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Characteristic Distribution and Source Apportionment of Heavy Metals (Zn, Pb, Cu, Ni and Cd) on Street Dust of Ikeja Area of Lagos State, Southwestern Nigeria

Ojiodu C.C.[1,*] , Eruola A. O.[2] , Damazio, O. A.[3] and Oshin, T. T.[3]

[1]College Central Research Laboratory, Yaba College of Technology, Yaba - Lagos, Nigeria.
[2]Department of Chemical Sciences, Yaba College of Technology, Yaba - Lagos, Nigeria.
[3]Department of Chemical Sciences, Lagos State University of Science and Technology, Ikorodu - Lagos, Nigeria.
Corresponding Author: *Ojioduchekwube@yahoo.com

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ABSTRACT

This research reports the results of heavy metals characteristic distribution and Source apportionment of heavy metals in dust of Ikeja area of Lagos State. The dust samples were collected randomly four times a month August - December, 2022 at ten different locations in Ikeja area. Samples were obtained by sweeping surface dust into plastic waste packer using plastic brush and transferred into pre-labeled polythene bags. The samples collected at each location were filtered through 75 µm stainless steel sieve, weighed and digested with appropriate amount of HNO_3 and H_2O for 2 hours. The concentrations of heavy metals were analyzed using Atomic Absorption Spectrophotometer (AAS) PG - 990. Results of the analysis showed that the percentage contribution of each heavy metal at Ikeja area were: Zn - 62.12 %, Pb - 26.47 %, Cu - 8.34 % , Ni - 2.23 % and Cd - 0.84 % . The most abundant pollutant heavy metal was Zn - 2445.53 mg/kg while the least was Cd - 33.10 mg/kg. The most polluted site is Ikeja Industrial area - 654.48 mg/kg while the least polluted site is Ayodele diyan street - 150.50 mg/kg with percentage contributions 16.60 % and 3.82 % respectively. The sequence and distribution follow the pattern: Zn > Pb > Cu > Ni > Cd. The Principal Component Analysis PCA showed that the major sources of heavy metals in Ikeja dust are mainly anthropogenic and two factors PC1 and PC2 accounted for 73.61% of the total variance. Each of these factors were identified as sources of heavy metals in dust of Ikeja area with industrial activities dominating. Pearson's significant correlation analysis revealed that there is strong positive correlation (0.871) between Pb - Cd and moderate correlation (0.554) between Zn - Cu at 0.01 levels of significant. The concentrations of heavy metal obtained exceeded the recommended limits of the Federal Ministry of Environment (FME), European communities (EC) and United Nations Environmental Programme (UNEP) permissible level for heavy metals in dust suggesting that the study area is polluted.

Keywords: Heavy metals, Atomic Absorption Spectrophotometer, Dust, Environment, Significant.

1.0. Introduction

The levels of heavy metals (Zn, Pb, Cu, Ni and Cd) in the environment going beyond the acceptable limits is a serious concern to the environmentalists. Characteristic distribution of heavy metals in Street dust may depend upon the types and intensities of anthropogenic activities in the study area (Wang *et al.*, 2016; Li *et al.*, 2017). Dusts are fine solid particles in the atmosphere from various sources such as soil, dust lifted by wind and pollutions. Dust acts as sink and source of toxic metals to its corresponding environment especially soil and air (Men *et al.,* 2020). Street dust is a fine powder inform of fine sand or earth which can be found in the street (Lu *et al.*, 2014; Rahman *et al.*, 2019). Direct inhalation of dust by people traversing the streets and those residing in the vicinity could be by ingestion through hand-to-mouth, eating poorly washed fruits and vegetables and dermal exposure are the routes of human exposure to road dust (Lorenzo *et al.*, 2011). Heavy metal levels in dust are an important indicator of environmental contamination (Yadav *et al.,* 2019;

Dytlow *et al.*, 2021; Jahandari *et al.*, 2020).There are various methods of sampling dust. Those that have been reported include the use of: a plastic dustpan and a brush (Wei *et al.*, 2009, Aguilera *et al.*, 2019, Praveena *et al.*, 2019), a plastic hand broom and dustpan (Zhang et al., 2012; Soltani *et al.*, 2015), brushing 1 m^2 of previously delimited surface of asphalt (Reyes *et al.*, 2013), an ABA- 1-120-02A portable aspirator (Sahakyan *et al.*, 2016; Saghatel *et al.*, 2014), a brush and plastic hand shovel (Trujilo-Gonzalez *et al.*, 2016), a vacuum cleaner (Yu *et al.*, 2016; Tanner *et al.*, 2008) and a portable high-pressure washer device with a piston fitted into a rigid, sealed rubber dome (Budai *et al.*, 2018).

