Assessment of Heavy Metals in Some Soft Plastic Toys Sold in Uyo Main Market

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Abstract

Polymers are materials widely used in industry and many areas of life. Polymers contain a wide variety of additives (plasticizers, antioxidants, stabilizers, curing agents, colouring agents etc.) tofulfill their physical and chemical properties. These components are present in a wide range of concentrations usually form t race to a few percentages level. The concentration of heavy metals such as Pb, Cd, e t c. In plastic baby t oys, for instance, is regulated in many countries due to the toxicity of these elements. The research is con ducted to determining the level of heavy metals Pb, Cd, Hg and As) in toys sold in Uyo Main Market. Toy samples randomly selected were tested for PVC before the analysis and found to be all positive. Digestion with concentrated acids (HNO_3 and H_2O_2), were carried out in triplicate using the atomic absorption spectrophotometer (AAS). The results were presented and compared with the WHO standards of acceptable limit.

Key Words: Digestion, Toys, Heavy metals, Polymers, Spectrophotometer

Introduction

Polymers are materials widely used in industry a nd many areas of life. Polymers contain a wide variety of additives (plasticizers, antioxidants, sta bilizers, curing agents, colouring agents etc.) tofu lfill their physical and chemical properties. These components are present in a wide range of con centrations usually from trace to a few percent le vel. The concentration of heavy metals such as Pb, Cd, etc. in
plastic baby toys, for instance, is regulated in ma ny countries due to the fear of heavymetalsToxicity. however, toys as well as o ther consumer products still contain these metasT oys areintegral part of children developmental pr ocesses. Beside providing entertainment to childr entoys also serve as educational materials for the m. A toy may mean different things to children o f differentgroups and henceexposure pathways al so differ. Toys can be categorized as soft toys, m echanical and electrical toys (Abhay and Prashan t, 2007). Lead poisoning from toys causelearning disabilities, kidney failure, anemia and irreversib le brain damage in children (WorldNet Daily, 20 09). The chewing, licking and swallowing behavi or of children is a common source of lead and cadmium exposure (Kelly et al., 2003). Children and pregnant women are particularly susceptible to lead poisoning. The digestive system of children absorbs up to 50% of the lead they
ingest (National Referral Centre, 2009), thus, no level of lead in blood is safe or normal (National Referral Centre, 2009). Toys that are made of Polyvinyl
Chloride (PVC) are potential source of risks to ch ildren. Polyvinyl Chloride, a leading chlorine containing plastic, is a polymer or a large chain-like molecule, made up of repeating units of Vinyl Chloride (a monomer), and commonly refe rred to as Vinyl or PVC. It is one of the most commonly used materials in the consumer marke t place. It is used in packaging, construction and automotive material, all categories of products, including toys, and medical equipment. PVC has a special problem of auto-digestion since free chlorine radicals in the structure reacts with free hydrogen radicals forming HCl
hydrochloric acid) leading to the digestion of PV C, which causes
a chain reaction and proceeds rapidly to complete ly loose strength. Lead or Cadmium is hence added to PVC as stabilizers, to prevent the free c hlorine radical's from reacting with hydrogen radicals to form HCl (Tuczai and Cortolano, 2002).

Statement of the problem

The source of heavy metal contamination in children environment is yet uncertain (Needleman, 2007), although a lot of researches have been conducted on the health implication of these heavy metals in human. Most of the conclusions are on its presence in the soil, water, and food substances. (Malviya et. al., 2007). Toys which are intimately linked to children's environment have not really been investigated as one of the sources of Lead, Cadmium and other heavy metal
toxicity. Due to the inadequate research of heavy metals in toys in the study area coupled with the fact that these materials dominate the children environment propels the need for this study.

Aim

The aim of this work is to assess the levels of hea vy metals in some soft plastic toys sold in the common market in Uyo in Akwa Ibom State, Nigeria.

