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CASE STUDY

Lead content in new decorative paints in India

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Abstract The paint industry in India is broadly classified into two categories: organized sector and unorganized sector. Multinational and big Indian companies form the organized sector, whereas the small- and medium-scale industries which produce paints for the local market form the unorganized sector. The present study was undertaken to determine the level of lead in decorative paints in India. A total of 148 paint samples sourced from four organized sector companies and six unorganized sector companies were analyzed for the total lead content. Results of this study reveal that 39 % of the total paints tested ($n = 148$) contain lead more than 300 ppm, the voluntary limit prescribed by Bureau of Indian Standards, BIS (IS 15489:2011), and 45 % of the tested paints contain lead more than 90 ppm, the US limit. Further analysis of the data indicates that only 5 % of the tested paints manufactured by organized sector companies contain lead more than 300 ppm ($n = 91$), whereas 93 % of the tested paints manufactured by unorganized sector companies contain lead more than 300 ppm ($n = 57$). Comparison with earlier reported data suggests that while organized sector companies are gradually abandoning the use of lead-based compounds in their paints, the unorganized sector companies are still adding lead-based compounds intentionally in their paints despite the potential health hazards associated with it. The maximum concentration of lead obtained was 80,350 ppm in one of the paints manufactured by an unorganized sector company. The presence of high concentration of lead in yellow and green color paints indicates that color can be a predictor of lead content in decorative paints.

Keywords Lead in paints · Indian paint · Organized sector · Unorganized sector

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1 Introduction

Lead poisoning through exposure to lead-containing paints is recognized as a major public health problem worldwide (Fewtrell et al. 2004; Jacobs et al. 2002; Lanphear et al. 1998; Meyer et al. 2003; Montgomery and Mathee 2005). The severity of the problem has led many countries to adopt legislation enforcing ban or restriction on the use of lead in paints intended for interior and exterior decorative use. Thus, the maximum allowable limits for total lead content in paints in different countries are USA: 90 ppm, Singapore: 600 ppm, and Australia: 1,000 ppm (Kumar and Gottesfeld 2008; US CPSC 2011). In China, the maximum allowable limit for soluble lead content in paints is 90 ppm. Contrary to this, there is no legislation in India and several Asian and African countries that prohibit use of heavy metals in paints intended for decorative use. This is possibly the reason why paints containing high amount of lead are readily available in the markets of many developing countries across the world. For example, in a recent report, Ewers et al. (2011) have reported that 56 % of Taiwan paints had lead levels above the 90 ppm US limit. Higher lead level in new enamel household paints was also reported from several countries of Asia, Africa, and South America (Clark et al. 2009, 2006; Kumar 2009). Lin et al. (2008) have reported that even though there are regulatory limits on the levels of lead in new paints in China, 50 % of new enamel paints tested contained lead greater than or equal to 600 ppm. Similarly, Adebamowo et al. (2007) have reported that 96 % of paints available in the markets of several African countries had lead concentration more than 600 ppm. In India, a study was undertaken to determine the levels of lead in new latex (water-based) and enamel paints (oil based) intended for decorative use (Kumar and Gottesfeld 2008). Out of 69 paint samples studied, 84 % of the enamel paints tested exceeded 600 ppm, whereas 38 % of total samples (including latex and enamel types) exceeded this regulatory level. In another study, 11 out of 29 paints of 5 different brands studied had high level of lead content (Clark et al. 2005).

