DETERMINATION OF HEAVY METALS' POLLUTION FROM MOTOR PARKS' SOILS OF GOMBE METROPOLIS, NIGERIA

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ABSTRACT

Heavy metals are regarded as the most concerned of the pollutant in many environments today because of the presence of industries, markets, motor parks, mining and other human activities. The study determined the heavy metals pollution in the uppermost soils of urban Motor Park in Gombe metropolis. Random sampling techniques were used in collecting the samples in all the sample points at each of the four packs and the control sides. A mass concentration profiles of 15 elements (Sn, Sb, Ag, Cr, Cd, Zr, Co, Rb, As, Rb, Ag, Sr, Bi, Se, W, and V) were established from the soil using Niton X-ray Fluorescence Techniques (NXRF). The degrees of heavy metal contamination in soils were calculated using selected pollution indices Geo-accumulation index (Igeo), Enrichment Factor (EF), with reference to geochemical background enrichment factor. The lowest to the highest mean ranges of Zirconium, Silicon, Antimony, Cadmium, Arsenic, cobalt, chromium, and Rubidium were found to be 54.54 ppm – 473.74 ppm, 1646 ppm -1478897 ppm, 2.43 ppm – 5.51 ppm, 1.32 ppm – 461ppm, 0.5 ppm – 1.00 ppm, 36.07 ppm – 21.01 ppm, 12.92 ppm – 17.72 ppm, 8.82 ppm - 136.06 ppm, and 3.58 – 35.54 ppm respectively, with a mean of 218.5 ppm, 5171.07 ppm, 3.9 ppm, 1.63 ppm, 1.30 ppm, 42.69 ppm, 6.13 ppm, 31.39 ppm, 7.97 ppm, 39.66 ppm in given order above. The results indicated that surface soils of Gombe Urban motor packs were moderately polluted by particulates containing Cd, Cr, Zr, Ag, Rb, Sn, Zr, Ag and As. Contamination with As, Ag, Sn, Sb, Co, and Sr was moderate (Igeo >4 and PLI>1). These metals may cause harmful effects on the populace using or earning their daily living in those areas. The pre-industrial activities such as improper disposal of toxic lubricants, heaps of metals scraps, electronic waste, and sanitization of vehicles that might have transported agricultural chemicals such as fertilizers, pesticides, and herbicides are important causative agents for releasing heavy metals on the studied areas.

Keywords: XRF Technique, Heavy metals, pollution, soil, Gombe Moto parks

INRODUCTION

Heavy metals are emitted during high temperature processes such as oil combustion in automobiles, electric power stations, and industrial plants as well as refuse incineration heavy metals occur either naturally in the soil through a pedagogic process of weathering of parent materials or by anthropogenic activities (Hankouraou and Yusuf, 2019). However, naturally occurring elements are rarely toxic and pose little or no threat to the soil ecosystem (Mohammad *et al*., 2015). Increased concentrations of heavy metal are

caused by anthropogenic activities and may lead to high risks to human health, plant and animals, among others. Anthropogenic heavy metals pollution may occur through different diffuse and point source (El-Hassan *et al.,* 2015).

Heavy metals are regarded as the most concerned of the pollutant in many environments today because of the presence of industries, markets, motor parks, mining and other human activities (Julili *et al.*, 2016). Due to hydrodynamic condition changes, biological disturbances, physical and chemical conditions and a series of complicated processes, heavy metals may be released from sediments and water producing secondary pollution (Julili *et al*., 2016). Human activities play an important role more forcefully than the soil degradation, soil sedimentation and others. Along this line, different types and intensities of activity in the soil and water ways may lead to significantly different heavy metal pollution statues for the water ways sediment (Qiao *et al*., 2011). Adegbola and Ayinde (2012) carried out a research on level of Heavy Metals in Soils of some selected Motor Parks in Ibadan Metropolis, Nigeria and their results indicated that, there is significant concentration of Copper (Cu), Chromium (Cr), Cadmium (Cd), and Lead (Pb) in the areas. This study aims to determine the current level of concentrations and effect of heavy metals such as Arsenic (As), Cadmium (Cd), Silver (Ag), Chromium (Cr), Zirconium (Zr), Antimony(Sb), Tin (Sn), Cobalt (Co), Rubidium (Rb), Strontium (Sr), Vanadium (V) and Tungsten (W) in the uppermost soil of Gombe metropolis Urban motor parks and to predict their possible accumulation with respect to time in relation to people's life living in the area.

