Toxics Link
for a toxics-free world

A Brush with Toxics

An investigation into lead in household paints in India

The metal lead has been shown by studies to be highly toxic to human health, with significant effects on the nervous system, and the potential to cause brain damage and even death. At greatest risk are young children, pregnant women and foetuses in the womb. In spite of these facts, this study finds that lead is still used extensively in enamel paints of all brands in India

Brush With Toxics

An Investigation on Lead in Household Paints in India

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Foreword

Lead is a heavy metal, which undisputedly has health effects at relatively low exposure levels, especially in children. This has been known for several decades. It is therefore surprising that its use, especially in countries like India has received such little attention, both by the government as well as by consumers. It was only recently that it was removed from gasoline here, since it was found to have very high levels in the city's ambient air. However it is still used in generic products like paints, pigments and certain types of plastics, despite the fact that lead in all such uses are replaceable by safe alternatives.

Toxics Link started to work on the issue of heavy metals beginning from its work on mercury and heavy metals contamination of food. Through empirical studies (such as the one on heavy metals in vegetables, as well as lead in toys) as well as through investigating the trade, supply and regulatory issues through researched reports, we have over the past 7 years attempted to highlight the extent and range of the problem. The conversations have been of late also of concern to the international community, as exemplified by decisions of the UNEP Governing Council on heavy metals, especially since both mercury and lead have long range transport problems. Alongside, as trade becomes more global, there have been rising concerns from developed country consumers and regulators about the issue of lead in toys, in children's jewellery and other products as well, resulting in products recalls. Some of these recalled products were manufactured in India.

This report on lead in paints is important since paints are widely used across products, and across households, giving rise to scattered and distributed contamination concerns. Lead free paint has been used in Europe, the US, Australia amongst other countries for several decades, and often the manufacturers are the same as those who sell in India. However owing both to the lack of governmental regulation as well as consumer awareness, industry has not reacted or taken action in India, even though there are some torch bearers amongst them. We hope that this report will lead to safer paints, and also set the ball rolling for safer products per se.

Ravi Agarwal
Director

About Toxics Link

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 all stakeholders working on similar issues and has been conducive to the formation of several common platforms for them. It also networks internationally and is part of international networks working on similar issues.

The mission of the organization is to:

"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"

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Abhay Kumar

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INTRODUCTION

Paints, depending upon the nature of their usage, can be categorized as decorative or industrial. Decorative paints are primarily used on the interior or exterior of homes and buildings and include other coatings such as emulsions, enamels, varnishes, wood finishes and distempers. Industrial paints find their use in automobile coatings, steel structures, marine coatings and for other high performance purposes. Based on solvents used decorative paints are classified into water- based and oil-based paints. Plastic paints are water- based while enamel paints are oil- based.

Use of Lead in Paints

Lead• is added to paint not only to impart colour but also to make it durable, corrosion resistant, and to improve drying. It provides longevity to coatings on walls, woods and metals. A number of lead compounds can be used as pigments in paints such as lead oxide, lead carbonate (also known as white lead) and lead chromates/molybdates (ILZSG, 2004). Lead carbonate was historically used for wall paint in households and still is a significant source of lead exposure. Lead chromates, molybdates and sulphates are still widely used. They are inorganic pigments for bright and opaque yellow, red and orange colours in paints. Lead chromates represent 1 percent of the total lead use worldwide (ILZSG, 2004). There are, however, readily available substitutes for all these lead compounds.

• Lead (Pb) is categorized as heavy metal belonging to group IV A (14) of the periodic table having atomic number 82 and relative atomic mass 207.2. Pure lead is a silvery- white metal that oxidizes and turns blue- grey when exposed to air (USA EPA, 1998). It is soft (enough to be scratched by fingernail), dense (11.3 g/cm^3), malleable and readily fusible. Alloying it with small amounts of arsenic, copper, antimony or other metals hardens lead. Lead- containing products are manufactured using these alloys. The use of lead, and the process of extracting lead from ore, date back to ancient times; the earliest known example of metallic lead is a metal figure recovered from the Temple of Abydus in Upper Egypt, considered to date from 4000 BC (Thornton et al., 2001). Metallic lead occurs rarely in nature. Lead is usually obtained from sulphide ores, often in combination with other elements such as zinc, copper and silver. Its abundance in Earth's crust is about 0.0013 percent. Lead exists in three oxidation states Pb(0)- elemental form, Pb(II) and Pb(IV) and has three chemicals forms, viz., metallic lead, inorganic lead compounds and organic lead compounds.

Paint Composition

In addition to lead, paints may contain a mixture of other metal pigments and compounds used as vehicles, pigments or additives. The liquid portion of paint (constituting 50-75 percent of paint) is also known as the 'vehicle', which is essentially composed of volatile organic compounds (VOCs). 'Pigments' are the solid portion of the paint, which is used to impart colour, durability and consistency to paints. Titanium dioxide and other metal compounds are the preferred compounds for this purpose. 'Additives' present in lower concentrations act as corrosion inhibitors, fungicides, preservatives, wetting agents, water resistance, gloss, etc. 'Binders' are generally oils, resins and plasticisers, which tend to hold pigment together.

Paint Industry in India

Some of the basic statistics related to paint industries in India are given in table 1 and 2. Figures 1 and 2 also show the sales figures of various paint companies and their forex earnings in goods.

Source: Industry: Market Size & Shares, Center for Monitoring Indian Economy

Table 1. Company wise trends in market shares: 2000-01 to 2005-06 (Per cent)

Name	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06
Asian Paints	33.32	33.76	35.52	36.73	35.84	38.05
Kansai Nerolac Paints Ltd.	16.36	15.37	16.24	17.39	16.98	17.43
Berger Paints India Ltd.	13.62	13.27	13.98	14.73	15.29	16.05
I C I India Ltd.	9.43	8.4	9.1	9.83	10.2	10.49
Shalimar Paints Ltd.	3.28	3.05	3	2.53	3.52	3.57
Bombay Paints Ltd.	1.2	0.84	0.42	0.33	0.41	0.42
Jenson & Nicholson (India) Ltd.	3.6	2.78	1.39	0.35	0.3	0.33

Table 2. Industrial details about the paint sector

	2002-03	2001-02	2000-01	1999-00
Number Of Factories	814	790	737	783
Factories In Operation	808	774	726	738
Income (in Rs Lakhs)	114259	119363	109966	58802
Profit (in Rs Lakhs)	73606	77585	72607	30731

Fig 1. Sales figures (in Rs. crores) of various paint industries between year 2003-2006

