***Original Research Article***

# Analysis of the pollution level and its Variation: A Case Study of some selected sites within Kano State Nigeria.

**ABSTRACT (ARIAL, BOLD, 11 FONT, LEFT ALIGNED, CAPS)**


**ABSTRACT**

**AIM:**

**This research was conducted to investigate the pollution level of heavy metals and their variation in some selected areas in Kano state, Nigeria, using vegetable amaranth (Amaranthus Cruennsus l) and sunflower (Helianthus Annus). The heavy metals investigated are Cadmium (Cd), Chromium (Cr), Manganese (Mn), Zinc (Zn), Lead (Pb), Copper (Cu), Iron (Fe), and Nickel (Ni).**

**PLACE AND DURATION OF STUDY:**

**The study was carried out in Kano state; one of the most populace states in the Republic of Nigeria. Five different geographic locations were selected this include: *Sharada*, *Naibawa* (N), *Kofar Ruwa* (K), *Bayero University Environment* (B U K – E), Screen House (B U K – S). The study covers a period of three months, February, March and April, 2017.**

**METHODOLOGY:**

**The presence and concentration of eight heavy metals were determined in five different places in Kano state, using Vegetable Amaranth (Amaranthus Cruennsus l) and Sunflower (Helianthus Annus). Atomic Absorption Spectrophotometry (AAS) (Model 210 VGP buck scientific) was employed as the technique for the analysis of the heavy metals.**

**RESULTS:**

**It was found that in all the five (5) locations of the study, there exist all the eight heavy metals in varying concentration. These are presented in the following order: (i) for the month of February the concentration of the heavy metals in vegetable amaranth was found to follow the order: Ni > Zn > Mn > Fe > Cu > Pb > Cr > Cd, while the concentration in sunflower was found to follow the order Zn > Ni > Fe > Cu > Mn > Pb > Cd >Cr. (ii) for March, the concentration of heavy metals in vegetable amaranth was found to follow the order Zn > Fe > Cu > Ni > Mn > Pb > Cd> Cr while the concentration in sunflower was found to follow the order Zn > Ni > Cu > Mn > Fe > Pb > Cr. (iii) The month of April the concentration of the heavy metals in vegetable amaranth was found to follow the order: Ni > Cu > Mn > Pb > Fe > Cd > Cr > Zn, while the concentration in sunflower was found to follow the order Zn > Ni > Fe > Cu > Mn > Pb > Cd >Cr.**

**Conclusion**

**The results obtained reveals that eight (8) heavy metals were determined - (Cr, Cd, Cu, Fe, Zn, Ni, Pb, and Mn). These heavy metals recorded different/varying concentrations (within the soil and the plants samples).**
**The correlation matrix generated from the concentrations of samples obtained shows that in each site, there are group of Heavy metals that originate from the same source(s) and others that emanate from other source(s). In Naibawa, Cd, Cr, Cu, Fe, Ni, Mn, and Pb have high probability of originating from the same source while Zn might have originated from a different source. For *Kofar Ruwa site*, Fe and Zn recorded high probability of originating from the same source while Cd, Cr, Cu, Ni, Mn and Pb are from other source(s). In BUK – E; Cd, Cr, Cu, Fe and Pb are probably from the same source, while Ni, Mn and Zn are from different source. In the control area (BUK C site), Cd, Ni, Mn, Pb recorded values have probabilities, indicating they are from the same source while Cr, Cu, Fe and Zn are contrary from the latter. In the overall sites, the data generated reveals that Cr and Cu are from the same source while Cd, Cr, Cu, Ni, Mn and Pb are from another source. From the soil pollution load index computed before, during and after planting, the study indicated decrease in the level of contamination in all the sites.**

Key words: AAS, Heavy Metals, Phythoremediator, Sunflower and Vegetable.

## 1. INTRODUCTION

Several efforts have been made towards safe-guarding the health of the society by conducting researches on the composition of samples using various techniques. These researches range from identification, determination, study and evaluation of samples (Biological and geological). Natasa *et al*., (2015) reported that; Melting operation, sludge dumping, intensive agriculture, traffic activities, power transmission, cement – pollution and smelting are possible ways of heavy metal accumulation. Metal Contamination in agricultural soil is of increasing concern, due to food safety issues and potential health risk (Yeasmin *et al,* 2013). Heavy Metal pollution has pervaded many parts of the developing countries and affects humans because of their longevity and accumulation in their organs via different ways (Li *et al.*, 2014 and Zhang *et al*, 2010). The non biodegradability of heavy metals and their potential to cause inappropriate effect made them the most noxious material (Seydou and Timoty, 2016). It is widely reported that they have both positive and negative role in human life. The elements play important role in biological process, but at high concentrations they may be toxic to biota, disturb the biochemical process and cause hazards. Excessive content of Heavy metals beyond maximum permissible level (MPL) leads to number of nervous, cardiovascular, renal, neurological impairment as well as bone diseases, which significantly contribute to decrease human life expectancy (9-10 years), within the affected area and several other health disorders (Yeasmin *et al*, 2013). Khan *et al.,* (2008), reported that National Research Council (NRC) has outlined four steps (processes) in estimating health risk agent, which are hazard identification, exposure assessment, dose/response assessment, and risk characterization. This problem is not an exception in Nigeria as Ahmed *et al.,* (2016) reported the risk level Nigerians and other African countries are exposed to. The scope of this research was restricted to Kano State, Nigeria (within five locations). Kano is a state in Nigeria, located between the latitude $12^{o}15'$S and $12^{o}35'$N of equator and the longitude $8^{o}20'$W and $8^{o}27'$E of meridian.

