Introduction

Environmental health hazards caused by heavy metals exposure are a continued threat to human health, particularly in developing countries. There is increasing awareness of consumer products with high heavy metal content. Heavy metals such as lead, cadmium, arsenic and so on are constituents of pigments which are added to paint formulations to increase brightness and longevity. Paints and coatings play an indispensable role in household appliances, buildings, cars, ships, aeroplanes, computers, furniture, and circuit boards.

Lead (Pb) is a toxic heavy metal even at very low levels of human exposure. Lead can cause central nervous system damage and is an important disease-causing agent in terms of environmental contribution to the total global burden of disease as measured in disability adjusted life years. Lead can also damage the kidney, liver and reproductive system, basic cellular processes and brain function. Its effect on the human body can be both acute or chronic depending on dose and exposure scenarios. Toxic symptoms can include anemia, insomnia, headache, dizziness, irritability, muscle weakness, hallucination and renal damage. Lead accumulates in the skeleton and its mobilization from bones during pregnancy and lactation causes exposure to the fetus and breast fed infants.

Cadmium (Cd) is a major pollutant that causes a range of pathological alterations. It is used in various industrial activities. Major industrial applications of cadmium include the production of alloys, pigments, and batteries. Cadmium is a severe pulmonary and gastrointestinal irritant, and can be fatal if inhaled or ingested. It accumulates primarily in the kidneys and has a long biological half-life of 10–35 years in humans. The primary effect of cadmium is kidney damage and bone fragility. There is evidence that cadmium is carcinogenic through the inhalation route, and humans are exposed to cadmium by inhalation and ingestion.

Both Pb and Cd are widely distributed in the environment (air, soil, surface and ground water, sediment, dust, food, paint) and in biological systems; and occur both naturally and through human activities. Unlike organic contaminants, lead and cadmium are not biodegradable and tend to accumulate in living organisms. They are readily transferred through the
Several studies have been conducted on metals in consumer products. Cadmium has been analyzed in cosmetics and personal care products, toys, children's jewelry, and decorative paints. Global studies on lead in new decorative paints conducted by Toxic Link showed that 68.5% of the 232 enamel samples collected from eleven countries had lead concentrations above the 90 ppm permissible limit of the US Consumer Product Safety Commission and 64.6% of the samples had lead concentrations above 600 ppm, which is the previous permissible limit of the US Consumer Product Safety Commission and the regulatory standard of Argentina, Chile and Uruguay. In addition, a study by Clark et al. showed a total of 57 (73%) out of 78 new enamel household paints had at least one sample with a lead concentration above or equal to 600 ppm.

Various countries have initiated laws that regulate or ban the use of hazardous chemicals and substances in paint with varying degrees of compliance. There are regulations in place in Nigeria stipulating that paints should contain less than 90 ppm (dry weight) of total lead and 100 ppm of cadmium, but these limits have not been enforced. Thus, we conducted a survey of decorative paints currently sold in Nigeria using Lagos and Ibadan as case studies. We assessed the levels of lead and cadmium in water-based paints so as to ascertain the levels of exposure to these metals from paint products.

**Methods**

**Sample Collection**

Paint samples were purchased in popular paint markets in Ibadan and Lagos, Nigeria based on color availability and the most commonly used water-based paints. Two samples each of the same color produced by 14 different manufacturers were collected. Six manufacturers were registered with the Standards Organization of Nigeria (SON), and 8 manufacturers were unregistered. A total of 12 different paint colors were collected, as shown in Table 1. Samples were stored in air-tight plastic containers and analyzed at the Council of Scientific and Industrial Research-National Environmental Engineering Research Institute Laboratory, Nagpur—Maharashtra, India.

**Sample Preparation and Pre-treatment**

Approximately 5 mL of the paint samples were spread on glass slides using a different brush for each sample to avoid cross contamination. The glass slides were placed in an oven at 120°C for 2 hours. About 1.0 g each of the dried paint film was weighed into closed Teflon vessels and digested in a closed microwave digestion system using 10 mL of 70% nitric acid and 3 mL of 98% sulphuric acid. Samples were analyzed according to the standard procedures for digestion of very difficult samples. Digestates were then filtered and analyzed using inductively coupled plasma-optical emission spectrometry (Thermo Scientific iCAP 6300 Duo).

