DETERMINATION OF LEAD IN PAINTS FLAKES FROM HOMES IN URBAN AND SUB URBAN ENVIRONMENTS

Supported by tetfund TERTIARY EDUCATION TRUST FUND

Akan George Archibong, Oluwatoyin Tirenioluwa Fatunsin* and Kehinde Ololade Olayinka
Department of Chemistry, University of Lagos, Akoka, Yaba, Lagos, Nigeria
*Corresponding author: oadetunde@unilag.edu.ng

Received: December 27, 2018 **Accepted:** March 11, 2019

Abstract: Lead used in paint pigments for its ability to improve drying, increase durability, retain fresh appearance and resist moisture that causes paint corrosion is also associated with lower IQ in children and other health issues. As a result, lead in paints is now being legislated. The aim of this study was to determine the concentration of lead in paint flakes from homes situated in urban and sub urban environments and the implication of exposure to humans. Paint flakes have were been collected from homes in both urban and sub urban areas of Lagos, Nigeria and concentration of lead was determined using an atomic absorption spectrometer (AAS) (Buck scientific Model 210 VGP, serial number: 1619) after acid digestion. Concentration of lead in paint flakes from homes were highly variable and spanned several order of magnitude (7.8 to 2330 mg/kg) with median concentrations of 29, 3.6 and 69 mg/kg for the three areas where homes were sampled. This result, indicate that pealed or weathered paint flakes is still an important exposure route to lead for humans especially for children and people with pica behavior.

Keywords: Lead, paint flakes, urban, sub urban

Introduction

Continuous exposure to lead may cause kidney damage, infertility, nerve and brain damage to humans in general (BCF, 2014). Other negative effects such as reduced intelligence and neurodevelopment, aggression, poor memory, poor academic performance and interaction have been associated with lead in children (Schnur and John, 2014). Children under the age of six are particularly vulnerable to the adverse health effects of lead because of their hand to mouth behavior and they absorb higher amounts than adults when ingested (Rebelo *et al*., 2015). No level lead in blood is regarded as safe since low level of lead in blood has been found to cause negative effects (Gottesfeld, 2015; Schnur and John, 2014).

Though the use of lead in paints for residential purposes have been legislated in many countries (UN, 2017). Aarchitectural/ decorative paints still contain significant concentration of lead. Lead in industrial paints has not been legislated (Gottesfeld, 2015). Some lead limits in new paints for residential purposes include the United States and the China standard of 90 ppm (dry weight) (Kumar and Gottesfeld, 2008). There is also a voluntary lead limit (the NIS 269: 2017) of 90 ppm (dry weight) in place for residential purpose paints in Nigeria set by Standard Organisation of Nigeria (SON) (Adegboye, 2017). Many other countries have also adopted values in the range of 90 to 600 ppm for lead in new paints (dry weight) (UNEP and IPEN, 2013). The non-legislation of lead in industrial paints pose as a major route for lead exposure since cars, roads, steels, and many other consumer products are painted with industrial paints. Some residences may be painted with industrial paints (Gottesfeld, 2015). US EPA standards CFR 745.103 and 745.223, defines "lead-based paint (referring to dried paints on walls) as paint with lead levels equal to or greater than 5000 mg/kg or 0.5% by weight" but legislation to change the value from 5000 to 600 mg/kg has commenced and should be in place by the end of the year 2018 (Duvall *et al*., 2018).

Lead-based residential paints (which are paints with lead greater than 5000 mg/kg) made up 20% of 80 paint flakes/peelings from homes, in both new and old suburbs of Johannesburg, South Africa (Montgomery and Mathee, 2005). Nduka *et al.* (2008) also found lead in paint flakes from buildings in Eastern Nigeria. Paints chips (flakes) from playing equipment installed in some Tokyo playgrounds contained also contained lead (30 to 89000 mg/kg) (Takaoka *et al*., 2006). Various surfaces of public playground structures, railings, gates, marking on road, playground facilities, telephone kiosks and bridges in Plymouth, south west England also had lead- based paint at median and mean concentrations of 4180 and 29,300 mg/kg, respectively (Turner and Solman, 2016). New enamel paints for domestic and residential uses have also been found with lead concentrations above 90ppm in Nepal, Cameroun, Nigeria, Taiwan, Lebanon, Paraguay and Russia (Clark *et al*., 2015; Gottesfeld *et al*., 2014; Ahamefuna *et al*., 2014; Gottesfeld *et al*., 2013; Ewers *et al*., 2011). However, new emulsion paints were found to generally contain low lead levels (22.5 – 80.5 mg/kg) (Ahamefuna *et al*., 2014).

