Environmental Research 138 (2015) 432–438

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

Total lead concentration in new decorative enamel paints in Lebanon, Paraguay and Russia

C. Scott Clark [a,b,*], Olga Speranskaya [c], Sara Brosche [b], Hebe Gonzalez [d], Daniela Solis [d], Naji Kodeih [e], Sandy Roda [a], Caroline Lind [a]

[a] Department of Environmental Health, University of Cincinnati, 3223 Eden Avenue, Cincinnati, OH 45267-0056, USA
[b] IPEN, 1962 University Avenue, Suite 4, Berkeley, CA 94704, USA
[c] Eco Accord, PO Box 43, 21B Kussinena St., 129010 Moscow, Russia
[d] ALTER VIDA, Itapua 1372, c/Primer Presidente. Barrio Trinidad, Asuncion, Paraguay
[e] Indy Act, Rmayl, Nahr Str., Jaara Building, 4th floor, PO Box 43, 14-5472, Beirut, Lebanon

ARTICLE INFO

Article history:
Received 21 November 2014
Received in revised form
24 January 2015
Accepted 18 February 2015

Keywords:
New paint lead
Lebanon
Paraguay
Russia
lead paint

ABSTRACT

Lead concentrations in new enamel decorative paints were determined in three countries in different areas of the world where data were not previously available. The average total lead concentration of the enamel decorative paints purchased in Lebanon, Paraguay and Russia was 24,500 ppm (ppm, dry weight), more than 270 times the current limit of 90 ppm in Canada and in the United States. Sixty-three percent of these paints contained concentrations greater than 90 ppm. Fifty-nine percent contained concentrations greater than 600 ppm, the current limit in some countries. The maximum concentrations found were 236,000 ppm in Lebanon, 169,000 ppm in Paraguay and 52,900 ppm in Russia. An average of 29% of the samples contained exceedingly high lead concentrations, $>=$10,000 ppm.

Five brands of paint were sampled in each of Lebanon and Paraguay and seven in Russia. Three colors from each brand were analyzed. For five of the six samples of the two brands in Lebanon with affiliations outside the country, the lead concentrations ranged from 1360 ppm to 135,000 ppm. In Lebanon the maximum concentration in the Egypt-affiliated brand (Sipes) was 135,000 ppm and the maximum for the USA-affiliated brand (Dutch Boy) was 32,400 ppm. Lead was not detected in any paints from the three of the four brands of paint purchased in Paraguay that had headquarters/affiliations in other countries (Brazil-Coralit), Germany (Suvinil) and USA (Novacor)). Two of the three paints from each of the other Paraguay brands contained high levels of lead with the maximum concentrations of 108,000 and 168,000 ppm; one of these brands was manufactured under a license from ICI in the Netherlands. All of the paints purchased in Russia were from Russian brands and were manufactured in Russia. All three paints from one brand contained below detection levels of lead. The maximum levels of lead in the other six brands in Russia ranged from 3230 to 52,900 ppm. The two brands with the highest lead concentration, TEKS and LAKRA, were produced by companies in the top three in market share.. Overall, lead concentrations were much higher in the colored paints such as red and yellow than in white paints. In each of the three countries a brand based in that country had a colored paint that either met a 90 ppm limit or was close to meeting the limit-demonstrating that practical technology was available in each of these countries to produce low lead bright colored enamel decorative paints. Even though technology for producing paint without added lead existed in each of these countries, twenty-nine (29) percent of the paints analyzed contained exceedingly high concentrations ($>=$10,000 ppm) of lead.

1. Introduction and background

Paints containing dangerously high lead concentrations are still available in many countries as has been documented by a number of investigators (Adebamowo et al. 2007, Berne et al. 2011, Clark et al., 2005, 2006, 2009, 2014a,b; Ewers et al., 2011, Gottesfeld et al., 2013, 2014, IPEN, 2013, Johnson et al., 2009, Kumar, 2007, Kumar and Gottesfeld, 2009, Lin et al., 2008, Mathee et al., 2007,

* Corresponding author at: 31 Brookstone Place, Candler, N.C. 28715-8463, USA. Tel.: +1 513 290 3446; fax: +1 828 633 2095.
E-mail addresses: clarkcs@ucmail.uc.edu (C.S. Clark), speransk2004@mail.ru (O. Speranskaya), sara.brosche@ipen.org (S. Brosche), heberepal07@hotmail.com (H. Gonzalez), dansoliso@gmail.com (D. Solis), najikodeih@gmail.com (N. Kodeih), smroda@etczone.com (S. Roda), carolinelind@live.com (C. Lind).

http://dx.doi.org/10.1016/j.envres.2015.02.020
0013-9351/

Montgomery and Mathe, 2005, Nganga et al., 2012, Toxics Link/IPEN Global Study, 2009, UNEP, 2013a and Van Alphen, 1999). High lead concentrations have even been found in a country ,China, with a legal restriction on the lead content (Lin et al., 2008, Clark et al., 2009). However in many other countries information on lead concentration in new decorative enamel (oil-based) paints is not available. Exposure to lead causes many very serious health problems, particularly to very young children (NTP, 2012), and the effects can persist in later years (e.g. Dietrich et al., 2001, Cecil et al., 2008). Health authorities have concluded that there is no safe limit for the concentration of lead in the blood of children (CDC, 2012). There is therefore an urgent need to ensure that paints are produced using only non-lead materials. This need applies to all paints used in housing and other areas where children are present, whether the paints are manufactured within the country where they are purchased or imported. In response to the concern over the continued use of lead in paints intended for use in areas where children and others are exposed a Global Alliance to Eliminate Lead Paint was created by the World Health Organization (WHO) and the United Nations Environmental Program (UNEP, 2013b).