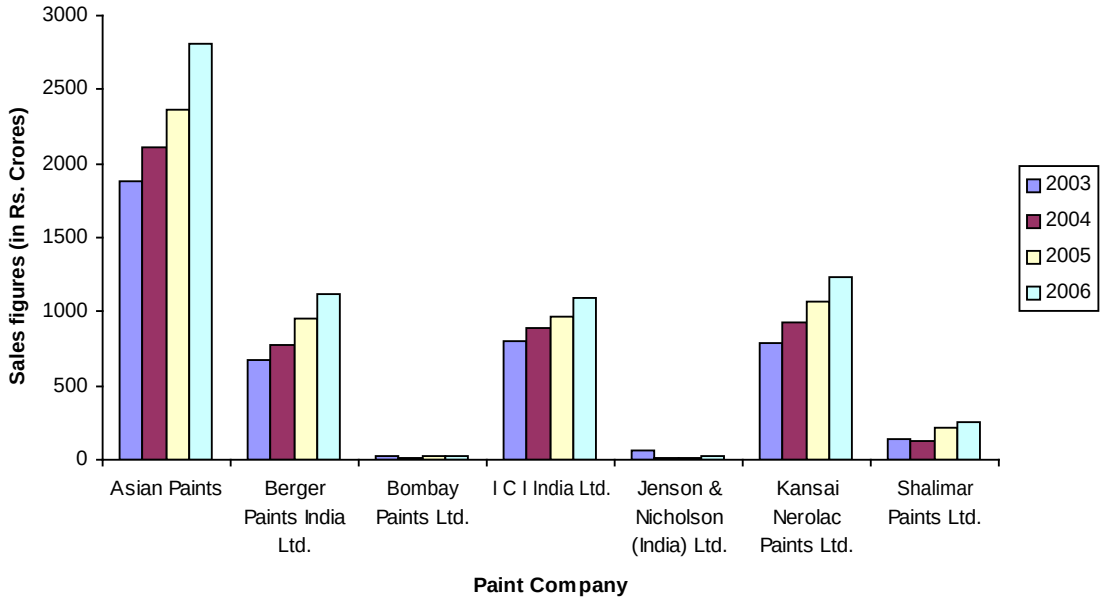
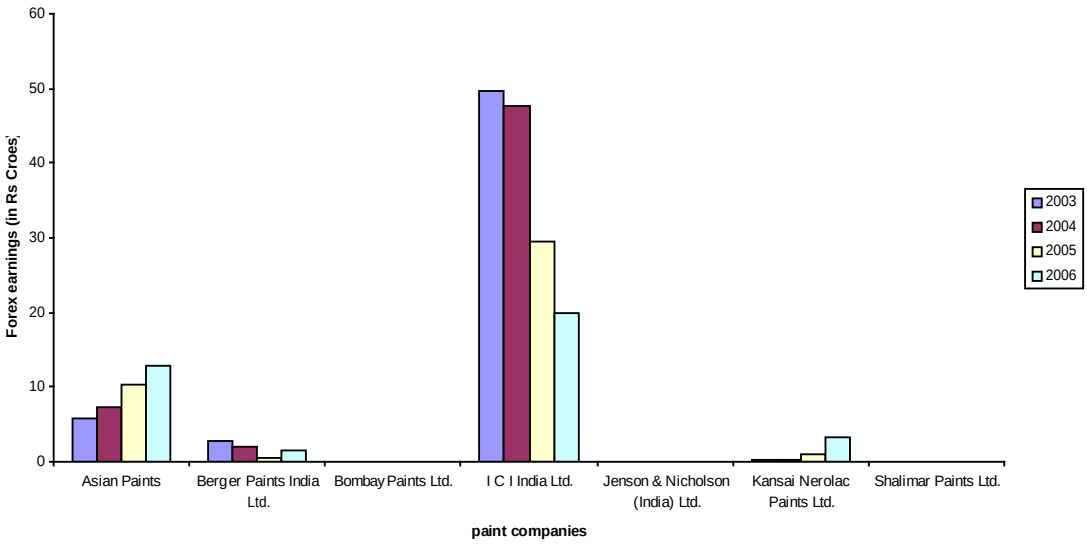


Fig. 2. Forex earnings from goods for various companies in year 2003 to 2006



As is evident from tables 1 and 2 that brands like Asian Paints, Berger, Nerolac, ICI Dulux, Shalimar, Bombay Paints and Jenson & Nicholson have major shares in paint products market; the three brands, viz., Asian paints, Nerolac and Berger among themselves control more than 70 percent of the market share. Asian paints is the industry leader. It has more than 15,000 retail outlets, while Nerolac has a distribution network of 10700 retail outlets. Figure 1 reveals that sales figures of all brands have consistently increased since 2003. While on one hand foreign exchange earned by selling goods have been substantial for ICI Dulux in comparison to other brands on the other it's also declining since year 2003 which is just reverse in case of Asian Paints (Fig. 2)

All the paint majors in India have tie-ups with global paint leaders for technical collaboration. About the various tie-ups, a website informs, "Asian Paints has formed a joint venture with PPG Industries Inc. while Berger gas a series of tie-ups for various purposes. It has a technical tie-up with Herbets Gmbh of Germany in addition to its joint venture with Becker Industrifag. With the agreement with Herbets coming to an end in 2001, Berger has now allied with the Japanese major Nippon Paints. It also has an agreement with Orica Australia Pvt. Ltd. to produce new generation protective coatings. The company also has tie-ups with Valspar Corp and Teodur BV for manufacturing heavy duty and powder coatings. ICI makes paints with the technical support of Herbets, which has been recently acquired by by E I Du Pont de Nemours of the US. Interestingly, Du Pont, which is a leader in automotive coatings in the US, has a technical tie-up with Goodlass Nerolac for the manufacture of sophisticated coatings for the automotive sector. Goodlass also has technical collaborations with Ashland Chemicals Inc, USA, a leader in the petrochemical industry, Nihon Tokushu Toryo Co and Oshima Kogyo Co Ltd, Japan". (http://www.domainb.com/industry/paints/200012_paint_overview.html)

Human Exposure Pathways

Although children are known to eat paint chips, more commonly lead paints in and around homes contribute to dust and soil contamination that is often the most significant source of exposure for children. Children then ingest lead from playing close to the ground and having frequent hand-to-mouth contact. Significant exposure may also occur from lead paint when smaller particles become airborne during sanding and scrapping while repainting and remodeling. In addition, damaged paint and the weathering of paints on the exterior of buildings also

contribute to lead in soil. Contaminated soil is a particularly significant source of exposure to children. Ingestion of contaminated soil, dust and lead based paint chips and toys due to hand-to-mouth activity form important sources of lead exposure in infants and young children. In addition to paint and dust, food and water may also be significant sources of lead exposure. However, relative importance of these sources varies amongst different populations. In infants and young children as much as 50 percent of dietary lead is absorbed, although absorption rates for lead from dusts/soils and paint chips can be lower depending upon the bioavailability (IPCS, 1995). Absorption routes and absorption itself are dependent on particle size, chemical speciation, and solubility in body fluids.

Health Impacts of Lead

The US ATSDR, 2005 document best summarizes the health impacts of lead. It states, "The main target for lead toxicity is the nervous system, both in adults and children. Long-term exposure of adults to lead at work has resulted in decreased performance in some tests that measure functions of the nervous system. Lead exposure may also cause weakness in fingers, wrists or ankles. Lead exposure also causes small increases in blood pressure, particularly in middle-aged and older people. Lead exposure may also cause anemia. At high levels of exposure, lead can severely damage the brain and kidneys in adults or children and ultimately cause death. In pregnant women, high levels of exposure to lead may cause miscarriage. High-level exposure in men can damage the organs responsible for sperm production" (U.S. ATSDR, 2005).

A WHO/UNECE, 2006 document further describes the health effects of lead. According to this document, "Lead is a well known neurotoxic metal. Impairment of neurodevelopment in children is the most critical lead effect. Exposure in uterus, during breast-feeding, and in early childhood may all be responsible for the effects. Lead accumulates in skeleton and its mobilization from bones during pregnancy and lactation causes exposures to foetus and breast fed infant. Hence, life time exposure of woman before pregnancy is important. Epidemiological studies show consistently that effects in children are associated with lead levels in blood (Pb-B) of about 100-150 μg/l. There are indications that lead is harmful even at blood lead concentrations considerably below 100 μg/l and there may be no threshold for these effects." (WHO/UNECE, 2006).

Toxicity Mechanism of Lead

Various mechanisms of lead toxicity have been proposed which include lead binding to the sulphydryl (SH) groups of proteins, lead displacing calcium and zinc inside proteins, lead having an affinity for cell membrane, lead interfering with mitochondrial oxidative phosphorylation, it impairing the activity of calcium dependent intracellular messengers and protein kinase C and lead inhibiting DNA repair and exerting genotoxic effect and also affecting sodium, potassium and calcium ATP-ase. (Skerfving et. al., 1998; Lidsky and Schneider, 2003; Toscano and Guilarte, 2005).

