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Assessment of Level of Lead and Cadmium in Selected Plastic Toys Imported from China on the Ghanaian Market

[1]Livingstone Kudjoe Gati, [1]Leticia Bokor ,[2]Emmanuel Offoh

1. Science Laboratory Technology Department, Accra Polytechnic, P. O. Box GP 561, Accra, Ghana

2. Tema Oil Refinery Limited Heavy Industrial Area- Tema, P. O. Box Co 599, Tema Ghana

Corresponding Author's Email: lstonegati@yahoo.co.uk

Abstract

In recent times, the US had ban and ordered the recall of made in China toys on the US market on account of high levels of Lead (Pb) and Cadmium (Cd) content. The Ghanaian market is flooded with all manner of soft plastic toys manufactured in China. This research was therefore carried out to assess the level of Lead and Cadmium in randomly selected brand-new soft plastic toys manufactured in China. Thirty (30) different soft plastic toys were obtained from Makola and Kasoa markets and analysed for the level of Lead and Cadmium. The samples were digested and Inductively Coupled Plasma-Atomic Emission Spectrophotometer (ICP-AES) was used for the analysis. The result obtained from the analysis showed that both Lead and Cadmium were present in all the thirty toys giving positive result. Concentration of Cadmium was in the range of 0.0658 mg/kg to 0.5689 mg/kg whiles was in the range of 0.6876 mg/kg to 50.0806 mg/kg. The results recorded were lower than 100ppm and 200ppm respectively for lead and cadmium. set by the US standard. Both Lead and cadmium are cumulative toxicant that affects multiple body systems. Children are particularly vulnerable to the neurotoxic effects of lead, and even low levels of exposure can cause serious and, in some cases, irreversible neurological damage. The positive results in this study, the low levels notwithstanding, suggest that children who play with these toys are at risk of lead and cadmium exposure. The study therefore recommends the continuous monitoring of soft plastic toys on routine basis to check the level of Lead and Cadmium entering the Ghanaian.

Keywords: concentration, digestion, assessment , heavy metals

1. Introduction

Polyvinyl Chloride (PVC, or Vinyl) is one of the most commonly used materials in the consumer marketplace. It can be found in packaging, construction and automotive material, and in a wide variety of consumer products, including toys and medical equipment.

A toy is anything that can be used in play. Toys are usually associated with children and pets, but it is not unusual for adults and some other animals to play with toys. Children play with toys and learn about the world.

Many soft plastic toys made of Polyvinylchloride (PVC). PVC has a special problem of auto-digestion since free chlorine radicals in the structure react with free hydrogen radicals forming hydrochloric acid (HCl) leading to digestion of PVC, which causes a chain reaction and proceeds rapidly to completely weaken the surface . Lead or cadmium is hence added to PVC as stabilizers to prevent the free chlorine radicals from reacting with hydrogen radicals to form HCl (Tucza *et al,* 1992). Lead compounds are the most common stabilizers in PVC .Some of them are basic lead carbonate, lead stearate, basic lead stearate, tribasic lead stearate, basic (dibasic) lead stearate and basic lead phthalate. Other metals have also been used when lead came under regulatory scrutiny, including Cadmium(Cd), Zinc(Zn), organotins, etc. Lead and cadmium are also added to PVC or other plastic products as colouring agents in the form of organo-metallic compounds. (Abhay and 2007)

A Greenpeace report released (Di Gangi, 1996) revealed that hazardous levels of lead and cadmium are found in vinyl plastic children's products. The study was prompted by the discovery of hazardous lead levels in vinyl mini-blinds and associated lead poisoning of children in 1996. The release mentioned that the PVC industry has been using lead stabilizers and pigments in vinyl since the 1950s (Di Gangi, 1996).

Lead and cadmium are known poisons, being neurotoxins and nephrotoxins respectively. Lead causes irreversible nervous system damage, decreased intelligence, behavioral abnormalities, and learning disabilities. Lead also interrupts normal kidney function and blood formation. Cadmium can cause kidney damage and lung cancer. Both metals are developmental and reproductive toxins and cause damage at extremely low doses (Di Gangi, 1996)

Many countries in Europe and the Americas have passed safety standards limiting the types of toys that can be sold on their markets. Most of these seek to limit potential hazards. The same cannot be said of the developing countries. Children, especially very small ones, often put toys into their mouths, so the materials used to make a toy are regulated to prevent poisoning. The chewing, licking and swallowing behaviour of children is a common source of lead and cadmium exposure (Kelley et al, 1993).