In this research the levels of concentrations in the soil in some selected areas within Kano State, Nigeria was investigated. The specific objective in this study is to identify the heavy metals in these areas, find out whether the metals comes from the same source or not and at what level of concentration are they placed and determine the level of contamination in the selected areas.

Figure 1 presents a map of the study areas.

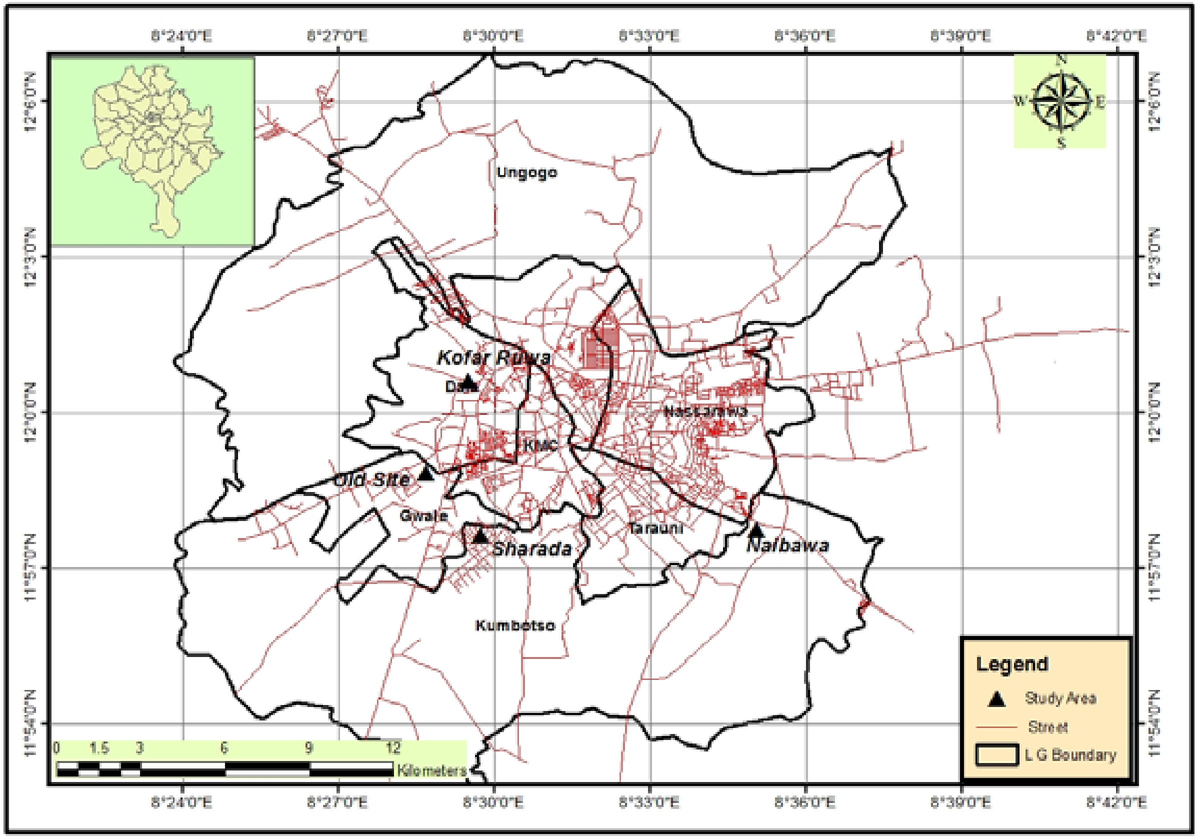


**Figure 1: The five (5) selected sample site: Sharada, Kofa Ruwa, Naibawa and Bayero University (two locations) Kano.**

## 1.1 THEORETICAL BACKGROUND

One of the governing equations that give a relationship between, α (the analyte's absorptivity with units of $cm^{-1}$ $conc^{-1}$); Concentration, C; Absorbance, A; and width, b; is the Beer's law (some time called Beer – Lambert Law), presented as equation (1):

$$A = \alpha bC \qquad (1)$$

If we express the concentration using molarity, then we replace *α* with the molar absorptivity,ε, which has unit of $cm^{-1}$ $M^{-1}$ . Then, we have:

$$A = \varepsilon bC \qquad (2)$$

The concentration of heavy metals is directly related to the absorbance of the metals by a substance. In this research work we are interested in the Biological and Soil Samples Concentration ($C_{sample}$), and Pollution Load Index (PLIs). In order to have the concentrations of these metals, the equations used by Udo *et al.* (2009) and Khan *et al.,* (2008) were employed.

$$C_1V_1 = C_2V_2 \qquad (3)$$

Where $C_n$ is the concentration of solution and $V_n$ is the volume (for n=1,2,3,…,n).

