RESEARCH Vol. 14, 2018

ISSN 2278–5485 EISSN 2278–5477

DISCOVERY Science

# Pollution indices and transfer factors of metals in selected medicinal herbs from Kano Metropolis

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**Article History**
Received: 06 August 2018
Accepted: 27 September 2018
Published: October 2018

**Citation**
Inuwa Y, Mohammed MI. Pollution indices and transfer factors of metals in selected medicinal herbs from Kano Metropolis. *Discovery Science*, 2018, 14, 100-108



## ABSTRACT

Medicinal herbs and their mixtures are widely used for the prevention and treatment of various diseases, but can also present health risks due to the presence of toxic metals such as Pb and Cd. The aim of this study was to determine the content, transfer factor and pollution index of lead, copper, iron and calcium in the plants samples collected from different areas. The samples were collected and prepared using standard analytical procedures and analytical grade reagents were used for digestion. Agilent 240FS AA model of fast sequential Atomic absorption spectroscopy was used for the analysis of the metal content of these samples.Ca ranged from 743.45 to 19926.94mg/kg, Fe ranged from 96.44mg/kg to 876.21mg/kg, Cu ranged from 4.41 to 30.78mg/kg and Pb ranged from 0.58 to 11.77mg/kg. TfBompai ranged from 0.07(Fe) to 3.00(Ca), TfChallawa ranged from 0.07(Fe) to 3.25(Ca), TfJakara ranged from 0.05(Fe) to 7.31(Ca), TfSharada ranged from 0.07(Ca) to 4.07(Ca) and TfWatari ranged from 0.05 to 14.55(Ca). Challawa sampling area exhibited highest mean PI value of 7.22 and Watari lowest with mean PI value of 2.11.

**Key words:** Medicinal herbs, metals, Challawa, Watari, Bompai, Sharada, Jakara

## 1. INTRODUCTION

The oldest component of the Nigerian health sector consists of traditional healers and birth attendants, who are the *de facto* providers of primary health care (Iwu, 1994). The use of traditional herbal medicine has spread both in the developing and the industrialized countries, as a complementary way to treat and to prevent illnesses (WHO, 2003). The use of medicinal plants in both crude and prepared forms has greatly increased, and although herbal remedies are often perceived as being natural and therefore safe, they are not free from adverse effects (Kirmani et al, 2011). The ecology of a plant community is greatly influenced by physical and chemical properties of soil, particularly presence of excess and deficiency of mineral nutrients (Bandita et al, 2011). However, environment, atmosphere, pollution, soil, harvesting and handling are some of the factors which may play important roles in contamination of medicinal plants by metals and microbial growth (Ajasa, *et al.,* 2004).

Medicinal herbs have been used since ancient times and their use has been increasing over time. World Health Organization (WHO) has revealed that 70 to 80% of world's population uses alternative remedies, especially medicinal herbs as their first step treatment and the tendency to use herbal products has recently grown (Mostafa et al, 2011). Using herbs in medical treatment of various illnesses one should be aware that apart from the pharmacological effect they could turn out to be toxic because of the presence of heavy metals like Pb, Cd, and other impurities. Certain elements at elevated levels are toxic; therefore quantification of various elements is important to determine the effectiveness, safety and scientific validation of therapeutic use of the plants (Ayoola, 2010). Various reports have discussed the potential health implications of trace metals in medicinalherbs, since the herbal bush is known to accumulate them (Arpadjan et al, 2008 and Gomez et al, 2007). Over one-third of the population in developing countries lack access to essential medicines, therefore, the provision of safe and effective herbal drug therapies could become a critical tool to increase access to health care (WHO, 2003).

Up to 80 % (WHO, 2008) or even 90% (BBC, 2006) of some populations depend almost entirely on Traditional Medicine (TM) for most of their primary healthcare needs, the dramatic irony is that among these same populations, TMs, including herbal drugs, are hardly regulated by the State. Because herbal preparations are usually not evaluated for purity and consistency of active components, they often contain unintentional contaminants.

The aim of this study was to determine the content, transfer factor and pollution index of lead, copper, iron and calcium in twelve herbs collected from Bompai, Challawa, Jakara, Sharada and Watari.

