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Lead Content of Enamel Paints in Leading Paint Companies in Bangladesh

Md. Lokman Hossain[1*], Mohammed Abdus Salam[2], Satyajit Roy Das[3], Md. Iqbal Hossain[4], Sultana Kamrun Nahar Nahida[4], Shamim Akter Mamun[4], Snigdha Talukder[3] and Maksuda Khanam[5]

[1]Environment and Social Development Organization, House # 8/1, Block-C, Lalmatia, Dhaka-1207, Bangladesh
[2] Faculty of Earth Science, University Malaysia Kelantan, Jeli campus, Kelantan, Malaysia
[3]Assistant Commissioner & Executive Magistrate, Office of Deputy Commissioner, Kishoreganj, Bangladesh
[4]Institute of Forestry and Environmental Sciences, University of Chittagong, Chittagong, Bangladesh
[5]Department of Anthropology, Jagannath University, Dhaka, Bangladesh
[*]lokmanbbd@gmail.com

Abstract: *Lead (Pb) compounds have been historically used by paint manufacturers. Lead is added to paint to speed up drying, increase durability, maintain a fresh appearance, and resist moisture that causes corrosion. The study was carried out to determine the total lead content in enamel paint in major paint companies in Bangladesh. Twenty five enamel paint samples from 5 brands (5 colours in each brand) manufactured by the major players- Berger, Asian, Roxy, Pailac and Elite Paints were randomly purchased from various markets in Dhaka, Bangladesh during the months of January- April 2012. The paint samples were purchased in the sizes of 50 ml, 100 ml, 200 ml, 500 ml and 1 L depending upon the availability. Samples were analysed by Atomic Absorption Spectrometer using Air-Acetylene flame at the wavelength of 217 nm, band pass 0.5 nm, measurement time 4 second, background correction –D_2 (prescribed by AA Spectrometers Methods Manual of Thermo Electron Corporation). Lead was found in all enamel paint samples tested. 96% (24 out of 25 samples) of the enamel paint samples did not meet the specification for lead content prescribed by US and China limit. The average concentration of lead in all enamel paint samples ranged from 55 to 114010 ppm. Highest (114010 ppm) concentration of lead was detected in Golden yellow of Robbialac Acrylic Distemper manufactured by Berger paints which is 1267 times higher than the US and China limit for new paints (90 ppm). Lowest (55 ppm) concentration of lead was detected in white brand of paints manufactured by Pailac paints. The average concentration of lead for yellow enamel paints of all the five brands was 75286 ppm followed by orange which was 54708.2 ppm, green 28926 ppm, black 14967.2 ppm and finally white enamel paint contained 357.4 ppm. Formulation of a national policy on paint manufacture and its proper implementation is inevitable to stop the use of lead in paints in Bangladesh.*

Key words: *Certification, decorative, enamel, lead, paint*

I. Introduction

1.1. Background

Lead is a toxic metal whose widespread use has caused extensive environmental contamination and health problems in many parts of the world (WHO, 1995; U.S. Department of Health & Human Services, 1988). It is a cumulative toxicant that affects multiple body systems, including the neurological, haematological, gastrointestinal, cardiovascular and renal systems. Children are particularly vulnerable to the neurotoxic effects of lead, and even relatively low levels of exposure can cause serious and, in some cases, irreversible neurological damage (Fewtrell *et. al*, 2003; IPCS, 1995). 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, 2007). A common source of lead exposure for children today is lead based paint and the contaminated dust and soil it generates (Clark *et al*. 1991; Lanphear *et al*., 1995, 1998; Lanphear and Roghmann, 1997; McElvaine *et al*., 1992; Rabinowitz *et. al*., 1985; Shannon and Graef, 1992).

1.2. Use of lead in paints

A number of properties of lead make it commercially attractive for its use in paints. It has colour vibrancies and the ability to hold pigments well. It helps paints stand up well to outside weather elements, impart high degree of corrosion resistance and also reduces drying time. In the form of lead carbonate and lead oxides, it has excellent adhesion, drying, and covering abilities. High levels of lead in paints are due to use of lead in paints for colour, corrosion resistance etc. Lead chromate is added to produce yellow, orange, red, and green paints. Lead carbonate ($PbCO_3$) is used to produce white paint. Lead oxide (red lead), Lead sulphate with lead oxide, zinc oxide, and carbon (blue lead) are the other commonly used compounds in paint manufacturing. Lead is also added in paints to add the quality of speed drying, increase durability, retain a fresh appearance, and resist moisture that causes corrosion. Lead flake is used as an exterior primer and lead oleate may be encountered as a drier in paints.

