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ABSTRACT

Heavy metal contaminations in surface soils within Bori were examined. The composite soil sample at 10 – 15cm depth was collected from each of the seven sampling locations including the control location using a stainless-steel hand auger. The soil samples were air-dried for 2 days, homogenized and sieved through a 2mm mesh to obtain uniform size. The soil samples were subjected to wet digestion method using nitric-perchloric acid. The digested samples were used for determination of concentrations of the heavy metals (Cd, Cr, Ni, Mn, Pb, Fe Cu and Zn) using the atomic absorption spectrophotometer (AAS). The mean concentrations of the heavy metals obtained ranged as follows: Pb (0.553 – 4.551 mg/kg), Cr (1.713 – 7.965 mg/kg), Cd (0.011 – 2.549 mg/kg), Mn (6.914 – 40.162 mg/kg), Ni (2.942 – 6.597 mg/kg), Zn (4.468 – 13.976 mg/kg) and Cu (1.90 – 11.503 mg/kg). The results were below the world average values except Fe (53.554 – 122.203mg/kg). The enrichment factor values ranged between 0.04 and 20.86 and showed low to moderate enrichment due to anthropogenic activities. The pollution load index (PLI) value was 1, the combined pollution index (CPI) values ranged between 0.39 and 1.73 and the metal pollution load index (MPL) value of 3.73 > 1 revealed pollution in urban surface soils of the study area. The high positive correlation result among the heavy metals in the sample soils of the study area suggested that they are of similar pollution sources. Based on the findings, the urban surface soils of the study area are contaminated with heavy metals. Therefore, there should be monitoring and environmental audit by relevant authorities to ensure adequate environmental quality of urban surface soils in the study area.

Keywords: *Heavy metals, contaminations, Bori, metal pollution load, combined pollution index.*

1.0: INTRODUCTION

Migration of people from rural to urban cities has increased human population density resulting into generation of large agricultural and municipal wastes containing heavy metals as contaminants (Onwudike*et al.*, 2017). These wastes are deposited on or along the roadsides, unapproved areas, open dumpsites in the markets or in water ways which lead to pollution and contamination of heavy metals.

Heavy metal contents of urban soils are of major significance due to their non-degradable nature and ability to accumulate for long period of time. The studies carried out by Marcus *et al.*, (2017), Nwineewii and Nna, (2016) revealed that heavy metals exhibited certain metallic properties which distinguished them from other metals. These heavy metals are known to be toxic when they reach or exceed certain concentrations in food, water, soil and air, although some of them are very important to humans, animals and plants at trace levels. The presence of heavy metals in an environment alters the structure and functions of the ecosystem. This is attributed to the fact that their presence has effect or influence on the nature of the physical and chemical properties of urban soil.

Bori urban is one of the urban areas with various anthropogenic activities including electrical, clothing, jewelry, furniture shops, supermarkets, fuel stations, numerous automobile services and repair workshops. Increased artesian and automobile repair workshops which include auto mechanic, auto welding, auto electrician and auto painting units may create varieties of wastes which contain heavy metals in course of their daily operations. These wastes include used oil, and fluids, dirty shops rags, used parts, asbestos from brake pads and wastes from solvents used for cleaning parts which contain heavy metals that are dangerous to human and the environment (Liang *et al.,* 2011).

Innumerable studies have been carried out in many cities around the world, investigating the heavy metal contents in urban soils. For instance, Salah, *et al.,* (2015) worked on heavy metals in urban soils in Baghdad city, Iraq, Mohammed *et al.,* (2015) worked on heavy metals in soils of Sirte city, Libya; Wang *et al.,* (2017) did work on heavy metals in urban soils within Suzhou city, China, all the findings of these investigations revealed elevated concentrations of heavy metals in urban soils. Al Obaidy&Mashhadi2013) worked on heavy metals in urban soil within Baghdad city, Iraq, reported in their study the contamination of urban soil with heavy metals.

