Journal of Occupational and Environmental Hygiene, 2: 38–44
ISSN: 1545-9624 print / 1545-9632 online

DOI: 10.1080/15459620590903011

Lead in Paint and Soil in Karnataka and Gujarat, India

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Blood lead surveys in several areas of India have found very high percentages of children with elevated blood lead levels. Fifty-three percent of children under 12 years of age in a seven-city screening had blood lead levels equal to or greater than 10 μg/dL, the level currently considered elevated by the U.S. Centers for Disease Control and Prevention (CDC). A number of these surveys focused on populations near lead smelters or in areas with high lead levels from combustion of lead-containing gasoline. There is little information available, however, on the levels of lead in paint in India and in soil. Field portable X-ray fluorescence analyzers were used to determine environmental lead levels in paint, dust, air, soil, and other bulk samples near several lead-using industries and in the residential environments of children with very high blood lead levels, at least four times as high as the CDC limit. Soils near industrial operations, such as secondary lead smelters, and battery dismantling units contained levels up to 100,000 ppm of lead. Four of 29 currently available paints from five manufacturers measured 1.0 mg/cm^2 or above—the current U.S. definition of lead-based paint in housing—after the application of a single coat; four others measured at least 1.0 after three coats, and three others likely reached this level after the application of an additional one or two coats. In 5 of 10 homes of the elevated blood lead children, three or more locations in or around the home were found to have lead paint levels of 1.0 mg/cm^2 or higher. Soil exceeding the U.S. standard for residential areas (400 ppm) was found at only one of the houses. Other sources of lead exposure, including traditional ayurvedic medicine tablets, were also observed. Similar surveys would be useful elsewhere in India and in other developing countries.

Keywords battery, India, lead paint, smelters, soil, XRF

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BACKGROUND

Blood lead surveys in several areas of India have found very high percentages of children with elevated blood lead levels (EBL). In a survey of 22,000 adults and children in seven cities in India conducted by The George Foundation,(1) 53% of children under 12 years of age had blood lead levels equal to or greater than 10 μg/dL, the level currently considered elevated by the U.S. Centers for Disease Control and Prevention.(2) A number of these surveys focused on populations near lead smelters or in areas with high lead levels from combustion of lead-containing gasoline prior to the phasing out of use of lead additives to gasoline that began in 1998.(3)

Lead smelters and the facilities involved in lead-storage battery recycling and manufacturing have long been recognized as potential sources of lead contamination of the environment and have shown to be a health hazard.(4–6) Many of the lead storage battery recycling and smelting operations are carried out in small facilities sometimes known as "backyard smelters." Because of the primitive nature of these operations and their enormous number, estimated to be in the tens of thousands, the control of contamination from them is a major challenge. Other potential sources of lead exposure could be certain ayurvedic, or traditional, medicines and automobile painting and body shops. Ayurvedic medicine pills formulated from nonstandardized recipes have often been found to contain lead and other heavy metals.(7)

A recent article(8) included lead-based paint as a major source of childhood lead poisoning in the United States, but not in its list of eight major sources of childhood lead poisoning worldwide: gasoline, lead-glazed ceramics, mining and smelting, battery repair and recycling, cottage industries, flour mills, medication and cosmetics, consumer products, and other. Yet, Chen(9) has recently found lead-based paints in the Chinatown and Little India neighborhoods of Singapore, which contain housing built before World War II. Although lead-based household paints were not available locally, they were available in a nearby country.(9) Singapore serves as a useful comparison as it is another South/Southeast Asian country that, in comparison with India, has a more highly developed regulatory system, and, more significantly, rigorous implementation of such laws.

