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Dust pollution and its potential health risk exposure to inhabitants of Covenant University and canaanland, Ogun state, Nigeria

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Abstract. Understanding the background concentration of heavy metals in dust samples is so much important for identifying and managing pollution. Thus, these concentrations in dust can be distributed indoors and outdoors in order of magnitudes. This study demonstrates the risk analysis of dust samples collected from selected buildings in both Covenant University and Canaanland using Atomic Absorption Spectrometer (AAS). The obtained concentrations were used to determine the Geo-accumulation, Contaminant Factor and the Pollution Loading Index (PLI). The highest geo-accumulation index and pollution loading index of 3.108 and 0.5836 due to chromium (Cr) contents in the dust samples were noted in Lecture Theatre 2 (LT2). The higher values found in LT2 may be due to the wide open of both doors and windows. Both the Geo-accumulation Index and Pollution Load Index were found to be lower than the permissible level suggested by World Health Organization (WHO) and United State Environmental Protection Agency (USEPA). Significantly, these observations from this study will provide the basis for the background concentrations and potential risks of some important heavy metals of environmental concern

1. Introduction

Dust is made up of particles in powdered form, spread on the earth's surface or spread around about by natural or mechanical forces [1]. There are two types of dusts indoor and outdoor dust but for this study we are going to focus on indoor dust. Dust found indoor is a combination of particulate matter gotten from different sources. Dust can get into buildings through different ways, which are infiltration from outside sources and internally from smoking, incense burning, building and furniture material, consumer product and occupants activities [2] [3]. Dusts on modern impervious surface have become one of the most pressing issues in modern environmental management. On one hand, exterior dusts can be easily re-suspended under definite outside dynamic condition; pollutants adsorbed on them enter human body by the pathways of respiratory inhalation and direct skin contact and cause negative health effects. Children and the elderly, whose immune systems are either underdeveloped or age-



compromised as well as the inadvertent ingestion of significant quantities of dust through hand-to-mouth pathways, are more vulnerable to toxicity. Biological mechanism is due to the effects from heavy metals especially from the bioaccumulation. Set of human beings (such as infant or child) are extremely prone to environmental interference due to the growth of their organ at the early stage of development, which cause them to be more susceptible to the disorder or functional damage [4]. It has been found out that the crystalline silica dust is a major health concern, considering the lodges in the lungs of human, as such causing respiratory damage like silicosis. It also increases the potential risk of lung disease like bronchitis, tuberculosis, etc. [5]. This present study aimed at assessing the geo-accumulation and pollution load indices to the dwellers of the selected buildings under assessment in both Covenant University and Canaanland.

1.1 The Geological Location of the Study Area

Covenant University is in Ogun State, which falls within the Eastern Dahomey (Benin) Basin of southwestern Nigerian that stretches along the continental margin of the Gulf of Guinea. Rocks in the Dahomey basin are Late Cretaceous to Early Tertiary in age. The stratigraphy of the basin has been classified into Abeokuta Group, Imo Group, Oshoshun, Ilaro and Benin Formations. The Cretaceous Abeokuta Group consists of Ise, Afowo and Araromi Formations consisting of poorly sorted ferruginized grit, siltstone and mudstone with shale-clay layers.