## 2. MATERIALS AND METHOD

### The Study Area

The study areas are Challawa, Bompai and along river Watari as control area (*Dawaki et al,* 2013) Kano State, Nigeria (Fig. 1).The vegetation is that of tropical savana. There are two dinstict seasons, the wet and the dry seasons.

### Sampling

Fresh samples of the plant species studied were collected from June to August, 2015. The samples were authenticated at the Herbarium Unit, Department of Plant Biology, Bayero University, Kano, and accession numbers were given to each sample. The plants were randomly sampled in each location and for each species, 1-2 kg of material was obtained from all locations. The plant samples were thoroughly washed with tap water and then de-ionized water to remove dust and other particles then dried at room temperature and ground to fine powder and finally stored in airtight cleaned plastic bottles. Soils were sampled at the same locations as the medicinal herbs samples at 0 to 20 cm depth rooting zone and mixed to form composite samples of each location. The soil samples were dried, ground and sieved to uniform size using 1 mm mesh sieve, then stored in a labeled cleaned plastic container.

### Ashing of plants samples

5g of air dried, ground and sieved plant samples were weighted into porcelain crucible and ash into a constant weight in a muffle furnace at a temperature of 550$^{o}$C, 20cm$^{3}$ of 0.1M $HNO_3$analaR grade was added to the ash sample in a beaker and boiled for few minutes on a hot plate, after the appearance of white fumes, the digest (usually colourless or pink) was allowed to cool then filtered through Nộ 1 Whatman filter paper into 100cm$^{3}$ volumetric flask and made up to the mark with the 0.1M $HNO_3$.

Blank was prepared using the same procedure without the sample. Both the samples and the blank were aspirated into the AAS for the determination of the metals. Absorbance values were recorded and the corresponding concentrations from the calibration curve plotted were determined and presented in mg/kg dry weight (Akubugwo et al 2007; Ibrahim and Jimoh, 2015).