In Nigeria, studies have equally been carried out on heavy metals in urban soils. Onwudike*et al.,* (2017) worked on heavy metals of Owerri soil; Ekwere*et al.* (2014) carried out a study on the distribution of heavy metals in urban soils; a case study of Calabar Area, South-Eastern Nigeria; Iwegbue*et al.,* (2013) did a work on the assessment of heavy metal contamination in soils around cassava processing mills in sub-urban areas of Delta State, Southern Nigeria; Edori and Kpee (2017) carried out a study on index models assessment of heavy metal pollution in soils within selected abattoirs in Port Harcourt, Rivers State, Nigeria. The findings of these researches revealed that the soil samples under study were highly contaminated or polluted with heavy metals. None of these studies investigated heavy metals in Bori urban surface soil, thereby creating a gap that needs to be filled. Studies concerning heavy metal contamination in urban soils are needed to develop strategies to protect urban environments and human health against long-term accumulation of heavy metals. The present study seeks to investigate heavy metals contaminations in surface soils within Bori.

2.0: MATERIALS AND METHODS

2.1: Soil Sample Collection and Analysis

Soil samples were collected from seven (7) selected study locations at 10-15cm depth including the control location and collected with the aid of a stainless-steel hand auger. Three soil samples from each sampling location were randomly collected to make a composite sample. The collected composite samples were stored in properly labeled polythene bags until time for analysis.

Soil samples were air-dried for 2 days, homogenized and sieved through a 2mm mesh to obtain uniform size. The soil samples were subjected to wet digestion method using nitric-perchloric acid in line with the works of (Ogunkunle *et al.,* 2013; Oladeji *et al.,* 2016).2 grams of each sample were weighed into a 50ml beaker, then added to the sample were 20mls and 10mls of concentrated nitric acid (HNO_3) and perchloric acid ($HClO_4$) respectively for 30-45 minutes under gentle heating at 60 ^{o}C. The solution was allowed to cool and was filtered into a 50ml volumetric flask and made up to the 50ml mark with distilled water. The digested samples were used for determination of concentration of the heavy metals of interest (Cd, Cr, Cu, Ni, Mn, Pb, Fe and ZN) using the Atomic Absorption Spectrophotometer (AAS).

2.2: Contamination Indices for Heavy Metal Analysis

To determine the status of contamination in the study area the following pollution indices were used:

2.2.1: Enrichment Factor (EF)

Enrichment factor was used to differentiate between heavy metals from anthropogenic source and natural source. It was also used to investigate the degree of contamination and that of anthropogenic impact (Salah *et al.,* 2013). The enrichment factor was calculated using the equation proposed by Ali *et al.,* (2015) as follows:

$$EF = \frac{\frac{Cn}{\mathrm{Cref}}\ of\ sample}{\frac{Cn}{Cref}\ \text{of reference metal}} \qquad ()$$

Where: Cn is the concentration of metal in soil sample (mg/kg)

Cref is the concentration of reference metal in soil sample (mg/kg).

In this study, Fe was adopted as reference metal because it is difficult to modify Fe by anthropogenic activities. The EF was classified into 5 contamination categories as indicated in Table1 below

Table 1: Classification of Enrichment Factor

Enrichment Factor (EF)	Classification
EF < 2	Minimal enrichment
EF = 2 -5	Moderate enrichment
EF = 5 – 20	Significant enrichment
EF = 20 – 40	Very high enrichment
EF > 40	Extremely high enrichment

Source: Ali*et al.*, (2013).

2.2.2: Pollution Load Index (PLI)

The extent of metal pollution for each sampling site was evaluated based on Pollution Load Index (PLI) adopted by Mmolawa*et al.*, (2011) as follows:

$$PLI = \sqrt[n]{CF, \times CF_2} \times CF_3 \times CF_n \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where: n is the number of metals studies

Where CF is the contamination factor as calculated using equation by Hamid *et al.*, (2016)

$$Cf\frac{Sample}{Ref} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{ (3)}$$

The PLI provides simple but comparative means for assessing a sampling site quality. When the value of PLI < 1, it denotes non-pollution and when PLI > 1, it indicates pollution.

