CURRENT STATUS AND FUTURE OF LEAD-BASED PAINTS AND PIGMENTS IN ASIA AND THE PACIFIC

-INTERIM REPORT-

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PURPOSE

This research is based on a contract between the United Nations Environmental Programme Regional Office for Asia and the Pacific (UNEP-ROAP) and National Institute of Advanced Industrial Science and Technology (AIST). It is to review the state of the art of existing national legal, regulatory, institutional and technical frameworks that relate to the global objective of eliminating lead paint by liaising with Asian and the Pacific countries. This analysis takes into account the overarching international commitment, lead by the Global Alliance to Eliminate Lead in Paint (GAELP), to "[…] *ensure that by 2020 all chemicals are used and produced in ways that minimize adverse effects on human health and the environment*," (GAELP2 draft report, para. 11).

The report also touches on the existence of lead in children's toys, which is one main objective of GAELP. The United Nations' Resolution II/4 of the International Conference on Chemicals Management recognises the need for attention to be given to issues relating to the sound management of chemicals and in that context resolution II/4/B focuses attention on "lead in paint" as an emerging policy issue.

Although the project needs to cover the above-mentioned subjects in Asia and the Pacific countries, largely due to both the scarcity of information and the time constraint, this interim report focuses on the result which was derived from information in Japan, and consequently, it mainly describes the past and present status of Japanese paint industry.

METHOD

AIST undertook a desk-based study as the first phase of this research. The aim of the desk study is (1) to briefly review the risk study on lead, (2) to identify major lead compounds for paints, (3) to identify key players in Japan's paint industry, and (4) to draw statistics of lead-based paints in Japan. In addition to the said study, the authors applied substance flow analysis (SFA) for estimating the amount of stock/waste in Japanese market for a period between 2000 and 2030.

BACKGROUND

Global Alliance to Eliminate Lead in Paint (GAELP)

This desk report provides a detailed analysis of some countries in Asia and the Pacific on lead in paint and their progress made towards achieving the global goal under GAELP.

GAELP's specific objectives include:

(a) To raise the awareness of government authorities and regulators, the private sector, manufacturers, consumers, workers, trade unions and health-care providers about the toxicity of lead in paints and the availability of technically superior and safer alternatives;

(b) To catalyse the design and implementation of appropriate prevention-based programmes to reduce and eliminate risks from the use of lead paints and products coated with lead paints;

(c) To help identify paint manufacturers and formulators that continue to produce and market paints containing lead so as to foster actions to phase out lead from their products;

(d) To promote the establishment of appropriate national regulatory frameworks to stop the manufacture, import, export, sale and use of lead paints and products coated with lead paints;

(e) As appropriate, to promote international third-party certification of new paint products to help consumers to recognize paint and coatings without added lead; and

(f) To share guidance and promote assistance to identify and reduce potential lead exposure in and around housing, childcare facilities and schools in which paint containing lead and paint dust is present and in industrial facilities producing or using paint containing lead to reduce workers' lead exposure

These objectives support to achieve the goal of eliminating lead in paint by the year 2020-fomulated under GAELP- linking to the business strategy of GAELP and taking into account the international commitment for sound chemicals management and the need for "[…] individual project targets that can realistically be completed in advance of 2020" to fulfill the commitment. GAELP's business approach is to mobilize this significant action by focusing on:

(a) Mobilizing stakeholders around a common yet flexible voluntary agenda, focusing on priority actions first;

(b) Facilitating stakeholder interactions in order to strengthen and complement existing initiatives and reduce duplication;

(c) Identifying and supporting specific opportunities where involvement of stakeholders from diverse stakeholder groups is necessary or where a vacuum of activities is identified;

(d) Encouraging companies to substitute lead compounds added to paint with safer alternatives; and

(e) Evaluating the Alliance's success and refining it's strategies as necessary.

GAELP's roadmap sets out the approach to pursue the goal of 2020 by focusing on five focal areas to undertake those focused tasks, which are health aspects; environmental aspects; workers health; legislation and regulation; and outreach to industry. The Global Alliance has further put forward indicators to measure the progress of developments towards 2020 (details can be found in the GAELP Business Plan, VII.).

In relation to GAELP's objectives especially on health aspects and worker's exposure, this desk report provides a detailed analysis of the Japan case on actions taken by the government and the industry to subsequently reduce the use of lead in paint. This Japan case could provide an example for other countries in the Asia and Pacific region to take similar measures in their national context.