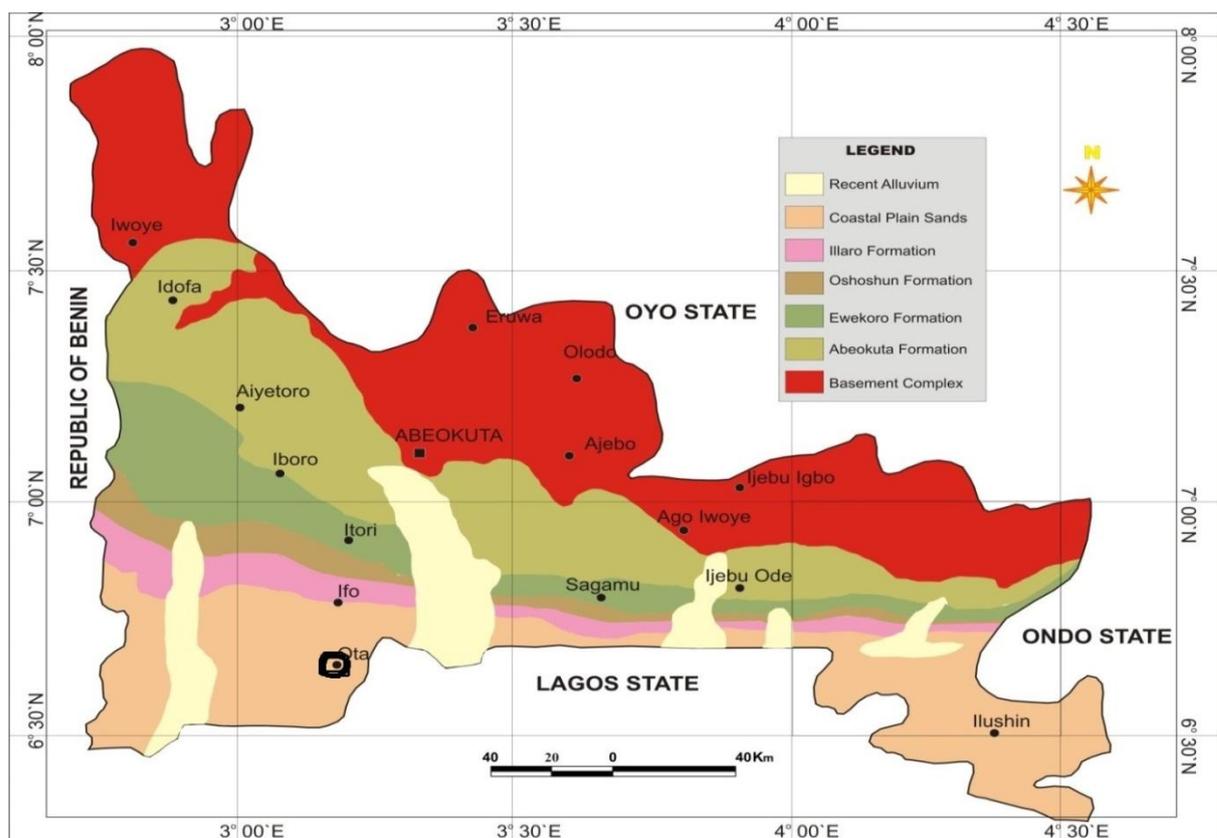


Figure 1: Geological Map of the Study Area

2. Materials and Methods

Dust samples were collected from 5 different buildings in both Covenant University (Lecture Theaters One and Two, African Development Centre, Chapel) and Canaanland (Faith Tabernacle) using a manual filter membrane with wooden handle and plastic packer. Each of the filters is destroyed after use to avoid cross-contamination. This method was according to the standard of Airborne Agents through Filtration[6]

2.1. Data collection

The samples were collected thrice per location for 3 weeks for accurate analysis and sieved through 75 μ m mesh for homogeneity and easy digestion. About 0.2g of the samples was accurately weighed into a container per fluoroalkoxy 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.[7] One replicate per digestion method was conducted per sample. The total content of heavy metals in the dust was analyzed using GF- AAS instrument connected to the intuitive WinLab32 software system comprises of the tools to analyze, report as well as achieving the measured data.[8] To calibrate the equipment, the standard solutions (panreac) of 100mgL⁻¹ of all metals were used, as such, were calibrated from 10 – 100ppb.

2.1.1. Instruments.

The major instrument used for the purpose of this study is a spectrophotometer. It is simply an instrument which determines the concentration of solutes in a solution by measuring the amount of light that is absorbed by the spectrophotometer. The light intensity is measured as a function of wavelength. A spectrophotometer optically determines the absorbance or transmission of characteristic wavelengths of radiant energy (light) by a chemical species in solution. Each molecule absorbs light at certain wavelengths in a unique spectral pattern because of the number and arrangement of its characteristic functional groups such as double bonds between carbon atoms. It is based on Beer-Lamberts Law which states that the amount of light absorbed at the particular wavelength is directly proportional to the concentration of the chemical species.

Quality Control for the analysis of Heavy Metals Dust Sample

In this study, the quality control for the analysis of the dust samples using GF-AAS with model No: Perkin Elmer A Analyst 600 with the standard operation procedures (SOPs) according to the manufacturer. All other measurement meters such as TDS, pH and conductivity meters as well as the weigh balance were operated according the instructions of the SOPs to reduce analysis errors. All the equipment used in this study was calibrated before taken measurements. A calibration curve close to 1 was obtained for GF-AAS before the analysis was conducted on the bottled water samples so that the absorption of the atom of each element to be measured will be more accurate.

2.1.2. Risk assessment

2.1.3.1 Geo-accumulation Index

In this study, the risk analysis for Geo-accumulation Index (I_{geo}) of each heavy metal was calculated using the formula below:

$$I_{geo} = \ln\left(\frac{C}{1.5 \cdot BV}\right)$$

1

Where,

I_{geo} = Geoaccumulation Index.

C = Contaminant Concentration.

BV = Background Value

2.1.3.2 Contamination Factor

Contamination factor is gotten from the equation stated below.

$$CF = \frac{\text{Concentration in the dust}}{\text{Background Value}} \quad 2$$

Contamination is gotten from Table 1 and Background value is gotten from Table 2

2.1.3.3 Pollution Load Index (PLI)

Pollution Load Index (PLI) is an index that is utilized in measuring the levels of heavy metals at the buildings for this study. The calculation was done using this equation stated below.

$$PLI = (CF_1 * CF_2 * \dots * CF_n)^{\frac{1}{n}} \quad 3$$

Where,

CF = Contaminant Factor.