Concentration of sample ($C_{sample}$)

$$C_{sample} = \left(\frac{Abs.}{Standard/Slope}\right) \times \frac{Volume}{Weight\ of\ Sample} \qquad (4)$$

where Abs. is Reading of absorbance (with respect to Heavy Metals)

Pollution Load Index Soil (PLIs)

Ahmed *et al.*, (2013), reported methods used in indicating the level of contamination of soil ranging from low, moderate and severe contamination. The equations are given as:

$$C_f = \frac{C_n}{C_r} \qquad (5)$$

where $C_f$ is the contamination factor, $C_n$ is the soil concentration and $C_r$ is the background level of the study area. The PLIs is a dimensionless quantity, which depends on $C_f$. The expression for PLIs is given as:

$$PLIs = \sqrt[n]{C_{f1} + C_{f2} + C_{f3} + \ldots + C_{fn}} \qquad (6)$$

## 2.0 Materials and Method

Five (5) experimental sites were set up within Kano State, Nigeria. These are: (a) Bayero University, Kano Screen House (BUK-C) – 8°28'0" E & 11°59'0" N , (b) Bayero University, Kano Environment (BUK-E) – 8°28'0" E & 11°59'0" N (c) Kofar Ruwa (K) – 8°29' 5" E & 12°1' 5" N,(d) Naibawa (N) – 8°35'0" E & 11°58'0"N and (e) Sharada (S)- 8°29'5"E & 11°58'0"N. as shown in Figure 1.

### 2.1 Sample Preparation, Preservation, Digestion and analysis

The samples were collected at three growth stages (4th, 5th and 6th months). The samples were then shade-dried for seven days on plastic trays. The dried samples were homogenized by grinding using ceramic coated grinder. The final samples were kept in labeled polythene bags at ambient temperature.

One gram (1g) of the soil samples were weighed into a beaker, and 30ml of Aqua regia ($HNO_3$ + HCL; 3:1) was added into the 50ml plastic bottle. The mixture was placed into a mixer (Vibrator) for one hour Thirty Minutes and then removed. The solution of the mixture (filtrate) was obtained through filtering with Whitman No.42 filter paper. The solution (Suspension) was filled to marked level (50ml) of the plastic bottle, with distilled water. The concentration of Pb, Cd, Ni, Cu, Cr, Zn, Mn and Fe were determined by Atomic Absorption Spectrometry (AAS) - MODEL 210 VGP BUCK SCIENTIFIC. Analysis of each sample was carried out in triplicate and the average was computed. The corresponding wavelengths for the heavy metals; Fe, Zn, Cu, Ni, Cr, Cd, Pb, Mn, Cu of interest are 248.3, 213.9, 232, 357.9, 228.8, 217, 279.5 and 324.8nm, respectively.

### 2.2 Statistical Method

SPSS 20.0 version was employed to analyze the concentrations of the eight heavy metals determined. Regression analysis was also used to obtain the slope values that were used to compute the concentrations. The correlation matrix was equally generated and the heavy metals were identifying and discussed to be from the same source(s) or different source(s). The correlation is in term of probabilities with a heavy metal selected as it reference base on the activities in the area.

## 3.0 Results and Discussion

### 3.1 Samples Concentrations

The concentration of heavy metals is directly related to the absorbance of metals by the samples. From equation (3), which was used to calculate the concentrations of metals in the sample, the need to obtain the Slope/standard arise.

### 3.2 Standard/Slope

The standard/slope for the eight Heavy Metals was computed using equation (4). Different volume of solutions at different concentrations was prepared and analyzed using AAS machine to obtain the absorbance. The concentration and absorbance for each metal are given in **Table 1**.

**Table 1: Cd, Cr, Cu Fe, Ni, Mn, Pb, and Zn Concentration (mg/kg) and Absorbance Values**

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | **Cadmium (Cd)** | | | |
| **Concentration** | 01.00 | 00.80 | 00.60 | 00.40 | 00.20 | 00.00 |
| **Absorbance** | 00.111 | 00.087 | 00.063 | 00.044 | 00.023 | 00.00 |
| | | | **Chromium(Cr)** | | | |
| **Concentration** | 01.00 | 00.80 | 00.60 | 00.40 | 00.20 | 00.00 |
| **Absorbance** | 00.118 | 00.097 | 00.071 | 00.049 | 00.026 | 00.00 |
| | | | **Copper(Cu)** | | | |
| **Concentration** | 05.00 | 04.00 | 03.00 | 02.00 | 01.00 | 00.00 |
| **Absorbance** | 00.111 | 00.088 | 00.066 | 00.043 | 00.022 | 00.00 |
| | | | **Iron(Fe)** | | | |
| **Concentration** | 10.00 | 08.00 | 06.00 | 04.00 | 02.00 | 00.00 |
| **Absorbance** | 00.262 | 00.212 | 00.164 | 00.112 | 00.054 | 00.00 |
| | | | **Nickle (Ni)** | | | |
| **Concentration** | 10.00 | 08.00 | 06.00 | 04.00 | 02.00 | 00.00 |
| **Absorbance** | 00.131 | 00.112 | 00.084 | 00.053 | 00.027 | 00.00 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **Manganese(Mn)** | | | | | | |
| **Concentration** | 10.00 | 08.00 | 06.00 | 04.00 | 02.00 | 00.00 |
| **Absorbance** | 00.202 | 00.162 | 00.122 | 00.081 | 00.042 | 00.00 |
| **Lead(Pb)** | | | | | | |
| **Concentration** | 10.00 | 08.00 | 06.00 | 04.00 | 02.00 | 00.00 |
| **Absorbance** | 00.223 | 00.174 | 00.129 | 00.086 | 00.045 | 00.00 |
| **Zinc(Zc)** | | | | | | |
| **Concentration** | 10.00 | 08.00 | 06.00 | 04.00 | 02.00 | 00.00 |
| **Absorbance** | 00.171 | 00.137 | 00.102 | 00.067 | 00.031 | 00.00 |