OBSERVATION

Risk

General risk of lead is well described and comprehensive reports were published by scientific institutes time to time. For example, the National Institute of Advanced Industrial Science and Technology published a report "AIST Risk Assessment Document Series No. 3, Lead" in 2007, and it is now available free online, http://unit.aist.go.jp/riss/crm/mainmenu/e_1-13.html

Lead-based paint and lead-contaminated dust in older buildings are the most common sources of lead poisoning in children. Other sources include contaminated air, water and soil. Adults who work with batteries, home renovations or in auto repair shops also may be exposed to lead. Fig. 1 shows an example of possible lead poisoning among workers in Thailand who use paint in their factory.

Compounds

Conventional material

Between paint producers and shops, lead is not traded as simple lead but in different forms of compound. Thus in order to formulate effective plans of elimination, it is imperative to identify which compound is major in usage of pigments and paints production. Table 1 shows representative lead compounds which are commonly used in the paint industry.

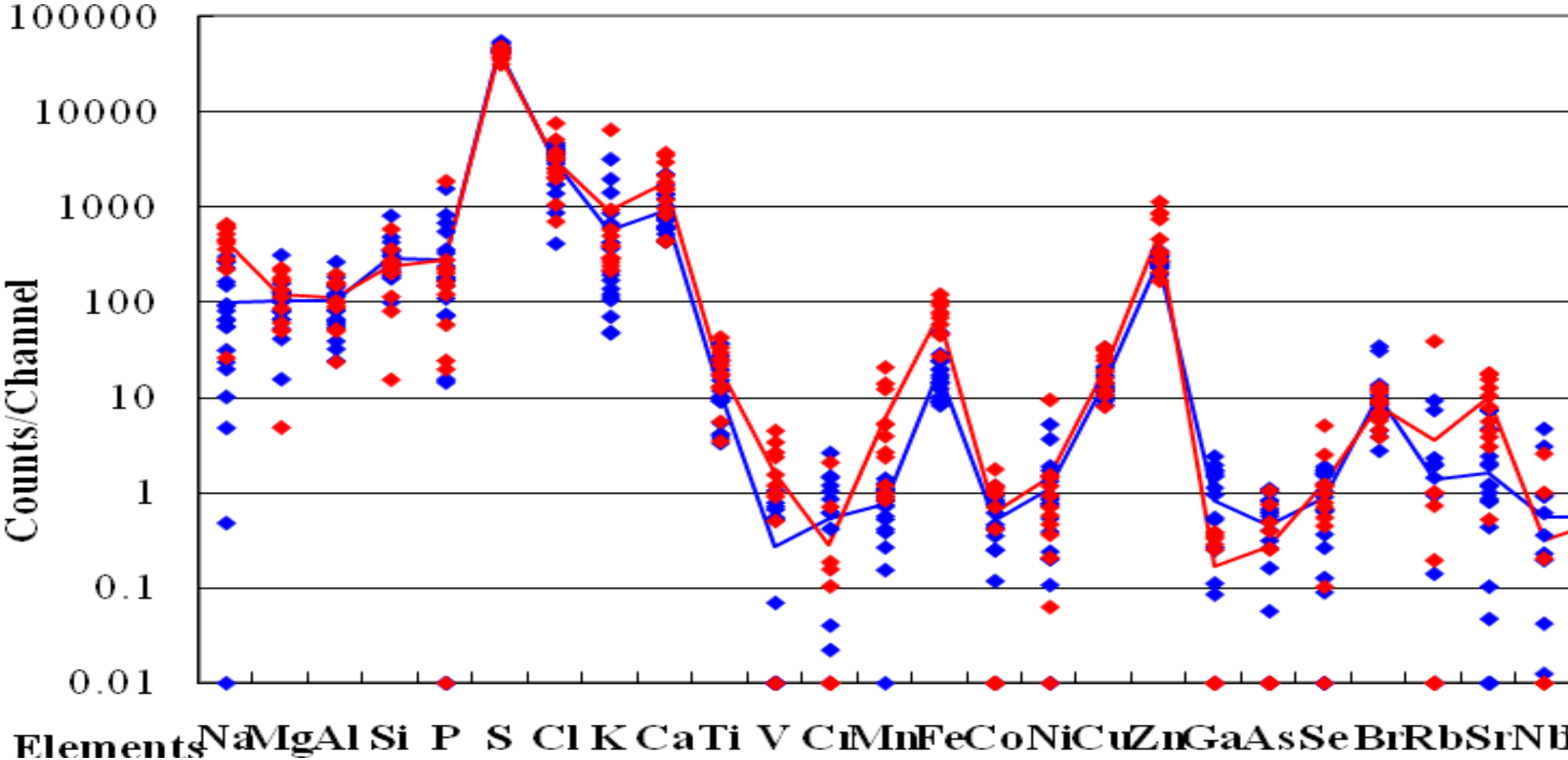


Figure 1. Hair analysis of Thai citizens by PIXE. Red dots indicate data for local people while blue shows control in Bangkok. *Analyst: Dr Koichiro Sera, Iwate Medical*

University.