N = Number of Elements.

2.1.3.4 Dermal Effect

The dermal effect was calculated using formula used is stated below:

$$D = \frac{(C * A * AF * EF * CF)}{BW} \quad 4$$

Where,

D = Exposure Dosage ($\text{mgkg}^{-1}\text{day}^{-1}$)

C = Contaminant concentration (mgkg^{-1})

A = Total soil adhered (mg)

EF = Exposure Factor (unit less) = 1

CF = Conversion Factor (10^{-6}kgmg^{-1})

BW = Body Weight (kg)

2.1.3.5 The Inhalation Effect

The Equation used is for inhalation effect is stated below:

$$D = \frac{(C * IR * EF)}{BW} \quad 5$$

Where,

D = Exposure Dose ($\text{mgkg}^{-1}\text{day}^{-1}$)

C = Contaminant Concentration (mgm^{-3})

IR = Intake rate ($\text{m}^3\text{day}^{-1}$)

EF = Exposure Factor (unit less)

BW = Body Weight (kg)

3. Results and discussion

3.1. Concentrations of Measured Heavy Metals in the Various Dust Samples

The concentrations of Lead (Pb), Chromium (Cr), Cadmium (Cd), Nickel (Ni), Iron (Fe), Arsenic (As), Copper (Cu) in all the samples collected from the buildings are presented in table below.

Table 1: Concentration of Heavy Metal in the dust samples from African Leadership & Development Centre (Aldc), Chapel, Faith Tabernacle (Ft), Lecture Theatre 1 (Lt 1) and Lecture Theatre 2 (Lt 2).

Sample	Pb	Cr	Cd	Ni	Fe	As	Cu
Aldc (Week1)	0.2521	12.8209	0	9.9964	3299.703	0	10.9979
Aldc (Weel2)	0.212	12.5612	0	9.88	3468.1	0	11.6612
Aldc (Week3)	0.3675	10.4912	0	11.72	4567.32	0	11.8771
Chapel (Week1)	0.1133	2.4891	0	8.93	3561.11	0	14.2119
Chapel (Week2)	0.1173	5.8761	0	10.55	3201.001	0.0001	13.998
Chapel(Week 3)	0	5.6723	0	7.69	4001.783	0	11.0135
Ft (Week1)	0	9.3572	0	7.9915	3012.557	0.00012	11.8334
Ft 2(Week2)	0.0001	14.1772	0	10.8751	3789.121	0	12.2435
Ft (Week3)	0.0081	7.1002	0	9.9214	3904.4	0	11.7017
Lt 1 (Week 1)	0.2712	0	0	10.576	4012.871	0	10.9993
Lt 1 (Week 2)	0.3299	0	0	10.1044	4077.101	0	12.7812
Lt 1 (Week 3)	0.3761	5.1207	0	8.9955	3102.41	0	12.9711
Lt 2 (Week 1)	0	14.9991	0	9.2391	3869.98	0	10.1274
Lt 2 (Week 2)	0.0092	9.0771	0	10.0001	3901.999	0.0021	12.1145
Lt 2 (Week 3)	0	14.0921	0	9.4112	3892.095	0	10.7331

3.2. Risk Analysis

The estimated concentration of Pb in all the samples varies from 0.0001mgkg^{-1} to 0.3761mgkg^{-1} with the highest value of 0.3761mgkg^{-1} found in Lecture theatre 1, whereas the lowest value of 0.0001mgkg^{-1} reported in Faith Tabernacle as shown in Figure 1. Comparing the highest value of Lead (Pb) obtained in this present study with the international standard by World Health Organization (WHO) and United States Environmental Protection Agency (USEPA) with a value of 55mgkg^{-1} , this present study is lower by a factor of 146.24.