MATERIALS AND METHODS

Study Site

Gombe is a city in north eastern part of Nigeria (and a local government area). It is the capital city of Gombe State and has an estimated population of 261,536 people (2006 census). Gombe metropolitan area has an area of 52 square kilometer and situated between latitude 9^0 $30^{'}$ and 12^0 $30^{'}$ N and longitude 8^0 $45^{'}$ and 11^0 $45^{'}$ E of the Greenwich meridian. It has two distinct climates, the dry season (November-April) and the rainy season (May–October) with an average rainfall of 850mm (Abdullahi and Rabiu, 2014).

Gombe is a confluence of economic activities by its position as the meeting point for business, people from the surrounding states. The states include Borno to the East, Yobe to the North, Taraba and Adamawa to the south and Bauchi to the west. This have made the state to be vibrant in almost all aspects of life, with numerous Motor Parks, Banks, Filling stations and Hotels supporting the commercial activities (Abdullahi and Rabiu, 2014). The study site for this research is the four renowned Motor Park within Gombe metropolis; that is Bauchi Motor Park, Dadinkowa Motor Park, Dukku Motor Park and Gombe line Motor Park plus controlled sites off Kumo road and FCE (T) Gombe; as indicated in Figure1, on map of Gombe Metropolitan for the study sites and sampling points.