Sample blanks were also prepared alongside the samples. Dilutions were

| Sample Number | Manufacturer | Number of paint colours collected | Total number of paint samples collected | Standards Organization of Nigeria registration |
|---------------|-------------|----------------------------------|----------------------------------------|-----------------------------------------------|
| 1             | A           | 9                                | 18                                     | Yes                                           |
| 2             | B           | 10                               | 20                                     | Yes                                           |
| 3             | C           | 9                                | 18                                     | Yes                                           |
| 4             | D           | 5                                | 10                                     | Yes                                           |
| 5             | E           | 5                                | 10                                     | Yes                                           |
| 6             | F           | 6                                | 12                                     | Yes                                           |
| 7             | G           | 8                                | 16                                     | No                                            |
| 8             | H           | 5                                | 10                                     | No                                            |
| 9             | I           | 5                                | 10                                     | No                                            |
| 10            | J           | 7                                | 14                                     | No                                            |
| 11            | K           | 6                                | 12                                     | No                                            |
| 12            | L           | 4                                | 8                                      | No                                            |
| 13            | M           | 4                                | 8                                      | No                                            |
| 14            | N           | 4                                | 8                                      | No                                            |

| Manufacturer | Number of paint colours collected | Total number of paint samples collected | Standards Organization of Nigeria registration |
|--------------|----------------------------------|----------------------------------------|-----------------------------------------------|
| A            | 9                                | 18                                     | Yes                                           |
| B            | 10                               | 20                                     | Yes                                           |
| C            | 9                                | 18                                     | Yes                                           |
| D            | 5                                | 10                                     | Yes                                           |
| E            | 5                                | 10                                     | Yes                                           |
| F            | 6                                | 12                                     | Yes                                           |
| G            | 8                                | 16                                     | No                                            |
| H            | 5                                | 10                                     | No                                            |
| I            | 5                                | 10                                     | No                                            |
| J            | 7                                | 14                                     | No                                            |
| K            | 6                                | 12                                     | No                                            |
| L            | 4                                | 8                                      | No                                            |
| M            | 4                                | 8                                      | No                                            |
| N            | 4                                | 8                                      | No                                            |
performed when necessary for the samples. Working standard solutions of 1–1000 µg/g were prepared from a multi-element standard. A recovery study was carried out and recoveries of 80% for Pb and 110% for Cd were obtained.

**Instrument Operation Conditions**

**Digestion of Paint Samples**

A MARS 6 microwave reaction system was used for sample digestion. Samples were weighed into Teflon vessels and digested at 200°C, 25 mins ramp time, 30 mins holding time, and 1000 watt power in one cycle digestion. The temperature guard of the instrument was set to not exceed 210°C. Cooling was automatically carried out by the instrument to 30°C for another 30 minutes.

**Inductively Coupled Plasma Optical Emission Spectrometer**

Digested samples were analyzed using Thermo Fisher Scientific inductively coupled plasma optical emission spectrometry (model iCAP 6300 Duo) which was coupled with an auto sampler CETAC ASX-52, and spectrometer (Echelle type) equipped with a simultaneous charge injection device detector measuring wavelengths from 166.00 nm to 847.00 nm. The operating condition of ICP-OES was 1150 W RF power, 15 L/min plasma flow, 50 rpm pump rate, 0.5 L/min auxiliary gas flow, and 0.5 L/min nebulizer gas flow. The carrier gas of the instrument was ultra-pure argon.

**Results**

The levels of Cd and Pb in the paint samples collected in Lagos and Ibadan, Nigeria are presented in the Supplemental Material, while Table 2 shows a comparison of the concentrations of Pb in the paint samples obtained in this study with previous studies reported in the literature.

Concentrations of Lead and Cadmium in Paint Samples by Manufacturer

The levels of Cd and Pb (µg/g, dry weight) in all the samples ranged from 98 1999 and 170–3231, respectively (Supplemental Material). The highest mean concentration of Cd was 1946±75 µg/g obtained in paints produced by manufacturer C, a registered manufacturer. This was followed by 1877±22 and 1845±24 µg/g in products produced by manufacturer L (unregistered) and C, respectively, while the lowest concentration was 98.5±1 µg/g in paints produced by manufacturer K, an unregistered manufacturer. The highest mean concentration of Pb was obtained in paints produced by manufacturer H (3117±161 µg/g), an unregistered manufacturer. This was followed by manufacturer L (3013±16 µg/g) and (2121±19 µg/g) from the same manufacturer, while the lowest concentration, 173±4 µg/g, was found in paints produced by manufacturer K.