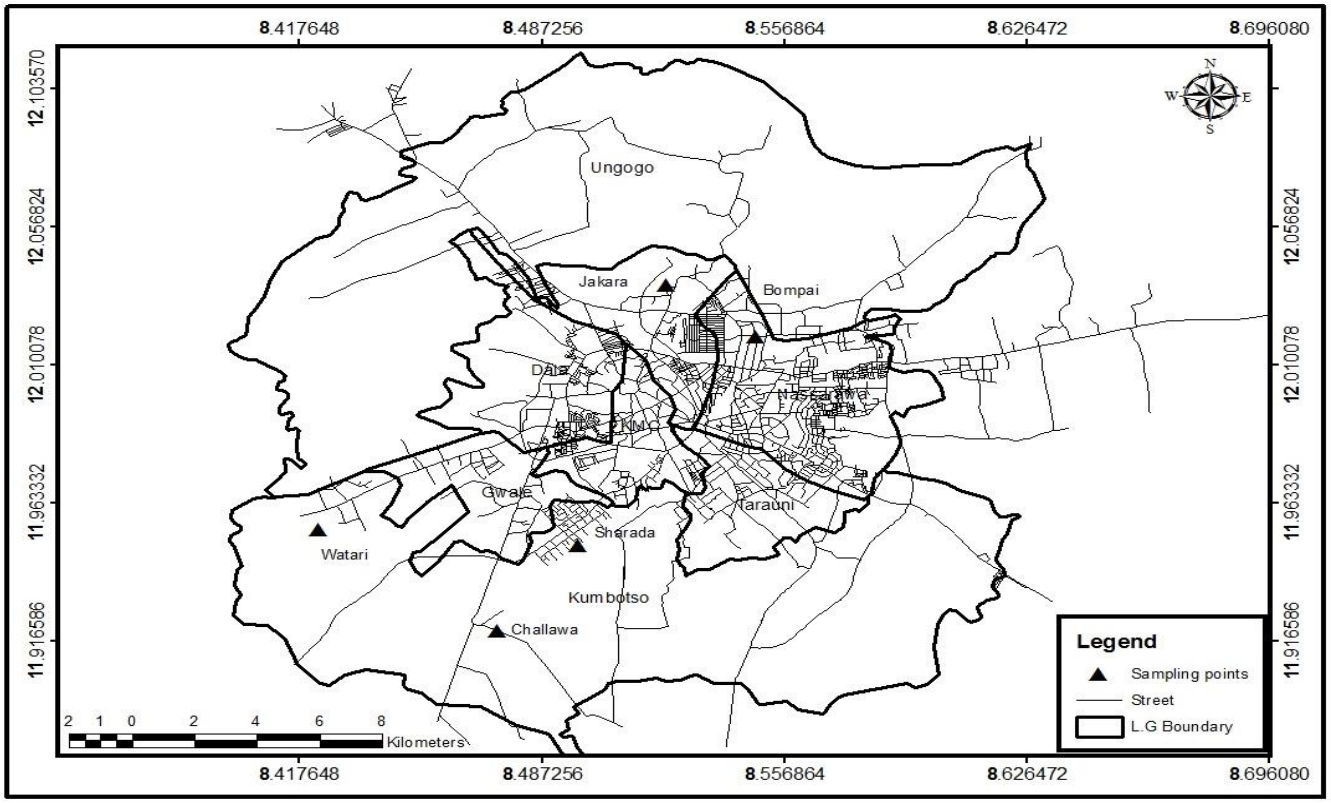


**Figure 1** Map of Kano State showing Sampling Areas

**Digestion of soil samples**

2 grams of each soil samples was weighed into a separate, labeled, clean, and dry 100cm$^3$ beaker. To each beaker 5cm$^3$ of water was added and then 5cm$^3$ concentrated $HNO_3$, each slurry was mixed with the bare glass end of a different stirring rod and each beaker was covered with a non-ribbed watchglass, placed concave up. All the samples were heated together on one hotplate until they were refluxing (that is, until vapor is condensing on the bottom of the watch glass and dripping back down into the beaker), and were kept at reflux for 10 minutes, stirring a few times. The samples were removed from the hotplate and allowed to cool until they can be safely handled. Another 5cm$^3$ of concentrated $HNO_3$ was added to each, the watch glasses were replaced, and refluxed for another 10 minutes. The samples were again allowed to cool enough to handle, then 5cm$^3$ of concentrated HCl was added and then 10cm$^3$ of water. The watch glass cover was replaced and refluxed for 15 minutes, stirring occasionally. Finally, each solution was filtered through No 1 filter paper into a 100cm$^3$volumetric flask and was made to the mark. Blank was prepared using the same procedure without the sample. Both the samples and the blank were individually aspirated into the flame of the AAS for the determination of the metals. Absorbance values were recorded and the corresponding concentrations from the calibration curve plotted were obtained by interpolation and presented in mg/kg dry weight (Mielke, 1999 and Yarnell, 2006).

## 3. RESULTS AND DISCUSSION

The analysis of the samples was done in triplicates under the same conditions as standards and blanks, Agilent 240FS AA model of fast sequential Atomic absorption spectroscopy was used for this study. The validity of the method used has been ensured by incorporating various quality control (QC) checks and analysis of certified reference material (CRM). The agreement between the certified values and the measured values were excellent, which demonstrates the accuracy of the generated calibration as well as the overall accuracy of the method.

The data was subjected to a two-way analysis of variance to bring out the effects of the plants location on the plants elemental content as well the effect the plant itself has on its mineral content. Anal Chem, Microsoft Excel (Window 7 Professional), Graphpad Prism and Sigma stat 3.5 Softwares were used. The concentrations vary among the individual herbs, the control and also among the sampling areas. The results were presented in tables and figures.

Figure 2 shows Calcium levels of the herbs across the five sampling areas. The level in Bompai ranged 743.45±12.15 to 8510.08±17.71mg/kg in Bermuda grass and Sickle wild respectively. In Challawa Morning glory has the lowest value of 438.33±9.28mg/kg while Coffesenna was the highest with 5466.27±24.58mg/kg. In Jakara the level of Ca ranged from 1638.91±39.36 to 19926.94±66.94mg/kg in Sodom apple and Coffesenna. Sharada has the range of 282.19±10.51mg/kg in Sickle wild to 17659.36±23.71mg/kg in Coffesenna. While in Watari the control area the level ranged from 104.57±1.58 to 28573.27±15.43mg/kg in Sickle wild and Coffesenna respectively. Analysis of variance (ANOVA) shows that P value is <0.0001.