There is little information available on the levels of lead in paint in India and in nearby soil; however, it has been reported that 10% of lead used in India is for paint.[10] This percentage corresponds to the amount of white lead used for paint in the year 1930 in the United States, a time when lead was still a common ingredient in household paint.[11] A study by Van Alphen[12] found that of 24 new paints applied to test surfaces and measured for lead, 17% had lead concentrations exceeding 0.5% lead by weight, 13% were higher than 1% lead, and 5% even exceeded 10% lead by weight. According to current standards in the United States and elsewhere, the nonvolatile or dry content of new paints marketed for residential use must contain less than 600 ppm of lead.[13] For existing paint in housing, any surface where the paint lead content is equal to or exceeds 5000 ppm or 1.0 mg/cm^2 is considered to be "lead-based" according to U.S. Environmental Protection Agency (EPA) standards.[14]

Health-based standards for lead in paint, soil, and dust in residential areas have been established in the United States.[13,14] In Singapore, a standard for lead in new paint has been established, but apparently none exists for soil and dust.[15] Guidelines for lead in soil are available in India, but there are no standards for paint.[16] These standards and guidelines are summarized in Table I.

A number of studies have shown that portable X-ray fluorescence (XRF) technology is useful for measuring lead in soil, air, and dust.[17–19] The availability for the first time in India of field portable XRF analyzers in 2003 provided the opportunity to conduct surveys to identify possible sources of exposure. Testing was conducted in industrial and residential areas in two states in India (Karnataka and Gujarat). *In situ* paint lead levels were measured, and lead levels in paints available for purchase in local supply stores were determined.

In addition to testing likely industrial sources of lead contamination, the XRF analyzer was also used to examine the home environments of children known to have EBLs. A randomly selected group of 107 schoolchildren from Mangalore, Karnataka, participated in a blood lead screening program early in 2003 that was organized by the National Referral Center for Lead Poisoning in India (NRCLPI), a nonprofit institution founded by The George Foundation and St. John's National Academy of Health Sciences, and with support from the Karnataka State Pollution Control Board. Seventy-eight percent of the students had blood lead levels at or above 10 μg/dL, the level considered to be a health risk according to U.S. standards.[20] Of those tested, 11 students had blood lead levels at or above 40 μg/dL. This study served to complement the blood lead survey by examining the highest EBL children's home environments for possible sources of exposure to lead.

Objectives

The major research objectives were to determine (1) lead levels in soil at/near secondary lead smelters (Bangalore, Karnataka), paint manufacturers (Vallabh Vidyanagar, Gujarat), auto body shops and small-scale battery servicing, and recycling operations (Bangalore and Vallabh Vidyanagar); (3) lead content in painted surfaces, soil, and dust in and around the home and play environments of children with elevated blood lead levels (Mangalore); and (2) lead content of currently available residential paints.

METHODS

Study sites were selected based on the types and accessibility of industries present in the geographic areas examined. In Bangalore, study sites were recommended by the NRCLPI.

Prior to the collection of composite soil samples, which would be sieved prior to examination, the XRF analyzers (Models XL-700 and XL-300; NITON Corp., Bedford, Mass.) were operated in the semiquantitative screening mode to determine locations of similar levels and to locate the high-lead areas. A map of estimated soil lead levels at the site could then be prepared in order to select areas of similar levels that could be included in the same composite soil sample, which contained about five subsamples. For these screening purposes, the XRF was placed directly on the surface of the soil using a protective shield known as a sled. This *in situ* soil screening, as

TABLE I. Standards and Guidelines for Lead in Paint, Soil, and Surface Dust

Media	Country	Level	Reference No.
Paint—existing housing	United States	<1.0 mg/cm^2 and <5000 ppm	14
Paint—new	United States	600 ppm	13
Paint—new/existing	India	No standard	—
Soil—bare play areas	United States	400 ppm	14
Soil—bare areas in rest of yard	United States	1200 ppm	14
Soil	India	100–300 ppm^A	16
Soil	India	1000 ppm^B	16
Dust—surface	United States	40 μg/ft^{2C}	14

^{A}Guidance level: "may be tolerable."
^{B}Guidance level: "contributes to child lead poisoning."
^{C}Floor areas of housing.

well as all other readings taken with the XRF, were executed according to manufacturer's guidelines.

