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Toxicity Risks of Selected Heavy Metal on Dwellers from Building Materials Used in Nigeria

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Abstract: Chemical toxicity risks from 14 different brands of building materials such as Cements, tiles, marbles and sands were analysed using Inductively Coupled Plasma Mass Spectrometry (ICP-MS). This study is aimed at determining the risk exposure to dweller of different age groups. The digested samples analysed using ICP-MS for the concentrations of Cr, Pb, Zn, Ni, Fe, As and Cd varies from 10 to 183, 8.96 to 68.70, 35.4 to 733.7, 14.4 to 690.5, 0.95 to 4.64 and 0.7 to 14.7 mgkg⁻¹ respectively. Statistical Analysis showed that 44% of the Concentrations of Toxic metals measured in the building material samples come from Ni, the scree plots of dermal and inhalation risks exposure to children aged from 0.5 to 11 years showed sharp drop after Ni metal compared to adult with ages ranges from 12 to 70 years where the drop is steady from the first factor. This indicated that Adults are not over-exposed compared to children to these heavy metals. The High factor value of 2.786 was seen in Goodwill Verified. Tile High factor scores were discovered from the exposure of children to both dermal and inhalation risks compared to the Adults. Some of these concentrations and risks exceed the permissible limits of the European Regulatory Standards and USEPA. Significantly, these chemical toxicity risks of heavy metal contents in the building materials may pose health risks on dwellers especially the under-aged children.

Keywords: Heavy metals, Building materials, ICP-MS, Health Risks

1. Introduction

Most of these building materials starting from cement, tiles, sands and marbles are made from rocks and soils that mainly contain heavy metals and natural radioactive elements. Studies show that the chemical and some metrological industries are the sources of these heavy metals in environments where most of these building materials are sourced [2]. In both developed and undeveloped countries, so many studies on the toxicity due to the heavy metals in the soil, and probably over 40 % was



degraded to different levels of erosion and desertification .In Europe, more than one million production sites were reported to have high contents of heavy metals [3]. As such, it was found at the same production site that more than 300,000 were found to be highly contaminated [4].Where most of the building/decorative materials of interest today are produced is having soil pollution challenges; most of the arable land are polluted with heavy metals [3].This study investigates the toxicity risks of heavy metals from the construction materials exposure to dweller that rely on them for building purposes.

2.0 Materials and Methods

2.1 Materials and Method for Toxic Metals Contents in the Samples: Building materials of different types were purchased for this study in Orile market in Lagos State, Nigeria. They were crushed, pulverized and sieve through 75 μm mesh for homogeneity, put in plastic vial, labelled with indelible marker for easy identification before sending to Bureau Veritas Laboratory LTd, Canada, for analysis . About 0.2 g of the samples was accurately weighed into a container perfluoroalkoxy polymer, which was then placed in a microwave pressure vessel (Ethos Plus Microwave Lactation, Milestone Inc., Shelton, CT, USA), using the standard of USEPA method 3052. After the addition of 4 ml concentrated nitric acid and 0.5 ml concentrated hydrochloric acid, the samples were digested by using a microwave power progressively increasing up to 400 W during 40 min. After cooling, the solutions were accurately diluted to 100 ml with water. However, an open digestion in a glass beaker was conducted with 0.5 g of sample, weighed perfectly, by heating with 12 ml of aqua regia for 40 min, followed by evaporation to dryness. 25 ml of concentrated hydrochloric acid and 2.5 ml of hydrogen peroxide were added to the hot residue with an accurate dilution of 50 ml of water. One replicate per digestion method was done for each sample. The total content of heavy metals in the building materials was analyzed using ICP-MS instrument connected to the intuitive WinLab32 software system comprises of the tools to analyze, report as well as achieving the measured data [7]. To calibrate the equipment, the standard solutions (panreac) of 100 mgL^{-1} of all metals were used, as such, were calibrated from 10 – 100 ppb

2.2 Quality Control for the analysis of Toxic Metals in the Sample: In this study, the quality control for the analysis of the samples using ICP-MS with model, Perkin Elmer ICP-MS was conducted with the standard operation procedures (SOPs) according to the manufacturer. All the equipment used in this study was calibrated before taken measurements. A calibration curve close to 1 was obtained for ICP-MS before the analysis was conducted on the samples so that the absorption of the atom of each element to be measured will be more accurate.

2.3 Statistical evaluation of Toxicity Risks of Selected Heavy Metal on Dwellers: Explanatory analysis of Toxic Metals Measured in the Building Material Samples was carried out using descriptive statistics. Statistical implications and Factor Analysis (FA) were also executed to identify the contributions of dermal contact and inhalation exposure dose risks to children aged from 0.5 to 11 years and to adult with ages ranges from 12 to 70 years. Data evaluation was accomplished by using statistical analysis tool of XLSTAT and data analysis functions in EXCEL application of Microsoft Office Application (MCA).

3.0 Results and Discussion

3.1 The Toxic Metal Concentrations Measured in the Samples: In Table 1, the concentrations of Cr, Pb, Zn, Ni, Fe, As, and Cd were measured using ICP-MS. The concentrations of Cr in all the building materials ranges from 10 ppm to 183 ppm with the highest value of 183 ppm found in Golden crown ceramics Nigeria, whereas the lowest value of 10 ppm was noted in Green pearl India marble. The

highest Pb concentration in the building materials was noted in Goodwill verified tile with a value of 68.70 ppm whereas a lower value of 8.96 ppm was found in Dangote Cement (42.5N) Grade. For Zn, the highest concentration reported in Goodwill ceramics with a value of 733.7 ppm, whereas the lowest value of 35.4 ppm was found in Green pearl India marble. The Ni concentration was found higher in Interlock Stone Site1 with a value of 690.5 ppm whereas a lower value of 14.4 ppm was found in Elephant Portland Cement. The Fe level reported higher in Black Galaxy with a value of 4.64 ppm and the lowest value of 0.95 ppm was noted in Goodwill verified tile. The As level in the building materials was found higher in Dangote Cement (42.5N) Grade with a value of 14.7 ppm whereas a lower value of 0.7 ppm reported in Golden pearl India marble. The concentration of Cd reported higher in Goodwill verified tile with a value of 2.9 ppm and a lower value of 0.14 ppm was noted in Black Galaxy India