1.3. Human exposure pathways

The most widespread source of lead exposure for children, workers and others is lead paints, that is, paints that contain lead pigments, lead drying agents and/or other intentionally added lead compounds. Although children are known to eat paint chips, more commonly lead paint on the interior and exterior of homes contributes to dust and soil contamination that is often the most significant source of exposure for children. Significant exposure can also occur from lead paint when smaller particles become airborne during sanding and scrapping while repainting and remodelling. In addition, damaged paint and the weathering of paint 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 licking of toys in hand –to-mouth activity are important sources of lead exposure in infants and young children (IPCS, 1995).

1.4. Health impacts of lead

Lead based decorative paints have posed several health problems in the developed world. Lead based paints have long been proven to be associated with elevated blood lead levels in children causing subsequent lead poisoning. Scientific evidences have established that children are the most vulnerable population and can be seriously affected even at very low levels of blood lead. While the toxicity of lead becoming apparent, several western countries have enacted ban or imposed restriction on the use of lead in interior paints (Markowitz and Rosner, 2000). Countries like the US and China have restricted its use to 90 ppm in decorative paints. Lead exposure is a particularly serious problem in many developing countries. Since 2002 there has been much progress made in reducing childhood lead exposure through an ambitious international programme that has eliminated lead additives from automotive fuels in most countries. Exposure to lead causes significant and widespread injury to human health. Of all toxic environmental pollutants, harms from lead exposure are probably better understood and better documented than are the affects of any other toxic environmental pollutant. Children are especially sensitive to lead and the World Health Organization has determined that there is no safe level of childhood lead exposure.

1.5. Regulations for lead in paints

For over 70 years now, dangers represented by lead based paint manufacturing and application had led many countries to enact bans on 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 in 1926; Poland in 1927; Spain and Yugoslavia in 1931; and Cuba in 1934 (Markowitz and Rosner, 2000). In 2008, the US congress lowered the standard for lead in residential paints and paints on products used by children from 0.06% (600 ppm) to 0.009% (90 ppm). In 1997, Australia recommended 0.1% of total lead as the maximum amount of lead in domestic paint (DEH, 2001). Singapore has a standard of 0.06% of lead in new paints. In china the standard is 90 ppm (Barboza, D., 2007).

1.6. Paint business in the world

Paint industry in most parts of the world can be called a mature industry. Developing economies of the industrial growth is the main driver of growth in the coatings industry. U.S. and European markets are expected to mature in the next few years, an increase due to increase technical and product development. North America accounted for 20% of the global paint sales and the United States alone accounted for 17% of the world, but paint production in the Asia-Pacific is considered to be the source of growth, accounting for 44% of the world (WPCIA, 2011).

Table-1: Regional paint production and sale

Region / Output	Asia-Pacific	Europe	North America	Latin America	Other	Total
Output (Million tons) Scale (%)	1557.6 44%	849.6 24%	601.8 17%	318.6 9%	212.4 6%	3540 Million tons
Output value (Billion) Scale (%)	$394.79 37%	$320.1 30%	$213.4 20%	$74.69 7%	$64.02 6%	USD 1067 billion

Source: WPCIA, 2011

From the high-growth markets including China, India, Indonesia and other leaders of the progress of the Asia-Pacific region's largest regional market stands tall. Europe and the United States close behind as the world's other major paint markets. Asian markets are also expected in other parts of the world's fastest rising ahead of the overall increase to the 4.2% annual growth. Product group, architectural coatings is clear market leader, accounting for about 51% of all paint sales volume and 44% of sales, on the other hand, the rapid growth of some products, especially the functional coating is expected to be recorded during the analysis of 2.8 percent compound annual growth rate (WPCIA, 2011).

