Toying with Toxics

AN INVESTIGATION OF LEAD AND CADMIUM IN SOFT TOYS IN THREE CITIES IN INDIA

Toxics Link
for a toxics-free world

Toxics Link
for a toxics-free world

Toying with Toxics

Summary of Findings*

AN INVESTIGATION OF LEAD AND CADMIUM IN SOFT TOYS IN THREE CITIES IN INDIA

By
Dr. Abhay Kumar – Sr. Program Officer, Chemicals and Health
Prashant Pastore – Sr. Program Coordinator, Waste Program

TOXICS LINK
Delhi. Mumbai. Chennai
India

August 2006

*For Complete Report Log on to www.toxicslink.org

Acknowledgement

The idea of the study came about through an interaction with Dr. Judy Stober, Executive Secretary of IFCS. The study objectives and methodology emerged in consultations with Ravi Agarwal.

We are most thankful to Joseph Di Gangi of IPEN for providing important insights, which proved crucial in the completion of this project.

We are also thankful to Dr. Kishore Wankhede, Coordinator, Mumbai Node, and Rajesh Rangrajan, Sr. Program Officer, Chennai Node, for their important contribution in collecting samples from Mumbai and Chennai and to Vinod Sharma for his help in collecting samples in Delhi.

Comments from Satish Sinha, Chief Programs Coordinator, and Ravi were important in further improving upon the quality of report.

Abhay Kumar
Prashant Pastore

About Toxics Link (www.toxicslink.org)

Toxics Link is an information outreach and environmental advocacy organization set up in 1996. It has a special emphasis on reaching out to grassroots groups and community based organization. The areas of its engagements include research, outreach and policy advocacy on issues of communities and urban waste, toxics free healthcare, hazardous waste and pesticides.

Toxics Link works closely with community groups and NGOs working on similar issues and has been conducive to the formation of several common platforms for these issues. It also networks internationally and is part of international networks working on similar issues.

The overall mission/mandate and objectives of the organization
"Working together for environmental justice and freedom from toxics. We have taken upon ourselves to collect and share both information about the sources and dangers of poisons in our environment and bodies, and information about clean and sustainable alternatives for India and rest of the world"

Delhi Address:
H-2 Jangpura Ext.
New Delhi – 110014, India
Phone + 91 11 24328006/ 23420711 fax: +91 11 24321747
info@toxicslink.org

Introduction

Toys can broadly be categorized as mechanical toys, electrical toys and soft toys. According to available figures, the global toy market presently is of the order of US$105.0 billion. USA is the world's biggest importer of toys (imports worth US$35.0 billion) having a market share of approximately 30%. This is followed by Germany, which provides for 18% of the world market (US$19.0 billion), succeeded by Hong Kong 13% (US$14.0 billion), with Britain coming next at 7% of the global market (US$8.0 billion) and France contributing 6% (US $ 6.5 billion) (1).

Toys made up of PVC (Polyvinyl Chloride, CH2=CHCl) are a potential source of risks to children. Polyvinyl Chloride, a leading chlorine containing plastic, is a polymer, or large chain-like molecule, made up of repeating units of Vinyl Chloride (a monomer), commonly referred to as Vinyl or PVC. It is one of the most commonly used materials in the consumer marketplace. 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 PVC, which causes a chain reaction and proceeds rapidly to completely loose strength (causing damage to manufacturing equipment as well). Lead or cadmium is hence added to PVC as stabilizers, to prevent the free chlorine radicals from reacting with hydrogen radicals to form HCl. (2) 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, which include Cd, Zn, organotins etc. Lead and cadmium are also added into PVC or other plastic products as colouring agents in form of organo-metallic compounds. What is noteworthy here is that, unlike popular perceptions, metal stabilizers are not bound to the polymer, but freely available to leach out over time or in response to light, chewing etc. So toys made up of PVC when chewed or sucked by children put them at a risk of severe exposure to lead and cadmium.

