Toying with Toxics

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

Toxics Link
for a toxics-free world

Toying with Toxics

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

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

TOXICS LINK
Delhi. Mumbai. Chennai
India

August 2006

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, Director, Toxics Link.

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, Toxics Link and Rajesh Rangrajan, Sr. Programme Officer, Chennai Node, Toxics Link 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 Programme Coordinator, Toxics Link and Ravi Agarwal 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 organisation set up in 1996. It has a special emphasis on reaching out to grassroots groups and community based organisation. 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 organisation
"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

Contents

Foreword

The study idea emerged from discussions with Dr. Judy Stober, Executive Secretary of IFCS, to contribute towards ongoing discussions on children and environmental health concerns. It is of great importance that this particular issue is gaining recognition of late, since this section of our population is highly vulnerable to the impacts of toxics and the extent of the problem is relatively unchartered. This is probably the first study of its kind carried out in a developing country.

Toxics Link, located in India, a country fast developing in terms of economic growth, has an ongoing focus on heavy metals. This is from our understanding that this class of pollutants is important to tackle in the context of a developing society, where the problem is only slowly being recognized. Also the presence of heavy metals in everyday use, such as in batteries, thermometers, paints, toys, food, plastics, alloys etc. is very widespread and probably causes exposures to large numbers of people. We have been specifically researching and working on areas of migration of heavy metals like lead and cadmium in vegetables, as well as use of mercury in various sectors like lighting, chlor alkali, healthcare and traditional medicines. Many reports are available on our website www. toxicslink.org.

It was hence important and appropriate that we examine the issue of lead and cadmium in toys, since a large number of them are imported into India, cheaply, or are made in the informal sector, with little or no quality control. It is common to see small children and infants chew and play with soft plastic toys, which are the subject of this investigation.

We hope this study, will help trigger off larger investigations both in the amounts of heavy metals as well as the exposure they cause to children. We would like to thank the whole team at Toxics Link, in its three offices in the country and to all those who commented on the study.

Ravi Agarwal
Director

Executive Summary

Opportunities and challenges of a globalised world have made India strive to gain foothold in the toy industry globally. 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 per cent. This is followed by Germany, which provides for 18 per cent of the world market (US$19.0 billion), succeeded by Hong Kong 13 per cent (US$14.0 billion), with Britain coming next at 7 per cent of the global market (US$8.0 billion) and France contributing 6 per cent (US $ 6.5 billion).

The unorganised sector dominates the toy manufacturing industry in India. It is estimated that the industry volume is US $1.0 billion in the organised sector and about US$1.5 billion in the unorganised sector. There are more than 1000 units in the small-scale sector and a larger number in the cottage sector, which is labour intensive and hence considered suitable for a poor country like India. Some Multi National Corporations (MNCs) (like Mattel) are also present in India.

Soft toys account for 35 per cent of India's total production of toys. Mumbai and Delhi account for nearly 95 per cent of the toy output. India has nearly 130 millions plus children below six years of age, who are the prime users of toys. More than 6 million children are living in slums in the country and they constitute 16.4 per cent of the total child population making every sixth urban child in the country in the age group 0-6 a slum dweller, all potential users of cheap plastic toys.

This makes it imperative to study and understand the toxic contents of toys since it concerns the future of children. It is widely accepted that no level of lead or cadmium in blood shall be considered as safe for children and hence every effort should be made to ensure that their environment remains free of any threat to exposure from any toxics metal. Children and pregnant women are especially vulnerable to lead poisoning. It also affects the cognitive function of brain. Therefore, toys, which form an important component of children's immediate environment, must be examined to find the toxic contents in it.

The present study was undertaken primarily with an aim to ascertain the levels of total lead and cadmium in PVC and non-PVC toys. Lead and cadmium can act as stabilizers in PVC toys. They can also be used in pigments to impart bright colours to them in order to attract children. In this study, a total of 111 non-branded toy samples were purchased randomly from three metropolitan cities of Delhi, Mumbai and Chennai, which were then sent to Delhi Test House*, a Delhi based NABL (National Accreditation Board for Testing and Calibration Laboratories, Department of Science and Technology, Government of India) accredited laboratory, for further analysis.

Findings

- Out of 111 toy samples tested for chlorine (Beilstein test), 77 were found to be made up of PVC materials while rest 34 toy samples were made up of non-PVC plastic materials. 43 out of 60 toy samples purchased from Delhi tested positive for PVC, all 30 toy samples purchased from Mumbai tested positive for PVC while Chennai samples had only 4 toys out of 21 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) were found to be present in all tested samples in varying concentrations.
- The overall average concentrations of lead and cadmium are 112.51 ppm and 15.71 ppm respectively. The range for lead concentration in tested samples was 2104 ppm to 0.65 ppm. For cadmium, the range was from 0.016 ppm to 188 ppm.
- 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. Five samples (close to 20 percent of Mumbai samples analysed) showed very high lead concentration (from 878.6 ppm to 2104 ppm) even exceeding the US EPA limit of 600 ppm in painted toys.

*Delhi Test House , A 62/3 G.T.Karnal Road , Azadpur , Delhi-110033.

Recommendations

The present study clearly demonstrates that soft plastic toys in India do contain lead and cadmium. Some even have very high concentrations. It does establish problems of toxic metals in toys. As stated earlier, there is no safe limit of toxic contents in toys. The entire issue of standards needs to be re-visited. No amount of lead or cadmium be allowed in toys. Standards need to be made compulsory in order to make toy manufacturers strictly adhere to it. The concern is higher for PVC toys since the plastic allows for easy leachability and also has other additives such as phthalates.

Introduction

Toys are an integral part of children's developmental processes. Children play with toys and learn about the world. Besides providing entertainment to children, toys also serve as educational materials for them. Wikipedia defines a toy as something used in play by children, adults or pets [1]. Unlike games, toy-play does not have any clearly defined goal. Many items are manufactured to serve as toys, but any other items can also be used as toys depending upon children's imagination and perception. The history of toys is as old as the history of human civilisation. Toys have also been unearthed from the sites of ancient Indus Valley civilisation.

Toys can broadly be categorised 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 per cent. This is followed by Germany, which provides for 8 per cent of the world market (US$19.0 billion), succeeded by Hong Kong 13 per cent (US$14.0 billion), with Britain coming next at 7 per cent of the global market (US$8.0 billion) and France contributing 6 per cent (US $ 6.5 billion) [2]. India's export-import figures of toys are given in annexure I and II.

A toy may mean different things to children of different age groups and hence exposure pathways also differ accordingly. A child of below 3 years may handle a toy in a completely different manner from a child of 3-6 years age group, for example. Toys may also inflict accidental injuries to children. Sharp edges of toys or other electrical, mechanical or flammable characteristics may cause accidents. Chemical exposure to children, especially from toys, is an emerging concern. Children suck toys or sometimes chew them resulting in ingestion of harmful substances. Even short-term exposure of such chemicals may cause severe and long-term impacts on children's health. Toy manufacturers add bright colours to toys to attract children. These only compound the problems as most of these colours are organo-metallic compounds and are added to toys during the last stage of manufacturing. Metals in materials and paints are loosely bound to the surface and can leach easily.