Table 1: The Concentrations of Toxic Metals Measured in the Building Material Samples

Sample ID	Country of Origin	Cr	Pb	Zn	Ni	Fe	As	Cd
Black Galaxy India	India	57	10.06	118.6	24.5	4.64	4.0	0.14
BN Ceramics Floor tiles	Nigeria	69	68.41	425.2	54.7	3.57	10.8	0.49
BN Floor tiles Benia-	Spain	58	67.62	448.2	71.8	2.77	6.5	1.24
Dangote Cement (42.5N) Grade	Nigeria	78	8.96	98.1	23.3	2.14	14.7	0.56
Elephant Portland Cement	Nigeria	65	9.81	61.1	14.4	1.73	10.4	0.65
Golden Crom Floor tiles Ogum-	Nigeria	182	52.36	259.6	268.7	2.00	6.1	0.22
Golden crown Ceramics Nig-	Nigeria	183	57.44	644.0	333.6	1.82	3.9	0.22
Goodwill ceramics	Nigeria	98	54.87	733.7	80.3	2.71	5.3	1.01
Goodwill verified tile	India	34	68.70	429.6	22.4	0.95	4.8	2.49
Green Pearl India	India	10	11.75	35.4	656.7	2.30	0.7	0.02
Goodwill Super Polish Porcelain tiles	India	95	39.48	696.6	103.6	2.28	3.4	0.46
Interlock stone tiles site 3-CU	Nigeria	35	17.75	86.6	1769.1	2.40	8.4	0.34
Interlock Stone Site1	Nigeria	21	16.10	58.9	690.5	2.47	5.0	0.19
Interlock Stone Site:2	Nigeria	34	26.60	91.5	431.7	3.24	5.2	0.20

The dermal absorption of chemical from contaminated building materials was estimated according to [9]. This dermal absorption of contaminants from the samples solely depends on the area of contacts, the duration of contact, the chemical and physical attraction between the contaminant and the samples, and the ability of the contaminant to penetrate the skin. Another factor to consider while ascertaining presentation dosages from dermal contact is the introduction recurrence and term. Youthful youngsters, more established kids, and grown-ups are relied upon to have diverse introduction recurrence and length. Youthful kids would have an expanded introduction recurrence since they have a tendency to lie on the floor with skin subsequent to contacting the floor. Grown-ups would have a

diminished presentation recurrence since they have a tendency to have less time to be presented to be in contact with the floor [9]. Adults are expected to have less due to less time to be exposed to these materials in contact [9]. The formula used in this present study can be found in [9]

$$D = \frac{(C \cdot A \cdot AF \cdot EF \cdot CF)}{BW} \quad 1$$

Where,

D = dose (mg/kg/day)

C = contaminant concentration (mg/kg)

A = total soil adhered (mg)

AF = bioavailability factor (0.1)

EF = exposure factor (unitless)

CF = conversion factor (10^{-6} kg/mg)

BW = body weight (kg)

To calculate the exposure factor for age 12–17 according to [9-10] respectively

$$EF = (F \times ED) / AT$$

$$EF = (365 \text{ days/year} \times 5 \text{ year}) / (17 \text{ years} \times 365 \text{ days/year})$$

The exposure factor (EF) for age 0.5 – 11 = 0.09

To calculate the exposure factor for age 18–70 according to [9-10] respectively

$$EF = (F \times ED) / AT$$

$$EF = (365 \text{ days/year} \times 52 \text{ year}) / (70 \text{ years} \times 365 \text{ days/year})$$

The exposure factor (EF) for age 12-70 = 1 approximately

In Table 2, the building materials dermal contact dose for age between 0.5 – 11 years in $\text{mgkg}^{-1}\text{d}^{-1}$ was calculated for the contaminants using Equation 2 due to the presence of Cr, Pb, Zn, Ni, Fe, As and Cd respectively in the building material samples. The dermal exposure to children from Cr metal varies from $1.03 \times 10^{-7} \text{ mgkg}^{-1}\text{d}^{-1}$ (BN Floor tiles Benia) to $3.26 \times 10^{-4} \text{ mgkg}^{-1}\text{d}^{-1}$ with the highest value of exposure of $3.26 \times 10^{-4} \text{ mgkg}^{-1}\text{d}^{-1}$ found in Golden crown Ceramics Nigeria. For K metal, the dermal exposure to children varies from $3.74 \times 10^{-7} \text{ mgkg}^{-1}\text{d}^{-1}$ (Dangote Cement (42.5N) Grade) to $5.17 \times 10^{-6} \text{ mgkg}^{-1}\text{d}^{-1}$ (BN Ceramics Floor tiles). The dermal dose exposure from Pb in the materials varies from 1.59×10^{-5} (Dangote Cement (42.5N) Grade) to $1.22 \times 10^{-4} \text{ mgkg}^{-1}\text{d}^{-1}$ (BN Floor tiles Benia and Goodwill verified tile). The dermal exposure to children from the presence of Zn contaminant in the samples ranges from $6.31 \times 10^{-5} \text{ mgkg}^{-1}\text{d}^{-1}$ (Green Pearl India) to $1.31 \times 10^{-3} \text{ mgkg}^{-1}\text{d}^{-1}$ (Goodwill ceramics). Contaminant of Ni dermal exposure to children was found to vary from $2.57 \times 10^{-5} \text{ mgkg}^{-1}\text{d}^{-1}$ (Elephant

Table 2: Dermal Contact Dose Exposure for Age Group Between 0.5-11 years (mg/kg/day) and Dermal Contact Dose Exposure for Age Group Between 12-70 years (mg/kg/day)

Sample ID	Cr	Pb	Zn	Ni	Fe	As	Cd
1. Black Galaxy India	1.02×10^{-6}	1.79×10^{-5}	2.11×10^{-4}	4.36×10^{-5}	8.27×10^{-6}	7.13×10^{-6}	2.49×10^{-7}
2. BN Ceramics Floor tiles	1.23×10^{-4}	1.22×10^{-4}	7.57×10^{-4}	9.74×10^{-5}	6.36×10^{-6}	1.92×10^{-5}	8.73×10^{-7}
3. BN Floor tiles Benia-	1.03×10^{-7}	1.20×10^{-4}	7.98×10^{-4}	1.28×10^{-4}	4.93×10^{-6}	1.16×10^{-5}	2.21×10^{-6}
4. Dangote Cement (42.5N) Grade	1.39×10^{-4}	1.59×10^{-5}	1.74×10^{-4}	4.15×10^{-5}	3.81×10^{-6}	2.62×10^{-5}	9.98×10^{-7}
5. Elephant Portland	1.15×10^{-4}	1.75×10^{-5}	1.09	2.57	3.08	1.85×10^{-5}	1.16×10^{-6}

