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Heavy Metal Assessment of Leachates of some Plastic Toys Purchased from Different Districts of UP, India

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Abstract

Childhood exposure to environmental heavy metals continues to be a major health concern. This study examined heavy metal content within the plastic children's toys purchased from local markets of different districts of Uttar Pradesh, India. The six different colours of toys; yellow six brands, orange five brands, green three brands, red and blue four brands, grey and purple five brands and pink and purple three brands used in present study for the determination of concentrations of heavy metals as per BIS, IP and other international guidelines by using atomic absorption spectrophotometer (AAS). The results showed that the presence of metals were in the range of 0.219-1.12, 0.005-0.110, 0.251-1.090, 0.119-1.111, 0.219-1.040, 0.000-0.531 and 0.990-1.070 (ppm) for Pb, Cd, Ni, Zn, Cr, Co and Mn respectively. A comparison of the mean concentrations of these metals in the toys analysed showed the pattern as: Pb > Zn > Ni > Mn > Cr > Co > Cd.

Keywords: Heavy metals, leachates, children's plastic toys, concentration, ppm.

Introduction

Polymers are materials widely used in industry and many areas of life. Polymers contain a wide variety of additives (plasticizers, antioxidants, stabilizers, curing agents, colouring agents etc.) to fulfil their physical and chemical properties. These components are present in a wide range of concentrations usually form trace (µg/Kg) to a few percent level. The concentrations of heavy metals such as Pb, Cd, Cr, etc in plastic baby toys, for instance, is regulated in many countries due to the obvious toxicity of these elements.[1] It is well known that heavy metals are toxic, especially to young children; however, toys as well as other consumer products still contain these metals.

Toys are integral part of children's developmental processes. Besides providing entertainment to children, toys also serve as educational materials for them. A toy may mean different things to children of different age groups and hence exposure pathways also differ accordingly. A child below 3 years of age may handle a toy in a completely different manner from a child 3–6 years of age. Chemical exposure to children, from toys, is an emerging concern. The chewing, licking and swallowing behaviour of children is a common source of lead and cadmium exposure [2, 3]. Metals in toys and other materials are loosely bound to the surface and can leach easily to enter the food chain.[4], to cause cancers, mental dysfunctions, energy, nervous system, kidney, lungs and other functions of organs to decline[5-7].

Lead poisoning from toys causes learning disabilities, kidney failure, anaemia and irreversible brain damage in children[8]. Children and pregnant women are particularly susceptible to lead poisoning[9-11].The digestive system of children absorbs up to 50% of the lead they ingest[12]. In fact, physicians and scientists agree that no level of lead in blood is safe or normal[12].

Cadmium compounds are used as stabilizers in PVC products, colours and pigments. Cadmium exposure produces a wide variety of acute and chronic effects in humans, leading to a build-up of cadmium in the kidney that can cause kidney disease[13]. The IARC has classified cadmium as human carcinogen (group-1) on the basis of sufficient evidence in both humans and experimental animals[14]. Lead and cadmium are known poisons, being neurotoxins and nephrotoxins. Neurotoxins are agents that can damage the nervous system while nephrotoxins are agents that can damage the kidney respectively[15]. European studies have shown signs of cadmium induced kidney damage in the general population at urinary cadmium levels around 2-3 µg Cd/g creatinine[16-17].

Nickel in small amount is needed by the human body to produce red blood cells; however, in excessive amount, can become mildly toxic. Short-term overexposure to nickel is not known to cause any health problems, but long-term exposure can cause decreased body weight, heart and liver damage, and skin irritation.

Although zinc is an essential requirement for good health, excess zinc can be harmful. Excessive absorption of zinc suppresses copper and iron absorption[18]. The free zinc ion is a powerful Lewis acid up to the point of being corrosive. Stomach acid contains hydrochloric acid, in which metallic zinc dissolves readily to give corrosive zinc chloride. This chloride can cause damage to the stomach lining due to the high solubility of the zinc ion in the acidic stomach[19]. The U.S. Food and Drug Administration (FDA) has stated that zinc damages nerve receptors in the nose, which can cause anosmia[20].