Impacts on Vulnerable Populations

Young children (below 6 years old) are recognized as the most susceptible to lead exposure even at low levels. Pregnant women are the second most vulnerable group. Lead also crosses the placenta and reaches the developing fetus. Absorbed lead is rapidly taken up by blood and soft tissue, followed by a slower redistribution to bone. Bone accumulates lead during much of the human life span and may serve as an endogenous source of lead that may be released slowly over many years after the exposure stops (IPCS, 1995).

Regulations for Lead in Paints

For over 50 years now dangers represented by lead paint manufacturing and application led to many countries' enacting bans or restrictions on the use of white lead for interior paint: France, Belgium, and Austria in 1909; Tunisia and Greece in 1922; Czechoslovakia in 1924; Great Britain, Sweden and Belgium in 1926, Poland in 1927; Spain and Yugoslavia in 1931; and Cuba in 1934 (Markowitz, 2000). In 1922 the third International Labour Conference of the League of Nations recommended the banning of white lead for interior use (AJPH, 1923).

With respect to the existing US standard for lead in new paints, the Consumer Product Safety Commission (CPSC) of US states, "that paint and similar surface-coating materials for consumer use that contain lead or lead compounds and in which the lead content (calculated as lead metal) is in excess of 0.06 percent of the weight of the total nonvolatile content of the paint or the weight of the dried paint film (which paint and similar surface-coating materials are referred to

hereafter as "lead-containing paint") are banned hazardous products under sections 8 and 9 of the Consumer Product Safety Act (CPSA), 15 U.S.C. 2057, 2058. (See parts 1145.1 and 1145.2 for the Commission's finding under section 30(d) of the Consumer Product Safety Act (CPSA) that it is in the public interest to regulate lead containing paint and certain consumer products bearing such paint under the CPSA.)" (CFR, 2004).

In 1997, Australia recommended 0.1 percent of total lead as the maximum amount of lead in domestic paint (DEH 2001). Singapore also has a standard of 0.06 percent of lead in new paints. China has the most stringent standard for lead in paints, which is 90 ppm (Barboza, D., 2007).

The existing Indian standard (which is voluntary) for maximum content of lead in paint is governed by IS 15489: 2004, superseding IS 5411 (Part 1): 1974 and IS 5411 (Part 2): 1972 (Bureau of Indian Standards, 2004). Under additional optional requirements for ECO-Mark, which was introduced by Ministry of Environment and Forests (MoEF) and is administered by the Bureau of Indian Standards (BIS) under the BIS Act, 1986 as per the Resolution No. 71 dated 20th February, 1991 published in Gazette of Government of India, the para 6.12.2.2 of IS 15489: 2004 states, "The product shall not contain more than 0.1 percent by mass (as metal), of any toxic metals such as lead, cadmium, chromium (VI) and their compounds when tested by the relevant Atomic Absorption Spectrophotometric methods". For a product to be eligible for ECO-Mark it shall carry standard mark of BIS for quality besides meeting additional optional environmental friendly (EF) requirements of Eco-Mark. Therefore, these voluntary standards, in effect, mean that no manufacturer is bound by any law to subscribe to these standards. Even if one wishes to follow IS 15489: 2004, one is not required to limit the lead concentration in paint products below 0.1 percent (1000 ppm) as the requirement for lead to be below 0.1 percent comes under an optional scheme of ECO-Mark. So a paint product labeled ISI (thereby confirming to the BIS voluntary standards) may not contain lead below 1000 ppm unless it also has ECO-Mark.

Table 3 summarizes the various standards for lead in new paints.

Table 3: Standards for Lead (Pb) in new paints in some countries.

USA	Australia	China	Singapore	India		
New paints				ISI voluntary standard (IS 15489: 2004	ECO- Mark (Optional under the same ISI voluntary standard	Intended for defense purposes (as PbO)
600 ppm (0.06 %)	1000 ppm (0.1 %)	90 ppm (0.009 %)	600 ppm (0.06 %)	No limit exists	1000 ppm (0.1 %)	50000 ppm (5 %)

LITERATURE REVIEW

An enormous body of literature exists on issues related to lead toxicity and blood lead concentrations in children. That lead is a toxic element has been well established (John, H., et al., 1991; WHO, 1995; US Department of Health and Human Services, 1988); Goldstein, 1992)). It is the toxicity of lead that led WHO and US Centers for Disease Control and Prevention (CDC) to consider lead concentrations in blood higher or equal to 10 µg/dl as elevated. In fact a recent body of literature points out that there may be no safety margin at existing exposures and that children exposed to even < 10 µg/dl have also shown intellectual impairment (Koller, et. al., 2004; Needleman, 1995; Needleman and Bellinger, 2001; Needleman, et. al., 2002) Sources of lead in the environment that have been shown to contribute greatly to elevated blood lead concentrations include petrol, paint, water, food, cosmetics and lead- glazed ceramics (Lanphear, et al., 1998; Brown, et al., 2000). Unlike overt lead toxicity, where there is usually one identifiable source, low- level environmental exposure to lead is associated with multiple sources (petrol, industrial processes, paint, solder in canned foods, water pipes) and pathways (air, household, dust, street dirt, soil, water food) (Tong, et al., 2000). Evaluation of the relative contributions of sources is therefore complex and likely to differ between areas and population groups (von Schirnding, 1999).

In a majority of developed countries, concerted efforts have led to a reduction in the release of lead into the ambient environment in recent years, reflecting a decline in the commercial use of lead, particularly in petrol (CDC, 1991; Edwards- Bert, Calder and Maynard, 1994). Blood lead levels in the general population in these countries have fallen dramatically over the past 20 years, thanks to the phasing out of lead from petrol and the reduction of environmental exposure to the metal (Edwards- Bert, Calder and Maynard, 1994; Annest, 1983; Pirkle, et. al., 1994). In the USA between 1976 and 1991 the mean blood lead level of persons aged 1- 74 years dropped by 78 percent, from 12.8 µg/dl to 2.8 µg/dl (Pirkle, et. al., 1994). Mean blood lead levels of children aged 1- 5 years declined by 72 to 77 percent for various social groups of children (Pirkle, et. al., 1994). Some recent investigations have revealed that even low- level and long term lead exposure can lead to health related problems such as renal dysfunction or delayed puberty in girls (Selvan, et.al., 2003; Wu, et.al., 2003; Marsden, 2003).

Lead continues to be a significant public health problem in developing countries where there are considerable variations in the sources and pathways of exposure (Tong and McMichael, 1999; Falk H, 2003)). In a study done on 281 children in Lebanon, it was found that the mean Pb-B was 66.0 µg/l with 14 percent children having Pb-B more than 100 µg/l (Nuwayhid, et al., 2003). Logistic regression analysis showed that elevated Pb-B was associated with paternal manual jobs (odds ratio [OR]: 4.74), residence being located in high traffic areas (OR: 4.59), summer season (OR: 4.39), using hot tap water for cooking (OR: 3.96 and living in older buildings (OR: 2.01). In a study investigating the prevalence of elevated blood lead (Pb-B) levels in children 1-6 years old in Kaduna, Nigeria, mean Pb-B was found to be 10.6 µg/dl and 2 percent of children had Pb-B levels higher than 30 µg/dl (Nriagu, 1997). The strongest associations were found between Pb-B and whether family owned a car or lived in a house on tarred road. In a similar study done in Karachi, it was found that about 80 percent (n=430) of children (aged 36-60 months) had blood lead concentrations higher than 10 µg/dl (Rahbar, et. al., 2002). It also derived that at the 5 percent level of significance, houses nearer to the main intersection in the city center, application of surma to children's eyes, father's exposure to lead at workplace, parent's illiteracy and child's habit of hand-to-mouth activity were among variables associated with elevated lead concentrations in blood.