The order of metal concentrations in the paint samples with respect to manufacturers was:

- Cd: M > A > L > F > J > C > G > D > N > B > I > H > K; and
- Pb: L > N > A > M > H > I > C > E > G > J > B > K > D > F.

The lowest concentrations of Cd and Pb were found in paint samples produced by unregistered and registered manufacturers, respectively. The lowest mean Cd and Pb concentrations (98.5±1 µg/g and 186±1 µg/g) were found in products produced by manufacturers K and F, respectively.

Concentrations of Lead and Cadmium in Paint Samples by Color

The range of levels of Cd and Pb in all the paint samples with respect to color was 98–1999 µg/g in red color and 170 (green)–3231 µg/g (cream) (Supplemental Material), respectively. Variation in mean metal concentrations with respect to color is presented in Figure 1. The highest Cd concentration was in red paint (1999 µg/g), followed by green (1893 µg/g) and red (1893 µg/g) colored paint products. The highest Pb concentration was in cream colored paint (3231 µg/g) (S 1) produced by manufacturer H, followed by green (3024 µg/g) produced by manufacturer L and cream (3003 µg/g) (S 2) also produced by manufacturer H. The highest mean Cd concentration was found in red colored paints (1946±75 µg/g), followed by pink (1845±24 µg/g) and cream (1813 ±28 µg/g), while the lowest concentration was in red (98.5±1 µg/g) colored paints.
| Countries       | Samples          | Number of Samples | Average concentration | Maximum concentration | Percentage of samples with concentrations ≥ 90 ppm<sup>*</sup> | Percentage of samples with concentrations ≥ 600 ppm<sup>†</sup> | Reference number |
|-----------------|------------------|-------------------|-----------------------|-----------------------|---------------------------------------------------------------|---------------------------------------------------------------|------------------|
| Nigeria         | water-based      | 174               | 811                   | 3231                  | 100                                                           | 72                                                            | This study       |
| Nigeria         | water-based      | 8                 | 86                    | 516                   | 5                                                             | none                                                          | 46               |
| Nigeria         | oil-based        | 25                | 45                    | 159                   | 11                                                            | none                                                          |                  |
| Cameroon        | oil-based        | 61                | NA                    | 50000                 | 66                                                            | 64                                                            | 47               |
| Brazil          | oil-based        | 20                | 5600                  | 5900                  | 35                                                            | 30                                                            | 41               |
| Sri Lanka       | water-based      | 11                | 4177                  | 45743                 | 10                                                            | 10                                                            | 38               |
| Philippines     | water-based      | 19                | 25210                 | 137325                | 68                                                            | 68                                                            |                  |
| Thailand        | water-based      | 15                | 28354                 | 189163                | 67                                                            | 60                                                            |                  |
| Tanzania        | oil-based        | 17                | 61893                 | 505716                | 47                                                            | 47                                                            |                  |
| South Africa    | oil-based        | 20                | 14537                 | 120862                | 100                                                           | 95                                                            |                  |
| Nigeria         | water-based      | 7                 | 8458                  | 34598                 | 100                                                           | 100                                                           | 38               |
| Senegal         | oil-based        | 23                | 36989.5               | 129837                | 100                                                           | 100                                                           | 38               |
| Belarus         | water-based      | 21                | 5866                  | 29717                 | 86                                                            | 76                                                            |                  |
| Mexico          | water-based      | 8                 | 58                    | 418                   | none                                                          | none                                                          |                  |
| Mexico          | oil-based        | 22                | 5558                  | 59387                 | 82                                                            | 68                                                            | 38               |
| Brazil          | water-based      | 10                | 6                     | 16                    | none                                                          | none                                                          | 38               |
| Brazil          | oil-based        | 20                | 51860                 | 163812                | 100                                                           | 100                                                           | 38               |
| India           | oil-based        | 24                | 15004                 | 170258                | 42                                                            | 37                                                            |                  |
| India           | oil-based        | 22                | 9411                  | 49593                 | 36                                                            | 36                                                            | 38               |
| India           | oil-based        | 26                | 16600                 | 134000                | 42                                                            | 35                                                            | 41               |
| India           | oil-based        | 5                 | 106000                | 290000                | 100                                                           | 100                                                           | 49               |
| India           | water-based      | 38                | NA                    | 140000                | 38                                                            | 49                                                            | 50               |
| India           | oil-based        | 31                | NA                    | NA                    | 84                                                            | NA                                                            |                  |
| India           | oil-based        | 17                | NA                    | NA                    | 100                                                           | NA                                                            | 51               |
| India           | oil-based        | 148               | NA                    | 80350                 | 85                                                            | NA                                                            | 52               |
| Armenia         | oil-based        | 26                | 25000                 | 130000                | 77                                                            | 77                                                            | 41               |
| Kazakhstan      | oil-based        | 26                | 15700                 | 71000                 | 81                                                            | 77                                                            | 41               |