- Chrome yellow: $PbCrO_4$
- Molybdenum red (chrome vermilion): $PbCrO_4 \cdot nPbMoO_4 \cdot mPbSO_4 \cdot x\ Al(OH)_3$
- Red lead: Pb_3O_4
- Litharge: PbO
- White lead: $2PbCO_3 \cdot Pb(OH)_2$

Table 1. Major lead compounds used for pigments and paints

Chrome yellow is relatively inexpensive yellow pigment with high covering power but it tends to be oxidised and darkened on exposure to air over time. It has been largely replaced by another pigment, cadmium yellow.

Molybdenum red (chrome vermilion) is lead chromate molybdate sulfate. It has the bright red colour, strong tinting strength, well heat resistance and well light resistance.

Red lead is a bright red to orange-red powder. A paint made with red lead is commonly used to protect iron and steel from rusting.

Litharge is lead mono-oxide. It is a yellowish/reddish, odorless, heavy, earthy, and water-insoluble solid; and is found in nature as secondary product of lead (galena) deposit.

White lead is a complex chemical compound, containing both a carbonate and a hydroxide portion. It has opaque quality and the satiny smooth mixture. This compound made a good pigment but due to the social concern that the pigment causes lead poisoning its use has been banned in most countries. As early as 1922, the third International Labour Conference of the League of Nations recommended the ban for interior use.

New materials

Various kinds of lead-free electrocoat are being developed by companies especially for automotive purpose. This is partly in response to the social concern and partly to the ELV (End of Life Vehicle) under which EU countries require the lead content of the registered vehicles lower than 1000ppm.

Material	Test 1	Test 2	Test 3	Test 4
Aluminium triphosphate	20.6	20.6	5.2	30.0
Silicon oxide	20.6	20.6	30.0	5.2
Titanium dioxide	26.8	26.8	26.8	26.8
Carbon black	1.0	1.0	1.0	1.0
Kaoline	31.0	31.0	37.0	37.0

Table 2. Pigment composition in weight percent for the Patent No. 4204353

When they invent new paints, it is imperative for engineers to achieve functionality of anticorrosion and opacity as high as lead-based paint. Acceptable products are already available for vehicles, electronics, furniture, ornaments and anti-fouling paint for ship bottom. For example, Japan's Patent No. 4204353 shows a material which contains aluminum phosphate as pigment (Table 2). Japanese car manufactures started to use such electrocoat around 1998 and now they eliminated all of the lead paints for both under coat and top coat.

Further research remains for the strict use of paints such as aeronautical beacon. Kitabatake (2003) stated that, for the time being, lead-based paint is the only option for aeronautical red and yellow at Japanese airports which must satisfy national standard JIS W 8301.

JAPAN'S CASE

Actions taken by the industry and government

In 1978, the US government restricted lead content in paint after determining that people were being poisoned by environmental exposures to this element. However not many actions have been recorded in Asia and the Pacific. In this report, Japan's experience is described as a possible model of lead elimination in Asia.

In Japan, lead is regulated by environmental rules such as *Environment Basic Law* (Table 3). These are to sustain the natural environment and most of the laws define the norm to keep the lead content low enough in air, water and soil.

Laws in table 2 are not effective to control industrial activities at upper and middle stream, i.e. production, disposition and waste management. But during the 1990s, the global society came to attention about the risk of lead use in industries. For example, OECD started chemical risk reduction project, with lead as one of the top five

candidates for reduction efforts.

· Environment Basic Law
· Agricultural Land Soil Pollution Prevention Law*
· Air Pollution Control Law
· Sewerage Water Law
· Water Pollution Control Law
· Soil Contamination Countermeasures Law

*It does not target lead.

Table 3. Example of Japanese national laws to protect the natural environment

In such circumstances, Japanese paint industry decided to voluntarily study the risk of lead and the countermeasures. In 1992, their association called Japan Paint Manufactures Association (JPMA) declared for "Risk Reduction on Lead". It was to promote risk reduction for lead and not to use lead for (1) products to which infants and expecting mothers may be exposed; and (2) products which may contact with water and food.

After the *Miami Declaration* in 1997, Japan as a G8 Member strengthened the administration (1) to develop and share individual country actions to accomplish the goals of the OECD Declaration on lead; (2) to establish principal points of contact and a mechanism for sharing timely information regarding lead hazards in toys and other products to which children might be exposed, including imported products; (3) to provide access to new technological developments on blood lead level testing.