India Related Studies

In a study on lead poisoning in major Indian cities, the George Foundation reported 51.4 percent of the total sampled population having more than 10 µg/dl of Pb-B while 12.6 percent having more than 20 µg/dl of Pb-B (The George Foundation, 1999). In cities like Delhi and Kolkata almost 19 percent of sampled population had blood lead concentration more than 20µg/dl. In Mumbai 14.7 percent of children had more than 20 µg/dl of blood lead concentration.

In a study conducted to estimate the Pb-B and prevalence of lead toxicity in school children and children residing in urban slums in Delhi, it was found that the mean Pb-B was 7.8 µg/dl and proportion of children having more than 10 µg/dl of Pb-B was 18.4 percent (Kalra, V., et al., 2003). It also suggested that distance of the residence or school from a main road appeared to be associated with higher blood lead concentrations, but these differences were not statistically significant. Similar reports highlight high concentrations of blood lead in children in

various other cities in India and relate it with local practices and exposure pathways (Kumar and Kesaree, 1999; Kaul, 1999; Patel, et. al., 2001).

Literature Related to Lead in Paints

It is evident from the research above that high blood lead levels in children are prevalent in India and developing countries. Most of these studies have tried to relate high blood lead concentrations to various exposure sources like lead-based gasoline and paint chips. However, with lead in gasoline being phased out worldwide, it becomes imperative to look into the whole issue of lead-based paint and its exposure to children. While developed countries have moved in this direction, in developing countries it leaves a lot to be desired. Public health policies must reflect the new findings in this regard. It is easier said that done as the lead industry has repeatedly sought to resist any shift to alternatives (Markowitz, 2000)

Lead based paint in older houses has long been associated with elevated blood lead in children residing within them (Clark, et al., 1985). The causal relationships were considered to be mainly due to ingestion of lead-based paint chips (Lin-Fu, 1967). In one of the first studies on lead in paints and soil, Clark, et. al., (2005) concluded that lead paint should be considered a significant potential source of lead poisoning in India. They also determined lead in 29 paint samples collected from Gujarat and Karnataka in India and reported that 11 of them were either equal or exceeded 1.0 mg/cm^3 after the application of one to three coats. In one of the studies to investigate the sources of lead in environment in children with elevated blood lead concentrations with the help of Field Portable X-Ray Fluorescence Analyzer, Kuruvilla A., et. al., (2004) attributed high blood lead levels in one student with the brightly coloured swings painted with lead based paint in an area where he routinely played. In another case high blood lead level was associated with a railing coated with lead based yellow paint where the child played. The third child with high blood lead level had the habit of licking the painted surface (pica) leading to ingestion of lead. In another interesting study done by Clark, et. al., (2005), they found sixty six percent of new paint samples purchased from China, India and Malaysia containing 5000 ppm or more while 78 percent contained 600 ppm or more. They also point out that lead content in paints depended upon the regulations. The same brand has different contents of lead in different countries depending upon whether any regulation existed or not (Clark,

et. al., 2006). They also reported that 100 percent (n=17) of paint samples from India had more than 600 ppm of lead concentration while 83 percent samples had more than 5000 ppm of lead contents.

STUDY OBJECTIVES AND METHODOLOGY

Objectives

The main objective of the present study was to determine the total concentration of lead (Pb) in decorative paints of all types viz., plastic (water based or latex) and enamel (oil based) intended for residential uses. Although lead as a source of health hazard has been studied in soil and in atmosphere, very few studies have been done on paints in India. The previous study done by C. S. Clark, et. al. (2006) included only 17 samples of new paints from India.

Sampling

All paint samples were purchased from different retail shops in Delhi and Mumbai between 23rd November 2006 to 11th December 2006 and then brought to the Toxics Link office in Delhi. These paints were easily available in various markets. According to shopkeepers, these paints were intended largely for residential uses for painting the interior and exterior surfaces of houses. Shopkeepers also informed us that what they called "plastic paints" were water based and largely used to coat interior plastered surfaces of house while "enamel paints" were mainly for painting wooden and metal surfaces. Enamel paints are also used as primers on walls. Although some of the paints are marketed especially for exterior or interior use, consumers use these paints according their own convenience based on the price, colour, shade and brands of the paints. Majority of the samples were purchased from Delhi while a few were also purchased from Mumbai markets. Samples were labeled and information mentioned on containers noted down. A total of 69 paint samples were purchased which included 38 plastic and 31 enamel paint samples.

While all plastic paint samples were purchased in 1 L container, enamel paints were purchased in 50/100/200 ml cans. The plastic paints are sold after blending base paints with colour pigments as per a fixed ratio provided by each brand depending upon the colour requirement. The price of plastic paints ranged from Rs. 150 to Rs. 360 for 1-liter can. Enamel paints cost Rs. 14-18 for 50 ml can and Rs 24-26 for 100 ml can. Price of 200 ml enamel paint ranged from Rs. 44 to Rs. 60. Most of the paint samples belonged to known branded products. Paint samples of one local brand were also purchased. No paint sample had ISI mark or ECO-mark on it. The complete description of the samples is given in

table 4. We came across a brand, which had a label indicating, "no added lead, mercury, chromium compounds".

Materials and Methods

Samples were analysed as according to Standard Operating Procedures for Lead in Paint by Hotplate or Microwave- based Acid Digestions and Inductively Coupled Plasma Emission Spectroscopy, EPA, PB92-114172, Sept. 1991; SW846- 740 (US EPA, 2001)

Sample preparation

1. Wet paint samples were applied on to individual clean glass surfaces (one sq. feet) using different brushes for each sample to avoid any cross contamination. Samples, thus applied were left to dry for a minimum of 72 hours.
2. After drying samples were scraped off from glass surfaces using sharp and clean knives. Same knife was not used again for other samples to avoid any contamination.
3. Thus scraped, samples were collected in polyethylene bags and sent via courier to the Galson Laboratories 6601 Kirkville Road, East Syracuse, NY 13057 Tel: (315) 432- 5227 Fax: (315) 437-0571, www.galsonlabs.com for further analysis.

Laboratory Methods

1. Scraped samples were crushed using mortar and pestle to make samples as homogenous as possible. Latex paint does not grind hence they were teared into small pieces using pre- cleaned steel scissors.
2. 1 g of each sample was weighed out into an acid –washed 100 ml beaker and then digested/extracted.
3. Standards were also taken similarly.

Digestion Procedures

1. 3 ml. of concentrated HNO_3 and 1 ml of H_2O_2 were added into beaker containing samples and standards and then covered with a ribbed watch glass.
2. Samples and standards were then heated on a hot plate at 140^0 Centigrade until most of the acid was evaporated. Then it were removed from hot plate and allowed to cool at room temperature.

3. Then 2 ml of HNO_3 and 1 ml 30% H_2O_2 were added into the beakers and dried on hot plate to dryness and then allowed to cool.
4. Step 3 was repeated once again.
5. Watch glass and walls of beaker were rinsed with 3 to 5 ml of 1MHNO_3. Solution was evaporated gently to dryness and then removed from heat and cool.
6. 5 ml of concentrated HNO_3 were added to residue and samples were then swirled for a minute or so to dissolve soluble species.
7. Samples were poured from beaker into a labeled, pre-measured 125ml wide mouth graduated container to achieve desired total volume. Samples were brought to 100 ml volume by adding DD and mixed vigourously.
8. Digested samples were then analysed for total lead (Pb) in Thermo 61E Trace Inductively Coupled Plasma (ICP) Spectrometer.