1.7. Paint business in Asia

Asia is an ever-growing market for paints. Various studies suggest that Asia will eventually emerge as the largest consumer of paints, keeping in mind the growth rate over the years. The coating solution sector has been growing at an average rate of about 10% in recent years. Overall, decorative paint accounts for 60-70% total paint market in the region. The players in the organized sector dominate the paint business and their market share is between 60-90% in different countries belonging to the region. Multinational brands such as Asian Paints, Berger, Nerolac, Jenson and Nicholson and ICI are the major players and happen to have overlapping interests in the paint market in the region. Per capita annual consumption of paints varies in different regions of the world. While the global average is 15 kg per capita annum, in developed countries the average is 22 kg. South-East countries consume 4 kg of paint per capita per annum. India's per capita per annum consumption is 0.5 kg while in case of Bangladesh the average is 0.25 kg.

1.8. Paint business in Bangladesh

The Bangladesh paint industry is worth about BDT 18 billion, approx 0.23 billion USD. According to Paint Manufacturer Association (BPMA), 51 large, small and medium sized companies are engaged in paint production in Bangladesh. With rising demand and competition, most of these companies are altering their marketing strategies by introducing new products and promotional offers.

1.8.1. Major market players in Bangladesh

Berger, Asian, Roxy, Pailac, Aqua and Elite are the major players and command over 90% market shares. Berger Paints (was known as Jenson and Nicholson in Bangladesh before 1970) alone holds 48% market share, followed by Asian Paints 12%, Roxy 10%, Pailac and Aqua each 7% and Elite Paints 5%. The Berger management sources however suggest they have a market share of about 55%. It is estimated that the paint industry here has posed a double-digit annual growth in recent times. With paint demand at nearly 77000 MT/year, per capita paint consumption in Bangladesh is roughly 250gms/capita, indicating tremendous scope for sector expansion in the coming years. Asian Paints and Berger claim to have gone lead free paints in Bangladesh.

1.9. Justification of the study

Very few studies on paint have been carried out in Bangladesh. In developed countries use of lead in paint is restricted upto a certain limit because it has proved that lead is one of the carcinogenic elements for human body. Bangladesh has no legal bindings to use of lead in paint manufacture. Two major paint manufacturers (Berger and Asian paints) declared promotion of lead free paint in Bangladesh. In fact, this study was designed to identify whether these 2 and other 3 major paint manufacturers manufacture lead free paint or not. The main objective of this study was to determine the total lead (Pb) content of enamel paints (oil based) intended for residential use.

II. Materials And Methods

2.1. Sampling Methodology

Twenty five enamel paint samples from 5 brands (5 colours in each brand) manufactured by the major market players- Berger, Asian, Roxy, Pailac and Elite Paints were randomly purchased from various markets in Dhaka, Bangladesh during the months of January- April 2012. The paint samples were purchased in the sizes of 50 ml, 100 ml, 200 ml, 500 ml and 1L depending upon the availability. 2 brands namely; Berger and Asian paints had warning on the labels. Berger paint has warning indicated 'Environment friendly: Lead free' and warning in Asian paints is 'No added lead'. Other 3 paint brands have no warning note on the label.

2.2. Sample Preparation

Samples were prepared according to Standard Operating Procedures for lead in paints by Hot plate and Inductively Coupled Plasma Emission Spectrometry, EPA, PB92–114172 Sept. 1991; SW 846-740. Wet paint samples were applied onto individual clean glass slides using different glass rods for each sample to avoid any cross contamination. Samples, thus applied were left to dry for a minimum of 72 hours. After drying samples were scraped off from glass slides using sharp and clean scalpel and accurately weighed to the nearest 0.1 g into an acid washed 100 ml beaker. 3 ml of concentrated HNO_3 and 1.0 ml of H_2O_2 were added into beaker containing samples and then covered with watch glass.

Reagent blank was also taken. Samples and reagent blank were then heated on a hot plate at 140^0C until most of the acid was evaporated. These were then removed from hot plate and allowed to cool at room temperature. 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. This step was repeated once again. Watch glass and walls of beaker were rinsed with 5.0 ml of 1M HNO_3. Solution was evaporated gently to dryness on the hot plate and then cooled. 1.0 ml of concentrated HNO_3 was added to residue and samples were then swirled for a minute or so to dissolve soluble species. Samples were poured from beaker into 10 ml volumetric flasks and diluted to 10 ml by distilled water and mixed vigorously.