In fact, physicians and scientists agree that no level of lead in blood is safe or normal. It is important to understand that what constituted 'safe' yesterday is no longer 'safe' today, and what is 'safe' today may not be 'safe' tomorrow. The present 'safe' limit of 10 mg/dl of lead in blood was actually 60 mg/dl in 1960s and then it was brought down to 30 mg/dl in 1970s, which was again revised in 1985 to 25 mg/dl and in 1991 to 10 mg/dl. Similarly, cadmium when released as fine airborne particles reacts almost immediately with oxygen to form respirable cadmium oxide, which is a carcinogen. Cadmium dust (cadmium oxide, CdO) is another source of cancer in human beings (UIB, 1984).

Polyvinyl chloride (PVC) also releases its metal stabilizers as dust on its surface, which may contain lead or cadmium (Abhay and Prashant 2007). 1n 1997 The Consumer Product Safety Commission of US conducted accelerated aging experiments to demonstrate whether the lead in vinyl blinds could become available as dust as the blinds deteriorated in the sun. Blinds were exposed to UV light and heat over a period of eight weeks. During exposure, increasing levels of surface dust containing lead were measured on the blinds (USCPSC, 1996). The results indicated that normal product use could make lead dust available to children. The deterioration of the vinyl and subsequent availability of lead continued despite washing or cleaning indicating that consumers were vulnerable despite good housekeeping practices (USCPSC, 1996)

The market in Ghana is currently flooded with cheap non-branded plastic toys that are often exposed to the hot scorching tropical sun. The absence of any study on lead and cadmium content in toys coupled with the fact that there are no known measures in place regulating such imports into Ghana has prompted this investigation to determine the level of Lead and Cadmium in randomly sampled brand-new soft plastic toys.

The major aim of this research is to assess the level of lead and cadmium in selected soft plastic toys manufactured in China and imported into Ghana.

2. Methodology

2.1 Sampling

A total of thirty (30) soft plastic toys, imported as new, were collected from two locations in the Accra and Kasoa metropolis. Sample points included mini-shops at the Kasoa Market and Makola Shopping Mall, Accra central. The samples included plane, car, doll, gun, phone, harmonica, guitar, trumpet, propeller, tambourine etc, all of which are unbranded. Each sample was placed in a separate polyethene bag, labeled and then transported to the laboratory for analysis.

2.2 Sample preparation and treatment

The samples collected from Makola were coded M1, M2, through to M15, whilst those collected from Kasoa were coded K1 , K2 through to K15. Each sample was cut into several pieces and further broken down in smaller particles using mortar and pestle.

5.0000 g of each plastic toy was accurately weighed in duplicate into pre-cleaned beaker. 5 ml solution of 69.7 % concentrated Nitric acid (HNO_3) was added to the plastic toys in the beaker and heated on a hot plate in a fume chamber for 1 minute. 5 ml of 97% concentrated Sulphuric acid (H_2SO_4) was added to the mixture in the beaker and heating continued until brown fumes ceased. 3 ml of 70% concentrated Perchloric acid ($HClO_4$) was added to the mixture in the beaker and heated for one minute until the mixture became clear. The mixture in the beaker was allowed to cool, filtered through Whatman No.1 filter paper into a 100 ml volumetric flask and topped with deionized water to the mark. The procedure was repeated for all the samples. Blank samples were also prepared similarly.

2.3. Standards

Standards were prepared with serial dilution technique within the range of 10–30 ppm for lead and 10–50 ppb for cadmium. The stock solutions used were of analytical grades standards provided by Merck (Darmstadt, Germany). Each stock standard had a concentration of 1,000 mg/L supplied in 0.1 N HNO_3. As a way of ascertaining the reliability of the results, recovery analysis was performed for each of the metal by separately

running a standard solution under identical conditions as the samples.