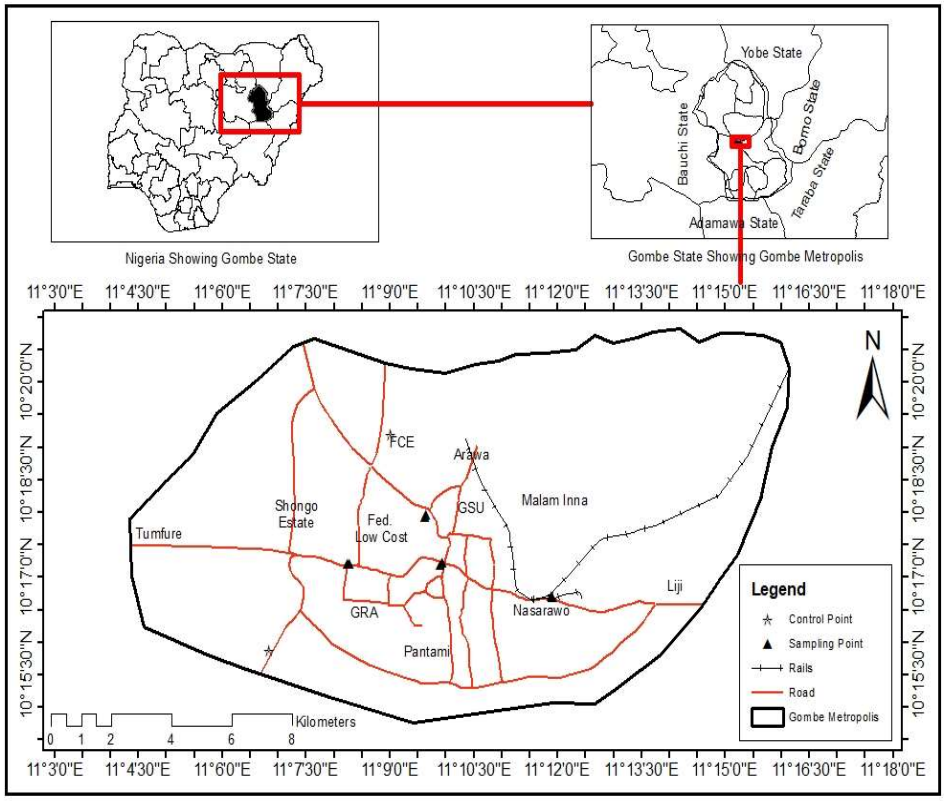

Figure 1: Map of Gombe Metropolitan showing Study Sites and Sampling points

Sample Collection and Preparation

Random sampling was adopted and used for the collection of soil samples from four selected motor parks (Bauchi, Dadinkowa, Dukku and Gombe line) all in Gombe Metropolis of Gombe State. The sample sites were selected because of their proximity to markets places and other activities such as auto mechanics site; Metal heaps and scrapes business (Bola Jari) site, vulcanization site, battery charging site, panel beating site, welding and fabrication site. The soil samples were collected using the Hands Trowel at two points with a distance of 20 meters between them in all the four selected study areas as well as noting the geo-referencing point using GPS hand held Instrument.

A soil sample from two control sites were also collected from where farming, mining and industrial activities were absent. These samples were transferred into polythene bags before transporting them into the laboratory; altogether ten samples were collected and transported to the laboratory for analysis. The samples were air-dried for a period of two weeks in a well-ventilated space. After the samples have been sieved into fineness, 2.50g of each sample was weighed on a weighing balance. The soil which are Soils were then grinded using ceramic Mortar and Pestle, then sieved using 4 μm into a fine powder. A small portion of the powdered samples were then prepared, weighed using precision Balance and then packed into polyethylene bag vials

for making pellets that will be taken for irradiation.

Samples Analysis

The Niton FXL X-Ray Fluorescence Analyser with serial number 83358 used for the analysis was calibrated by the NIgerian Institute of mining and Geosciences (NIMG) No 1 Metropolitan avenue, Tudun Wada Campus Jos Plateau State and has been in used for samples analysis by many organizations. The method consists of comparing the fluorescence parameters of the samples to a second material designated as the standard. The said standard has a predetermined concentration of the appropriate elements of interest. The quintessence is that the standard must be in line with the best practice of some certified organization (Seydou, 1998).

Data Evaluation

After the determinations of the heavy metals in all the Samples collected from the study sites, the quality of studied uppermost soil samples is assessed by calculating a number of pollution indices and passing the results through various statistical analyses in order to study the trend distribution of the elements. This pollution indices and statistical analysis includes different geochemical methods such as the enrichment factors, Geo-accumulation index and Pearson correlation were determined.

Enrichment factors (EF)

An assessment of heavy metal and level of contamination in soils require pre-anthropogenic knowledge of metal concentrations to act as perfect values. For instance, the determination of enrichment factors can predict the variation concentration of an elements determine with respect to the concentration in the earth crust (Vega *et al.*, 2009). This method is based on the standardization of a tested metal against a reference one. Conservative elements, such as Mn, Al, Me, Fe, Ti, or Ca are generally used as reference elements for calculation of EF. The knowledge can also assist in establishing a reference data for the study sites. However, a number of different enrichment calculation methods and different reference material have been reported (Olubunmi and Olorunsola, 2010). Since Fe has been measured in this study, it is expected to be a conservative element and be chosen as the reference element. Then the (EF) can be calculated using the following formula adapted from Sutherland *et al.,* (2000) as follows:

$$EF = \frac{\left(C_E/C_{Fe}\right)_{sample}}{\left(C_E/C_{Fe}\right)_{background}} \quad (1)$$

Where EF is the enrichment factor, $\left(C_E/C_{Fe}\right)_{sample}$ is the ratio of metal and Fe concentration of the sample and $\left(C_E/C_{Fe}\right)_{background}$ is the ratio of metals and Fe concentration of the background. The five contamination categories for EF are shown in Table 1.