The term heavy metal may refer to any metallic substance with relatively high density and such a substance is toxic at low concentrations. Although, heavy metals are naturally occurring elements that are found in the earth's crust, they are mostly environmental, domestic and agricultural contaminants (Herawati *et al.*, 2000 and He *et al.*,2005). Examples of heavy metals include Zinc (Zn), Nickel (Ni), Copper (Cu), Mercury (Hg), Cadmium (Cd) , Chromium (Cr), Thallium (Tl) and Lead (Pb). Heavy metals are group of non-biodegradable pollutants. They are not readily detoxified and removed by metabolic activities once they are available in the environment. They cannot be degraded or destroyed. Heavy metals are dangerous because they tend to bio-accumulate (Bawuro *et al.*, 2018). To a small extent they enter our bodies via food, drinking water and air. As trace elements, some heavy metals (Copper, Lead, Zinc) are essential to maintain the metabolism of the human body. However, at higher concentrations they can lead to poisoning. Heavy metals can thus penetrate into the human body and pose a great threat to human (Aeolian *et al.*, 2008; Lu *et al.*, 2010). Sources of heavy metals in the environment include geogenic, industrial, agricultural, pharmaceutical, domestic effluents, and atmospheric sources (He *et al.*, 2005).The sources of toxic metals in dust can be from the resuspension and erosion of surrounding natural environment (soil parent materials) as well as anthropogenic activities such as fossil fuel combustion, traffic activities (e.g., brake lining, tire and asphalt wear), industrial activities, construction and demolition, waste dumping, and domestic emission (Ali *et al.*, 2017; Hou *et al.*, 2019; Wang *et al.*, 2020).The five metals to be addressed in this study (Zn, Pb, Ni, Cu and Cd) are among the most often found heavy metals in the atmosphere including dust and to a large extent are harmful to human beings and the entire ecosystems. For instance, Consumption of excessive amounts of Zinc might result in pancreatic problems, anemia, and muscle soreness (Roney *et al.*, 2006). Studies on atmospheric dust fall reported that Zn likely comes from the combustion of engines, fossil fuels, tire wear, vehicular emissions (Valotto *et al.*, 2015; Valotto, Cattaruzza and Bardelli, 2017; Hwang *et al.*, 2016; Kui Cai *et al.*, 2019). Pb in Street dust might be accumulated from traffic emission, industrial activity and as pollution from the use of arsenical pesticides, herbicides, crop desiccants and metal smelting (Bhuiyan *et al.*, 2015; Men *et al.*, 2018; Xiao *et al.*, 2020 ; Rahman *et al.*, 2019). Cu is regarded as a tracer for non-exhaust vehicle emission (Cui *et al.*, 2019; Rai *et al.*, 2021). Cu is used in lubricants to improve friction stability and emits during brake abrasion (Querol *et al.*, 2007; Amato *et al.*, 2014). Sources of Cu also include non-ferrous metallurgical industry, metal processing and refinery industry (Ramírez *et al.*, 2018; Men *et al.*, 2018). High levels of Copper exposure can impair the immune system; induce liver, renal, and gastrointestinal problems as well as Wilson's syndrome and anxiousness (Taylor *et al.*, 2020; Briffa *et al.*, 2020). Exposure to excessive amounts of Cd has been linked to renal disease, infertility, mental and digestive issues, and cancer (Faroon *et al.*, 2012). A number of health problems are associated with prolonged exposure to Cadmium particularly in children, including neurologic problems, kidney problems, high blood pressure, heart disease, and reproductive system problems (Abadin *et al.*, 2007). The major source of Cd in Street dust might be lubricating oil, diesel fuel, tire, and brake wear, batteries, plastic and building materials (Foti *et al.*, 2017; Men *et al.*, 2020; Heidari *et al.*, 2021; Wei *et al.*, 2010). Human exposed to Nickel, are more likely to suffer from respiratory problems, cardiovascular disease, and cancer (Buxton *et al.*, 2019).

Although, there are enormous studies on the levels of heavy metals on Street dust in the world (Cai K, Li C (2019); Abassi *et al.*, 2020; Yesilkanat and Kobya, 2021; Wang *et al.*, 2020; Xu *et al.*, 2021; Kara *et al.*, 2020; Li *et al.*, 2020) but currently there are little or no literature on heavy metals on Street dust in Lagos State, particularly in Ikeja area. The choice of Ikeja as the study area is due to the high vehicular and industrial activities within the study area. Therefore, the main objectives of the present study were to :(1) assess and evaluate the Characteristic distribution of heavy metals on Street dust of Ikeja area(Table 1). (2) determine whether there are significant differences in the levels of heavy metals in each of sites in the study area (Figure 1) and (3) determine the Sources of the heavy metals in the study area. It is hopeful that this study will provide the percentage contributions of each Heavy metal to pollution in Ikeja.

2.0. Methodology

2.1. Study Area

The study was conducted in the following areas of Ikeja (N6^0.61489 and E3^0.34174 - N6^0.59547 and E3^0.3363) Lagos State which include the Residential areas : Ojulowo street , Abeokuta street and Oyelola street ; Major roads - Agege motor road , Awolowo way and Ikeja under bridge and Industrial areas - Ladipo Oluwole Street , Ayodele diyan street, Oba Akran Industrial area and Ikeja Industrial area .