Chromium metal and chromium (III) compounds are not usually considered health hazards; chromium is an essential trace mineral. Hexavalent chromium is very toxic and mutagenic when inhaled, as publicized by the film 'Erin Brockovich', released in March, 2000. Cr (VI) has not been established as a carcinogen when in solution, though it may cause allergic contact dermatitis (ACD). The lethal dose of poisonous chromium (VI) compounds is about one half teaspoon of material.

Cobalt is an element that can be both beneficial to an individual's health and detrimental to it. At its lowest levels, cobalt can be found in the chemical makeup of vitamin B12, which is necessary for optimum health, but if the body comes in contact with a high level of cobalt, it could ultimately be harmful to the heart and lungs[21].

Manganese overexposure is most frequently associated with manganism. Manganism is a biphasic disorder. In its early stages, an intoxicated person may experience depression, mood swings, compulsive behaviors, and psychosis. Early neurological symptoms give way to late-stage manganism, which resembles Parkinson's disease. Symptoms include weakness, monotone and slowed speech, an expressionless face, tremor, forward-leaning gait, inability to walk backwards without falling, rigidity, and general problems with dexterity, gait and balance[22].

Physicians and scientists agree that no level of heavy metals in blood is safe or normal. The disturbing fact is that exposure to extremely small amount can have long-term and measurable effects in children while at the same time causing no distinctive symptoms.

Another problem of heavy metals exposure is it being cumulative in nature. After they have been absorbed into the blood, some of them are filtered out and excreted, but the rest are distributed in the liver, brain, kidney and bones[4].

The consumer Product Safety Commission experimentally demonstrated that light and heat can cause degradation of toys and liberation of lead dust but unfortunately for children's, toys released lead and other metals during normal product use[23]. Given the known potential toxicity, the serious health effect and the ability of heavy metals, to leach out of children's toys through contact, the continued use of lead and other heavy metals in children's toy raises serious concern.

This study determined the current pattern in the use of lead and other heavy metals as stabilizer in plastic toys, using analytical techniques that would yield empirical data. The data collected were used to provide a clear picture of hazardous chemicals in plastic toys.

Material and Methods

Total 26 brands of plastic toys used in the present study were purchased from local markets of Lucknow, Allahabad, Mau, Varansi and Kanpur districts of Uttar Pradesh India and categorised into 6 groups on the basis of their colour (6 yellow, 5 orange, 3 green, 4 red and blue, 5 grey and purple, 3 pink and purple) because metal contamination greatly depend on the colouring materials which are used in manufacturing of toys [24]. Plastic toys were washed thoroughly with sterilized double distilled water prior to the leaching. Double distilled water, Ethanol (8% v/v) and Sodium Chloride (0.9% w/v) were used as the simulating solvents and then the toys were exposed in 100 ml of each simulating solvents in a sterile beakers at a ratio of $2cm^2$ /ml. The samples were kept at 40 ± 2^0C for 24 hrs. Parallel sets having simulating solvents only were also run under identical conditions and it was serving as basal control[25]. The simulated solvents (100 ml) were taken in conical flask and digested with concentrated nitric acid in a fuming chamber. The digested samples were scaled down to 10 ml with 0.1 N HNO_3. The final processed samples were quantitatively analyzed by using Perkin- Elmer-500 atomic absorption spectrophotometer (AAS). The instrument was first calibrated with standards prepared from stock solution provided by Merck. The concentrations of the selected heavy metals were determined in triplicate and the result is given as a mean ± standard deviation. The concentrations of metals in different leachates of samples presented in ppm. Metal content should not be more than 1.000 ppm (Cd should not be more than 0.100 ppm) according to BIS, IP, USP and other regulatory agencies.

Statistical analysis: The results were expressed as mean ± standard deviation and comparisons were made by applying one way analysis of variance (ANOVA) to assess the level of significance using computer based software 'GraphPad PRISM-5'. The *p* value less than 0.05 marked with * in figure1-3, is considered as significant.