The exposure to lead of young children is often through contact with dust contaminated with chips of lead paint (Bornschein et al., 1985, Clark et al., 1991, Jacobs et al., 2002, Gaitens et al., 2009). Lead-contaminated dust is created as painted surfaces deteriorate and particularly when previously painted surfaces are prepared for repainting by removing loose-paint in an un-safe manner. Regulations to require that persons engaged in renovation, repainting and remodeling and lead abatement activities are trained in lead-safe work practices have been enacted in the United States (USEPA, 2008, 2010, 2012) and would also be useful in other countries. Hazards from previously applied leaded paints can exist for many years after lead has been eliminated from new paints. For example, in the United States lead-based paint hazards still exist in 24 million housing units many years after the use of lead in paints was prohibited in 1978 (Jacobs et al., 2002). Evidence of reduced intelligence caused by childhood exposure to lead has led the World Health Organization to list “lead caused mental retardation” as a recognized disease. WHO also lists it as one of the top 10 diseases whose health burden among children is due to modifiable environmental factors (WHO, 2010). This research was designed to help fill the gaps in knowledge of lead concentrations in new paint in countries, in different areas of the world, where such data are missing. Lead concentrations in new enamel decorative paints were therefore determined in Lebanon, Paraguay and Russia.

2. Materials and methods

This project was a cooperative effort between IPEN, IndyACT in Lebanon, ALTERVIDA in Paraguay, EcoAccord in Russia and the University of Cincinnati (UC) in 9 the United States, IndyACT, ALTERVIDA, and EcoAccord are each members of IPEN, an international network of non-governmental organizations (NGOs) of health and environmental organizations from all regions of the world. IPEN is a leading global organization working to establish and implement safe chemicals policies and practices to protect human health and the environment. Its mission is a toxics-free future for all. IPEN helps build the capacity of its member organizations to implement on-the-ground activities, learn from each other's work, and work at the international level to set priorities and achieve new policies.

Three colors, usually red, white and yellow, from each of five brands of paint were obtained in Lebanon and in Paraguay. In Russia, three colors from each of seven brands were sampled. These three colors were chosen because previous studies have indicated that yellow paints tend to have the highest lead concentration, white paints the lowest and red intermediate (Clark et al., 2009). The brands that were sought to be included from each country were the most popular brands and a brand from a smaller company. The brands selected in Russia included two of the three brands with the largest market share, TEKS and LAKRA (Tikkurila, 2015a). Samples were prepared in each country on wood according to a protocol described elsewhere (Clark et al., 2014a,b) using supplies shipped from UC. Detailed information was obtained for each paint sample such as: the country where the paint was manufactured, the country of the brand headquarters/, affiliations date paint manufactured (if provided) and information on the label regarding lead content (if provided). This information was recorded on the laboratory submittal form completed for each country. The dried paint samples were shipped from each country to UC where they were analyzed for total lead content by the Hematology and Environmental Laboratories. Paint was carefully removed from the painted wood by means of a clean sharp paint scraper using care to not remove any of the wood. The paint scrapings were extracted with nitric acid and hydrogen peroxide according to the method: Standard Operating Procedures for Lead in Paint by Hotplate or Microwave-based Acid Digestions and Atomic Absorption of Inductively Coupled Plasma Emission Spectroscopy, EPA, PB92-114172, September 1991 (US EPA, 1991). Extracts were analyzed by flame atomic absorption spectroscopy using a Perkin-Elmer 5100 spectrometer. The H and E Laboratory was accredited by the American Industrial Hygiene Association (AIHA) as an environmental lead laboratory under the National Lead Laboratory Accreditation Program. The laboratory participated in the Environmental Lead Proficiency Analytical Testing (ELPAT) proficiency program operated by the AIHA under a program established by the U.S. Environmental Protection Agency. Strict quality control procedures were maintained according to the accreditation guidelines. The accreditation program operated by AIHA meets all international program requirements which comply with ISO/IEC 17025 and subsequently ISO/IEC 17011. AIHA is a full member of the International Laboratory Accreditation Cooperation (ILAC). The AIHA accreditation program is recognized globally.

Total lead concentrations in parts per million (ppm) dry weight were compared by country where paints were purchased, brand headquarters country, color, and by lead concentration distributions, such as number of samples with lead concentrations $>=$90 ppm, 600 ppm, 10,000 ppm, $<=$90 ppm by brand and country. These concentrations were chosen because 90 ppm is the current limit in the United States (CPSIA, 2008), Canada (Health Canada, 2010 and Nepal, 2014), 600 ppm is the current limit in some other countries (e.g. Brazil (Brazilian Federal Law, 2008), the Philippines (Philippines DENR, 2013), Singapore (Singapore NEA, 2004), Sri Lanka (Sri Lanka CAA, 2011), and Uruguay (Uruguay NEO, 2011), and 10,000 ppm is considered an exceedingly high concentration.

3. Results

Data on individual samples are presented in Tables 1, 2 and 3 for Lebanon, Paraguay and Russia, respectively. There was a wide range of lead concentrations detected in the paints from each country (Table 4), with the percent of the samples containing levels of lead greater than or equal to 90 ppm ranging from 27% in Paraguay to 87% in Lebanon. The average concentration of lead was 48,300 ppm in the paints from Lebanon, 23,100 ppm in the paints from Paraguay and 8340 ppm in the paints from Russia. The maximum detected concentration was 236,000 ppm in paint from Lebanon. All paints were purchased in October 2011, but the dates on which the paints were manufactured were only provided on

Table 1
Total lead concentration (ppm) in new enamel architectural paints purchased in Lebanon.