From **Table 1,** the slopes were deduced with the values as; Cd (0.109), Cr (0.119), Cu (0.022), Fe (0.026), Ni (0.013), Mn (0.02), Pb (0.022) and Zn (0.017). Using equation (4) the concentrations were generated and presented in **Figures 2**.

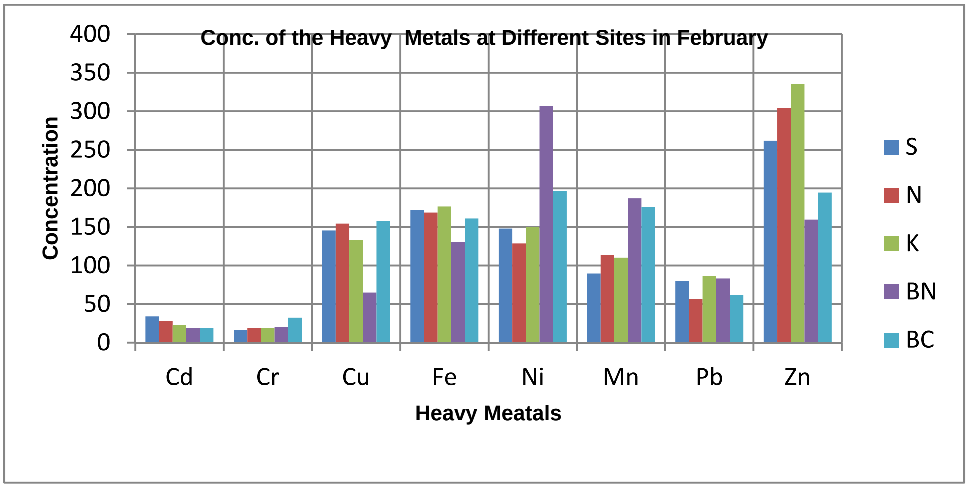


**Figure 2a**

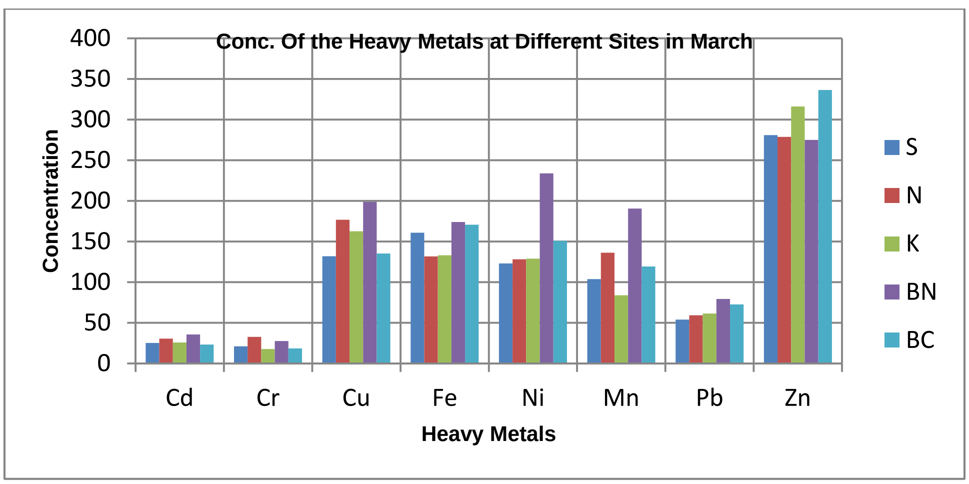


**Figure 2b**

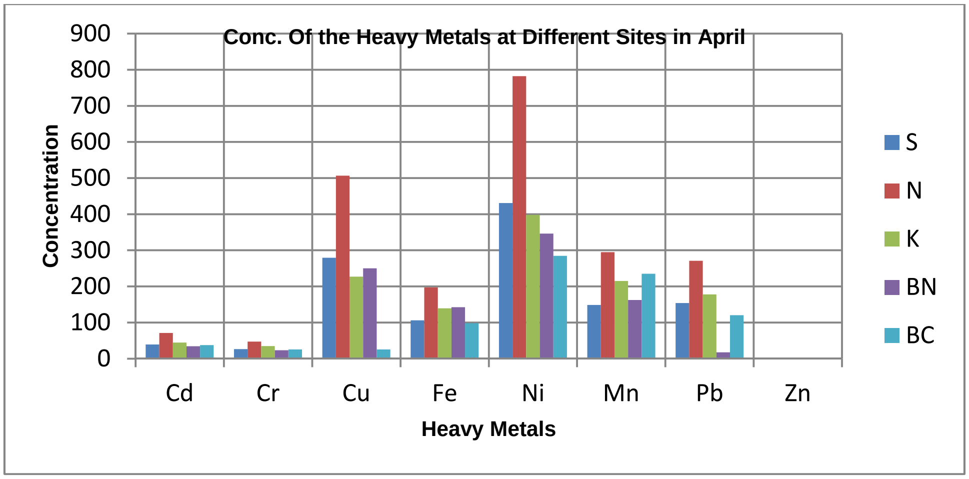


**Figure 2c**

**Figures 2.0: Concentration of Heavy Metals at Different Sites from February to April**

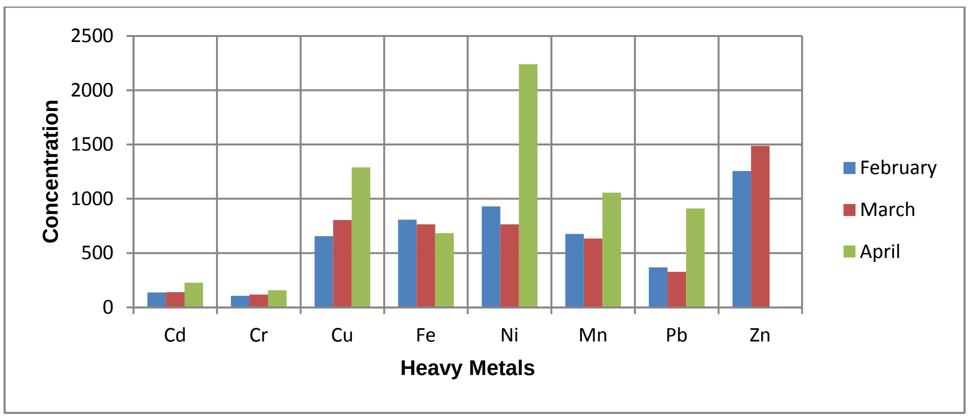


**Figure 3.0: Total concentration of the Heavy Metals for Three Months**

Considering figure 3.0, **Ni** recorded the highest concentration and **Cd** has the least. Overall the concentration base on monthly basis ascend from February, March, and then April.

### 3.2 Correlation of the Eight Heavy Metals.

The concentrations computed using equation (4) were used to illustrate the correlation between the Heavy Metals using SPS20.0.The values were given in tables 2, 3, 4, 5, and 6.

**Table 2**: **Correlation Matrix of the Heavy Metals from Naibawa site.**

| | **Cd** | **Cr** | **Cu** | **Fe** | **Ni** | **Mn** | **Pb** | **Zn** |