Results and Discussion

The results of our study showed that mean concentration of heavy metals in the various leachates of the toys analysed are given in figure 1-3.

The highest mean concentration of Pb was detected (1.12 ppm) in case of double distilled water in yellow toys (figure-1) which is above by (0.12 ppm) their permissible limit while the minimum concentration was detected in case of sodium chloride (0.219 ppm) in green toys (figure-3).

The highest mean concentration of Cd was detected (0.111 ppm) in green toys of double distilled water (figure-1) which is above by (0.011ppm) of their permissible limit while the minimum concentration were detected in pink and purple toys (0.005 ppm) in saline solution (figure-3).

Highest mean concentration of Ni was found (1.090 ppm) in pink and purple toys of double distilled water (figure-1) which is above than its permissible limit of (1.000 pmm) whereas its minimum level were detected in yellow samples of ethanol (0.251 ppm , figure-2).

Highest mean concentration of Zn was detected (1.111ppm) in grey and purple toys of double distilled water (figure-1) which is above than its permissible limit of (1.000 pmm) whereas its minimum level were detected in pink and purple samples of sodium chloride (0.119 ppm, figure-3).

Highest mean concentration of Cr was detected (1.040 ppm) in green toys of ethanol (figure-2) which is above by (0.040ppm) of their permissible limit while its lower level were detected in red and blue toys (0.219 ppm) in sodium chloride (figure-3).

Co was not detected in many toys in all simulating solvents (figure-1-3.), while its highest mean concentration was detected in sodium chloride solution of red and blue toys (0.531 ppm, figure-3).

Highest mean concentration of Mn was detected in pink and purple toys in ethanol (1.070 ppm) which is above by (0.070 ppm) from their permissible limit (figure-2), while its lower concentration was detected in red and blue samples of same solvent (0.099 ppm, figure-2).

There were significant differences between mean concentrations of metals in different colours of toys samples in double distilled water ($P < 0.05$).

There were significant differences between mean concentrations of metals in different colours of toys samples in 8 % ethanol ($P < 0.05$).

There were significant differences between mean concentrations of metals in different colours of toys samples in saline solution ($P < 0.05$).

The result showed that the highest mean concentration of Pb was found in yellow toys, Ni in pink and purple toys, Zn in grey and purple toys in the leachates of double distilled water and ethanol, Cr in green toys and Mn in pink and purple toys in the leachates of 8 % ethanol and 0.9 % sodium chloride.