Objectives

The primary objectives of this study are as itemized below:

i. To determine the presence of PVC in toy sample through qualitative analy sis.

ii. To calculate the mean, standard deviation and variance using Microsoft spread sheet and SPSS software version 2020.

iii. The result obtained would be compared with those of the standard regulatory bodies, such as WHO, FDA, etc.

Literature review

Heavy metals are natural elements characterized by their rather high atomic mass and their high density. Although typically occurring in rather low concentration, they can be found all through the crust of our planet. Commonly, a density of at least $5gcm^{-3}$ is used to define a heavy metal and to differentiate it from other, light‖ metals. Other, broader definitions for heavy metals‖ require an atomic mass higher than 23 or an atomic number exceeding 20; these definitions are highly error prone and confusing. Both alternative definitions cause the inclusion even of nonmetals; resorting to the atomic mass criterion, the maximum number of elements classified as heavy metals rockets high to 99 out of the in total 118 building blocks of our universe. Typically, heavy metals occur in the earth's crust in rather low concentrations between the low ppb ranges (noble metals) and up to 5% (iron); here, heavy metals are mainly found chemically bound in carbonate, sulfate, oxide, or silicate rocks or also occur in their metallic, elemental form. Weathering and erosion resulted in their leaching and mitigation into soil, rivers, and groundwater. About 4–5 billions of years ago, when Earth's mantle was still liquid, heavy metals sank to Earth's center and formed Earth's core, which today predominately consists of the heavy metals iron and nickel (Ghosh Singh, 2005)

Lead (Pb), cadmium (Cd), mercury (Hg) and arsenic (As) are heavy metals which are widely dispersed in the environment. These elements have no beneficial effects in humans, and there is no known homeostasis mechanism for them (Draghici et al., 2010; Vieira et al., 2011). They are generally considered to be the most toxic heavy metals to humans; the most adverse human health effects associated with exposure to these elements, even at low concentrations, are diverse and include, but are not limited to, neurotoxic and arcinogenic actions (Castro-González & Méndez-Armenta, 2008; Jomova & Valko, 2011;).

Experimental/Methods

Reagents

Distilled water, Hydrogen peroxide (H_2O_2) and Nitric acid (HNO_3)

Apparatus

Crucible, filter paper, hot plate, plastic containers and AAS machine, digital weighing balance, measuring cylinder, beaker.

Sample collection

Three (3) types of toys namely: Baby, Rattle and Truck will be collected in from the Uyo main market

Methods

The method used for the purpose of this study is the ashing breakdown and digestion method by Abhay and Prashant, (2007), in which Individual samples broken down into pieces followed by complete ashing in muffle furnace. The crucible was then taken out of the furnace and kept in desiccators for cooling. After cooling, the samples were powdered and in homogeneous form in the silica crucible. To this, 1g of the sample was taken in separate silica crucible for acid digestion. Analytical grade Nitric acid (65%) and Hydrogen peroxide (30%) were used for digestion in an open vessel. The digest was filtered through a filter paper to remove particle that are found to be insoluble in the solvents used. The shortfall was top-up and the quantity brought to a final volume of 50 ml with deionize

d water. Glass wares, crucibles and plastic containers were washed with liquid soaps, rinsed with distilled water and soaked in 10% HNO_3 for 24h cleaned with deionized water and in such a manner that no contamination occurred (Adnan, 2003). Standards were prepared with serial dilution technique within the range of 0.5 - 2.5 ppm for lead, cadmium and mercury. The instrument was first calibrated with stock solutions of the prepared standards before analysis. The final processed samples were quantitatively analyzed using Buck Scientific VGP 210 Flame Atomic Absorption Spectrophotometer. After every sample analyzed using AAS, the first sample was repeated for quality check. Only when the results were within 10% of earlier readings did the analysis continue.

Results and Discussion

The results for the presence of PVC, heavy metal concentration and the analysis of variances for the experiment is presented in tables 1-3 below.