RESULTS AND DISCUSSION

Results

The total concentrations of lead (Pb) in plastic paint samples are given in table 5. Lead concentration in enamel paint samples are presented in table 6. Tables 7 and 8 give average and median values of enamel paint data for various brands and colour- wise respectively. Table 9 gives the percentage of enamel paints samples that exceed existing standards for lead in paint.

1. As per table 5, all water- based plastic paints contained less than 25 ppm of total lead concentration. These paints therefore comply with the voluntary standard, under Indian Eco Mark Scheme, which suggests that total lead concentration in paints should not exceed 1000 ppm (0.1 percent).

2. Table 6 shows that most oil- based enamel paints contain high concentrations of lead (Pb), ranging up to 140000 ppm (0.0025 to 14 percent). Only one paint brand sample had results consistently less than 600 ppm. The average concentration of lead ranged from 49.7 ppm to 39900 in other brands tested. (Table 7)

3. The average concentration of lead for brand 'D' enamel paint samples was 49.7 ppm, while brand 'A' enamel samples had an average of 39900 ppm of lead. Similarly, the average concentration of lead for 'B' enamel samples was 36300 ppm. Enamel paint samples of 'E' and 'G' had average lead concentration as 33345.3 ppm and 27666.7 ppm respectively. Enamel samples of brand H had an average concentration of 16250 ppm of lead.

4. As per table 8, the white enamel paints had the lowest concentration of lead among all colors tested. The average concentration for white enamel paint was 991.8 ppm while the maximum average concentration of lead was found in yellow colour enamel paints followed by orange, green, red, blue and then black.

5. As per the US standard, new paint containing more than 600 ppm (0.06 percent) of total lead is banned for residential use and from products intended to be used by children. Table 9 gives the percentage of enamel paint samples falling above various Indian and US standards. Of 31 enamel samples analysed for total lead

concentration, 83.87 percent of samples had more than 600 ppm of lead. The same percentage of samples exceeded 1000 ppm limit set by Eco Mark scheme, while 61.3 percent of paint samples contained more than 5000 ppm. In sum 38 percent of all samples, including plastic, enamel and exterior types, contained lead at levels above 600 ppm.

Discussion

The results clearly indicate that water-based plastic paints have low level of lead concentration in all brands. The lead concentration is much below the Indian standard of 1000 ppm or US standard of 600 ppm, which is now widely accepted as the maximum limit of lead concentration in new paints. However, high concentration of lead in enamel paints is the most worrying part of the whole issue of "lead in paints". Except for one brand, all others had multiple samples that contained high concentration of lead, exceeding the voluntary Indian standard of 1000 ppm (0.1 percent) and the US standard of 600 ppm. The scatter plot of lead concentration (%) in enamel paints (Figure 3) indicates that the lead concentration in enamel paint samples ranged from below 1 percent to 14 percent.

Table 10 provides a comparison of results of the present study with that of paint samples collected in India by Clark, C. S. et. al., 2006. Although not mentioned, it appears that the data obtained by Clark et al., 2006 relates to enamel paints. Their study reported that 100 percent of new paint samples from India exceeded 600 ppm whereas the present study reports that 83.87 percent of enamel paints sampled have lead concentrations greater than 600 ppm. In general terms, the range of lead concentrations observed are consistent for enamel paints in this study.

Table 10. Comparison of present data with that of Clark et. al., 2006

Comparison of present data with that of Clark et. Al., 2006		
	Clark et. al., 2006	The Present Study (of enamel paints)
Yellow	159200 ppm *	90000 ppm
Green	39200 ppm	21250 ppm
Brown	10980 ppm	-
All Samples Median value	16720 ppm	7800 ppm 26131 ppm (average)
No of paints having more than or equal to 600 ppm	100 (n =17)	83.87 (n = 31) 38 (n = 69)**
Maximum	187200 ppm	140000 ppm
	* of 2 samples (187200 and 131300 ppm)	** taking into account all samples

Cleaner substitutes for lead based pigments are available for some time now and titanium dioxide is generally used as a substitute for lead. At least one brand within the same price range appears to have eliminated the use of lead pigment and other lead additives. Indian paint companies can shift to lead-free alternatives and still remain competitive without affecting quality.

CONCLUSION

1. Plastic paints contain low concentration of lead across the brands, well below the Indian voluntary standard of 1000 ppm.

2. Majority of the enamel samples (83.87 %) contained more than 600 ppm of lead. Same percentage also exceeded 1000 ppm. 61.3 percent of samples had more than 5000 ppm.

3. The average concentration of lead for brand 'A' was highest while brand 'D' had the lowest concentration of lead. Lead concentration in other brands has following order:

   Brand B > brand E > brand G > brand H

4. 38 percent of all samples, including plastic and enamel types, contained lead at levels above 600 ppm, an international standard formulated by the US EPA.

5. Lead concentrations in paint also appear to be dependent upon colour of the paints and follow the following order: White<Black<Blue<Red<Green<Orange<Yellow.

Table 4. Sample description

Sample No	Brand types	Nature of Paints	Colour	Mfg Date	Place of Purchase	Other information
1	A	Plastic	Red X 117	Aug-06	Delhi	
2	A	Plastic	Yellow X 104	Aug-06	Delhi	
3	A	Plastic	Green Jungle Trail 7565	Jul-06	Delhi	
4	A	Plastic	Ink Blue 7246	Jul-06	Delhi	
5	B	Plastic	Red	Sep-06	Delhi	
6	B	Plastic	Blue	Sep-06	Delhi	
7	B	Plastic	Black	Sep-06	Delhi	
8	B	Plastic	Orange	Sep-06	Delhi	
9	B	Plastic	Green	Sep-06	Delhi	
10	B	Plastic	Yellow	Sep-06	Delhi	
11	B	Plastic	Base	Sep-06	Delhi	
12	B	Plastic	White	Sep-06	Delhi	
13	G	Plastic	Yellow	Sep-06	Delhi	
14	G	Plastic	Blue	2006	Delhi	
15	G	Plastic	Red	2006	Delhi	
16	G	Plastic	Green	2006	Delhi	
17	G	Plastic	White	Nov-05	Delhi	
18	A	Plastic	White	Jun-06	Delhi	
19	D	Plastic	Red	Aug-06	Delhi	The can mentions "no added lead, mercury, chromium compounds" around a mark of green tree
20	D	Plastic	White	Nov-06	Delhi	The can mentions "no added lead, mercury, chromium compounds" around a mark of green tree
21	D	Plastic	Blue	Nov-06	Delhi	The can mentions "no added lead, mercury, chromium compounds" around a mark of green tree
22	D	Plastic	Green	Nov-06	Delhi	The can mentions "no added lead, mercury, chromium compounds" around a mark of green tree
23	D	Plastic	Yellow	Nov-06	Delhi	The can mentions "no added lead, mercury, chromium compounds" around a mark of green tree
24	D	Plastic	Brilliant White	Nov-06	Delhi	The can mentions "no added lead, mercury, chromium compounds" around a mark of green tree
25	A	Enamel	White	May-06	Delhi	
26	D	Enamel	Black	Mar-06	Delhi	The can mentions "no added lead, mercury, chromium compounds" around a mark of green tree
27	D	Enamel	White	Apr-06	Delhi	The can mentions "no added lead, mercury, chromium compounds" around a mark of green tree