Figure 3 shows Iron concentrations in the herbs and among the five sampling areas. Iron concentration in Bompai ranged from 163.95±6.24mg/kg in Sodon apple to 446.37±5.85mg/kg in Rice flatsedge. The concentration of iron in Challawa ranged from 104.71±8.49mg/kg in Sickle wiid to 812.84±1.08mg/kg in Morning glory. Jakara has Iron levels range of 34.44±1.95mg/kg in Sickle wild to 796.30±1.95mg/kg in Rice flatsedge. In Sharada iron level was found to be 71.64±1.95mg/kg in Sickle wild and 876.21±1.56mg/kg in Sodon apple. Watari has the range of 108.84±3.89 to 673.69±5.85mg/kg in Sickle wild and Rice flatsedge. Analysis of variance (ANOVA) shows that P value is <0.0001.

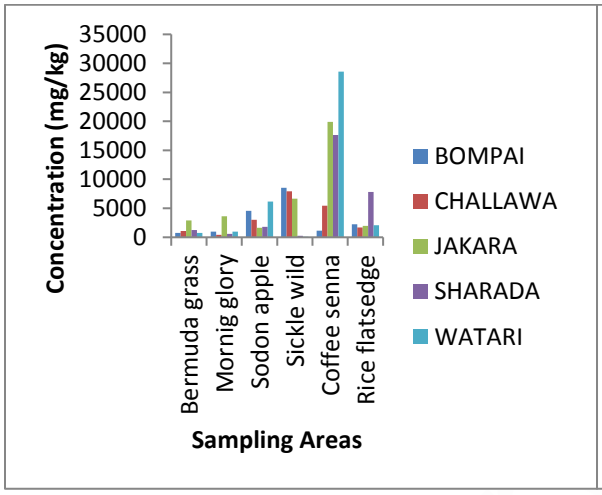


**Figure 2** Calcium Concentrations

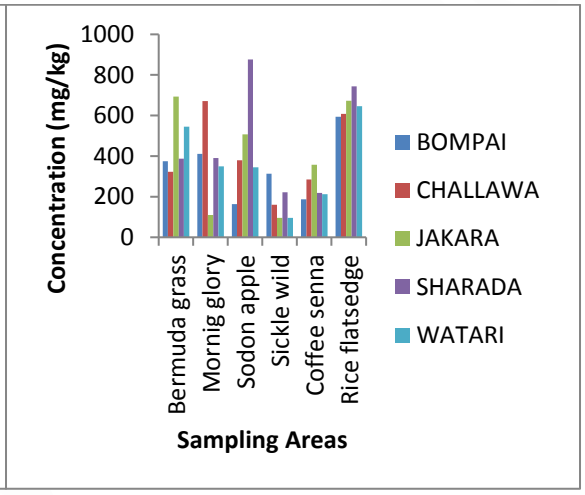


**Figure 3** Iron Concentrations

Figure 4 shows the levels of Copper in the herbs and the five sampling areas. In Bompai lowest level was 4.49±0.45mg/kg in Sickle wild and highest was 30.78±1.51mg/kg in Bermuda grass. In Challawa, levels of Copper ranged from 6.01±0.27mg/kg in Coffesenna to 14.71±1.42mg/kg in Morning glory. The level of Cu in Jakara ranged 4.41±0.44 to 8.19±0.50mg/kg in Morning glory and Bermuda grass respectively. In Sharada Cu level ranged from 4.73±0.77 to 12.88±1.45mg/kg Bermuda grass and Morning glory. Analysis of variance (ANOVA) shows that P value is <0.0001.