Cement			$\times 10^{-4}$	$\times 10^{-5}$	$\times 10^{-6}$	$\times 10^{-5}$	
6. Golden Crown Floor tiles Ogun	3.24×10^{-4}	9.33×10^{-5}	4.62 $\times 10^{-4}$	4.79 $\times 10^{-4}$	3.56 $\times 10^{-6}$	1.09×10^{-5}	3.92×10^{-7}
7. Golden crown Ceramics Nig-	3.26×10^{-4}	1.02×10^{-4}	1.15 $\times 10^{-3}$	5.94 $\times 10^{-4}$	3.24 $\times 10^{-6}$	6.95×10^{-6}	3.92×10^{-7}
8. Goodwill ceramics	1.75×10^{-4}	9.78×10^{-5}	1.31 $\times 10^{-3}$	1.43 $\times 10^{-4}$	4.83 $\times 10^{-6}$	9.44×10^{-6}	1.79×10^{-6}
9. Goodwill verified tile	6.06×10^{-5}	1.22×10^{-4}	7.65 $\times 10^{-4}$	3.99 $\times 10^{-5}$	1.69 $\times 10^{-6}$	8.55×10^{-6}	4.44×10^{-6}
10.Green Pearl India	1.78×10^{-5}	2.09×10^{-5}	6.31 $\times 10^{-5}$	1.17 $\times 10^{-3}$	4.09 $\times 10^{-6}$	1.25×10^{-6}	3.56×10^{-8}
11. Goodwill Super Polish Porcelain tiles	1.69×10^{-4}	7.03×10^{-5}	1.24 $\times 10^{-3}$	1.85 $\times 10^{-4}$	4.06 $\times 10^{-6}$	6.06×10^{-6}	8.19×10^{-7}
12. Interlock stone tiles site 3-CU	6.24×10^{-5}	3.16×10^{-5}	1.54 $\times 10^{-4}$	3.15 $\times 10^{-3}$	4.28 $\times 10^{-6}$	1.49×10^{-5}	6.08×10^{-7}
13. Interlock Stone Site1	3.74×10^{-5}	2.87×10^{-5}	1.05 $\times 10^{-4}$	1.23 $\times 10^{-3}$	4.40 $\times 10^{-6}$	8.91×10^{-6}	3.38×10^{-7}
14. Interlock Stone Site:2	6.06×10^{-5}	4.74×10^{-5}	1.63 $\times 10^{-4}$	7.69 $\times 10^{-4}$	5.77 $\times 10^{-6}$	9.26×10^{-6}	3.56×10^{-7}
1. Black Galaxy India	6.06×10^{-5}	1.07×10^{-5}	1.26 $\times 10^{-4}$	2.61 $\times 10^{-5}$	4.94 $\times 10^{-6}$	4.25×10^{-6}	1.49×10^{-7}
2. BN Ceramics Floor tiles	7.34×10^{-5}	7.28×10^{-5}	4.52 $\times 10^{-4}$	5.82 $\times 10^{-5}$	3.79 $\times 10^{-6}$	1.15×10^{-5}	5.21×10^{-7}
3. BN Floor tiles Benia-	6.17×10^{-5}	7.19×10^{-5}	4.77 $\times 10^{-4}$	7.64 $\times 10^{-5}$	2.95 $\times 10^{-6}$	6.91×10^{-6}	1.31×10^{-6}
4. Dangote Cement (42.5N) Grade	8.29×10^{-5}	9.53×10^{-6}	1.04 $\times 10^{-4}$	2.48 $\times 10^{-5}$	2.28 $\times 10^{-6}$	1.56×10^{-5}	5.96×10^{-7}
5. Elephant Portland Cement	6.91×10^{-5}	1.04×10^{-5}	6.49 $\times 10^{-5}$	1.53 $\times 10^{-5}$	1.84 $\times 10^{-6}$	1.11×10^{-5}	6.91×10^{-7}
6. Golden Crown Floor tiles Ogun	1.94×10^{-4}	5.57×10^{-5}	2.76 $\times 10^{-4}$	2.86 $\times 10^{-4}$	2.13 $\times 10^{-6}$	6.49×10^{-6}	2.34×10^{-7}
7. Golden crown Ceramics Nig-	1.95×10^{-4}	6.11×10^{-5}	6.85 $\times 10^{-4}$	3.55 $\times 10^{-4}$	1.94 $\times 10^{-6}$	4.15×10^{-6}	2.34×10^{-7}
8. Goodwill ceramics	1.04×10^{-4}	5.84×10^{-5}	7.80 $\times 10^{-4}$	8.54 $\times 10^{-5}$	2.88 $\times 10^{-6}$	5.64×10^{-6}	1.07×10^{-6}
9. Goodwill verified tile	3.62×10^{-5}	7.31×10^{-5}	4.57 $\times 10^{-4}$	2.38 $\times 10^{-5}$	1.01 $\times 10^{-6}$	5.11×10^{-6}	2.65×10^{-5}
10.Green Pearl India	1.06×10^{-5}	1.25×10^{-5}	3.77 $\times 10^{-5}$	6.99 $\times 10^{-4}$	2.45 $\times 10^{-6}$	7.45×10^{-7}	2.13×10^{-8}
11. Goodwill Super Polish Porcelain tiles	1.01×10^{-4}	4.19×10^{-5}	7.41 $\times 10^{-4}$	1.10 $\times 10^{-4}$	2.43 $\times 10^{-6}$	3.62×10^{-6}	4.89×10^{-7}
13. Interlock stone tiles site 3-CU	3.72×10^{-5}	1.88×10^{-5}	9.21 $\times 10^{-5}$	1.88 $\times 10^{-3}$	2.55 $\times 10^{-6}$	8.94×10^{-6}	3.62×10^{-7}
14. Interlock Stone Site1	2.23×10^{-5}	1.71×10^{-5}	6.27 $\times 10^{-5}$	7.34 $\times 10^{-4}$	2.63 $\times 10^{-6}$	5.32×10^{-6}	2.02×10^{-7}
15. Interlock Stone Site:2	3.62×10^{-5}	2.83×10^{-5}	9.73 $\times 10^{-5}$	4.59 $\times 10^{-4}$	3.45 $\times 10^{-6}$	5.53×10^{-6}	2.13×10^{-7}