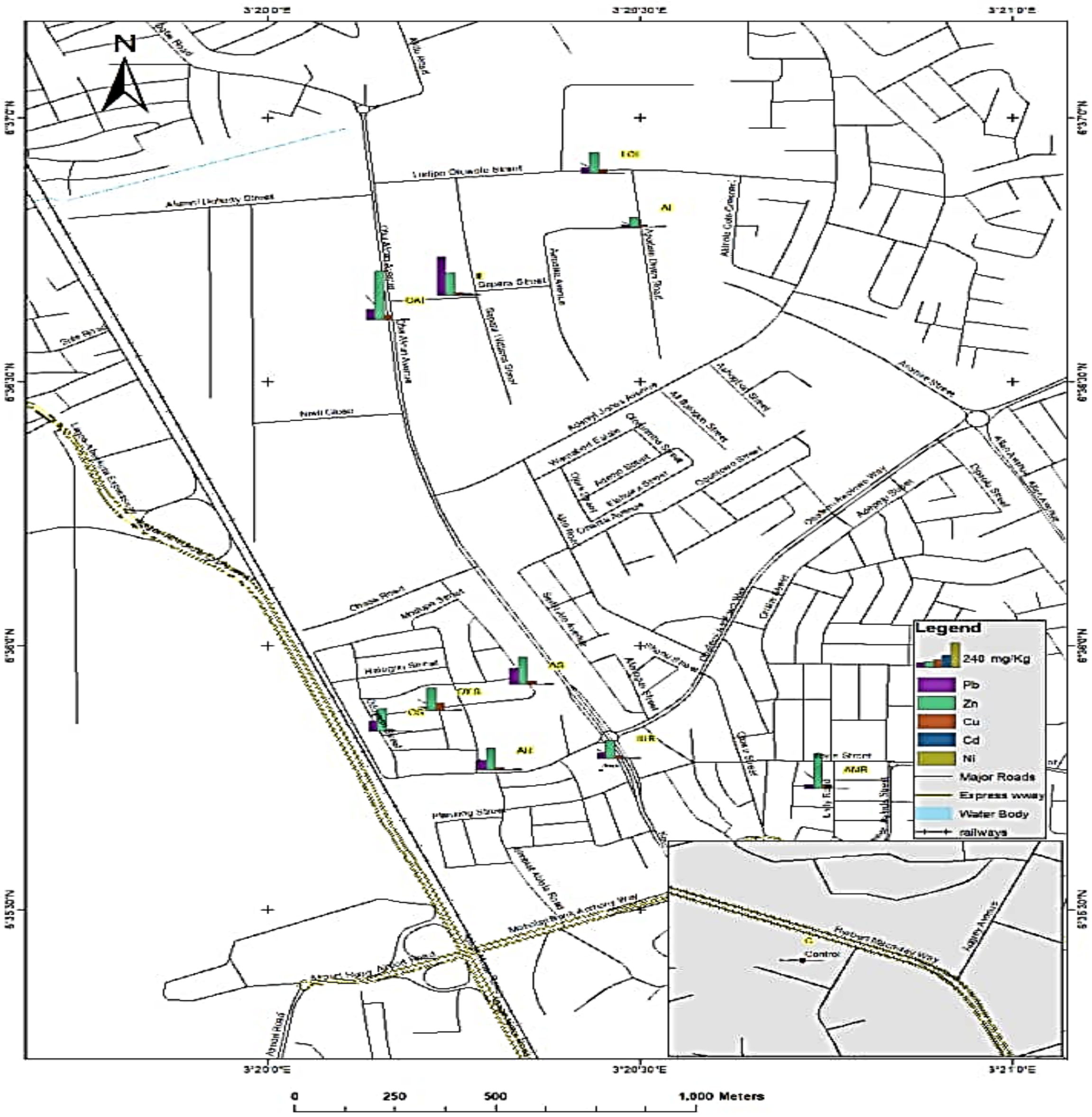

Figure 1: GPS Map of Ikeja showing average mean concentration of Heavy metals.

2.2 Selection of Sampling Sites

The eleven sites including the control site were carefully chosen based on accessibility, availability of open spaces and of course area with maximum influence from anthropogenic activities such as vehicular traffic density, human activities as well as industrial activities. The geo-referencing was carried out by using GPS MAP 76S (Garmin).

Table 1 : Sampling sites, Characteristics and their Coordinates in Ikeja Area.

Location/Sites	Code	Latitude	Longitude	Site Description
Ojulowo street	OS	N6^0.59644	E3^0.3412	It is a residential area with a micro finance bank, carpentry, spraying and painting workshops. Smoking of cigarette and marijuana is also prominent on this street.
Abeokuta street	AS	N6^0.59876	E3^0.33924	It is a residential area with low human activity.
Oyelola street	OYS	N6^0.59793	E3^0.33719	It is a residential area with high commercial activities, there are Mechanic workshops.
Awolowo road	AR	N6^0.59607	E3^0.33853	It is a major road with high commercial activities such as sales of cellular phone stores, fast food joints, Car spare parts shops and high vehicular activities.
Ikeja under bridge	IUR	N6^0.59644	E3^0.3412	It is a major road with high commercial activities such as sales of cellular phone stores, fast food joints, spare part stores, hairdressing salons and vehicular activities and smoking is also prominent.
Agege Motor road	AMR	N6^0.59547	E3^0.33583	It is a major express road with high commercial and vehicular activities.
Ladipo Oluwole street	LOI	N6^0.61489	E3^0.34084	It is an industrialized area with industries such as Mouka foam, Chelsea gin, pure water production lots of ware houses.
Oba Akran road	OAI	N6^0.61027	E3^0.33603	It is an industrialized area with industries such as Dangote, Newbisco, Nigerite, Textile production companies, Vita foam, Guinness and lots of banks and high vehicular activities.
Ayodele Diyan street	AI	N6^0.6132	E3^0.34174	It is an industrial area with no commercial activities.
Ikeja Industrial area	II	N6^0.61104	E3^0.33761	It is an industrialized area with most industries.
YCT Botanical garden (control)	BG (CTL)	N6^0.51626	E3^0.37369	It is an area with little or no Anthropogenic activity. A site where different agricultural crops and plant are grown.

