International Journal for Pharmaceutical Research Scholars (IJPRS)

V-3, I-1, 2014 ISSN No: 2277 - 7873

RESEARCH ARTICLE

Toxic Metal Contamination in Locally Made Plastic, Polymeric Toys

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Manuscript No: IJPRS/V3/I1/00073, Received On: 10/02/2014, Accepted On: 17/02/2014

ABSTRACT

The main objective of this study was to determine the concentrations of toxic heavy metals (Cd, Mn, Cu, Ni and Cr) in locally made plastic toys purchased from Lucknow, Kanpur, Allahabad, Varanasi and Mau districts of Uttar Pradesh, India. All samples were digested with concentrated nitric acid (USP-400220 method) and analyzed by using atomic absorption spectrophotometer (AAS) to determine the metal concentrations, which lie in the range of Cd (0.172-0.0 ppm), Mn (1.521-0.0 ppm), Cu (1.251-0.0 ppm), Ni (1.211-0.0 ppm) and Cr (1.251-0.0 ppm).

KEYWORDS

Heavy metals, Concentrations, Plastic, Toys, Health, Toxic

INTRODUCTION

Plastic materials have achieved tremendous diversity today, and used in countless number of applications. Plastic products are made by polymerization process in which additives are added to enable certain desired properties for a specific application[1] Fig.1.

Toys are an integral part of a children's development. Children play with toys and learn about the world. Production and consumption of plastic toys have doubled in last 15 years due to increase of global annual production of plastics.[2] However, technological developments in toys market have raised new issues with respect to the safety and health.[3] During the first decade of this century, the children exposure to toxic additives contained in plastic polymeric toys has received special attention because presence of these toxic additives constitutes a category of pollutants that cannot be neglected since children are more sensitive than adults in many ways.

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The chewing and licking behaviour of children is a common source of these pollutants exposure.[4] The digestive system of children absorbs more toxic metals as compared to adults.[5] Numerous name brand toys in United States were recalled from the market due to heavy metal contamination which affected almost 14.5 million items.[6] Through October 2008, there have been an additional recalls which affected about more than 4 million items which were coming from China, Korea, Peru, Taiwan, Vietnam and India.[7-10]

There are various studies which have been carried out on health, the impacts of heavy metals on humans, but very less has been done to ascertain their source in children. Heavy metals have mostly been studied in soil, water and food.[11-14] Toys which are supplementary part of children environment have not really been studied which may be the source of toxic metals, except a few when researchers at the State university of New York Syracuse found lead in vinyl play kit, gloves and basketball toys.[15] After this lead testing in children's toys and products started in Chicago and then widened in 10 major cities of United States.[16] And continued in other countries also.[17-19]

Since heavy metals have about five times more density than water so it cannot be metabolized easily by the human body, therefore it can be accumulated in the body and when their concentrations reach to its maximum than permissible limit, can cause toxic effects such as disorders in mental function, energy, kidney, nervous system, respiratory system and many other systems of the body.[20-24]

In India there are several small-scale and also some large-scale industries which are manufacturing plastic toys in unorganized way by using harmful additives above the permissible limits and these products are generally not tested by regulatory agencies for the purpose of safety. As a result, the life as well as the quality of products is reduced. In this regard, this study was designed to ascertain the levels of Cd, Mn, Cu, Ni and Cr in locally made plastic toys which were purchased from Lucknow, Kanpur, Allahabad, Varanasi and Mau districts of Uttar Pradesh, India.