|---|---|---|---|---|---|---|---|---|
| **Cd** | 1.000 | | | | | | | |
| **Cr** | 0.952 | 1.000 | | | | | | |
| **Cu** | 0.990 | 0.900 | 1.000 | | | | | |
| **Fe** | 0.947 | 0.804 | 0.983 | 1.000 | | | | |
| **Ni** | 0.980 | 0.873 | 0.998 | 0.992 | 1.000 | | | |
| **Mn** | 0.996 | 0.923 | 0.998 | 0.971 | 0.993 | 1.000 | | |
| **Pb** | 0.982 | 0.78 | 0.999 | 0.990 | 1.000 | 0.995 | 1.000 | |
| **Zn** | -0.993 | -0.908 | -1.000 | -0.979 | -0.997 | -0.999 | -0.998 | 1.000 |

**Table 3: Correlation Matrix of the Heavy Metals from Kofar Ruwa site.**

| | **Cd** | **Cr** | **Cu** | **Fe** | **Ni** | **Mn** | **Pb** | **Zn** |
|---|---|---|---|---|---|---|---|---|
| **Cd** | 1.000 | | | | | | | |
| **Cr** | 0.977 | 1.000 | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Cu** | 0.985 | 0.925 | 1.000 | | | | | |
| **Fe** | -0.376 | -0.170 | -0.531 | 1.000 | | | | |
| **Ni** | 0.979 | 1.000 | 0.929 | -0.178 | 1.000 | | | |
| **Mn** | 0.947 | 0.994 | 0.876 | 0.057 | 0.993 | 1.000 | | |
| **Pb** | 0.943 | 0.992 | 0.871 | 0.047 | 0.991 | 1.000 | 1.000 | |
| **Zn** | -0.996 | -0.996 | -0.967 | 0.296 | -0.993 | -0.971 | -0.968 | 1.000 |

