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LEAD MENACE: A PERSISTENT ISSUE IN PAINTED HOUSING UNITS IN LAGOS, NIGERIA

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ABSTRACT

This study evaluates Pb occurrence in homes in order to assess the toxicity risk in Lagos, Nigeria. Painted wall scrapings were collected from selected locations in Lagos metropolis. The relationship between Pb-based paints applied on family housing units and socio-economic status of residents were compared. Forty eight exterior and interior samples were collected from twelve urban locations and twelve rural locations. The bacterial population density in paint scrapings from rural locations ranged from 1.0 - 2.1 and 0.5 - 1.9 x 10^5 cfu/g. However, in the urban samples, it ranged from 1.6 - 26.1 and 2.0 – 24.0 x 10^4 cfu/g for the exterior and interior samples respectively. Atomic absorption spectrophotometry (AAS) showed that in rural samples, Pb concentration ranged from 0.000 – 3.175 and 0.000 – 2.688 ppm while in urban samples, 0.129 – 19.26 and 0.000 – 18.21ppm for exterior and interior samples respectively. Generally, Pb concentration was higher in urban interior and exterior samples than in rural samples. The isolated bacteria were identified using the Analytical Profile Index (API) to be Bacillus megaterium, Enterobacter gergoviae, B. circulans, and B. subtilis from rural samples and Pseudomonas putida, Proteus mirabilis, B. lentus, E. amnigenus, Klebsiella oxycota, Citrobacter youngae and Pantoea sp. from the urban samples respectively.

Keywords: Paints, Lead poisoning, Lead-based paints, Paint hazard, Paint dust, Painted wall scrapings.

Contribution/ Originality

The paper's primary contribution is the comparison of prevalence of lead-based paints in a big developing city - Lagos, Nigeria. The study investigates the current existence of lead-based paints in housing units which hitherto is believed to be phased out or banned in most cities with reference to socio-economic status.

1. INTRODUCTION

Lead poisoning has become a major public health issue of global concern and has been traced to Pb-based paint in the home [1, 2] . It is used in developing countries that do not regulate its use to add color, to improve the ability of the paint in hiding the surface it covers, as drying agent and as pigment for durability. Previous research has shown that chronic lead exposure has continued to be a significant health problem in developing countries in Africa. It has also been attributed to lead colic [3, 4].

Human exposure to Pb is estimated to account for 143,000 deaths every year and 0.6% of the global burden of disease [5]. Therefore, studies on the continual existence of lead-based paint in developing countries is indispensable in controlling its use. Pb is a cumulative toxicant that affects multiple body systems, including the neurological, haematological, gastrointestinal, cardiovascular, renal and reproductive systems [6]. Children are particularly vulnerable to the neurotoxic effects of Pb, and even low levels of exposure can cause serious and, in some cases, irreversible neurological damage. This is because their nervous systems are still developing, hence, their absorption rates are higher.

Children also have higher likelihood of engaging in hand to mouth practices and frequently spend time on the floor and on soil areas which make them to be more likely to be exposed to Pb from paint dust in their domestic environment [7, 8]. If not detected early, children with high levels of Pb in their bodies (> 10 µg/dL) or even lower [9] can suffer from damage to the brain and nervous system; behavior and learning problems such as hyperactivity, slowed growth, hearing problems and headaches. Childhood Pb exposure is estimated to contribute to several cases of children with intellectual disabilities every year [10]. Despite recent reductions in the use of Pb in petrol (gasoline) and plumbing, significant sources of exposure to Pb still remain, including Pb-based paint. Pb-based paint has been used, and is still in use in some countries, to paint the interiors and exteriors of homes and other buildings [11-13]. This require urgent attention. Exposure to Pb is however reduced in advanced countries as indicated by reduced blood Pb levels (BLLs) [14].