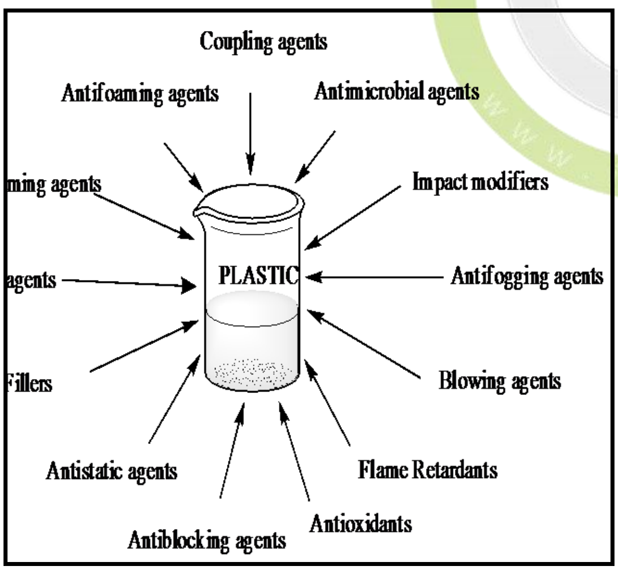

Figure 1: Various Additives used in Plastics

MATERIALS AND METHOD

A total of 84 toys samples were purchased from different districts of Uttar Pradesh, India and categorized as Table 1, then subjected to an indicative test for PVC (Polyvinylchloride) by using the Beilstein test which is a preliminary test for PVC[19,25] and then subjected for toxic heavy metals analysis.

Table 1: Details of Toys Sample Used for the Study

Sample Code	Description	Colour
S1	Toy gun, Toy telephone, Toy car (Total 6 samples)	Grey
S2	Bird, Dice, Cargo toy train (Total 6 samples)	Purple
S3	Baby rattle, Train rail, Toy car (Total 6 samples)	Green
S4	Ball, Building block, Key ring (Total 12 samples)	Red
S5	Feeding bottle, Dice, Aeroplane (Total 6 samples)	Maroon painted
S6	Train rail, Toy mug, Police car (Total 6 samples)	Pink
S7	Toad, Rabbit, Dice (Total 12 samples)	Sky-blue
S8	Toy car, Ball, Puzzle box (Total 18 samples)	Red & blue
S9	Toy tank car, Toy gun, Toad (Total 12 samples)	Pink & purple

Method

Leachate Preparation and Scanning

The methodology involves subjecting samples first to leaching with simulating solvents. For this the samples were washed thoroughly with sterilized double distilled water prior to the leaching. Double distilled water, Acetic acid (3% v/v) and Sodium Chloride (0.9% w/v) were used as the simulating solvents. The samples were exposed in 100 ml of each simulating solvents in sterile beakers at a ratio of $2cm^2$ /ml. Parallel sets having simulating solvents only were also run under identical conditions and were serving as basal control.[26] The simulated solvents (100 ml of each) were taken in conical flask and digested with concentrated nitric acid in a fuming chamber. The digested samples were scaled down to 10 ml with 0.1 N HNO_3. The final processed samples were quantitatively analyzed by using Perkin- Elmer-500 atomic absorption spectrophotometer (USP-400220). The instrument was first calibrated with standard prepared from stock solution provided by Merck. The concentrations of the selected heavy metals were determined in triplicate and the result is given as a mean ± standard deviation. The concentrations of metals in different leachates of samples are presented in ppm. Metal content should not be more than 1.0 ppm (Cd should not be more than 0.10 ppm) according to BIS, IP, USP and other regulatory agencies.

RESULTS AND DISCUSSION

The results obtained from the analysis of the toys for heavy metals are depicted in table.2. All samples were found positive in Beilstein test which is an indication of presence of halides and hence may be considered to be made up of PVC materials. All the samples were found to contain Cadmium, Manganese, Copper, Nickel and Chromium in varying concentrations. The highest mean concentration of Cd (0.172 ppm in 3% acetic acid) was found in S5 samples; the concentration of Mn (1.521 ppm in 3% acetic acid), was maximum in S5 samples; the maximum mean concentration of Cu (1.251 ppm in double distilled water) was seen in S9 samples; highest mean concentration of Ni (1.211 ppm in 0.9% sodium chloride) was noted in S3 samples; and the maximum concentration

Table 2: Heavy Metal Concentrations (ppm). The results are reported as a Mean ± Standard Deviation from Three Set of Experiments.