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. (3) However, it is widely believed that industry had knowledge of this problem through their internal studies for a much longer time. This study was initiated after health department officials failed to locate the known sources of lead poisoning in children from Arizona, North Carolina and Virginia. In fact they found the source to be rigid vinyl mini blinds in the children's rooms, which had very large amount of lead dusts on blinds and windowsills. Children were exposed to lead upon chewing it. A Greenpeace study on lead and cadmium contents in PVC (polyvinyl chloride) toys collected from USA markets raised concerns about children's health. (4) It found significantly high concentrations of lead and cadmium in a significant number of samples of PVC toys. It also found high concentrations of lead and cadmium in their leachates. The chewing and swallowing of toys by children is a common path for lead and cadmium exposure. The leaching study was carried out to imitate normal behaviour by keeping the commonly chewable toy products in mildly acidic conditions at body temperature. Lead and cadmium concentrations were, then, determined in the leachates.

Lead and cadmium are 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. Physicians and scientists agree that no level of lead in blood is safe or normal. 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. Another problem of lead exposure is it being cumulative in nature. After lead is absorbed into blood, some of it is filtered out and excreted, but the rest is distributed in the liver, brain, kidneys and bones. What's more disturbing is what happens when lead gets into the bones. Bone stores lead and stay there for decades. It 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.

Rationale of the Study

Although numerous epidemiological studies have been carried out on the health impacts of lead on children in India, very little has been done to ascertain its source in children's environment. (5, 6, 7) Lead as a source has mostly been studied in aerosols or atmosphere or in paints (8, 9, 10, 11). Toys, particularly soft toys, which are intimately linked to children's environment, have not been investigated as one of the possible sources of lead, cadmium and other heavy metals exposure to children.

Moreover, India now produces and imports a wide range of toys, namely plastic and mechanical activity toys, plastic and soft dolls, stuffed toys, board games, puzzles, educational games and toys, metal and tin toys, electronic toys and games. The unorganized sector dominates the toy manufacturing industry. It is estimated that the industry volume is US $1.0 billion in the organized sector and about US$1.5 billion in the unorganized sector. (12) There are more than 1000 units in the small-scale sector and a larger number in the cottage sector and labour intensive and hence also suitable for a large country like India. Some multi national corporations (MNCs) like Mattel, Lego and Funskool are also present in India. Soft toys account for 35 per cent of India's total production of toys (13).

Objectives of the Study

1. To ascertain the total contents of lead and cadmium in the sampled PVC toys and other soft toys collected from three metropolitan cities of Delhi, Chennai and Mumbai
2. To understand the usage of toys and the potential risks involved.

Methodolgy

Sampling: The samples of toys were collected from the three metropolitan cities of India viz. Mumbai, Delhi and Chennai. These cities were identified for the sample selection, as they are one of India's largest manufacturer and supply centres for unbranded toys to their surrounding sub-urban and rural areas. Mumbai and Delhi account for nearly 95% of the toy output in India (14). All the samples from Delhi, Mumbai and Chennai were brought to one place (Toxics Link head office) in Delhi.

Lab Methodology

All toy samples were brought to a laboratory for further tests. The lab tests were carried out in DTH (Delhi Test House), an NABL (National Accreditation Board for Testing and Calibration Laboratories, Department of Science and technology, Government of India) accredited laboratory in Delhi. All toy samples were first tested for PVC using the Beilstein test. The Beilstein test is based on the principle that copper halides vaporize readily, giving off a blue-green colored flame owing to the presence of copper. (15) All toy samples, which tested positive for PVC, were further tested for total contents of lead and cadmium. A few non-PVC toy samples were also tested for the total content of lead and cadmium. The methodology included subjecting samples first to ashing to breakdown the PVC and then digesting in accordance with EPA SW-846 3050 (digestion with Nitric Acid and Hydrogen Peroxide) (16). The final processed samples were quantitatively analyzed in AAS (GBC 632+) with graphite furnace. The instrument was first calibrated with standards prepared from stock solution provided by Merck.

Results

The average, range and standard deviation of this set of data are presented in table 1.

Table 1. Average, range and standard deviation of Pb and Cd concentration related data (ppm)				
		Delhi		
	Average	Max	Min	Std dev
Pb	27.8	121.8	0.65	23.49
Cd	26.53	188	0.016	48.98
		Chennai		
	Average	Max	Min	Std dev
Pb	20.67	51.3	4.9	13.88
Cd	3.10	14.5	0.16	4.48
		Mumbai		
	Average	Max	Min	Std Dev
Pb	278.73	2104	1.68	512.03
Cd	2.61	11.6	0.03	2.76
		All		
	Average	Max	Min	Std Dev
Pb	112.51	2104	0.65	319.64
Cd	15.71	188	0.016	37.98

Discussion

General

Of 111 toy samples tested, 77 were found to be made up of PVC materials while 34 toy samples were non-PVC plastic materials. Forty-three out of 60 toy samples purchased from Delhi tested positive for PVC, while all 30 toy samples purchased from Mumbai tested positive for PVC. Chennai samples had only 4 out of 21 toy samples testing positive for PVC.