2.2.3: Pollution Index (CPI)

It was stated by Karim *et al.*, (2015) that some heavy metal contamination in the surface soil was associated with a mixture of contaminants rather than one metal contamination. They projected that the concept of a Combined Pollution Index (CPI) can be used as another commonly evaluation methods of heavy metal accumulation and to identify multi-element contamination which results in increased over all metal toxicity. Nezhad *et al.*, (2015) proposed that CPI is calculated using this equation.

$$CPI = \frac{Metal\ content\ in\ soil/permissible\ level\ of\ metal}{Number\ o\ fmetals} \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

They classified the calculated values of CPI indicated in Table 3.3.

Table 2: Classification of CPI Values

CPI Values	Classification
CPI $\leq$ 1	Low multi-element contamination

$1 < CPI \leq 2$	Middle multi-element contamination
$CPI > 2$	High multi element contamination

Source: Nezhad *et al.,* (2015).

Wang *et al.,* (2012) further classified CPI values that if CPI ≤ 1 indicates no heavy metal accumulation in soil and if CPI > 1 indicates heavy metal accumulation in soil.

2.2.4: Metal Pollution Index (MPI)

According to Sarala & Uma (2013), Metal Pollution Index (MPI) was calculated to enable the results from the metal concentrations for the study to be presented as one value. This implies that the heavy metal concentrations for the study must be normalized to make it possible to sum up and average the different metal concentrations into one value. Thus, MPI is calculated using the equation.

$$mpi = Log \sum \frac{(\times)}{(ref)} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (5)$$

Where: MPI = Metal pollution index

(x) = Mean value of metal concentration from the sampling sites.

Ref = Reference value for each of heavy metals for the study.

If MPI < 1 it indicates non pollution and

If MPI > 1 it indicates pollution.

2.2.5: Statistical Analysis

Statistical analysis was used based on descriptive statistics where minimum and maximum values, mean and standard deviation values were calculated. Pearson correlation matrix was equally used to identify the level of interactions between the heavy metals under study.

3.0: RESULTS AND DISCUSSION

The statistical analyses of the concentrations of heavy metals are presented in Table 4.

3.1: Heavy Metals Distribution

Distributions of heavy metals in the various sampling locations of the study area in the summary of mean concentrations with standard deviations are presented in Table 4. The various land use areas have the mean concentrations of the heavy metals.

3.1.1: Lead (pb)

From the results in Table 4 below, the mean concentrations of Lead (Pb) in the land use areas range from 0.553 mg/kg to 4.581 mg/kg. The motor part area was with the highest mean value of 4.581 mg/kg and the hospital area was with the lowest mean concentration 0.553 mg/kg. The sequence of lead distribution in the land use area were motor park (4.581) > market area (3.489) > major road side (3.120) > residential area (1.718) > school area (0.750) > hospital area (0.553).The mean concentrations of Pb in the sampling locations were higher than the mean concentration of the control sample (0.220 mg/kg). The mean concentrations of Pb in all the sampling locations were below the world average of unpolluted soils (44 mg/kg) (Alobaidy*et al.*, 2013).

Table 4: The mean concentrations (mg/kg) of heavy metals in soil samples from various locations.