Brand	Brand headquarters/affiliation[a]	Label information about lead content[b]	Color	Lead concentration (ppm)
Tinol	Lebanon	Free of lead	White	< 9
Tinol	Lebanon	Free of lead	Yellow	236,000
Tinol	Lebanon	Free of lead	Red	101
Sipes	Egypt	No information	White	2780
Sipes	Egypt	No information	Yellow	135,000
Sipes	Egypt	No information	Red	27,700
Noula	Lebanon	No information	White	2630
Noula	Lebanon	No information	Yellow	58,300
Noula	Lebanon	No information	Red	45,600
Omega	Lebanon	No information	White	61.0
Omega	Lebanon	No information	Yellow	83,800
Omega	Lebanon	No information	Red	131,000
Dutch Boy[c]	USA	Lead free	White	16.1
Dutch Boy[c]	USA	Lead free	Yellow	1360
Dutch Boy[c]	USA	Lead free	Red	32,400

[a] All paints sampled were manufactured in Lebanon.
[b] Dates of manufacturing not indicated on labeling.
[c] **Chemipaint**, the company manufacturing Dutch Boy brand paints in Lebanon, indicated on its web site it has a license to manufacture these paints from Dutch Boy U.S.A.

Table 3
Total lead concentration (ppm) of new enamel architectural paints purchased in Russia.

Brand	Brand headquarters[a]	Date manufactured	Color	Lead concentration (ppm)
TEKS	Russia	June 15, '11	White	1680
TEKS	Russia	Aug 29'09	Blue	52,900
TEKS	Russia	May 5, '09	Green	1690
LAKRA	Russia	Sept 2 '11	White	3400
LAKRA	Russia	July 9, '11	Red	35,400
LAKRA	Russia	Sept 26, '11	Yellow	24,000
Rastsvet	Russia	July '11	White	< 9
Rastsvet	Russia	May '11	Red	8010
Rastsvet	Russia	May '11	Yellow	27,200
Kvil	Russia	Aug 10, '11	White	< 9
Kvil	Russia	July '11	Red	3230
Kvil	Russia	Aug '11	Yellow	166
Profilux	Russia	Sept '11	White	1840
Profilux	Russia	March '11	Yellow	436
Profilux	Russia	June '11	Blue	1940
Kazachka	Russia	May 10, '11	Black	< 9
Kazachka	Russia	July 5, '11	White	< 9
Kazachka	Russia	May 3, '11	Red-brown	< 9
Olivesta	Russia	Feb '11	White	2340
Olivesta	Russia	May '11	Red	3600
Olivesta	Russia	Aug '11	Green	7190

[a] All paints sampled were manufactured in Russia.

the labels for the paints purchased in Russia (Table 3), where the dates of manufacture were from May 5, 2009 to Sept 26, 2011 with about 90% in the period from Feb to Sept 2011. In Paraguay (Table 2) three brands based in other countries contained labels with a "paint expiration" date. For the paint with the latest expiration date the apparent shelf life at the time of purchase was at least three years.

3.1. Lead content information on labels

Information on the label regarding lead content was only present on paints from Lebanon, and only from two brands which contained the words "free of lead" (brand based in Lebanon) or "lead free" (brand with a U.S. affiliation-Dutch Boy). For each of these two brands, contrary to the indication on the label, one or more of the samples contained a high level of lead with the highest for one brand, 236,000 ppm (yellow) and for the other, 32,400 (red).

3.2. Comparison of lead concentration by country of brand headquarters/affiliations

Two of the brands purchased in Lebanon had their headquarters or an affiliation in other countries (Sipes -Egypt and United States -Dutch Boy USA). Each of these paints had colors with high lead; the average for these two brands was about half of that in the brands based in Lebanon. Four of the five brands purchased in Paraguay had headquarters or affiliations elsewhere (Coralit-Brazil, Suvinil-Germany, Novacor-USA) and (Albalux) operating with a license from ICI in the Netherlands. The first three of these four brands had lead concentrations below detection while the paints from Albalux had concentrations of < 9 ppm, 5,100 ppm and 169,000 ppm. All of the paints purchased in Russia were from Russia-based brands and were manufactured in Russia.

Table 2
Total lead concentration (ppm) of new enamel architectural paints purchased in Paraguay.

Brand	Brand headquarters/affiliation	Country where paint manufactured	Expiration date[e]	Color	Lead concentration (ppm)
Bambilux	Paraguay	Paraguay	No Info	White	< 9
Bambilux	Paraguay	Paraguay	No info	Yellow	108,000
Bambilux	Paraguay	Paraguay	No info	Red	64,600
Albalux[a]	Netherlands	Paraguay	No info	White	5100
Albalux[a]	Netherlands	Paraguay	No info	Yellow	169,000
Albalux[a]	Netherlands	Paraguay	No info	Red	< 9
Novacor[b]	USA	Brazil	04/2013	White	< 9
Novacor[b]	USA	Brazil	02/2013	Yellow	< 9
Novacor[b]	USA	Brazil	09/2012	Tobacco	< 9
Coralit[c]	Brazil	Brazil	01/2013	White	< 9
Coralit[c]	Brazil	Brazil	09/2012	Yellow	< 9
Coralit[c]	Brazil	Brazil	11/2011	Black	< 9
Suvinil[d]	Germany	Brazil	01/2014	White	< 9
Suvinil[d]	Germany	Brazil	02/2014	Yellow	< 9
Suvinil[d]	Germany	Brazil	11/2014	Graphite	< 9

[a] The label on the paint can purchased for this study indicated that it was an ICI licensed product and also contained the Delux logo. At the present time the cans do not contain the license information and do not contain the Dulux logo. ICI is based in the Netherlands.
[b] Sherwin–Williams.
[c] A.
[d] BASF.
[e] No information provided on date of manufacture; some labels contained paint expiration date.