2.4 Analysis with Inductively Coupled Plasma–Atomic Emission Spectrophotometer (ICP-AES)

Analyses were performed on the blanks, calibration standards followed by the digested sample using Iris Intrepid brand Inductively Coupled Plasma–Atomic Emission Spectrophotometer (ICP-AES) (Model # 1441030210). The instrument is semi-automated and equipped with an auto-sampler and it is interfaced with a computer.

The blank and the calibration standards were sequentially aspirated via the tube of the auto-sampler. A calibration curve was then generated and stored. Subsequently the samples were run. The level of the metal in each sample was computed as mg/kg taking into account the mass of the sample digested and volume of the digested sample.

3. Results and Discussion

The entire toy samples analysed contained both lead and cadmium. In all cases the levels of cadmium were significantly lower than the lead levels. The mean concentrations of cadmium and lead recorded for sample obtained from Makola is as shown in table 1 whist those for Kasoa is shown in table 2. Figures 1and 2 shows the general results for lead and cadmium respectively.

The results showed that the cadmium concentrations ranged between 0.0695 - 0.5689 mg/kg, while the lead concentration ranged from 0.6877 - 56.0806 mg/kg in the different toys.

The fact that all the products contain lead and cadmium gives cause for worry because both heavy metals are neuro-toxins. The findings agree with results obtained by Abhay and Pranshant (2007) who analyzed plastic toy samples manufactured in India.

The highest value of lead of 56.0806 mg/kg was recorded in machined gun followed by doll with a value of 33.2922 mg/kg. The remainder of the samples recorded values below 16.0000 mg/kg. The machine gun and the doll were the most colourful of all the toys. The rather high levels could be due to the brightly coloured paintcoatings that may be lead based.

The mean level of Cadmium in the samples obtained from Makola was 0.3561 mg/kg while the samples from Kasoa had a mean level of 0.3020 mg/kg. These mean values compare favourably with only a difference of 0.0541mg/kg. The overall mean level of cadmium for all thirty(30) samples was 0.3281 mg/kg. The average cadmium levels found in plastic toys in India in 2007 was 15.71 mg/kg (Abhay and Prashant 2007). A similar study in china showed that the concentration of soluble lead and cadmium in the toys which had a paint coating were respectively from 110.3 mg/kg to 5,156.0 mg/kg and from 0.34 mg/kg to 35.50 mg/kg (Zhonghua and Yi Xue, 1991). Comparatively the mean levels of cadmium in this study were only in trace amounts. According to Al-Saleh and others (2009), trace amounts of cadmium in PVC are unavoidable even under conditions of good manufacturing practice. The very low levels could therefore mean that cadmium might have been introduced inadvertently through the manufacturing process. This result however suggested that the children who are likely to handle and play with these toys could only be exposed low levels of cadmium, if any.

The mean level of lead in toys sampled from Makola was 14.1987 mg/kg and those from Kasoa recorded a mean level of 7.3769 mg/kg. The difference in the mean levels form the two locations is quite significant; in percentage terms the level recorded for Kasoa is about 52% that of Makola. The overall mean for the samples polled from the two sites was 10.7878 mg/kg. The overall mean is below those recorded in India which was 112.51 mg/kg (Abhay and Prashant, 2007) and even far below the US EPA limit of 600 mg/kg for lead in painted toys. Kelley and others (1993), had demonstrated in a study that a known source of lead poisoning is simply by chewing and sucking on plastic cables containing lead. Therefore, in the absence of any leaching studies it can still be stated that children who play with these toys are at risk of lead exposure since chewing and swallowing is common behaviour of children. Furthermore the presence of lead in the samples is it does indicate that toys pose a worrying and potential risk to children's health and indeed all that handle such products. Physicians and scientists agree that no level of lead in blood is safe or normal.

Yearly tons of plastic toy enter Ghana. The implication is that cumulatively cadmium and lead are being introduced into the environment and this could have a dire consequence for the environment. This is because these metals are not biodegradable and therefore persist in the environment. In addition, a common practice of solid waste management in this part of the globe is by incineration. As plastic toy get destroyed and are disposed

off, they are likely to find their way to disposal site where they may be incinerated. This practice could be a possible course of lead and cadmium fume in the environment which could further jeopardize public health.