However, with toxic chemicals, both organic and inorganic, in children's immediate environment has come into the focus of both environmentalists and medical scientists. Environmental hazards and their impacts on children's health is an emerging area of modern public health science. It goes without saying that children's health, both physical and mental, are important for society and for the future generations, and the state must ensure that children's immediate environment remains free of toxic chemicals.

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 market. It is used in packaging, construction and automotive material, all categories of products, including toys, and medical equipments. 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 stabilisers, to prevent the free chlorine radicals from reacting with hydrogen radicals to form HCl. [3]. Lead compounds are the most common stabilisers 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, Zinc, 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 stabilisers 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. [4]. 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 toys collected from USA markets raised concerns about children's health. [5]. 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.

Health Impacts of Lead and Cadmium

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 reenter the body when bone breaks down as part of a regular metabolic process or due to some specific physiological conditions like osteoporosis, causing reexposure.

Lead

Children and pregnant women are particularly susceptible to lead poisoning. Children's digestive systems absorbs up to 50 per cent of the lead they ingest. [6]. The high retention occurs from birth to the age of 6 years, when the brain is developing. Lead interferes with its development. By the time physical symptoms are evident - headache, lethargy or hyperactivity, nausea, stomach aches, vomiting, and constipation - significant brain damage has probably already occurred.
Abdominal pain, vomiting and constipation helps greatly to differentiate lead from infectious disease that cause similar symptoms and are common, but result only in diarrhoea. Children pick up lead dust from the floor, from toys and pets, from house paints and from vinyl blinds. They ingest lead when they put their hands in their mouths, when they eat with their hands, when they suck their thumb and when they ingest soil. Blood lead levels in children of around 10 µg/dl are associated with disturbances in early physical and mental growth and in later intellectual functioning and academic achievement. These effects persist into adulthood and may be irreversible.

In fact no level of lead in blood is safe. [7]. 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 µg/dl was actually 60 µg/dl in sixties and then it was brought down to 30 µg/dl in seventies, which was again revised in 1985 to make it 25 µg/dl only to be revised again in 1991 as 10 µg/dl as the safe limit. [8]. Progressive elevation of blood lead levels in a child's system can cause a potential genius to drop to an average achievement level and an average child to become learning disabled. The foetuses of pregnant women are severely affected by lead exposure since lead can pass through the placenta directly into the baby. When an expectant mother maintains a poor diet, the problem is compounded since she will start breaking down bone to release calcium and other minerals, thereby releasing lead stored in the bones, which passes to the developing baby. High lead exposure could also result in fetal death. The World Health Organisation (WHO) estimates that 15-18 million children in developing countries are suffering from permanent brain damage owing to lead poisoning. [9]. Hundreds of millions of children and pregnant women in practically all the developing countries are believed to be exposed to elevated levels of lead.

Cadmium

Human uptake of cadmium takes place mainly through food. Foodstuffs that are rich in cadmium can greatly increase the cadmium concentration in human bodies. An exposure to significantly higher cadmium levels occurs when people are exposed to tobacco smoke either directly or indirectly, since tobacco smoke transports cadmium into the lungs. Blood will transport it through the rest of the body where it can increase effects by potentiating cadmium that is already present from cadmium-rich food.

Cadmium is first transported to the liver through the blood. There, it bonds to proteins to form complexes that are transported to the kidneys. It accumulates in kidneys, where it damages filtering mechanisms. This causes the excretion of essential proteins and sugars from the body and further kidney damage. It takes a very long time before cadmium that has accumulated in kidneys is excreted from a human body. Cadmium dust (cadmium oxide, CdO) is another source for cancer in human beings[10]
Cadmium when released as fine airborne particles then reacts almost immediately with oxygen to form respirable cad - mium oxide, which is a carcinogen. It is important to mention that PVC releases its metal stabilisers as dust on its surface.

Other health effects that can be caused by cadmium are:

- Diarrhoea, stomach pains and severe vomiting
- Bone fracture
- Reproductive failure and possibly even infertility
- Damage to the central nervous system
- Damage to the immune system
- Psychological disorders
- Possibly DNA damage or cancer development

Exposure Pathways

The chewing and swallowing behaviour of children is a common source of lead and cadmium exposure. However, swallowing is not even necessary for exposure. Simply chewing and sucking on plastic cables is a known source of lead poisoning[11]. Lead and cadmium contaminated dust is another source of exposure and is especially dangerous as it can enter into the body in multiple ways. Routes of ingestion include licking, sucking, mouthing, inhalation and hand-to-mouth behaviour. Another source of exposure to lead and cadmium can be the toxic dust released during the degradation of vinyl children's products. So a child may simultaneously be exposed to toxic metals like Pb and Cd through various sources. A standard or regulation for an individual product based on its risk assessment may not match with the reality.

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. [12, 13, 14]. Lead as a source has mostly been studied in aerosols or atmosphere or in paints [15, 16, 17, 18]. 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 or 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 unorganised sector dominates the toy manufacturing industry. It is estimated that the industry volume is US $1.0 billion in the organised sector and about US$1.5 billion in the unorganized sector. [19]. 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 (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 [20].

The absence of any study on lead and cadmium content in toys coupled with the fact that the soft toys dominate the toy industry, led us to this study on non-branded on non-branded, cheap soft toys probably used by the bulk of the bulk of the chldren in India.

Objective 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.

Methodology

The present study has used following methods:

1. Collection of sample
2. Identification of PVC toys
3. Laboratory analysis for lead and cadmium

Sampling

The samples of toys were collected from the three metropolitan cities of India viz. Mumbai, Delhi and Chennai. (Fig 1.) These cities were identified for the sample selection, as they are 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 per cent of the toy output in India [21]. All the samples from Delhi, Mumbai and Chennai were brought to one place (Toxics Link head office in Delhi). These samples were then codified based on their place of purchase (see annexure III).

Challenges of Sampling

One of the challenges of collecting PVC toys from markets was to identify PVC materials. PVC has a typical 'shower-curtain' smell. Shopkeepers were often alarmed when toys were smelt by the researchers before purchasing. However, they cooperated fully on being told about the study. In fact, most of our understanding on the state of the local market for toys were based on inputs provided by these shopkeepers.

Only cheap toys were purchased within the price range of Rs 10-100 (approximately 30 cents to US$ 3). They mostly cater to the needs of children of poor families. It was also found that poor economic conditions forced these families to use same toys from the one child to the next resulting into enhanced risks from ageing toys. Toys purchased were mostly of bright colours of green, red and yellow, which presumably are used to attract young kids. Most of them were of common pets, birds and human beings in different forms. Dolls seemed to be the most popular toy in the market.

A total of 111 (One hundred and eleven) toy samples were purchased from three metropolitan cities- 60 from Delhi, 30 from Mumbai and 21 from Chennai.

