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ASSESSMENT OF THE LEVEL OF HEAVY METAL CONCENTRATION IN THE STREET DUST IN SOME SELECTED LOCATIONS IN ZARIA METROPOLIS, KADUNA STATE, NIGERIA

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ABSTRACT

The study investigate the level of heavy metal concentration in street dust in some selected locations in Zaria metropolis, by monitoring the concentration of Chromium (Cr), Cadmium (Cd), Nickel (Ni), Lead (Pb), and Copper (Cu) for eight weeks. Street dust samples were collected by placing polyethylene bags on randomly selected roof tops and road sides at 20 cm to 30 cm to form composite sample. Sample collected were pre-treated and digested using standard procedure. Atomic Absorption Spectrophotometer (AAS) was used to determine the concentration of heavy metals. Results obtained showed that the concentration of Cr range from 16.670 ±2.20 µg/g to 31.895 ±1.845 µg/g, Cd concentration range from 0.280 ±0.042 µg/g to 1.900 ± 1.202 µg/g, Ni concentration range from 1.560 ±0.254 µg/g to 5.880 ±1.173 µg/g, Pb concentration range from 22.290 ±2.248 µg/g to 95.485 ±3.019 µg/g, Cu concentration range from 0.225 ±0.063 µg/g to 1.280 ±0.353 µg/g. The concentration of all heavy metals are below the limit set be World Health Organization (WHO) and therefore do not pose any health risk to humans. In sampled areas, the main sources of these heavy metals were anthropogenic activities such as open waste incineration, vehicle traffic, and ongoing construction at certain locations.

Keywords: Heavy metals, Concentration, Chromium, Cadmium, Nickel, Lead and Copper.

INTRODUCTION

Heavy metal contamination is among the major sources of air pollution. They may accumulate in the topsoil from anthropogenic activities by sedimentation, impaction, and interception. Roadside and top soil pollution in urban areas are sources of heavy metal exposure due to the atmospheric deposition. It has been reported that roadside soils near heavy traffic are polluted with Pb and other metals. In recent years, heavy metal pollutants in roadside dust have become a growing concern. In Nigeria, roadside dust is one of the main ways in which heavy metals can find their way into soils and, subsequently, into living tissues of plants and human beings. In the monitoring of urban pollution, consideration must be given to materials that cause the occurrence of pollutants. Chemical and biological measures are of importance as they provide information on concentrations and accumulation in the environment (Raymond and Felix, 2011).

Heavy metal contamination can occur from several causes, but most commonly results from metal purification, e.g. copper smelting and nuclear fuel preparation. Like environmental contaminants, heavy metals do not degrade and thus pose a particular kind of remediation problem. As a measure of environmental contamination, the following metals were selected for analysis: iron (Fe), chromium (Cr), cadmium (Cd) and lead (Pb) Vhahangwele and Khathutshelo (2018).

Many trace elements, in particular heavy metals, remain almost forever in the soil. Such metals remain bound to organic matter until they are mechanically remobilized as wind-blasted particles. The exposure of human to metals and their compounds in the environment is through food, drink and water. Other forms of uptake are via contact with the skin (Ewers, 1991). Over time, however, adverse toxic effects may occur as a result of long-term low-level exposure (Ewers, 1991).

Motivations for controlling the concentrations of heavy metals in gas streams are diverse, some are hazardous to health or the environment (e.g. Hg, Cd, As, Pb, Cr), some may cause corrosion (e.g. Zn, Pb), and some are harmful in other ways (e.g. Arsenic may pollute catalysts). As, Cd, Co, Cr, Cu, Hg, Mn , Ni , Pb, Sn and Tl, whose emissions are regulated in waste incinerators, are of the highest concern within the European Community. Some of these components are potentially essential for humans in small quantities (Co, Cu, Cr, Mn, Ni) while others are carcinogenic or harmful, affecting, among others, the central nervous system (Mn, Hg , Pb, As), the kidneys or the liver (Hg, Pb , Cd, Cu) or the skin , bones or teeth (Ni, Cd, Cu, Cr) (Banerjee, 2003; Charlesworth et al., 2003).