5. Conclusion

All the toys contained varying amount of both lead and cadmium. In all cases the levels of lead is higher than that of cadmium, a trend that agrees with other research findings elsewhere. The results showed that the cadmium concentrations ranged between 0.0695 - 0.5689 mg/kg, while the lead concentration ranged from 0.6876 - 56.0806 mg/kg in the different toys.

As children play with, and as they chew, suck and or lick on them they will ingest measurable amount of lead and cadmium as long as they are present in the sample.

It is hereby recommended that there should be a continuous monitoring of all PVC based consumer product that enter the Ghanaian market. Further more government must promulgate laws that will restrict product containing lead and cadmium on the market. Also regulatory agencies must be empowered to enforce the laws that would be promulgated.

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Table 1. Mean concentration(mg/kg) of cadmium (Cd) and lead(Pb) in toys sampled from Makola, Accra.

Sample	code	Cadmium	Lead
Pistol	M1	0.3215	11.6313
Organ	M2	0.2196	15.1604
Green Kaili	M3	0.4098	10.1368
Yellow Kaili	M4	0.3803	4.1540
Helicopter	M5	0.4867	12.5113
Ball	M6	0.5112	13.1612
Machine Gun	M7	0.2048	56.0806
Truck	M8	0.3217	6.6109
Bell	M9	0.0695	6.0903
Doll	M10	0.3785	33.2922
Sports Car	M11	0.4316	8.6486
Sports Car	M12	0.5689	9.2806
Tanker	M13	0.4340	14.3106
Lego	M14	0.3348	4.3106
Wrist Watch	M15	0.2687	7.5430
Mean		0.3561	14.1948
SD		0.1299	13.5433
RSD		36.4806	95.4100

Table 2. Mean concentration(mg/kg) of cadmium (Cd) and lead(Pb) in toys sampled from Kasoa, Central Region.

Sample	code	Cadmium	Lead
Airplane	K1	0.1058	2.3254
Car	K2	0.3100	20.4904
Doll	K3	0.5331	0.6876
Guitar	K4	0.2311	4.7214
Mobile Phone	K5	0.3771	1.1174
Violet Kaili	K6	0.3346	7.5206
Red Kaili	K7	0.3991	6.0703
Trumpet	K8	0.2066	3.4484
Propeller	K9	0.0754	1.6054
Tambourine	K10	0.0658	1.6824
Boat	K11	0.4328	10.5402
Water gun	K12	0.3637	15.3608
Revolver	K13	0.5100	19.3108
Mickey Mouse	K14	0.2680	8.4040
Sword	K15	0.3173	7.3681
Mean		0.3020	7.3769
SD		0.1451	6.4839
RSD		48.0565	87.8955