Table 4
Summary of lead concentrations (ppm) in new enamel architectural paints from Lebanon, Paraguay and Russia.

Country	# samples	Average (ppm)	Median (ppm)	% > =90 ppm	% > =600 ppm	% > = 10,000 ppm	Minimum (ppm)	Maximum (ppm)
Lebanon	15	48,300	30,100	87	73	53	< 9	236,000
Paraguay	15	23,100	< 9	27	27	20	< 9	169,000
Russia	21	8340	2140	76	67	19	< 9	53,000

The lead concentrations varied widely by brand with the two brands with the highest concentrations and in the top three in market share, TEKS and LAKRA had average concentrations of 21,000 ppm and 18,800, respectively. In another brand (Kazachka) all samples contained less than detectible concentrations. Lead concentrations by country where paint was purchased and country of brand headquarters/affiliations are shown in Table 5. The results differ markedly by country. In Lebanon most of the paints from brands based in other countries contained high levels of lead. In Paraguay, all of the paints from three of the four brands with headquarters/affiliations located elsewhere contained less than detectible amounts of lead. The parent company of USA-affiliated brands in Lebanon (Dutch Boy) and Paraguay (Coralit) appears to be the same. The Dutch Boy brand in Lebanon contained high levels of lead, and the label indicated that the paint was "lead-free", while the paints in Paraguay did not contain detectible amounts of lead but the labels did not indicate lead content.

3.3. Brands of paint with lead Concentrations less than 90 ppm

For eleven (11) of the total of seventeen (17) brands of paint analyzed, one or all three samples contained lead concentrations below 90 ppm (Table 6). For four of the eleven brands (Coralit, Novacor and Suvinil in Paraguay and Kazachka in Russia) all three samples contained low levels of lead (below 90 ppm) including the colors red and yellow. For each of these eleven brands, these results document that the technology exists within that brand to produce paint with a low concentration of lead. Each country had at least two brands for which one or more of the samples contained a concentration of less than 90 ppm indicating that low lead paint technology was present in each of at least two brands.

3.4. Lead concentration by paint color

The distribution of lead concentration by color (Table 7) showed that the results were similar to that in other surveys (e.g. Clark et al., 2009, Gottesfeld et al., 2014). The red and yellow paints tended to have much higher concentrations of lead than the white paints. However the lead concentration of 41% (7 of 17) of the white samples still exceeded 600 ppm but the highest contained only 5,100 ppm, which is only 4% as high as the maximum red paint concentration and 2% as high as that for yellow. Table 8.

Table 6
Paint brands by country and number of samples with lead concentrations < 90 ppm.

Country	# of brands sampled[a]	# Brands with no samples < 90 ppm	# Brands with one sample < 90 ppm	# Brands with two samples < 90 ppm	# Brands with all three samples < 90 ppm
Lebanon	5	2[b]	3[c]	0	0
Paraguay	5	0	2[d]	0	3[e]
Russia	7	4	2	0	1
Total	17	6	7	0	4

[a] Three samples analyzed for each brand.
[b] One brand (Sipes) based in another country (Egypt).
[c] One brand (Dutch Boy) has an affiliation in another country (USA).
[d] One brand with an affiliation in another country (Netherlands)
[e] All three brands based in other countries: Novacor (USA) and Suvinil (Germany).

3.5. Follow-up analysis of US-affiliated brand purchased in Lebanon

As shown in Table 1, two of three samples of a US-affiliated brand purchased in Lebanon (Dutch Boy) contained high concentrations of lead, 1360 ppm and 32,400 ppm. In a follow-up, twenty samples from this brand, including the three colors included in the initial study, were purchased in Lebanon seven months after the first samples were purchased. These samples were analyzed for total lead by the RTI Laboratory, an AIHA-accredited laboratory that also participated in the ELPAT proficiency testing program. Results for the colors analyzed on both occasions were similar in the follow-up analyses: less than 9 ppm, 381 ppm and 66,000 ppm in the follow-up compared to 16.1 ppm, 1360 ppm and 32,400 ppm initially. Of the other seventeen (17) samples 9 (53%) contained greater than or equal to 90 ppm and four (23%) contained greater than or equal to 600 ppm with the highest at 4700 ppm in a reddish-shade color.

3.6. Comparison with lead concentrations in brands previously analyzed in other countries

High concentrations of lead in white (2780 ppm) and red (27,700 ppm) were detected in paints of the Egypt-based brand (Sipes) purchased in Lebanon. However, lead was not detected in white Sipes paint purchased in Egypt in an earlier study (Clark

Table 5
Summary of lead concentration in parts per million (ppm) of new enamel architectural paints by country where purchased and location of paint brand headquarters or affiliation.

Country	Brand headquarters or affiliation (number of brands)	Average	% > = 90 ppm	% > = 600 ppm	% > = 10,000 ppm	Maximum ppm
Lebanon	Lebanon (3)	62,000	78	67	56	236,000
Lebanon	Egypt (1)	55,200	100	100	67	135,000
Lebanon	USA (1)	11,300	67	67	33	32,400
Paraguay	Paraguay (1)	57,800	67	67	67	108,00000
Paraguay	Brazil (1)	< 9	0	0	0	< 9
Paraguay	Germany (1)	< 9	0	0	0	< 9
Paraguay	Netherlands(1)[a]	58,000,	67	67	33	169,000
Paraguay	USA (1)	< 9	0	0	0	< 9
Russia	Russia (7)	8340	76	67	19	52,900

[a] The brand was manufactured under a license from ICI which is based in The Netherlands.