Bulk samples, consisting of about five subsamples, were collected and sieved for XRF analysis. A minimum of 20% of the samples was also analyzed later by atomic absorption at the University of Cincinnati, and excellent correlation was observed. Bulk soil samples were collected using a small metal spatula. Two to 4 cm^3 soil subsamples were collected from the top 1 cm of areas with similar lead concentrations as determined by the XRF in the screening phase. These subsamples were combined and mixed in a collection bag to make composite samples, which are referred to as such in the Results section. Dust wipes were collected according to U.S. EPA procedures on one-square-foot areas in locations of interest, such as floor areas of housing and lunchroom/table surfaces in workplaces and folded as prescribed by XRF manufacturer's procedures. In a laboratory, soil samples were sieved to $<250\ \mu$m, placed in plastic sample cups with a Mylar cover, and lead levels measured at 60 nominal seconds, as per the manufacturer's guidelines.[21]

The types of samples analyzed consisted of paint (mg/sq ft), soil (ppm)—both *in situ* and laboratory prepared—dust wipes (μg/ft^2), bulk dust (ppm), and other solid substances such as traditional medicines and foodstuffs (ppm). The analytical method utilized was field portable XRF analysis (NITON XL-700 and XL-300 series models). Results were later confirmed by atomic absorption laboratory analyses in the hematology and environmental laboratories of the University of Cincinnati. The results reported below are atomic absorption values when available. Air samples were collected using personal air sampling pumps operating at 2 L/min to assess ambient lead levels at one of the paint manufacturing plants.

To examine potential sources of lead exposure among the group of EBL school children in Mangalore, the paint, soil, and dust in and around their home and play environments were tested with the XRF. Paint and soil screenings were taken on site, and bulk dust and composite soil samples were prepared for analysis. In addition to soil, dust, and painted surfaces, other areas tested included floor tiles, kitchen platforms, grinding stone, utensils, spice mixture additives, batteries, and medicines taken. Parents and other family members were also questioned regarding the child's possible exposure to activities such as battery recycling, as well as any use of traditional medicines and lead-containing kitchen items. The interviewing addressed the habits, hobbies of the child and family, and the child's general health to gain information on potential factors contributing to the child's elevated blood lead level. The home visit procedures were based on EBL child home investigation practices, with additions and adjustments made as appropriate to the local circumstances. The common use in India of traditional folk medicines that may contain lead and other metals, for example, prompted us to inquire about any tablets the EBL child might be taking.

To assess lead levels in residential paints currently available on the Indian market, wooden blocks were painted in three successive coats with paint purchased locally. A new brush was used for each paint, and coats were applied as uniformly and consistently as possible. A series of three measurements were taken with the XRF after each individual paint coat had dried. Readings were then averaged by coat for each individual paint.

RESULTS

Secondary Lead Smelters

Five composite soil samples from near the secondary smelter entrance (A) ranged between 711 and 182,000 ppm of lead (Table I) with the highest concentrations found adjacent to the facilities. The 711 ppm measurement was taken at a distance of 73 m from the smelter on a lane running alongside the plant. At 43 m from the smelter entrance, the soil concentration measured 3089 ppm of lead. At the front entrance to the facility, the soil lead level was 23,920 ppm. A soil sample taken on the edge of the scrap pile outside showed 182,000 ppm of lead. To provide an instructive comparison, the lead product itself—recovered from the batteries to be resmelted—measured 530,000 ppm of lead. Three dust wipes were taken in the office immediately adjacent to the smelting area, with results ranging from 7300 to 27,040 μg/ft^2. The surface of a worker's boot contained 22,330 μg/ft^2. Although the smelter was located in an industrial zone, children were observed coming to the work site and some lived in adjacent buildings.

Bulk samples that had previously been collected from another secondary smelter (B) by the Karnataka State Pollution Control Board were sieved and tested with the XRF analyzer. The product from this particular smelter showed 238,700 ppm of lead. Soil 2 m in front of the factory entrance at this smelter measured 107,000 ppm of lead. No dust wipes were taken. A summary of the results from the secondary lead smelters is presented in Table II.

