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Levels of Heavy Metals in Imported Toys Sold in Lagos, Nigeria

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ABSTRACT

Heavy metals in plastic toys have been recognized as one of the sources of metal intake in children due to their small body volumes and developing nervous system. Eighty plastic toys imported from China, England, USA and Thailand were analysed for the levels of heavy metal. Fifty of the toy samples were fairly used toys obtained from Westminster Toy Market, Apapa Wharf, Lagos; while thirty of the toy samples were new toys obtained from Toy Market in Idumota, Lagos, Nigeria. The toys were fragmented into small bits, subjected to wet oxidation digestion using ternary acid mixture (HNO_3, H_2SO_4 and $HClO_4$) and analysed for heavy metals using Atomic Absorption Spectrometer (AAS). Lead was found in 79 of the samples ranging from 6.8 to 701.10 ppm with mean Pb concentration of 166.78 ppm for fairly used toys and 167.37 ppm for new toys. Chromium was found in 78 of the toy samples ranging from 1.33 ppm to 30.3 1ppm with a mean Cr concentration of 8.21 ppm for fairly used toys and 7.59 ppm for new toys. Concentration of Cr in all the toy samples (fairly used and new) were below the USEPA and CPSC limit for Cr (60 pmm) in children's toys. Forty eight samples (30 fairly used and 18 new toys) showed elevated level of Pb higher than 90 ppm, exceeding the USEPA and CPSC limit of 90 ppm for Pb in children's toys The results generally showed that pollution by heavy metals in toys are high for lead and negligible for chromium; while categories of toy (fairly used or new) as well as toy weight were not a determinant in the evaluation of children's exposure to heavy, metals.

KEY WORDS: Heavy Metals, Toy, AAS, Pollution.

INTRODUCTION

Heavy metals in plastic toys have been recognized as one of the sources of metal intake in children due to their developing nervous system and small body volumes [1}. Toys made of polyvinyl chloride (PVC) are potentially toxic to children as PVC contains heavy metals, especially lead. Heavy metal compounds act as stabilizers but they readily leach out [1]. Also, they can be used in

pigments to impart bright colours to toys in order to attract children. The present study was undertaken to ascertain the levels of lead and chromium in soft plastic toys.

A toy is any object that can be used for play [2]. Toys are usually associated with children and pets, but it is not unusual for adult and some other animals to play with toys. They are integral part of a child's development processes, since children play with toys and learn about the world. Many items are designed to serve as toys, but goods produced for other purposes can also be used. A toy may mean different things to children of different age groups and hence exposure pathways also differ accordingly. A child below 3 years of age may handle a toy in a completely different manner from a child 3 – 6 years of age. Broadly, toys can be categorized as mechanical, electrical and soft toys. Others include construction sets, dolls, animals, miniatures, vehicles, puzzles, physical activity and collectibles [3-5]

Toys may also inflict accidental injuries to children. Sharp edges of toys or other electrical, mechanical or flammable characteristics may cause accidents. Chemical exposure of children, especially from toys, is an emerging concern. Metals in materials and paints are loosely bound to the surface and can leach easily. The chewing, licking and swallowing behaviour of children is a common source of heavy metal exposure[6]. Children and pregnant women are particularly susceptible to heavy metal poisoning. The digestive system of children absorbs up to 50% of the lead they ingest [7]. In fact, physicians and scientists agreed that no level of lead in blood is safe or normal [7].

Lead poisoning is one of the commonest occupational disease, although in recent years there has been a decline in both the number of reported case and the severity of the symptoms presented, hence lead poisoning has shifted from industrial hazard to an environmental one. Established limit of lead in the United States (ASTMF – 963) and the European Standard (EN 71) for soluble lead in toys is 90 ppm (90 mg/L) [12, 15] Lead affects the red blood cells (anemia and other effects on the haemopoietic system are the commonest effects) and caused damage to organs including the liver, kidneys, heart, and male gonads, as well as causes effects to the immune system. Symptoms are often precipitated by alcohol or exercise. Also, it affects peripheral airway function and causes lung fibrosis and emphysema. In the central nervous system, Lead causes edema, and its effects are often irreversible. Reduced IQ, learning and behavioural difficulties have been reported in children even with low blood levels [8].

