
ORIGINAL ARTICLE**Estimation of Lead (Pb) in Toys Using X-Ray Fluorescence Technology**

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Abstract:

Background: Lead exists extensively in the environment and it is a heavy metal, which is neurotoxic in nature which is harmful to children. In contrast to trace elements such as iron (Fe) and zinc (Zn), lead has no recognized beneficial effects in human body. With the economic development in India in recent years, the concentration of lead has increased in the environment and henceforth, lead pollution has become a severe problem in the country. Lead poisoning can create an immense damage and irreversible harm to foetal growth, the growth of teenagers and psychological, behavioural and cognitive development. *Aim and Objectives:* To estimate the lead content in the sample of toys. *Material and Methods:* 97 different toys were collected and coded as TS, these toys were kept in plastic lock cover which were lead proof. At first the toys were arranged in order according to the serial number of the code (TS1 – TS97). The FP X-ray fluorescence (Innov-X ray analyzer) instrument was placed with the window of the analyzer on the surface of the toy vertically in such a way that there was no gap between the toy surface and the sampling window. The parts per million (ppm) values of all toys were recorded. *Results:* Out of 97 samples tested, 22 samples were above permissible limits. The different materials demonstrate significant correlation with the lead content in ppm. Lead is used as a stabilizer in some toys as well as children's items made from PVC

plastic. Baby toys made up of plastic have higher concentration of lead. Lead can leach out of products when children handle and swallow them involuntarily.

Keywords: Baby toys, Children, Lead, Poisoning.

Introduction:

Lead is a chemical element with symbol Pb (from Latin: plumbum, "pipe metal") and atomic number is 82. Lead poisoning has tremendous consequence on public health for centuries. Lead is a cumulative poison, exposure to it and its compounds is toxic to humans and affects ecosystem severely. Nowadays, it has become one of the important chronic environmental infirmities that affects present generation. Lead is non-biodegradable. Excessive amount of lead in the body causes blood disorders in mammals [1, 2]. Lead may be found in the paint on toys. Lead in paint has been banned for use in house paint, products marketed to children, and dishes or cookware in the United States since 1978; however, it is still widely used in other countries and therefore that is the reason it can be found in imported toys. It may also be found on older toys made in the United States before the ban in 1978. Lead may also be used in plastic toys to stabilize the plastic molecules from heat. It makes the

plastic more flexible and softens the plastic so that it can go back to its original shape. The use of lead in plastics has not been banned. When the plastic is exposed to substances such as sunlight, air, and detergents, the chemical bond between the lead and plastics breaks down and forms a dust [3, 4]. As lead becomes gradually accumulated in the body, it is regarded as the most harmful environmental toxins to toddlers. When the blood lead levels arrive at about 10-50 $\mu\text{g/L}$ in children's body, it can damage intelligence, memory, growth and behaviour even when there are no clinical manifestations. Lead poisoning can affect learning and Intelligence Quotient (IQ) is inversely proportional to blood lead level in the body [5]. These effects of lead exposure on neurological dysfunctions in children are persistent, especially in 2-year old children, an age that appears to be the most critical period for a child's later intelligence quotient and academic achievements [6]. Among the risk factors of lead poisoning in children include poor living habits such as finger sucking, nail biting, putting foreign objects into the mouth, playing with plasticine (a modelling clay material that does not get dry on exposure to air) and using frequently coloured tableware. Exposure to lead can also occur through puffed foods, preserved eggs, and canned foods, smoking by a family members, living near a large road, and currently done room decoration [7]. The "subclinical" exposure to lead not only alter behaviour but also affects the brain structure and causes clear neuropathological changes including oedema, herniation and atrophy which have been reported clinically in lead intoxicated children. White matter degeneration and volume