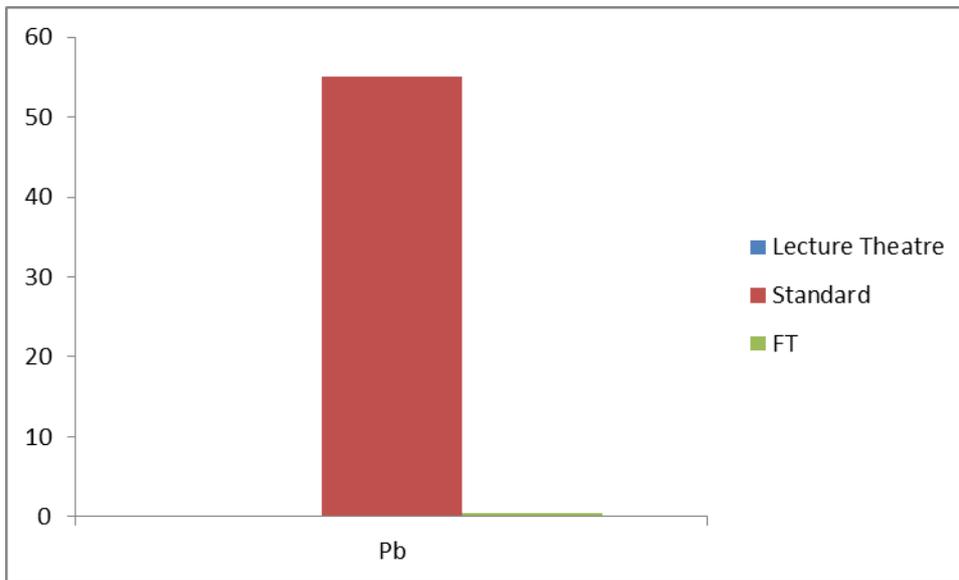


Figure 2: Comparing the Highest Values of Pb in the Dust Samples and the International Reference Standard

The concentration of Chromium (Cr) in the various samples ranges from 2.4891mgkg⁻¹ to 14.9772mgkg⁻¹ with the highest value of 14.9772mgkg⁻¹ which is found in Lecture Theatre 2 and the lowest value of 2.4891mgkg⁻¹ found in Chapel as shown in Figure 3. When comparing the highest value of Chromium (Cr) gotten in this present study with the international standard by United States Environmental Protection Agency (USEPA) and World Health Organization (WHO) with a value of 3.8mgkg⁻¹, this current study is higher by a factor 3.94 which means faith tabernacle is harmful to individual due to the chromium concentration and precautions should be taken.

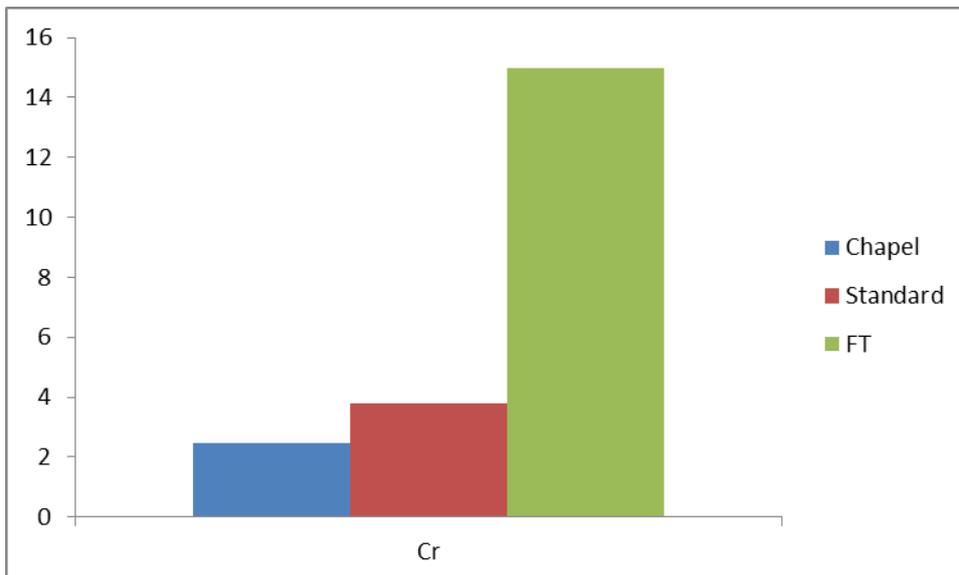


Figure 3: Comparing the Highest Values of Cr in the Dust Samples and the International Reference Standard

The concentration of Cadmium (Cd) in the samples collected from the various locations is not detected. Therefore it doesn't conflict with the international standard by World Health Organization

(WHO) and United States Environmental Protection Agency (USEPA) with a mark of 0.76mgkg^{-1} which means the environment is cadmium free.

The concentration of Nickel (Ni) in the samples collected varies from 7.69mgkg^{-1} to 11.72mgkg^{-1} with the most concentrated level of 11.72mgkg^{-1} found at the African Leadership & Development Centre (ALDC) and with the least concentrated level of 7.69mgkg^{-1} found at Chapel. When the most concentrated amount is compared to that of the international standard by United States Environmental Protection Agency (USEPA) and World Health Organization (WHO) with a value of 2.6mgkg^{-1} , this recent study shows that the highest concentration of the samples is higher by a factor of 4.51 which identifies ALDC as harmful to people to concentration levels and steps should be taken to prevent ailments to individuals.