Auto Body and Battery Servicing Shops

Lead testing with the XRF analyzer was conducted at two auto paint and repair shops in Bangalore. At Auto Body Shop A, dust wipes were taken on a car hood in the repair bay and on the office floor and measured 25 μg/ft^2 and 109 μg/ft^2, respectively. A soil sample taken from the walkway 1 m in front of the shop's entrance measured 48 ppm. Auto Body Shop B showed similar levels of soil and dust lead. The dust

TABLE II. Secondary Lead Smelters—Lead in Soil, Product, and Dust

Facility	Soil (ppm)^A	Product (ppm)	Dust Wipe (μg/ft^2)
Smelter A	42,500 (711–182,000) n = 5	530,000	18,900 (7300–27,040) n = 3
Smelter B	107,000	238,700	None taken

^{A}Composite samples.

wipe taken from a car hood in the scrapyard measured 31 μg/ft^2 of lead, and another in the repair bay measured 61 μg/ft^2. An office floor wipe contained 38 μg/ft^2 of lead. A dust wipe was also taken from the lunchroom table and showed 6 μg/ft^2. A bulk floor dust sample collected 1 m outside the office entrance measured 153 ppm of lead.

A retail battery store that performs maintenance was also inspected, although they do not dismantle batteries for lead recovery purposes at this site. The manager reported that this activity is done off site at licensed company facilities. A dust wipe on the actual service area floor contained a very high amount of lead, 5470 μg/ft^2, but the other surfaces screened in the office area, and soil screened 3 m in front of the entrance at the curb, showed negligible levels of lead, that is, less than the XRF detection limit of 100 ppm.

Lead levels measured in the auto body and battery servicing shops are summarized in Table III.

Small-Scale Battery Recycling

Soil samples collected from in and around two small-scale battery recycling sites showed dangerously high lead levels. As would be expected, the highest concentrations at both sites were found in the areas where the actual dismantling took place—3920 ppm at Battery Recycler Site A and 8970 ppm at Battery Recycler Site B, respectively. Lead levels steadily dropped as one moved away from the workstation yet remained high enough to be a cause for concern. Samples at Site A, located in a busy, mixed-use neighborhood, ranged from 463 to 8973 ppm of lead. The 463-ppm measurement was taken 25 m past the shop entrance on the sidewalk. Thirty-seven meters past the entrance, lead levels were actually higher, at 1640 ppm. Four meters in front of the shop at the curb, the soil measured 6233 ppm of lead. Testing at and around Site B revealed a narrower range of lead concentrations, from 602–3920 ppm. Bulk floor dust sampling also indicated high levels of lead contamination in and around the work sites. A sample collected from the workroom floor at Site A measured 21,200 ppm, and one from Site B measured 95,300 ppm. Dust wipe samples were taken only at Site A, on workroom surfaces, and ranged from 175–3550 μg/ft^2.

TABLE III. Auto Body and Battery Servicing Shops—Lead in Soil and Dust

Facility	Soil (ppm)^A	Bulk Dust (ppm)	Dust Wipe (μg/ft^2)
Auto shop A	48	None taken	25 (car hood) 109 (office floor)
Auto shop B	46	153	31 and 61 (car hood) 38 (office floor) 6 (lunch table)
Battery sales shop	None taken	<100 ppm	5470 (service area floor)

^{A}Composite samples.

Paint Manufacturing Companies

The lead survey of paint companies in Gujarat focused on soil, dust, and air lead at manufacturing plants, as well as the lead content of actual pigments and paints. Air samples were collected only at Paint Company B; however, neither Company A nor B was operating at the time of the visits. Two composite soil samples at the plant entrance to Company A showed 139 and 468 ppm of lead, respectively. A bulk dust sample by the charging area on the work floor measured 3740 ppm, and another bulk sample by the mixing area measured 1620 ppm of lead. A dust wipe taken on the floor of the watchman's house within the factory compound gave a reading of 29.3 μg/ft^2. A dust wipe taken at the main entrance to the plant measured 293 μg/ft^2.

Results from composite soil samples from Company B were about nine times as high as those at Company A. Samples from Company B ranged from 37 to 3880 ppm of lead (n = 9). Dust wipes taken at Company B, ranging from 239–4583 μg/ft^2, were also many times higher. A dust wipe measuring 2010 μg/ft^2 was taken from the floor adjacent to a workers' rest area. Two dust wipes were taken in the areas where workers sit for lunch and measured 1000 μg/ft^2 and 3280 μg/ft^2 of lead, respectively. No bulk dust samples were obtained at Company B. Air lead levels were below the detection limit (<5 μg/m^3). Results from the paint manufacturing companies and the small-scale battery recycling facilities are presented in Table IV.