**Table 4: Correlation Matrix of the Heavy Metals for BUK Environs site.**

| | Cd | Cr | Cu | Fe | Ni | Mn | Pb | Zn |
|---|---|---|---|---|---|---|---|---|
| **Cd** | 1.000 | | | | | | | |
| **Cr** | 0.873 | 1.000 | | | | | | |
| **Cu** | 0.943 | 0.662 | 1.000 | | | | | |
| **Fe** | 0.753 | -0.978 | 0.492 | 1.000 | | | | |
| **Ni** | -0.237 | -0.680 | 0.99 | -0.818 | 1.000 | | | |
| **Mn** | -0.339 | 0.162 | 0.632 | 0.364 | -0.834 | 1.000 | | |
| **Pb** | 0.412 | -0.085 | 0.691 | -0.290 | 0.788 | -0.997 | 1.000 | |
| **Zn** | -0.026 | 0.465 | -0.356 | 0.638 | -0.965 | -0.949 | -0.922 | 1.000 |

**Table 5: Correlation Matrix of the Heavy Metals for BUK Screen House site.**

| | Cd | Cr | Cu | Fe | Ni | Mn | Pb | Zn |
|---|---|---|---|---|---|---|---|---|
| **Cd** | 1.000 | | | | | | | |
| **Cr** | 0.353 | 1.000 | | | | | | |
| **Cu** | -0.875 | 0.144 | 1.000 | | | | | |
| **Fe** | -0.975 | -0.137 | 0.961 | 1.000 | | | | |
| **Ni** | 1.000 | 0.351 | -0.876 | -0.976 | 1.000 | | | |
| **Mn** | 0.986 | 0.501 | -0.784 | -0.926 | 0.986 | 1.000 | | |
| **Pb** | 0.866 | -0.162 | -1.000 | 0.955 | 0.867 | 0.773 | 1.000 | |
| **Zn** | -0.996 | -0.433 | 0.830 | 0.952 | -0.996 | -0.997 | -0.820 | 1.000 |

**Table 6: Correlation Matrix of the Heavy Metals for all the sites**.

| | Cd | Cr | Cu | Fe | Ni | Mn | Pb | Zn |
|---|---|---|---|---|---|---|---|---|
| **Cd** | 1.000 | | | | | | | |
| **Cr** | 0.993 | 1.000 | | | | | | |
| **Cu** | 0.989 | 0.993 | 1.000 | | | | | |
| **Fe** | -0.963 | 0.989 | 0.992 | 1.000 | | | | |
| **Ni** | 0.984 | -0.963 | 0.946 | -0.989 | 1.000 | | | |
| **Mn** | 0.985 | 0.985 | 0.949 | -0.902 | 1.000 | 1.000 | | |
| **Pb** | 0.943 | 0.990 | 0.958 | -0.915 | 0.999 | 1.000 | 1.000 | |
| **Zn** | -0.975 | -0.975 | -0.931 | 0.879 | -0.999 | -0.999 | -0.997 | 1.000 |

At Naibawa site, the correlation values obtained indicate the high probability of Cd, Cr, Cu, Fe, Ni, Mn, and Pb of originating from the same source while Zn might have originated from a different source. This is expected, considering the nature of the Naibawa site (dump site). From **Table 3**, Kofar Ruwa site shows that Fe is originated from a source while Cd, Cr, Cu, Ni, Mn and Pb might have been from a different source(s). Cd, Cr, Cu, Fe and Pb in BUK environment are probably from the same source while Ni, Mn and Zn might have been from a different source as indicated in **Table 4**. But in the control area, the BUK C site, Cd, Ni, Mn, Pb were suspected to be from the same source, while Cr, Cu, Fe and Zn might have been from another source. In the overall sites, indicated that Cr and Cu are from the same source while Cd, Cr, Cu, Ni, Mn and Pb are from another source.

## 3.3 Pollution Load Index (PLIs)

The concentrations of the eight heavy metals for the geological samples were equally computed using equations (4). These computed concentrations were used to obtain the level of pollution within the soil at three different periods (i.e the geological samples were collected before, during, and after planting of the samples) and equations (5) and (6) were used in determining the pollution load index (PLI), and contamination factors (Cf), which were presented in **Figures 4** (Contamination factor Values) and Table 7 (Pollution Load Index Values) respectively.