A total of 88 samples (77 PVC and 11 non-PVC) were further analysed for lead and cadmium. Pb (lead) and Cd (cadmium) are found to be present in all tested samples in varying concentration. Thus the study establishes that Indian unbranded PVC toys do contain lead and cadmium. Since the study concentrated on non-branded toys nothing can be said about the branded ones at present juncture.

In the present study two standards for lead in toys have been taken for discussion. One is 600 ppm as the limit for lead in painted toys as prescribed by US EPA (Environmental Protection Agency) and another is 200 ppm for lead in vinyl blinds as prescribed by Consumer Products Safety Commission (CPSC), USA. India does not have a standard for the total content of lead and cadmium in toys. The Indian standard is with respect to bioavailability of lead and cadmium, which is only voluntary in nature. The state of California has recognized cadmium as a carcinogen under Proposition 65 in 1987. (17) The no-significant risk for cadmium dust was set at 0.05 µg/day, which is one-tenth the level set for lead.

Lead in toy samples

The average concentration of Pb (lead) is found to be least in the toys from Chennai (3.10 ppm). It may be due to fewer toy samples (n = 11) being analysed for Pb and Cd in comparison to that of Delhi and Mumbai. Cadmium concentration is generally lower than that of Pb in toys across the region. However, concentration of Cd is generally high in samples from Delhi. In fact the maximum for Cd (188 ppm) is higher than that of Pb (121.8 ppm). It is also observed in Delhi samples that cadmium concentration is higher in some of the samples, which have lower Pb concentration. Although the correlation coefficient between Pb and Cd in Delhi samples is not statistically significant (-0.0378), it may still be argued that it is either Pb or Cd, which is used as stabiliser in toys or a combination of pigments and poor quality control. If lead is high then cadmium is low and vice-versa. Similar but even weaker correlation is found between Pb and Cd in Mumbai samples (correlation coefficient: -0.01385). The weak negative correlation may be due to other source of lead and cadmium in toys, that is from the surface coatings of paints. However, overall Pb (lead) seems to be largely in use as stabliser in the PVC toy manufacturing. The Cd concentration is found to be low in the samples brought from Mumbai and Chennai. However, this requires further study of the manufacturing processes to confirm this heterogeneity in the lead and cadmium concentration in toys across the country.

Lead concentration is very high in Mumbai samples. Pb concentration is very high. In fact Mumbai average (278.3 ppm) is higher than that of national average (112.51 ppm). It is interesting to find that these toys from Mumbai cater to the demands of surrounding sub-urban and rural centers. There is not any demand locally. What is crucial to note here is that out of 30 samples analysed for total concentration of Pb and Cd in toys brought from Mumbai, eight samples showed concentration higher than 200 ppm, which is the limit proposed by Consumer Product Safety Commission (CPSC) in vinyl blinds. (18). In fact five samples (close to 20 percent of Mumbai samples analysed) showed very high lead concentration (from 878.6 ppm to 2104 ppm) even exceeding US EPA limit of 600 ppm in painted toys. Such high quantities of lead in toys pose a real threat to children's health. It must be noted here that exposure from lead is in addition to that of cadmium. Hence children playing with toys having both lead and cadmium have a combined exposure from both toxic metals. This is an important concern and any regulatory mechanism must take this into account.

Cadmium in toy samples

Cadmium in toy samples varies from 0.016 ppm to 188 ppm. Five toy samples (from Delhi) have more than 150 ppm of cadmium. Overall seven samples (all from Delhi) have more than 50 ppm of cadmium. Cadmium concentration is low in rest of the samples.

Lead and Cadmium in non-PVC toy samples

Lead and cadmium were found in non-PVC plastic toys as well. Lead concentration in non-PVC materials ranged from 22.4 ppm to 56.2 ppm in Delhi toys while it varied from 11.4 ppm to 32.4 ppm in Chennai toys. Similarly total cadmium concentration varies from 8.74 to 16.35 ppm in Delhi toys and 0.21 ppm to 14.5 ppm in Chennai toys. Not much can be said about the occurrence pattern of lead and cadmium in non-PVC plastic toys as only 11 samples of non-PVC toys were analysed. Incidence of lead and cadmium in non-PVC toys may be ascribed to surface coatings by paints containing lead and cadmium. However, it must be said here that high concentrations of lead were found only in PVC toys.