Table 7
Distribution of lead concentration of new enamel architectural paints by color.

Color	# of samples	% < 90 ppm	% > =90 ppm	% > =600 ppm	% > =10,000 ppm	Average (ppm)	Maximum (ppm)
Red	11	9	91	82	55	32,000	131,000
White	17	59	41	41	0	1170	5100
Yellow	14	21	79	64	57	60,500	236,000
Other	9	56	44	44	11	7080	52,900

Table 8
Total lead concentration in second round[a] of paint from Lebanon from a US-affiliated brand (1st round results in parenthesis).

Color	Lead concentration (ppm)
White	< 9 (16.1)
Sunshine (yellow)	381 (1365)
Passion Red	66,000 (32,400)

[a] Second round samples collected seven months after first round samples.

Table 9
Comparison of lead concentration of paints analyzed in current study with those previously analyzed in other countries.

Brand	Color	Current country	Current concentration (ppm)	Other country (year)	Concentration in other country (ppm)
Sipes	White	Lebanon	2780	Egypt[b]	< 9
Suvinil	Yellow	Paraguay	< 9	Brazil[c]	< 9
Suvinil	Yellow	Paraguay	< 9	Brazil[d]	21,000
Rastsvet[a]	White	Russia	< 9	Kazakhstan[c,e]	73
Rastsvet[a]	Yellow	Russia	27,200	Kazakhstan[c,e]	50,000

[a] The brand Rastsvet is a major brand of the paint company Empils. In Kazakhstan the paint was identified as from Empils. Blue and white paints from a related brand analyzed in Kazakhstan, Rascvet, had lead concentrations of 2,500 ppm and 1940 ppm respectively.
[b] Clark et al. (2014b).
[c] Clark et al. (2014a).
[d] Toxics Link-IPEN Global Study (2009).
[e] Paints were manufactured by the same company that manufactured Rastsvet paint in Russia. In addition, a blue paint from this same company purchased in Kazakhstan contained 2500 ppm.

et al., 2014a,b).

Yellow paint from the Germany-based brand (Suvinil) purchased in Paraguay where lead was not detected in this project, contained high lead (22,000 ppm) in a sample purchased in Brazil in an earlier study (Toxics Link/IPEN Global Study, 2009). However, lead was not detected in this paint in Brazil after the regulatory limit of 600 ppm became effective Jan. 1, 2013. Concentrations of lead in white and yellow paints from the Rastsvet brand purchased in Russia contained concentrations of below detection and 27,200 ppm, respectively, which are similar to the concentrations detected in Kazakhstan (73 ppm and 50,000 ppm respectively) from paint from the same company (Empils). However, white paint from a related brand from the Empils Company purchased in Kazakhstan contained 1940 ppm lead and a blue paint from this brand contained 2500 ppm (Clark et al., 2014a,b). Paints of the ICI brand from a number of other countries have been found to have very low lead concentrations (for example: Clark et al., 2009) in contrast to concentrations of 5100 ppm and 169,000 ppm in paints of an Albalux brand in Paraguay that was a product licensed by ICI. A summary of the comparisons with lead paint concentrations determined in previous studies is presented in Table 9.

3.7. Comparison of lead concentrations in paints from Lebanon, Paraguay and Russia with concentrations in paints in nearby countries

Paints from Lebanon, compared with those in Azerbaijan, Egypt, Ethiopia and Tunisia, contained similar percentages of paint samples greater than or to 90 ppm (range of 69–80% with Lebanon at 73%). However a higher percentage of paints in Lebanon contained lead concentrations greater than or equal to 10,000 ppm, 53%, compared with a range of the others of 7–30% (Table 10). Lead concentrations of paints from Paraguay along with those from six other South American countries (Table 11) shows Paraguay having lower percentages equal to or greater than 90 ppm, 600 ppm and 10,000 ppm than those in Ecuador and Peru, but much higher than those in Chile and Uruguay and similar to those in Argentina and Brazil. The highest concentration, 168,000 ppm was detected in Paraguay.

Paints in Russia, compared with those in Armenia, Azerbaijan, Belarus, Kazakhstan and Krygyzstan (Table 12) are similar in percentages of samples greater than equal in lead concentration of 90 ppm (range of 67–82%) and 600 ppm (range of 57–77%) with the percentages of 81–67%, respectively, in Russia. The percentage of samples from Russia with exceedingly high lead concentrations (> =10,000 ppm), 19%, was intermediate in the range from all of these countries, 7–38%.

4. Discussion

The inaccurate information on lead content that was found on some of the paint can labels in Lebanon has also been found in other countries (Gottesfeld et al., 2013, Clark et al., 2014a,b). The statement in a 2002 publication (Rubin et al., 2002) that lead-based paints are not available in Russia is not consistent with the

Table 10
Comparison of lead concentration (parts per million (ppm) total lead, dry weight) in new paints from Lebanon with those available for other countries in the region.

Country	# samples	Minimum (ppm)	Maximum (ppm)	% > = 90 ppm	% > = 600 ppm	% > = 10,000 ppm
Azerbaijan[a]	30	16	20,000	77	67	7
Egypt[b]	52	< 9	122,000	69	48	28
Ethiopia[a]	23	< 15	130,000	87	83	30
Lebanon	**15**	**< 9**	**236,000**	**80**	**73**	**53**
Tunisia[a]	30	< 5	170,000	70	63	27

[a] UNEP (2013b).
[b] Clark et al. (2014b).

Table 11
Comparison of lead concentration (ppm) total lead, dry weight) in new paints from Paraguay with those available for other countries in South America.