reductions in regions of cortical gray matter have also been found [8]. Lead poisoning is cumulative. After some weeks or months continuing ingestion of small amounts of lead, symptoms begin to appear. Early symptoms may be irritability, fretfulness, or disturbed gastrointestinal function characterized by lack of appetite, constipation, vomiting or cramps. A secondary anaemia resulting into pallor is often present [9, 10]. It's a silent killer that could be taking a heavy toll on young children. A study by doctors in Kolkata reveals that at least 20% of the city's children are affected by lead poisoning, which is turning out to be a bigger threat than anyone imagines [11] XRF Spectrometry is used to identify the elements in a substance and measures the amount of those elements. An element is identified by its characteristic X-ray emission wavelength (λ) or energy (E). The amount of an element present is quantified by measuring the intensity of its characteristic line. XRF Spectrometry ultimately determines the elemental composition of a material [12].

Material and Methods:

97 different toys were collected which were made up of plastic, rubber, cloth and thermocol. These toys were covered with plastic lock cover which is lead proof cover to protect toys. At first, arranged the toys were serially according to the code number. The samples were placed onto a flat surface (Fig. 3). The window of the analyser was placed onto the sample to begin the test (Fig.2). Now, by using XRF instrument, the samples were tested. Results were recorded (Fig. 3).



Fig. 1: FP XRF Instrument

Toys, Plastic Lock Covers and FP-XRF Analyzer (Innova-X Analyzer)



Fig. 2: Samples of Toy



Fig. 3: Detection of Lead Content in Toys

Result:

The commonly used material in toys is plastic, rubber, thermocol and cloth. Type of material and the mean lead content showed a markedly higher mean lead content of 106.88ppm in plastic toys (Table 1). It was observed that the higher than permissible limit of lead is 90ppm according to Consumer Product Safety Commission (CPSC) [12] which was found in many of baby toys, which were made of plastic (Table 2). There was no significant difference in between the materials

used in toys given to children for playing between rubber, cloth and thermocol ($\chi^2=2.821$, $p=0.2440$) however the mean lead levels for plastic toys were significantly higher than the other toys (Table 1) and were above permissible level of 90 ppm (Table 2). The different materials showed significant correlation with the ppm of lead content. Pb is used as a stabilizer in some toys and other children's items made from PVC plastic. Pb can leach out of products when children handle or swallow them (Fig. 4, 5).

Table 1: Type of Material Used in Toys and Lead Content

Types of Material	Total Number	Percentage of Total Number	Number of Lead Content Toys	Percentage of Number of Lead Content Toys	Lead Content in ppm (Mean± SD)	P- Value (Degree of Freedom = 4-1=3)
Plastics	71	73.19	55	85.93	106.88 ± 267.32	Chi Square value = 15.34 P value= between 0.001- 0.0025
Rubber	14	14.43	3	4.68	6.5 ± 31.56	
Thermocol	09	9.27	4	6.25	18.55 ± 28.36	
Cloth	03	3.09	2	3.12	16.33 ± 15.13	
Total	97		64			

Table 2: Proportion of Toys Containing Lead Content above Permissible Limits

Types of Material	Total Number	Percentage of Total Number	Number of Toys with Lead Content Above Permissible Limit	Percentage	Chi Square Value
Plastic	71	73.19	22	31.0	59.816
Rubber	14	14.43	0	0	
Thermocol	09	9.27	0	0	
Cloth	03	3.09	0	0	