Table 2 — Comparison of the Present Study with Other Studies Reported in the Literature for Lead in Paint Samples

Note: NA—not available; *Present permissible limit of 90 ppm for Pb and †previous permissible limit of 600 ppm for Pb by the US Consumer Product Safety Commission.
mean Pb concentration was in cream (3117 ± 161 μg/g) paints produced by manufacturer H, followed by green (3013 ± 16 μg/g) and blue (2121 ± 19 μg/g), both produced by manufacturer L while the lowest concentration was also in green paints (173 ± 4 μg/g) produced by manufacturer K.

The order of Cd and Pb in the paint samples collected with respect to colors was:

Cd: violet > grey > yellow > pink > green > chocolate > brown > blue > white > cream > red > orange; and

Pb: violet > brown > cream > grey > green > blue > yellow > chocolate > white > orange > red > pink.

Only one manufacturer (A) out of the fourteen manufacturers considered in this study produced violet colored paints, which ranked first with respect to the levels of Cd and Pb. In addition, only two manufacturers (B and A) produced grey colored paints, which also ranked second and fourth with respect to the levels of Cd and Pb, respectively.

Discussion

In all the paint samples analyzed in this study, the levels of Pb was above the 90 ppm permissible limit of the US Consumer Product Safety Commission, which came into effect on August 14, 2009, while the levels of Cd were above the 100 ppm permissible limit of the European Union (EU), which came into effect on March 7, 2016. The concentrations of Cd and Pb in all of the 174 samples collected in Lagos and Ibadan, Nigeria were above the permissible limits of the EU and US Consumer Product Safety Commission, respectively (Supplemental Material and Table 2). These results could be attributed to the raw materials used in the production of paint samples and weak product regulation and enforcement, as registered manufacturers had the highest mean Cd (M) and Pb (L) concentrations in their products. It has been reported that only about 15 paint companies in Nigeria have met the SON product standard. The health hazards associated with exposure to lead and cadmium in the domestic environment have been insufficiently studied in developing countries, although their importance as a source of morbidity is widely recognized. Previous studies in Nigeria have shown that over 70% of children have blood lead levels above 10 μg/dL and that flaking paints are an important exposure source. Recently, studies showed that blood lead levels once thought safe are associated with increased risk of death from many causes.

The levels of Pb obtained in this study were higher than those reported in Nigeria, Brazil, Mexico, Belarus, Senegal, Tanzania and the Philippines, but lower than some previous studies in Nigeria, Thailand and Sri Lanka (Table 2). However, in most cases, the numbers of samples considered in previous studies were far lower than those reported in this study.

Conclusions

The present study examined the levels of Cd and Pb in paint samples sold in Lagos and Ibadan, Nigeria. In all the 174 paint samples collected and analyzed, the levels of Cd and Pb were above the permissible limits of 100 ppm and 90 ppm of the EU and US Consumer Product Safety Commission, respectively.

The order of metal concentrations with respect to manufacturers were:

Cd: M > A > L > E > F > J > C > G > D > N > B > I > H > K; and

Pb: L > N > A > M > H > I > C > E > G > J > B > K > D > F.

The order of metal concentrations with respect to color were:

Cd: violet > grey > yellow > pink > green > chocolate > brown > blue > white > cream > red > orange; and

Pb: violet > brown > cream > grey > green > blue > yellow > chocolate > white > orange > red > pink.

Presently, there are regulations in place in Nigeria that stipulate that paints should contain less than 90 ppm (dry weight) of total lead and 100 ppm of cadmium, but these limits have yet to be enforced, leading to high concentrations of these toxic metals in the paint samples. There is a need for the enforcement of permissible limits in paints produced in Nigeria to safeguard public health and to prevent possible exposure of the population to these metals, which are known to be particularly dangerous to humans.