Table 1: Classification and description of enrichment factor (EF)

EF_{value}	Enrichment Level
40 < EF	Extremely high enrichment
20 < EF < 40	Very high enrichment
5 < EF < 20	Significantly enrichment
2 < EF < 5	Moderate enrichment
EF < 2	Deficiency to minimal enrichment

Geo-accumulation Index (Igeo)

The geoaccumulation index (Igeo) has bee n used since the late 1960s, and has been in service. The Igeo enables the assessment of pollution by comparing recent concentrations of the metals with those from pre-industrial measurements (Armid *et al.*, 2014). The Igeo of this study was calculated using Equation (2) below:

$$I_{geo} = Log_2\left(\frac{C_n}{1.5B_n}\right) \quad (2)$$

Where C_n is the concentration of the measured metal in the sample and B_n is the pre-industrial
(geochemical surroundings) content of this metal.

In this study, world soil concentrations value of elements has been chosen as the criterion values. The constant 1-5 compensates for possible natural fluctuations in the content of a given substance in the environment (Lacatusu., 2000). The seven proposed descriptive classes for Igeo values are given in Table 2 (Muller, 1969).

Table 2: The Igeo classes with respect to soil quality

Igeovalue	Igeoclass	Designation of soil quality
> 5	6	Extremely contaminated
4 – 5	5	Strongly to extremely contaminated
3 - 4	4	Strongly contaminated
2 - 3	3	Moderately to strongly contaminated
1 - 2	2	Moderately contaminated
0 – 1	1	Uncontaminated to moderately contaminated
0	0	Uncontaminated

RESULTS

An X-ray fluorescence analysis has been effectively used in determining the heavy metal presence in the surface soils of the four urban motor parks and two unsuspected areas of heavy metals presence in Gombe metropolis using The Niton FXL X-ray fluorescence analyzer. The sites at which the samples were collected has been named and coded as indicated in the table 3 below.

Table 3: The samples locations with their codes

Location	Sample Codes
Bauchi Motor Park	BHMP1, BHMP2
Dadinkowa Motor Park	DKMP1, DKMP2
Dukku Motor Park	DKUMP1, KUMP2
Gombe Line Motor Park	GMLMP1, MLMP2
Uncultivated Areas	CNTRL1, CNTRL2

Table 4 below gives out the concentration values of heavy metals determined at the four motor parks place side by side with the controlled sites value

A total of ten samples that has been analyzed and fifteen heavy metals were detected Sb, Sn, Cd, Ag, Zr, Sr, Rb, Bi, As, Se, W, Co, Fe, Cr, and V even though some shows very little concentration. Table 3 gave the detail descriptions of the elements and their concentrations were measured in part per million (ppm).

The data were analyzed using SPSS (Statistical Package for the Social Sciences) software to evaluate Mean and Pearson correlation. Some other geochemical Indices have also been used to give complete analysis of the heavy metal's pollution, trend of distribution,

accumulation and toxicity. The indices were; enrichments factor, and Geo-accumulation index, to all the sample locations for evaluating their toxicity; Table 4 gives concentrations of heavy metals of interest that are known as potentially toxic elements (PTEs).

Table 4: Heavy metals concentrations determined from four Motor Parks and the controlled sites

Elements	BHMP (ppm)	DKMP (ppm)	DKUMP (ppm)	GMLMP (ppm)	CNTRL (ppm)
Sb	3.91	5.51	2.43	3.50	ND
Sn	19.12	11.10	9.64	ND	ND
Cd	2.18	4.61	1.32	ND	ND
Ag	1.00	0.50	1.00	1.00	0.50
Zr	215.52	54.54	473.74	207.54	141.15
Sr	13.24	18.31	17.13	34.62	6.30
Rb	7.78	19.66	10.98	35.54	3.58
Bi	33.74	2.48	15.25	13.68	5.86
As	176.62	36.07	76.78	62.41	48.88
Se	1.00	1.55	1.00	1.00	1.00
W	290.89	278.95	193.97	146.20	381.36
Co	ND	12.92	ND	17.72	ND
Fe	12980.64	9773.21	9885.50	10461.73	2956.92
Cr	ND	136.06	12.08	8.82	ND
V	8.74	44.13	29.35	ND	ND