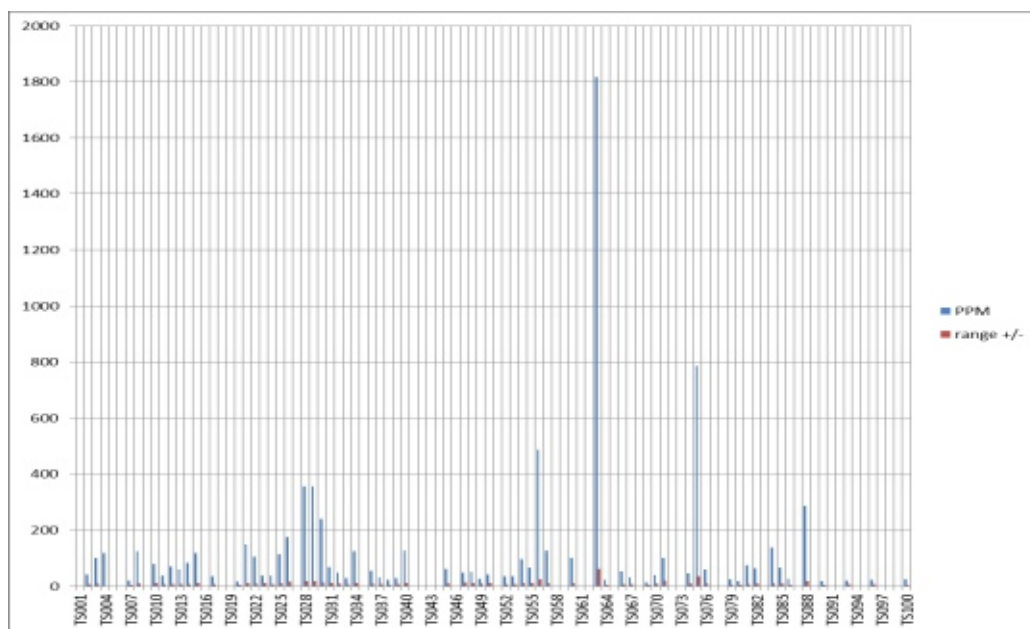


Fig. 4: Sample of Toys with ppm Value along its Range showing the Lead Content in ppm Range shown on XRF Screen

Discussion:

The results obtained by us show how much lead content is in the toys which are played by children. Lead is an extremely toxic substance, exposure to which can fabricate a wide range of adverse health effects. Both adults and children can suffer from the effects of lead poisoning, but childhood lead poisoning is much more frequent. Over many years since we have recognized the hazards of lead, tens of millions of children have suffered due to its ill health effects. Even today, in 2015, there are still an estimated 3, 10,000 children under the age of six who have too much lead in their blood [5].

There are many ways of life in which humans are exposed to lead through decorating paints, household dust, bare soil, air, drinking water, food, ceramics, home remedies, hair dyes and other cosmetics. A large amount of this lead is microscopic in size, invisible to the naked eye. More often than not, children with elevated blood lead levels are exposed to lead in their own home. Lead testing kits that can be purchased at hardware stores or over the internet. These kits generally use chemicals that change colour in the presence of lead to give an idea of the amount of lead in the tested surface. Since they often cannot tell high lead levels from low lead levels, these tests are not recommended by the US Environmental Protection Agency (USEPA). This process contains chemical hazard, but compared to XRF technology there is no hazard of radiation. The detection of lead content by using X-ray Fluorescence is very simple and easy. One should undertake safety measures to prevent radiation

hazard while using XRF instrument. The results could be achieved very fast and displayed on digital screen, which can be transferred to computer for further analysis. The lead toxicity in children can be further confirmed by child's health care system, which can be helped in diagnosis of lead poisoning by performing blood test to see if the child has an elevated blood lead level. A blood lead test is the only way that can tell if your child has an elevated blood lead level. It can be performed by an instrument named "Lead care II" [13].

Conclusion:

From 14th August 2008, CPSC has enforced stricter limits on lead in children's products. The limit on lead paint and other coatings is now 90 parts per million (ppm). Out of 97 samples we tested, 22 samples were out of permissible limit. This study gives us an alarming and shocking picture that a small amount of lead present in toys may create huge harmful effect at the beginning of child's life. Lead is invisible to the naked eye and has no smell. Children may be exposed to lead unknowingly as well as unintentionally to consumer products available in market through normal hand-to-mouth activity. As part of normal development, young children often place their toys, fingers, and other objects in their mouth, which puts them in contact with the lead paint or dust. Labels with lead contents displayed clearly on the toys will be useful to the parents in purchasing the toys for children and shopkeepers in selling them after they are made aware of the maximum permissible level of lead of 90 ppm.

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