Portland Cement) to $3.15 \times 10^{-3} \text{mgkg}^{-1}\text{d}^{-1}$ (Interlock stone site 3-CU). Dermal exposure from the Fe contaminant in the samples ranges from $3.08 \times 10^{-6} \text{mgkg}^{-1}\text{d}^{-1}$ (Elephant Portland Cement) to $8.27 \times 10^{-6} \text{mgkg}^{-1}\text{d}^{-1}$ (Black Galaxy India). The dermal dose exposure to children from the contaminant of As in the building materials varies from $1.25 \times 10^{-6} \text{mgkg}^{-1}\text{d}^{-1}$ (Green Pearl India) to $2.62 \times 10^{-5} \text{mgkg}^{-1}\text{d}^{-1}$ (Dangote Cement (42.5N) Grade). Dermal exposure to children from Cd contaminant in building materials ranges from $2.49 \times 10^{-7} \text{mgkg}^{-1}\text{d}^{-1}$ (Black Galaxy India) to $4.44 \times 10^{-6} \text{mgkg}^{-1}\text{d}^{-1}$ (Goodwill verified)

Also in Table 2, the building materials dermal contact dose for age group between 12 - 70 years in $\text{mgkg}^{-1}\text{d}^{-1}$ was calculated using Equation 2 for the contaminants due to the presence of Cr, Pb, Zn, Ni, Fe, As and Cd respectively in the building material samples. The dermal exposure to children from Cr metal varies from $1.03 \times 10^{-7} \text{mgkg}^{-1}\text{d}^{-1}$ (BN Floor tiles Benia) to $3.26 \times 10^{-4} \text{mgkg}^{-1}\text{d}^{-1}$ with the highest value of exposure of $3.26 \times 10^{-4} \text{mgkg}^{-1}\text{d}^{-1}$ found in Golden crown Ceramics Nigeria. The dermal dose exposure from Pb in the materials varies from 1.59×10^{-5} (Dangote Cement (42.5N) Grade) to $1.22 \times 10^{-4} \text{mgkg}^{-1}\text{d}^{-1}$ (BN Floor tiles Benia and Goodwill verified tile). The dermal exposure to children from the presence of Zn contaminant in the samples ranges from $6.31 \times 10^{-5} \text{mgkg}^{-1}\text{d}^{-1}$ (Green Pearl India) to $1.31 \times 10^{-3} \text{mgkg}^{-1}\text{d}^{-1}$ (Goodwill ceramics). Contaminant of Ni dermal exposure to children was found to vary from $2.57 \times 10^{-5} \text{mgkg}^{-1}\text{d}^{-1}$ (Elephant Portland Cement) to $3.15 \times 10^{-3} \text{mgkg}^{-1}\text{d}^{-1}$ (Interlock stone site 3-CU). Dermal exposure from the Fe contaminant in the samples ranges from $3.08 \times 10^{-6} \text{mgkg}^{-1}\text{d}^{-1}$ (Elephant Portland Cement) to $8.27 \times 10^{-6} \text{mgkg}^{-1}\text{d}^{-1}$ (Black Galaxy India). The dermal dose exposure to children from the contaminant of As in the building materials varies from $1.25 \times 10^{-6} \text{mgkg}^{-1}\text{d}^{-1}$ (Green Pearl India) to $2.62 \times 10^{-5} \text{mgkg}^{-1}\text{d}^{-1}$ (Dangote Cement (42.5N) Grade). Dermal exposure to children from Cd contaminant in building materials ranges from $2.49 \times 10^{-7} \text{mgkg}^{-1}\text{d}^{-1}$ (Black Galaxy India) to $4.44 \times 10^{-6} \text{mgkg}^{-1}\text{d}^{-1}$ (Goodwill verified)

The dermal contact dose from age 12 – 70 years is presented in Table 3. The dermal exposure to children from Cr metal exposure varies from $2.23 \times 10^{-5} \text{mgkg}^{-1}\text{d}^{-1}$ (Interlock Stone Site1) to $1.95 \times 10^{-4} \text{mgkg}^{-1}\text{d}^{-1}$ with the highest value of exposure of $1.95 \times 10^{-4} \text{mgkg}^{-1}\text{d}^{-1}$ found in Golden crown Ceramics Nigeria. The dermal dose exposure from Pb metal in the building materials varies from 9.53×10^{-6} (Dangote Cement (42.5N) Grade) to $7.28 \times 10^{-5} \text{mgkg}^{-1}\text{d}^{-1}$ (BN Ceramics Floor tiles). The dermal exposure to dwellers from the samples due to Zn metal contaminant ranges from $3.77 \times 10^{-5} \text{mgkg}^{-1}\text{d}^{-1}$ (Green Pearl India) to $7.80 \times 10^{-4} \text{mgkg}^{-1}\text{d}^{-1}$ (Goodwill ceramics). The dermal effect of Ni contaminant was found to vary from $1.53 \times 10^{-5} \text{mgkg}^{-1}\text{d}^{-1}$ (Elephant Portland Cement) to $1.88 \times 10^{-3} \text{mgkg}^{-1}\text{d}^{-1}$ (Interlock stone site 3-CU). Dermal exposure from the Fe contaminant in the samples ranges from $1.01 \times 10^{-6} \text{mgkg}^{-1}\text{d}^{-1}$ (Goodwill verified tile) to $4.94 \times 10^{-6} \text{mgkg}^{-1}\text{d}^{-1}$ (Black Galaxy India). The dermal dose exposure from the contaminant of As in the building materials varies from $7.45 \times 10^{-7} \text{mgkg}^{-1}\text{d}^{-1}$ (Green Pearl India) to $1.56 \times 10^{-5} \text{mgkg}^{-1}\text{d}^{-1}$ (Dangote Cement (42.5N) Grade). Dermal exposure due to the presence of Cd metal contaminant in the building materials ranges from $1.49 \times 10^{-7} \text{mgkg}^{-1}\text{d}^{-1}$ (Black Galaxy India) to $2.65 \times 10^{-5} \text{mgkg}^{-1}\text{d}^{-1}$ (Goodwill verified)