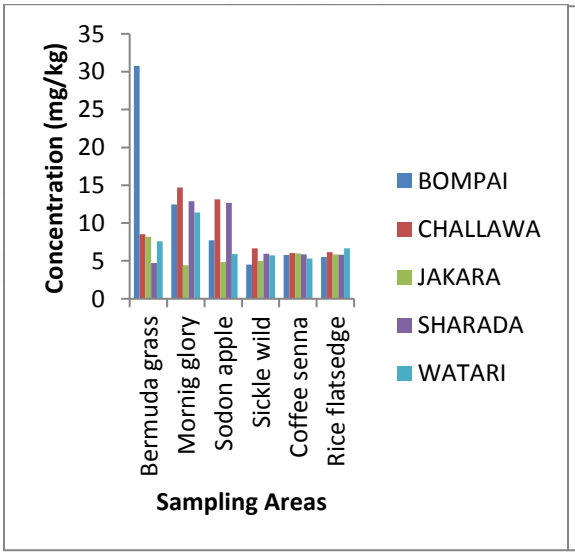


**Figure 4** Copper Concentrations

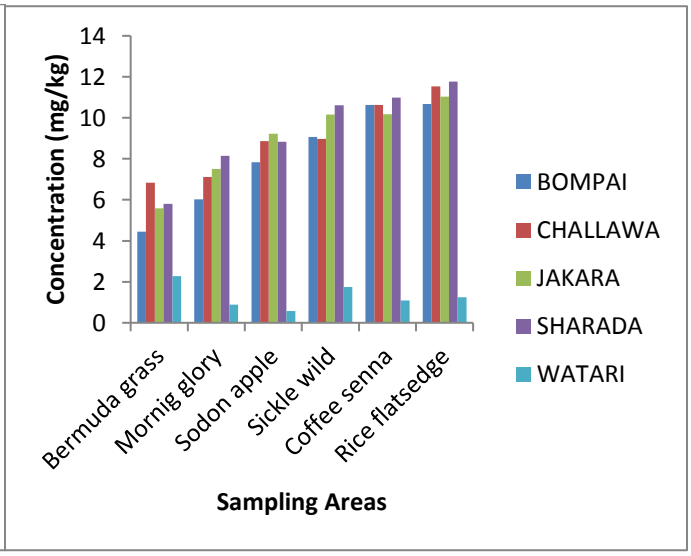


**Figure 5** Lead Concentrations

Figure 5 shows lead concentration in different medicinal herbs in five sampling areas. In Bompai Pb ranged 5.81±0.43 to 16.83±0.78mg/kg in Morning glory and Bermuda grass. Challawa Pb ranged 6.89 ±0.37 to 14.99±0.63mg/kg in Morning glory and Bermuda grass. In Jakara, Pb ranged from 7.34±0.37 to 11.63±0..57mg/kg in Morning glory and Bermuda grass. In Sharada Pb ranged from 7.96±0.22 to11.78±0.57mg/kg in Morning glory and Bermuda grass. Watari ranged from 2.60±0.22to 5.66±0.57mg/kg in Sickle wild and Bermuda grass. Analysis of variance (ANOVA) shows that P value is <0.0001.

Figure 6 shows the concentration pattern of elements in the soils of the five sampling areas. Calcium concentration ranged from 1962.47±20.25 to 4340.35±53.35mg/kg in Watari and Sharada areas respectively. Calcium is the fifth most abundant element by mass in the Earth's crust and the fifth most abundant dissolved ion in seawater by both molarity and mass, after sodium, chloride, magnesium, and sulfate (Dickson and Goyet1994). Iron concentration in the soil samples ranged from 699.18±2.54 to 2805.33mg/kg in Watari and Bompai respectively. Nganje et al, (2013) reported higher soil Iron concentration range of 1900 to 18000mg/kg and lower range of 141.80 - 159.00µg/g was reported by Abechi et al, (2010). Iron is the sixth most abundant element in the Universe, formed as the final step of nucleo synthesis, by silicon fusing in massive stars. Iron is consequently the most abundant element on Earth, but only the fourth most abundant element in the Earth's crust(John and Edward, 1980)(Lyons and Reinhard, 2009). Copper ranged from 17.30±1.99 to 38.08±2.53mg/kg in Watari and Jakara which was lower than 50 – 125mg/kg the maximum allowable Limits (MAL) in Soil (Fagbote and Olanipekun, 2010). Lower range of 3.2- 13.5 mg/kg was reported by Umaru, (2013) while Adamu et al, (2013) reported higher range of 80 to 1118.5mg/kg. Copper is produced in massive stars and is present in the Earth's crust in a proportion of about 50 parts per million (ppm) (Emsley, 2011). It was estimated that the median value of worldwide emissions of Cu into soils was 956 $x10^{-6}$ kg $yr^{-1}$ (Nriagu and Pacyna, 1988). Although Cu is essential for plant growth, a very small amount of Cu is required by plants, for example, 5 to 20 µg g-1 (DW) in plant tissue (Adriano, 1986). However, over 20 µg g-1 (DW) can be found in plants from contaminated area, especially plant roots grown in mining and smelting sites(Jung, and Thornton, (1997); Adriano, (1986) and Alloway, (1995).