2.3 Sample Collection

Dust samples were collected from eleven sites within the study area, at least 100m apart, four times a month from August to December, 2022. Samples were collected in the morning while the dust has settled well throughout the night and before heavy morning traffic movement that can disrupt the dust. The samples were randomly collected from both sides of the road by weeping surface dust into plastic waste packers using plastic brush and transferred into pre- labeled polythene bag(Shabbaj *et al.*, 2018 Aguilera *et al.*, 2019; Praveena *et al.*, 2019). All irrelevant materials such as cigarette ends, papers, plastics etc. were carefully handpicked. Thereafter, samples collected at each location were filtered through 75µm stainless steel sieve. The samples were then taken to the laboratory for further treatment and analysis.

2.4 Digestion of dust Samples for Heavy metals

2.0g of sieved dust was weighed using an analytical balance and transferred into a conical flask for digestion. 30ml nitric acid and 10ml concentrated hydrochloric acid prepared in the ratio 3:1 was added. The solution was mixed thoroughly and heated on magnetic heated stirrer, then refluxed at 90^{o}c for 20minutes. After the disappearance of brown fumes, the digested solution was cooled and then filtered through Whatman type 589/2 filter paper. The filtrate was diluted to 50cm3 with de-ionized water. The metal contents in the filtrate were determined using an Atomic absorption spectrophotometer (AAS) PG-990(Men *et al.*,2019; Benhaddya *et al.*, 2016).

2.5 Statistical Analysis

Analysis of Heavy metals were carriedout using ANOVA to check for the standard error and Significant differences of the mean concentration of the results from August - December, 2022 in Ikeja area (Table 3). Kaiser-Meyer-Olkin and Battlet's test were carried out to confirm the Sampling Adequacy(Table 2).

Table 2: KMO and Battlet's test

		Heavy metals
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.743
Bartlett's Test of Sphericity	Approx. Chi-Square	2447.309
	Df	55
	Sig.	0.000

3.0. Results and Discussion

3.1. Characteristic Distribution of Heavy metals in Ikeja Area

The most polluted site in Ikeja is Ikeja Industrial Area- 654.48 mg/kg; 16.60 %. (Table 3). This is as a result of anthropogenic activities going in and around the site such as release of gases from near by industries, fumes from generators and numerous heavy duty vehicular / traffic emission and commercial activities in and around the site while the least polluted site is Awolowo road - 150.50 mg/kg ; 3.82 %. The most abundant heavy metals is Zinc - 2449.53 mg/kg; 62.12 % while the least abundant heavy metal is Cadmium- 33.10 mg/kg ; 0.84 % (Figure 2**).** This can be attributed to the versatile use of Zinc in form of Zinc oxide present in paints, rubber tyres, cosmetics, pharmaceuticals, wearing of brake lining of vehicules, lossess of oil and cooling liquids from automobile, corrosion of galvanized steels, scrap iron bars and improper disposal of industrial waste in the area. There is a significant difference in the levels of Zinc metal in Ikeja Industial Area compared to other sites. The highest heavy metals Zn - 476.12 mg/kg ; Cu- 44.60 mg/kg and Ni- 2.39 mg/kg were recorded at Oba Akran Industrial site while the highest concentration of Pb - 378.60 mg/kg and Cd - 22.93 mg/kg were recorded at Ikeja Industrial site. The highest presence of lead in Ikeja Industrial site may be due to the high Industrial, commercial, automobile and vehicular activities in the area, spillage of petroleum products, smoking of cigarettes, paint chips from the walls of industrial buildings, careless discards of lead acid batteries used in automotive as well as the use of industrial grade and non - domestic paints by the surrounding industries. The level of Lead in Ikeja Industrial site significantly different ($p < 0.05$) from all other sites. The highest concentration of Copper and Nickel at Oba Akran Industrial site may be due to the manufacturing of electrical cables, mining of metal, production of cans and the use of pesticides, combustion of fossil fuels, smelting of metals, vehicular emission, traffic congestion and industrial processes that uses these metals or their compounds fuel combustion from generators as well as frequent bush burning in that surrounding. The level of Nickel at Oba Akran Industrial site is significantly different from all other sites ($p < 0.05$). The Characteristics distribution and degree of bioaccumulation of Heavy metal content of Ikeja dust is as follows: Zn > Pb > Cu > Ni > Cd, with the mean concentration of - 244.95, 104.37, 32.90, 8.81 and 3.3 mg/kg respectively (Table 3).

Table 3: Mean Concentration of Heavy Metals of all the sites in Ikeja Area for August - December, 2022. (mg/kg)

Sample Location/ Sites	Pb	Zn	Cu	Cd	Ni	Total	Percentage %
LOI	55.70	206.23	37.41	0.155	7.61	307.09	7.78
AS	162.03	273.11	32.86	0.44	10.00	478.43	12.13
AI	22.38	98.73	19.05	0.86	9.12	150.50	3.82
OS	99.915	221.30	17.08	0.59	6.49	345.37	8.76
OYS	39.30	224.75	74.41	1.57	9.94	349.97	8.87
II	378.60	217.32	25.05	22.96	10.54	654.48	16.60
IUR	50.81	173.51	23.94	2.97	6.73	257.95	6.54
AMR	39.96	343.59	38.66	2.31	7.52	432.05	10.96
OAI	101.36	476.12	44.60	1.196	12.39	635.66	16.12
AR	93.33	214.86	15.91	0.07	7.75	331.91	8.42

BG(CTL)	0.80	3.25	0.57	0.12	0.02	4.77	0.12
Total	1043.73	2449.53	328.97	33.10	88.09	3943.41	
Average	104.3727	244.96	32.90	3.31	8.81		
Percentage %	26.47	62.126	8.34	0.84	2.23		

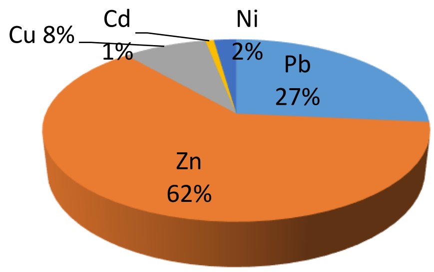

Figure 2: Percentage contribution of Heavy metals to Pollution in the dust of Ikeja.