Since paints sold in the past were not regulated for lead in Nigeria, many existing houses may still contain dangerously high levels of lead (Adebamowo *et al*., 2007). Wall paints in good condition is not a hazard itself. Dried paints chippings present a major route for lead exposure especially where leaded paints were used for wall decorations. They pose as a hazard to humans in that environment especially to children (BCF, 2014). Walls with paint chippings/flakes are common features in many environments and buildings especially in Nigeria. There is dearth of information on lead in paints from walls of homes. Available studies only assessed lead in new unused paints (Apanpa-Qasim *et al*., 2016; Ahamefuna *et al*., 2014; Adebamowo *et al*., 2007; Adebamowo *et al*., 2006; Wright *et al*., 2005). Montgomery and Mathee (2005) and Nduka *et al.* (2008) studied lead in paint flakes from buildings but Montgomery and Mathee (2005) was a study in South Africa while Nduka *et al*. (2008) which was a study in Nigeria only looked at urban buildings at the Eastern part of Nigeria and it done out ten years ago. This study aims to assess the current situation of lead in flakes of decorative Paints from homes in Urban and Sub Urban Environments.

Materials and Methods

32 set of paint flake samples were collected from walls of residences with flaking paints in urban (Yaba) and sub-urban (Agbado Ijaiye and Alapere) areas of Lagos, Nigeria. Samples were collected using the procedure in Montgomery and Mathee (2005). These samples were emulsion (water based) and enamel (latex) paints from houses. Information on the colour of paint were also noted. Paint flake samples were crushed in a mortar and pestle to make samples homogenous. 0.5 g of a sample was weighed into acid- washed 100 ml beakers. Samples were digested a mixture of nitric acid and perchloric acid (3:1 Vol/Vol) prior to analysis. All acids used were of analytical grade and analysis were by a certified laboratory using atomic absorption spectrometer (AAS) (Buck Scientific Model 210 VGP, serial number: 1619).

Results and Discussion

Paint flake samples collected from walls of residences in urban and sub-urban areas of Lagos, were analyzed and the results are shown in Tables 1 to 3. Concentration of lead were in the range of 9.75±0.35 and 677.50±3.547 mg/kg, 6.75±2.47 and 1442.50±915.70 mg/kg, 11.00 ± 0.70 and 2329.50 ± 12.02 mg/kg for Agbado Ijaiye, Alapere (Sub urban areas) and Yaba (urban area) respectively. Kumar and Gottesfeld (2008) and Johnson *et al*. (2009) conducted experiments to determine lead in new paints for residential purposes and found lead concentration up to 140,000 mg/kg and 184733, respectively. There were no distinct differences in lead levels found in paint flakes from sub urban and urban homes of Lagos. Similar observations were made in the study by Montgomery and Mathee (2005). They studied paint flakes from homes in Johannesburg, South Africa (100 to 290000 mg/kg). Lead in paint flakes from both new and old suburbs occupied by people of different socioeconomic class did not show any difference. Nduka *et al*. (2008) also studied 53 enamel and 6 emulsion paint flakes from walls of buildings in the eastern part of Nigeria had a range of 39.385 ± 1.111 to 74.352 ± 0.571 mg/kg.

Table 1: Lead concentration for twelve paint samples from Agbado Ijaiye

Sample code	Concentration of lead in paint (mg/kg)	Type of Paint	Color of Paint
A1	17.8±0.4	Emulsion	Green
A2	19.5±0.7	Emulsion	Green
A3	15.8± 0.4	Emulsion	Yellow
A4	21.5±0.7	Emulsion	Yellow
A5	9.8±0.4	Emulsion	Blue
A6	30.0±0.7	Emulsion	Pink
A7	678±3.5	Enamel	Brown
A8	264±65.1	Emulsion	Brown
A9	23.5±1.4	Emulsion	Brown
A10	7.8± 0.4	Emulsion	Brown
A11	212 ±257	Enamel	Grey

Table 2: Lead concentration for twelve paint samples from Alapere

Sample code	Concentration of lead in paint (mg/kg)	Type of paint	Color of paint
K1	400±88.4	Enamel	green
K2	14.5±2.1	Emulsion	Green
K3	17.0±5.7	Emulsion	Yellow
K4	20.5±5.7	Emulsion	Pink
K5	1333±0.4	Emulsion	Pink
K6	145.5±28.1	Emulsion	Peach
K7	1442.5±915.7	Emulsion	Brown
K8	22.8±24.4	Emulsion	Brown
K9	19.0±2.1	Emulsion	Ash
K10	29.0±1.4	Emulsion	Cream