3.2 Exposure Doses Due to Inhalation of Toxic Metals in the Sample: Inhalation is an essential pathway for human introduction to contaminants that exist as environmental gases or are adsorbed to airborne particles or strands. Inward breath introduction of contaminants from perilous waste destinations can happen because of direct arrival of gases and particles from an on location office, volatilization of gases from polluted soils or water bodies, or re-suspension of dust and particles from debased soil surfaces [11]. While evaluating introduction to barometrical gases, by and large, the estimation of breathed in dosage isn't essential. The dosages in the toxicological writing are accounted for as focuses that can be specifically contrasted with fixations estimated at a site. Inward breath rates are considered when contemplating measurement reaction connections and in building up the screening esteems. A measurement count might be vital while considering introduction of contaminants clung to the samples and breathed in. As the wellbeing assessor, it ought to as well consider the inward breath of dusts from polluted soils. In the both children and adults, the measurement of a dirt contaminant from oral ingestion is probably going to surpass the dosage due to

dust inward breath [11]. In any case, for defiled dusts, chemicals that have particular harmful impacts on the respiratory tract (e.g., chromium and lung disease) may require extraordinary concern. The Equation used is in [11]

The Inhalation Risk Exposure from Heavy Metals in Building Materials (Age of 0.5 – 11)

The inhalation risk exposure due to toxic metals in building materials between the age group of 0.5 – 11 years emanating from Cr, Pb, Zn, Ni, Fe, As and Cd are presented in Table 4 using Equations 1 and 2 respectively. For Cr, the highest value of $81.9\text{mgkg}^{-1}\text{d}^{-1}$ found in Golden crown Ceramics Nigeria. The lowest value of the inhalation risk was found in Green Pearl India with a value of $4.5\text{mgkg}^{-1}\text{d}^{-1}$. Also, for Pb content in the samples, the highest value of $30.915\text{mgkg}^{-1}\text{d}^{-1}$ was found in Goodwill verified tile, whereas the lowest value of $4.032\text{mgkg}^{-1}\text{d}^{-1}$ was noted in Dangote Cement (42.5N) Grade. The inhalation risks due to Zn contents in the materials varies from 15.93 to $201.69\text{mgkg}^{-1}\text{d}^{-1}$ with the highest value of $201.69\text{mgkg}^{-1}\text{d}^{-1}$ found in BN Floor tiles Benin and the lowest value of $15.93\text{mgkg}^{-1}\text{d}^{-1}$ was noted in Green Pearl India. The Ni contents reported higher in Golden Crom Floor tiles Ogom with a value of $120.915\text{mgkg}^{-1}\text{d}^{-1}$ and the lowest value of $6.48\text{mgkg}^{-1}\text{d}^{-1}$ was found in Elephant Portland Cement. For Fe level in the samples, the highest value of $2.088\text{mgkg}^{-1}\text{d}^{-1}$ was found in Black Galaxy India whereas the lowest value of $0.4275\text{mgkg}^{-1}\text{d}^{-1}$ was noted in Goodwill verified tile. The inhalation risk from As in the samples noted higher in Dangote Cement (42.5N) Grade with a value of $6.615\text{mgkg}^{-1}\text{d}^{-1}$, whereas a lower value of $0.315\text{mgkg}^{-1}\text{d}^{-1}$ reported in Green Pearl India. The toxic content of Cd in the samples was noted higher in Goodwill verified tile with a value of $1.1205\text{mgkg}^{-1}\text{d}^{-1}$ and a lower value of $0.009\text{mgkg}^{-1}\text{d}^{-1}$ was found in Green Pearl India.

Table 3: The Inhalation exposure dose for Children, 0.5 - 11 years and The Inhalation Risk Exposure from Heavy Metals in Building Materials (Age of 12 – 70)

Company Name	Cr	Pb	Zn	Ni	Fe	As	Cd
1. Black Galaxy India	25.65	4.527	53.37	11.025	2.088	1.8	0.063
2. BN Ceramics Floor tiles	31.05	30.7845	191.34	24.615	1.6065	4.86	0.2205
3. BN Floor tiles Benin-	26.1	30.429	201.69	32.31	1.2465	2.925	0.558
4. Dangote Cement (42.5N) Grade	35.1	4.032	44.145	10.485	0.963	6.615	0.252
5. Elephant Portland Cement	29.25	4.4145	27.495	6.48	0.7785	4.68	0.2925

6. Golden Crom Floor tiles Ogum-	81.9	23.562	116.82	120.915	0.9	2.745	0.099
7. Golden crown Ceramics Nig-	82.35	25.848	289.8	150.12	0.819	1.755	0.099
8. Goodwill ceramics	44.1	24.6915	330.165	36.135	1.2195	2.385	0.4545
9. Goodwill verified tile	15.3	30.915	193.32	10.08	0.4275	2.16	1.1205
10. Green Pearl India	4.5	5.2875	15.93	295.515	1.035	0.315	0.009
11. Goodwill Super Polish Porcelain tiles	42.75	17.766	313.47	46.62	1.026	1.53	0.207
12. Interlock stone tiles site 3- CU	15.75	7.9875	38.97	796.095	1.08	3.78	0.153
1. Black Galaxy India	12.54	2.2132	26.092	5.39	1.0208	0.88	0.0308
2. BN Ceramics Floor tiles	15.18	15.0502	93.544	12.034	0.7854	2.376	0.1078
3. BN Floor tiles Benin-	12.76	14.8764	98.604	15.796	0.6094	1.43	0.2728
4. Dangote Cement (42.5N) Grade	17.16	1.9712	21.582	5.126	0.4708	3.234	0.1232