Acknowledgements

Ajoke F. I. Apanpa-Qasim is grateful to The World Academy of Sciences for the Advancement of Science in developing countries and the Council of Scientific and Industrial Research for funding this research (FR number: 3240275040). In addition, the director of the National Environmental Engineering Research Institute, Nehru Marg, Nagpur, India is highly appreciated.

References

1. Millennium development goals [Internet]. New York, NY: United Nations; 2015 [cited 2016 Feb 2]. Available from: http://www.un.org/millenniumgoals/

2. Lead and zinc statistics [Internet]. Lisboa, Portugal: United Nations; c2016 [cited 2016 Jun 1]. Available from: www.ilo.org/static/statistics.aspx?from=1

3. Osemeahon SA. Effect of different polyols on the esterification of monomethylol urea with polyol. Res J Pharm Bio Chem Sc [Internet]. 2014 May – Jun [cited 2016 Apr 3];5(3):2002-11. Available from: http://www.rjpbsc.com/pdf/2014_5(3)/[213].pdf

4. Pruss-Ustun A, Corvalan C. Preventing disease through healthy environments: towards an estimate of the environmental burden of disease [Internet]. Geneva,
13. Draft final review of scientific information on cadmium [Internet]. Nairobi, Kenya: United Nations Environment Programme; 2008 Nov [cited 2016 Jan 3]. 188 p. Available from: http://www.unep.org/hazardoussubstances/Portals/9/Lead_Cadmium/docs/Interim_reviews/Final_UNEP_Cadmium_review_Nov_2008.pdf

14. Wallin M. Cadmium, kidney and bone [Internet]. Gothenburg, Sweden: Department of Occupational and Environmental Medicine Institute of Medicine, Sahlgrenska Academy at University of Gothenburg; 2016 [cited 2016 Sep 1]. 65 p. Available from: https://gup.ea.uk/etd/2017/395501/gupare_2017_39550_1.pdf

15. Tchounouw PB, Yedjou CG, Patiolla AK, Sutton DJ. Heavy metal toxicity and the environment. In: Luch A, editor. Molecular, clinical and environmental toxicology [Internet]. Basel, Switzerland: Springer Basel; 2012 [cited 2016 Sep 1]. p. 133-64. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4144270/

16. Chemical Fact Sheets [Internet]. Geneva, Switzerland: World Health Organization; 2006 [cited 2016 Feb 2]. 177 p. Available from: http://www.who.int/water_sanitation_health/dwq/gdwq0506_12.pdf

17. Bernard A. Cadmium & its adverse effects on human health. Indian J Med Res [Internet]. 2008 Oct [cited 2016 Sep 1];128(4):557-64. Available from: http://www.imr.org.in/temp/IndianJMedRes1284557-4980748_135007.pdf

18. Cadmium and cadmium compounds. In: IARC Monographs on the evaluation of carcinogenic risk of chemicals to humans: beryllium, cadmium, mercury and exposures in the glass manufacturing industry [Internet]. Vol. 58. Lyon, France: International Agency for Research on Cancer; 1993 [cited 2016 Mar 22]. p. 121-45. Available from: https://monographs.iarc.fr/ENG/Monographs/vol100C/mono100C.pdf

19. Suruchi, Khanna P. Assessment of heavy metal contamination in different vegetables grown in and around urban areas. Res J Environ Toxicol [Internet]. 2011 [cited 2016 Sep 1];5(3):162-79. Available from: http://scialert.net/fulltext/?doi=rjet.2011.162.179

20. Musoke L, Banadda N, Sempala C, Kigoni J. The migration of chemical contaminants from polyethylene bags into food during cooking. Open Food Sci J [Internet]. 2015 [cited 2016 Sep 1];9:44-8. Available from: http://benthopen.com/contents/pdf/TOPS/TOPS9-14.pdf

21. Final review of scientific information on lead: version of December 2010 [Internet]. Nairobi, Kenya: United Nations Environment Programme; 2010 Dec [cited 2016 May 4]. 325 p. Available from: http://www.unep.org/hazardoussubstances/Portals/9/Lead_Cadmium/docs/Interim_reviews/UNEP_GC26-INF_11_Add_1_Final_UNEP_Lead_review_and_appendix_Dec_2010.pdf

22. Appenroth KJ. Definition of “heavy metals” and their role in biological systems. In: Sheranthi I, Varma A, editors. Soil heavy metals [Internet]. Vol. 19. Berlin, Germany: Springer Berlin Heidelberg; 2010 [cited 2016 Sep 3]. p. 19-29. Available from: http://link.springer.com/ chapter/10.1007%2978-3-642-02436-8_2 Subscription required to view.