ND = Not Detected

The range, mean of some potentially toxic heavy Metals are found to be as follows; Sb 2.43-5.51 ppm, which slightly above the recommended value of 5.00 ppm as reported by WHO 1984 and 1989, Cd has 1.32-4.61 ppm, Ag has 0.5- 1.00 ppm, As 36.07-21.44 ppm, Co has 12.92-17.72ppm, Cr has 8.82-136.06 ppm. Al has 448.14-2669.28 ppm. With a vivid comparison of respective heavy metals in all the motor parks when compared to the control sites, it could be seen that; the concentration of Cd, Co, Cr, Rb, Sb, Sn and Sr when compare in the respective sister motor parks with control sites, some has shown concentration Cd, Co, Cr, Rb, Sb, Sn, Sr and Zr slightly above the controlled sites. Gombe line Motor Park for instance has recorded the highest concentration of Cr, Co, Rb, Sb, Sn, Sr and Zr, this might be associated with high number of vehicles patronizing the area. But little concentrations of Ca, Mo, Sn, Zr and Fe were observed in comparison with those obtained at Dukku and Dadinkowa motor parks. Bauchi Motor Park also has some concentrations of Cd, Cr, Rb, Sb, Sn and Sr in its uppermost soil. Going by the classification of crustal enrichment factor (Vega *et al.*, 2009) stated in Table 1, and referring to Table 5, for enrichments for this work was presented, it is observed that all motor parks' soils were highly enriched with some heavy metals, with enrichment factors greater than 40. This means extremely high enrichment. The enrichments might be as a result of constant and regular vehicular release of toxic gases, coupled with the deposits of some heaps and scrapes of some metals in those areas.

The results of the present study show that most of the metals are enriched in the studied soils (Table 5), the Igeo values in Table 6 below can be classified according to the level of contamination. These results that the soil of the study areas can be categorized as follows: moderately to strongly polluted with As, Ag, Cd, Sb, Sr (0< average Igeo<4), and strongly to extremely polluted with Co, Cr, Rb, Sn, Zr (4< average Igeo<6).

Table 5: Crustal Enrichment Factor (CEFs) of the heavy metals determined and control sites

Elements	BHMP	DKMP	DKUMP	GMLMP	CNTRL
Sb	7.4	13.8	6.0	8.2	NA
Sn	16.7	12.8	11.0	NA	NA
Cd	49	138.7	39.3	NA	NA
Ag	17.4	11.6	22.9	21.6	38.3
Zr	1.9	0.6	5.4	2.2	5.4
Sr	0.2	0.3	0.3	0.6	0.4
Rb	0.2	0.5	0.3	0.9	0.3
Bi	207	20.2	122.6	103.9	157.6
As	36.4	9.9	20.8	15.9	44.2
Se	7.8	16.1	10.3	9.7	34.3
W	26.4	33.6	23.1	16.4	152
Ta	NA	565	ND	77.7	125
Co	NA	3.0	NA	3.8	NA
Cr	NA	6.7	0.6	0.4	NA
V	0.2	1.6	1.1	NA	NA

NA: Not Applicable

According to Muller 1969, the Igeo is distinctly variable suggesting that, soil around the motor park areas ranges from unpolluted to strongly/extremely, contaminated. The calculated values for Igeo suggests that the study area have been moderately affected by heavy metals from As, Cd, Cr, Rb, Co and Zr. These high metal levels made the soil potentially hazardous source of contaminants.

The Igeo values for the heavy metals of environmental interest ranges from 1.0-1.6 for As, 0.0 for Ag, 0.0 for Co, 0-16.3 for Cd, 8.0-11.3 for Rb, 15.3-16.3 for Cr, 1.0-1.6 for Sb, 10.5-11.9 for Sr, 13.2-16.3 for Zr, and 4.1-4.3 for Sn (Table 6). The average Igeo values of Cd (8.15), Zr (14.75), Cr (15.8) and Sr (11.2) the significance of this indicate that the sampling sites are slightly polluted with these metals.

