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Determination of Lead in Selected Paints Marketed in Nigeria

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Abstract
Lead levels of decorative paints sold in Makurdi-Nigeria were studied. Lead concentrations from 30 paint samples involving 6 brands were determined using Atomic Absorption Spectrophotometry (AAS). It was found that the concentration values of lead obtained for emulsion paints and gloss paints ranged from 23.60 µg g^{-1} to 2604.51 µg g^{-1} and 106.16 µg g^{-1} to 2502.33 µg g^{-1} respectively. Exactly 9 emulsion paint samples contained lead concentrations below the World Health Organization (WHO) standard limit of 90 µg g^{-1} and it was observed that, Green B emulsion paint has the highest concentration level of lead (2604.51 µg g^{-1}). It was also observed that, twenty one (21) paint samples contained lead concentrations above the WHO standard limit of 90 µg g^{-1}. Generally, gloss paints had higher lead levels than emulsion paints. These results indicate potential risk of lead poisoning in paints especially in children. Regulatory bodies are therefore called upon to urgently switch into action to checkmate paint products manufactured, imported or distributed in Nigeria to protect public health.
Keywords*: Paint; Heavy metals; Toxicity; AAS*

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I. Introduction

Lead toxicity is an environmental disease and its effects on humans are devastating. Lead as a toxic heavy metal even at very low levels of human exposure is used in different consumer products including as a pigment in industrial paints and household decorative paints. The accumulation of this toxic heavy metal in indoor dust and outdoor soils makes it hazardous especially to children. Lead exposure in early childhood can result in reduced cognitive abilities, dyslexia, attention deficit disorder and antisocial behaviour. Lead exposure can also cause hypertension, renal impairment, immunotoxicity and toxicity to the reproductive organs.

Environmental health hazards caused by heavy metals exposure are a continued threat to human health, particularly in developing countries [1]. Heavy metals such as lead, cadmium, arsenic and so on are constituents of pigments which are added to paint formations to increase brightness and longevity [2].

Lead is used in different consumer products including industrial paints and household decorative paints [3, 4]. Industrial paints find their use in automobile coatings, steel structures, marine coatings and for other high-performance purposes while decorative paints which are either water based or oil based are primarily used for the interior or exterior decoration of buildings and homes [3, 5]. Lead compounds commonly used as pigments in paints include; lead chromates, lead oxides, and lead sulphates and the most common form is lead tetraoxide, commonly called red lead [4]. Paint manufacturers intentionally add lead compounds to paint for the following purposes: to give the paints their colour, help to spread evenly and dry fast on surfaces, as well as act as corrosion resistance agents on metal surfaces [6, 7].

Leaded paint has been used, and is still in use in some countries, to paint the interiors and exteriors of homes and other buildings and to paint toys, furniture, playground equipment and other articles with which children can come into contact. Leaded paint can be found in virtually every country. It is still available and in use in many parts of the world; even in countries where lead has been banned for specific uses. Lead is a cumulative toxicant that affects multiple body systems, including the neurological, haematological, gastrointestinal, cardiovascular and renal systems [5, 8, 9]. Children are particularly vulnerable to the neurotoxic effects of lead, and even relatively low levels of exposure can cause serious and, in some cases, irreversible neurological damage [10, 11].

Non-occupational exposure to lead from paint occurs mainly at home, from house paint that has flaked or chalked as it has aged or that has been disturbed during home maintenance and renovation. This results in the generation of lead-containing dust that can be inhaled or ingested. Soil around the home may also become contaminated. Lead-contaminated house dust has been recognized as a major contributor to the total body burden of lead in children [12, 13]. Young children are particularly at risk of ingesting lead through normal hand-to-mouth activity. In addition, some children with pica persistently pick off and eat fragments of leaded

paint. Young children can also be exposed to lead through the mouthing of painted objects and toys. In some countries, leaded paint may be the most widespread and dangerous high-dose source of lead exposure for children [9].

However, significant sources of exposure to lead still remain, particularly in developing countries. Further efforts are required to continue to reduce the use and release of lead and to reduce environmental and occupational exposures, particularly for children and women of childbearing age.

The main objective of this study was to determine the total lead contents of selected paints marketed in Nigeria following its removal from premium motor spirit or gasoline as an additive.

II. Materials and Methods

Sample Collection

Paint samples of different brands were collected at High Level and New GRA markets in Makurdi, Benue State, Nigeria. Six different brands of paints were randomly selected for both water and oil-based paints and for each paint brand, five paint samples of different colours were randomly selected. Thirty (n = 30) paint samples for the six brands were used. These include fifteen (n = 15) water-based paints and fifteen (n = 15) oil-based paints. They were purchased in 30 mL containers. The paint samples were homogenized and put in labeled plastic bottles and kept at room temperature awaiting digestion and analysis.

The glassware and plastic containers were cleaned with soap and then rinsed with distilled water. All the glassware used in this study were dried at 105 °C.

Sample Preparation

The homogenized samples were thoroughly stirred and 5 mL of the stirred samples were applied onto separate clean glass slides. The glass slides were placed in an oven at 120 °C for 2 hours. The scraper were used to scrape off the glass surface. Thereafter, the scraped water-based paint samples were crushed using porcelain mortar and pestle to homogenize the samples while the oil-based paint samples were cut into small pieces using new razor blade for each sample. 1.00 g each of the samples were accurately weighed using analytical weighing machine and put into 100 mL beakers.