5. Elephant Portland Cement	14.3	2.1582	13.442	3.168	0.3806	2.288	0.143
6. Golden Crom Floor tiles Ogum-	40.04	11.5192	57.112	59.114	0.44	1.342	0.0484
7. Golden crown Ceramics Nig-	40.26	12.6368	141.68	73.392	0.4004	0.858	0.0484
8. Goodwill ceramics	21.56	12.0714	161.414	17.666	0.5962	1.166	0.2222
9. Goodwill verified tile	7.48	15.114	94.512	4.928	0.209	1.056	0.5478
10. Green Pearl India	2.2	2.585	7.788	144.474	0.506	0.154	0.0044
11. Goodwill Super Polish Porcelain tiles	20.9	8.6856	153.252	22.792	0.5016	0.748	0.1012
12. Interlock stone tiles site 3- CU	7.7	3.905	19.052	389.202	0.528	1.848	0.0748
13. Interlock Stone Site1	4.62	3.542	12.958	151.91	0.5434	1.1	0.0418
14. Interlock Stone Site:2	7.48	5.852	20.13	94.974	0.7128	1.144	0.044

The Inhalation Risk Exposure from Heavy Metals in Building Materials (Age of 12 – 70)

The inhalation exposure dose for adult due to heavy metal contents are shown in Table 4. The highest value obtained from Cr was found in Golden crown Ceramics Nigeria with a value of $40.26 \text{ mgkg}^{-1}\text{d}^{-1}$, whereas a lowest value of $2.2 \text{ mgkg}^{-1}\text{d}^{-1}$ reported in Green Pearl India. For Pb dose exposure, the highest value of $15.114 \text{ mgkg}^{-1}\text{d}^{-1}$ was found in Goodwill verified tile and the lower value of $1.9712 \text{ mgkg}^{-1}\text{d}^{-1}$ was noted in Dangote Cement (42.5N) Grade. The Zn content exposure dose noted higher in Goodwill ceramics with a value of $161.414 \text{ mgkg}^{-1}\text{d}^{-1}$ whereas the lowest value of $7.788 \text{ mgkg}^{-1}\text{d}^{-1}$ was found in Green Pearl India. The dose exposure due to inhalation from Ni shows higher value of $389.202 \text{ mgkg}^{-1}\text{d}^{-1}$ from Interlock stone tiles site 3-CU and a lowest value of $3.168 \text{ mgkg}^{-1}\text{d}^{-1}$ reported in Elephant Portland Cement. The highest exposure dose from Fe reported in Black Galaxy India with a value of $1.0208 \text{ mgkg}^{-1}\text{d}^{-1}$ and $0.209 \text{ mgkg}^{-1}\text{d}^{-1}$ lower value noted in Goodwill verified tile. The As exposure from the building materials indicated higher value in Dangote Cement (42.5N) Grade with a value of $3.234 \text{ mgkg}^{-1}\text{d}^{-1}$ and the lowest value of $0.154 \text{ mgkg}^{-1}\text{d}^{-1}$ was noted in Green Pearl India. The dose exposure from Cd noted higher in Goodwill verified tile with a value of $0.5478 \text{ mgkg}^{-1}\text{d}^{-1}$, whereas a lower value of $0.0044 \text{ mgkg}^{-1}\text{d}^{-1}$ reported in Green Pearl India.

3.3 Statistical analysis Using Principal Factor Analysis (PFA):

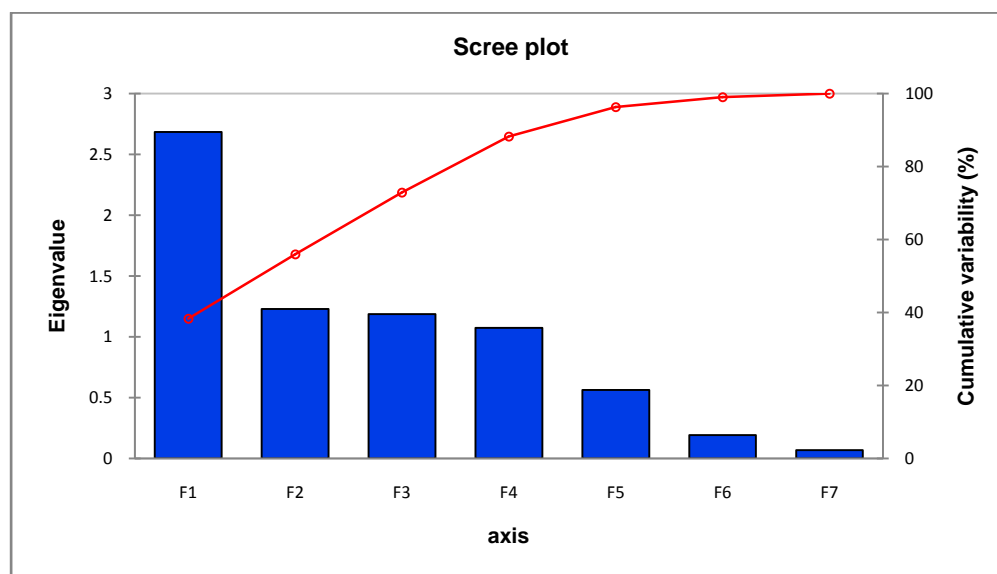


Figure 1. Scree plot of Dermal Contact Dose Exposure for Age Group Between 0.5-11 years (mg/kg/day)

From the figure 1.above, a sharp drop is noticed immediately after Factor 4 (F4) which is Ni. This simply means that other heavy metals after Ni have little or no effect on the children of this category.