A study on Pb levels of paints manufactured in Nigeria showed that 96% of the paints had higher than recommended levels of Pb. The study concluded that efforts should be undertaken to assess the presence of high Pb levels in existing housing and if detected, intervention programs for eliminating risk of exposure should be implemented in addition to measures to increase awareness and enforce regulations leading to the elimination of Pb-based domestic paint [15]. In this study, forty eight samples of painted wall scrapings were collected from both interior and exterior surfaces of rural and urban locations. The samples were analysed for Pb concentrations using the AAS approach. The main objective of the study was to reveal current use of lead-based paints and investigate the relationship between prevalence of Pb in painted family housing units and poverty level. Furthermore, a study on the pattern of microbial distribution in the wall paint scrapings was also attempted. This provided a valuable basis for further investigation on Pb-resistant bacteria. Even though Pb is known to disrupt microbial membrane functions and enzymatic activities [16, 17] some microorganisms have developed various mechanisms of resistance to lead. The resistance of *Pseudomonas marginalis* and *Bacillus megaterium* to Pb has also been reported [18]. This was linked to environmental Pb exposure in these organisms. Previous studies also indicate that increase in lead toxicity leads to increased microbial growth [19]. Some species of *Arthrobacter*, *Alcaligenes* and *Corynebacterium* have been reported to resist Pb toxicity [20], while some species of *Pseudomonas*, *Acinetobacter*, *Flavobacterium*, and *Aeromonas* have the ability to convert lead nitrate or trimethyl lead acetate to tetramethyl lead [21]. The intracellular accumulation of Pb as dense particles or granules within the cytoplasm has also been reported as a common occurrence in *B. megaterium* [22].

2. MATERIALS AND METHODS

2.1. Paint Scraping Samples

Painted wall scrapings were collected aseptically from interior and exterior surfaces of urban and rural locations in Lagos metropolis. The urban locations included: Palmgroove (PG), Ikeja (IK), Victoria Island (VI), Commercial road (CR), Moore Road (MR), Maryland (ML), Opebi (OP), Allen Avenue (AL), Adelabu (AD), Apapa (AP), Ogba (OG) and University of Lagos Campus (UN). The rural areas included: Oshodi (OS), Iyana Ipaja (IP), Iwaya (IW), Alapere (AL), Festac (FE), Orile (OR), Ojuelegba (OJ), Alagomeji (AG), Mushin (MU), Bariga (BA), Ajegunle (AJ), and Oworo (OW). The painted wall scrapings in sterile Mc Cartney bottles were brought into the laboratory for investigation.

2.2. Enumeration and Characterization of Organisms

The painted wall scrapings were pulverised and one gram of each sample was weighed aseptically, introduced into 9mls of sterile distilled water in a test tube and homogenized. Six fold serial dilutions were carried out and aliquots from appropriate dilutions were inoculated into sterile petri dishes containing nutrient agar (NA) and Mc Conkey agar (MCA). The plates were incubated aerobically at 30^{0}C for 24-48hrs.

2.3. Identification of Isolates

The various microorganisms were subjected to conventional biochemical tests and the analytical profile index (API) system (BioM´erieux) with API 20E and API 50 CHB. Overnight subcultures of the microorganisms were used in both API systems as per the manufacturer's instructions. The preparation of inoculum was also according to the manufacturer's instructions. In the API 20E, the cupules were slightly overfilled. Incubation of the strips was at 29°C for 24h. Subsequently, the profiles were determined with the API20E Analytical Profile Index software program. For the API 50 CHB, the inoculum was also prepared as per the manufacturer's instructions and inoculated strips were incubated at 30°C for 48 h. Profiles were determined with API software program [23, 24].

2.4. Atomic Absorption Spectrophotometry (AAS)

Samples were digested by heating 50 ml of the sample with 10ml concentrated nitric acid until the brown fumes disappeared leaving the white fumes. Subsequently, the digested samples were reconstituted by addition of ten ml of deionized water, homogenized and filtered. Each digested sample was then employed at the correct concentration for the flame analysis using atomic absorption spectrometer (Perkins Elmer-Analyst 200) equipped with a cathode lamp. The radiation obtained from the hollow cathode lamp was passed into the flame where the sample was aspirated. The unabsorbed radiation in the flame was allowed to pass through the filter and the detector. Finally the excited atom was amplified and recorded. Analytical measurements were done based on the mean absorbance following stipulated conditions [25].