MATERIALS AND METHODS

Sampling Area

Zaria lies on latitude 10°28'N and longitude 7°25'E (Africa Atlas, 2002). It is located in the central area of what used to be called the Northern Region of Nigeria. The mean annual rainfall in the area ranges from 924.3-1543.6 mm. Annual temperature varies between 29°C-38.6°C (Africa Atlas, 2002). Zaria is a local government in Kaduna State.

The selected areas for this investigation are areas with high traffic and business activities. These areas are busy within the hours of 6.30 – 8.30 am when offices and commercial activities commence and 4.00 – 7.30 pm in the evening at the close of work and market activities.

Four sampling locations were selected and considered for this analysis. The Sites include; Kwangila, which is characterized by a minipark for trucks, petroleum dispensing station and runoff from the gutter; Tudun Wada roundabout, which houses a mini-park for vehicles and motorcycles, with shops surrounding the site and presence of refuse dump site; Chindit barracks junction which has a T-junction and a mini-park for motorcycles and tricycles; and Aminu road Sabon-gari which has a mini-park for motorcycles and tricycles and also has boutiques and shops with regular use of generators and other gasoline-powered equipment. The sale of building materials is also noticed around the site as well as gutter presence. A last location known as Polo field was selected to serve as control as all the activities associated with the other locations are absent here.