Lead poisoning is a matter of concern in India for the last two decades. US Centers for Disease Control and Prevention (CDC) proposes that blood lead level of 10 μg/dL or more can induce neuropsychological and behavioral impairment in small children (Koller et al. 2004; CDC 1991). In fact, recent policy change by US CDC indicates that blood lead level of 5 μg/dL or above in small children is a matter of concern (CDC 2012). In India, a survey conducted by George Foundation in (1999) revealed that over 51 % of the children below the age of 12 living in major urban areas of India had unacceptably elevated levels of blood lead of 10 μg/dL or more (The George Foundation 1999; Van Alphen 1999). Later studies by Nichani et al. (2006) and Singh and Singh (2006) revealed that the lead poisoning decreased significantly after the ban imposed by Government of India on use of leaded gasoline (petrol) in 2000. Still in 2003, 33.2 % of the 754 tested children in Bombay (Mumbai) had blood lead levels $\geq$10 μg/dL (Nichani et al. 2006). Similarly, 67 % of the 297 tested children between the age group of 6 months and 6 years in Nagpur city, India, had blood lead levels $\geq$10 μg/dL (Patel et al. 2001). Lead in house hold paints was one of the major contributors for such high elevated blood lead levels. In yet another study conducted among 107 school children in the city of Mangalore, India, Kuruvilla et al. (2004) have identified lead in paints as the likely source of exposure for 10 children with blood lead levels above 40 μg/dL.

The Indian paints and coatings industry is a 112 billion rupees ($ 2.2 billion) sector and has been enjoying in recent years a growth rate of about 15 % which is 1.5- to twofold than India's GDP/year (Focus on Powder Coatings 2011). The paint industry in India is broadly classified into two categories: organized sector and unorganized sector. Generally, all

enterprises which are either registered or come under the purview of any one of the acts like the Indian Factories Act 1948, Mines and Minerals (Regulation and Development) Act, 1957, the Company Law, the Central/State Sales Tax Acts, the Shops and Establishment Acts of the State governments, are part of the organized sector. All unincorporated enterprises and household industries which are not regulated by any acts of the above-mentioned type and which do not maintain any annual reports presenting the profit and the loss and balance sheets are classified as unorganized sector (NAS 1980). In the present study, the multinationals and big Indian paint companies form the organized sector and small-scale industries which produce paints for the local market form the unorganized sector. According to the Department of Industrial Policy and Promotion, Ministry of Commerce and Industry, Government of India, the organized sector companies cater to about 57 % of the overall demand, whereas the unorganized sector companies take care of the remaining 43 % in the value terms (DIPP 2009). There are 10–12 main players in the organized sector, and the top six companies in terms of market share are Asian Paints, Kansai Nerolac, Berger Paints, Akzo Nobel India (previously known as ICI India), Jenson & Nicholson, and Shalimar Paints (DIPP 2009; Toxic Link 2011). The unorganized sector on the other hand is very scattered, and an indicative number of unorganized sector paint companies in India can be obtained from the fact that the Indian Paint and Coating Association (IPCA), which represents both the organized and unorganized sector in the paint and coating industry in India, has around 950 members (www.ipcaonline.com). There is no legislation in India that prohibits the use of lead in household paints. However, in 2004, a voluntary component of the ECO Mark scheme under the Bureau of Indian Standards (BIS) cited a limit of 0.1 % (1,000 ppm) of lead in paints (Bureau of Indian Standards 2004) which was reduced to 300 ppm in 2011(Bureau of Indian Standards 2011). In recent years, organized sector companies in India are claiming to have stopped using lead in their paints which is reflected in some of the literature reports. For example, in 2007, a study carried out by a non-government organization (NGO) Toxics Link, New Delhi, had revealed that among the paints of organized sector brands available in New Delhi, 83.9 % of the studied paints had lead content >600 ppm while 61.3 % samples had lead content >5,000 ppm ($n = 31$). In 2009 ($n = 27$) and 2011 ($n = 9$), the percentage of paints containing lead >600 ppm decreased to 65 and 20 %, respectively (Toxic Link 2011).

The present study aims to report the current status of the concentration of lead in decorative paints available in the Indian market. A thorough study was performed in which the paints of selected organized sector and unorganized sector industries were analyzed for their total lead content. None of the literature reports available so far have reported lead content in paints manufactured by organized and unorganized sector companies of India separately. This is important especially for India as the big organized sector companies, some of them also do business outside India, generally tend to follow international norms and regulations but the small- and medium-scale unorganized sector companies seldom follow such regulations. The focus of this study is to find out whether all the paint manufacturers in India have started to abandon the use of lead in their paints or it is the organized sector companies only.