Toy Market Scenario in Three Metro Cities

PVC Toys in Mumbai

The plastic toy market of Mumbai is a huge one as the city is a regional hub for them. Plastic toys from here are supplied to the surrounding sub-urban areas of Mumbai and other parts of Maharashtra and Gujarat. The toys market is located near the famous Crawford Market of Mumbai around Abdul Rehman Street. It's a wholesale market for toys. The market stocks all types of toys, made of plastics, cloth, rubber, etc. Most of the soft toys are made up of PVC. As per the traders in Mumbai market, Chinese dominate the toy market and after that comes the toys manufactured in Delhi.

Surprisingly, the shopkeepers seem to be aware of the terms such as 'toxic' and 'non-toxic', and also about the leaching of plastics. Thus they sell less smelly toys to aware consumers. The toys made of PVC and with a foul smell are generally very cheap and distributed to markets in small towns such as Satara, Miraj, Solapur, etc. A toy is priced as per its shape and size, for example, a doll can cost from Rs. 10 (30 cents) to Rs.100 rupees (approx USD 3) depending on its shape and size.

PVC Toys in Delhi

There exists a huge toy market in Delhi. Toys are manufactured here and supplied not only locally but also to other States and cities of India including Mumbai and Chennai. Here, the key market for unbranded toy is located in Sadar Bazaar (Chandni Chowk- Old Delhi). This is one of the major wholesale markets, not just for Delhi but also for other surrounding States as well. These unbranded toys have a huge demand in the economically lower income groups. This section of the population lives in various resettlement and slum• colonies. The typical market structure of toys in Delhi has Sadar Bazar in Old Delhi as its central point. From here small shopkeepers, street vendors and individuals form a parallel chain of supply in different areas and localities. These toys are then sold in the market located near or within the poor localities. Conversation with some of the toy sellers revealed that these toys are in greater demand in poor and rural communities than in higher income group. This is one of the main reasons that these toys are absent from up-market shops, where only branded toys are sold. Over 40 per cent of Delhi's 15 million populations would classify in the poorer income category.

PVC Toys in Chennai

Interviews with shopkeepers here revealed that most of the toys of Chennai are imported from China. However, there is a considerable market of unbranded toys arriving from Delhi and Mumbai. There are also some large shop owners who have their own manufacturing units in and around Chennai and Pondicherry. The local toy manufacturers are located in the areas of Kodungaiyur, Ambattur and Vyasarpaadi. Kodungaiyur has around 100 toy manufacturing units. Like in Mumbai and Delhi the unbranded toys market largely caters to the poor localities and rural areas of Tamil Nadu.

Underprivileged Population of Delhi, Chennai and Mumbai

According to the census of India 2001, Mumbai alone hosts more than half of its inhabitants (54.5 per cent), in slums•. [22]. Mumbai slum dwellers form the largest group of people among the metropolitan areas of India. Delhi is the capital of India

---

• Govt of India has adopted the definition of 'Slum' areas as follows: -
a. All areas notified as 'Slum' by State/Local Government and UT Administration under any Act;
b. All areas recognised as 'Slum' by State/Local Government and UT Administration, which have not been formally notified as slum under any Act;
c. A compact area of at least 300 population or about 60-70 households of poorly built congested tenements, in unhygienic environment usually with inadequate infrastructure and lacking in proper sanitary and drinking water facilities

and its urban population as per Census 2001 was about 13 million with nearly 40 per cent of its population living in slum. In Chennai, nearly 26 per cent of the population lives in slums and as urban squatters. India has nearly 130 million children below six years of age, the population which could be the prime users of toys.

Around 2.5 million children in the age group 0-6 are living in the slum areas of million plus cities, which constitutes 27.3 per cent of the total child population of these 27 cities. In Greater Mumbai alone, the number of children in the age group 0-6 are 0.86 million (13.2 percent of cities total child population) followed by 0.3 million (16.2 percent of total child population) in Delhi. The child population in slums to the total child population in Chennai is 11.5 percent.

Toys' Description

All types of toys were purchased from the locations specified. The toys were typically bright in colour and are available in largely darker shades of red, yellow, purple and green or a mix of these colours. Almost all of these toys were soft and easily squeezable. The main types of toys were replicas of fruits, animals, baby, dolls and birds. Some of them were replicas of attractive eatables such as cakes, pastries, etc.

Lab Methodolgy

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.

Test for PVC

All toy samples were first tested for PVC using the Beilstein test. The Beilstein test is based on the principle that copper halides vapourise readily, giving off a blue-green colored flame owing to the presence of copper. [23]. To perform this test, copper wire (18-20 gauge), inserted into a cork (which served as an insulated handle), was heated in a blue Bunsen burner. The hot wire was touched to an inconspicuous part of the plastic toy to be tested in order to melt some of the polymer onto the wire; and then the wire was reheated in the flame. A blue-green coloured flame, which persisted only a few seconds, indicated the presence of a halogen (excluding fluorine) and suggested that the polymer was PVC.

Test for Lead and Cadmium

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) (24). The step-wise methodology for quantitative estimation of lead and cadmium in PVC toys are as follows:

1. 2 gm of sample was weighed and taken in a silica Crucible and then charred on a hot plate till fumes ceased.
2. Next the crucible was kept in a muffle furnace at 480^0 C for 4 hrs. for complete ashing.
3. Subsequently crucible was taken out of the furnace and kept in desiccators for cooling.
4. After cooling, samples were powdered and homogenised in the silica crucible.
5. Samples were then acid digested. Supra-pure Merck (lead and cadmium free) nitric acid and hydrogen peroxide were used for digestion in an open vessel.

6. After complete digestion, samples were transferred to 100 ml Tarson bottles and the volumes were made upto 100 ml.
7. Blank samples were also similarly prepared.
8. Standards were prepared with serial dilution technique within the range of 10-30 ppb (for lead) and 10-50 ppb for cadmium. The stock solutions of standards were NIST certified and provided by Merck.
9. The final processed samples were quantitatively analysed in AAS (GBC 932+) with graphite furnace. The instrument was first calibrated with standards prepared from stock solution provided by Merck.

Data Processing

Data was processed in MS Excel for making graphs. SAS software was used for determining some common statistical parameters and frequency distribution figures.

Results

The data related to total concentration of Pb and Cd in toy samples are given in annexure IV. Graphical representations of the same data are presented in figures 2, 3 and 4 for three different cities Delhi, Chennai and Mumbai respectively. The average, range and standard deviation of this set of data are presented in table 1. Frequency distribution of Pb and Cd concentration in samples from Delhi, Mumbai and Chennai has been depicted in figure 5, 6, 7, 8, 9 and 10.