Toxicity from PVC toys

It must be kept in mind that lead and cadmium exposure from PVC toys are in addition to exposure from phthalates esters, which act as plasticisers to make PVC soft and pliable. Phthalates migrate easily out of the PVC polymer since it is not at all bound to the PVC molecule. Mechanical stress (bending, pressure, chewing), solvents such as fats, oils, saliva and temperature over 850F cause phthalates to migrate out of PVC. (19) Phthalate toxicity is again cumulative in nature and causes liver damage. (20) It is obvious here that PVC by nature is chemically dependent and by itself PVC is of no use.

Uncertainties Related to the Standards

Defining standards is a first step in any regulatory mechanism and prevention is the key to safe environmental health. Unfortunately India does not have an enforceable standard for the total content of lead, cadmium and other toxics metals in toys. Whatever standard India has in this regard is with respect to migratory elements from toy materials, which has been adopted from European Union safety requirements (BS EN 71-3:1995) and International Standards (International Organization for Standardization, ISO 8124-3:1997 Migration of Certain Elements). This is only voluntary in nature. Manufacturers have to comply with this standard only when they export toys to Europe or other countries. A standard, which is voluntary in nature, cannot be termed as standard. It is rather perturbing, that an important policy feature relating to crucial implications for children's health has not been given due consideration, as yet.

The Indian Standard								
Toy Material	Element (ppm)							
	Sb	As	Ba	Cd	Cr	Pb	Hg	Se
Any toy material given in clause 1, except modeling clay and finger paint	60	25	1000	75	60	90	60	500
Modeling clay and finger paint	60	25	250	50	25	90	25	500

Source: Indian Standard SAFETY REQUIREMENTS FOR TOYS Part 3 Migration of certain elements (First revision) IS 9873 (part 3): 1999, Bureau of Indian Standards, 1999

EU or ISO standards are the same as above. EU also addresses the maximum daily intake of lead and cadmium. In particular, for the protection of children's health, bioavailbility resulting from the use of toys must not, as an objective, exceed 0.6 microgram for Cd and 0.7 microgram for lead per day. (21) A crucial shortcoming of these standards is the absence of any correlation between the bioavailable elements and their total content in toys. The scientific community is still grappling with this and there seems to be no agreement. However, the Health and Consumer Protection Directorate-General of European Commission appointed a scientific committee on toxicity, ecotoxicity and the environment (CSTEE) on assessment of the bioavailability of certain elements in toys. (22) This committee gave its comments on a number of questions including on choice of elements, basis for assumption on total daily intake from toys and consideration of bioavailability. This committee was of the opinion that besides As, Ba, Cd, Cr, Hg, Pb, Se and Sb; Ni should also be included under regulatory mechanism. This committee also opined that to ensure a high level of protection of young children the maximum limits set for migration should be set at a lower value to ensure the maximum allowed daily intake of the selected eight elements is achieved in practice. It also said that bioavailability should be defined not as soluble extract having toxicological significance but as the amount of each element in the toy which could be absorbed into the systemic circulation of a child. Based on these considerations it recommended 87.5 ppm of bioavailable lead instead of earlier limit of 90 ppm. However, as stated earlier, any level may be considered too high for children.

Preventive Approaches Needed

India as a state must provide safe environment to children so that they are not exposed to toxic chemicals. As discussed earlier this can only be achieved by implementing a robust regulatory mechanism and a preventive approach. The presence of heavy metals like lead and cadmium in toys poses equally damaging threat to the environment as these heavy metals ultimately end up being locked in soil and the air. A poor state of affairs of solid waste management make this even more damaging. Burning toxic toys results in releases of dangerous toxics like dioxins. PVC is known for releasing dioxins upon burning. Since no level of lead and cadmium should be considered safe in toys and hence all attempt must be made to replace materials having toxic potential by safer materials without heavy metals or other leachable chemicals.