2 Methods

A total of 148 synthetic enamel paints from 10 brands intended for decorative use were purchased from the easily accessible domestic Indian retail market of Kolkata, West Bengal and Jamshedpur, Jharkhand. Latex paints (water-based) and paints intended for

automotive and industrial use were not selected. Latex paints were not selected because an earlier study by Kumar and Gottesfeld (2008) revealed that latex paints available in Indian market contain very low amount of lead. The colors of the enamel paints selected were mainly black, blue, green, red, brown, yellow, and white. While sampling, the objective was to select maximum number of samples from each brand, so that a thorough study is done about the total lead content in all the paints of that particular brand. Accordingly, the number of selected samples per brand varied widely (from 6 to 31, Table 1). While a large number of paints of organized sector brands were readily available, only limited numbers of paints of unorganized sector brands were available in the market. Among organized sector brands, Asian Paints, Berger Paints, Kansai Nerolac, and ICI were selected because these brands were selected in earlier studies by Kumar (2009) and comparison can be made between the present data and the reported data. The paints were purchased as 1L cans. Note that no information about the lead content in the paints was printed on the containers when it was purchased from stores. Before opening the can, the paint samples were properly stirred to make it homogeneous. Extraction of Pb from paint samples and its analysis was done at Analytical Chemistry (ANC) Division of CSIR-National Metallurgical Laboratory (CSIR-NML), Jamshedpur, India, following the method: Standard Operating Procedure for Lead in Paint by Hotplate of Microwave based Acid Digestion and Atomic Absorption Spectroscopy, EPA, PB92-114172 (US EPA 2001). The result is reported on dry basis. ANC Division of CSIR-NML is a laboratory accredited by National Accreditation Board for Testing and Calibration Laboratories (NABL), Department of Science and Technology, Government of India in accordance with ISO/IEC 17025:2005. For Pb analysis, each paint sample was placed on a new glass petri dish and dried completely at room temperature for 72 h. One gram of the dried paint sample was accurately weighed into a 100-mL glass beaker, and 10 mL of water was added to it followed by 20 mL of concentrated nitric acid and 10 mL of hydrogen peroxide. After 2 h of digestion on hot plate at 100–105 °C, the solution was filtered, washed twice with warm Millipore water, and the filtrate along with the washings was collected in a 100-mL volumetric flask. The volume was then made-up with Millipore water, and the solution was analyzed for Pb using Thermo 3000 flame

Table 1 Total lead content in Indian decorative paints manufactured by organized and unorganized sector companies

Companies	Number of paint samples	Max. (ppm)	Min. (ppm)	Average (ppm)	% Paints ≥300 ppm	% Paints ≥90 ppm
Organized sector						
Asian paints	23	125	6	15	0	5
Berger paints	31	2,000	27	231	16	23
ICI	12	220	8	23	0	9
Kansai Nerolac	25	200	6	21	0	4
Unorganized sector						
Kingcoat	4	19,800	1,850	11,203	100	100
Deepali	14	80,350	135	13,716	93	100
Glaxci	6	18,200	2,403	10,547	100	100
Globe	14	27,400	300	7,709	100	100
Universal	12	45,400	215	18,981	75	100
Ujjala	7	7,340	640	4,213	100	100

atomic absorption spectrometer. For quality control, all the paint samples were analyzed in duplicate, and NIST standard reference material 2581 (Pb in paints) was analyzed following the same procedure. The experimentally determined value of Pb in NIST SRM 2581 was 0.43 % which is very close to the certified value of 0.449 ± 0.011 % confirming the accuracy of the analytical results. Standard stock solution of Pb (1,000 ppm) was procured from Merck India Ltd. for making calibration curves with appropriate dilutions. Analytical reagent grade (AR grade) nitric acid, hydrochloric acid, and hydrogen peroxide (30 %) were procured from Merck India Ltd.