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

Fig 1: Sampling locations

Fig 2: Pb (ppm) and Cd (ppm) Total Pb (ppm) and Cd (ppm) Concentration in Toy Samples from Delhi

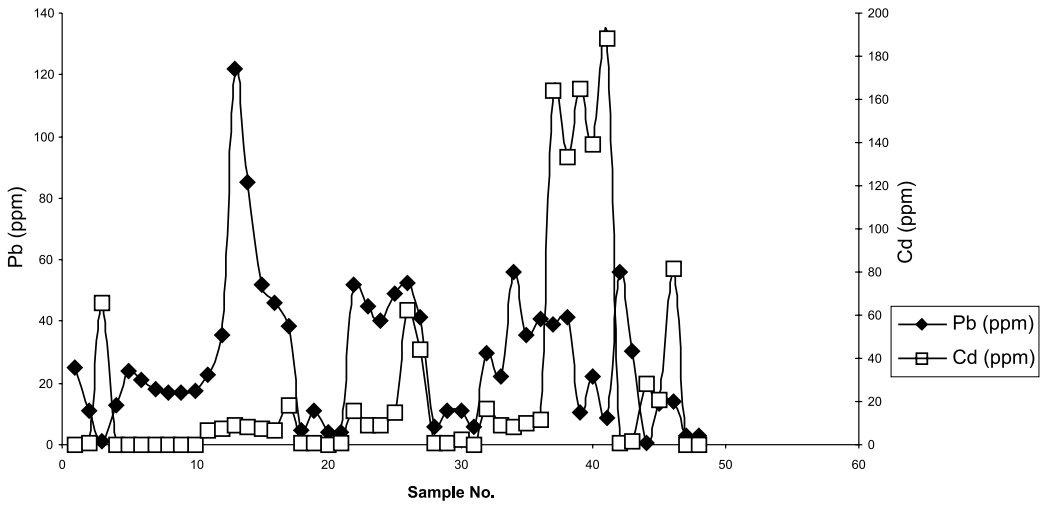


Fig 3: Total Pb (ppm) and Cd (ppm) Concentration in Toy Samples from Chennai

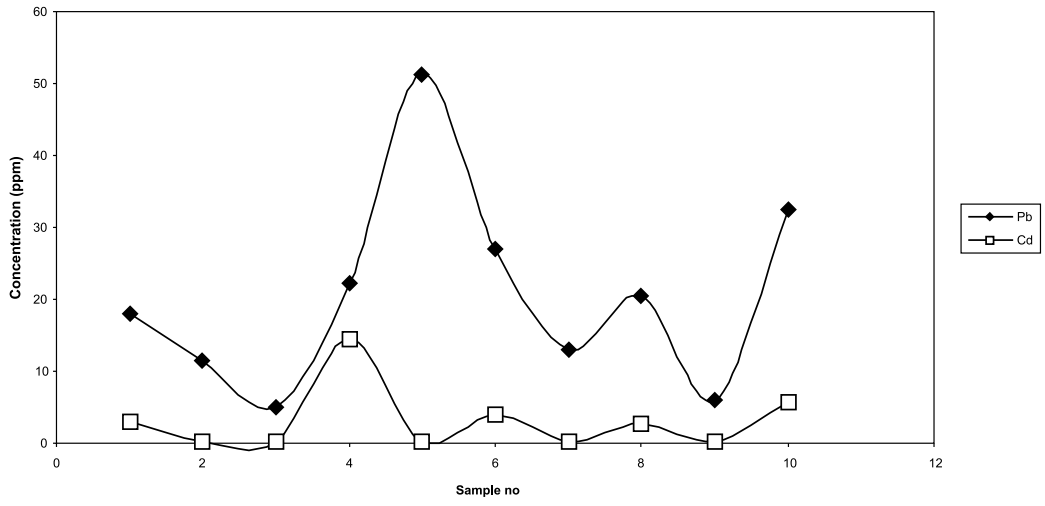


Fig 4: Total Pb (ppm) and Cd (ppm) Concentration in Toy Samples from Mumbai

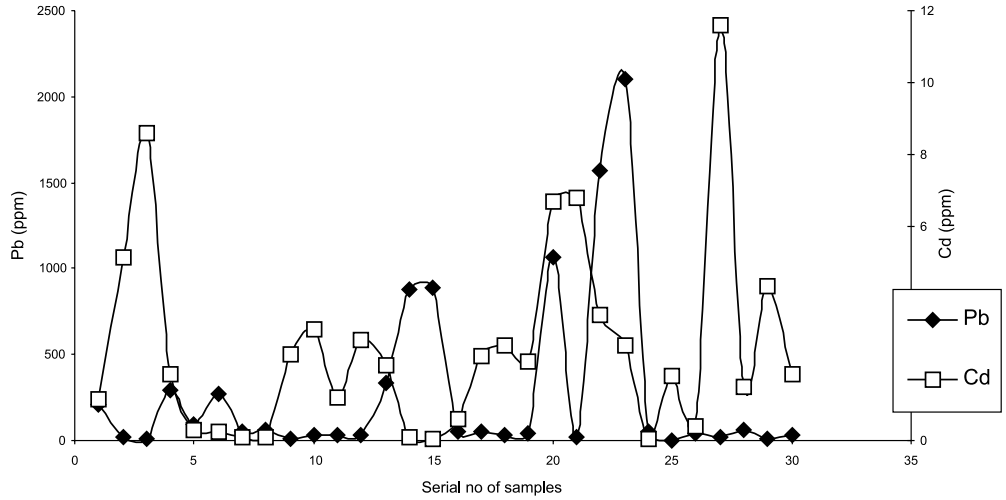


Fig 5: Frequency distribution for Pb in Toy Samples from Delhi

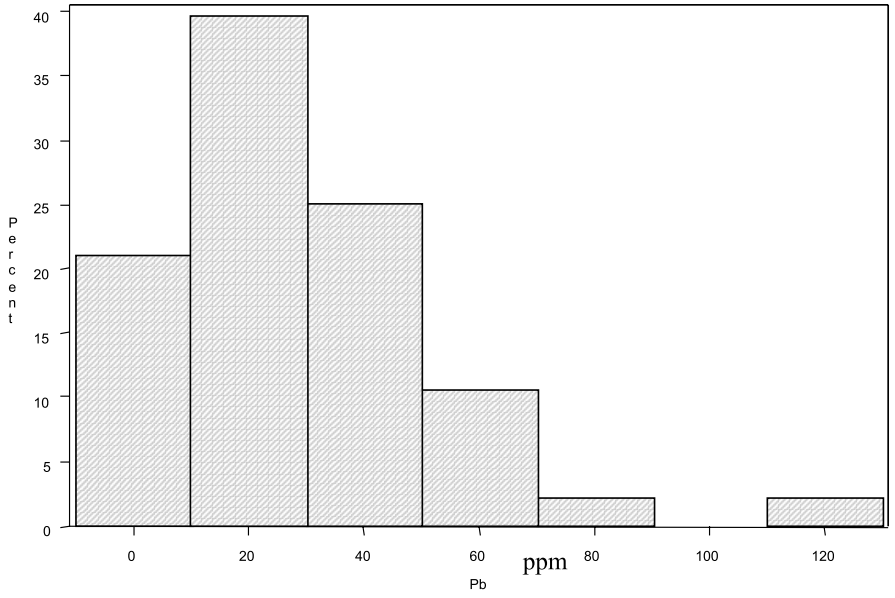


Fig 6: Frequency distribution for Cd in Toy Samples from Delhi

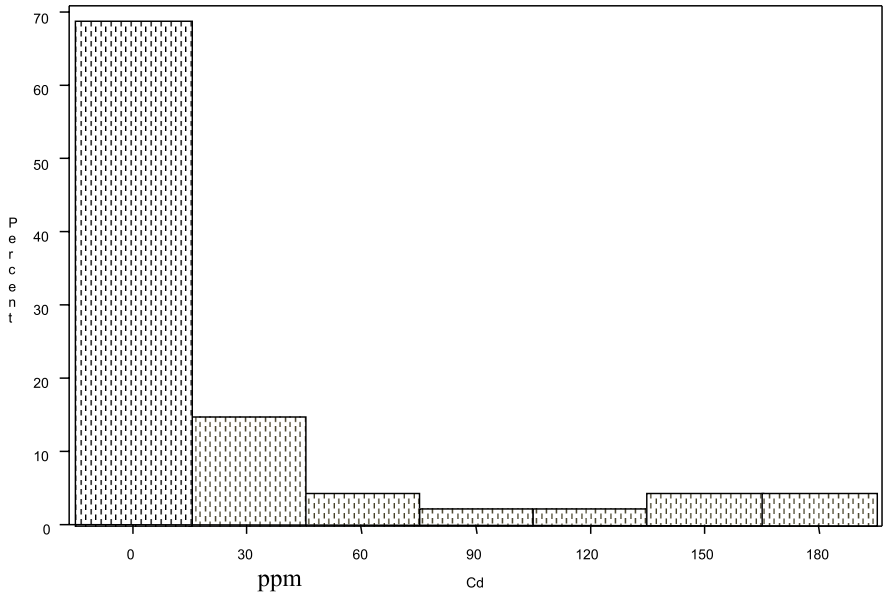


Fig 7: Frequency distribution for Pb in Toy Samples from Chennai

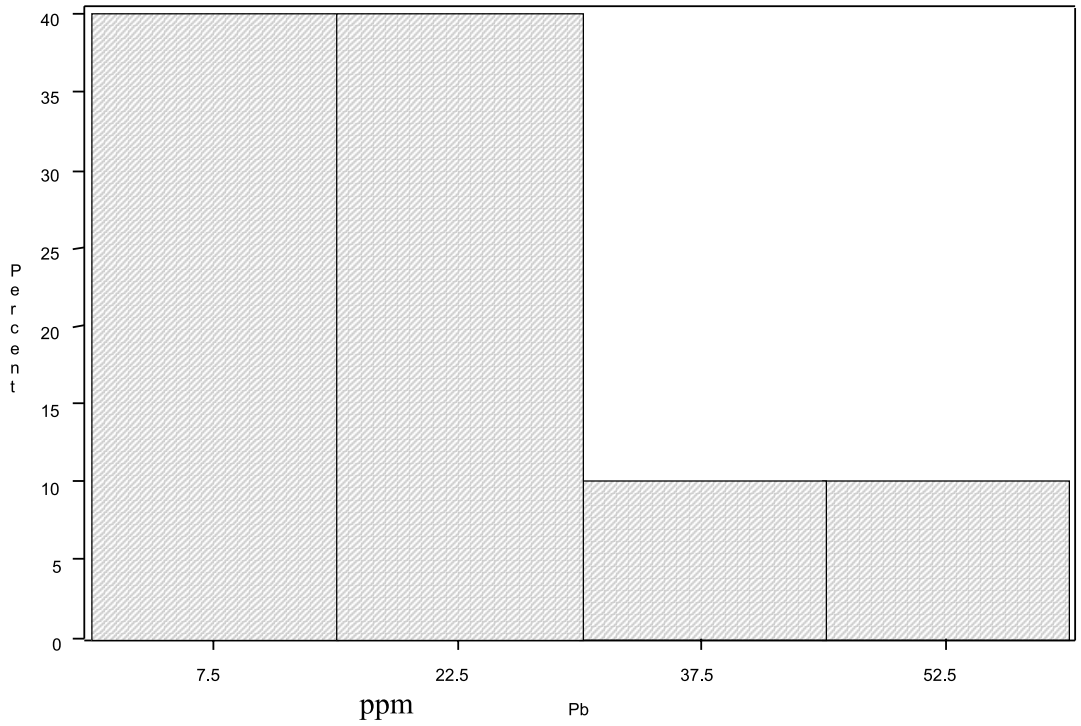


Fig 8: Frequency distribution for Cd in Toy Samples from Chennai

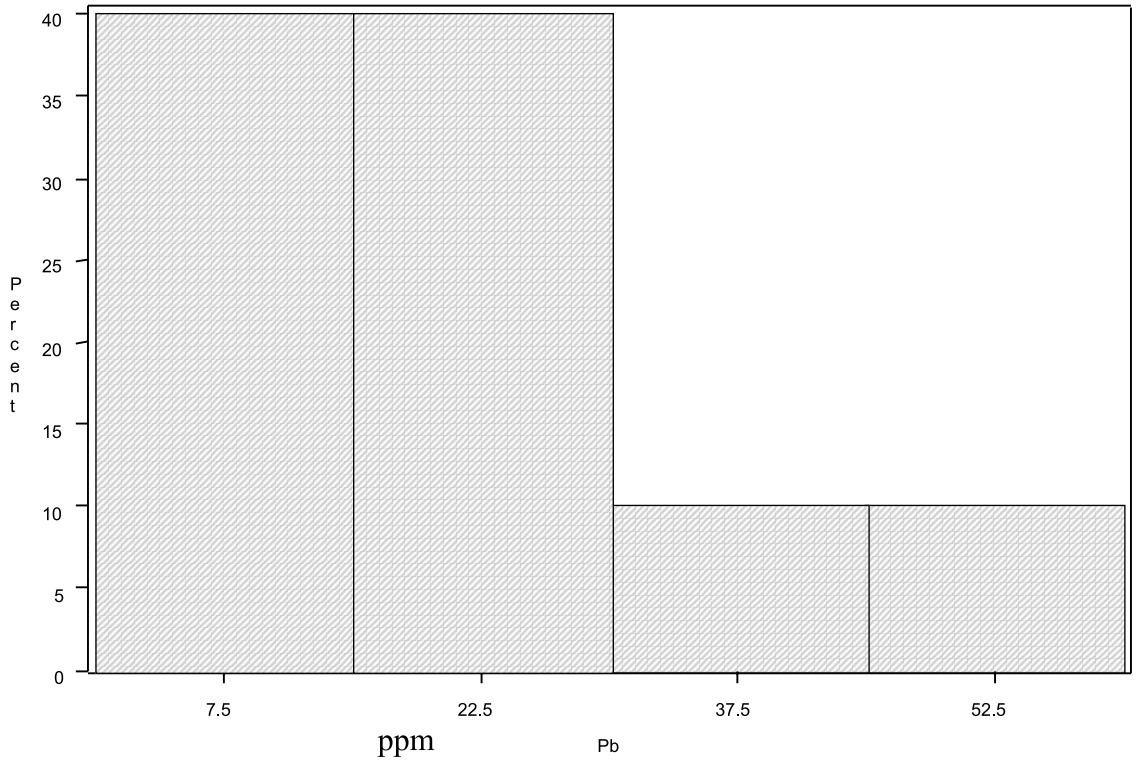