Conclusion

Lead and cadmium were found in varying concentration in all toy samples especially PVC samples. Five samples (close to 20 percent of Mumbai samples analysed) showed very high lead concentration (from 878.6 ppm to 2104 ppm) even exceeding US EPA limit of 600 ppm in painted toys, which poses real threat to children exposed to such toys. The fact that these toys were made to look attractive to children make it even more sinister.

In the absence of any leaching studies it is difficult to ascertain the levels of exposure unbranded toys available in India can cause to children. However, with all toy samples containing lead and cadmium in varying concentration and some even showing very high lead concentration, it does indicate that Indian toys pose a worrying and potential risk to children's health. Extreme weather conditions and the fact that poor families, owing to sheer economic issues, tend to keep the same toys for longer periods further compounds the problem. A lack of any enforceable mechanism makes this even worse.

References

1. Project Brief of Trust Fund Agreement between The United Nations Industrial Development Organisation and Ministry of small scale industries and agro and rural industries, Government of India, July 2000
2. Tuczai, E., Corolano, F. Reformulating PVC to eliminate heavy metals and protect performance. Modern plastics p 123-124. 1992
3. http://www.turnertoys.com/PVC_framepage1.htm (accessed in Julyt 2006)
4. Di Gangi Joseph. 1996. Lead and Cadmium in Children's Vinyl products, A Greenpeace Study. http://composite.about.com/gi/dynamic/offsite.htm?site=http://www.greenpeaceusa.org (accessed in June 2006)
5. Sharma, Mukesh., Mayank Maheshwari, and S. Morisawa. Dietary and Inhalation Intake of Lead and Estimation of Blood Lead Levels in Adults and Children in Kanpur, India. Risk Analysis, Vol. 25, No. 6, 2005
6. Krishnamurti, C. R., & Vishwanathan, P. (1991). Lead in the Indian environment and its human health implications. In C. R. Krishnamurti & Pushpa Vishwanathan (Eds.), Toxic Metals in the Indian Environment. New Delhi: Tata McGraw-Hill.
7. Basu, K., Mondal, R. K., Banerjee, D. P. 2005. Epidemiological aspects of acute childhood poisoning among patients attending a hospital at Kolkata. Indian Journal of Publci Health. Vol. 49. No. 1.
8. Tripathi, R. M., Raghunath, R., & Krishnamoorthy, T. M. (1997). Dietary intake of heavy metals in Bombay city, India. The Science of the Total Environment, 208, 149–159.
9. Malviya, R., & Wagela, D. K. (2001). Studies on lead concentration in ambient air, roadside dust and its influence on the healthy traffic police personnel at Indore city. Pollution Research, 20 (4), 635–638.
10. Sharma, M., & Maloo, S. (2005). Assessment of ambient air PM10 and PM2.5 and characterization of PM10 in the city of Kanpur, India. Atmospheric Environment, 39, 6015–6026.
11. Clark, C.S., K.G. Rampal, V. Thuppil, C.K. Chen, R. Clark and S. Roda. September 2006, Pages 9-12. The lead content of currently available new residential paint in several Asian countries Environmental Research Vol. 102, Issue1
12. Project Brief of Trust Fund Agreement between The United Nations Industrial Development Organisation and Ministry of small scale industries and agro and rural industries, Government of India, July 2000
13. Ibid
14. Ibid
15. .Mohrig, J. R.; Hammond, C. N.; Morrill, T. C.; Neckers, D. C. Experimental Organic Chemistry; W. H. Freeman and Company: New York, 1998; pp 535–536.
16. http://www.epa.gov/epaoswer/hazwaste/test/pdfs/3050b.pdf
17. Reproductive and Cancer Hazard Assessment Section, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency. Draft. Evidence of development and reproductively toxicity of cadmium. 1996
18. US Consumer Product Safety Commission. Memo from A. Schoem, Office of Compliance to P. Rush, executive director, Window Covering Safety Council. July 16, 1996
19. http://www.turnertoys.com/PVC_framepage1.htm (accessed in June 2006)
20. Ganning A.E., Brunk U., Dallner J. (1984) Phthalate Esters and their Effect on the Liver. Hepatology V4 No 3, Pp 541-547
21. http://europa.eu.int/eur-lex/en/consleg/pdf/1988/en_1988L0378_do_001.pdf (accessed in August 2006)
22. http://ec.europa.eu/health/ph_risk/committees/sct/documents/out235_en.pdf (accessed in August 2006)