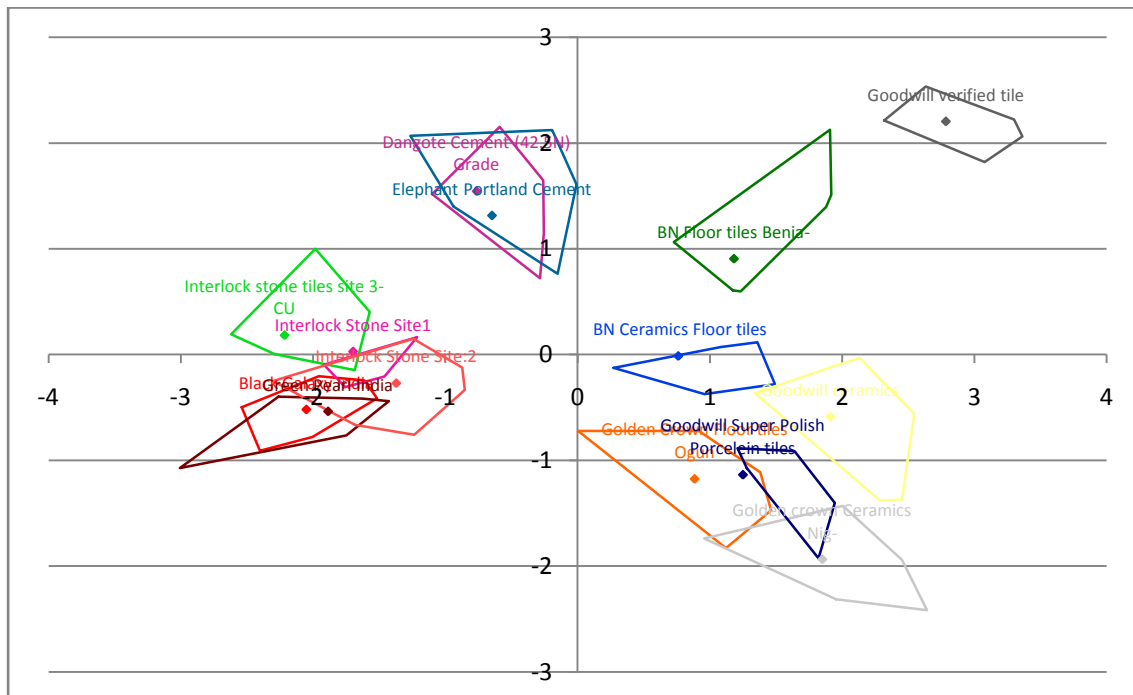


Figure 2. Plot showing the factor scores of Cr, Pb, Zn and Ni of Dermal Contact Dose Exposure for Age Group Between 0.5-11 years (mg/kg/day) against selected building materials in Nigeria.

These four metals were picked by factor analysis because of their significant risks due to the high Dermal Contact Dose Exposure values gotten from the experiments. The high factor loadings are due to these four heavy metals. High factor value of 2.786 was seen in Goodwill Verified Tile.

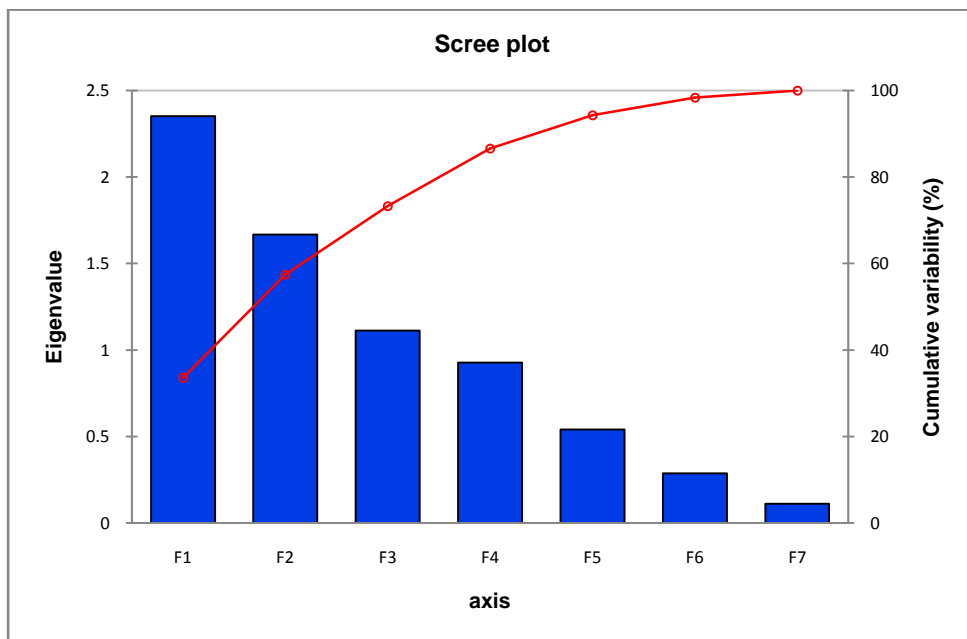


Figure 3. Scree plot of Dermal Contact Dose Exposure for Age Group Between 12-70 years (mg/kg/day)

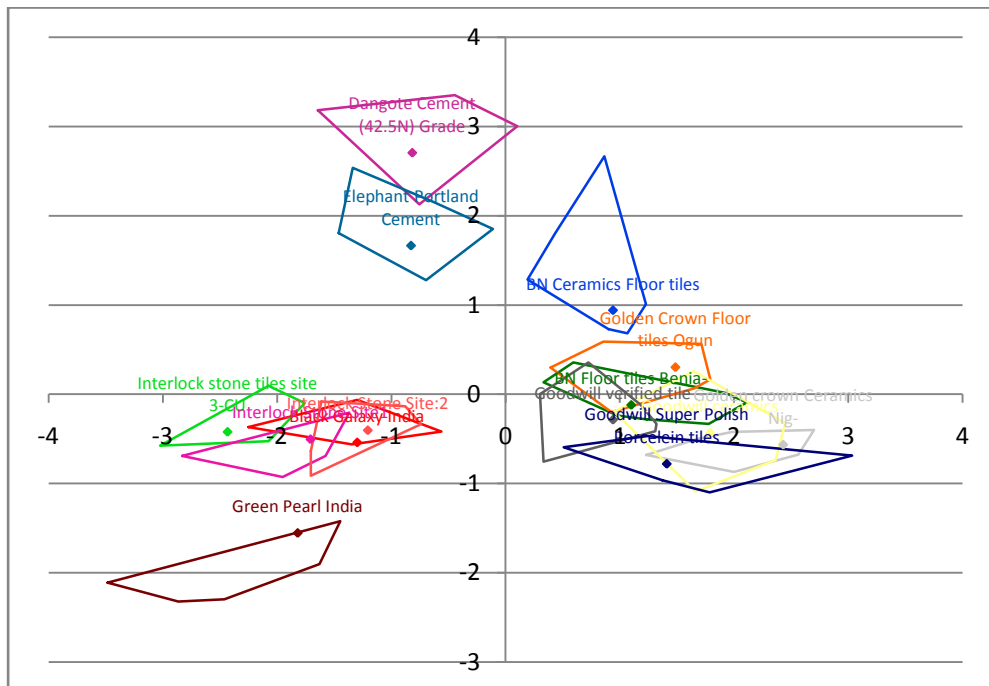


Figure 4. Plot showing the factor scores of Cr, Pb, Zn and Ni of of Dermal Contact Dose Exposure for Age Group Between 12-70 years (mg/kg/day) against selected building materials in Nigeria.