3. RESULTS

The microorganisms isolated from urban locations were identified as *Bacillus lentus, Citrobacter youngae, Enterobacter amnigenus, Klebsiella oxytoca, Proteus mirabilis, Pseudomonas putida and Pantoea sp.* while in the rural locations, *B. megaterium, E. gergoviae, B. circulans* and *B. subtilis* were identified. Table 1 shows the characteristic reactions of the urban isolates using the API 20E kit while Table 2 reveals the characteristic reactions of *Bacillus lentus* isolates using the API 50CHB test strips. The microbial population density in the rural locations ranged from 1.0 - 2.1 and 0.5 -1.9 x 10^5 cfu/g in the exterior and interior samples respectively as shown in Fig.1. In the urban samples, bacterial population density ranged from 1.6 - 26.1 and 2.0 – 24.0 x 10^4 cfu/g in the exterior and interior samples respectively (Fig.2). The results revealed that a higher population density of bacteria was isolated from the exterior samples than the interior samples in both locations. This probably is because microorganisms in the exterior surfaces receive sufficient oxygen for their respiration as well as appropriate sunlight and moisture levels which is required for their proliferation. During harsh environmental conditions, microorganisms such as *Bacillus* species produce spores [26] which make them resistant to harsh environmental conditions and are therefore, persistently present and difficult to eliminate. The results of this study showed that Pb was detected in 83% of samples tested. Pb concentration was found to be higher in the urban samples with the highest being 19.26 ppm. This suggests that the occupants of these urban areas use lead-based paints more frequently than their poor counterparts in the rural areas. The urban inhabitants are also ignorant of the composition of these Pb-based paints as well as the dangers inherent in such paints. The Pb concentrations were observed to be higher in the interior samples (Fig. 3) and the exterior samples (Fig. 4) of the urban locations than in the rural locations. *P. putida, Proteus mirabilis, B. lentus, E. amnigenus,* and *Citrobacter youngae,* and *Klebsiella oxycota* isolated from the urban samples thrived very well despite the high Pb concentration indicating certain levels of Pb resistance.

4. DISCUSSION

The results of the study show that despite continuous developments in many urban areas such as Lagos, Nigeria, considerable amount of Pb-based paint remain a constant feature, occurring in 83% of the sampled housing units in Lagos, Nigeria. The prevalence of Pb-based paint and its hazards increases with socio-economic status in Lagos, Nigeria. Pb concentration found to be higher in the urban samples suggested the prevalence of poor quality paints in these environments which are regarded as big cities in developing countries. Generally, Pb-based paint is assumed to be hazardous if it has a Pb content ≥ 1 mg/cm^2 or 0.5% [27, 28]. The Pb-based paint hazard is referred to as toxic, when the lead quantity is above the minimal levels specified in the HUD regulations [28] or is above the levels established by the U.S. EPA. Previous studies have shown that considerable neurologic damage to children occurred even at very low levels of exposure [29-32] yet, Pb-based paint has continued to be used in developing countries in spite of significant progress. It has been reported that only a small amount of Pb-based paint is needed to produce very high dust lead levels [32]. At the moment, adverse health effects have been observed for all BLLs [33-35] therefore, attempts to prevent Pb exposure in young children requires immediate attention in big, yet developing cities like Lagos.

The painted wall scrapings were observed to harbor diverse population of bacteria. These bacteria colonize paints and paint scrapings because of the variety of natural and synthetic pigments used in paint manufacture [36] which constitute a rich source of nutrient for microbial growth. High microbial population levels in the exterior samples may also be attributed to favorable environmental factors such as humidity, temperature, light, and to a lesser extent pH that affect the density and composition of bacterial population in paints [37] and painted wall scraping. The highest bacterial population (1.0 - 2.1 x 10^5 cfu/g) was observed in exterior samples while the lowest (2.0 - 24.1 x 10^4 cfu/g) was found in the interior samples. The exterior locations have considerable amount of sunlight exposure while the interior samples have reduced exposure to light which probably accounted for the higher bacterial population density of the exterior samples. *Pseudomonas putida* was regularly encountered in both the exterior and interior samples of urban locations. Members of the *Pseudomonas* genus exhibit a great deal of metabolic diversity and consequently, are able to colonize a wide range of habitats. *Pseudomonas* species have been isolated in various environments including soil, water, plants and hospitals [38, 39]. The occurrence of bacteria in the Pb contaminated paint scrapings from urban locations also suggest that the bacteria isolated from such samples may be Pb-tolerant as they proliferate very well irrespective of the high Pb concentration. The Pb concentration which was highest in the urban locations also suggested the prevalence of poor quality paints in these environments confirming that Pb-based paint has continued to be used in underdeveloped countries.