The most influential rule to the industry was enacted in 2000 and was put in force in 2001: *Law Concerning the Promotion of Procurement of Eco-Friendly Goods and Services by the State and Other Entities* (Ministry of the Environment, 2000). It intends to shift the society in demand towards eco-friendly goods, and encourages the national organizations, state agencies, and local governments to procure eco-friendly goods.

In 2002, Tokyo Metropolitan Government announced a guideline of lead paints for the sake of children. According to this guideline, every specification of public work in the metropolitan area requests the usage of lead-free paint. Because of the vast size of the

metropolitan market, the industry was forced to develop lead-free paints.

In 2003 in November, JPMA adopted a volunteer standard JISK5674 (lead and chromium free anticorrosive paint). In 2007, *JPMA Standard Paint Colors Version D* excluded all lead-based paints.

With respect to tableware and toys, Japan regulates the safety through the *Food Sanitation Act.* In 2008, Ministry of Health, Labour and Welfare amended the *Ordinance for Enforcement of the Food Sanitation Act* and *Standards and criteria for food and food additives, etc.* which are under the said act by setting up new numbers of lead limit for tableware and toys.

The ministry's Department of Food Safety circulated the document No.0731001 to each prefect and mayor to ensure that its new norm of lead in the *Standards and criteria for food and food additives, etc.* be strictly enforced for tableware. The porcelain industry follows the standard well keeping the product safe. Some companies are voluntarily eliminating lead-based glaze. For example, *Touan Co., Ltd*. developed lead-free glazes which do not spoil artistic charm of the product (Kyoto Industry Support Center, 2011). The Department also issued a circular No.03310007 to reaffirm the change in toys regulation.

In 2012, a specific guideline to enforce the *Law Concerning the Promotion of Procurement of Eco-Friendly Goods and Services by the State and Other Entities* was proclaimed by the Cabinet. It determines that primer (under coat) should be lead- and chromium-free when used in public constructions (Cabinet of Japan, 2012).

Time-series analysis

Substance flow analysis

In order to estimate the amount of stock in the market or waste, we applied substance flow analysis (SFA). In SFA, the Weibull distribution function, which explains the lifetime distribution of durable goods, is often used. The ratio that a product used for y years is disposed at the end of year t is represented by the cumulative distribution function (here, $W_t(y)$ stands for the ratio), $W_t(y)$ is expressed by the following formula.

$$W_t(y) = 1 - \exp[-(\frac{y}{y_t})^b * \{\Gamma(1+\frac{1}{b})\}^b] \qquad \text{(Formula 1)}$$

Here, $\overline{y_t}$ is the average life period, Γ is the gamma function, and *b* is a parameter indicating the range of the distribution of period of use. $\overline{y_t}$ is specific to a use category and as for paint, it is assumed to be 5 years (i.e. an average of 2.5 years for consumer use and 7.5 years for construction use. *b* is assumed to be 3.5.

Using the above formula, the ratio of the amount of domestic supply in an arbitrary year to the disposed amount in year of interest is calculated. Then, the disposed amount in year of interest is estimated by multiplying the amount of domestic supply in the year and the ratio. The amounts of stock are obtained by subtracting the cumulative amount disposed from the cumulative amount supplied.

- International Lead and Zinc Study Group
- Japan Inorganic Chemical Industry Association
- Japan Oil, Gas and Metals National Corporation
- Japan Paint Manufacturers Association
- *Kouzan* journal
- *Lead & Zinc* journal
- Metal Economics Research Institute, Japan
- Minerals Yearbook Are Reports: International 2005 Asia and the Pacific Vol.III, USGS.
- Monthly Report of Chemical Industry Statistics
- Yearbook of Iron, Steel, Non-ferrous Metals, and Fabricated Metals Statistics, METI.
- Yearbook of Mineral Resources and Petroleum Products Statistics, METI.

Table4. Major information source on quantity of paint materials traded in Japan

Data

Our investigation has revealed that the number of information source (Table 4) on paint industry is small, the information is scarce, and the same information is often duplicated in publications.

As for domestic supply (Table 5), statistical data for amount of Pb as sum of industrial inorganic chemicals is available from 1970 to 2010 in Japan. Data of Pb amount used for lead paint is available only in 2002. Thus we used a ratio of Pb amount used for lead

paint to um of industrial inorganic chemicals for estimation of Pb for paint. Here we assumed this ratio was constant from 1970 to 2010. The ratio was 6.7% in 2002.