Table 1. Test for the Presence of PVC in Toy Samples

S/N	Toy Sample	PVC
1	**Baby**	**+**
2	**Rattle**	**+**
3	**Truck**	**+**

From the results obtained, Table 1 showed that all the Toy samples analysed tested positive for presence of PVC. The samples were then further digested with concentrated acids (HNO_3 and H_2O_2) for further analyses.

The result from table 2 below indicated the presence and concentration of different heavy metals in the Toy samples analysed by means of Atomic Absorption spectrophotometer.

Table 2. Mean Heavy Metal Concentration (ppm) in Toy Samples Using AAS

S/N	Toy Sample	Lead (Pb)	Cadmium (Cd)	Mercury (Hg)	Arsenic (As)
1	Baby	0.280±0.025	0.198±0.001	0.105±0.001	0.100±0.002
2	Rattle	0.180±0.030	0.099±0.001	0.040±0.001	0.199±0.003
3	Truck	0.398±0.091	0.081±0.001	0.030±0.000	0.051±0.001

The result of the study indicated the presence of heavy metals in the Toy samples which includes Lead (Pb), Cadmium (Cd), Mercury (Hg) and Arsenic (As). concentration of Lead (Pb) present in the toy samples ranges from 0.180, 0.280 and 0.398 (ppm) in Rattle, Baby and Truck toys respectively. Cadmium concentration ranges from 0.081in truck, 0.099 in rattle and a higher value of 0.198 (ppm) in Baby toys while the values for Mercury are generally low compared to the other heavy metal studied and ranges from 0.030 for truck, 0.040 for Rattle and 0.105 for the Baby Toys (ppm). It was also observed that the Arsenic values are 0.100, 0.199 and 0.051 (ppm) for Baby, Rattle and Truck respectively. The result of the study generally indicates that the concentration of theses heavy metals is higher in truck and Baby Toys. This can be attributed to the paint coatings as these might also contain some traces of the elements under consideration resulting in increased concentration.

The analysis of variance (ANOVA) showed significant variation ($P<0.05$) both within and between the toy samples for the heavy metals studied, as presented in Table 3.

Table 3. One Way Analysis of Variance Using Duncan Multiple Range Test for Means of Heavy Metal Concentration in Toy Sample (P<0.05)

S/N	Toy Sample	Baby	Rattle	Truck	SEM
1	Lead	0.265^{a}	0.190^{a}	0.501^{a}	0.030^{*}
2	Cadmium	0.201^{b}	0.090^{a}	0.076^{c}	0.000^{*}
3	Mercury	0.111^{b}	0.040^{a}	0.030^{c}	0.001^{*}
4	Arsenic	0.123^{a}	0.250^{b}	0.050^{c}	0.000^{*}

^{a,b,c} = Means within the same row with different superscript differ significantly; * = Significant @ P<0.05

The concentration of lead (Pb) in Baby Toys (0.265^{a}) is significantly different when the value is associated to that present in other samples. The same is applicable to the concentration of Cadmium in Truck Toys sample with 0.076^{c} which is very significantly different from that of the other samples. Similar result was obtained by Abhay and Prashant, (2007), in which the concentration of Lead and Cadmium were studied in three different cities in India.

The World Health Organisation (WHO) regulations clearly set limits for heavy metals which form the basis for comparism and provide for Lead (Pb) to be 401.78ppm, Cadmium (Cd) 18.48ppm, Mercury (Hg) 0.007ppm and Arsenic (As) 0.005ppm.

Conclusion

From the result of this study, it can be concluded that, most of the Toys obtain from the Uyo main market are made of PVC. All the samples studied were seen to contain heavy metals at different concentration after analysis. Also, all the samples were found to contain Lead (Pb), Cadmium (Cd), Mercury (Hg) and Arsenic (As).

Recommendation

The presence of these heavy metals in the samples can be a potential source of heavy metal toxicity therefore, it is highly recommended that appropriate monitoring and intermittent examination should be carried out to ensure that the toys are within the WHO acceptable limit of heavy metals concentration. Also, plastic toys should be certified by regulatory agency like SON to ensure safety of usage by consumer.

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