Chromium has three main forms namely Cr(0), Cr(III), and Cr(VI). Chromium(III) compounds are stable and occur naturally, in the environment. Chromium(0) does not occur naturally and chromium(VI) occurs only rarely[9,10]. The carcinogenity of chromate dust is known for a long time, and in 1890 the first publication described the elevated cancer risk of workers in a chromate dye company. Based on sufficient evidence for humans and animals, Cr (VI) has been placed in the EPA weight of evidence classification A, human carcinogen [11]. For inhalation exposure, the unit risk value is 1.2E – 2 $(mg/m^3)^{-1}$ and slope factor is 4.1E + 01$(mg/kg/day)^{-1}$.

Toys made of PVC (CH_2 = CHCl) are a potential source of risk to children. 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 the digestion of PVC, which causes a chain reaction and proceeds rapidly to completely weaken the structure (causing damage to the manufacturing equipment as well) [1]. Heavy metals are hence added to PVC as stabilizers to prevent the free chlorine radicals from reacting with hydrogen radicals to form HCl [1]. 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 Cd, Cr, Ni, Zn, Organotins, etc. Heavy metals are also added to PVC or other plastic products as colouring agents in the forms of organo-metallic compounds.

Heavy metals in general are poisonous, being neurotoxins, nephrotoxins, etc. Although numerous epidemiological studies have been carried out on the health impacts of heavy metals on children, little has been done to ascertain its source in children's environment. Toys, particularly soft plastic toys, which are intimately linked to children's environment, have not been investigated as one of the possible sources of lead, chromium and other heavy metals.

The absence of any study on lead and chromium content in imported toys in Nigeria coupled with the fact that soft plastic toys dominate the Nigerian toy markets, justify this work on cheap soft imported fairly used and new plastic toys probably used by bulk of the Nigerian children, with the sole objective to ascertain the total contents of lead and chromium in the sampled toys imported from China, England, USA and Thailand.

MATERIALS AND METHODS

The 80 toy samples (fairly used and new) were purchased from 8 different toy shops in Lagos; 50 fairly used toy samples were purchased from 5 different toy shops at Westminster Toy Market, Apapa Wharf, Lagos and 30 new toy samples were purchased from 3 different toy shops at Idumota Toy Market, Lagos. All the toy samples (fairly used and new) were brought to the Chemistry Laboratory, University of Lagos. These samples were then labeled based on their weight, colour, description and country of manufacture.

The toy samples were first subjected to fragmentation by the use of a grinding machine model 613: 600 x 450 – 3D model (TOYA 79201) with a cutting wheel made of silicon carbide (Type C). The fragmented samples were further ground to about 0.2 cm to 1.2 cm size, packaged individually in a polyethene bag and labeled appropriately. The methodology included subjecting the fragmented toy samples to wet oxidation digestion method using tenary acid mixture. 2 g of individual toy sample was weighed into a 250 ml beaker, 20 ml of analytical grade acid mixtures – nitric, sulphuric and perchloric acids – in the ratio 1:1:2 were added. The beaker was covered with watch glass, placed on electric hot plate and allowed to boil slowly at a temperature of about 90^{o}C until about 4ml was left in the beaker. Another 20 ml of analytical grade acid mixture was added. The mixture was allowed to boil until a clear solution was obtained which indicates complete digestion. After cooling for about 30 minutes, 50mL of distilled – deionized water was added to the solution in the beaker and the resulting solution was then filtered through Whatman filter paper grade 1.11 μm (size 110 mm) to remove small quantities of solids and made up to a final volume of 100 mL with distilled –deionized water. The 100 mL solution was then transferred into a plastic sample bottle and properly labeled with the sample number. Pb and Cr concentrations were later determined by AAS. Blank samples were also prepared similarly. Standards were prepared with serial dilution technique. The stock solutions of standards (1000 ppm) of lead, and chromium were prepared by dissolving 1.5985 g $Pb(NO_3)_2$ and 2.8285 g anhydrous $K_2Cr_2O_7$ respectively in distilled –deionized water in a beaker. The solutions were then transferred into one litre volumetric flask and were made up to mark with distilled –deionized water [13]. The instrument was calibrated with standards prepared from stock solution. After every ten samples analysed using AAS, the first sample was repeated for quality check. Only when the results were within 10% of earlier readings did the analysis proceed further.