The geo-accumulation index classification shown (Table 7) below shows that Ag, Co, Cr, Rb, S, Sb, Se, Sn, Sr and V are moderately distributed across the sampled areas as shown by their enrichment factor values. On the other hands As, Cd, W and Zr were highly distributed across all the sampling sites. The enrichment, contaminations and variation with regards to sample sites were also in good agreements with the Clark ratios. Thus, it could be said that, the environments investigated were mostly polluted with the above stated heavy metals. However, (Bowen, 1979) stated that depleted elements like Sr and Co might be toxic but others elements like Fe and Co are probably important to plants.

Table 6: Igeo contamination Index with respect to soil quality of the study sites

Element	BHMP	DKMP	DKUMP	GMLMP	CNTRL
Sb	1.6	2.1	1.0	1.5	NA
Sn	5.1	4.3	4.1	NA	NA
Cd	0.0	0.0	0.0	NA	NA
Ag	0	0	0.0	0.0	0.0
Zr	15.2	13.2	16.3	15.1	14.6
Sr	10.5	11.0	10.9	11.9	9.5
Rb	9.2	10.5	9.7	11.3	8.0
Bi	3.1	0.0	1.9	1.8	0.5
As	10.3	8.0	9.1	8.9	8.5
Se	0.0	0.0	0.0	0.0	0.
W	8.9	8.6	NA	5.8	4.6
Ta	NA	3.4	NA	3.8	NA
Co	NA	8.6	8.0	NA	NA
Fe	14.6	8.8	11.2	10.1	10.6
Cr	NA	16.3	15.5	16.0	15.3

NA: Not Applicable

Table 7: EF and Igeo classes and the value obtained from this study

EF Class and Elements within		Igeo Class and Elements within	
20 < EF < 40	As, Ag, Cd,	4 < Igeo < 6	Co, Cr, Rb, Sn, Zr
5 < EF < 20	Rb, Sn, Sb, Cr, Zr, Sr, Co	0 < Igeo < 4	As, Ag, Cd, Sb, Sr

Table 8 shows the coefficients of correlation of elemental concentrations determined in order to see which of the motor parks correlates in terms of heavy metals pollution together with the control site uppermost soil contents, the respective parks indicates that, there were strong correlations between BHMP and DKUMP ($r = 1.000^{**}$). While GMLMP correlated strongly with DKMP motor parks ($r = 0.760^{**}$), but there was no strong correlation with CNTRL (r = 1.00), but DKMP, BHMP, DKUMP and CNTRL also correlate positively.

Table 8: The Pearson Correlation with reference to different heavy metals obtained in the study

Locations	BHMP	DKMP	DKUMP	GMLMP	CNTRL
BHMP	1.00	1.000^{**}	1.000^{**}	0.764^{**}	1.000^{**}
DKMP	1.000^{**}	1.00	1.000^{**}	0.760^{**}	1.000^{**}
DKUMP	1.000^{**}	1.000^{**}	1.00	0.768^{**}	1.000^{**}
GMLMP	0.764^{**}	0.760^{**}	0.768^{**}	1.00	0.768^{**}
CNTRL	1.000^{**}	1.000^{**}	1.000^{**}	0.768^{**}	1.00

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

CONCLUSION

The results obtained in this work, has shown that Gombe Urban motor parks is contaminated, with heavy metals most especially Zirconium, Antimony, cadmium, Arsenic, cobalt, chromium, Tin and Rubidium with concentrations ranging between 54.54 ppm - 473.74 ppm, 2.43 ppm - 5.51 ppm, 1.32 ppm - 4.61 ppm, 36.07 ppm - 21.01 ppm, 12.92 ppm - 17.72 ppm, 8.82 ppm - 136.06 ppm, 9.64 ppm - 19.12 ppm and 3.58 ppm - 35.54ppm respectively. This shows the general populace livings in those areas might be in danger due the high levels of these heavy metals in the concerned environment. The pollution may result from environmental misconduct such as improper disposal of toxic lubricants, heap and scrape metals, electronic waste, sanitization of cars that carries agricultural chemicals such as fertilizers and pesticides.

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