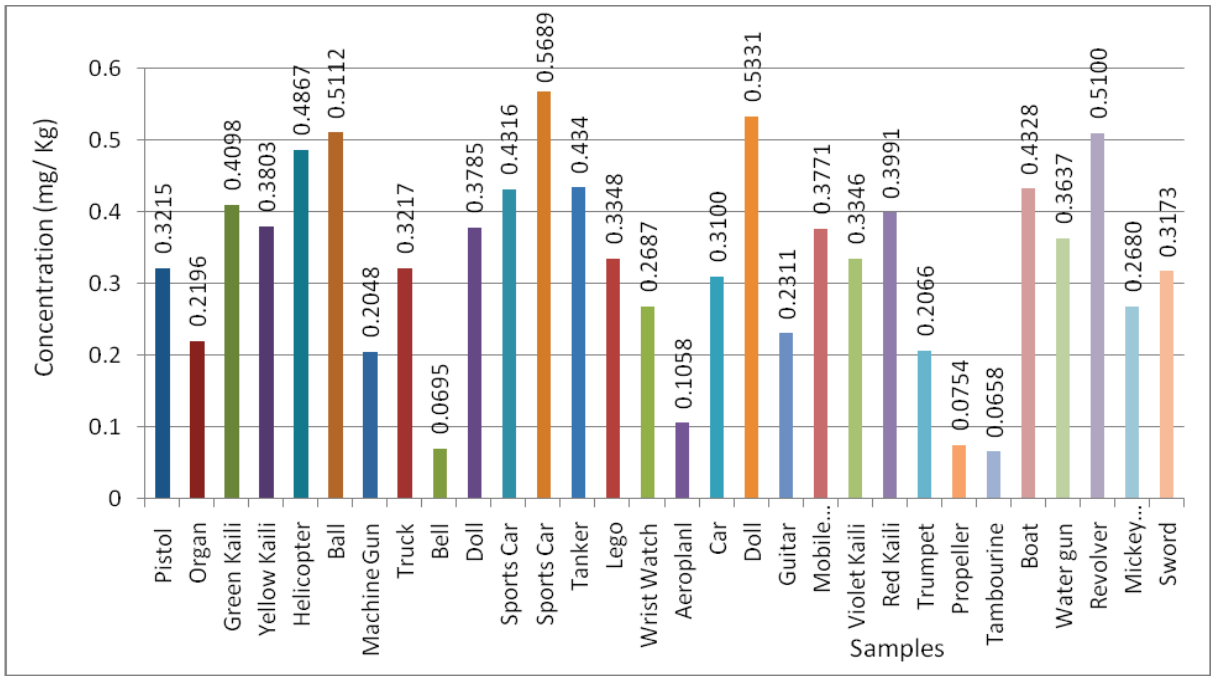

Figure 1: Mean concentration of cadmium

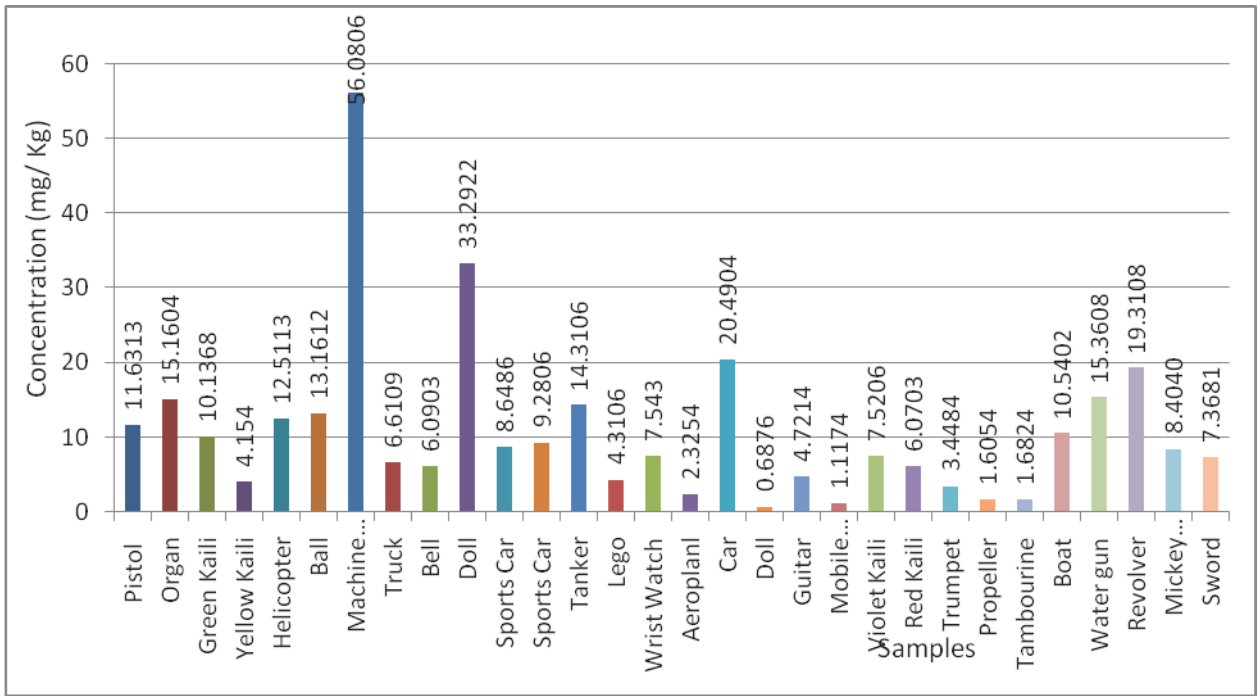

Figure 2: Mean concentration of Lead