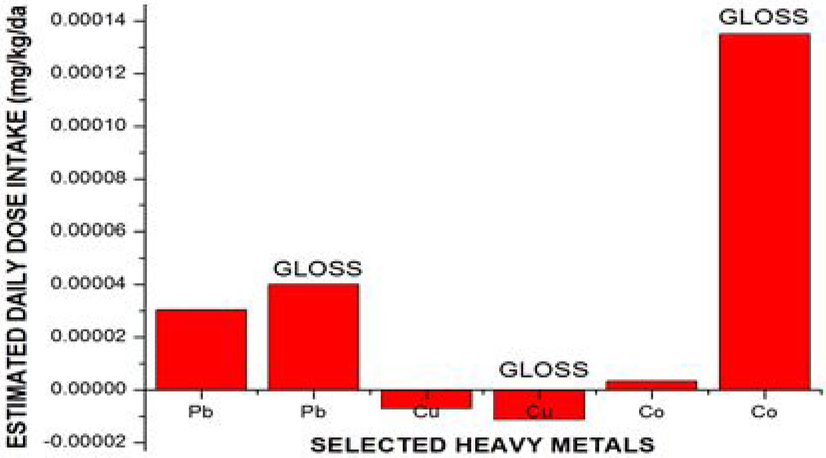

Figure 4: Comparing the EDDI obtained from the two major types of paints produced

Producer S has the highest EDDI obtained from Co and the second highest from the Pb both from the paint type Gloss from this producer. Emulsion have obtained EDDI lower than that of the Gloss from this paints producer S. In comparing the EDDI from this two major paints producer S and B obtained results is as illustrated in figure 4.

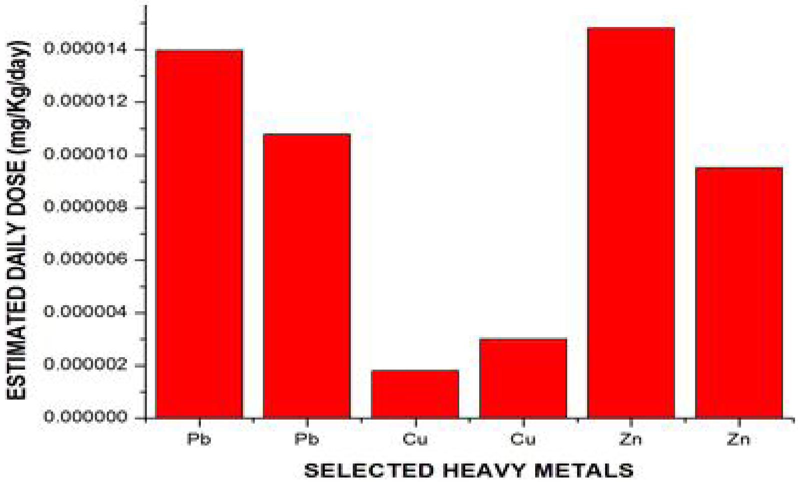

Figure 5: Estimated daily dose intake from the use of Plaster of Paris

Plaster of Paris (POP) is usually imported to the country and the manufacturers are from several companies from different countries, nevertheless, these materials found its way to a common marketing point in and around Lagos. Plaster of Paris are generally used for both the residential and work place buildings, therefore it's of interest for this study. The heavy metal EDDI in POP are as follows Pb, Cu and Zn, 1.396 $x10^{-5}$, 2.990 $x10^{-6}$ and 9.519 $x10^{-6}$ mg/kg/day respectively. Therefore, the EDDI from POP due to Pb, Cu and Zn are 1.390 $x10^{-5}$, 1.812 $x10^{-6}$ and 1.482 $x10^{-5}$ mg/Kg/day respectively and the second samples of POP from the second points of sales have the EDDI results as for Pb, Cu and Zn are 1.079E-05, 2.990 $x10^{-6}$ and 9.518 $x10^{-6}$ mg/kg/day.

Discussions

The health Impacts of Pb, Co, Zn, and Cu on our society today is very enormous as reported by various studies on toxic metals around the world by the scientific community. Lead absorption may be influenced by factors such as age and physiological status, nevertheless; greatest percentage of lead is taken into the kidney, followed by the liver and the other soft tissues such as heart and brain, and the skeleton represents the major body fraction [13]. The nervous system is the most vulnerable target of lead poisoning. Headache, poor attention spam, irritability, loss of memory and dullness are the early symptoms of the effects of lead exposure on the central nervous system [14]. Lead is the most systemic toxicant that affects several organs in the body including the kidneys, liver, central nervous system, hematopoietic system, endocrine system, and reproductive system [15]. Lead exposure usually results from lead in deteriorating household paints, lead in the work place, lead in crystals and ceramic containers that leaches into water and food, lead use in hobbies, and lead use in some traditional medicines and cosmetics [16]. The carcinogenic potential of cobalt and its compounds were evaluated by IARC in 1991, which concluded that there was inadequate evidence for carcinogenicity in humans (lung cancer) but sufficient evidence in experimental animals [17].