23. Fränzle S, Markert B. Metals in biomass. Environ Sci Pollut Res Int [Internet]. 2007 Sep [cited 2016 Sep 3];14(6):404-13. Available from: http://link.springer.com/article/10.1007%29esp2006.12.372 Subscription required to view.

24. Ackah M, Osei J, Anim AK, Zakaria N, Nyarko ES, GysiMT, Enti-Brown S, Hanson JE, Bentil NO, Tulasii D. Status of some metals contained in imported nail polish and lipsticks on the Ghanaian market. Proc Int Acad Ecol Environ Sci [Internet]. 2015 [cited 2016 Sep 1];5(4):142-7. Available from: http://www.iaaes.org/publications/journals/papers/articles/2015-5(4)/status-of-some-metals-in-imported-nail.pdf

25. Borowska S, Bezorka MM. Metals in cosmetics: implications for human health. J Appl Toxicol [Internet]. 2015 Jun [cited 2016 Sep 1];35(6):551-72. Available from: http://onlinelibrary.wiley.com/doi/10.1002/jat.3129/full

26. Zulaikha SR, Norkhadijah SS, Praveena SM. Hazardous ingredients in cosmetics and personal care products and health concerns: a review. Public Health Res [Internet]. 2015 [cited 2016 Sep 1];5(1):17. Available from: http://article.sapub.org/10.5923/j.phr.20150501.02.html

27. Omenka SS, Adeyi AA. Heavy metal content of selected personal care products (PCPs) available in Ibadan, Nigeria and their toxic effects. Toxicol Rep [Internet]. 2016 [cited 2016 Sep 1];3:628-35. Available from: http://www.sciencedirect.com/science/article/pii/S224750016300555

28. Adepoju-Bello AA, Oguntibeju OO, Adebiyi RA, Okpala N, Coker HA. Evaluation of the concentration of toxic metals in cosmetic products in Nigeria. Afr J Biotechnol [Internet]. 2012 Dec 4 [cited 2016 May 12];11(97):16360-4. Available from: http://pajoosheshyazsusums.ac.ir/attachments/93-01-04-8612/article1380726928_Adepoju%2B%20%2B%20a.pdf

29. Omolayo JA, Uzairu A, Gimba CE. Heavy metal assessment of some soft plastic toys imported into Nigeria from China. J Environ Chem Ecotoxicol [Internet]. 2010 Oct [cited 2016 Sep 1];2(8):126-30. Available from: http://www.academicjournals.org/journal/JECER/article-full-text-pdf/0872883014

30. Kerfalli SI, Sabra R, Jurdji M, Taleb RI. Assessment of toxic metals and phthalates in children’s toys and
days. Arch Environ Contam Toxicol [Internet]. 2013 Oct [cited 2016 Sep 1];65(3):368-81. Available from: http://link.springer.com/article/10.1007/s00244-013-9925-1 Subscription required to view.

31. Dahab AA, Elhag DE, Ahmed AB, Al-Obaiad HA. Determination of elemental toxicity migration limits, bioaccessibility and risk assessment of essential childcare products. Environ Sci Pollut Res [Internet]. 2016 Feb [cited 2016 Sep 1];23(4):3406-13. Available from: http://link.springer.com/article/10.1007/s11356-015-5594-0 Subscription required to view.

32. SindhuK OK, Osibanjo O. Some priority heavy metals in children's toy's imported to Nigeria. J Toxicol Environ Health Sci [Internet]. 2011 Apr [cited 2016 May 3];3(4):109-15. Available from: http://www.academicjournals.org/article/article1359428542_SindhuK%20and%20Osibanjo.pdf

33. Cui XY, Li SW, Zhang SJ, Fan YY, Ma LQ. Toxic metals in children's toys and jewelry: coupling bioaccessibility with risk assessment. Environ Poll [Internet]. 2015 May [cited 2016 Sep 1];200:77-84. Available from: http://www.sciencedirect.com/science/article/pii/S0269749115000718 Subscription required to view.

34. Guneey M, Zargary GJ. Contamination by ten harmful elements in toys and children's jewelry bought on the North American market. Environ Sci Technol [Internet]. 2013 [cited 2016 Sep 1];47(11):5921-30. Available from: http://pubs.acs.org/doi/abs/10.1021/es304969n Subscription required to view.