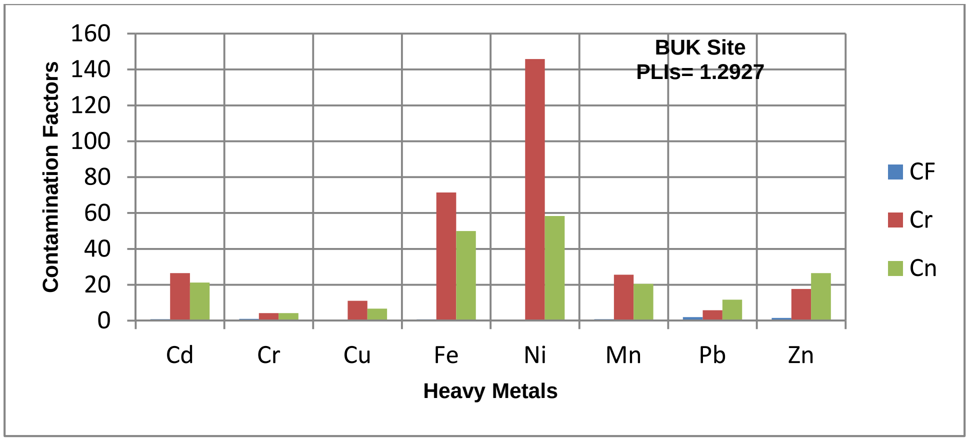


**Figure 4a**

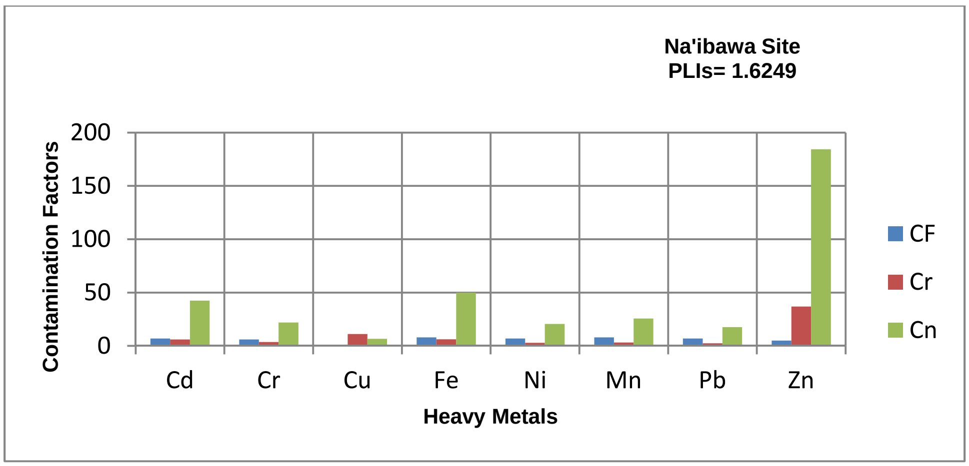


**Figure 4b**

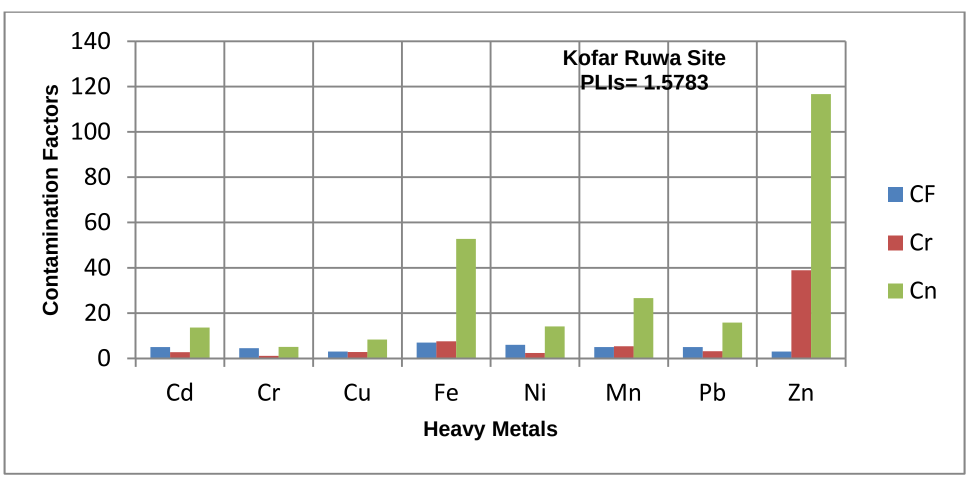


**Figure 4c**

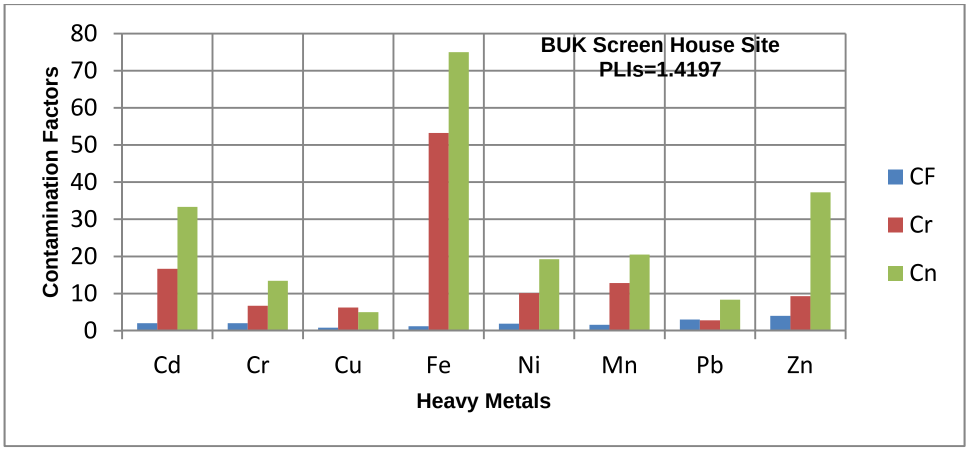


**Figure 4d**

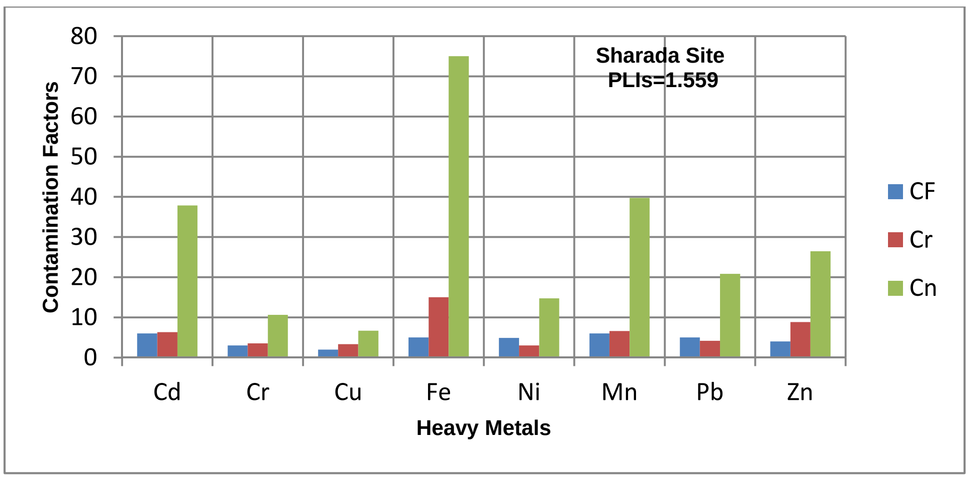


**Figure 4e**

Considering figures 4a to 4e, the computed contamination factors are all greater than 1, this means that the sites is contamination.

**Table 7: Pollution Load Index of Soil (PLIs) Site**

| PLIs | Before Planting of the Samples | During Planting of the Samples | After Planting of the Samples |
|---|---|---|---|
| **BUKS** | 1.2927 | 1.2444 | 1.2318 |
| **Naibawa** | 1.6249 | 1.6067 | 1.5098 |
| **Kofar Ruwa** | 1.5783 | 1.5386 | 1.4372 |
| **BUKN** | 1.4197 | 1.4029 | 1.3028 |
| **Sharada** | 1.5590 | 1.5253 | 1.4449 |

The values computes in relation to the concentrations ($C_n$, $C_r$, and $C_f$), were used to compute the level of contamination. PLIs was use to indicate at what level is our site place base on the values obtained. According to Ahmed *et al.,* (2014), if the $C_f < 1$, indicate low contamination, $1 \leq C_f \leq 3$ ;Moderate Contamination, $3 \leq C_f \leq 6$ and $C_f > 6$; Severe Contamination. While for PLIs: when PLIs < 1; absence of Contamination, PLIs = 1; Low contamination, and PLIs >1; High contamination. Figure 5 show the representation of table 7 in form of bar chart.

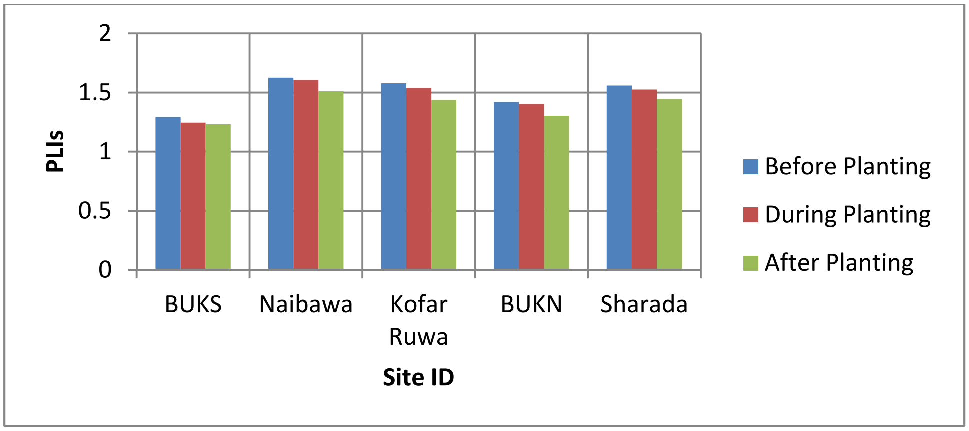


**Figure 5: Bar chart representing contamination levels from the five sites.**

It can be deduced that the five sites are contaminated with heavy metals. However looking at the different periods in which pollution level varies, one can say that the pollution reduces with time relative to the plantation of the samples. This indicates that the PLIs decreases as the plants grow in the five sites as a result of absorption of the metals by the plants.

## 4.0 CONCLUSION

The concentration of eight (8) heavy metals (Cr, Cd, Cu, Fe, Zn, Ni, Pb, and Mn) were determined. These heavy metals recorded different/varying concentrations, within the soil and the plants samples.

The correlation matrix generated from the concentrations of samples obtained reveals that in each site, there are group of Heavy metals that originate from the same source(s) and others that emanate from other source(s).

The Pollution Load Index computed (PLI) in each site was greater than 1, hence the sites are considered to be contaminated. However the pollution Load Index computed, before, during, after planting of the two samples, It shows that there is significant decrease in the level of contamination which could be attributed to some amount of the heavy metals absorbed by the samples during plantation of the samples, and if more were planted, the metal level in the soil would be reduced drastically.

## 5.0 ACKNOWLEDGMENTS

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