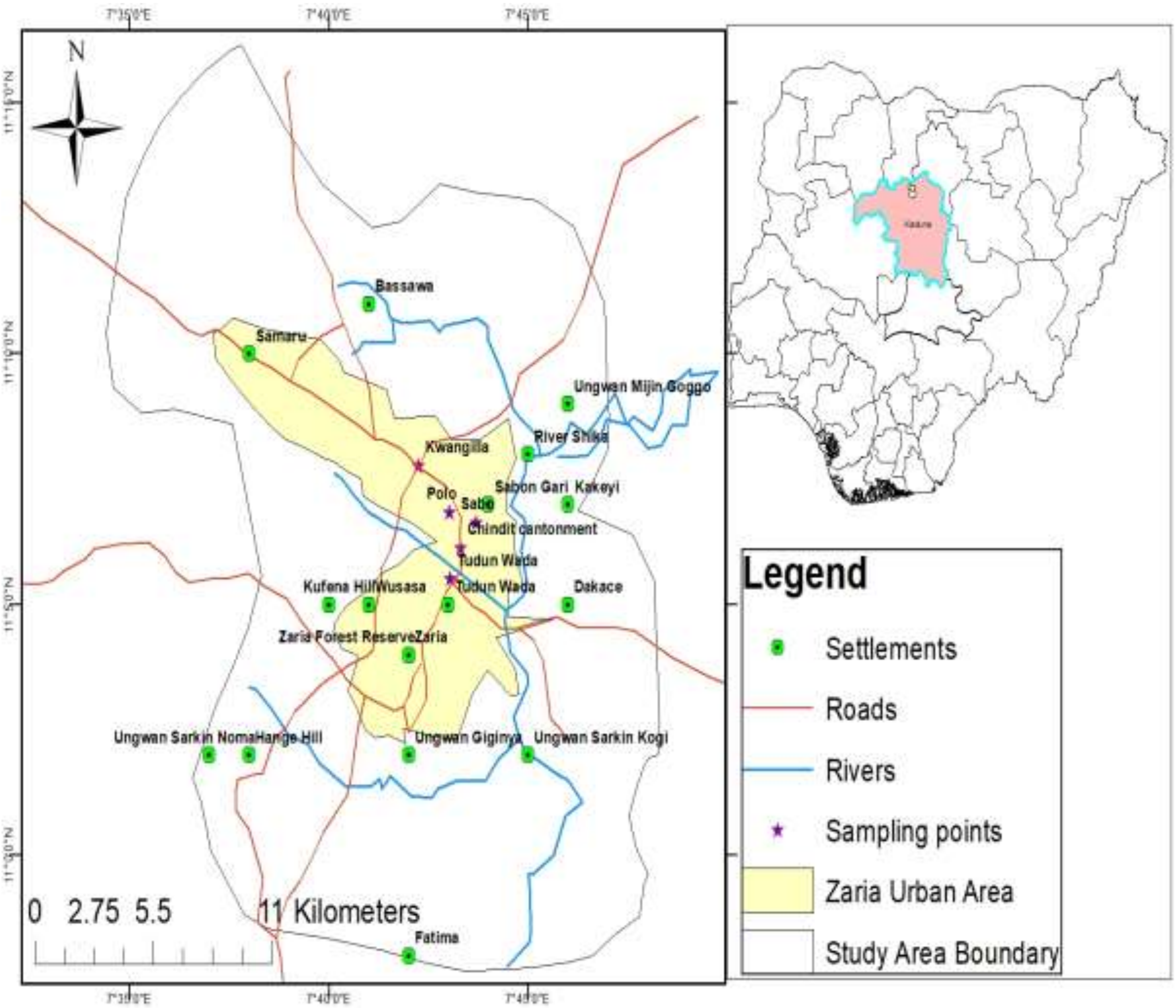

Fig. 1 Map of Zaria showing sample locations

Sampling of Street Dust Particles

Street dust samples were collected by placing polyethylene bags on randomly selected roof tops and road sides at 20 cm to 30 cm to form composite sample. The samples collected were stored in the clean polyethylene bags till the analysis. At each sampling site, composite samples were obtained by mixing subsamples from four points at each site (Marsan *et al*., 2008). The samples were differentiated via labeling using the respective sites in the location. The coordinate of each sample location was recorded using a Global Positioning System (GPS) Receiver (Garmin model 60 CSx).

Street Dust Sample Pre-treatment

The Samples were dried using an Oven at 105^{o}C to a constant mass and then sieved through a 2-mm stainless steel sieve to remove extraneous matter. Care was taken to reduce the disturbance of the fine particles, which could be readily lost by re-suspension (Victor *et al*., 2013).

Digestion of Dust Sample

The method described by Sonawane *et al.* (2013) was used to digest the samples. Exactly 2.0 g were each measured into 250 cm^3 glass beakers and 8 cm^3 of aqua-regia (3:1 HCl and HNO_3) was added. The mixture was then heated at 200ºC on a hot plate for 2 hrs. On evaporation to near dryness, the sample was then dissolved with 10 cm^3 of 2% nitric acid and filtered through Whatman's No.1 filter paper before being diluted to mark with distilled. Atomic Absorption Spectrophotometer was used to determine the heavy metals in the solution.

Determination of pH

Exactly 20 g of soil sample was weighed into a 100 cm^3 beaker and 40 cm^3 of distilled water was added. The suspension was stirred continuously at intervals for about 30 minutes to ensure adequate mixing and dissolution of all soluble compounds. Whatman No. 1 filter paper was then used to filter the mixture and the pH of the filtrate taken. Before use, the pH meter was calibrated using buffer 4 and 7 solutions and was rinsed with distilled water before and after each individual reading (Herdershot *et al*., 1993).