Table 3: Lead concentrations for twelve paint samples from Yaba

Sample code	Concentration of lead in paint (mg/kg)	Type	Color of paint
L1	11.0 ± 0.7	Emulsion	peach
L2	2330 ± 12.0	Emulsion	blue
L3	120.8 ± 1.8	Emulsion	grey
L4	47.0 ± 1.4	Emulsion	grey
L5	276.3± 1.8	Emulsion	grey
L6	20.5 ± 3.5	Emulsion	grey
L7	66.8 ± 1.8	Emulsion	cream
L8	206± 0.7	Emulsion	cream
L9	24.0 ± 0.7	Emulsion	cream
L10	226 ± 1.1	Emulsion	white
L11	24.8 ± 0.4	Emulsion	white

Lead was identified in all the paints flakes sampled from both urban and suburban homes from Lagos. However there were variations in lead concentration from house to house. Minimum value of lead concentration in Agbado Ijaiye, Alapere and Yaba homes were 7.78, 14.5 and 11 mg/kg. Other statistics for the three location varied (Table 4 and Fig. 1). In this study the concentration range was between 7.8 and 2330 mg/kg. The frequency of samples with lead concentration between 0 and 499 mg/kg was the highest (87.5%).

40% (13) homes in this study had lead concentration above 90 mg/kg (the proposed limit for lead in new paints for residential purposes in Nigeria and also the currently used limit for lead in paint by USA and other countries) (Adegboye, 2017; UNEP and IPEN, 2013) (Fig. 2). The thirteen samples with lead higher than 90 mg/kg were seven emulsion paints and the three enamel paints samples. In this study, only three homes had enamel paints on their walls. Enamel paints are more expensive in Nigeria thus are rarely used in homes for residential purposes. Adebamowo *et al*. (2006) in their study of lead in new paints for sale found enamel paints had higher lead levels than emulsion paint. Kumar and Gottesfeld (2008) also observed that enamel paint samples have higher lead concentrations than latex (also called emulsion) paint samples. In this study, lead concentration of in enamel paint flake samples (677.50±3.54, 211.50±256.68 and 400.00±88.40 mg/kg) were all higher than their median values (210 and 123 mg/kg).

Table 4: Minimum and maximum value, first, second and third quartile values and of lead value in paint chippings from houses in Agbado, Alapere, Yaba (mg/kg)

Percentile	Agbado Ijaiye Homes	Alapere Homes	Yaba Homes	All the Homes Sampled
Minimum	7.78	14.5	11.0	7.8
Q1	16.8	19.375	13.4	19.4
Median	21.5	25.9	69.4	26.9
Q3	166.5	336.375	112.1	219
Maximum	678	1442.5	2123	2330
Number of samples	11	10	11	32