Table-1. Characteristic Reactions of Urban Isolates Using Api 20e Test Strips

TESTS	I	II	III	IV	V	VI
ONPG	+	+		+	-	+
ADH	-	+	+	+	-	-
LDC	-	-		-	-	+
ODC	-	+		-	+	-
CIT	+	+	+	+	+	+
H_2S	-	-		+	+	-
URE	-	-	-	-	+	+
TDA	-	-		-	+	-
IND	-	-		-	-	+
VP	+	+		-	-	+
GEL	-	-	-	-	+	-
GLU	+	+	-	+	+	+
MAN	+	+	-	+	-	+
INO	+	-		-	-	+
SOR	+	+		+	-	+
RHA	+	+		+	-	+
SAC	+	-		-	-	+
MEL	+	+		-	-	+
AMY	+	+		-	-	+
ARA	+	+	+	+	-	+
OX	-	-	+	-	-	-
NO_3			-			
TRP			-			
ESC			-			
PNG			-			
MNE			+			
NAG			-			
MAL			-			
GNT			+			
CAP			+			
ADI			-			
MLT			+			
PAC			+			
GLU			+			
NO_2			+		+	+
N_2			-		-	-
MOB			+		+	-
McC			+		+	+
OF-O			+		+	+
OF-F			+		+	+

5. CONCLUSION

This study revealed that several people living in the urban areas are still exposed to the Pb-based paint hazard. The Pb-based paints apparently are more available and accessible to the high class populace who purchase them more often. Low income in poor, developing countries have also supported the blooming Pb-based paint market. This is largely because such developing countries have no laws restricting or prohibiting the manufacture and use of Pb-based paints.

Table-2. Characteristic Reactions of *Bacillus Lentus* Using Api 50 Chb Test Strips

S/N	TESTS	REACTIONS
0	0	-
1	GLY	+
2	ERY	-
3	DARA	-
4	LARA	+
5	RIB	+
6	DXYL	-
7	LXYL	-
8	ADO	-
9	MDX	-
10	GAL	+
11	GLU	+
12	FRU	+
13	MNE	+
14	SBE	-
15	RHA	+
16	DUL	-
17	INO	-
18	MAN	+
19	SOR	-
20	MDM	-
21	MDG	+
22	NAG	+
23	AMY	+
24	ARB	+
25	ESC	+
26	SAL	+
27	CEL	+
28	MAL	+
29	LAC	+
30	MEL	+
31	SAC	+
32	TRE	+
33	INU	-
34	MLZ	-
35	RAF	+
36	AMD	+
37	GLYG	+
38	XLT	-
39	GEN	+
40	TUR	+
41	LYX	-
42	TAG	-
43	DFUC	-
44	LFUC	-
45	DARL	-
46	LARL	-
47	GNT	-
48	2KG	-
49	5KG	-

These countries also evidently lack the necessary Pb detection facilities which has contributed to continual manufacture and sale of Pb-based paints. It is clear that Pb-based paint hazard may actually be linked to the socio-economic status of people in Lagos, Nigeria.

Majority of the rural locations where most poor people reside are not regularly painted as is the case in the urban settings. Since the costs of Pb paint abatement are extremely high, and the removal will involve a house to house process, rather than a simultaneous effort, there must be substantial commitment to further reduce Pb poisoning among vulnerable children in developing countries like Nigeria. *Pseudomonas putida*, *Proteus mirabilis*, *Bacillus lentus*, *Enterobacter amnigenus* and *Citrobacter youngae* isolated from Pb-contaminated samples in the study appear to be Pb-resistant.

Fig-1. Bacterial Population Density in Rural Locations

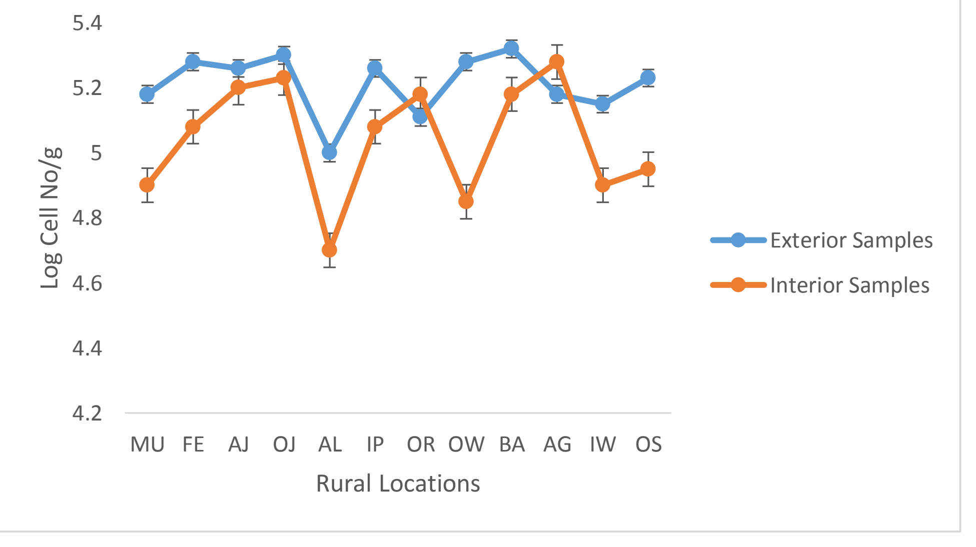


Fig-2. Bacterial Population Density in Urban Locations

Fig-3. Lead Concentrations (ppm) in Interior Samples of Urban and Rural Locations