RESULTS AND DISCUSSION

The mean, minimum, range and standard deviation of Pb, and Cr concentration (ppm) in the toy samples are presented in Table I. Pb and Cr were detected in all the tested samples in varying concentrations except in sample number 77 where Pb and Cr concentration were not dictated and sample number 63 where Cr was not dictated. Lead had a higher mean concentration of 166.9948 ppm and then chromium with mean concentration of 7.9795 ppm. Lead had the maximum concentration of 701.10 ppm, while chromium have maximum concentration of 30.31 ppm.

Table I: Results of Analyses of Fairly Used Plastic Toy Bits

Sample No.	Weight (Grams)	Country of Origin	Pb (ppm)	Cr (ppm)
1	63.7	China	270.10	1.98
2	98.6	China	216.50	3.44
3	113.3	England	634.30	11.32
4	118.4	England	432.80	6.81
5	57.8	England	48.30	17.52
6	92.3	China	175.20	6.34
7	53.1	China	126.10	22.81
8	48.1	China	140.30	7.11
9	124.6	Thailand	76.90	6.81
10	105.3	China	418.50	11.28
11	75.2	China	78.30	4.15
12	34.4	England	370.40	10.13
13	54.8	USA	59.20	11.32
14	156.6	USA	97.80	5.81
15	86.3	China	183.10	6.91
16	70.5	England	380.40	7.98
17	44.1	USA	201.30	6.05
18	31.0	China	58.50	4.18
19	257.8	China	701.10	20.31
20	71.6	England	51.80	5.15
21	164.2	England	95.20	5.32
22	195.1	China	131.40	4.13
23	18.4	China	42.30	6.93
24	134.0	England	7.65	3.22
25	83.4	China	39.38	5.17
26	215.3	England	7.11	1.33
27	87.5	China	53.90	3.21
28	57.4	England	63.50	7.14
29	52.2	China	430.90	6.30
30	49.7	China	201.80	4.55
31	63.8	China	51.70	6.01
32	49.7	China	131.50	4.23
33	54.6	China	93.70	4.88

34	59.6	China	77.80	11.01
35	35.3	China	59.30	9.86
36	203.1	USA	114.60	8.19
37	77.3	England	111.50	15.30
38	52.7	China	62.40	10.05
39	35.8	China	511.70	9.06
40	51.8	China	103.60	8.34
41	37.9	China	91.70	10.21
42	29.6	China	47.60	8.13
43	43.4	China	121.31	6.45
44	23.1	China	104.70	7.11
45	18.8	USA	72.14	18.21
46	175.4	China	481.30	5.88
47	376.9	China	107.50	8.14
48	401.7	China	47.30	5.81
49	20.6	China	42.10	21.40
50	14.7	China	111.50	7.18

Table 2: Results of Analyses of New Plastic Toy Bits

Sample No.	Weight (g)	Origin Country	Pb (ppm)	Cr (ppm)
52	57.3	China	48.50	5.32
53	49.2	China	10.40	4.31
54	52.8	China	38.20	2.30
55	53.9	China	6.81	4.51
56	53.3	China	71.40	1.81
57	58.2	China	81.60	3.81
58	32.4	China	371.80	6.45
59	41.3	China	204.30	5.80
60	47.9	China	63.10	3.81
61	62.4	China	150.80	4.05
62	57.6	China	113.80	3.18
63	47.2	China	81.41	-
64	44.2	China	431.40	30.31
65	23.4	China	77.30	19.44
66	71.4	China	330.90	16.22
67	14.5	China	49.50	9.74
68	53.4	China	106.80	5.42