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Chemicals [1]	38,300	29,300	20,100	20,600	25,700	19,400					
Industrial inorganic chemicals [2]		27,186	20,610	22,085	22,972	15,671	11,940	10,389	5,742	5,451	4,610
Pigments and paints*		1,821	1,381	1,480	1,539	1,050	800	696	385	365	309

* Proportional distribution based on the data in 2002; [1] ILZSG (2008); [2] Kouzan (2011) Vol.64, No.7, p.94.

Table 5. Lead amount used to produce pigments in Japan

Results

Figure 2 shows a time-series amount of Pb paint, for both production and waste in Japan. As for wastes, a delay (time-lag) is shown compared to the time of sale of the produced paint. The figure further shows the progress towards 2020 as set out by the Global Alliance to Eliminate Lead in Paint (GAELP).

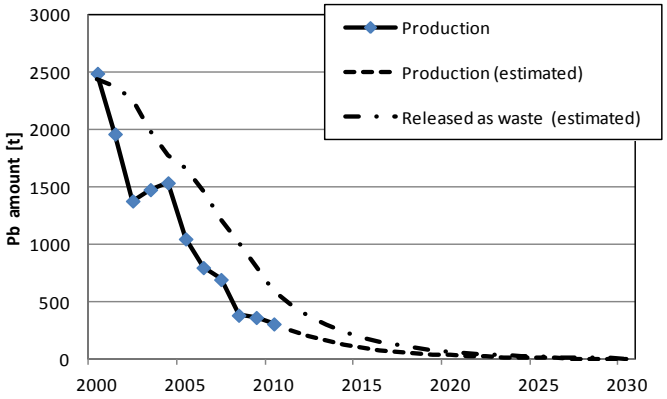
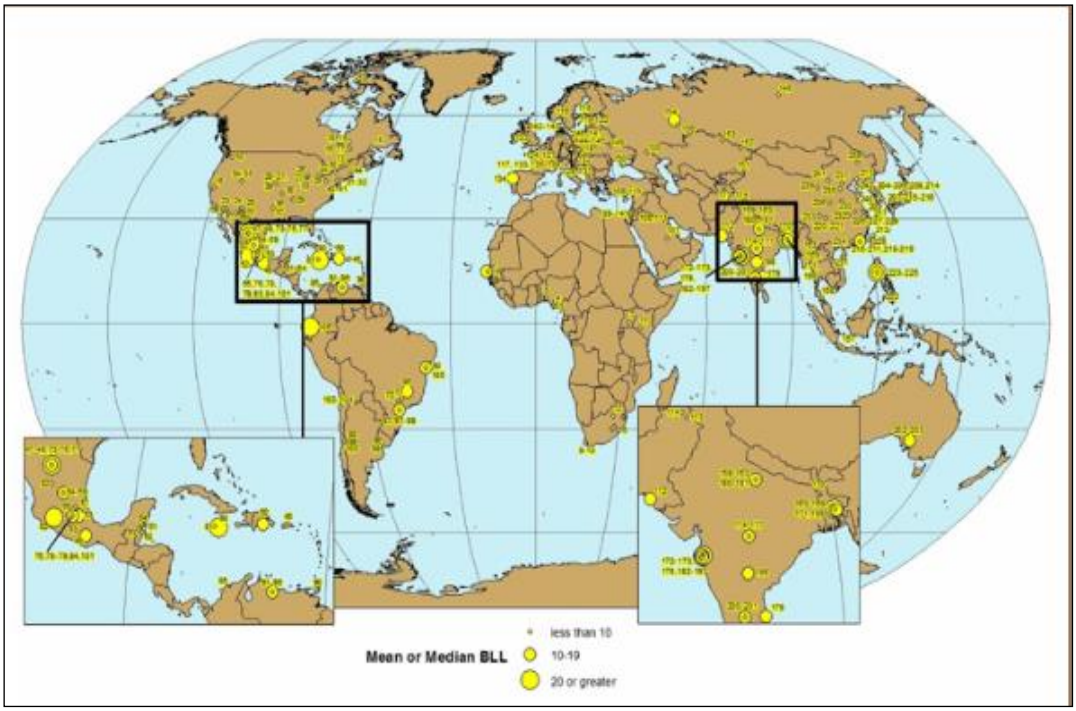


Figure 2. Current and future trend of lead-based paint (production and waste) in Japan

OTHER COUNTRIES

Contrasting trend

Statistics on production, trade and waste of lead-based paint is scarce in Asia and the Pacific. In 2011, Clune, Falk and Riederer mapped the global environmental lead poisoning in children, which within the Asia Pacific region identified South Asia as the subregion with the highest blood lead levels in children (see map below).