Sampling Locations	Heavy Metals							
	Pb	Cr	Cd	Mn	Ni	Zn	Cu	Fe
Motor Park	4.581±0.38	7.965±0.17	2.549±0.14	40.162±0.65	6.597±0.48	13.976±0.40	11.503±0.54	122.203 ± 0.88
Motor Road side	3.120±0.41	5.271±0.56	1.503±0.40	30.398±0.49	4.965±0.14	9.769±0.09	7.70±0.28	105.367 ± 1.43
Market Area	3.489±0.49	6.883±0.40	1.739±0.18	24.474±0.51	5.768±0.17	11.206±0.08	8.537±0.43	92.931 ± 0.36
Residential Area	1.718±0.26	3.736±0.18	0.431±0.38	10.743±0.18	3.649±0.38	7.770±0.24	4.870±0.12	67.664 ± 0.44
School Area	0.750±0.15	2.891±0.31	0.011±0.00	5.718±0.27	1.912±0.27	4.392±0.49	2.742±0.16	60.369 ± 1.18
Hospital Area	0.553±0.11	1.713±0.24	0.011±0.00	6.914±0.19	2.942±0.12	4.468±0.51	1.910±0.13	53.554 ± 1.07
Control Sample	0.220±0.00	0.204±0.04	0.001±0.00	2.966±0.02	0.165±0.16	2.477±0.07	0.156±0.00	46.525± 0.51
World Average of unpolluted soils (Al Obaidy and Mashhadi, 2013)	44	83	0.53	525	34	100	24	53
WHO standard value (Onwudike*el al.,* 2017)	0.10	5.00	0.01	20	5.00	10	10	10
World Average Shale (Fazeli*et al.,* 2018)	20	39	0.30	850	68	95	39	4.7(%)
Mean earth crust value (Barbieri 2016)	14	100	0.1	950	80	75	50	4.4(%)

However, the mean concentrations of Pb in all the sampling stations were above the WHO standard values (0.10 mg/kg) (Onwudike *et al.*, 2017).

The results of this study agree with the findings from the studies of Alobaidy *et al.,* (2013), Proshad *et al.,* (2019) and Onwudike *et al.,* (2017), on heavy metal contaminations in urban soil in Baghdad City, Iraq and Owerri, Nigeria respectively. The findings of this study revealed the same sequence of Pb distribution in different land use areas, showing that the mean concentration of Pb was below the world average unpolluted soils and above the WHO standard values. Pb can enter the urban soils during various anthropogenic activities and it can be very toxic to health. Deposition related to transportation activities can contribute to accumulation of Pb in motor parks, roadside and market surface soils. Hence Pb has been shown to accumulate to high levels in urban surface soil from range of sources including that derived from leaded gasoline (Jin *et al.*, 2014). Ogundele *et al.,* (2015) reported that the high concentration of Pb depicts the urban soil was polluted due to human activities such as fuel combustion and vehicular emissions. They supported the fact that lead has toxic properties and was found in large amounts in many electronic devices, because, it is a major constituent of lead-acid battery extensively used in car batteries and tyres which could end up in soil through corrosion.

3.1.2: Chromium (Cr)

The chromium mean concentration varies from 1.713 mg/kg to 7.915 mg/kg as indicated in Table 4. This result shows that the sequence of the mean concentration was in the order of motor park (7.915 mg/kg) > market area (6.883 mg/kg) > major road side (5.271 mg/kg) > residential area (3.736 mg/kg) > school area (2.891 mg/kg) > hospital area (1.713 mg/kg). This indicates that the motor park has the highest mean concentration while hospital area has the lowest. Of course, the mean concentrations of Cr in the different sampling locations were above the mean concentration of the control sample (0.204 mg/kg). The observed values of Cr are below the world average value of unpolluted soils (83.0 mg/kg) (Alobaidy *et al.*, 2013). The observed mean values of motor park (7.965mg/kg), major road side (5.271 mg/kg) and that of market area (6.833 mg/kg) were above WHO standard value (5.00 mg/kg) while those of residential area (3.736 mg/kg), school area (2.891 mg/kg) and hospital area (1.713 mg/kg) were below the WHO standard value (5.00 mg/kg).