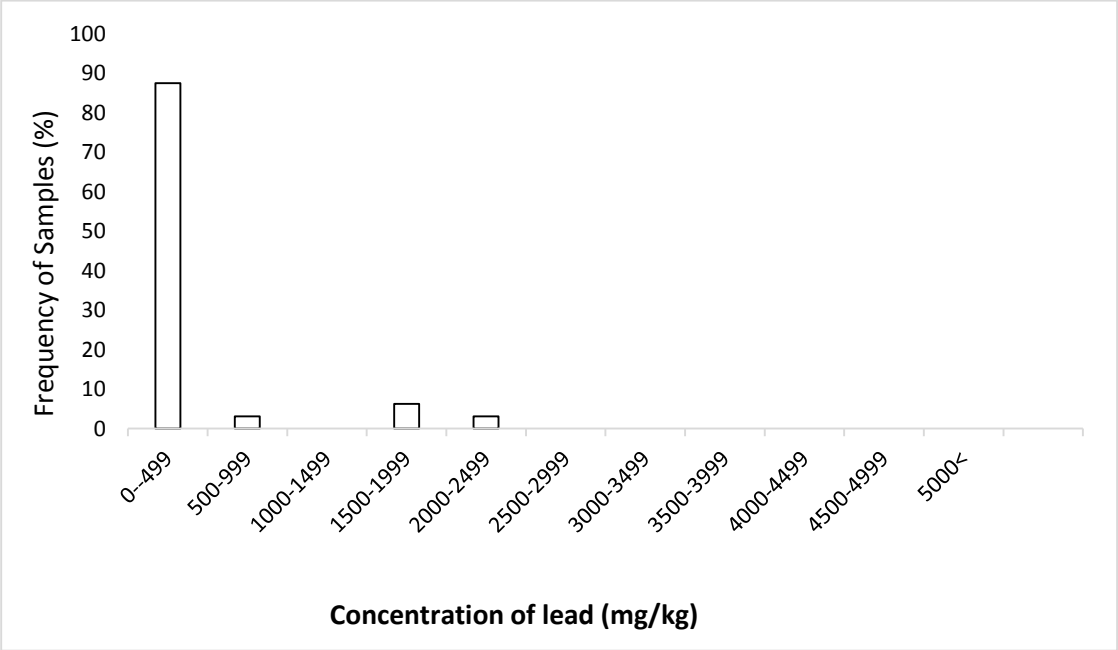

Fig. 1: Distribution of all residential paint samples by lead concentration

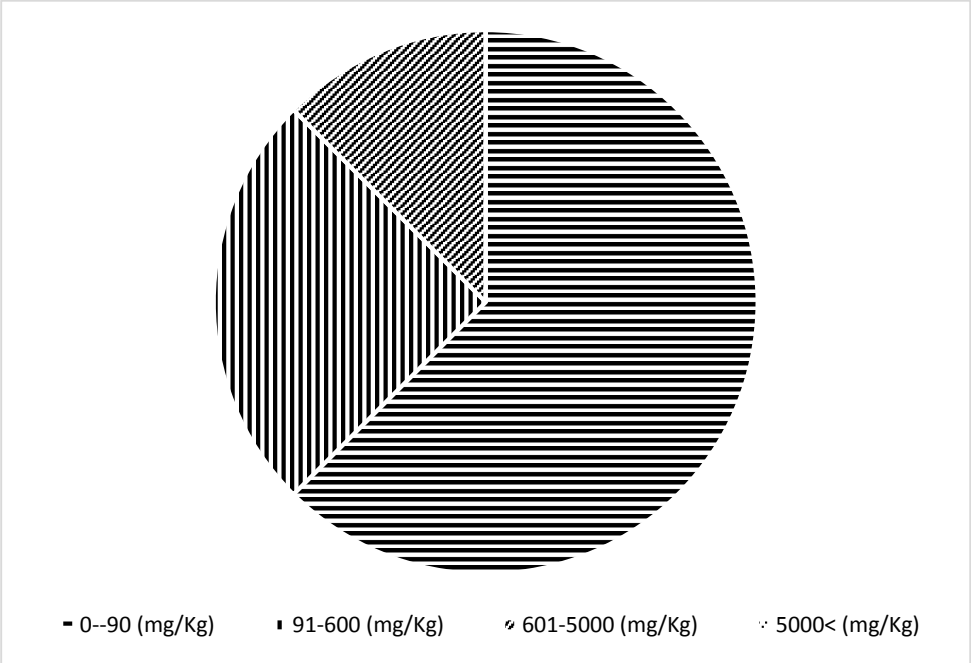

Fig. 2: Distribution of all residential paint samples in relation to lead limits in paints

Base on the 5000 mg/kg used to define lead-based paint, in US EPA Standards CFR 745.103 and 745.223 (Duvall *et al*., 2018; Mielke and Gonzales, 2008) no paint sample in this study can be classified as a lead-based paint but base the new definition lead –based paint (600 mg/kg) which is to take effect at the end of the year 2018 four samples (A7, K2, K5 and L2) (13%) with concentrations of 677.50±3.54, 1442.50±915.70, 1333.25±0.36 and 2329.50 ± 12.02 can be classified as lead–based paint (Fig. 2). Samples A7, K2, K5 and L2 were collected from old homes whose architecture shows they were built over 30 years ago when there was no awareness of leaded paints in Nigeria. Age of housing is often used as a surrogate for the amount of Pb in paint (Mielke and Gonzales, 2008). This study reveals that lead in paint especially from weathered, peeled or chipped paints in wall of homes is still an exposure route to lead in Nigeria with serious health implication for children or people with pica behaviors in those homes.

Paint flakes/chips into dust like particles and disperses into dust. The presence of lead in paint flakes exacerbates the problem of dust. Indoor dust is known to contain many chemicals (such as flame-retardants and other chemicals used in the house), microbes and dead skin cells with all their attendant health issues even at low concentration. Lead has affinity for sulfur containing protein amino acids. Series of low molecular weight proteins, analogous to metallothione in which are lead-binding. These proteins segregates lead in a nontoxic form in several organs (kidney, brain, lung, liver, erythrocyte) which leads to a reduction in normal metabolic functions such as molecular dysfunctions associated with neurodegenerative diseases (Gonick, 2011).

This study show that pealed or weathered paint flakes is still an important exposure route to lead for humans especially for children and people with pica behavior.