Table 4. Showed the concentrations of heavy metals in Major roads in Ikeja. The most polluted site in all the Major roads in Ikeja is Agege motor road - 432.05 mg/kg while the least polluted is Ikeja under bridge- 257.96 mg/kg. This may be due to high vehicular activities within and around the Major roads in the area. At the Major roads, the highest concentration of Pb - 93.33 mg/kg and Ni- 7.75 mg/kg were recorded at Awolowo road (AR). Similarly, Zn - 343.59 mg/kg and Cd- 2.97 mg/kg were recorded at Ikeja under bridge (IUR) while the highest concentration of Cu - 38.67 mg/kg were recorded at Agege motor road (AMR). Table 5 Showed the concentrations of heavy metals in Industrial area of Ikeja. At the Industrial Areas, the highest concentration of Zn - 476.12 mg/kg; Cu- 44.60 mg/kg and Ni- 12.39 mg/kg were recorded at Ikeja Industrial Area (II) while the concentrations of Pb-378.60 mg/kg and Cd-22.96 mg/kg were recorded at Oba Akran Industrial Area (OAI).The most polluted Industrial site in Ikeja is Ikeja Industrial Area-654.47 mg/kg while the least polluted industrial site is Ayodele diyan Street - 148.75 mg/kg. This may be due to the proliferation of various industries in Ikeja Industrial Area. Table 6. Showed the concentrations of heavy metals in the Residential Areas. The most polluted Residential Area is Oyelola street- 349.95 mg/kg and the least polluted Residential site is Abeokuta street - 325.48 mg/kg .The high polluted Residential area is due to high human and commercial activities. At the Residential Areas, the highest concentration of Zn - 224.75 mg/kg; Cu- 74.41 mg/kg and Cd - 1.57 mg/kg were recorded at Oyelola street (OYS) while the concentrations of Pb-162.03 mg/kg and Ni -10.00 mg/kg were recorded at Abeokuta street (AS).). There is a significant difference between the levels of Zn, Pb, Cu, Cd and Ni in Industrial, Major roads and Residential Areas ($P_V < 0.05$).

Table 4: Heavy metals Content in Street dust from Major Roads in Ikeja (mg/kg).

Locations/Sites	**Pb**	**Zn**	**Cu**	**Cd**	**Ni**
IUR	50.81 ± 0.12^c	173.51 ± 13.18^b	23.94 ± 4.77^b	2.97 ± 0.80^b	6.73 ± 1.18^b
AMR	39.96 ± 2.48^b	343.59 ± 16.15^d	38.67 ± 2.82^c	2.31 ± 0.43^b	7.52 ± 0.84^b
AR	93.33 ± 2.45^d	214.86 ± 4.17^c	15.91 ± 2.05^b	0.07 ± 0.03^a	7.75 ± 0.15^b
C	0.95 ± 0.46^a	3.43 ± 0.23^a	0.74 ± 0.06^a	0.04 ± 0.00^a	0.04 ± 0.01^a
F – Statistics	$F_{3,8}$= 466.132; < 0.001	$F_{3,8}$=174.487;p < 0.001	$F_{3,8}$ = 28.737;p < 0.001	$F_{3,8}$=11.205;p = 0.001	$F_{3,8}$=25.473;p< 0.001

NB: Major Roads with the same superscript across heavy metals are not significantly different at 5%.

Table 5: Heavy metals Content in Street dust from Industrial Areas in Ikeja (mg/kg).

Locations/ Sites	Pb	Zn	Cu	Cd	Ni
OAI	101.369 ± 5.89[a]	476.12 ± 5.89[d]	44.60 ±5.89[c]	1.19 ± 0.01[c]	12.39 ±0.69[d]
II	378.60 ± 69.40[b]	217.32 ± 11.66[c]	25.05 ± 1.85[b]	22.96 ± 0.12[d]	10.54 ± 0.09[cd]
AI	20.99 ± 4.46[a]	98.73 ± 0.69[b]	19.05 ± 0.12[b]	0.86 ± 0.01[b]	9.12 ± 0.69[bc]
LOI	55.63 ± 0.64[a]	206.23 ± 5.89[c]	37.41 ± 0.69[c]	0.15 ± 0.01[a]	7.61 ± 0.69[b]
C	0.95 ± 0.46a	3.43 ± 0.0.23[a]	0.74 ± 0.06[a]	0.04 ± 0.00[a]	0.04 ±0.01[a]
F – Statistics	$F_{4,10}$=5605.463;p < 0.001	$F_{4,10}$ = 22.928; p < 0.001	$F_{4,10}$ = 1577.788;p < 0.001	$F_{4,10}$=158.023;p <0.001	$F_{4,10}$=25.473;p < 0.001

NB: Industrial Areas with the same superscript across heavy metals are not significantly different at 5%.