3.1.3: Cadmium (Cd)

The Cadmium (Cd) mean concentration varies from 0.011 mg/kg to 2.549 mg/kg, with motor park having the highest value (2.549 mg/kg) and the hospital area having the lowest value of 0.011 mg/kg. The sequence of the mean concentrations of the land use areas are in the order of motor park (2.549 mg/kg) > market area (1.739 mg/kg) > major road side (1.503 mg/kg) > residential area (0.431 mg/kg) > school area (0.011 mg/kg) and hospital area (0.011 mg/kg) as shown in Table 4 above. The observed values of the heavy metals in various sampling locations of the study area were above the mean concentration (0.001 mg/kg) of the control sample.

The observed values of Motor Park (2.549 mg/kg), major roadside (1.503 mg/kg) and market area (1.739 mg/kg) were above the world average of unpolluted soils (0.53 mg/kg) but those of residential area (0.431 mg/kg), school area and hospital area of 0.011 mg/kg each were below the world average of unpolluted soils. However, the observed values of the various sampling locations were above the WHO standard value 0.01 mg/kg as indicated in Table 4.

The findings of the study done by Lu &Bai (2010) agree with the results of this study. In their studies on assessment of metal contamination in soils samples of Nashik, District, India, the finding revealed that Cd amongst other metals like Cu, Zn, Cr and Ni was found in more concentration of all the stations under investigation. The mean concentrations above 0.53 mg/kg and 0.01 mg/kg could reflect the influence of human activities. The anthropogenic activities led to increase in the level of Cd as a result of urban-industrial and agricultural activities to the environment. Many anthropogenic activities can increase the level of Cd in urban soil surface well above background levels, such as the application of solid wastes from industries, homes. Cd could accumulate in the human body over a long period of time, and it is highly mobile and toxic (Lu and Bai, 2010).

3.1.4: Manganese (Mn)

The observed mean concentration of Mn varies from 6.914 mg/kg to 40.162 mg/kg indicating that motor park has the highest value (40.162 mg/kg) and the school area with the lowest value (5.718 mg/kg). The sequence of the observed mean concentrations are in the order to motor park (40.162 mg/kg) > major roadside (30.398 mg/kg) > market area (24.474 mg/kg) > residential area (10.743 mg/kg) > hospital area (6.94 mg/kg) > school area (5.718 mg/kg) as indicated in Table 4. The observed mean concentrations of Mn in the various sampling stations were below the world average of unpolluted of soil 525 mg/kg. However, on comparison with the control sample value, all the observed mean concentrations were above the control sample mean concentration (2.966 mg/kg). This observation was in agreement with the finding of the study by Alobaidy *et al.,* (2013) on heavy metal contaminations in urban soil within Baghdad. The findings of their studies revealed that the Mn observed values were less than the reported world average of unpolluted soil (525 mg/kg) and that these values of Mn in the studied soil samples were observed to be higher than the value of the rural soil samples being the control.

3.1.5: Nickel (Ni)

Nickel (Ni) mean concentration varies from 1.912 mg/kg to 6.597 mg/kg revealing that motor park has the highest value (6.597 mg/kg) and the school area with the lowest value (1.912 mg/kg). The sequence of the mean concentrations of Ni as indicated in Table 4.9 are in the order motor park (6.597 mg/kg) > market area (5.768 mg/kg) > major roadside (4.965 mg/kg) > residential area (3.649 mg/kg) > hospital area (2.942 mg/kg) > school area (1.912 mg/kg). The observed values are below the world average of unpolluted soil (34 mg/kg).Further, considering the analyzed value of the control sample as 0.165 mg/kg, revealed that Ni mean concentrations of the various sampling stations were above the Ni value in the control sample.