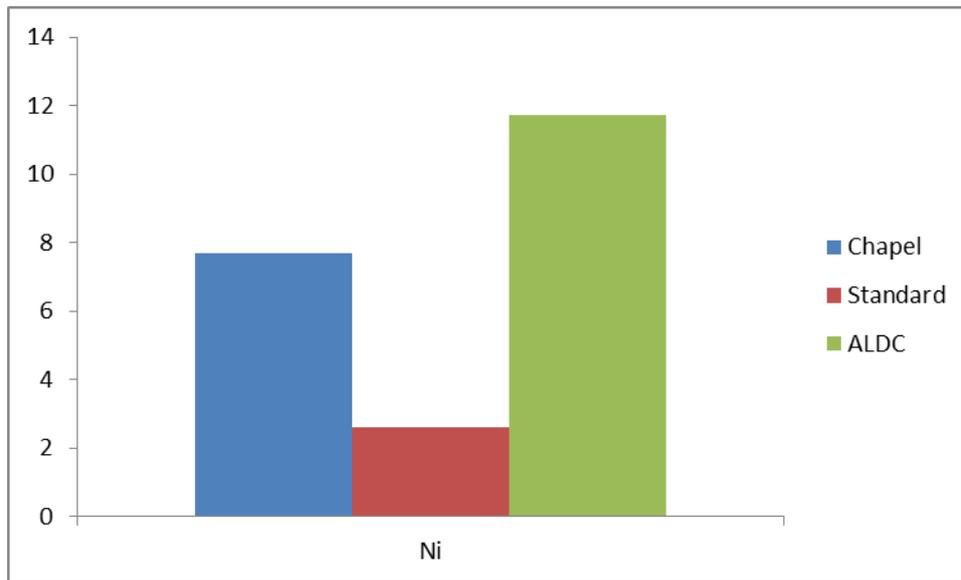


Figure 4: Comparing the Highest Values of Ni in the Dust Samples and the International Reference Standard

The concentration of Arsenic (As) in the various samples ranges from 0.0001mgkg^{-1} to 0.0012mgkg^{-1} with the highest value of 0.0021mgkg^{-1} which is found in Lecture theatre 2 and the lowest value of 0.0001mgkg^{-1} found in Chapel. When comparing the highest value of Arsenic (As) gotten in this present study with the international standard by United States Environmental Protection Agency (USEPA) and World Health Organization (WHO) with a value of 4.5mgkg^{-1} , this current study is lower than the standard.

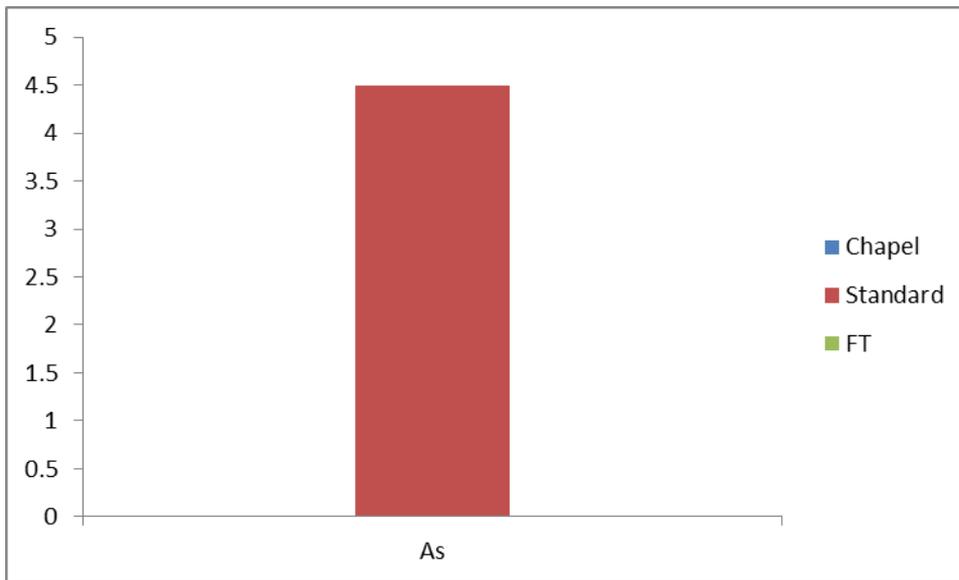


Figure 5: Comparing the Highest Values of As in the Dust Samples and the International Reference Standard

The concentration of Copper (Cu) in the samples collected varies from 10.1274mgkg⁻¹ to 14.2119mgkg⁻¹ with the most concentrated level of 14.2119mgkg⁻¹ found at Chapel and with the least concentrated level of 7.69mgkg⁻¹ found at Lecture Theatre 2. When the most concentrated amount is compared to that of the international standard by United States Environmental Protection Agency (USEPA) and World Health Organization (WHO) with a value of 3.5mgkg⁻¹, this recent study shows that the highest concentration of the samples is higher by a factor of 4.06 which identifies Chapel as harmful to people due to concentration levels and steps should be taken to prevent ailments to individuals.

