Journal of Toxicology and Environmental Health Sciences Vol. 3(4) pp. 109-115, April 2011
Available online at http://www.academicjournals.org/JTEHS
ISSN 2006-9820 ©2011 Academic Journals

Full Research Paper

Some priority heavy metals in children toy's imported to Nigeria

Sindiku O. K.* and Osibanjo O.

Department of Chemistry, University of Ibadan, Oyo State, Nigeria.

Accepted 19 January, 2011

A total number of 51 toys manufactured from different countries were purchased and analysed to determine the level of lead, cadmium, chromium and nickel in the plastic components which was digested with concentrated HNO_3 (CPSC-CH-E1002-08 method) and analyzed using atomic absorption spectrophotometer (AAS) to determine heavy metal concentration. The results obtained show that lead, cadmium, chromium and nickel were high and ranged 28.5 to 12600 mg/kg Pb; 0.15 to 9.55 mg/kg Cd; 1.30 to 394.50 mg/kg Cr, and 5.9 to 1911 mg/kg Ni. A comparison of the mean concentration of these metals in the toys sample analyzed showed the following pattern: Pb>Ni>Cr>Cd. Compared with the elemental concentration threshold limits concentration (TTLC) of 90, 75 and 60 mg/kg for lead, cadmium and chromium respectively, Consumer Product Safety Commission, USA, Bureau of Indian Standard and Thailand Industrial Standard for Toys suggest that these toys are hazardous and therefore not safe for children use. This underscores the need for urgent national policy and resolution control on the removal of heavy metals especially lead from children toys.

Key words: Heavy metals, total threshold limit concentration, plastic toys, atomic absorption spectroscopy.

INTRODUCTION

Heavy metal poisoning has become an increasingly major health problem, especially since the industrial revolution. Heavy metals are in the water we drink, the foods we eat, the air we breathe, our daily household cleaners, our cookware and our other daily tools. A heavy metal has a density of at least 5 times that of water and cannot be metabolized by the body, therefore accumulating in the body. Heavy metal toxicity can cause our mental functions, energy, nervous system, kidneys, lungs and other organ functions to decline. Heavy metals include mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), thallium (Tl), and lead (Pb) and nickel (Ni) (Duffus, 2002).

Lead is a toxic metal and is ubiquitous in the human environment as a result of industrialization. Children are particular susceptible to its toxic effects. Lead poisoning is widespread and most poisoned children have no symptoms (CDC, 1991). Lead in the environment may enter the body through inhalation, ingestion or percutaneous absorption (WHO, 1995). Lead causes harm and there is no specific contamination route for lead. Humans can intake lead through inhalation or consumption of food. The World Health Organization's (WHO) "safe" limit for lead in blood, originally set in 1995, is 10 µg/dl. Incidences of lead poisoning in children led to the first public study to ascertain the presence of lead in PVC by Arizona Health Department in 1995 (CPSC, 1997). The chewing and swallowing of toys by children is a common path for lead and cadmium exposure (CPSC, 1997). Lead has also been linked to drops in IQ points, behavioral problems, and attention deficit hyperactivity disorder (ADHD). Lead exposure can also cause anaemia, damage to the gastrointestinal tract, and kidneys. Chronic exposure can even lead to DNA damage (Thuppil, 2007).

Cadmium is also a potential environmental hazard. Human exposures to environmental cadmium are primarily the result of the burning of fossil fuels and municipal wastes. Cadmium exposure produces a wide variety of acute and chronic effects in humans, leading to a build-up of cadmium in the kidneys that can cause kidney disease (UNEP, 2006). Lead and cadmium are

*Corresponding author. E-mail: thayor17@yahoo.com.

known poisons, being neurotoxins and nephrotoxins. Neurotoxins are agents that can cause toxic effects on the nervous system while nephrotoxins are agents that can cause toxic effects on the kidney respectively (ATSDR, 2005).

Chromium metal and chromium (III) compounds are not usually considered health hazards; chromium is an essential trace mineral. Trivalent chromium (Cr (III) or Cr^{3+}) is required in trace amounts for sugar metabolism in humans (Glucose Tolerance Factor) and its deficiency may cause a disease called chromium deficiency. In contrast, hexavalent chromium (Cr(VI) or Cr^{6+}) is very toxic and mutagenic when inhaled, as publicized by the film Erin Brockovich. Cr(VI) has not been established as a carcinogen when in solution, though it may cause allergic contact dermatitis (ACD). The lethal dose of poisonous chromium (VI) compounds is about one half teaspoon of material.