Sample No	Brand types	Nature of Paints	Colour	Mfg Date	Place of Purchase	Other comments
28	D	Enamel	Red	Mar-06	Delhi	The can mentions "no added lead, mercury, chromium compounds" around a mark of green tree
29	B	Enamel	Deep Orange	May-05	Delhi	
30	B	Enamel	Golden Yellow	Sep-05	Delhi	
31	E	Enamel	Signal Red	Aug-03	Delhi	
32	E	Enamel	Brilliant white	Dec-05	Delhi	
33	E	Enamel	Orange	Jul-05	Delhi	
34	E	Enamel	Golden Orange	Feb-05	Delhi	
35	G	Superlac Hi Gloss Enamel	Red	Feb-06	Delhi	
36	G	Superlac Hi Gloss Enamel	Golden Yellow	Dec-05	Delhi	
37	G	Superlac HiGloss Enamel	Green	Oct-04	Delhi	
38	G	Superlac HiGloss Enamel	Oxford Blue	May-02	Delhi	
39	H	Synthetic Enamel	Golden Blue	Jul-06	Delhi	
40	H	Synthetic Enamel	Bus Green	Sep-06	Delhi	
41	H	Synthetic Enamel	Phiroza	Aug-06	Delhi	
42	H	Synthetic Enamel	Black	Sep-06	Delhi	
43	H	Synthetic Enamel	White	Aug-06	Delhi	
44	H	Synthetic Enamel	Red	Oct-06	Delhi	
45	E	Enamel	Bus Green	Apr-04	Delhi	
46	E	Enamel	Oxford Blue	Apr-05	Delhi	
47	B	Hi Gloss Enamel	Bus Green	Nov-05	Delhi	
48	B	Hi Gloss Enamel	Snow White	Mar-06	Delhi	
49	B	Hi Gloss Enamel	Signal Red	Apr-06	Delhi	
50	B	Hi Gloss Enamel	Black	Jun-06	Delhi	
51	B	Hi Gloss Enamel	Oxford Blue	Jun-06	Delhi	
52	A	Premium Gloss Enamel	P.O. Red	Mar-06	Mumbai	
53	A	Premium Gloss Enamel	Golden Yellow	Mar-06	Mumbai	
54	A	Premium Gloss Enamel	Black	Feb-06	Mumbai	
55	A	Premium Gloss Enamel	Oxford Blue	Dec-04	Mumbai	
56	A	Premium Gloss Enamel	Deep orange	Nov-05	Mumbai	
57	E	Plastic	NBE White	Aug-06	Delhi	
58	F	Acrylic Plastic Emulsion	Radiant White	Mar-01	Delhi	
59	E	Premium Acrylic Emulsion	Wonder white	Jun-04	Delhi	
60	E	Excel Acrylic Exterior	White	Aug-97	Delhi	

Sample No	Brand types	Nature of Paints	Colour	Mfg Date	Place of Purchase	Other comments
61	F	Exterior Finish	Base	Feb-00	Delhi	
62	D	Watershield Acrylic Exterior Wall Finish	Base	Nov-04	Delhi	The can mentions "no added lead, mercury,chroium compunds" around a mark of green tree
63	F	Sheen Emulsion	Base-C	Jun-02	Delhi	
64	B	Weather coat Smooth Finish 100 percent acrylic	White		Delhi	
65	A	Apex weather proof exterior emulsion	Classic White	Oct-05	Delhi	
66	E	Emulsion	No 60 with fast yellow stains (E hi-power universal stainer)	Oct-06	Delhi	
67	E	Emulsion	No 61 with fast yellow stains (E hi-power universal stainer)	Oct-06	Delhi	
68	E	Emulsion	No 62 with fast yellow stains (E hi-power universal stainer)	Oct-06	Delhi	
69	E	Emulsion	No 64 with fast yellow stains (E hi-power universal stainer)	Oct-06	Delhi	
70	E	Emulsion	No 65 with fast yellow stains (E hi-power universal stainer)	Oct-06	Delhi	

Table 5: Lead (Pb) concentration in plastic paint samples

Sample No	Sample Description	Pb (ppm)	Pb (%)
1	Brand type A /Red X 117/ Plastic	< 25	< 0.0025
2	Brand type A /Yellow X 104/ Plastic	< 24	< 0.0024
3	Brand type A /Green Jungel Trail 7565/Plastic	< 24	< 0.0024
4	Brand type A /Ink Blue 7246/ Plastic	< 24	< 0.0024
5	Brand type B/Red/Plastic	< 25	< 0.0025
6	Brand type B /Blue/Plastic	< 25	< 0.0025
7	Brand type B /Black/Plastic	< 25	< 0.0025
8	Brand type B /Orange/Plastic	< 25	< 0.0025
9	Brand type B /Green/Plastic	< 25	< 0.0025
10	Brand type B /Yellow/Plastic	< 25	< 0.0025
11	Brand type B /Base/Plastic	< 24	< 0.0024
12	Brand type B /White/Plastic	< 24	< 0.0024
13	Brand type G/Yellow/Plastic	< 23	< 0.0023
14	Brand type G /Blue/Plastic	< 25	< 0.0025
15	Brand type G /Red/Plastic	< 24	< 0.0024
16	Brand type G /Green/Plastic	< 24	< 0.0024
17	Brand type G /White/Plastic	< 24	< 0.0024
18	Brand type A /White/Plastic	< 25	< 0.0025
19	Brand type D/Red/Plastic	180	0.018
20	Brand type D /White/Plastic	< 24	< 0.0024
21	Brand type D /Blue/Plastic	< 24	< 0.0024
22	Brand type D /Green/Plastic	< 25	< 0.0025
23	Brand type D /Yellow/Plastic	< 25	< 0.0025
24	Brand type D /Brilliant White/Plastic	< 25	< 0.0025
57	Brand type E/ Plastic/ NBE White/08.06/Third quality	< 25	< 0.0025
58	Brand type F/ Acrylic Plastic Emulsion/ Radiant White/03.01	< 25	< 0.0025
59	Brand type E/Premium Acrylic Emulsion/Wonder White/06.04	< 24	< 0.0024
60	Brand type E/Excel Acrylic Exterior Paint/White/ 08.97	< 25	< 0.0025
61	Brand type F/ Acrylic Exterior Finish/02.00/Base A	< 25	< 0.0025
62	Brand type D/Weather shield Acrylic Exterior Wall Finish/ Base/11.04	< 25	< 0.0025
63	Brand type F/ Insta acryl Base -C/ Sheen Emulsion/ 06.02	< 25	< 0.0025
64	Brand type B/Weather coat Smooth Finish/100 % acrylic/White	< 25	< 0.0025
65	Brand type A/Apex Weather Proof exterior/ Emulsion/10.05/classic white	< 24	< 0.0024
66	No 60 with fast yellow stains (brand type E hi-power universal stainer 10.06/200ml)	< 25	< 0.0025
67	No 61 with fast yellow stains (brand type E hi-power universal stainer 10.06/200ml)	< 24	< 0.0024
68	No 62 with fast yellow stains (brand type E hi-power universal stainer 10.06/200ml)	< 23	< 0.0023
69	No 64 with fast yellow stains (brand type E hi-power universal stainer 10.06/200ml)	< 24	< 0.0024
70	No 65 with fast yellow stains (brand type E hi-power universal stainer 10.06/200ml)	< 25	< 0.0025
	Average	Less than 25 ppm	