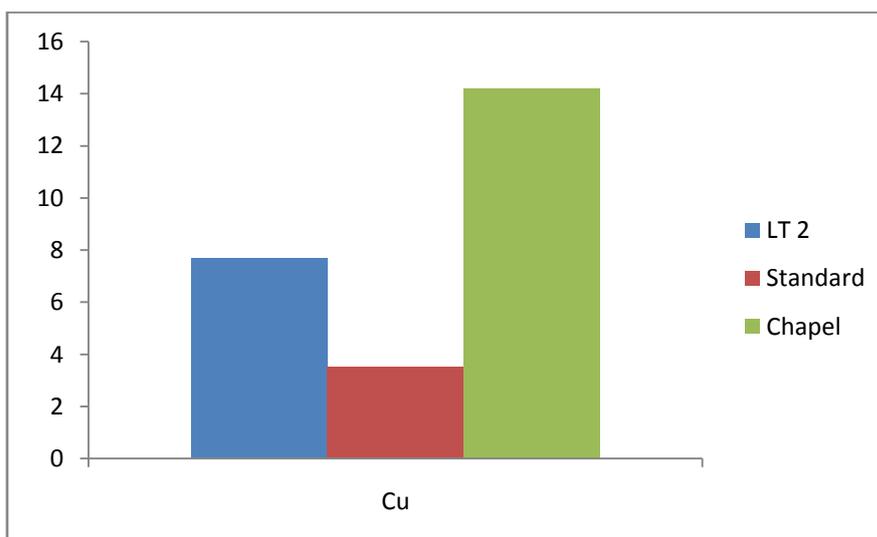


Figure 6: Comparing the Highest Values of Cu in the Dust Samples and the International Reference Standard

The pollution risk assessment methods used for this study which are the Geo-Accumulation Index (I_{geo}) and Pollution Load Index which is also known as PLI. They were adopted in this present study to assess the levels of contamination due to heavy metals originating from the dust samples.

3.3. Geo-accumulation Index

Geo-accumulation Index (I_{geo}) which is the used to estimate the level of heavy metal accumulated or contained in the sample was measured using the formula below suggested by[9]

$$I_{geo} = \ln\left(\frac{C}{1.5 \cdot BV}\right) \quad 6$$

Where,

I_{geo} = Geoaccumilation Index.

C = Contaminant Concentration.

BV = Background Value.

The 1.5 is to bring down the effect of likely deviation in the sample background values. The I_{geo} for each heavy metal was computed and classified [10] “uncontaminated” ($I_{geo} \leq 0$); “uncontaminated to moderately contaminated” ($0 < I_{geo} \leq 1$); “moderately contaminated” ($1 < I_{geo} \leq 2$); “moderately to heavily contaminated” ($2 < I_{geo} \leq 3$); “heavily contaminated” ($3 < I_{geo} \leq 4$); “heavily to extremely contaminated” ($4 < I_{geo} \leq 5$); “extremely contaminated” ($I_{geo} \geq 5$)

Note: Contaminant Concentration can be gotten from Table 1

Table 2: This represents the background value of chromium, Nickel, Iron and Copper.

Background Value			
Cr	Ni	Fe	Cu
0.42	68	47600	45

Table 3: This shows the geo-accumulation index of Chromium, Nickel, Iron and Copper.

Geo-Accumulation Index of Heavy Metals				
Sample ID	Cr	Ni	Fe	Cu
ALDC (Week 1)	-	-	-	-
	3.013112	2.32275	3.07447	1.81442
ALDC (Week 2)	-	-	-	-
	2.992648	2.33446	3.02469	1.75586
ALDC (Week 3)	-	-	-	-
	2.812572	2.16368	2.74937	1.73752
Chapel (Week 1)	-	-	-	-
	1.373957	2.43556	2.99823	1.55805
Chapel (Week 2)	-	-	-	-
	2.232929	2.26885	3.10483	1.57321
Chapel (Week 3)	-	-	-	-
	2.19763	2.58505	2.88156	1.81301
FT (Week 1)	-	-	-	-
	2.698182	2.54659	3.16551	-1.7412
FT (Week 2)	-	-	-	-
	3.068565	-2.2385	2.93616	1.70713
FT (Week 3)	-	-	-	-
	2.422158	2.33028	2.90619	1.75239
LT 1 (Week 1)	-	-	-	-
	0	2.26639	2.87879	-1.8143
LT 1 (Week 2)	-	-	-	-
	0	-2.312	2.86291	1.66415
LT 1 (Week 3)	-	-	-	-
	2.095327	2.42825	3.13612	-1.6494
LT 2 (Week 1)	-	-	-	-
	2.955167	2.40153	2.91505	1.89688
LT 2 (Week 2)	-	-	-	-
	2.66779	2.32238	2.90681	1.71772
LT 2 (Week 3)	-	-	-	-
	3.10765	2.38307	2.90935	-1.8388

This present study of the Geo-Accumulation Index shows that Chromium (Cr) was found to be lower at Chapel (week 1) with a value of 1.373957, whereas the highest value was noted in Lecture theatre 2 (Week 2) with a value of 3.10765 as shown in Table 1. With this value closer to the recommended value, it implies that Lecture Theatre may be contaminated if not properly swept daily.