Nickel in small amounts is needed by the human body to produce red blood cells; however, in excessive amounts, can become mildly toxic. Short-term overexposure to nickel is not known to cause any health problems, but long-term exposure can cause decreased body weight, heart and liver damage, and skin irritation. The EPA does not currently regulate nickel levels in drinking water. Nickel can accumulate in aquatic life, but its presence is not magnified along food chains.

Physicians and scientists agree that no level of heavy metals in blood is safe or normal (NRC, 1993). The disturbing fact is that exposure to extremely small amounts can have long-term and measurable effects in children while at the same time causing no distinctive symptoms (CDC, 1991). Another problem of heavy metals exposure is it being cumulative in nature. After they have been absorbed into the blood, some of them are filtered out and excreted, but the rest are distributed in the liver, brain, kidneys and bones. What is more disturbing is what happens when lead gets into the bones. Bone stores lead and stay there for decades. Lead can re-enter the body when bone breaks down as part of a regular metabolic process or due to some specific physiological conditions like osteoporosis, causing re-exposure (ATSDR, 2005).

Lead and other heavy metals are widely used in PVC (poly vinyl chloride or vinyl) toys and other children's products to stabilize polymers in order to avoid degradation from heat, sunlight and wear. Vinyl requires the addition of metal stabilizers because it contains chlorine. Without a stabilizer, the chlorine can degrade the product by forming hydrochloride acid (CPSC, 1997). The consumer Product Safety Commission experimentally demonstrated that light and heat can cause degradation of vinyl toys and liberation of lead dust but unfortunately for children, vinyl toys released lead during normal product use (CPSC, 1997). The chewing and swallowing behavior of children is also a common source of lead exposure (Kelley et.al., 1993).

Given the known potential toxicity, the serious health effect and the ability of heavy metals, to leach out of children's toys through contact, the continued use of lead and other heavy metals in children's toy raises serious concern (CDC, 2004). Lead testing of children's toys and products began in Chicago, and then widened to include 10 major U. S. cities and Montreal, Canada (CSPC, 1997). Also researchers at the state University of New York Syracuse found lead in a vinyl play kit, gloves and basket ball toys (Hunt et al., 1997).

This study determined the current pattern in the use of lead and other heavy metals as stabilizer in PVC toys, using analytical techniques that would yield empirical data. The data collected were used to provide a clear picture of hazardous chemicals in PVC toys and other high contact children toys.

MATERIALS AND METHODS

Toys samples were weighed and recorded (Table 1). Adequate sample preparation was done by separating different parts of the toys sample into two major components: Plastics, which is the malleable parts and the metal, rods, nuts, screws etc.

Toys samples were grounded using a specially fabricated heavy duty harmer mill with uniformly sized holes.

The ground samples were then sieved through < 2 mm nylon sieve to ensure efficient extraction of the stabilizer. Milled samples were mixed thoroughly to achieve homogeneity of samples and appropriate amount of the ground sample was taken for analysis.

The grounded samples were wet digested as described by CPSC-CH-E1002-08. The final processed samples were quantitatively analyzed using Buck Scientific Model 210 VGP Atomic Absorption Spectrometer in the flame mode using appropriate resonance wavelengths. The instrument was first calibrated with standards prepared from stock solution provided by Merck. The final processed samples were quantitatively analysed using AAS. After every ten samples analysed using AAS, the first sample was repeated for quality check.

RESULTS

The result of the concentration of heavy metals in the various toys sample analysed is given in Table 2. The average, range, standard deviation and total threshold limit concentration of Pb, Cd, Cr and Ni concentration are also given.

All statistical analyses were performed using Microsoft excel and SPSS 15.0 and the mean, standard deviation and co-efficient of variation were calculated. A student t-test was also used to test the relationship of the mean of the concentration of the metals and the total threshold limit for each metal at 99% confidence level.

A pie chart showing the comparison of the mean value of Pb, Cd, Cr, and Ni in the toys sample analysed is given in Figure 1.

The result of a test of hypothesis between the concentrations of lead in the toys sample and the total threshold limit showed that the paired sample t-test r evealed a statistically reliable difference between the mean of the lead concentration and the threshold limit.

Table 1. Toys sampled in Lagos and used for the study.