Fig 9: Frequency distribution for Pb in Toy Samples from Mumbai

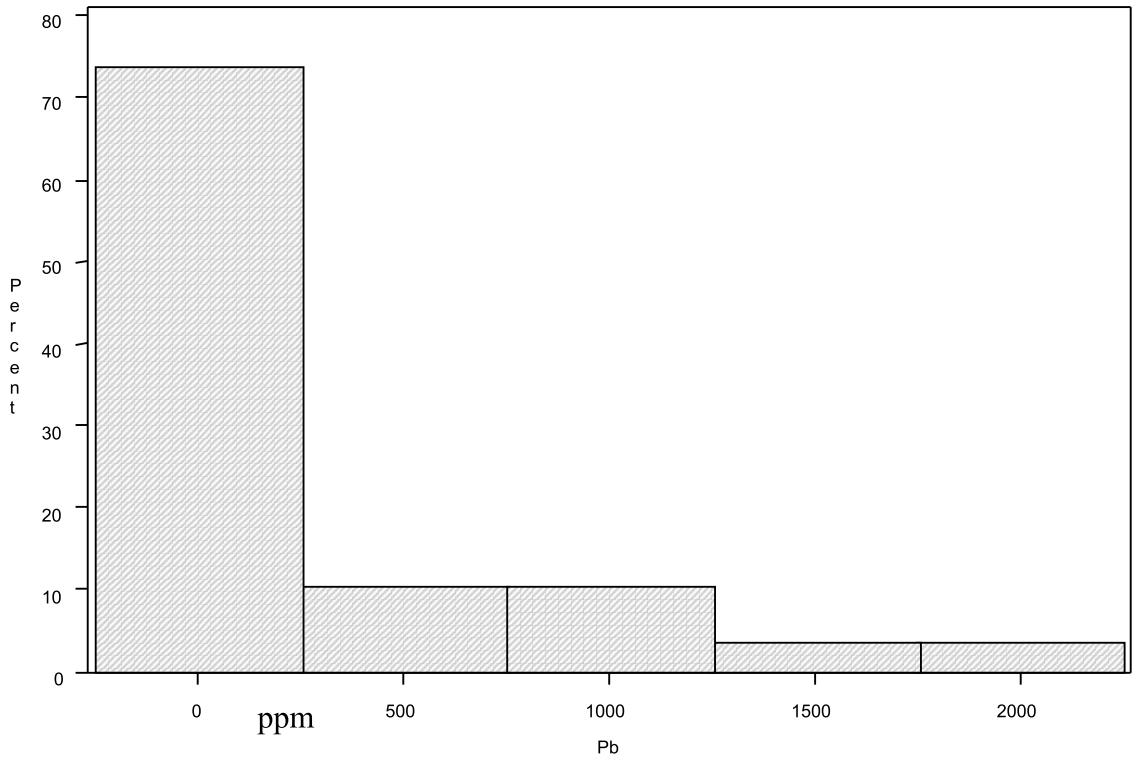
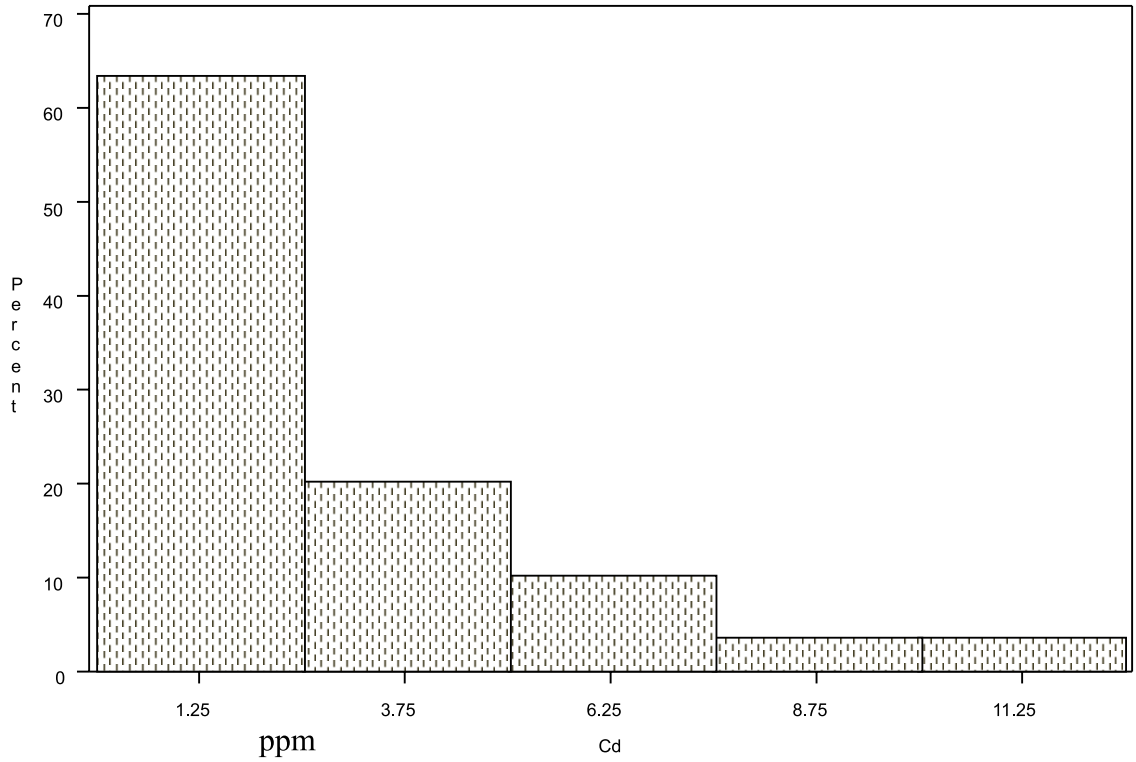


Fig 10: Frequency distribution for Cd in Toy Samples from Mumbai



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. 43 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 and Cd 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 bio-availability of lead and cadmium, which is only voluntary in nature. The state of California of USA has recognised cadmium as a carcinogen under Proposition 65 in 1987. [25]. 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 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. Concentration of Pb in Delhi samples varies from 0.65 ppm to 121.8 ppm with an average of 27.8 ppm. 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 (fig2). 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 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.

Concentration of lead in some of the toy samples brought from Mumbai were 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 centres. There isn't 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. [26]. In fact, five samples (close to 20 per cent 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 ranges from 22.4 ppm to 56.2 ppm in Delhi toys while it varies 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.

PVC and Toxicity

It must be kept in mind that lead and cadmium exposure from PVC toys are in addition to exposure from phthalate 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. [27]. Phthalate toxicity is again cumulative in nature and causes liver damage. [28]. It is obvious here that PVC by nature is chemically dependent and by itself PVC is of no use.