3 Results

3.1 Lead concentration by brands

Results obtained from chemical analysis of 148 enamel paint samples of 10 different companies (organized and unorganized sectors) were first analyzed to get information about total Pb content in paints available in Indian market. The data are presented in Table 1. In addition to maximum, minimum, and average lead concentrations, percentage of paints which contain lead more than 300 and 90 ppm (Indian voluntary limit prescribed by Bureau of Indian Standards and US limit, respectively) are presented in Table 1. A quick look at the data in Table 1 reveals that majority of the paints manufactured by organized sector companies contain relatively low amount of lead, whereas the paints manufactured by unorganized sector companies contain significantly high amount of lead. In fact, 100 % of tested paints manufactured by organized sector companies Asian Paints, ICI, and Kansai Nerolac Paints contain lead below 300 ppm. Some paints manufactured by Berger Paints contain lead more than 300 ppm (5 out of 31), and these are primarily of brown color or its derivatives (gray, sand stone, truck brown, etc.). On the contrary, 100 % of tested paints manufactured by unorganized sector companies and marketed in the brand names of Kingcoat, Glaxci, Globe, and Ujjala contain lead more than 300 ppm. Only 17 % of paints marketed in the brand name of "Deepali" and 25 % of paints marketed in the brand name of "Universal" manufactured by unorganized sector companies contain lead less than 300 ppm. The maximum lead content was 80,350 ppm (8.03 %) in one of the "Deepali" brand paints. A graphical presentation of average lead content in paints manufactured by organized and unorganized sector companies is presented in Fig. 1. It can be observed from Fig. 1 that lead is apparently not added to most of the paints of organized sector companies, whereas high concentration of lead is intentionally added in paints of unorganized sector companies.

3.2 Lead concentration by color

The lead content in paints of different colors analyzed in this study is presented in Table 2. The data are divided into two categories: lead in different color paints manufactured by organized sector and unorganized sector companies. Very high level of lead was detected in paints of every color manufactured by the unorganized sector companies. Highest lead was obtained in yellow color paints followed by green, red, black, white, brown, and blue. The highest total lead content was 80,350 ppm (8.03 %) in the yellow color paint manufactured by unorganized sector company in the brand name of "Deepali." Data in Table 2 reveal that 100 % of yellow, green, white, and blue color paints manufactured by

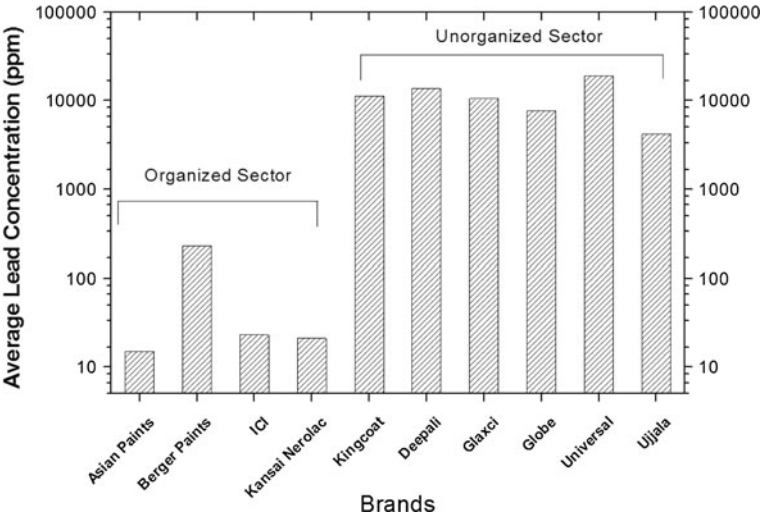

Fig. 1 Average lead content in paints manufactured by organized and unorganized sector companies

Table 2 Lead content in decorative paints of different colors available in India

Color	Organized sector			Unorganized sector		
	No. of samples	Maximum (ppm)	% Paints ≥300 ppm	No. of samples	Maximum (ppm)	% Paints ≥300 ppm
White	7	45	0	3	17,600	100
Blue	7	59	0	16	12,300	100
Black	3	6	0	5	32,300	80
Brown	9	2,000	55	4	14,120	50
Red	10	180	0	8	44,500	87
Green	6	40	0	8	45,400	100
Yellow	6	46	0	9	80,350	100

unorganized sector companies have total lead content greater than 300 ppm. Similarly, 87 % of red, 80 % of black, and 50 % of brown color paints studied manufactured by these companies have lead greater than 300 ppm. One significant observation from data presented in Table 2 is that paints of all colors manufactured by organized sector companies have lead level below 300 ppm except for brown color paints manufactured by Berger Paints.