Table 6. Lead concentration in enamel paint samples

Sample No	Brand type	Paint Types	Colour	Pb (ppm)	Pb (%)
25	A	Enamel	White	< 25	< 0.0025
26	D	Enamel	Black	56	0.0056
27	D	Enamel	White	62	0.0062
28	D	Enamel	Red	31	0.0031
29	B	Enamel	Deep Orange	67000	6.7
30	B	Enamel	Golden Yellow	110000	11
31	E	Enamel	Signal Red	5700	0.57
32	E	Enamel	Brilliant white	72	0.0072
33	E	Enamel	Orange	86000	8.6
34	E	Enamel	Golden Yellow	77000	7.7
35	G	Hi gloss Enamel	Red	8000	0.8
36	G	Hi gloss Enamel	Golden yellow	64000	6.4
37	G	Hi gloss Enamel	Green	11000	1.1
38	G	Hi gloss Enamel	Oxford Blue	12000	1.2
39	H	Synthetic Enamel	Golden blue	59000	5.9
40	H	Synthetic Enamel	Bus Green	14000	1.4
41	H	Synthetic Enamel	Phiroza	3300	0.33
42	H	Synthetic Enamel	Black	3000	0.3
43	H	Synthetic Enamel	White	2200	0.22
44	H	Synthetic Enamel	P.O. Red	16000	1.6
45	E	Enamel	Bus Green	30000	3
46	E	Enamel	Oxford Blue	1300	0.13
47	B	HiGloss/Enamel	Bus Green	30000	3
48	B	HiGloss/Enamel	Snow white	2600	0.26
49	B	HiGloss/Enamel	Signal red	3700	0.37
51	B	HiGloss/Enamel	Oxford Blue	4500	0.45
52	A	Premium Gloss Enamel	P.O. Red	5800	0.58
53	A	Premium Gloss Enamel	Golden Yellow	140000	14
54	A	Premium Gloss Enamel	Black	7800	0.78
55	A	Premium Gloss Enamel	Oxford Blue	6900	0.69
56	A	Premium Gloss Enamel	Deep Orange	39000	3.9
	Average			26131	
	Median			7800	

Table 7: Average and median values for various brands of the enamel pain samples

Paint types	Average (ppm)	Median (ppm)
Brand type D/Enamel	49.7	56
Brand type B/Enamel	36300	17250
Brand type E/Enamel	33345.3	17850
Brand type G/Enamel	27666.7	27000.7
Brand type H/enamel	16250	8650
Brand type A/Enamel	39900	7800
	27001	7900

Table 8: Average and median concentrations of lead in various colours of enamel samples

Colours	Average	Median
White	991.8	72
Black	3618.7	3000
Blue	5600	4500
Red	6538.5	5800
Green	21250	22000
Orange	4000	67000
Yellow	90000	77000

Table 9: Percentage of Enamel Paint samples Exceeding Applicable Standards

Above 600 ppm	Below 600 ppm	Above 1000 ppm	Above 5000 ppm
83.87	19.1	83.87	61.3

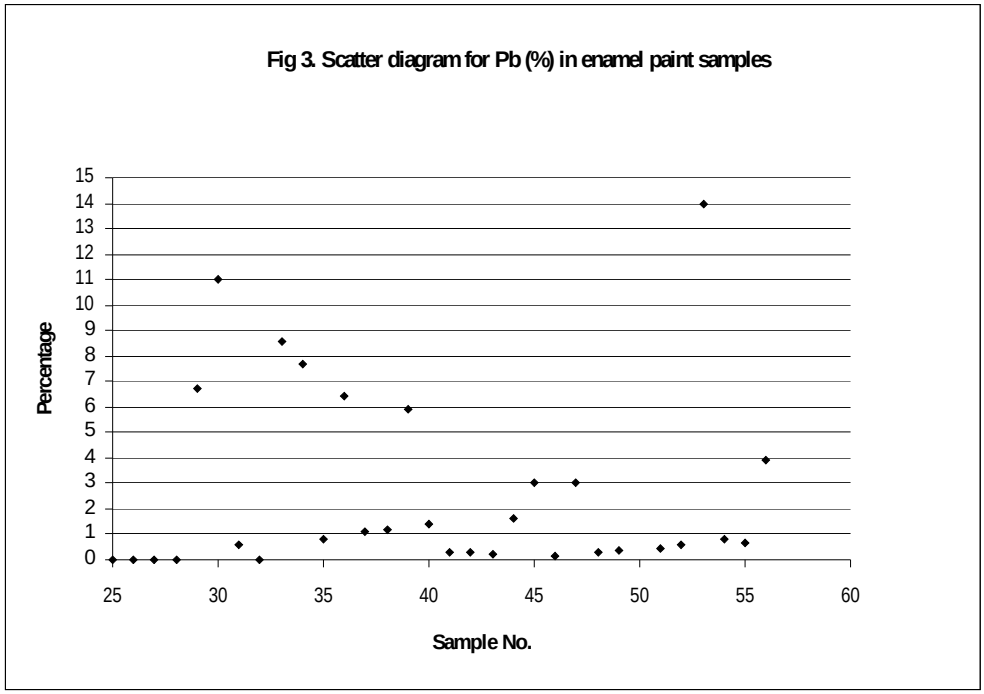


Fig 3. Scatter diagram for Pb (%) in enamel paint samples
Percentage
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
25
30
35
40
45
50
55
60
Sample No.

REFERENCES

American Journal of Public Health, 1923. Prohibition of white lead in Belgium. 13. 337

Annest, J. L., 1983. Trends in the blood lead levels of the US population. In Rutter M, Jones RR, eds. Lead versus health.Chichester, England, John Wiley & Sons, 33- 58

Barboza, David., 2007. 11 September. Why Lead in Toy Paint? It's Cheaper. New York Times. http://www.nytimes.com/2007/09/11/business/worldbusiness/11lead.html?_r=1&th&emc=th&oref=slogin (accessed in September)

Brown, M. J., Hu, H., Gonzales- Cossio, T., Peterson, K. E., Sanin, L. H., de Luz, Kageyama. M., 2000. Determinants of bone and blood concentrations in the early postpartum period. Occupational and Environmental Medicine. 57, 534- 541

Bureau of Indian standards, 2004. Indian Standard Paint, Plastic Emulsion- Specification. IS 15489:2004 Superceding IS 5411 (part 1): 1974 and IS 5411 (part 2): 1972

Centre for Disease Control and Prevention, 1991. Preventing lead poisoning in young children: a statement by the Centers for disease Control and Prevention. Atlanta, GA

Clark, C.S., Bornshein, R.L., Succop, P., Que Hee, S.S., Hammond, P.B. and Peace, B., 1985. Condition and Type of Housing as an indicator of potential Environmental Lead Exposure and Pediatric Blood Lead Levels. Environemntal Research. 38, 46- 53

Clark, C.S., K.G. Rampal, V Thuppil, C.K. Chen, R Clark, S. Roda., 2006. The lead content of currently available new residential paint in several Asian countries. Environmental Research. 102, 9- 12

Clark, C.S., Thuppil, V., Clark, R., Sinha, S., Menezes, G., S'Souza, H., Nayak, N., Kuruvila, A., Law, T., Dave, P. and Shah, S., 2005. Lead in Pints and Soil in Karnataka and Gujarat, India. Journal of Occupational and Environmental Hygiene, 2: 38- 44

Code of Federal Regulatory, 2004. Chapter II http://frwebgate.access.gpo.gov/cgi- bin/get-

cfr.cgi?TITLE=16&PART=1303&SECTION=1&YEAR=2000&TYPE=TEXT (accessed in August 2007)

Department of Environment and Heritage, 2001. Australian Government http://www.environment.gov.au/atmosphere/airquality/publications/housepaint.html (accessed in August 2007)

Edwards- Bert, P., Calder, I. C., Maynard, E. J., 1994. National review of public exposure to lead in Australia. Adelaide, South Australian Health Commission

Falk, Henry., 2003. International Environmental Health for the Pediatrician: Case Study of Lead Poisoning. Pediatrics. 112, 259- 264

Goldstein, G.W., 1992. Neurological concepts of lead poisoning in children. Pediatric Annals. 21 (6): 384- 388

ILZSG, 2004. World lead chemicals productions and usage. International Lead and Zinc Study Group, Lisbon, Portugal

IPCS, 1995. Inorganic Lead- Environmental Health Criteria 85. World Health Organisation, International Programme on Chemical Safety. World Health Organisation, Geneva, Switzerland.