Table 6: Heavy metals Content in Street dust from Residential Areas in Ikeja (mg/kg).

Locations/ Sites	Pb	Zn	Cu	Cd	Ni
OS	99.91 ± 1.06[c]	221.3 ± 0.56[c]	17.08 ± 0.19[b]	0.59 ± 0.06[b]	6.49 ± 0.41[b]
OYS	39.28 ± 0.38[b]	224.75 ± 0.84[c]	74.41 ± 1.42[d]	1.57 ± 0.05[c]	9.94 ± 0.51[c]
AS	162.03 ± 1.44[d]	119.88 ± 43.68[b]	32.86 ± 0.70[c]	0.71 ± 0.31[b]	10.00 ± 0.36[c]
C	0.95 ± 0.46[a]	3.43 ± 0.23[a]	0.74 ± 0.06[a]	0.04 ± 0.00[a]	0.04 ± 0.01[a]
F – Statistics	$F_{3,8}$ = 5605.463; p < 0.001	$F_{3,8}$ = 22.928; p < 0.001	$F_{3,8}$ = 1577.788;p < 0.001	$F_{3,8}$ = 158.023;p = 0.001	$F_{3,8}$=25.473;p < 0.001

NB: Residential Areas with the same superscript across heavy metals are not significantly different at 5%.

There were progressive increase in the level of bioaccumulation of these heavy metals from August to December, 2022. The high significant levels of Zn, Pb and Cu obtained in the samples from Ikeja is an indication of their concentration in the dust while the low concentration of Cadmium Cd and Nickel Ni suggest low contributing factors to their spread and as well as dust inability to preferentially accumulate these metals (Table 3). There is significant variation in the level of heavy metals in the study area ($P_v < 0.05$). The trend and percentage contribution of each site to pollution of Ikeja dust is as follows: II – 16.60 % > OAI -16.12 % > AS-12.13 % > AMR -10.96 % > OYS - 8.87 % > OS- 8.76 % >AR- 8.42 % > LOI- 7.78 % > IUR- 6.54 % > AL- 3.82 % > BG(CTL) -0.13 % (Figure 3). The result of this research agrees with the results obtained other Areas of the world(Wang *et al.*, 2021; Li *et al.*, 2020; Kui Cai (2019) ; Xu *et al.*, 2020; Kara *et al.*, 2019). The results also showed that concentration of Heavy metals depends on the nature of activities in the sites (Adie *et. al.* 2014 ; Ekpo *et. al.*, 2012 ; Mohsen *et al.*, 2012; Christoforidis *et al.*, 2009; Lu *et al.*, 2010; Karbassi *et al.*, 2005 ; Ojiodu *et. al.*, 2017; 2018a, 2018b). The concentrations of Zinc, lead, Copper, Cadmium and Nickel in Ikeja dust is high compared to the levels in other cities of the world (Table 7). This may be due to differences in vehicular and human activities (burning / dumping of waste), environmental management policies and technologies employed, frequency of city street cleaning and local meteorological conditions such as rains, temperature, windspeed which can affect the Heavy metals in dust of Ikeja.

Table 7: Mean concentration of Heavy metals in street dusts of Ikeja and other selected cities of the world (mg/kg).

CITY	Pb	Zn	Cu	Cd	Ni
Ikeja (this study)	1043.73	2449.53	328.97	33.10	88.09
Central China / Arid Desert(Chiana) (Xu *et al., 2021*)	91.55	222.82	20.00	0.39	-
Shijiazhuang (China) Chang Li *et al.*, 2019	154.78	496.17	91.06	1.86	40.99
Xian(Chiana) Pan *et al.*, 2017	97.4	169.2	46.6	0.72	29.3
Shanghai (Korea) Li *et al.*, 2015	295	735	197	1.23	84
Chengdu(Korea) Li *et al.*, 2015	375	1117	244	4.4	88.1
Guizhou(Korea) Duan *et al.*, 2017	67.81	185.98	129.80	0.62	61.07
Shihwa(Japan) Jeong *et al.*, 2019	612	1824	992	2.22	164
Delhi (India) Suryawanshi *et al.*, 2016	120.7	284.5	191.7	2.64	36.4
(South Africa) Olowoyo *et al.*, 2016	754.3	304.6	157.2	2.54	74.3

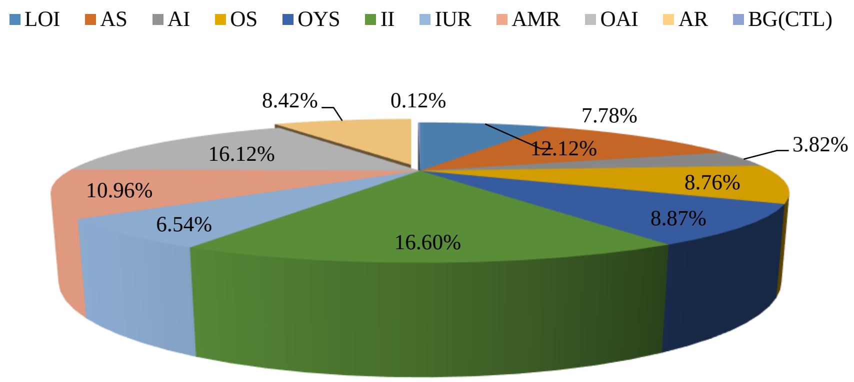

Figure 3: Percentage contribution of each site to pollution in the study Area.