Determination of phosphate (PO_4^{3-}) (Agbenin, 1995)

Precisely 15 cm^3 of 1.0 M NH_4F and 25 cm^3 of 0.5 M KCI was mixed with 460 cm^3 of distilled water and the mixture stored in a glass bottle giving the extraction solution. Exactly 0.2197 g of KH_2PO_4 was oven dried at 105^0C for 1 hour, dissolved in distilled water and diluted to 1000 cm^3 in a volumetric flask giving phosphate stock solution (1 cm^3 = 0.05 mg). Working standards of 5, 10, 15, 20 and 25 µg PO_4^{-3}, were prepared. Absorbances were read with colorimeter at 690nm and a calibration curve of absorbance versus concentration was plotted. Precisely 5 g of the dust sample was weighed into an extraction bottle and 35 cm^3 of extraction solution was added. The bottle was shaken for 1 minute and filtered into dry beaker. Filtration was repeated until filtrate was clear. 10 cm^3 of the filtrate was shaken with 0.4 cm^3 of ammonium molybadate reagent (Denige's reagent) and 2 drops of stannous chloride were added. Absorbance was measured after 11 minutes for all samples at 690 nm and concentration read from the curve. Victor *et al*., (2013)

$$PO_4^{-3}\ \text{mg/kg} = \frac{\text{Concentration (from curve) x Extraction Volume}}{\text{Volume of Sample aliquot x Sample weight}}$$

Determination of Chloride Victor *et al*., (2013)

Exactly 20 g of the dust sample was dried at 110ºC for 1hr and cooled in a desiccator. 10 g of the sample was weighed into a 250 cm^3 Erlenmeyer flask and dissolved to about 40 cm^3 of distilled water stirred with a glass rod and allow to stand overnight. 20 cm^3 of the extract was pipetted into a 25 cm^3 conical flask. About 4 drops of K_2CrO_4 was introduced and the solution was titrated with 0.01 mol/dm^3 $AgNO_3$ to the first permanent appearance of red $Ag_2Cr_2O_4$.

$$Cl^-\ \text{mg/kg} = \frac{\text{Titre (cm}^3\text{) x Molality (AgNO}_3\text{) x Extraction Volume x 103}}{\text{Weight of Sample x Volume of Sample Aliquot (cm}^3\text{)}}$$

RESULTS AND DISCUSSION

Heavy Metal Pollution of the Dust Particle

Table 1: Concentration of some Heavy Metals in Dust Sample from different Sampling Points in µg/g.

S/N		Cr	Cd	Ni	Pb	Cu
1	**T/Wada**	17.190±0.381a	0.385±0.021a	2.705±0.219ab	28.180±1.173a	0.430±0.084a
2	**S/Gari**	17.345±2.227a	1.900±1.202b	3.745±0.346b	95.485±3.019d	1.280±0.353b
3	**Polo field**	16.670±2.220a	0.280±0.042a	1.560±0.254a	22.290±2.248	0.225±0.063a
4	**Kwangila**	20.675±0.742a	0.550±0.042ab	5.880±1.173c	41.76±2.001b	0.255±0.063a
5	**Chindit Junction**	31.895±1.845b	0.455±0.346ab	2.750±0.339ab	60.255±4.023c	0.605±0.091a
	ANOVA	0.001	0.140	0.005	0.001	0.008

Values are mean± standard deviation of replicate measurements

Table 1 shows the levels of these heavy metals across the five site Tudun wada, Sabon gari, Polo field, Kwangila junction and Chindit Junction respectively, their respective values are as follow: **Cr** 17.190 ± 0.381a, 17.345 ± 2.227a, 16.670 ± 2.220a, 20.675 ± 0.742a and 31.895 ± 1.845b, **Cd** 0.385 ± 0.021a, 1.900 ± 1.202b, 0.280 ± 0.042a, 0.550 ± 0.042ab and 0.455 ± 0.346ab, **Ni** 2.705 ± 0.219ab, 3.745 ± 0.346b, 1.560 ± 0.254a, 5.880 ± 1.173c and 2.750 ± 0.339ab, **Pb** 28.180 ± 1.173a, 95.485 ± 3.019d, 22.290 ± 2.248a, 41.76 ± 2.001b and 60.25 ± 4.023c, **Cu** 0.430 ± 0.084a, 1.280 ± 0.353b, 0.225 ± 0.063a, 0.255 ± 0.063a and 0.605 ± 0.091a.