Copper intake varies greatly for individuals depending on food choices and dietary customs, as well as environmental factors. Most diets contain enough Cu (1-5 mg) to prevent a deficiency and not enough to cause toxicity. It can result in brain damage, liver failure, or death if it is not treated. Normally, your liver gets rid of extra copper by sending it out in bile. Disruptions in the homeostasis of Cu is associated with tissue damage and a number of diseases [18] Chronic Cu toxicity in the form of liver cirrhosis and damage to other organs is seen in genetic abnormality of Cu metabolism (Wilson's disease) and in the presumed environmental disorder Indian Childhood Cirrhosis (ICC) [19]. Cu has also been implicated in the pathogenesis of such common neurodegenerative diseases as Alzheimer's, Parkinson' and Huntington's diseases as well as amyotrophic lateral sclerosis.

There are three major routes of entry for zinc into the human body; by inhalation, through the skin, or by ingestion [20]. Inhalation of zinc-containing smoke generally originates from industrial processes like galvanization, primarily affecting manufacture workers. Ingestion was caused by the moderately acidic nature of the food or drink, enabling the removal of sufficient zinc from the galvanized coating. The resulting symptoms included nausea and vomiting, epigastric pain, abdominal cramps, and diarrhea [21]. The obtained results of the Estimated Daily Dose Intake (EDDI) from the samples of the selected building materials and the detectable heavy metals shows that the EDDI from POP due to Pb, Cu and Zn are 1.390x10^{-5}, 1.812x10^{-6} and 1.482x10^{-5} mg/kg/day respectively for the first sample while for the second samples of POP (Different manufacturer) have the EDDI results as for Pb, Cu and Zn are 1.079 x10^{-5}, 2.990 x10^{-6} and 9.518 x10^{-6} mg/kg/day. For the paint type, EDDI from producer B obtained are as follows for Pb, Cu and Co are 9.900 x10^{-5}, -1.156 x10^{-5} and 3.990 x10^{-6} mg/kg/day respectively. While for the second paint producer S, obtained EDDI for Pb, Cu and Co are 3.044 x10^{-5}, -7.116 x10^{-6} and 3.331x10^{-6} mg/kg/day respectively. From the producer B of paint type; Gloss has the highest EDDI in Pb while both paints type Emulsion and Gloss have the lowest EDDI from the producer B of the paints. Cu was found to be below the detectable limit of the equipment used for analyzes. But for the Red bricks samples collected from the two major Red bricks (S and B) producers in Lagos, the EDDI obtained from producer A for Pb, Cu and Zn are 1.844 x10^{-5}, 8.711 x10^{-6}, 3.159 x10^{-5} mg/kg/day respectively, while for producer B 1.651E-05, 4.325 x10^{-6} and 1.359 x10^{-9} mg/kg/day for Pb, Cu and Zn respectively. The EDDI from the producer A contains the highest EDDI from Pb, Cu and Zn which are 1.844 x10^{-6}, 8.711 x10^{-6} and 3.156 x10^{-5} mg/kg/day respectively while that obtained from producer B Red bricks are 1.651 x10^{-5}, 4.325 x10^{-6} and 1.358 x10^{-5} mg/kg/day for Pb, Cu and Zn respectively.

Conclusions

Even through Zn is required by human body system, excess of it in the human body becomes very dangerous. Zinc Recommended Dietary Allowance (RDA) for adults is 11 mg/day for men and 8 mg for women. Pregnancy and lactation requires slightly more at 11 mg and 12 mg, respectively. The Tolerable Upper Intake Level is the maximum daily intake unlikely to cause harmful effects on health. [22] Pb estimated daily dose intake (EDDI) from the two types of Asbestos are 4.562 x10^{-7} mg/kg/day and 5.141 x10^{-7}; while Cu the EDDI detected was 1.578 x10^{-6} and 4.061 x10^{-5} mg/kg/day then; the EDDI obtained or Zn is 2.185 x10^{-4} mg/kg/day respectively. The Zn as heavy has EDDI the highest in the Asbestos while the Pb EDDI is the lowest in this material. Copper Recommended Dietary Allowance for median intake of copper from food in the United States is approximately 1.0 to 1.6 mg/day for adult men and women. The Tolerable Upper Intake Level for adults is 10 mg/day, a value based on protection from liver damage as the critical adverse effect. [23] In case of lead, FDA recommended Dietary Allowance for RDA is 3µg per day and 12.5 µg per day for children and adult respectively; while cobalt the RDA is 5 - 50 µg/day for men and women. However; ICRP have a set minimum permissible daily dose for each of the heavy metals however, from the results so obtained in this study shows that the Pb EDDI in Paints is 1.567x10^{-4} mg/kg/day. The bio-cumulative effects at this level of EDDI for year are very dangerous. Also from the other samples Zn is 3.804 x10^{-4} mg/kg/day.

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