The level of heavy metals in the study area were far greater than the recommended limits of the Federal Ministry of Environment (FME), European Communities (EC) and United Nations Environmental Programme (UNEP) permissible level for heavy metals in the atmosphere (EC, 2006). The concentration of heavy metals in all the sites was higher than the control value (Table 3). This may be due to the fact that the control site is an area with little or no anthropogenic activity.

3.2. Source Apportionment

3.2.1 Using principal component analysis (PCA) to identify the potential sources of heavy metals in Ikeja Area

The Principal Component Analysis (PCA) are the primary factor analysis techniques that uses eigen values to apportion data sets to identify emission sources depending on the data sets that have been submitted for PCA. It is widely used to reduce large data sets to a few components, and here it makes it easier to understand the potential sources of Heavy metals in Ikeja dust. It is used to classify variables into groups that can then be associated with factors that contributes to pollutant levels at receptors. The data acquired at Ikeja sites were used to conduct PCA analysis. The data for PCA were arranged in a matrix, with the columns representing concentrations of Zn, Pb, Ni, Cu and Cd in dust and the rows representing the sampling locations/ sites. The variance - normalized data matrix were used to identify the predominant components for implicating the potential Heavy metals sources. Varimax rotation with Kaiser Normalization was used in the PCA.(Table 8). Data were subjected to factor analysis using Principal component analysis extraction method and orthogonal Varimax rotation. All KMO values for the individual items (0 > 0.70) were well above 0.5 and the Kaiser - Meyer Olkin measured was 0.743 indicating that the data were sufficient for Exploratory Factor Analysis (EFA).(Table 2). The Bartlett's test of Sphericity $\chi^2_{(10)}$ = 163.813, p < 0.05 showed that there were patterned relationships between the items The Scree plot confirmed the findings of retaining two (2) factors. The results in Table 8 showed the factor loadings after rotation using a significant factor criterion of 0.50. Using the Eigen value greater than one rule, two factors are identified. The two factors were identified as those contributing to the measured values in Ikeja area. The PCA analysis classified the dataset of Heavy metals into two principal components (PCs) PC1 and PC2 which accounted for the variances of 73.61% of the total variation in the dataset collected from Ikeja area of Lagos state. PC1: This factor 1 accounted for 38.35% of the total variance in the data. This factor was highly loaded with Pb and Cd . The source of this Heavy metals were from emissions from Traffic / Vehicules, industrial wastes, lubricating oil, diesel fuel, tire, and brake wear (Foti *et al.*, 2017; Men *et al.*, 2020; Heidari *et al.*, 2021). PC2: This factor 2 accounted for 35.27% of the total variance in the data. This factor is loaded with Zn, Cu and Ni. This Heavy metals are released from emissions from Traffic / Vehicules, Industrial activities, combustion of fossil fuels, gasoline and diesel exhaust.

Table 8 : The rotated component matrix for data of Heavy metals in street dusts of Ikeja

Heavy metals	Principal Components	
	PC1	**PC2**
Pb	**0.957**	0.110
Zn	0.006	**0.834**
Cu	-1.09	**0.847**
Cd	**0.961**	-0.021
Ni	0.256	**0.581**
Eigen values	1.917	1.763
% of Variance	38.345	35.266
% of Cumm. Variance	38.345	73.611

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

3.2.2. Correlation coefficient analysis

Pearson's significant correlation analysis were employed to statistically link the concentrations of heavy metals with the sources of Street dust. Pearson correlation coefficient, r, was used to measure the strength of the inter-relationship between the heavy metals. (Table 9). shows pearson correlation coefficients, its significance values, and the total number of observations. The values of the correlation coefficient ranges from -1 to 1. The sign of the correlation coefficient indicates the direction of the relationship (positive or negative). The absolute value of the correlation coefficient indicates the strength, with larger absolute values indicating stronger relationships. There is a significant strong positive correlation amongst the heavy metals. The correlation coefficients on the main diagonal are always 1 because each variable has a perfect positive linear relationship with itself. Pearson's correlations were computed for each variable. The correlation for the five heavy metals in Ikeja area of Lagos state were moderately correlated and significant, which indicates that fewer components are required to account for the variation. We can see that the sample correlations among Zn, Pb, Cu, Cd, Ni ranges between -0.03 to 0.871 which shows that the variables were suitable for the principal component analysis. There is strong positive correlation (0.871) between Pb - Cd and moderate correlation (0.554) between Zn - Cu at 0.01 levels of significant (Enuneku *et al.,* 2017; Kara *et al.,* 2020; Wang *et al.,* 2021). This results shows that Zn, Pb, Cu, Cd and Ni are from common anthropogenic sources such as Traffic /Vehicular, industrial wastes, Waste dumpsite/ improper disposal of domestic wastes and sewage, Industrial activities, combustion of fossil fuels, gasoline and diesel exhaust.