2.3. Sample Analysis

Digested samples and reagent blank were then analysed for total lead (Pb) by Atomic Absorption Spectrometer using Air-Acetylene flame at the wavelength of 217 nm, band pass 0.5 nm, measurement time 4 second, background correction–D_2 (prescribed by AA Spectrometers Methods Manual of Thermo Electron Corporation). The calibration curve for lead was prepared by using five concentrations (2 to 10 µg/ml) from the lead stock standard solution (1000 µg/ml). A linear calibration graph of absorbance vs. solution concentration (µg/ml) was obtained. The absorbance of the blank and sample solutions was determined using AAS operated in the above said conditions. A standard was aspirated for every 10 samples to check the instrument drift. The sample solutions were diluted with distilled water by an appropriate factor in order to ensure that the measurements are taken within the linear calibration range. The lead content of the blank solution was determined and subtracted from the lead content of the samples. Recovery of lead from samples was estimated by adding known amounts of standards and processing of the samples by the same method. It was found to be more than 90% in each case.

2.4. Calculations

Lead concentration was calculated as follows:

$$\text{Pb } (\mu\text{g/g or ppm}) = \frac{(\mu\text{g/ml in sample solution}) \text{ x total dilution}}{\text{Sample weight in grams}}$$

III. Results And Discussion

25 samples of popular enamel paints were analysed for lead with a widely and internationally used methodology. Lead was found in all enamel paint samples tested. 96% (24 out of 25 samples) of the enamel paint samples did not meet the specification for lead content prescribed by China and US limit. Lead content prescribed by China and US standard for new paints is 0.009% or 90 ppm. 4% (1 out of 25 samples) of the enamel paint samples were within the US and China limit for lead in paints (Table-2).

The average concentration of lead in all enamel paint samples ranged from 55 to 114010 ppm. Highest (114010 ppm) concentration of lead was detected in Golden yellow of Robbialac Acrylic Distemper manufactured by Berger paints which is 1267 times higher than the US and China limit for new paints (90 ppm). Lowest (55 ppm) concentration of lead was detected in white brand of paints manufactured by Pailac paints (Table-2).

Table-2: Concentration of lead in enamel paints of various colors of different brands

Sl. no.	**Brand name**	**Color**	**Company**	**Lead (ppm)**	**Average**
1.	Robbialac Acrylic Distemper	Golden yellow	Berger	114010	75286
2.	Apcolite	Golden yellow	Asian paint	68540	
3.	Acrylic Distemper	Golden yellow	Roxy paint	62014	
4.	Distemper	Golden yellow	Pailac	72541	
5.	Distemper	Golden yellow	Elite Paints	59325	
6.	Robbialac Acrylic Distemper	Deep orange	Berger	78965	54708.2
7.	Apcolite	Deep orange	Asian paint	51306	
8.	Acrylic Distemper	Deep Orange	Roxy	52024	
9.	Distemper	Deep Orange	Pailac	48245	
10.	Distemper	Deep Orange	Elite Paints	43001	
11.	Robbialac Acrylic Distemper	Bus green	Berger	33652	28926
12.	Apcolite	Bus green	Asian paint	29781	
13.	Acrylic Distemper	Bus green	Roxy	32541	
14.	Distemper	Bus green	Pailac	22354	
15.	Distemper	Bus green	Elite Paints	26302	

16.	Robbialac Acrylic Distemper	Black	Berger	18325	14967.2
17.	Apcolite	Black	Asian paint	16214	
18.	Acrylic Distemper	Black	Roxy	14012	
19.	Distemper	Black	Pailac	15250	
20.	Distemper	Black	Elite Paints	11035	
21.	Robbialac Acrylic Distemper	White	Berger	1275	357.4
22.	Apcolite	White	Asian paint	124	
23.	Acrylic Distemper	White	Roxy	214	
24.	Distemper	White	Pailac	55	
25.	Distemper	White	Elite Paints	119	

The average concentration of lead in yellow enamel paints of all the five brands was 75286 ppm followed by orange 54708.2 ppm, green 28926 ppm, black 14967.2 ppm and finally white enamel paint 357.4 ppm. The results indicate that main determinants of lead content were the colors. High levels of lead were detected in yellow color followed by orange and green (derivatives of yellow color) then black and finally white. White enamel paint had lowest levels of lead; 1 out of the 5 white enamel paints had lead content below the recommended level of US and China. The lead concentration in different colours of enamel paints in decreasing order is shown in figure 1.