Critically, looking at the mean concentrations of Ni from the various studied samples also revealed that the observed values were above the WHO standard value (2.6 mg/kg) except the mean value of Ni in the school area (1.912 mg/kg) that was below the WHO standard value. The result of this study is in agreement with the finding of the study by (Oladeji *et al.,* 2016). The finding of their study revealed that the mean value of Ni (70.38 mg/kg) obtained was higher than the recommended safe limit of 66.9 mg/kg. They went further to acknowledge the primary source of nickel pollution to be from diesel fuel, gasoline and lubricating oil coming in contact with the soil. This makes the urban soil to have significant amount of Ni as a result of different human activities. Alobaidy *et al.,* (2013) supported this position by reporting that Ni content of many domestic cleaning products, e.g. soap, 100 – 700 mg/kg; powdered detergents 400 – 700 mg/kg and powdered bleach, 800 mg/kg, may have significantly contributed to the sources of Ni in the urban surface soils.

3.1.6: Zinc (Zn)

The mean concentration of Zn varies from 4.392 mg/kg to 13.976 mg/kg, revealing the motor park has the highest value (13.976 mg/kg) and the school area (4.392 mg/kg) the lowest value. Following the sequence of the mean concentrations of Zn from the various sampling stations, the order are motor park (13.976 mg/kg) > market area (11.206 mg/kg) > major roadside (9.769 mg/kg)> residential area (7.770 mg/kg) > hospital area (4.468 mg/kg) >school area (4.392 mg/kg) as indicated in Table 4. In Table 4, the mean concentrations of Zn from various sampling locations were above the control sample (2.477 mg/kg) but all the observed values were below the world average of unpolluted soil (100.00 mg/kg). Comparing the observed values with the WHO value of 15.00 mg/kg, all the observed values of Zn were below the WHO standard value (15.00 mg/kg). Michael *et al.,* (2015), in their study carried out on the distribution and variation of heavy metals and soil properties in Gboko, equally found out the higher level of Zn as compared to the standard. In their study, the mean concentration of zinc was found to be (76.69 mg/kg), while the highest value was 123.45 mg/kg) in the soil samples investigated. They deduced that Zn particles could be derived from Mechanical abrasion vehicles, as they are used in the production of brass alloy and from brake linings, oil leak pumps and cylinder head gaskets, which result into accumulation of high level of Zn in urban soils.

3.1.7: Copper (Cu)

The observed values of Cu varied from 1.910 mg/kg to 11.503 mg/kg, showing that motor park with the highest value of 11.503 mg/kg and hospital area the lowest value of 1.910 mg/kg. The sequential order of the mean concentration of Cu are in the order, motor park (11.503 mg/kg) > market area (8.537 mg/kg) > major roadside (7.720 mg/kg) > residential area (4.870 mg/kg) > school area (2.742 mg/kg)> hospital area (1.910 mg/kg), as in Table 4. The observed values of Cu are above the control sample (0.156 mg/kg) but all the observed values were below the world average of unpolluted soil (24.00 mg/kg). These results tend to support the finding of Li & Tan (2016) who carried out study on distribution and risk evaluation of heavy metals in the soil of typical grassed swale. They found out that the concentration of Cu was between 138.6 – 167.3 mg/kg, which greatly exceeded the evaluation criteria and showed a heavy pollution condition. Cu contributions could be envisaged from dumping or accumulation of solid wastes, application of fungicides, livestock manures, sludges and atmospheric deposition (Alobaidy *et al.,* 2013). Cu is used in numerous applications due to its physical properties. The toxicity of Cu for humans is not very high but its accumulation in urban soil can be explained by the bioaccumulation of the metal and anthropogenic activities (Meng *et al.*, 2017).