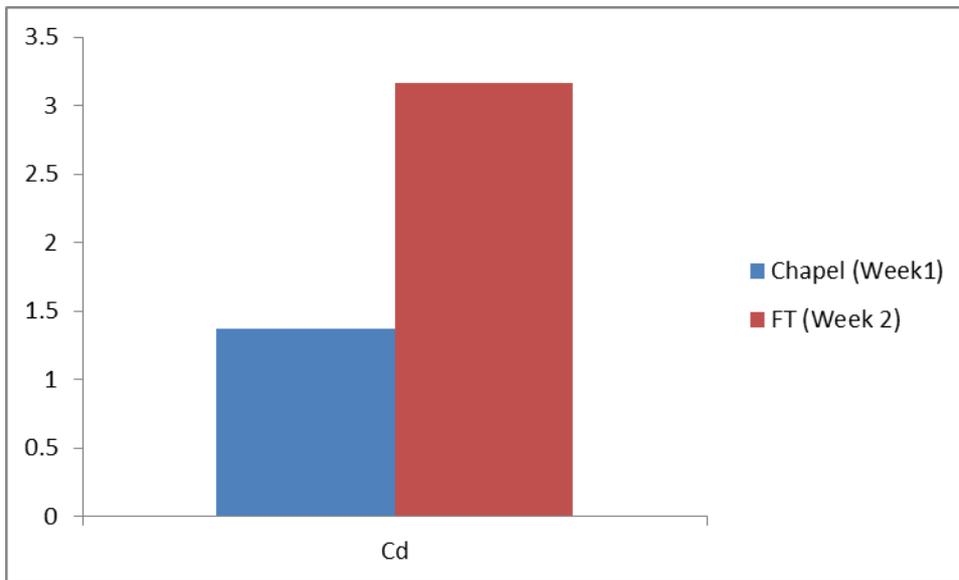


Figure 7: Comparing the Highest Values of Geo-Accumulation Index Due to Cr in the Dust Samples and the International Reference Standard

Chromium (Cr) is found to be lower at Chapel (week 3) with a value of -2.58505 and the highest value was noted at ALDC (Week 3) with a value of -2.16368 as shown in Table 2. Geoaccumulation due to Nickel (Ni) was found to be lower at Faith Tabernacle (Week 1) with a value of -3.16551 and the highest was noted at ALDC (Week 3) of about -2.74937 as shown in Table 2. For Copper (Cu), it is lower at Lecture Theatre 2 (Week 1) with a value of -1.89688 and the highest value was found at Lecture Theatre 1 (Week 2) with a value of -1.66415 as shown in Table 2 which means no building is contaminated by copper. With these values, lower than the recommended values indicate that none of the buildings is contaminated.

3.4. Contamination Factor

Contamination factor is gotten from the equation stated below.

$$CF = \frac{\text{Concentration in the dust}}{\text{Background Value}} \quad 7$$

Concentration is gotten from Table 1 and Background value is gotten from Table 2.

Table 4: This shows the conservation factors of Chromium, Nickel, Iron and Copper.

Sample ID	Contamination Factor			
	Cr	Ni	Fe	Cu
ALDC (Week 1)	30.52595	0.147006	0.069322	0.244398
ALDC (Week 2)	29.90762	0.145294	0.072859	0.259138
ALDC (Week 3)	24.97905	0.172353	0.095952	0.263936
Chapel (Week 1)	5.926429	0.131324	0.074813	0.31582
Chapel (Week 2)	13.99071	0.155147	0.067248	0.311067
Chapel (Week 3)	13.50548	0.113088	0.084071	0.244744
FT (Week 1)	22.27905	0.117522	0.063289	0.262964
FT (Week 2)	35.66	0.159928	0.079603	0.272078
FT (Week 3)	16.90524	0.145903	0.082025	0.260038
LT 1 (Week 1)	0	0.155529	0.084304	0.244429
LT 1 (Week 2)	0	0.148594	0.085653	0.284027
LT 1 (Week 3)	12.19214	0.132287	0.065177	0.288247
LT 2 (Week 1)	28.80738	0.135869	0.081302	0.225053
LT 2 (Week 2)	21.61214	0.14706	0.081975	0.269211
LT 2 (Week 3)	37.55262	0.1384	0.081767	0.238513

3.5. Pollution Load Index

Pollution Load Index (PLI), is an integrated pollution index was also utilized in measuring the levels of pollution of heavy metals at the selected buildings. The calculation was done using this equation stated below according to [11][12].

$$PLI = (CF_1 * CF_2 * \dots * CF_n)^{\frac{1}{n}} \quad 8$$

Where,

CF = Contaminant Factor.