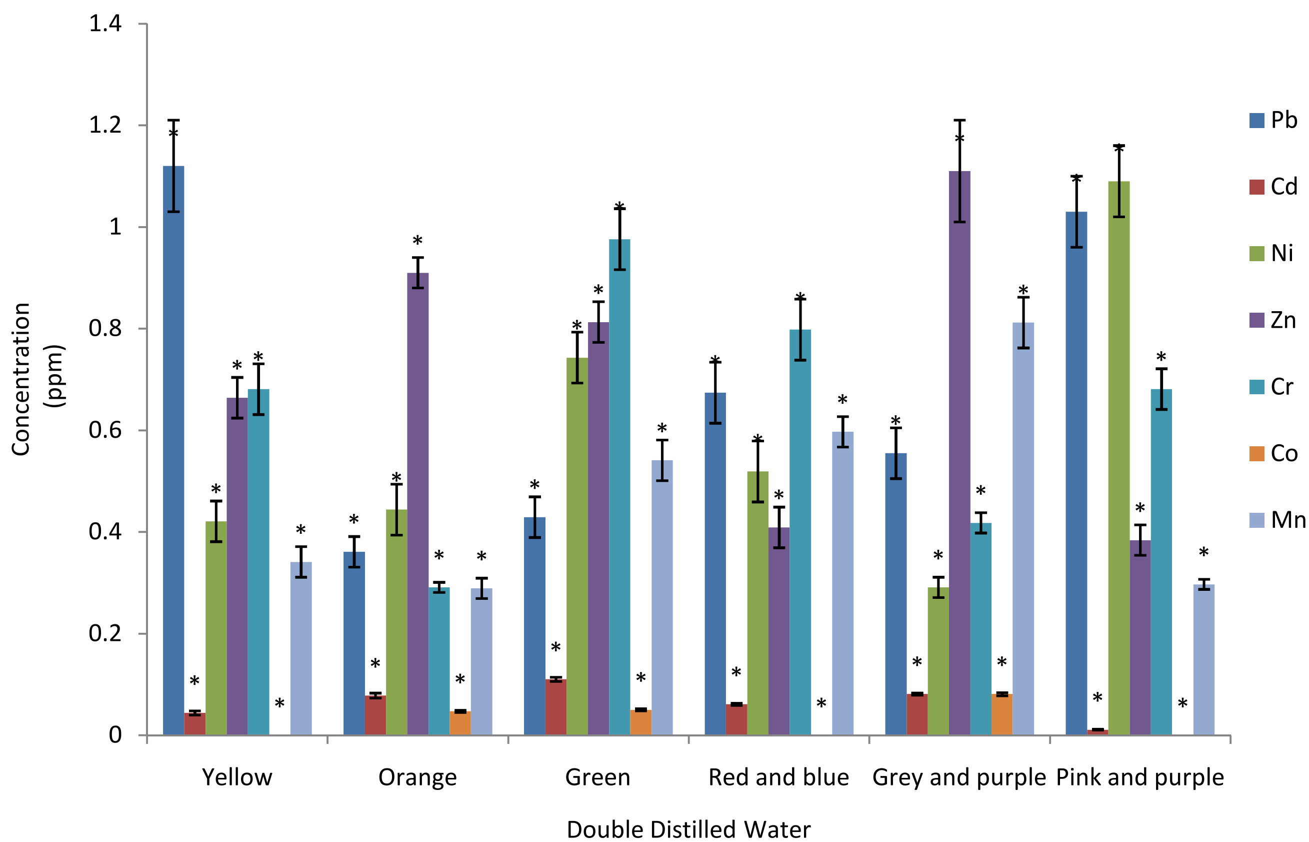

Figure-1

The concentration of metals (ppm) in double distilled water at 40±2ºC for 2 hrs. The results were reported as a mean ±SD from three set of experiments. * p<0.05