69	43.6	China	204.50	9.77
70	14.5	China	370.80	12.14
71	53.8	China	218.40	5.62
72	42.5	China	210.30	7.38
73	26.5	China	170.30	1.71
74	14.5	China	205.40	2.58
75	45.5	China	516.30	9.81
76	48.2	China	280.50	7.05
77	70.6	China	-	-
78	35.4	China	79.38	6.38
79	26.0	China	115.80	19.41
80	54.1	China	109.30	6.30

All tested samples contained Pb at varying levels except sample number 77 where Pb was not dictated (Table 2). 60.0% of the fairly used toy samples (30 samples) were with elevated levels of Pb above the USEPA standard for lead in children's toys (< 90 ppm), whereas 60% of the new toy samples (18 samples) were also found with elevated levels of Pb above the USEPA and CPSC standard as presented in Tables 3 and 3 [12, 15]

Table 3: Range, Percent and Mean Pb Concentration of fairly used toys

Old Toy	Sample No	Range	Mean (ppm)	Percent
High (>90 ppm)	30	91.70 – 701.10	243.06	60.0%
Low (<90 ppm)	20	7.11 – 78.30	52.36	40.0%

Table 4: Range, Percent and Mean Pb Concentration of New Toys

New Toy	Sample No	Range	Mean (ppm)	Percent
High (>90 ppm)	18	106.80 – 516.30	235.89	60.0%
Low (<90 ppm)	12	7.11 – 78.30	50.63	40.0%

All the tested samples contained varying levels of chromium with exception of samples numbers 63 and 77 were chromium was not dictated. All the fairly used toy samples (50 samples) were

found to contain low or moderate levels of chromium which were below the USEPA and CPSC standard for Cr in children's toys (< 60 ppm) as presented in Table 5. Also all the new toy samples (30 samples) were found with low and moderate levels of chromium which were below the USEPA and CPSC standard for Cr in children's toys (< 60 ppm) as presented in Table 6.

Table 5: Range, Percent and Mean Cr Concentration of fairly used toys

Old Toy	Sample No	Range	Mean (ppm)	Percent
High (>60 ppm)	-	-	-	0%
Low (<60 ppm)	50	1.33 – 22.81	8.20	100%

Table 6: Range, Percent and Mean Cr Concentration of new toys

New Toy	Sample No	Range	Mean (ppm)	Percent
High (>60 ppm)	-	-	-	0%
Low (<60 ppm)	30	1.71 – 30.31	7.34	100%

The result shows the presence of Pb in all the seventy nine out of the eighty toy samples analysed, while the other heavy metal (chromium) was dictated in seventy eight out of the eighty toy samples analysed. The levels of Pb in 60% of the fairly used and 60% of new toy samples were above the USEPA and CPSC limit for Pb in toys of 90 ppm. Also, the levels of chromium observed in all the toy samples (fairly used and new toys) were below the USEPA and CPSC limit for Cr in toys of 60 ppm.

High levels of lead observed in the samples pose a threat to children's health who are exposed to high amount of lead in their toys through ingestion, biting, swallowing and chewing of toy parts. Low levels of Cr observed in almost all the analysed toy samples indicates that children are not greatly exposed to Chromium toxicity from toys. The level indicates the compliance of manufacturers to the CPSC and USEPA limits ascribed in August, 2009 [12, 15]. Also, the low

levels of chromium may be relatively due to its unimportance in the manufacturing process when compared with lead which seems to be largely in use as stabilizer in polyvinylchloride (PVC) plastic toy manufacturing [14].

CONCLUSION

Lead and chromium were found in varying concentrations in all the toy samples analysed. Concentration of Cr in all the toy samples (fairly used and new) were below the USEPA and CPSC limit for Cr (60 ppm) in children's toys. The toy samples (48, consisting of 30 fairly used and 18 new toys) showed elevated level of Pb higher than 90 ppm, exceeding the USEPA and CPSC limit of 90 ppm for Pb in children's toys. In the absence of any leaching studies, it is difficult to ascertain the levels of exposure that these imported fairly used and new plastic toys available in Nigeria can cause to children. However, with all toy samples (fairly used and new) containing Pb and Cr in varying concentrations and some even showing high Pb concentration, it does indicate that imported plastic toys in Nigeria pose a worrying and potential risk to children's health.

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