Sample	Simulants	Mean conc.(ppm) of Cd ± SD	Mean conc.(ppm) of Mn ± SD	Mean conc.(ppm) of Cu ± SD	Mean conc.(ppm) of Ni ± SD	Mean conc.(ppm) of Cr ± SD
S1	Double Distilled Water	ND	0.125±0.008	0.894±0.120	0.024±0.003	ND
S2		0.012±0.002	0.141±0.004	ND	0.064±0.002	ND
S3		0.016±0.003	0.089±0.003	ND	0.161±0.002	*1.004±0.002
S4		ND	0.211±0.004	ND	0.067±0.003	ND
S5		*0.130±0.002	*1.311±0.101	0.019±0.002	0.751±0.101	*1.251±0.058
S6		0.030±0.002	0.149±0.031	ND	ND	0.009±0.001
S7		ND	*1.008±0.022	0.121±0.001	0.009±0.001	ND
S8		ND	ND	0.184±0.003	ND	ND
S9		0.011±0.003	*1.099±0.004	*1.251±0.002	0.591±0.001	0.023±0.002
S1	3% Acetic Acid	ND	0.152±0.003	0.589±.003	*1.009±0.023	ND
S2		0.010±0.002	0.128±0.021	0.987±0.004	0.029±0.003	0.009±0.001
S3		ND	ND	ND	0.008±0.001	ND
S4		0.021±0.002	*1.062±0.001	*1.002±0.001	ND	0.009±0.001
S5		*0.172±0.003	*1.521±0.006	*1.111±0.012	0.891±0.002	0.089±0.004
S6		ND	0.396±0.004	ND	0.002±0.002	ND
S7		0.022±0.003	*1.002±0.003	ND	ND	*1.007±0.023
S8		0.041±0.003	ND	0.121±0.001	0.125±0.003	ND
S9		0.079±0.002	ND	0.008±0.001	ND	0.008±0.002

S1	0.9% Sodium Chloride	ND	0.001±0.001	ND	0.258±0.003	0.821±0.002
S2		ND	ND	ND	ND	ND
S3		ND	*1.001±0.004	0.091±0.002	*1.211±0.001	0.239±0.003
S4		0.043±0.003	ND	ND	ND	*1.143±0.021
S5		*0.149±0.003	*1.002±0.002	*1.023±0.003	0.997±0.004	0.089±0.003
S6		0.087±0.001	ND	0.521±0.003	0.009±0.001	ND
S7		ND	*1.201±0.012	0.841±0.012	*1.201±0.003	0.989±0.003
S8		0.024±0.001	0.189±0.002	*1.081±0.006	ND	ND
S9		0.085±0.002	0.981±0.004	0.004±0.001	0.229±0.002	*1.001±0.004

*Concentrations above permissible limit, ND = Not Detected.

Table 3: Correlation Matrix in Double Distilled Water

	Cd	Mn	Cu	Ni	Cr
Cd	1.000				
Mn	0.568	1.000			
Cu	-0.253	0.213	1.000		
Ni	0.744	0.785	0.320	1.000	
Cr	0.733	0.348	-0.309	0.612	1.000

Table 4: Correlation Matrix in 3% Acetic Acid

	Cd	Mn	Cu	Ni	Cr
Cd	1.000				
Mn	0.574	1.000			
Cu	0.387	0.513	1.000		
Ni	0.447	0.216	0.462	1.000	
Cr	-0.034	0.413	-0.211	-0.162	1.000

Table 5: Correlation Matrix in 0.9% Sodium Chloride

	Cd	Mn	Cu	Ni	Cr
Cd	1.000				
Mn	0.220	1.000			
Cu	0.340	0.295	1.000		
Ni	0.011	0.295	0.294	1.000	
Cr	-0.165	0.194	-0.394	0.069	1.000

of Cr (1.251 ppm in double distilled water) was detected in S5 samples.

The results also showed that the concentrations of the metals are linearly correlated to a large extent in all simulants which are depicted in Table 3-5. The correlation matrix in double distilled water, shows a good correlation between Ni and Mn (r = 0.785), Ni and Cd (r = 0.744), Cr and Cd (r = 0.733), Ni and Cr (r = 0.612), Mn and Cd (r = 0.568) Table 3. In 3% acetic acid, a good correlation was between Mn and Cd (r = 0.574), Mn and Cu (r = 0.513).

CONCLUSION

The present study reveals that all toys samples were made of PVC materials, having metals in various concentrations. Among the 84 samples analyzed, some samples show high concentrations of metals than permissible limits prescribed by various regulatory agencies such as BIS, WHO, IP, USP and BP etc. and are indicated by * in the Table 2, may pose hazards to children's health and create a major health hazard to its use and disposal. Therefore it is necessary to make the society aware of the harmful effects and to reduce the use of plastic toys and other products, especially local plastics having no details of additives.

AKNOWLEDGEMENT

Author and all coauthors are thankful to Prof. S.W. Akhtar, Vice Chancellor, Integral University, Lucknow, for providing facilities. Authors are also thankful to Er Adnan Habib, Mr. Imran Khan and Mr. T.A. Khan for their help and kind suggestions.

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