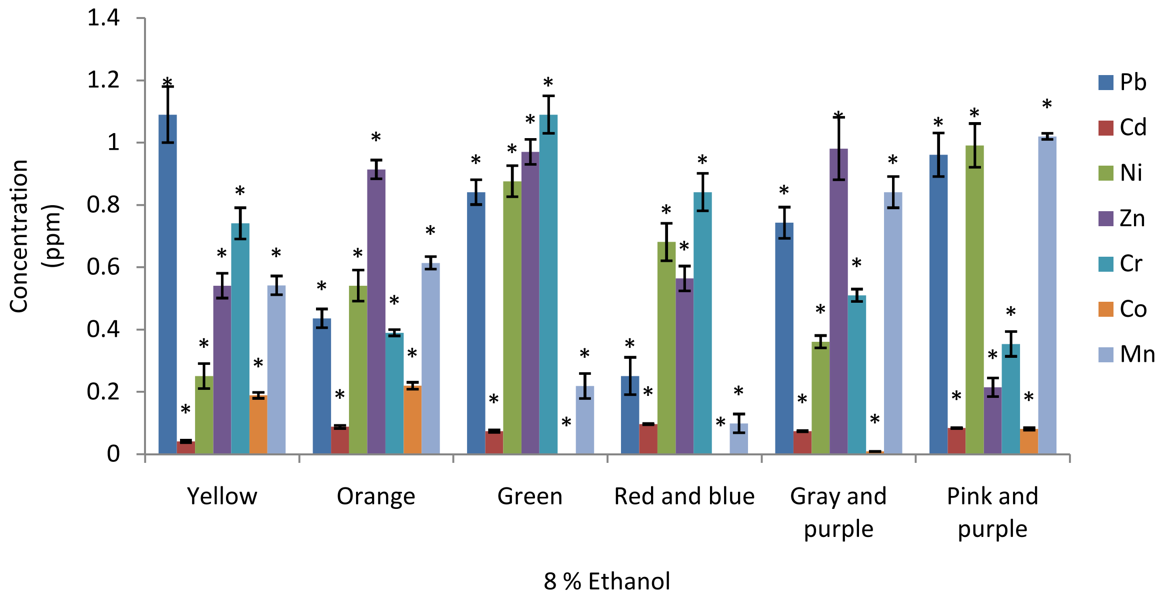

Figure-2
The concentration of metals (ppm) in 8 % ethanol at 40±2ºC for 2 hrs.
The results were reported as a mean ±SD from three set of experiments. * p<0.05

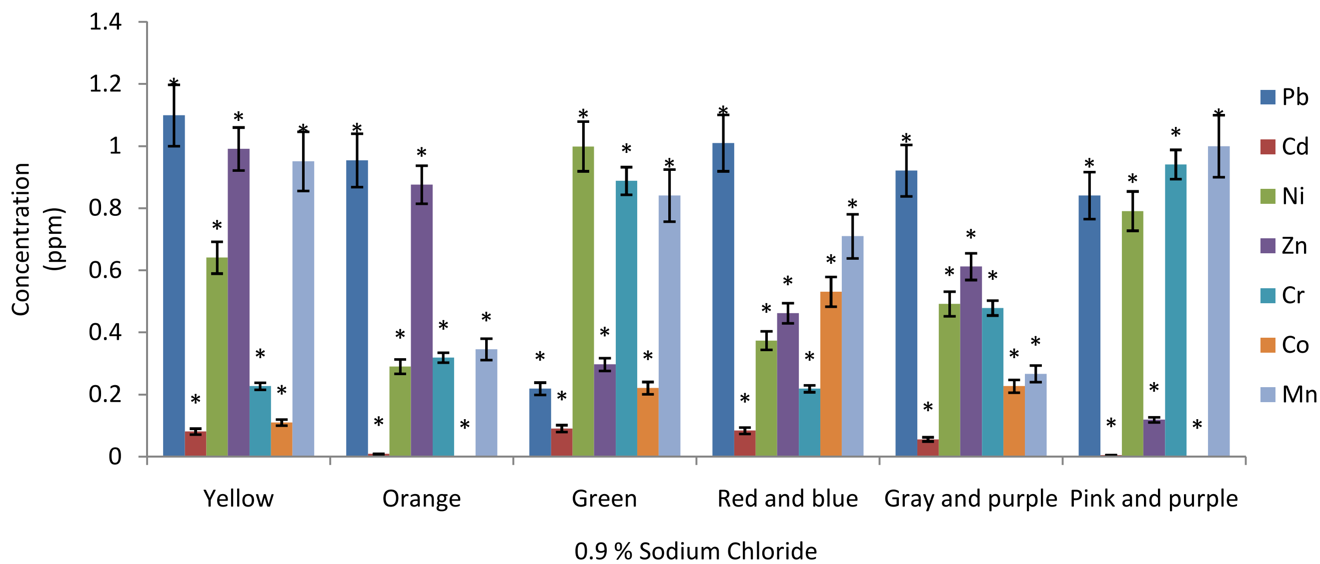

Figure-3
The concentration of metals (ppm) in 0.9 % sodium chloride at 40±2ºC for 2 hrs. The results were reported as a mean ±SD from three set of experiments. * p<0.05

Conclusion

The toys purchased from various districts of U.P. India contain toxic heavy metals, such as Pb, Cd, Ni, Zn, Cr, Co and Mn in varying concentrations and most of them showing high concentrations of their permissible limits that may pose hazards to children's health and create a major health hazard in its use and disposal.

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