N = Number of Elements.

The result of PLI = 0 means “background concentration”, $0 < PLI < 1$ means “unpolluted”,

$1 < PLI < 2$ indicates “unpolluted to moderately polluted”, $2 < PLI < 3$ means “moderately polluted”, $3 < PLI < 4$ signifies “moderately to highly polluted”, $4 < PLI < 5$ depicts “highly polluted” whereas $PLI > 5$ corresponds to “very highly polluted”.

Note: Concentration factor can be found in the table above and Background value is gotten from Table 2.

Table 5: This Table represents the values for the pollution load index.

Pollution Load Index (PLI)	
ALDC (Week 1)	0.525100322
ALDC (Week 2)	0.535194105
ALDC (Week 3)	0.574627945
Chapel (Week 1)	0.368246326
Chapel (Week 2)	0.461613968
Chapel (Week 3)	0.421038388
FT (Week 1)	0.456888624
FT (Week 2)	0.512833268
FT (Week 3)	0.478924759
LT 1 (Week 1)	0
LT 1 (Week 2)	0
LT 1 (Week 3)	0.417218198
LT 2 (Week 1)	0.517312461
LT 2 (Week 2)	0.514625869
LT 2 (Week 3)	0.583577407

In this recent study, Pollution Load Index (PLI) is found to be lower in Chapel (Week 3) with a value of 0.421038388 and higher at Lecture theatre2 (Week 2) with a value of 0.583577407 as shown in Table 4. In contrast with the international standard, all of the selected buildings indicate unpolluted with the pollution loading index reference values.

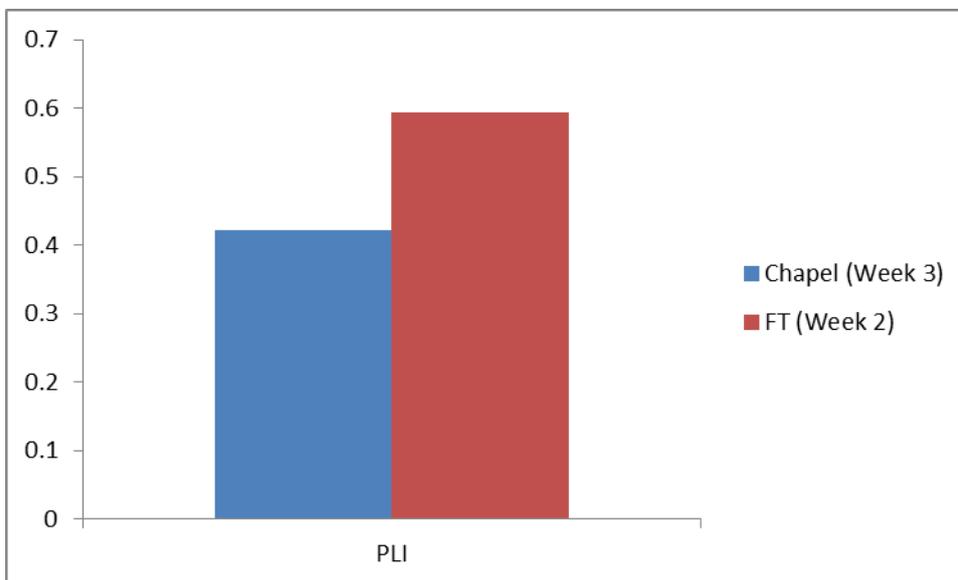


Figure 8: Comparing the Highest Values of Pollution Load Index in the Dust Samples and the International Reference Standard

4 Conclusion

This present study aimed at monitoring the impact of distribution of heavy metal contamination in surface dust samples in selected buildings to understand the exposure and health assessments due to fine particle size dust to dwellers. The result revealed that the geoaccumulation index and pollution loading index for all the areas under study do not exceed the pollution limit level suggested by United State Environmental Agency (USEPA). This present study will serve as the pollution control/management to promote the health of the people living in both urban and highly industrialized areas. There is real urgency for Nigerian government to look into creating a separate agency solely for monitoring dust pollution. This study also suggests the need for awareness to dangers of dust to be brought to the attention of people. Further studies can be carried out using more enhanced methods and instruments to detail the contaminant levels as well as risks on inhabitants.

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