3.1.8: Iron (Fe)

From table 4, the observed values of Fe ranged from 46.525 mg/kg to 122.203 mg/kg, the observed values of Fe are in the order, motor park (122.203 mg/kg) > major road side (105.367 mg/kg) market area (92.931 mg/kg) > residential area (67.664 mg/kg) > school area (60.369 mg/kg) > hospital area 953.554 mg/kg) > control sample (46.525 mg/kg). All the observed values of heavy metals in this study were greater than the 53 mg/kg of the world average of unpolluted soils (Alobaidy & Mashhadi, 2013), 10 mg/kg of WHO standard value (Onwudike *et al.*, 2017), 4.7% of world average shale value (Fazeli *et al.*, 2018) and 46.525 mg/kg of the control sample. The observed mean values of Fe for roadside, market area, residential area in the study were lower than those reported for Fe by Alobaidy & Mashhadi (2013) for roadside (1902.58 mg/kg, market area (1989.78 mg/kg) and residential area (2284.12 mg/kg) respectively in their studies on heavy metal contaminations in urban soil within Baghdad city, Iraq. The anthropogenic sources of Fe have been reported to include the iron and steel activities, sewage and dust from Fe activities (Garba and Abubakar, 2018).

3.2: Contamination Index

Contamination index of the heavy metals from the results analyzed is discussed under Enrichment Factor (EF), Pollution Load Index (PLI), Combined Pollution Index (CPI) and Metal Pollution Index (MPI).

3.3: Enrichment Factor (EF)

The enrichment factor results are presented in Table 5. The minimal enrichment and high enrichment values of EF (10.04 –20.86) as shown in Table 5, indicate that significant heavy metals pollution is likely to come from the anthropogenic activities.

Table 5: Enrichment Factor for Heavy Metals

Sampling Locations	Pb	Cr	Cd	Mn	Ni	Zn	Cu
Motor park	3.75	0.13	20.86	0.17	0.11	0.12	0.10
Major Roadside	2.96	0.10	14.26	0.15	01.0	0.10	0.08
Market Area	3.76	0.15	18.72	0.14	0.13	0.12	0.09
Residential Area	2.54	0.12	6.37	0.09	0.12	0.13	0.08
School Area	1.24	0.10	0.18	0.05	0.06	0.07	0.05
Hospital Area	1.03	0.07	0.22	0.07	0.12	0.09	0.04
Control Sample	0.487	0.01	0.03	0.04	0.01	0.06	0.01

In Table 5, the EF values of the heavy metals in the different land use areas were all higher than the EF values of the control location.

The sequential pattern of EF values revealed that the urban soils of the study area were highly enriched with heavy metals such as Cd, Pb, Zn and Ni which were observed to show extremely high enrichment, while Cr, Cu and Mn were observed to show significant enrichment. These results agree with findings of the study by Alobaidy *et al., et al.,* (2013), in that, they observed that Pb and Cd were extremely highly enriched heavy metals in urban soils within Baghdad, the study area. Bello *et al.,* (2016) pointed out that EF values are significantly higher than 1, which indicated that the origin of heavy metals is from anthropogenic sources such as vehicle emission, industrial discharges and other activities. Moreover, some of the heavy metals for the study were highly toxic for humans, so the risks of their potential entry in the food chain must be carefully considered.

3.4: Metal Pollutions Load Index

The metal pollution load index includes, Pollution Load Index (PLI), Combined Pollution Index (CPI) and Metal Pollution Index (MPI) which the calculated results are presented in Table 6, which shows that PLI values were higher than 1 in all cases with the exception of residential area and school area land. The higher values of PLI > 1 in cases of motor park, major roadside, market area and hospital area indicate that the studied locations were polluted as a result of anthropogenic activities. This study seems to agree with the research carried out by Mamum *et al.,* (2015) on potential ecological risk of hazardous elements in different land-use urban soils of Bangladesh. They found out in their study that the PLI of some of the land uses including motor park, major roadside etc. were higher than 1 indicating that the land-use areas were polluted by anthropogenic activities. The study carried out by Zhang *et al.,* (2015) on heavy metal pollution in Eastern China revealed otherwise, in that the finding of the study showed that the PLI values of different land-use were lower than 1, indicating non-pollution of the study area. In Table 6, it is observed that almost the studied locations were polluted by anthropogenic activities due to the PLI values higher than 1.