Table 9 : Correlation Analysis among the heavy metals in the dust of lkeja (N = 77)

Metals	**Pb**	**Zn**	**Cu**	**Cd**	**Ni**
Pb	**1**				
Zn	0.171	1			
Cu	-0.023	0.554**	1		
Cd	0.871**	-0.042	-0.034	1	
Ni	0.207	0.255*	0.294**	0.159	1
Mean	93.41	220.52	29.97	3.03	8.98
SD	101.08	118.81	18.55	6.41	3.18

**.Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

3.2.3. Cluster Analysis

The bi-plot suggested that there are two clusters groups for the heavy metals in Ikeja dust. (Figure 4). We used hierarchical clustering because the datasets were small and continuous in nature and its' represented by dendrogram.(Figure 5). There are two clusters 1(Pb and Cd) and Cluster 2 (Zn , Cu and Ni).The heavy metals in each cluster are from the same origin or Source i.e Traffic / Vehicules, Industrial activities, industrial wastes, Waste dumpsite/ improper disposal of domestic wastes and sewage Industrial activities, combustion of fossil fuels, gasoline and diesel exhaust. The results of the cluster analysis is in agreement with the results from the Principal component analysis Factor 1 PC1- Cluster1 - Pb (0.957) and Cd (0.961), Factor 2 PC2 - Cluster 2 - Zn(0.834),Cu (0.847) and Ni (0.581) and **P**earson's significant correlation analysis.

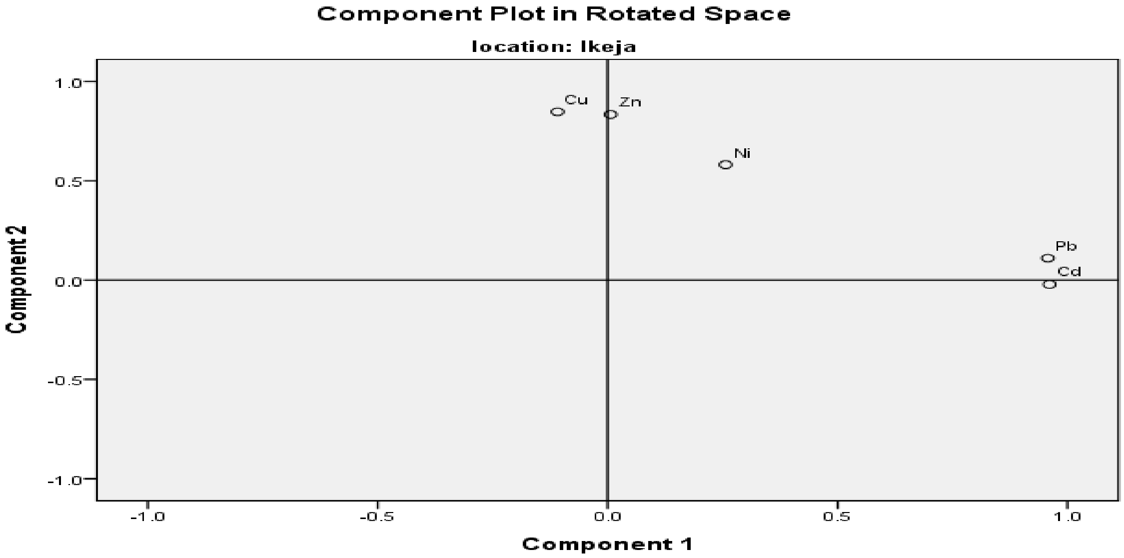

Figure 4: Bi-plot for the heavy metals components

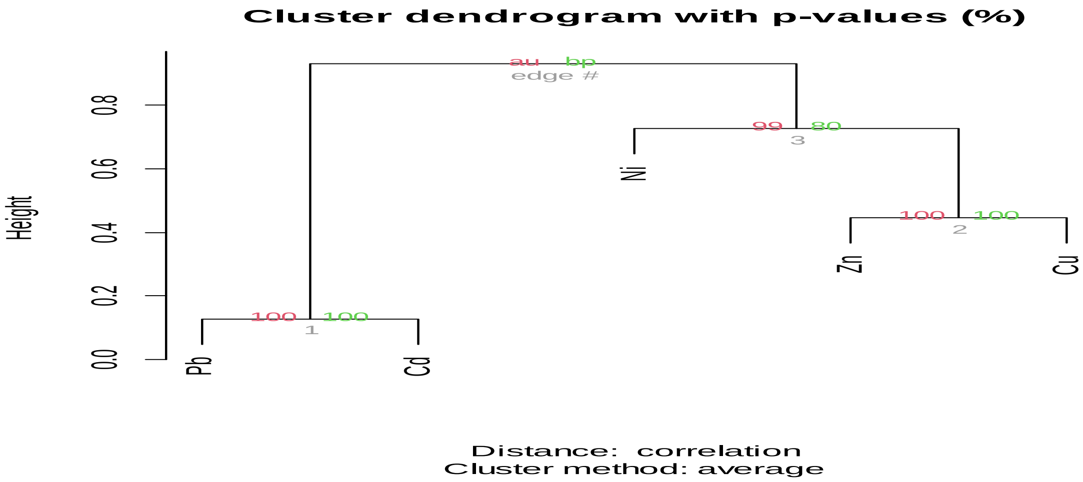

Figure 5: Cluster dendrogram

4.0. Conclusions

The Charactristic distribution and degree of bioaccumulation of Heavy metal content of Ikeja dust is as follows: Zn > Pb > Cu > Ni > Cd. The high levels of Zn - 62.12 %, Pb - 26.47 %, Cu - 8.34 %, Ni - 2.23% and Cd - 0.84 % obtained in the dust samples from Ikeja area could be attributed to anthropogenic activities such as traffic / vehicular emission, industrial activities, industrial wastes with industrial activities dominating. The low concentration of Cadmiun Cd suggest low contributing factors to their spread and as well as the dust inability to preferentially accumulate this metal. Therefore, there is need for constant environmental Monitoring of Ikeja area due to the high concentration of heavy metal pollution which could be very hazardous to human and plants existence.

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