Country	#samples	Minimum	Maximum	% > = 90 ppm	% > = 600 ppm	% > = 10,000 ppm
Argentina[a]	30	< 5	130,000	23	23	13
Brazil[b]	20	< 9	71,000	35	20	10
Chile[a]	23	< 5	1,100	4	4	0
Ecuador[c]	10	< 14	101,000	70	60	60
Paraguay	**15**	**< 9**	**169,000**	**27**	**27**	**20**
Peru[c]	10	34	35,000	90	90	40
Uruguay[a]	30	< 5	63	0	0	0

[a] UNEP (2013b).
[b] Clark et al. (2014a).
[c] Clark et al. (2009).

Table 12
Comparison of lead concentrations (parts per million (ppm) total lead, dry weight) in new paints from Russia with those available for other countries in the region.

Country	# samples	Minimum (ppm)	Maximum (ppm)	% > = 90 ppm	% > = 600 ppm	% > = 10,000 ppm
Armenia[a]	26	< 9	130,000	77	77	38
Azerbaijan[b]	30	16	20,000	77	67	7
Belarus[a]	22	0.6	54,000	82	68	9
Kazakhstan[c]	26	< 9	71,000	81	77	38
Krygyzstan[b]	30	< 5	99,000	67	57	10
Russia	**21**	**< 9**	**52,900**	**81**	**67**	**19**

[a] Toxics Link-IPEN Global Study (2009).
[b] UNEP (2013b).
[c] Clark et al. (2014a).

current finding reported herein of high concentrations of lead in many new paints in Russia. The brand in Russia that has the highest lead concentration, TEKS, is a major brand of the Tikkurila Company (Tikkurila, 2015b). Tikkurila has the highest share of the market in Russia and also has a production unit in the Ukraine and is expanding operations in Belarus and Kazakhstan (Tikkurila, 2015a). Paints in Paraguay and Uruguay (UNEP, 2013a), countries very close to each other, had markedly different average lead concentrations: 23,100 ppm in Paraguay and 9.8 ppm in Uruguay. The maximum concentration in Paraguay was 169,000 ppm and in Uruguay, only 63 ppm. These differences are very likely associated the existence of a regulation in Uruguay limiting the lead concentration in decorative paints to 600 ppm (Uruguay NEO, 2011). The legislation in Uruguay was enacted February 15, 2011 and became effective February 15, 2013. All elements of the legislation in Uruguay were to be in effect within two years of the date it was passed, by February 15, 2013. The paints analyzed in Uruguay were purchased in November 2012, three months prior to the when the limit was mandatory. One brand was analyzed in both countries, Suvinil, for which concentrations were < 90 ppm in each country. When compared to lead concentrations in paints from other countries nearby, relative concentrations of paints from Lebanon, Paraguay and Russia differed. Concentrations in Lebanon were higher, concentrations in Peru lower and those in Russia were similar, In two instances concentrations of lead in white paint in Russia and Egypt, countries where the brands were based, contained concentrations below detection while the concentrations were 2000 ppm or higher in other countries, Lebanon and Kazakhstan. A US-affiliated brand of paint (Dutch Boy) purchased in Lebanon that contained high concentration in two of three paint colors analyzed contained high concentrations in these colors in a follow-up testing. The labels on the paint cans purchased on each occasion indicated that the paint was “lead-free”. Concentrations of lead in paints manufactured more recently than those analyzed in this study may be different than those reported herein.

5. Conclusions

In the first known analysis of lead in new decorative paint purchased in Lebanon, Paraguay and Russia, the average total lead concentration in the paints ranged from 93-times (Russia) to 537-times (Lebanon) the regulatory limit of 90 ppm in the United States and Canada. The maximum concentrations found were 236,000 ppm in Lebanon, 169,000 ppm in Paraguay and 52,900 ppm in Russia. The percent of paints that contained exceedingly high concentrations of lead (> =10,000 ppm) ranged from 19% in Russia to 53% in Lebanon. Two of the paint samples from a US-affiliated paint brand (Dutch Boy- Sherwin Williams) purchased in Lebanon, in cans labeled “lead-free”, contained high lead concentrations (1360 ppm and 66,000 ppm). In contrast, paints purchased in Paraguay from a related US-based brand (Novacor- Sherwin Williams) concentrations below detection. Three of the five brands of paint from Paraguay had below detection concentrations in all of their paints tested. The two other brands each had high concentrations on two of their three samples. Paint from one of these brands was produced under license from ICI, a company based in the Netherlands which has been found in other countries to have very low lead paint. Paints from six of the seven brands sampled in Russia had high concentrations of lead in their paints. The highest average concentrations were detected in two of the brands with high market share. Concentrations of lead in yellow and red paints were much higher than those in white paints. Fifty-five (57) % and fifty-seven (55) of the yellow and red paints, respectively, contained greater than 10,000 ppm lead. The percentage of paints that contained exceedingly high lead concentrations (> =10,000 ppm) was 53% in Lebanon and 20% and 19% in Paraguay and Russia, respectively. For 11 of the total of 17 brands tested, including at least one brand from each country, one or more of their paints had a concentration less than 90 ppm indicating that technology was already being used within each of these countries to produce paint for the public without the addition of lead compounds. There is thus no practical reason why all paints in these countries cannot be produced without use of lead compounds. In order to protect the health of

present and future generations of children and others in each of these countries there is an urgent need to enact enforceable regulations to limit the concentration of lead in paints.

Acknowledgments

Financial support was provided by the International POPs Elimination Network (IPEN), a non-profit public interest organization. It was conducted with the cooperation of IPEN member organizations and their staffs: (IndyACT in Lebanon, Alter Vida in Paraguay, and Eco-Accord in Russia) and with the University of Cincinnati. The authors want to specifically express their appreciation to the following individuals for their support in conducting this study: Jack Weinberg, Jennifer Federico, and Bjorn Beeler of IPEN; Fernando Bajarano of RAPAM (Mexico) and IPEN; Antonia Weishaupt and Michele Matta of IndyACT, Mario Paredes of Alter Vida; Olga Ponizova of EcoAccord and David Binstock of RTI International.