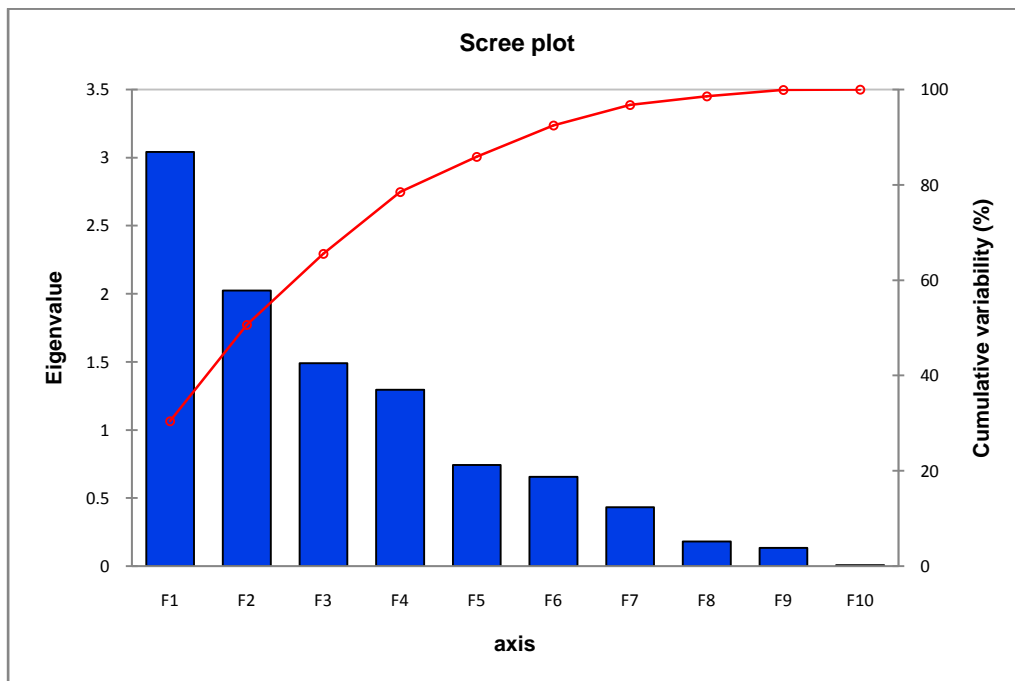


Figure 5. Scree plot of Inhalation exposure dose for Children, 0.5 - 11 yr.

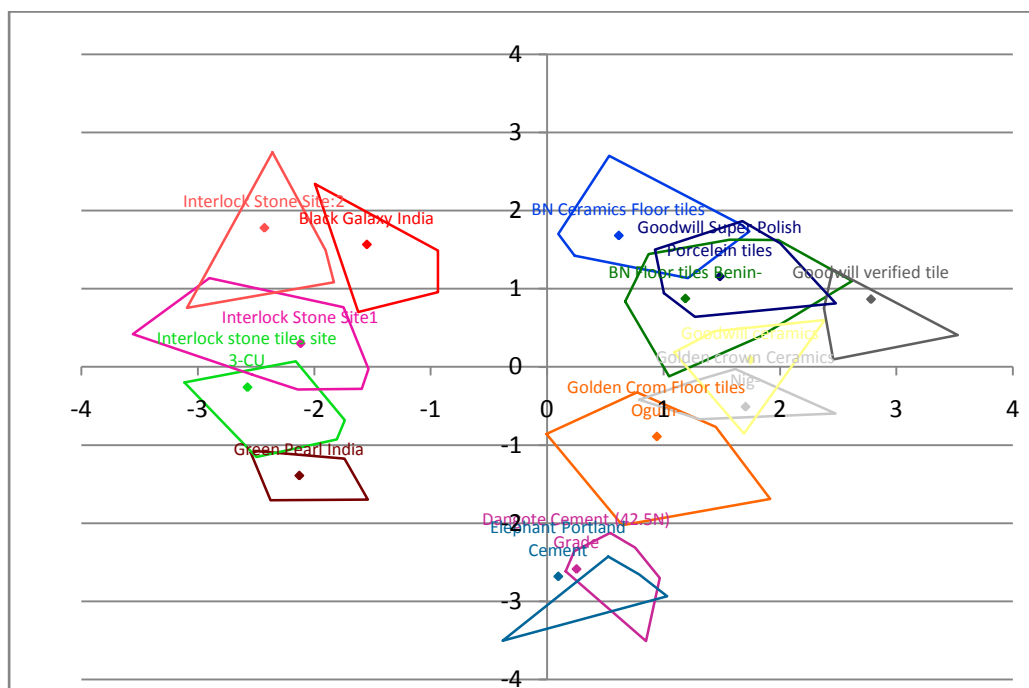


Figure 8. Plot showing the factor scores of Cr, Pb, Zn and Ni of Inhalation exposure dose for Adult, 12-70 yrs. against selected building materials in Nigeria.

4 Conclusion

Highly elevated heavy metals of Cr, Pb, Zn, Ni, Fe, As and Cd were found presence above the recommended level by European Regulatory Standard (EUS) and United State Environmental Protection Agency (USEPA), permissible limit indicating a threat to the general public that rely on these materials. The few that are below 100 mgkg^{-1} for Cr, 150 mgkg^{-1} for Pb, 30 mgkg^{-1} for Zn, 50 mgkg^{-1} for Ni, 150 mgkg^{-1} for Fe and 3 mgkg^{-1} for Cd by WHO, USEPA and EURS permissible level pose health risk due to its toxicant features as well as bio-accumulative in nature. Significantly, this study has shown that the potential risks to the users due to the heavy metals toxicity risks may pose higher risks on under-aged children within the 0.5 to 11 years old. This study will be used for bio-accumulative assessment and indoor pollution control.

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