Furthermore, Table 6 reveals that CPI values were greater than 1 (CPI > 1) in all cases of motor park, major roadside and market area, with the exception of residential area, school area and hospital area. The extent of pollution or contamination indicated by the CPI values in the decreasing order of motor park (1.73) > major roadside (.125) > market area (1.23) > residential area (0.70) > school area (0.40) > hospital area (0.39). The CPI values for motor park, major roadside and market area indicate high pollution while those of residential area, school area and hospital area indicate low pollution. With the CPI values, whether high pollution or low pollution, reveals that the different land uses in urban environment are polluted by heavy metals due to anthropogenic sources. The finding of this study is in agreement with the work on heavy metal contaminations in urban soil in Baghdad done by (Alobaidy & Mashhadi, 2013). Their study revealed the values in the sequence of pollution as roadside soils (1.36) > commercial area (1.31) > residential area (.098). They observed that the urban soils in Baghdad city were moderately or highly polluted with heavy metals due to anthropogenic sources, as it is the observation or finding made in the present study of Bori urban soil.

The results of Metal Pollution Index (MPI) of the study area are presented in Table 6. The MPI value of the Bori urban soil was 3.57, which is greater than 1, indicating that the urban soil of the studied areas are polluted by heavy metals due to anthropogenic activities.

Table 6: Metal Pollution Load Index (MPI)

Sampling Locations	PLI	CPI	MPI
Motor Park	1.45 Pollution	1.73 High pollution	
Major Roadside	1.31 Pollution	1.25 High pollution	
Market Area	1.25 Pollution	1.23 High pollution	
Residential Area	0.99 No pollution	0.70 Low pollution	3.57 pollution
School Area	0.99 No pollution	0.40 Low pollution	
Hospital Area	1.02 Pollution	0.39 Low pollution	
Control Sample	0.13 No pollution	0.13 Low pollution	

3.5: Correlational Analysis (CA)

The correlation among heavy metals can be used to speculate their sources. For investigation of inter-metal relationship in soils, the concentrations of the heavy metals (mg/kg) were subjected to correlation analysis and the correlation coefficients are shown in Table 7.

Table 7: Pearson Correlation Coefficient of Heavy Metal contents in Soils.

Correlations	**Pb**	**Cr**	**Cd**	**Mn**	**Ni**	**Zn**	**Cu**
Pb	1**						
Cr	.975**	1**					
Cd	.989**	.944**	1**				
Mn	.974**	.920**	.980**	1**			
Ni	.948**	.960**	.911**	.912**	1**		
Zn	.991**	.981**	.967**	.951**	.971**	1**	
Cu	.994**	.998**	.972**	.964**	.963**	.995**	1**

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

Results show that positive correlation exists among the heavy metals under study as indicated in Table 7. The highly positive correlation among heavy metals in the studied sample soils suggests that the heavy metals in soils have similar pollution sources. The results of the study were in consonant with the findings of study carried out by Meng *et al.,* (2017) on soils in China. Their findings revealed positive correlation among Cd, Cu, Pb, Zn, Cr and Ni which indicated the similar pollution sources and combined soil pollution by multi-heavy metals.

Therefore, the positive correlation among heavy metals in sample soils of the study indicate the combined soil pollution by multi-heavy metals due to rapid urbanization and development as well as human activities.

4.0: CONCLUSION

Heavy metal contaminations in surface soils within Bori urban were examined. Seven heavy metals (Pb, Cr, Cd, Mn, Ni, Zn, Cu and Fe) in the different sampling locations were investigated including the control location. From the results, the combined pollution index of 3.57 >1 revealed that the urban soil of the study area is polluted. Based on the findings, the urban surface soils of the study area are polluted with heavy metals. Therefore, there should be monitoring and environmental audit by the relevant authorities to ensure adequate environmental quality of the soil in Bori urban.

5.0: REFERENCES

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