Yellow > Orange > Green > Black > White

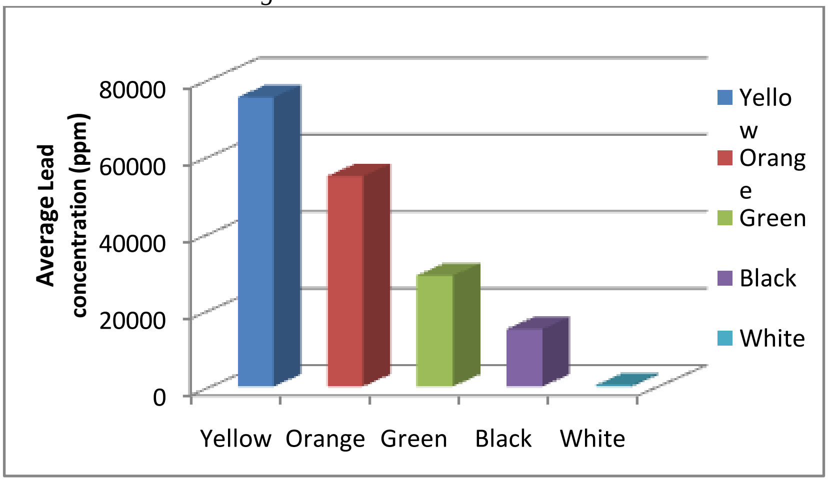

Figure-1: Average lead content in enamel paints of various colors of different brands

IV. Conclusion

Lead exposures occur in most, or all, countries of the world. However, there is a substantial decrease in environmental lead exposure in countries that have eliminated lead from petrol, soldered cans and paints, and that have reduced lead in drinking water. As more information came out about the adverse impacts of lead on health, many of the lead uses and environmental releases have been reduced significantly in industrialized countries. However, some of the uses of lead which have been phased out may remain in some parts of the world, e.g. in certain paints. The lack of regulations about lead in paint or their poor enforcement, together with increasing international trade may result in health and environmental risks that may go across borders. A global ban on lead-based paint is needed to protect the more than three billion people who may be exposed in the countries allowing distribution of lead-containing paints.

V. Recommendation

Substitutes for lead pigments are available. Lead is being replaced by Titanium oxide and Barium-Zinc-Sulfur combinations and their durability can be improved by adding Silicon or Aluminium oxides. The increase in cost resulting from the substitution is relatively small and cannot be compared with the harm caused to human beings due to continued exposure to lead.

The paint manufacturers must immediately shift to a lead-free regime in Bangladesh. They must stop pushing their products to new corners of the world where the issue is less known. While the industry works out the technological leapfrog, the governments must lay down effective guidelines for manufacturers and users to minimize the toxic trail and impact. The manufacturers must share the market intelligence and information with the public. Following steps can be considered for minimizing hazards of lead paints.

I. Regulation: It is inevitable to enact mandatory national regulations for limiting lead concentrations below 90 ppm in paints.

II. Monitoring: For effective implementation of the lead standards, a proper monitoring plan should be devised to ensure that the industry complies with the standards. The government agencies in collaboration with non-government organization can play a key role in monitoring the presence of lead in paints.
III. Legacy issues: Paint industry and health care professionals should set guidelines to reduce exposure to lead while removing old paints or recoating with new ones.
IV. Public awareness: A mass awareness campaign should be launched to reduce and make people aware of the hazards associated with lead. People should purchase the lead free paint.
V. Levelling: The paint industry should include a lead free paint symbol on products as well as guidelines for use including for home decorative or industrial and commercial.
VI. Global effort: The global partnership on lead in paints formed under UNEP and WHO on May 2009 ICCM2 is an example of global efforts. All stakeholders, particularly national governments and industry, must support this effort.
VII. Certification: A third party certification for paint manufacturer can be an ideal approach to stop lead in paints.

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