Laboratory number	Country of manufacture	Description	Weights (grams)	Colour
A1	China	Caterpillar OP	410.8	Black and ash
A2	China	Toy train	136.2	Brown and black
A3	China	Blue toy gun	38.8	Blue
A4	USA	Bonbon buddies	38.0	Red and black
A5	USA	Toy jewery box	34.1	Purple
A6	China	Vanity toy hand drier	44.0	Purple
A7	China	Barbie doll	104.3	Brown
A8	USA	Toy telephone	73.5	Blue and white
A9	China	Snake toy gun	66.4	Black and gold coated
A10	China	Dolphin rattle	42.5	White
A11	China	Train rail	107.9	Black
A12	China	Darby star train rail	108.2	Black
A13	China	McDonald robot doll	61.0	Green, pink and brown
A14	China	Banana case	60.2	Yellow
A15	China	Alien flying gun	562.5	Blue and silver coated
A16	China	Children toaster	129.8	Light blue
A17	China	Bendi frendi box	301.4	Pink
A18	China	Toy warship	15.8	Yellow
A19	China	NYPD Bike	69.5	White paint
A20	China	Water gun	101.2	Yellow
A21	China	Jelly fish toy	56.2	Blue, white, and yellow
A22	China	Harry potter lamp	82.7	Green and purple
A23	China	Toy heroes badge	334.0	Green
A24	China	High school cabinet	118.8	Lilac
A25	USA	Viewmaster telescope	119.2	Red, blue and white
A26	Vietnam	Dolphin tomy	57.4	Orange
A27	China	Sleepingbeauty castle	37.4	Grey and purple
A28	China	Puzzle box MP	81.9	Blue
A29	China	Toy powerbike	175.8	Blue and silver coated
A30	China	Golden stallion horse	104.3	Golden brown
A31	China	Painted toy house	168.4	Red, white and yellow
A32	China	Toy feeding bottle	44.1	Transparent plastic
A33	China	Fischerprice rattle	37.7	Red and black
A34	China	3 secret box	191.2	Pink and purple
A35	Romania	Stallion horse	164.5	Peach with silvery hair
A36	China	Barbie microphone	35.2	Lilac
A37	China	Moffett lorry car	32.7	Red and black
A38	China	Cargo toy train	148.2	Brown and black
A39	China	Police car	31.2	Blue and black
A40	China	Rabbit rattle	83.4	Red and white
A41	China	Armoured tank car	54.8	Green
A42	China	Space car with fan	58.0	Black and grey
A43	U.K	Baby bed toys	469.0	Yellow
A44	China	Baby rattle	26.6	White
A45	U.k	Baby show off	284.4	Yellow
A47	China	Toy gun	102.1	Black and blue
A48	China	Aeroplane	125.2	Red and blue
A49	China	Toy feeding bottle	45.1	White
A50	China	Toy jewery	21.7	Silver and pink
A51	China	Children tiara jewery	24.3	Silver

Table 2. Concentrations (mg/kg) of Pb, Cd, Cr and Ni in the Nigerian toys samples analysed.

Toy type	Laboratory number	Pb	Cd	Cr	Ni
Caterpillar toy car	A1	155.50	1.60	1.55	23.25
Toy train	A2	290.00	0.85	2.95	30.65
Blue toy gun	A3	178.50	1.05	15.55	50.95
Bonbon buddies box	A4	68.00	2.60	4.60	18.40
Toy jewery box	A5	49.00	1.30	5.50	11.10
Vanity toy handrier	A6	459.50	0.5	6.40	36.60
Barbie doll	A7	327.00	0.55	4.95	113.80
Toy telephone	A8	45.00	0.65	4.70	12.30
Snake toy gun	A9	648.00	3.30	22.60	35.20
Dolphin rattle	A10	93.00	1.55	5.45	10.95
Playmobil train rail	A11	165.00	1.20	2.95	17.30
Darby star train rail	A12	105.50	1.05	4.65	19.30
Mcdonald robot doll	A13	100.50	1.60	18.45	13.55
Banana toy case	A14	50.00	0.40	13.05	13.30
Alien flying gun	A15	137.50	0.15	13.95	72.85
Toy toaster	A16	538.50	3.30	95.10	14.85
Bendifriendi box	A17	125.00	2.25	8.90	35.75
Toy warship	A18	76.00	1.65	7.50	31.00
NYPD toy bike	A19	660.00	2.15	11.75	39.50
Water gun	A20	115.50	1.25	4.90	61.00
Toy jelly fish	A21	126.50	3.30	5.20	21.00
Harrypotter toy lamp	A22	765.50	1.70	4.75	16.95
Heroes badge	A23	36.50	2.20	4.70	9.75
Highschool toy cabinet	A24	260.50	3.60	5.85	71.35
Viewmaster telescope	A25	1505.00	1.60	394.50	14.20
Dolpin toy	A26	47.50	1.15	3.95	10.70
Sleeping beauty castle	A27	68.50	9.55	8.65	9.55
Puzzle box	A28	44.50	0.65	4.25	6.75
Toy power bike	A29	224.50	1.00	3.50	20.10
Painted toy house	A30	111.00	1.00	3.65	19.75
Golden stallion horse	A31	12600.00	1.70	10.05	59.70
Toy feeding bottle 1	A32	284.00	1.40	1.30	68.95
Fischer-price rattle	A33	386.00	1.50	3.20	48.65
3 secret box	A34	825.00	2.35	9.00	58.90
Stallion horse 2	A35	639.00	1.35	10.70	46.15
Barbie microphone	A36	28.50	0.95	4.10	6.80
Moffetti toy lorry car	A37	241.00	9.00	34.75	31.65
Toy cargo train	A38	144.00	1.15	6.55	11.70
Police toy car	A39	173.00	2.20	37.65	1911
Rabbit rattle	A40	3220.00	1.20	2.40	37.25
Armoured toy tank	A41	41.50	0.80	19.75	27.85
Toy space car	A42	870.00	1.95	3.05	6.45
Toy baby bed holder	A43	89.50	1.15	7.25	121.65
Jemina baby rattle	A44	185.50	0.60	25.45	23.95
Bluebird toys	A45	29.00	1.20	10.85	31.90
Toy canoe	A46	282.50	1.15	5.60	20.40
Toy gun	A47	173.00	1.40	3.35	5.90
Toy aeroplane	A48	113.50	1.00	14.25	15.50
Toy feeding bottle 2	A49	251.00	0.60	3.25	44.45
Toy jewery 1	A50	621.00	1.20	5.45	431.10