Reference

Adebamowo EO, Agbede OA, Sridhar MKC & Adebamowo CA 2006. An evaluation of lead levels in paints for residential use sold in the nigerian market. *Indoor and Built Environment,* 15: 551–554.

Adebamowo EO, Clark CS, Roda S, Agbede OA, Sridhar MK & Adebamowo CA 2007. Lead content of dried films of domestic paints currently sold in Nigeria. *Sci. Total Environ,* 388: 116-20.

Adegboye K 2017. Safe Environment: Stakeholders Advocate National Policy on Elimination of Lead in Paints. *Vangauard*.

Ahamefuna NC, Osibanjo O, Sunday AA & Ogoko EC 2014. Current levels of lead in paint sold in nigeria. *South Ame. J. Public Health,* 2: 135-150.

Apanpa-Qasim AFI, Adeyi AA, Mudliar SN, Raghunathan K & Thawale P 2016. Examination of lead and cadmium in water-based paints marketed in Nigeria. *J. Health and Poll.,* 6: 43-49.

BCF 2014. Lead in painted surfaces guide on repainting and removal for DIY and professional painters and decorators. *In:* Federation BC (ed.). Britain.

Clark CS, Speranskaya O, Brosche S, Gonzalez H, Solis D, Kodeih N, Roda S & Lind C 2015. Total lead concentration in new decorative enamel paints in Lebanon, Paraguay and Russia. *Environ Res.,* 138: 432-8.

Duvall MN, Serie TM & Wang S 2018. Appeal from the United States District Court for the Northern District of California. *News Alert*, 27 January, 2018, pp. 1-5.

Ewers L, Scott Clark C, Peng H, Roda SM, Menrath B, Lind C & Succop P 2011. Lead levels in new residential enamel paints in Taipei, Taiwan and comparison with those in mainland China. *Environmental Research,* 111: 757-760.

Gonick HC 2011. Lead-binding proteins: A review. *Journal of Toxicology,* 68: 6050.

Gottesfeld P 2015. Time to ban lead in industrial paints and coatings. *Frontiers in Public Health,* 3: 144.

Gottesfeld P, Kuepouo G, Tetsopgang S & Durand K 2013. Lead concentrations and labeling of new paint in Cameroon. *J. Occupational and Envtal. Hygiene,* 10: 243-249.

Gottesfeld P, Pokhrel D & Pokhrel AK 2014. Lead in new paints in Nepal. *Environmental Research,* 132: 70-75.

Johnson S, Saikia N, Sahu R, Mathur HB & Agarwal 2009. Lead in paints. India: Centre For Science and Environment.

Kumar A & Gottesfeld P 2008. Lead content in household paints in India. *Science of The Total Environment,* 407: 333-337.

Mielke HW & Gonzales C 2008. Mercury (Hg) and lead (Pb) in interior and exterior New Orleans house paint films. *Chemosphere,* 72: 882-885.

Montgomery M & Mathee A 2005. A preliminary study of residential paint lead concentrations in Johannesburg. *Environmental Research,* 98: 279-283.

Nduka JKC, Orisakwe OE & Maduawguna CA 2008. Lead levels in paint flakes from buildings in Nigeria: A preliminary study. *Toxicol. and Ind. Health,* 24: 539-542.

Rebelo A, Pinto E, Silva MV & Almeida AA 2015. Chemical safety of children's play paints: Focus on selected heavy metals. *Microchemical Journal,* 118: 203-210.

Schnur J & John RM 2014. Childhood lead poisoning and the new centers for disease control and prevention guidelines for lead exposure. *J. Am. Assoc. Nurse Pract.,* 26: 238-47.

Takaoka M, Yoshinaga J & Tanaka A 2006. Influence of paint chips on lead concentration in the soil of public playgrounds in Tokyo. *J. Environ Monit.,* 8: 393-8.

Turner A & Solman KR 2016. Lead in exterior paints from the urban and suburban environs of Plymouth, south west England. *Science of the Total Envt.,* 547: 132-136.

UN 2017. Update on the Global Status of Legal Limits on Lead in Paint: September 2017 UN Environment.

UNEP & IPEN 2013. Lead In Enamel Decorative Paints. *In:* UNEP (ed.) *National Paint Testing Results: A Nine Country Study*. The United Nations Environment Programme (UNEP) and International POPs Elimination Network.

Wright NJ, Thacher TD, Pfitzner MA, Fischer PR & Pettifor JM 2005. Causes of lead toxicity in a Nigerian city. *Arch. Dis. Child,* 90: 262-6.