Lead in Currently Available Paint Products

Twenty-nine paints were obtained from local suppliers, 10 in Bangalore and 19 in Gujarat, representing a total of five different brands of paint. The paint lead loadings from these samples, measured after application of the first, second, and third coats are presented in Figure 1. Three readings were usually taken after the application of each coat of paint. Values shown in the figure are the average of the readings taken of these readings.

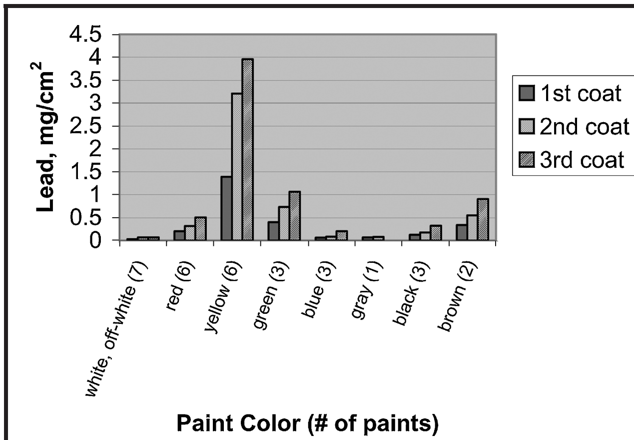

FIGURE 1. Comparison of lead levels in successive coats of new paint

TABLE IV. Paint Manufacturing Companies and Small-Scale Battery Recycling Facilities—Lead in Soil and Dust

Facility	Soil (ppm)[A]	Bulk Dust (ppm)	Dust Wipe (μg/ft^2)
Paint company A	139 and 468	3740 and 1620	102 (<4–289) n = 3
Paint company B	675 (37–3880) n = 9	None taken	208 (239–4580) n = 5
Battery recycler A	2040 (602–3920) n = 4	17,400 and 21,200	1040 (175–3550) n = 4
Battery recycler B	3690 (463–8970) n = 3	6230 and 95,300	None taken

[A]Composite samples.

Four of 29 currently available paints from five manufacturers measured 1.0 mg/cm^2 or above after the application of a single coat; four others measured at least 1.0 after three brush coats, and three others were likely to have reached this level after the application of an additional one or two brush coats. As shown in Figure 2, where averages of all paints of a particular color and number of coats of paint are shown, yellow paints showed the highest lead levels as compared with other colors. Yellow paint pigments containing 200,000 ppm of lead were obtained as samples in paint manufacturing facilities and in an academic paint technology department. Yellow-derivative paints (green and brown) had the next highest amount of lead. After a third coat, the red paints also exceeded the given standard of 1.0 mg/cm^2.

Sources of Lead Exposure in EBL Children in Mangalore

Probable sources of lead exposure could be determined in 7 of the 10 cases of children with blood lead levels at or above 40 μg/dL. There was no evidence of lead exposure sources in the school or playground of the government school attended by 8 of the 11 children in the >40 μg/dL blood lead level group.

At the neighborhood playground where one of the boys played every day, bright yellow- and orange-painted jungle gym equipment was tested with the XRF. The yellow paint gave a maximum reading of 3.5 mg/cm^2 of lead, whereas the orange was associated with a reading of 2.4 mg/cm^2 of lead. A composite sample of the soil contained a relatively low level of lead, 119 ppm. It was later learned, however, that the soil had recently been placed in the area near the play equipment.

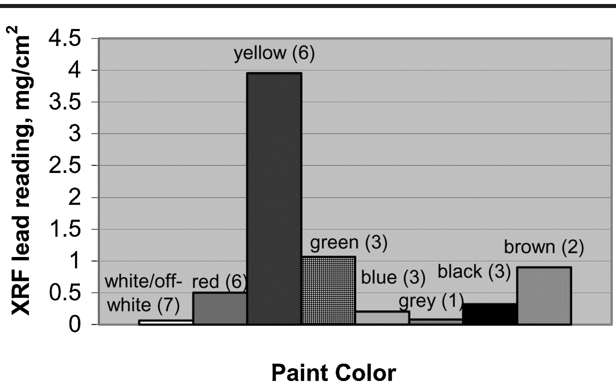

FIGURE 2. Comparison of lead content of new paint by color (based on third coat readings)