UNCERTAINTIES RELATED TO STANDARDS

Defining standards is a first step in any regulatory mechanism and prevention, perhaps, 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 Organisation for Standardisation, ISO 8124-3:1997 Migration of Certain Elements). (see Table 2) This is only voluntary in nature. Our enquiries with Bureau of Indian Standards (BIS) have revealed that not a single toy manufacturer in India has registered with BIS to conform to this voluntary standard. 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.

Table 2: 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, bio-availability 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. [29]. A crucial shortcoming of these standards is the absence of any correlation between the bio-availability 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 bio-availability of certain elements in toys. [30]. 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 bio-availability. This committee

was of the opinion that besides Arsenic (As), Barium (Ba), Cd, Chromium (Cr), Mercury (Hg), Pb, Selenium (Se), Antimony (Sb); Nickel (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 bioavailability lead instead of earlier limit of 90 ppm. However, as stated earlier, any level may be considered too high.

Preventive approach 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 preventive approach. The unrestricted presence of heavy metals like lead and cadmium in toys possess 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 per cent 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 possess 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. http://en.wikipedia.org/wiki/Toy (accessed in August 2006)
2. 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
3. Tuczai, E., Corolano, F. Reformulating PVC to eliminate heavy metals and protect performance. Modern plastics p 123-124. 1992
4. http://www.turnertoys.com/PVC_framepage1.htm (accessed in Julyt 2006)
5. 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)
6. National Referral Centre for Lead poisoning in India http://www.tgfworld.org/lead.html. (accessed in June 2006)
7. ibid
8. 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)
9. National Referral Centre for Lead poisoning in India http://www.tgfworld.org/lead.html. (accessed in June 2006)
10. http://www.cdc.gov/niosh/84116_42.html. Urgent Intelligence Bulletin 42 Cadmium (Cd). September 27, 1984 (accessed in June 2006)
11. Kelley, M., Watson, P., Thorton, D., and Halpin, T. J. Lead intoxication associated with chewing plastic wire coating. Morbidity and Mortality Weekly Report 42: 465-467. 1993
12. 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
13. 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.
14. 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.
15. 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.
16. 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.
17. 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.
18. 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, Issue 1
19. 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
20. Ibid
21. Ibid
22. Census of India 2001.
23. 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.
24. http://www.epa.gov/epaoswer/hazwaste/test/pdfs/3050b.pdf

25. 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

26. US Consumer Product Safety Commission. Memo from A. Schoem, Office of Compliance to P. Rush, executive director, Window Covering Safety Council. July 16, 1996

27. http://www.turnertoys.com/PVC_framepage1.htm (accessed in June 2006)

28. Ganning A.E., Brunk U., Dallner J. (1984) Phthalate Esters and their Effect on the Liver. Hepatology V4 No 3, Pp 541-547

29. http://europa.eu.int/eur-lex/en/consleg/pdf/1988/en_1988L0378_do_001.pdf (accessed in August 2006)

30. http://ec.europa.eu/health/ph_risk/committees/sct/documents/out235_en.pdf (accessed in August 2006)

Annexture - I : Toy Exports from india						in INR Millions
HS Code	Commodity	2000-01	2001-02	2002-03	2002-03	2003-04
9501	Wheeled toys ridden by children, dolls carriages/ strollers tricycles, scooters, pedal cars.	3.30	1.20	11.50	11.50	23.80
9502	Dolls, representing only human beings, and amp; parts etc	79.40	71.40	74.00	73.70	159.00
9503	Other toys; scale models; puzzles; parts & amp; blocks, tea sets, kites, balls, ballons	248.00	291.50	251.50	238.40	309.70
9504	Articles for arcade, table or parlor games, bowling alley equipment; parts & amp; accessories pinball, bagatelle, billiards, casino tables, cards, video games, chess, checkers, dominoes	127.40	232.00	151.90	170.80	208.10
	Total	458.10	596.10	488.90	494.40	700.60

Annexture - II : Toy Imports into India						in INR Millions
HS Code	Commodity	2000-01	2001-02	2002-03	2002-03	2003-04
9501	Wheeled toys ridden by children; dolls carriages/ strollers tricycles, scooters, pedal cars.	24.30	18.00	20.10	31.90	41.70
9502	Dolls, representing only human beings, and amp; parts etc	30.8	49.0	69.9	44.2	56.9
9503	Other toys; scale models; puzzles; parts & amp; blocks, tea sets, kites, balls, ballons	800.00	774.4	721.7	922.6	1203.1
9504	Articles for arcade, table or parlor games, bowling alley equipment; parts & amp; accessories pinball, bagatelle, billiards, casino tables, cards, video games, chess, checkers dominoes	281.80	264.00	182.60	170.70	183.90
	Total	1136.90	1105.40	994.30	1168.40	1485.60

Annexture - III : Samples Catalogue	
Sample No	Description of toys and the market from where toys were purchased
D-1	Purchased from Chandni chowk, New Delhi
D-2	Purchased from Chandni chowk, New Delhi
D-3	Purchased from Chandni chowk, New Delhi
D-4	Purchased from Chandni chowk, New Delhi
D-5	Purchased from Chandni chowk, New Delhi
D-6	Purchased from Chandni chowk, New Delhi
D-7	Purchased from Chandni chowk, New Delhi
D-8	Purchased from Chandni chowk, New Delhi
D-9	Purchased from Chandni chowk, New Delhi
D-10	Purchased from Chandni chowk, New Delhi
D-12	Purchased from Sadar Bazar, Delhi
D-13	Purchased from Sadar Bazar, Delhi
D-14	Purchased from Sadar Bazar, Delhi
D-15	Purchased from Sadar Bazar, Delhi
D-16	Purchased from Sadar Bazar, Delhi
D-17	Purchased from Sadar Bazar, Delhi
D-18	Purchased from Sadar Bazar, Delhi
D-19	Purchased from Sadar Bazar, Delhi
D-20	Purchased from Sadar Bazar, Delhi
D-21	Purchased from Sadar Bazar, Delhi
D-22	Purchased from Sadar Bazar, Delhi
D-23	Purchased from Sadar Bazar, Delhi
D-24	Purchased from Sadar Bazar, Delhi
D-25	Purchased from Sadar Bazar, Delhi
D-26	Purchased from Sadar Bazar, Delhi
D-27	Purchased from Sadar Bazar, Delhi
D-28	Purchased from Sadar Bazar, Delhi
D-29	Purchased from Sadar Bazar, Delhi
D-30	Purchased from Sadar Bazar, Delhi
D-31	Purchased from Sadar Bazar, Delhi
D-32	Purchased from Sadar Bazar, Delhi
D-34	Purchased from Road side vendors, Jungpura, New Delhi
D-37	Purchased from Road side vendors, Jungpura, New Delhi
D-38	Purchased from Road side vendors, Jungpura, New Delhi
D-40	Purchased from Tigri resttlement area, New Delhi
D-48	Purchased from Tigri resttlement area, New Delhi
D-49	Red fruit; Purchased from Munirka, New Delhi
D-50	Yellow fruit; Purchased from Munirka, New Delhi
D-51	Light pink fish; Purchased from Munirka, New Delhi
D-52	Yellow fish; Purchased from Munirka, New Delhi
D-53	Green fish; Purchased from Munirka, New Delhi
D-54	Yellow star; Purchased from Munirka, New Delhi
D-55	Blue starfish; Purchased from Munirka, New Delhi
D-56	Pink starfish; Purchased from Munirka, New Delhi
D-57	Green small dog; Purchased from Munirka, New Delhi
D-58	Yellow small dog; Purchased from Munirka, New Delhi

Contd...