Kalra, Veena., Chitralekha, K. T., Dua, T., Pandey, R.M. and Gupta, Y., 2003. Blood lead levels and risk factors for lead toxicity in Children from schools and an Urban Slum in Delhi. Journal of Tropical Pediatrics 49 (2): 121- 123

Kaul, B., 1999. Leas exposure and iron deficiency among Jammu and New Delhi children. Indian J Pediatrics. 66, 27- 35

Koller, Karin; Terry, Brown., Anne, Spurgeon. and Len, Levy., 2004. Recent Developments in Low- Level Lead Exposure and Intellectual Impairment in Children, Environmental Health Perspectives. 112, 9, 987- 994

Kumar, R. K. and Kesaree, N., 1999. Blood lead levels in urban and rural Indian children. Indian Pediatrics, 36. 303- 306

Kuruvilla, A., Pillay, V.V., Venkatesh, T., Adhikari, P., Chakrapani, M., Clark, C.S., D'Souza, H., Menezes, G., Nayak, N., Clark, R., Sinha, S., 2004. Portable lead analyser to locate source of lead. Indian Journal of Pediatrics, 71: 495- 499

Lanphear, B. P., Burgoon, Da., Rust, S. W, Eberly, S., Galke, W., 1998. Environmental exposures to lead and urban children's blood lead levels. Environmental Research. 76, 120- 130

Lidsky, T. I., and Schneider, S. J., 2003. Lead neurotoxicity in children: basic mechanism and clinical correlates. Brain. 126, 5- 19.

Lin- Fu, J. S., 1967. Lead poisoning in children. Social and Rehabilitations Service. US Department of Health, Education and Welfare. Children's Bureau Publication 452, US Government Printing office, Washington, DC as cited in Clark et al., 1985

Lotus Strategic Management Consultants, The Indian paint industry - an overview, http://www.domain-b.com/industry/paints/200012_paint_overview.html (accessed in August 2007)

Markowitz, Gerald., 2000. "Cater to the Children": The Role of the Lead Industry in a Public Health Trajedy, 1900- 1955. American Journal of Public Health., 90, 1, 36- 46

Marsden, A. Philip, 2003 Increased body lead burden- causes or consequences of chronic renal insufficiency? The New England Journal of Medicine. Editorials. 348,4,345- 347

Needleman, H.L., 1995. Environmental lead and children's intelligence. Studies included in the meta- analysis are not representative [Letter]. Br. Med J. 310, 1408

Needleman, H. L., Bellinger, D., 2001. Studies of lead exposure and the developing central nervous system: a reply to Kaufman. Arch Clin Neuropsychol. 16, 359- 374

Needleman, H. L., McFarland, C., Ness, R. B., Fienberg, S.E., Tobin, M. J., 2002. Bone lead levels in adjudicated delinquents. A case control study. Neurotoxicol Teratol. 24, 711- 717

Nriagu, J., Ngozi, T., Oleru, Charles, cudjoe., Ada, Chine., 1997. Lead poisoning of children in Africa, III. Kaduna, Nigeria. The Science of the Total Environment. 197, 13- 19

Nuwayhid, Iman., Nabulsi, M., Muwakkit, S., Kouzi, S., Salem, G., Mikati, M. and Ariss, M., 2003. blood lead concentrations in 1- 3 year old Lebaneses

children: A Cross-sectional study. Environmental Health: A Global Access Science Source. 2:5 (http://www.ehjournal.net/content/2/1/5)

Patel, A.B., Willimas, S.V., Frumkin, H., Kondawar, V.K., Glick, H., Ganju, A.K., 2001. Blood lead in children and its determinants in Nagpur, India. International Journal of Occupational Environmental Health. 7, 119-126

Patel, K.S., K. Shrivas, P. Hoffman and N. Jakubowski., 2006. A survey of lead pollution in Chattisgarh State, central India. Environmental Geochemistry and Health. 28, 11-17

Pirkle, J. L., Brody, D. J., Gunter, E.W., Kramer, R. A., Paschal, D. C., Flegal, K. M., Matte, T. D., 1994. The decline in blood lead levels in the United States. The National Health and Nutrition Examination Surveys. Journal of the American Medical Association 272 (4):284-291

Rahbar, M.H., Franklin, White., Mubina, Agboatwalla., Siroos, Hozhabri., Stephen, Luby., 2002. Factors associated with elevated blood lead concentrations in children in Karachi, Pakistan in Bulletin of the World Health Organisation. 80 (10)

Robinowitz, M. B. and Needleman, H. L., 1982. Temporal trends in the lead concentrations of umbilical cord blood. Science. 216, 1429-1431

Selevan, S. G., Deborah, C. R., Karne, A., Hogan, Susan Y. Euling, Andrea Pfahles-Hutchens and James Bethel, 2003. Blood lead concentration and delayed puberty in girls. The New England Journal of Medicine. 348, 16, 1527-1536

Skerfving, S., Gerhardsson, L., Schutz, A. and Stromberg, U., 1998. Lead-Biological monitoring of exposure and effects. Journal of Trace Elements in Experimental Medicine. 11, 289-301.

The George Foundation. Project lead-free: a study of lead poisoning in major Indian cities. In: George AM, ed. Proceedings of the International Conference on Lead Poisoning Prevention and Treatment, February 8-10, 1999. Bangalore, India: The George Foundation; 1999: 79-85

Tong, S., McMichael, A. J., 1999. The magnitude, persistence and public health significance of cognitive effects of environmental lead exposure in childhood. Journal of environmental Medicine. 1. 103-110

Toscano, C. D. and Guilarte, T. R., 2005. Lead neurotoxicity: form exposure to molecular effects. Brain research review 49, 529-554.

United States Department of Health and Human Services, 1988. The nature and extent of lead poisoning in children in the United States: a report to Congress. Atlanta, GA, United States

United States Environmental Protection agency (US EPA), 2001. Standard operating Procedures for Lead in Paint by Hotplate or microwave-based Acid Digestions and Atomic Absorption or Inductively Coupled Plasma Emission Spectroscopy, EPA, PB92-114172, September, 1991.

U.S. ATSDR, 2005. Toxicological profile for lead. (Draft for public Comment) U.S. Department of Health and Human Services. Public Health Service. Agency for Toxic Substances and Disease Registry, Atlanta, U.S.A.

Von, Schirnding, YE., 1999. The impact of lead poisoning on the workforce and society. In Proceedings of the International Conference on Lead Poisoning, Bangalore, India, 8-10 February 1999, Bangalore, The George Foundation. 41-47

WHO/UNECE, 2006. Health risks of heavy metals from long-range transboundary air pollution. Draft of May 2006. World Health Organisation (WHO) and United Nations Economic Commission for Europe (UNECE), Geneva, Switzerland. (To be updated when final version is available).

World Health Organisation, 1995. Inorganic Lead (Environmental Health Criteria, No. 165), Geneva

Wu, T., Germaine, M. Buck and Pauline, Mendola., 2003. Blood lead levels and sexual maturation in US girls: the third national health and nutrition examination survey, 1988-1994. Environmental Health Perspectives. 111.5. 737-741

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