35. Kameti CM. Determination of lead and cadmium levels in decorative paints sold in Nairobi, Kenya [master's thesis]. [Nairobi City, Kenya]: Kenyatta University; 2013 Aug. 85 p.

36. Lead in enamel decorative paints, national paint testing results: a nine country study [Internet]. Nairobi, Kenya: United Nations Environment Programme; 2013 [cited 2016 May 4]. 43 p. Available from: http://www.unep.org/chemicalsandwaste/Portals/9/Mercury/Documents/publications/Lead_in_Enameled_decorative_paints.pdf

37. Raheem AA, Olowu OA. Production of household paint using clay materials. Int J Eng Res Appl [Internet]. 2013 Mar-Apr [cited 2016 Apr 3];3(2):85-93. Available from: www.ijeja.com/papers/Vol3_issue2/K32088593.pdf

38. Toxic Link and IPEN. Lead in New Decorative paints. A Global Study. New Delhi, Chennai India; 2009. 1-59 p. [cited 2016 November 20]. Available from: http://www.ipe.org/IPENweb/documents/work%20documents/global_paintstudy.pdf

39. Clark CS, Rampal KG, Thuppil V, Roda SM, Succop P, Menrath W, Chen CK, Adebamowo EO, Agbede OA, Sridhar MK, Adebamowo CA, Zakaria Y, El Safty A, Shinde RM, Yu J. Lead levels in new enamel household paints from Asia, Africa and South America. Environ Res [Internet]. 2009 Oct [cited 2016 Feb 2];109(7):930-6. Available from: http://www.sciencedirect.com/science/article/pii/S0013935510001315 Subscription required to view.

40. Clark CS, Speranskaya O, Brosche S, Gonzalez H, Solis D, Kodeih N, Roda S, Lind C. Total lead concentration in new decorative enamel paints in Lebanon, Paraguay and Russia. Environ Res [Internet]. 2015 Apr [cited 2016 Jul 5];138:432-8. Available from: http://www.sciencedirect.com/science/article/pii/S0013935515000481 Subscription required to view.

41. Clark CS, Kumar A, Mohapatra P, Rajankan P, Nyck Z, Hambartsumyan A, Astanina L, Roda S, Lind C, Menrath W, Peng H. Examination of lead concentrations in new decorative enamel paints in four countries with different histories of activity in lead paint regulation. Environ Res [Internet]. 2014 Jul [cited 2016 Jul 6];132:233-43. Available from: http://www.sciencedirect.com/science/article/pii/S0013935514000516 Subscription required to view.

42. Consumer Product Safety Improvement Act of 2008, Pub. L. 110–314, 122 Stat. 3016 (Aug 14, 2008).

43. Tsang JW. EU specifies restriction limit for cadmium in certain paints [Internet]. Geneva, Switzerland: SGS; 2016 Feb 25 [cited 2016 Jul 23]. [about 2 screens]. Available from: http://www.sgs.com/en/news/2016/02/safeguards-04316-eu-specifies-restriction-limit-for-cadmium-in-certain-paints-under-reach Subscription required to view.

44. SÖN, stakeholders partner on lead reduction in paints [Internet]. Lagos, Nigeria: Standard Organisation of Nigeria; 2016 [cited 2016 Oct 21]. [about 3 screens]. Available from: http://son.gov.ng/son-stakeholders-partner-on-lead-reduction-in-paints/ Subscription required to view.

45. MARS 6 microphone digestion system [Internet]. Belfast, Northern Ireland: CEM; 2016 [cited 2015 Oct 21]. Available from: http://cem.com/mars-6/

46. Adebamowo EO, Agbede OA, Sridhar MK, Adebamowo CA. Lead content in new decorative enamel paints in Nigeria. J Environ Res Dev [Internet]. 2012 Jul [cited 2016 Aug 23];6(2):115–23. Available from: http://onlinejolibrary.com/doi/10.1046/j.1467-0658.2000.00069.x/abstract Subscription required to view.

47. Wright NJ, Thacker TD, Pfitzner FM, Pettifor JM, Choi K. Lead concentrations and labeling of new paint in Cameroon. J Occup Environ Hyg [Internet]. 2013 [cited 2016 Oct 21];10(5):243-9. Available from: http://www.tandfonline.com/doi/abs/10.1080/15459624.2013.768934 Subscription required to view.