Map 1: Global Environmental Lead Poisoning in Children (source: Clune A, Falk H, Riederer A. Mapping Global Environmental Lead Poisoning in Children. Journal of Health & Pollution . Vol. 1, No. 2 Nov 2011)

A general trend can be drawn from sporadically disclosed information that at least two groups of countries are identified in the Asia Pacific region, one that is already eliminating lead and the other group is not yet. For example, Table 6 shows that Korea has been reducing the use of lead in paints over the years indicated. On the other hand, India and Thailand indicate stable levels of consumption of lead compounds and this fact implies that they still use lead-based paint.

Year	2000	2001	2002	2003	2004	2005	2006
India	13,100	11,500	11,800	12,700	13,500	12,800	-
Korea	21,400	10,500	20,300	21,200	4,100	3,300	3,000
Korea (pigment*)	9,452	4,638	8,966	9,363	1,811	1,458	1,325
Thailand	15,400	14,300	18,200	19,600	19,400	18,100	-

-: not available; *Proportional calculation but for 2006.

Table 6: Use of lead for pigments and chemical compounds in India, Korea and Thailand (International Lead and Zinc Study Group, 2008; for Korea in 2006, the number is based on interview to chemical companies)

Table 7 shows various Asia Pacific countries that still use lead for their products.

Country	Residential	Industrial	Toys	Jewellery	Consumers products	Others
India	Y	Y	Y	NA	NA	NA
Myanmar	Y	Y	Y	NA	Y	NA
Nepal	Y	Y	Y	Y	Y	Y
Philippines	Y	Y	Y	Y	Y	Y
Solomon Is.	N	N	N	N	Y	Y
Sri Lanka	Y	Y	NA	NA	NA	NA
Thailand	Y	Y	Y	Y	Y	NA
Vietnam	Y	Y	Y	Y	Y	NA
Iran	NA	NA	Y	NA	NA	NA
Percentage of YES	**78%**	**78%**	**78%**	**44%**	**67%**	**33%**

Y: yeas; NA: information not available

Table 7 Existing use off lead paint

(source: country presentations at the 2nd GAELP presentation by Mendoza, June 2012/Bangkok)

National legislation

One of the targets under the business plan of GAELP refers to the existing national legislation on lead in paint and specifies to have 30 countries with national legislations by 2013 aiming to more than double this target to 70 countries by 2015 and to achieve global coverage by 2020. In reference to that target it can be said that five out of eight Asia Pacific countries participating in the second GAELP Meeting do have or will soon have national legislations (see Table 10 below).

Country	Presence of Legisla-tion	Application of legislation to existing uses	Existing Underdeveloped
India	YES	BHDT standards on paint	Discussion stage
Myanmar	YES	Residential Paint Industrial Paint	YES, just upon receipt of survey
Nepal	No	NOT APPLICABLE	YES
Philippines	YES	DENR AO 2007-23,	Draft CCO for lead & lead

		DOH-BHDT AO 2007-0032 DOH-BHDT 2009-0005 B	Compounds and HB no. 1669 on Regulating Children Toys
Solomon Islands	No	NOT APPLICABLE	Unknown
Sri Lanka	YES	Consumer Affairs Authority, Government Gazette Extra Ordinary No. 1725/30 On September 30, 2011	To be effected from 1st of January, 2013
Thailand	Unknown	NOT APPLICABLE	NOT APPLICABLE
Vietnam	YES	Yes - very old and needs amendment	Umbrella master plan/strategy in process

Table 10: Overview of existing national legislation in selected Asia Pacific countries (source: country presentations at the second GAELP Meeting in Bangkok, June 2012)

Present status

Bangladesh

The regulation of lead-based paints is quite lax with Bangladesh because of the lack of legal mechanism. Environment and Social Development Organization of Bangladesh (ESDO) tested paints and found that products from 24 out of 29 companies exited the permitted level (ESDO, 2010). Toxics Link (2011) even indicated 121,900ppm for a product that is sold in Bangladesh.

India

India does not have mandatory regulation for lead limits in paints, but volunteer scheme called *Eco Mark* exists. In this scheme, it is suggested that lead should be less than 0.1% in certain types of paints.

Kumar and Gottesfeld (2008) reported that 84% of enamel paint samples had lead concentration in excess of 600ppm. They also found that except one brand (ICI Dulux), enamel paint samples of all other brands had lead concentration above 600ppm.

In 2009, an NGO Centre for Science and Environment published a result of a test for Indian paints to see the quantity of lead in them. Lead was found in 23 of the 25 enamel paint samples that were randomly purchased for this study. Of these 72 per cent of the samples did not meet the voluntary specification for lead content prescribed by Bureau of Indian Standards (Dutta et al., 2009).