Acid digestion for AAS analysis

Nitric acid/perchloric acid digestion was performed, following the procedure recommended by the AOAC (2012) [14]. One gram of sample was placed in a 250 mL digestion tube and 10 mL of concentrated HNO_3 was added. The mixture was boiled gently for 30-45 min to oxidize all easily oxidizable matter. After cooling, 5 mL of 70 % $HC1O_4$ was added and the mixture was boiled gently until dense white fumes appeared. After cooling, 20 mL of distilled water was added and the mixture was boiled further to release any fumes. The solution was cooled, further filtered through Whatman No. 42 filter paper and 0.45 µm pore size Millipore filter paper (to screen out bacteria and other microorganisms that may add to the poisoning of paint apart from Pb) and transferred quantitatively to a 25 mL volumetric flask by adding distilled water. All samples were analyzed for lead using Atomic Absorption Spectrophotometer (AAS) model PG990.

III. Results

Lead concentration in water-based paints

The results for the water-based paints analyzed (n = 15), from the three brands are tabulated in the following sections.

Table 1: Lead levels in paint A

S/No	Colour	Paint type	Pb concentration [µg g^{-1}]
1	Dark grey	Emulsion	28.80
2	Rose	Emulsion	26.20
3	Red	Emulsion	235.20
4	Sand	Emulsion	39.45
5	Abuja brown	Emulsion	23.60

Table 2: Lead levels in paint B

S/No	Colour	Paint type	Pb concentration [µg g^{-1}]
1	White	Emulsion	49.40
2	Magnolia	Emulsion	109.95
3	Light blue	Emulsion	42.15
4	Cream	Emulsion	29.30
5	Green	Emulsion	2604.51

Table 3: Lead levels in paint C

S/No	Colour	Paint type	Pb concentration [µg g^{-1}]
1	Dove	Emulsion	314.70
2	Rose	Emulsion	106.20
3	Blue	Emulsion	77.15
4	White	Emulsion	66.85
5	Cream	Emulsion	134.95

Lead concentration in oil-based paints.

The results for the oil-based paints analyzed (n = 15), from the three brands are tabulated in the following sections.

Table 4: Lead levels in D paint

S/No	Colour	Paint type	Pb concentration [µg g^{-1}]
1	Yellow	Gloss	409.90
2	White	Gloss	2502.33
3	Black	Gloss	408.59
4	Ordex Oct.	Gloss	646.56
5	Blue	Gloss	245.96

Table 5: Lead levels in E paint

S/No	Colour	Paint type	Pb concentration [µg g^{-1}]
1	Chocolate	Gloss	372.29
2	Blue	Gloss	1593.48
3	White	Gloss	420.99
4	Cream	Gloss	172.52
5	Green	Gloss	759.21

Table 6: Lead levels in F paint

S/NO	Colour	Paint type	Pb concentration [µg g^{-1}]
1	Yellow	Gloss	1662.10
2	Red	Gloss	2298.98
3	Cream	Gloss	976.79
4	Ash	Gloss	112.04
5	Chocolate	Gloss	106.16

IV. Discussion

The concentration values of lead obtained for emulsion and gloss paints ranged from 23.60 µg g^{-1} to 2604.51 µg g^{-1} (Tables 1-3) and 106.16 µg g^{-1} to 2502.33 µg g^{-1} (Tables 4-6) respectively. Twenty-one or 70% of paint samples investigated contained lead concentrations above the WHO and US standard limit of 90 µg g^{-1}. This finding is largely in agreement with those of Clark *et al* [12] in which 96% of 25 paint samples studied had lead concentrations above this limit. It was also observed that, Green Ranness emulsion paint had the highest concentration level of 2604.51µg g^{-1} (Table 2).

The white gloss (or enamel) paints were observed to have the highest concentration of Pb (2502.33 µg g^{-1}). This finding is at variance with those of other researchers [15, 16] where Pb was most highly indicated in the yellow paints. White paints are predominantly pigmented with white lead, $2PbCO_3.Pb(OH)_2$ and although a market survey as to choice of colour by consumers did not form part of this study, it is probable that users of gloss paints in Nigeria show a preference to white paints over the other colours. In terms of colour, the least concentrations of Pb were found in brown and chocolate for emulsion and gloss paints respectively. From the analysis, it was noted that gloss paint had higher lead levels compared to emulsion paint. Lead is known for its teratogenic effect and the levels of lead in paints may cause inhibition of haemoglobin synthesis, dysfunction in the kidneys, joints, reproductive system and cardiovascular system [17]. Other effects of lead poisoning are gastro-intestinal damage, mental retardation in children, abnormalities in fertility and pregnancy [18, 19].

The results show that lead concentration of most paints produced or sold in Nigeria exceed the World Health Organization and US regulations and controls on lead in paint.

V. Conclusions

From the result of the brands of paints sampled, twenty one out of 30 samples contained lead concentrations above the WHO standard limit of 90 µg g^{-1}. Urgent attention of the concerned regulatory bodies is therefore needed to check the illegal production and importation of paints that may contain lead levels above the permissible limits looking at the debilitating health impacts of lead on all age groups and particularly children and pregnant women. A recommendation to manufacturers as to the use of safer pigments such as titanium oxide, barium sulphate and silicon or aluminum oxides as substitutes for lead-based pigments will serve in this direction.

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