Copper was found to be the least metal in all the sites while lead was the highest metal found in all locations. This could be so because lead is the main product of gasoline combustion.

The results as shown in Table 1, shows that the highest level of chromium (Cr) in street dust samples were found in at Chindit Junction (mean = 31.895 µg/g); while the lowest is found in Polo Field (mean = 16.670 µg/g). The level of chromium in the investigated area was generally lower than the set standards by world health Organization (WHO). The level of chromium in all the sites were generally lower than those determined in other cities in developed countries (El-Sayed *et al*., 2010 and Victor 2011). Similarly, Akilu (2013) as obtained maximum Cr concentration was 126.17 µg/g and minimum value was 92.86 µg/g at depth of 0-10 cm in tannery effluents in Ethiopia which was also lower than the results obtained. Although chromium is a major part of automobile bodies, it's concentration in the samples are not considered dangerous (El-Hassan *et al*., 2006). Concentration of Cr in this study did not exceed the limit set by the United Kingdom of 300 µg/g and 100 mg/L by WHO (Solano, 2013).

The highest mean for cadmium (Cd) concentration was found in Sabon Gari (1.900 µg/g) with the minimum at Polo Field (0.280 µg/g). The levels of cadmium in the samples were generally lower than the permissible limit of (0.5-4.0µg/g; Fergusson and Kim, 1991). The dust sample in this study showed higher levels of cadmium contamination than 0.75µg/g (Jaradat *et al.*, 1999), 2.11µg/g (Amusan *et al*., 2003) and 1.47 µg/g (Victor, 2011). The levels of cadmium could be due to lubricating oils and/or old tires that are frequently used on the roads which increase the wearing of tires.

The values of Ni in the dust samples were found to be within the range 1.560 -5.880 µg/g. The highest mean value of nickel was found in the sample from Kwangila while the lowest in Polo Field. The mean concentration of nickel was lower than the world-wide value (50-100µg/g) (Fergussion and Kim, 1991) and with the range of 0.3 to 0.6 µg/g as found by Victor O., (2011), thus, it does not pose any health risk. Nickel pollution on a local scale is caused by emission from vehicle engines that use nickel gasoline and by the abrasion and corrosion of nickel from vehicle parts (Al-Shayep and Seaward, 2001).

The highest lead (Pb) values were detected in street dust samples collected from Sabon Gari (95.485µg/g). The minimum was found in Polo Field (22.290 µg/g). It is as well within the permissible limit and does not pose any major health problem. This is in agreement with the report of Abechi *et al*., (2010) and Victor O. (2011). When compared with other literatures the mean concentration of lead was found to be lower than those reported by 236 µg/g for Amman, Jordan, 697.2 µg/g for Bahrain, 265 µg/g for Manchester, UK, Australia (100 µg/g), Poland (100 µg/g), and United Kingdom (100 µg/g) and Germany (500 µg/g) (Mamtaz & Chowdhury, 2006).

The level of Cu in the street dust collected from the sampled site varied from 0.225 - 1.280 µg/g. The highest Cu level was found at Sabon Gari and the lowest was at Polo Field the control site. According to the research made by Odoh *et al*. (2011) and Najib *et al*. (2012), the result of copper obtained were 238.33 µg/g and 623.7 µg/g respectively which was found to be higher. Improper disposal of waste lubricant and other anthropogenic activities are responsible for copper found in street dust. Results obtained are however below the permissible limits set by Great Britain (100 mg/Kg), Canada (100 mg/Kg), Japan (125 mg/Kg) and Poland (100 mg/Kg) (Pam *et al*., 2013)

Correlation between Heavy Metal Concentrations in Street Dust

Table 2: Correlation Matrix among Heavy Metals in µg/g.