Pb ranges ranged from 5.73±0.47 to 129.10±1.24mg/kg in Watari and Bompai which was lower than 100 – 500mg/kg the maximum allowable Limits (MAL) in Soil (Fagbote and Olanipekun, 2010). Pb range from about 4.79 mg/kg to 264.94 mg/kg was reported by Dawaki et al (2013). Lower Lead range of 1.59 to 12.10 µg/g was also reported by Abechi et al, (2010) and higher range of 247 to 2100mg/kg by Adamu et al, (2011), while similar range of 4.0 to 28.0 mg/kg was by Umaru, (2013).

Lead's abundance in the Earth's crust is 16 ppm, Metallic lead does occur in nature, but it is rare. Lead is used in building construction, lead-acid batteries, bullets and shot, weights, as part of solders, pewters, fusible alloys, and as a radiation shield. Lead is frequently used in polyvinyl chloride (PVC) plastic, which coats electrical cords; lead is also used in some candles to treat the wick to ensure a longer, more even burn (Zweifel, 2009; Wilkes *et al,* 2005). If ingested or inhaled, lead and its compounds are poisonous to animals and humans. Lead is a neurotoxin that accumulates both in soft tissues and the bones, damaging the nervous system and causing brain disorders. Excessive lead also causes blood disorders in mammals (Hernberg, 2000).

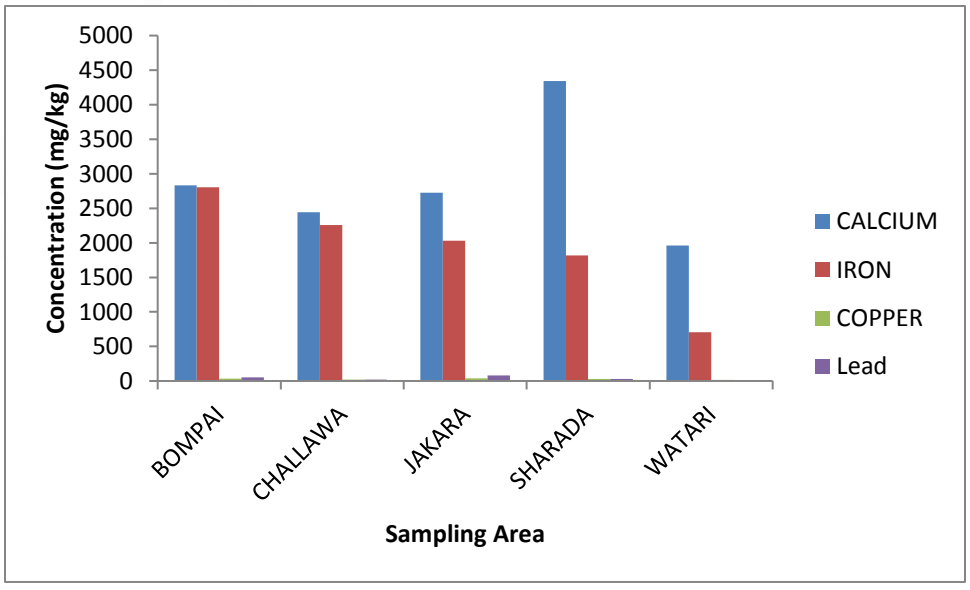


**Figure 6** Metals concentrations in the soils of sampling areas

**Mean Soil-Herbs Transfer Factor (Tf)**

Transfer factor (TF) was used to understand the extent of risk and associated hazard due to transfer of heavy metals from the soil into the herbal plants and its subsequent accumulation, using the relation according to Cui et al, (2004); Anita et al,(2010) and Ibrahim and Jimoh, (2015):

TF= Cp/Cs

Where: Cp = concentration of metal in the herb, Cs = metal concentration in the in soil sample.