References

Adebamowo, E.O., Clark, C.S., Roda, S., Agbede, O.A., Sridhar, M.K.C., Adebamowo, C. A., 2007. Lead content of dried films of domestic paint currently sold in Nigeria. Sci. Total Environ. 388, 116–120.

Berne, R., Rajankar, P., Sah, R., Hossain, S., 2011. Double Standard: Investigating Lead (Pb) Content In Leading Enamel Paint Brands in South Asia, Toxics Link (India).

Bornschein, R.L., Succop, P., Dietrich, K.N., Clark, C.S., Que Hee, S., Hammond, P.B., 1985. The influence of social and environmental factors on dust lead, hand lead, and blood lead levels in young children. Environ. Res. 38, 108–118.

Brazilian Federal Law, 2008. 11.762, dated August 1, 2008. Canada, Health 2011. Order Amending Schedule I to the Hazardous Products Act Surface Coatings Materials. SOR/2010-224. Canada Gazette. 2010; 44 (23).

Cecil, K.M., Brubaker, C.J., Adler, C.M., Dietrich, K.N., Altaye, M., Egelhoff, J.C., Wessel, S., Elangovan, I., Hornung, R., Jarvis, K., Lanphear, B.P., 2008. Decreased brain volume in adults with childhood lead exposure. PLoS Med. 5 (5), e112. http://dx.doi.org/10.1371/journal.pmed.0050112 2008 May 27.

Centers for Disease Control and Prevention (CDC), 2012. CDC Response to Advisory Committee on Childhood Lead Poisoning Prevention Recommendations in "Low Level Lead Exposure Harms Children: A Renewed Call of Primary Prevention". ⟨http://www.cdc.gov/nceh/lead/acclpp/cdc_response_lead_exposure_recs.pdf⟩.

Clark, S., Bornschein, R., Succop, P., Roda, S., Peace, B., 1991. Urban lead exposures of children in Cincinnati, Ohio. Chem. Speciat. Bioavail. 3 (3/4), 163–171.

Clark, C.S., Kumar, A., Mohapatra, P., Rajankar, P., Nycz, Z., Hambartsumyan, A., Astanina, L., Roda, S., Lind, C., Menrath, M., Peng, H., 2014a. Examination of lead concentrations in new decorative enamel paints in four countries with different histories of activity in lead paint regulation. Environ. Res. 132, 233–243.

Clark, C.S., Menrath, W., Zakaria, Y., El-Safty, A., Roda, S.M., Lind, C., Elsayed, E., Peng, H., 2014b. Follow-up on high lead concentrations in new decorative enamel paints available in Egypt. Environ. Pollut. 3, 33–40.

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

Clark, C.S., Rampal, K.G., Thuppil, V., Roda, S.M., Succop, P., Menrath, W., Chen, C.K., Adebamowo, E.O., Agbede, O.A., Sridhar, M.C., Adebamowo, C.A., Zakaria, Y., El-Safty, A., Shinde, R.M., Yu, J., 2009. Lead levels in new enamel household paints from Asia, Africa and South America. Environ. Res. 109, 930–936.

Clark, C.S., Thuppil, V., Clark, R., Sinha, S., Menezes, G., D'Souza, H., Nayak, N., Kuruvilla, A., Law, T., Dave, P., Shah, S., 2005. Lead in paints and soil in Karnataka and Gujarat, India. J. Occup. Environ. Hyg. 2, 38–44.

Consumer Product Safety Improvement Act (CPSIA) of 2008, Public Law 110-314, August 11. Washington, DC.

Dietrich, K.N., Ris, M.D., Succop, P.A., Berger, O.G., Bornschein, R.L., 2001. Early exposure to lead and juvenile delinquency. Neurotoxicol. Teratol. 23 (6), 511–518 2001 Nov–Dec.

Ewers, L., Clark, C.S., Peng, H., Roda, S.M., Menrath, B., Lind, C., Succop, P., 2011. Lead levels in new residential enamel paints in Taipei, Taiwan and comparison with those in Mainland China. Environ. Res. 111 (6), 757–760.

Gaitens, J.M., Dixon, S.L., Jacobs, D.E., Nagaraja, J., Strauss, W., Wilson, J.W., Ashley, P. J., 2009. U.S. children's exposure to residential dust lead, 1999-2004: II. The contribution of lead-contaminated dust to children's blood lead levels. Environ. Health Perspect. 117 (3), 468–474. http://dx.doi.org/10.1289/ehp.11917 (available at.

Gottesfeld, P., Kuepouo, G., Tetsopgang, S., Durand, K., S., 2013. Lead concentrations and labeling of new paint in Cameroon. J. Occup. Env. Hyg. 10, 243–249.

Gottesfeld, P., Pokhrel, D., Pokhrel, A.K., 2014. Lead in new paints in Nepal. Environ. Res. 132. http://dx.doi.org/10.1016/j.envres.2014.03.036, Epub 2014 Apr 16.

Health Canada, 2010. Order Amending Schedule I to the Hazardous Products Act, Surface Coating Materials. SOR/2010-224. Canada Gazette 144(23).

IPEN, Asian Lead Paint Elimination Project, 2013 ⟨http://www.ipen.org/projects/asia-project-2012-2015⟩ (accessed 25.09.13).