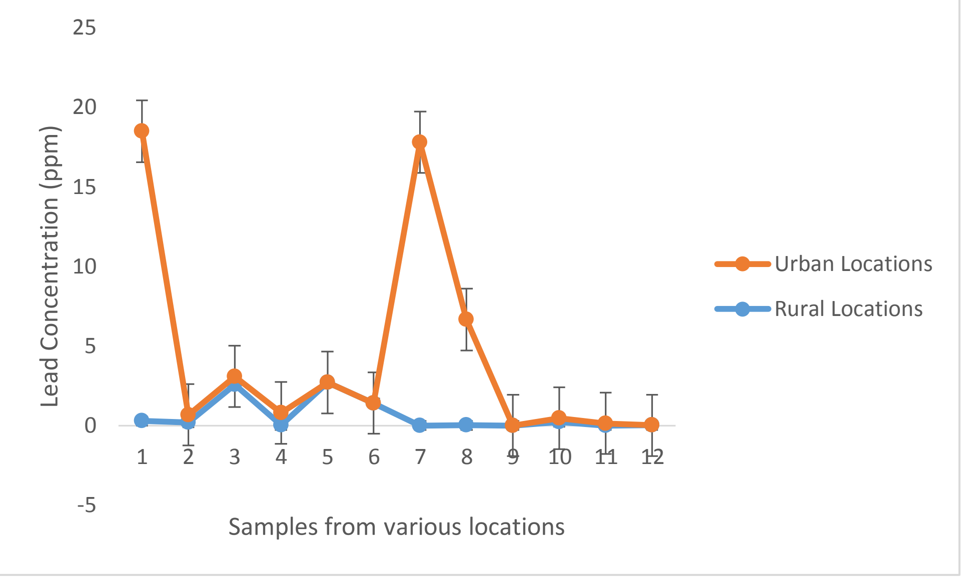
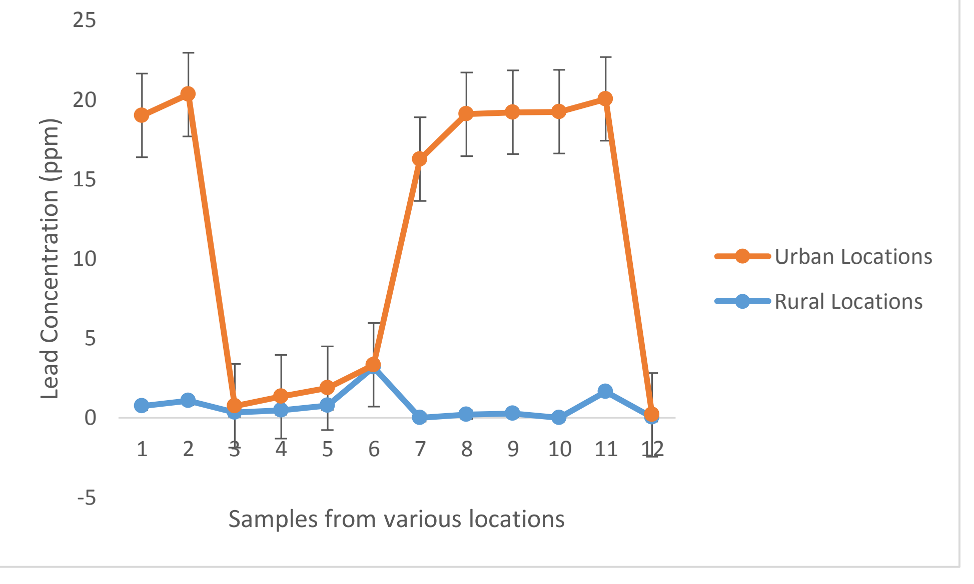


Fig-4. Lead Concentrations (ppm) in Exterior Samples of Urban and Rural Locations



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