	Cr	Cd	Ni	Pb	Cu
Cr	1				
Cd	-.230	1			
Ni	.033	.275	1		
Pb	.199	.908**	.285	1	
Cu	-.009	.935**	.060	.940**	1

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

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

The correlation between Heavy metals in street dust gotten from the various sampling sites was calculated using the SPSS (Statistical program for the social sciences) computer software package (SPSS Inc., version 17). The strength of the linear relationship between any two variables on a scale of -1 (perfect inverse relation) through 0 (no relation) to +1 (perfect sympathetic relation) is measured by the coefficient.

From Table 2, the correlation coefficient statistical analysis conducted on the metal concentrations at 95 % and 99 % confidence level indicates a significant positive correlation relationship between Ni and Cd (r = 0.330 µg/g) and between Ni and Cd (r = 0.275 µg/g), Pb and Cr (r = 0.199 µg/g), Pb and Cd (r = 0.908 µg/g), Pb and Ni (r = 0.285 µg/g), Cu and Cd (r = 0.935 µg/g), Cu and Ni (r = 0.060 µg/g) and Cu and Pb (r =

0.940 µg/g). This relationship shows the interdependence of these metal pairs and could be said to be due to the presence of these metals in similar source (i.e. the body parts and tires of automobiles as well as vehicular emissions). Negative correlation relationship was found between Cd and Cr (r = - 0.230 µg/g), and Cu and Cd (r = - 0.009 µg/g), this shows that sources other than automobile emission, wear and tire of body parts and tires could contribute to concentration of these metals in the street dust.

Physiochemical Parameters of Street Dust in the Sampling Sites

Table 3: Mean pH, Concentration of chloride and phosphate at sampling point

S/N		P^H	Chloride (mg/kg)	Phosphate (mg/kg)
1	**T/Wada**	6.930±0.098ab	13.440±1.046a	0.880±0.141ab
2	**S/Gari**	8.520±0.452c	108.835±3.514c	1.12500±0.247b
3	**Polo field**	6.675±0.502ab	72.715±2.566b	0.540±0.183a
4	**Kwangila**	6.470±0.339a	135.590±8.782d	0.430±0.098a
5	**Chindit Junction**	7.420±0.113b	205.500±10.182e	1.165±0.176b
	ANOVA	0.010	0.001	0.027

Table 3, shows the mean pH, concentration of Chloride and Phosphate at different sampling points within Zaria Metropolis which in the order of pH is Sabon gari > Chindit Junction > Tudun wada > Polo field > Kwangila junction, for chloride is Chindit Junction > Kwangila junction > Sabon gari > Polo field > Tudun wada and for phosphate is Chindit Junction > Sabon gari > Tudun wada > Polo field > Kwangila Junction.
The physiochemical parameters of street dust within the study area is as shown in Table 4.2. The pH level ranges from 6.47-8.52 which indicates slightly acidic to slightly alkaline conditions. This is within the range as reported by Tanushree *et al.*, (2013). The pH serves as useful index for availability of nutrients, the potency of toxic substances presents in the soil and the physical properties of the soil. Several studies have shown that availability of heavy metals is pH dependent (Iwegbue *et al*., 2006). The pH values of the study areas indicated tendency for availability of these heavy metals.
The level of phosphate and Chloride varied from 0.0430 mg/L -1.165 mg/L and 13.440 mg/L -205.500 mg/L respectively.

CONCLUSION

The study ssessed the level of heavy metals (Cr, Cd, Cu. Ni and Pb) concentrations in high traffic areas in some selected locations in Zaria Local Government Area, Kaduna State. The results indicated that the mean concentration of the heavy metals in street dust samples were in the order Pb > Cr > Ni > Cd > Cu. The continual usage of gasoline powered vehicles, motorcycles, tricycles, and other equipments on the road could lead to the accumulation of these metals, therefore continuous inhalation by humans could be detrimental to health.

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