A boy from a middle-income family who had a blood lead level of 68 μg/dL appeared to be ingesting sizeable amounts of lead via ayurvedic medicine tablets he had been taking for a few months as a remedy for assorted health complaints. The unmarked tablets, in an unlabeled bag that the family could not give a name for, had been prescribed by an ayurvedic doctor. The tablets were crushed in the bag and analyzed while in the bag using the NITON XRF analyzer in the screening mode. The results showed a value of 636 ppm of lead. Laboratory testing of a sieved sample of the powder revealed a concentration of 850 ppm of lead, and an even higher level of mercury, an estimated 30,800 ppm. The boy had been taking a total of nine tablets per day (2.26 g), which would result in an intake of about 1920 μg of lead per day. Eight weeks after he had been advised to discontinue the tablets, the boy's blood lead level dropped from 68.8 μg/dL to 28.8 μg/dL.

For another child, a discarded motorcycle battery in the home was found to be a potential source. The child frequently mouthed, or put her lips and/or tongue to, the battery whose surface measured 7.7 and 8.4 mg/cm^2. Two weeks after the battery was removed from the house, as recommended, there was a sharp drop in the child's blood lead, from 58 μg/dL to 16 μg/dL.

The home of another child was painted many different colors. The red paint on the doorframe indicated a value of 3.2 mg/cm^2, and the window bars, which were painted yellow, had a maximum value of 4.6 mg/cm^2 of lead. On questioning the parents it was found out that this child had the habit of licking the paint off walls (pica). The child frequently played with a friend in a nearby house under construction that contained metal scaffolding painted with a lead-containing yellow paint. Paint measurements of this scaffolding were as high as 1.9 mg/cm^2. Dust wipes were below the detection limit of about 8 μg/ft^2.

The frequency distribution of XRF paint lead readings in the Mangalore housing study is presented in Figure 3. A total of 210 readings were taken in the home environments of 10 children who had tested with blood lead levels greater than or equal to 40 μg/dL in a recent survey conducted by the NRCLPI in the Department of Biochemistry and Biophysics at St. John's Medical College.[20] The graph shows that more

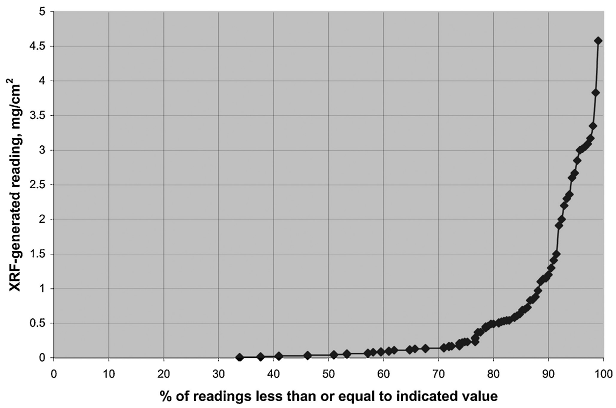

FIGURE 3. Frequency distribution of XRF paint lead readings in Mangalore Housing Study (February 2003, n = 210)

than 10% of the paint readings were equal to or greater than 1.0 mg/cm^2. About 35% of the paint readings were zeroes (lower limit of quantitation 0.01 mg/cm^2). The highest reading was 4.6 mg/cm^2 of lead.

DISCUSSION

The secondary lead smelter visited was said to be in compliance with the lead air pollution control standard, but workers and the children seen visiting the facility were clearly being exposed to high levels of lead in the dust and soil at the facility, and even up to a block away from it. Barefoot children entered the smelter and others played in high lead areas very close to the smelter. Workers were not using respiratory protection.

Automotive and retail battery shops did not appear to contribute significant amounts of lead to the soil in adjacent areas, but dust lead levels were very high in one of the battery shops where battery recycling occurred off site. The high level observed may have been due to contaminated dust brought from the recycling site. The public, therefore, should not have access to this area, and take-home protection procedures for workers should be in place.