4 Discussion

Though lead exposure is harmful to both adults and children, children are more susceptible to the neurobehavioral toxicity of lead exposure because their nervous system is still developing, their absorption rates are higher, and they have higher likelihood of engaging in hand to mouth practices and frequently spend time on the floor and on soil areas, so they are more likely to be exposed to lead from paint dust, soil, and water in their domestic

Table 3 Comparison of present data with earlier reported data

	Clark et al. (2006)	Kumar and Gottesfeld (2008)	Present study	
			Unorganized sector	Organized sector
% of paint having lead concentration ≥600 ppm	100 ($n = 17$)	84 ($n = 31$)	85 ($n = 57$)	3 ($n = 91$)
Maximum lead concentration	187,200 ppm	140,000 ppm	80,350 ppm	2,000 ppm
Yellow (max)	159,200 ppm	90,000 ppm	80,350 ppm	46 ppm
Green (max)	39,200 ppm	21,250 ppm	45,400 ppm	40 ppm
Brown (max)	10,980 ppm	–	14,120 ppm	2,000 ppm

environment. Occupational hazards on the other hand are the leading cause of elevated blood lead levels in adults (for example, those experienced by painters, maintenance/renovation, and abatement workers who use unsafe paint removal practices). Earlier studies by Clark et al. (2006) and Kumar and Gottesfeld (2008) have revealed that enamel paints available in Indian market at the time of their reporting contained very high amount of lead. In fact, 100 % of the paints in the former study ($n = 17$) and 84 % of the paints in the latter study ($n = 31$) were found to contain lead more than 600 ppm. In those studies, the organized and unorganized sector brands were not studied separately, but in all probability, the results presented in those studies include the paints manufactured by organized sector companies because these paints are the most abundant in Indian market. The present study presents a distinctly different picture for the Indian enamel paint industry. Organized sector companies apparently have started abandoning use of lead-based compounds in their paints. For example, in 2009, all the paints manufactured by Berger Paints and some paints of Asian Paints (organized sector companies) contained very high amount of lead (>1 %) (Kumar 2009). The present study on the contrary reveals that all the paints manufactured by Asian Paints and majority of the paints manufactured by Berger Paints contain low amount of lead. The unorganized sector companies, on the other hand, continue to add lead-based compounds in their paints. A comparison of the present data with the earlier reported data for Indian enamel paints is presented in Table 3. While the data for paints manufactured by unorganized sector companies are similar to the earlier reported results, the result of organized sector brands differs significantly. Eighty-five percentage of the enamel paints manufactured by unorganized sector companies in the present study contains lead more than 600 ppm and only 3 % of the paints manufactured by organized sector companies contain lead more than 600 ppm. A closure look at the results given in Table 1 provides very useful information. A generalized conclusion is that the organized sector companies are trying to follow the voluntary Indian limit of 300 ppm prescribed by Bureau of Indian Standards (BIS 2011) and the US limit of 90 ppm (US CPSC 2011). On the other hand, data obtained for unorganized sector companies are alarming. Very high amount of lead is being added to the paints manufactured by these companies which can cause severe health hazards for the children.

5 Conclusions

One hundred and forty-eight samples of popular synthetic enamel paints were procured from eastern India to analyze total lead content in decorative paints. It was found that the

paints contain a substantial amount of lead specifically the paints which are manufactured by small, unorganized sector companies. However, big organized sector companies have started to abandon use of lead in their paints over the period of time. The presence of high amount of lead in paints increases the risk of health hazard, especially to children, in domestic environment. Suitable mandatory standards should be formulated in India by the government to prevent unorganized paint companies from using lead in paints. Substitutes for lead-based pigments are available over many decades, and titanium dioxide is commonly used for this purpose. Awareness programs should also be initiated in India among the common people and the paint manufacturers for eliminating the risk of lead poising through paint.

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