Samples Catalogue	
Sample No	Description of toys and the market from where toys were purchased
D-59	Pink small dog; Purchased from Munirka, New Delhi
D-60	Pink lithci fruit; Purchased from Munirka, New Delhi
C-1	Blue Krishna doll; Purchased from Basant nagar beach, street vendor, , Chennai
C-2	Clown; Purchased from Tambram market, Chennai
C-4	Green frog; Purchased from pavement bazar, Pondy bazar, Chennai
C-5	Green ball; Purchased from Thiruvanmiyar market, Chennai
C-6	Little boy; Purchased from Pondy bazar, Chennai
C-8	Clolouful small animal; Purchased from Thiruvanmiyur market, Chennai
C-15	Drum beating clown Purchased from Tambram Market, Chennai
C-16	Orange sunglasses; Purchased from Street vendor, Basant nagar beach, Chennai
C-19	Spiderman mask; Purchased from Thirvuanmiyur market, Chennai
C-20	Hero spiderman; Purchased from Thiruvanmiyur market, Chennai
M-2	Yellow doll; Purchased from Mumbai
M-3	Red doll; Purchased from Mumbai
M-4	Green parrot; Purchased from Mumbai
M-5	Appu; Purchased from Mumbai
M-6	White dog; Purchased from Mumbai
M-7	Yellow dog; Purchased from Mumbai
M-8	Boy on horse; Purchased from Mumbai
M-9	Fish; Purchased from Mumbai
M-10	Pink fish; Purchased from Mumbai
M-11	Green fish; Purchased from Mumbai
M-12	Green fish; Purchased from Mumbai
M-13	Yellow sparrow; Purchased from Mumbai
M-14	Doll; Purchased from Mumbai
M-15	Green boy doll; Purchased from Mumbai
M-16	Smart boy with hat; Purchased from Mumbai
M-17	Cow Policeman; Purchased from Mumbai
M-18	Orange, cow; Purchased from Mumbai
M-19	Calf deer; Purchased from Mumbai
M-20	Bridegroom; Purchased from Mumbai
M-21	Pink hare; Purchased from Mumbai
M-22	Kangaroo; Purchased from Mumbai
M-23	Doctor; Purchased from Mumbai
M-24	Doll; Purchased from Mumbai
M-25	Doll with puppy; Purchased from Mumbai
M-26	Tortoise; Purchased from Mumbai
M-27	Babydeer; Purchased from Mumbai
M-28	White green horse; Purchased from Mumbai
M-29	Doll with hair; Purchased from Mumbai
M-30	Doll; Purchased from Mumbai

Data related to Lead and Cadmium concentration in toy samples

Annexture - IV : Lead and cadmium concentration in PVC and non PVC toys			
Sample No.	Pb (ppm)	Cd (ppm)	Beilstein Test
D-1	25.1	0.016	Positive
D-2	11.3	0.71	Positive
D-3	0.95	65.5	Positive
D-4	12.6	0.1	Positive
D-5	23.7	0.28	Positive
D-6	20.8	0.3	Positive
D-7	17.95	0.21	Positive
D-8	17.1	0.24	Positive
D-9	17.2	0.23	Positive
D-10	17.5	0.29	Positive
D-12	22.8	6.3	Positive
D-13	35.4	7.1	Positive
D-14	121.8	9.1	Positive
D-15	85.2	8.6	Positive
D-16	51.9	7.4	Positive
D-17	46.1	6.6	Positive
D-18	38.6	18.6	Positive
D-19	4.9	0.76	Positive
D-20	10.8	0.6	Positive
D-21	4.2	0.12	Positive
D-22	4.1	0.94	Positive
D-23	52.2	16.1	Positive
D-24	45	8.9	Positive
D-25	40.3	9.4	Positive
D-26	48.8	15.4	Positive
D-27	52.3	62.2	Positive
D-28	41.6	44.3	Positive
D-29	6.1	0.63	Positive
D-30	11.1	0.61	Positive
D-31	11.2	2.5	Positive
D-32	5.8	0.11	Positive
D-34	29.7	16.35	Negative
D-37	22.4	9.07	Negative
D-38	56.2	8.74	Negative
D-40	35.6	9.85	Negative
D-48	40.9	11.67	Negative
D-49	39.3	164	Positive
D-50	41.6	133	Positive
D-51	10.4	165	Positive
D-52	22.2	139	Positive
D-53	8.9	188	Positive
D-54	56.04	1.2	Positive
D-55	30.3	1.5	Positive
D-56	0.65	28.7	Positive
D-57	13.2	20.9	Positive

Contd...

Lead and cadmium concentration in PVC and non PVC toys			
Sample No.	Pb (ppm)	Cd (ppm)	Beilstein Test
D-58	14.2	81.6	Positive
D-59	2.96	0.39	Positive
D-60	3.12	0.27	Positive
C-1	18.02	2.89	Negative
C-2	11.4	0.21	Negative
C-4	4.9	0.2	Positive
C-5	22.3	14.5	Negative
C-6	51.3	0.24	Positive
C-8	26.9	3.91	Negative
C-15	12.9	0.21	Positive
C-16	20.6	2.86	Negative
C-19	6	0.16	Positive
C-20	32.4	5.86	Negative
M-1	208	1.16	Positive
M-2	16.4	5.1	Positive
M-3	13.9	8.6	Positive
M-4	292.6	1.85	Positive
M-5	91.3	0.28	Positive
M-6	271	0.26	Positive
M-7	51	0.091	Positive
M-8	62.3	0.1	Positive
M-9	14.3	2.4	Positive
M-10	29.1	3.1	Positive
M-11	26.6	1.2	Positive
M-12	28.9	2.8	Positive
M-13	332.5	2.1	Positive
M-14	878.6	0.084	Positive
M-15	891	0.03	Positive
M-16	55.2	0.62	Positive
M-17	49.2	2.37	Positive
M-18	30.7	2.68	Positive
M-19	38.2	2.2	Positive
M-20	1065	6.7	Positive
M-21	17.2	6.8	Positive
M-22	1567.7	3.5	Positive
M-23	2104	2.67	Positive
M-24	56.9	0.07	Positive
M-25	1.68	1.81	Positive
M-26	44.3	0.42	Positive
M-27	18.3	11.6	Positive
M-28	58.9	1.49	Positive
M-29	12.4	4.3	Positive
M-30	34.6	1.88	Positive