Finding lead-contaminated soil near battery dismantling operations was not unexpected, but what is particularly disturbing is that these operations are commonly located in busy residential-commercial areas frequented by young children and others. Battery Recycler A claims to be an authorized recycling operation, which would suggest that even "approved" recyclers operate dangerously.

Lead-based paints were available in 1999[12] and results from the study reported here indicate that the situation has not changed significantly. For the first time, lead-based paints have been found in existing housing stock. It is important to determine the extent of lead-based paint in housing elsewhere in India because the prevailing view apparently had been that such lead paint did not represent an important source of exposure to children in India.[8]

The playground in Mangalore was the only one tested, but the use of bright yellow and other colors is quite common for children's play equipment throughout India. As numerous lead-containing yellow paints were found to be readily available, it is quite possible that many other playgrounds are contaminated. Later investigations revealed that two manufacturers of playground equipment used in Mangalore indicated that their equipment was painted with lead-based paint. The lead-based paint on the playground equipment in Mangalore was subsequently replaced with lead-free paint based on the findings in this study.

A recent report in the United States[22] documents 12 cases of lead poisonings in adults attributed to ayurvedic medicines containing lead. Some branches of this practice consider heavy metals to be therapeutic; lead levels have been found to range from 0.4 to 261,200 ppm.

Based on this study, 11% of surfaces in existing houses in Mangalore that were tested contained at least 1.0 mg/cm^2 lead, with a median of 0.04 mg/cm^2. In comparison, Chen[9] recently found 14% of existing household paints of older housing in Singapore's Little India had levels of 1.0 mg/cm^2 or higher, and 63% of the surfaces tested in Singapore's Chinatown were greater than or equal to 1.0 mg/cm^2. The median level in Little India was 0.2 mg/cm^2, and in Chinatown, 2.5 mg/cm^2. A recent large study of paint lead in the United States housing stock revealed that 66% of exterior painted surfaces contained greater than or equal to the standard of 1.0 mg/cm^2, and 3.5 mg/cm^2 was the median reading. For interior surfaces, 53% were greater than or equal to 1.0 mg/cm^2, with a median reading of 0.5 mg/cm^2.[23,24] Although lead-based paint was detected in housing in India, the levels were similar to those found in Little India but lower than those found in Chinatown and in the United States.[9,23]

At least one of the companies producing lead-based paints for the Indian market produces paints of the same color without lead for other markets. Chen[9] found that red paint and green paint from a particular company in Singapore measured 0.02 and 0.00 mg/cm^2, respectively. The samples of paint of these colors from the same company, purchased in India, contained much higher levels of lead—0.34 mg/cm^2 for the red paint and 1.62 mg/cm^2 for the green. The lack of an enforced legislative ban on lead in household paint in India may, in part, explain this disparity.

Efforts are currently under way to follow up on results of the above observations. The information from this study has been shared with government agencies and NGOs in India.[24]

CONCLUSIONS

Contaminated soil and lead-based paints represent a serious risk to children and adults in India. The highest soil lead levels, up to 18% lead, were found at secondary smelters. Heavily contaminated small-scale battery recycling operations were found in busy residential-commercial areas. Both of these types of facilities showed lead levels exceeding the government of India's "contributing to childhood lead poisoning" guideline of 1000 ppm[16]. Persons working in paint manufacturing facilities, secondary lead smelters, and battery dismantling operations, and others with access to these sites, are at risk of exposure and should be periodically monitored for blood lead levels. Exposure reduction procedures were not evident and therefore need to be developed and rigorously implemented. Lead-based paints are readily available for purchase for household use in India. Eleven of 29 currently available paints from five manufacturers would equal or exceed 1.0 mg/cm^2 after the application of one to three coats. Yellow and yellow-derivative paint colors (green and brown) had the highest lead content. More than 10% of surfaces in housing tested contained lead-based paint. Lead paint, therefore, should be considered a significant potential source of lead poisoning in India.

The follow-up study of schoolchildren with 40 μg/dL or higher blood lead levels in Mangalore suggests that many children are being exposed to lead, and from a variety of sources, including batteries, ayurvedic pills formulated with heavy metals, and paint.

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