Jacobs, D.E., Clickner, R.P., Zhou, J.Y., Viet, S.M., Marker, D.A., Rogers, J.W., Zeldin, D. C., Broene, P., Friedman, W., 2002. The prevalence of lead-based paint hazards in U.S. housing. Environ. Health Perspect. 110, A509–A506.

Johnson, S., Salkia, N., Sahu, R., 2009. Lead in Paints, Centre for Science and Environment, PML/PR-34/2009, New Delhi India.

Kumar, A., 2007. A Brush with Toxics: An Investigation on Lead in Household Paints in India, Report by Toxics Link, New Delhi, India ⟨http://toxicslink.org/?q=content/brush-toxics-investigation-lead-household-paints-india⟩.

Kumar, A., Gottesfeld, P., 2009. Lead content in household paint in India. Sci. Total Environ. 407, 333–337.

Lin, G.Z., Peng, R.F., Chen, Q., Wu, Z.G., Du, L., 2008. Lead in housing paints: an existing source still not taken seriously for children lead poisoning in China. Environ. Res. 109, 1–5.

Mathee, A., Röllin, H., Levin, J., Naik, I., 2007. Lead in paint: three decades later and still a hazard for African children? Environ. Health Perspect. 115, 321–322.

Montgomery, M., Mathe, A., 2005. A preliminary study of residential paint lead concentration in Johannesburg. Environ. Res. 98, 279–283.

National Toxicology Program (NTP), 2012. NTP Monograph on Health Effects of Low-Level Lead. Research. National Institute of Environmental Health Sciences, Triangle Park, NC, National Toxicology Program.

Nepal, 2014. Government of Nepal, MOSTE, Lead in Paint Regulation Nepal Gazette, Khand 64, Number 30, dated 22 December 2014, Notice No. 3.

Nganga, C., Clark, S., Weinberg, J., 2012. Lead in Kenyan Household Paint. University of Cincinnati, Nairobi, Kenya, IPEN, September, 2012, iLima.

Philippines Department of Environment and Natural Resources DENR, 2013. Chemical Control Order (CCO) for Lead and Lead Compounds, 23 December 2013. ⟨http://goo.gl/07Z081⟩.

Rubin, C.H., Esteban, E., Reissman, D.B., Daly, W.R., Noonan, G.P., Karpati, A., Gurvitch, E., Kuzman, S.V., Privalova, L.I., Zukov, A., Zlepki, A., 2002. Concurrent evaluation of childhood lead exposure in Ekaterinburg, Krasnouralsk and Volgograd. Environ. Health Perspect. 110, 559–562.

Singapore National Environmental Agency (NEA), 2004. List of Controlled Hazardous Substances, Table 1. ⟨http://app2.nea.gov.sg/docs/default-source/anti-pollution-radiation-protection/chemical-pollution/hazardous-substances/hs–table-1(021012).pdf?sfvrsn=0⟩.

Sri Lanka Consumer Affairs Authority (CAA), 2011.Gazette Extra Ordinary No 1725/30, September 30, 2011.

Tikkurila. 2015a. ⟨http://www.tikkurilagroup.com/files/2400/20130815⟩ (accessed 07.01.15).

Tikkurila, 2015b, ⟨http://www.tikkurilagroup.com/brands/teks⟩ (accessed 07.01.15).

Toxics Link-IPEN Global Study, 2009. Lead in New Decorative Paints. (⟨http://www.ipen.org/ipenweb/documents/work%20documents/global_paintstudy.pdf⟩.

United Nations Environmental Program, 2013a. Global Alliance to Eliminate Lead Paint. ⟨http://www.unep.org/hazardoussubstances/hazardoussubstances/LeadCadmium/Prioriti esforAction/GAELP/tabid/6176/Default.aspx⟩ (accessed 25.09.13.).

United Nations Environmental Program, 2013b. UNEP, IPEN, Lead in Enamel Decorative Paints. National Paint Testing Results: A Nine Country Study, ⟨http://www.ipen.org/sites/default/files/documents/lead_in_enamel_decorative_paints-en.pdf⟩.

U.S. Environmental Protection Agency, 1991. Standard Operating Procedures for Lead in Paint by Hotplate or Microwave-based Acid Digestions and Atomic Absorption or Inductively Coupled Plasma Emission Spectroscopy, PB9 1991, EPA, 2–114172.

U.S. Environmental Protection Agency, 2008. TSCA Section 402/404 Lead-Based Paint Renovation Program: 40 CFR Part 745 Subpart E: Residential Property Renovation State, Territorial and Tribal Program Authorization Application Guidance: December 8, 2008. ⟨http://www2.epa.gov/lead/tsca-section-402404-lead-based-paint-renovation-program-40-cfr-part-745-subpart-e-residential⟩, (accessed 12.11.14).

U.S. Environmental Protection Agency, 2010. EPA Lead Certification. ⟨https://www.greenedu.com/epa-lead-rrp-overview⟩ (accessed 12.11.14).

U.S. Environmental Protection Agency, 2012. America's Children and the Environment, 41 Third ed., EPA 240-R-13-001, January 2013. ⟨http://www.epa.gov/ace/pdfs/ACE3_2013.pdf⟩.

Uruguay National Environment Office (NEO), 2011. Ministry of Housing, Land Use Management and Environment, Decree 069/2011 Lead content in Paint, (approved 15.02.11).

Van Alphen, M., 1999. "Lead in Paints and Water in India", pgs. 265-272, in Lead Poisoning Prevention & Treatment: Implementing a National Program in Developing Countries In: George, A.M. (Ed.), 1999. The George Foundation, Bangalore, India.

World Health Organization (WHO), 2010. Childhood Lead Poisoning, Childhood Lead Poisoning. World Health Organization, Geneva.