Table 2. Contd.

Children tiara jewery	A51	680.00	1.10	5.30	43.50
Mean		577.53	1.76	17.99	77.09
Range		28.50 - 12600	0.15 – 9.55	1.30 - 394.50	5.9 - 1911
Standard deviation		1789.50	1.72	55.66	2368.98
Total threshold limit concentration (TTLC)		90	75	60	_

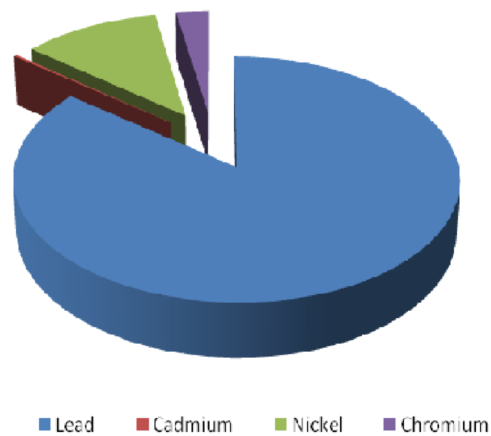

Figure 1. Comparison of the mean values of Pb, Ni, Cd and Cr in the toy samples analysed.

The result of the test of hypothesis between the concentrations of cadmium and chromium in the toy samples and the total threshold limit showed that the paired sample test failed to reveal a statistically reliable difference between the their means and the threshold limit.

DISCUSSION

This study investigated the use and presence of some heavy metals in children toys imported into Nigeria. Pb, Cd, Cr and Ni were found in all the tested toy samples in varying concentrations.

It was observed that majority (92.2%) of the toys sample analyzed in this study were made of plastics of different colours. A full breakdown of the country of manufacture of toys shows that 84.3% were made from China, 8% from USA, 4% from UK, 2% from Vietnam and 2% from Romania. This was attributed to the fact that China is the largest toy seller in the world with about 8,000 toy factories that employ up to 3 million workers (The Children's Toy Business, 2009).

The results of heavy metals analysis in the toy-samples tested were compared with the total threshold limit concentration (TTLC). The total threshold limit concentration for cadmium is 75 mg/kg (Bureau of Indian standard for toys, 1999; Thailand industrial standard for toys, 1997). The cadmium level in the toy-samples was observed to be far below the threshold limit of 75 mg/kg), with mean concentration of 1.76 mg/kg, and range concentration of 0.15 to 9.55 mg/kg. This can be attributed to the fact that cadmium is one of the six substances banned by the European Union's Restriction on Hazardous Substances directive (UNEP Chemicals, 2006). Cadmium and several cadmium-containing compounds have been reported to be carcinogenic and can induce many types of cancer (Wallace, 2001).