Nepal

There is no regulatory mechanism to restrict the lead concentration in paints in Nepal. Consequently lead-based paints are sold nationwide. But *Lead Paint Elimination Campaign in Nepal* is being conducted by the Center for Public Health and Environmental Development with high-level government engagement: Hon. Minister of Environment call for enacting stringent standard to regulate lead in paint. Multinational paint industries are making improvements in terms of lead content, labeling and commitments.

Under this campaign, awareness level was raised and information was made accessible through different means (radio, TV, News, interaction, workshops). Industries are showing great concern and making shift now. The campaign will be continuing through a program with *EU SWITCH ASIA LEAD PAINT ELIMINATION* project.

Philippines

The Philippino Government identifies lead as one of the priority chemicals that should be regulated. However, there is no standard set out by the Government for paints and pigments.

According to the presentation at the 2nd GAELP meeting, the Philippines Department of Environment and Natural Resources distributed inquiries to the paint industry and 72.7% of manufacturing members replied. Regarding lead content of the paints, the result showed that (1) 56% of manufacturers still used lead; (2) 87.5% do so with company direction; (3) 87.5% limit the use of lead to below 90 ppm; (4) 68.8% are ready to comply, 31.3% not ready to comply, and 6.3% are not applicable. Also 75% requested a period of 2-5 years to eliminate lead in paint from their production processes. In addition, 18.8% of manufacturers stated they could be ready in less than 2 years.

The leading paint company in the Philippines, Pacific Paint Philippines Inc. (Boysen) already announced that all paint products coming out of its factories, whether water or oil-based, were lead free. The company voluntarily phased out its last lead-containing product *Red Lead Primer* in 2007.

Singapore

Singapore has a standard of 0.06% of lead in new paints. But Clark et al. (2009)

indicated that paint companies sampled in Singapore tend to have high lead concentrations (median concentration of 5,330 ppm, maximum of 75,600 ppm)

Sri Lanka

It is noteworthy that Sri Lanka has introduced lead in paint standards. Its Consumer Affairs Authority published a Gazette order on September 30, 2011 regulating permissible maximum lead content on paints and accessories. It shall come into force from January 1, 2013.

- ✧ Paints for Toys and Accessories for Children (soluble in HCI acid) 90 mg/kg
- ✧ Enamel Paints 600 mg/kg
- ✧ Emulsion Paints for Exterior use 90 mg/kg
- ✧ Emulsion Paints for Interior use 90 mg/kg
- ✧ Floor Paints 600 mg/kg

Table 8 Permissible maximum lead content in Sri Lanka

Thailand

Thailand's paint industry can be classified into decorative and industrial segments with the latter dominating the former. For decorative paints, the country has a series of product standards for lead, but they are voluntary by nature (Table 9). Up to now thirteen paint companies, who cover 198 decorative paint products already got the green label certificates from Thailand's Environment Institute.

Unleaded paints have been first launched in Thailand by TOA Paint over 15 years ago. Since then, the unleaded paints have been the selling point of many paint companies. Now, the lead chrome pigment in paint was largely replaced by organic pigments while the manganese and calcium driers were used instead of lead driers. Recently Jotan and Chugoku Paint have announced that all their marine paints are unleaded paints.

Standard number	Standard name	Pb concentration
TIS 272-2549	Emulsion paints for general purposes	<0.01% by weight of non volatile substances
TIS 1406-2540	Flat enamel	<0.06% by weight of non volatile

		substances
TIS 1005-2548	Standard for semi-gross enamel	<0.06% by weight of non volatile substances

Table 9 Some voluntary standards to limit lead in decorative paints in Thailand

In Thailand, the increase in consumer and producers' awareness of the dangers of lead in paint has resulted in an increased consumer demand for unleaded paints and consequently, in a shift in production and supply by the Thai paint industry. This resembles the importance of awareness education and the power of consumers to substantially contribute to shifting to lead-free paints.

In early 2012, Thai Paint Manufacturers Association distributed a questionnaire to the members, whether the governmental ban of lead in decorative materials is acceptable. There was no objection, and an official letter of consent was sent out to the Ministry of Industry through the Federation of Thai Industries.

Vietnam

Vietnam is becoming the home of increased technological ventures and people's health challenges are expected to increase unless protection guidelines are implemented and enforced. Already lead poisoning is reported both for adults (Luz, 2006) and children (Beaudet et al., 2011). In spite of such situation, the cause of the lead poisoning has not been clarified yet.

Islamic Republic of Iran

Iran currently has a non-compulsory legislation for lead in paint, but is the only country from the Middle East region to have legislation in place to protect and provide health care services to workers. The Environmental Protection Department of the Ministry of Health undertakes field research and upon detection of lead in consumer products awareness education programs on chronic lead toxicity and human health risks are conducted. Regarding health care services, treatment of already exposed children and adults is provided, but preventive health care programmes or structured legislation are both lacking. Iran faces severe challenges regarding the lack of data, information, knowledge on lead paint availability and awareness of health risks among public and respective officials is low.