The total threshold limit concentration for chromium is 60 mg/kg (Bureau of Indian standard for toys, 1999; Thailand industrial standard for toys, 1997). Also, the chromium levels in almost all the toy-samples was observed to be far below the threshold limit of 60 mg/kg, with a mean concentration of 18.0 mg/kg and a range concentration between 1.3 and 394.5 mg/kg (Table 2). 96% of the toy samples have chromium levels far below the threshold limit while 4% (two samples; Toy toaster and view master telescope) were above the threshold limit. This is due to the fact that hexavalent chromium (Cr(VI) or Cr^{6+}) is very toxic and mutagenic when inhaled and is also one of the substances whose use is restricted by the European Restriction of Hazardous Substances Directive (UNEP Chemicals, 2006).

The threshold limit concentration for nickel was not stated. It was observed that nickel was present in all the toy samples analysed in this study with a mean concentration of 77.1 mg/kg and a range concentration between 5.9 and 1911 mg/kg. This may be attributed to the fact that small amounts of nickel are needed by the human body to produce red blood cells; however, in excessive amounts, can become mildly toxic. Also, short-term overexposure to nickel is not known to cause any health problems, but long-term exposure can cause decreased body weight, heart and liver damage, and skin irritation. The EPA does not currently regulate nickel levels in drinking water because nickel can accumulate in aquatic life, but its presence is not magnified along food chains (U.S Environmental Protection Agency, 2002).

The total threshold limit concentration for lead is 90 mg/kg (CPSC, 2009). It was observed that lead levels are very high in almost all the toys samples with a mean concentration of 577.5 mg/kg and a range concentration between 28.5 to 12600 mg/kg, exceeding the regulatory limit. 76% of the toy samples tested have lead levels exceeding the current threshold limit of 90 mg/kg; while 24% of the toy samples tested have lead levels below the threshold limit. Such high quantities of lead in toys pose a threat to children's health. High levels of lead in children body may damage their brains, nervous system, and kidney, reduce intelligence quotient, slow down growth, and cause hearing problems. It can also cause behavioral and learning problems and can result in coma, convulsions, and even death (EPA, 2007; CDC, 1991).

According to CPSC (1997), lead is the most commonly used stabilizer in plastic toys, due to the fact that it is readily available and it is the cheapest. A comparism of the mean values of the heavy metals in the toy samples was analysed as shown in Figure 1 shows that lead is the most commonly used metal stabilizer (86%), followed by nickel (11%), chromium (3%) and cadmium (0%). Also, lead is mined in more than forty countries of the world, used and traded globally as a metal in various products. There is extensive global trade of lead raw materials (UNEP, 2006).

A consistent correlation was also found between the country of manufacture and the presence of heavy metals in the toys tested. 81% (35 products) of toys from China had lead levels above 90 ppm, while 19% (8 products) had lead levels below 90 ppm. This may be attributed to the fact that China is the world's major producer and user of lead (UNEP, 2006). Four (4) toys manufactured in the U.S.A were sampled and 25% (1 toy) of those had lead level above 90 ppm, while 75% had lead levels below 90 ppm. Also, 25% (stallion horse from Romania) of toys from other countries had levels above the threshold limit. This suggests that lead poisoning from toys is not just from China.

Previous study by Greenpeace in USA (1997), reported that the lead and cadmium levels exceeded the TTLC in children products and toys purchased at national chain stores like Kmart, Wal-mart, toys R Us in the US with mean concentration of 2893.14 and 70.34 mg/kg for lead and cadmium respectively and range concentration of 104 to 22550 and 0 to 344 mg/kg for lead and cadmium respectively (Joseph, 1997). This value is at a higher concentration than the average reported in this present study. This discrepancy is likely due to the awareness created against the use of lead and other heavy metals as stabilizers in plastics toys and also the recall incidence of some of China toys suspected of containing lead by CPSC in 2007 (Denver post, 2007; CPSC, 2007). This may also due to the fact that lead and cadmium are known poisons, being neurotoxins and nephrotoxins (ATSDR, 2005).

It must be noted that exposure from lead is in addition to that of cadmium, chromium and nickel. Hence, children playing with toys having both lead and cadmium are exposed to both toxic metals. This is an important concern and any regulatory mechanism must take this into account. These data demonstrated that toys manufacturers who seek to design product that will be exempted from current recall crisis will need to address not just lead, but most importantly, the nickel levels.

Conclusion

Children's toys imported into Nigeria irrespective of the country of manufacture especially toys from China contain toxic heavy metals, such as lead, nickel, chromium and cadmium in varying concentrations and some even showing high lead concentration that may pose hazards to children's health and create a major environmental health hazard in its use and disposal. Especially alarming is the presence of high lead levels in a China made toy feeding bottle designed to put into children's mouth and a stallion horse toy from China.

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