FUTURE WORK

With respect to the children's exposure to lead, the concept and practice of risk management should be introduced in the Asia Pacific region. Risk assessment is done based on the information (1) what are hazards, (2) ways of uptake of the hazardous materials by people/animals, and (3) what is the amount of 'exposure'. The definition of exposure as used by the International Programme on Chemical Safety is "contact of an organism with a chemical or physical agent, quantified as the amount of chemical available at the exchange boundaries of the organism and available for absorption."

The process of a chemical entering the body can be described in two steps: contact (exposure) followed by entry (crossing the boundary). In the context of environmental risk assessment, risk to an individual or population can be represented as a continuum from the source through exposure to dose to effect.

U.S. Environmental Protection Agency (EPA) developed an approach to estimating soil and dust ingestion, i.e., using a probabilistic human-activity-based physical model called "SHEDS". This approach is to combine diary information on sequential time spent in different locations and activities from EPA's Consolidated Human Activity Database (CHAD) or its Child-Specific Exposure Factors Handbook, micro-activity data (e.g., hand-to-mouth frequency, hand-to-surface frequency), micro-environmental surface/object soil or dust loadings, and other exposure factors (e.g., soil to-skin adherence, saliva removal efficiency).

EPA utilizes videography of children in everyday activities indoors and outdoors. Also, frequency and type of contact with different surfaces, objects, and body parts are listed. It should be helpful to use such approach for more realistic estimation of child exposure to lead paint.

CONCLUDING REMARKS

Over the past 40 years, many countries have taken regulatory actions to reduce environmental and occupational exposures to lead, including the elimination of lead additives, such as tetraethyl lead, in gasoline, and restrictions on lead use in food cans, drinking water plumbing, glass or ceramic utensils and house paint.

However, preventive measures taken by countries in Asia and the Pacific have not been known much and the experiences not shared among the stakeholders. Further investigation including the site visits is necessary to capture clearer picture of the region.

Other severe challenges include lack and availability of data on lead exposure by various groups and lead in consumer goods, but also human and financial resources for relevant equipment and to conduct research.

As can be seen in Table 7, on average 75% of surveyed countries in Asia and the Pacific do still use lead in residential and industrial paints, toys and consumer goods. The high level of unavailability of data further corresponds to information provided by countries and the severe challenges elaborated above (see under "NA" in Table 7).

Finally, it should be stated that business ethics seem to be another challenge for producers and traders. There are suspicions that despite stipulating in contracts a required use of lead–free pigments in their paints, Chinese toy makers tend to use cheaper lead-based paints instead (Yanagida, 2008).

Recently, a power plant causing lead poisoning mostly in children in the neighboring communities (of more than 200mg blood lead level) and local authorities attempting to minimize the seriousness of the situation has ended in an uprising by the local Chinese residents and the power plant's operations were suspended. This may be taken as an indicator "[…] *that industrial development at any cost is no longer sustainable*".

Some recommendations to approach the challenge of eliminating lead in paint from various angles, i.e. environmental and health hazards, legislative approaches and outreach to paint manufacturers are given below. They are in line with recommendations made by countries, technical experts and international organizations at the second GAELP meeting and take into account that individual achievable targets will need to be developed to achieve the goal of eliminating lead by 2020 as set out under the business strategy of GAELP.

Recommendations include:

- Industries require technical assistance to help them eliminate lead paint step by step from their production processes and push for collaboration between industry and governments to come up with guidelines on suitable substitutes for the lead compounds used in paint manufacturing
- Acknowledge the unique dangers of exposure to lead hazards and lead dust to children and workers and target health and awareness programmes accordingly

- Increase consumer awareness in countries in Asia and the Pacific to shift consumer demand to lead-free paints and achieve change in supply and production (see TOA case in Thailand)
- Provide health rationale to industry, government, and other stakeholders to stimulate action and strengthen the public health aspects of lead paint legislation
- Develop a guideline for a regulatory framework to support governments' efforts in coming up with national legislations and regulations
- Develop a labelling system for paints as highlighted on various occasions by various countries during the second GAELP Meeting in Bangkok, June 2012
- Given the high level of exposure to lead due to their daily work environment, the health hazards faced by workers and migrant workers should be addressed adequately through targeted health programmes and considered a key point of focus when working towards the goal to eliminate lead in paint by 2020- the detailed Japan case in this desk report and measure taken by Japan could be further explored and taken as an example for action.

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