Among the different plant species, there are differences in the uptake of heavy metals, which depends on their genetic characteristics, on the influence of the surface of root system and its capacity for absorption of ions, on the shape of root excretion and the speed of evapotranspiration (Alloway, 1995). At control Area, transfer factor for all the metals was lower as compared to the other sampling areas.

**Table 1** Transfer factor of metals through different herbs at Bompai sampling area

| **HERBS** | **TRANSFER FACTOR** | | | |
|---|---|---|---|---|
| | **Ca** | **Fe** | **Pb** | **Cu** |
| Bermuda grass | 0.26 | 0.13 | 0.08 | 0.95 |
| Mornig glory | 0.34 | 0.15 | 0.11 | 0.39 |
| Sodon apple | 1.61 | 0.06 | 0.15 | 0.24 |
| Sickle wild | 3.00 | 0.11 | 0.17 | 0.14 |
| Coffee senna | 0.39 | 0.07 | 0.20 | 0.18 |
| Rice flatsedge | 0.80 | 0.21 | 0.20 | 0.17 |

**Table 2** Transfer factor of metals through different herbs at Challawa sampling area

| **HERBS** | **TRANSFER FACTOR** | | | |
|---|---|---|---|---|
| | **Ca** | **Fe** | **Cu** | **Pb** |
| Bermuda grass | 0.44 | 0.14 | 0.42 | 0.42 |
| Mornig glory | 0.18 | 0.29 | 0.27 | 0.27 |
| Sodon apple | 1.25 | 0.17 | 0.42 | 0.42 |
| Sickle wild | 3.25 | 0.07 | 0.43 | 0.43 |
| Coffee senna | 2.24 | 0.13 | 0.54 | 0.54 |
| Rice flatsedge | 0.69 | 0.27 | 0.39 | 0.39 |

**Table 3** Transfer factor of metals through different herbs at Jakara sampling area

| **HERBS** | **TRANSFER FACTOR** | | | |
|---|---|---|---|---|
| | **Ca** | **Fe** | **Cu** | **Pb** |
| Bermuda grass | 1.06 | 0.34 | 0.22 | 0.07 |
| Mornig glory | 1.32 | 0.05 | 0.12 | 0.09 |
| Sodon apple | 0.60 | 0.25 | 0.13 | 0.12 |
| Sickle wild | 2.45 | 0.05 | 0.13 | 0.13 |
| Coffee senna | 7.31 | 0.18 | 0.16 | 0.13 |
| Rice flatsedge | 0.72 | 0.33 | 0.15 | 0.14 |

**Table 4** Transfer factor of metals through different herbs at Sharada sampling area

| **HERBS** | **TRANSFER FACTOR** | | | |
|---|---|---|---|---|
| | **Ca** | **Fe** | **Cu** | **Pb** |
| Bermuda grass | 0.29 | 0.21 | 0.17 | 0.19 |

| | | | | |
|---|---|---|---|---|
| Mornig glory | 0.14 | 0.22 | 0.46 | 0.27 |
| Sodon apple | 0.42 | 0.48 | 0.45 | 0.29 |
| Sickle wild | 0.07 | 0.12 | 0.21 | 0.35 |
| Coffee senna | 4.07 | 0.12 | 0.21 | 0.36 |
| Rice flatsedge | 1.79 | 0.41 | 0.20 | 0.38 |

**Table 5** Transfer factor of metals through different herbs at Watari sampling area

| **HERBS** | **TRANSFER FACTOR** | | | |
|---|---|---|---|---|
| | **Ca** | **Fe** | **Cu** | **Pb** |
| Bermuda grass | 0.39 | 0.55 | 0.44 | 1.27 |
| Mornig glory | 0.51 | 0.55 | 0.66 | 0.49 |
| Sodon apple | 3.14 | 1.24 | 0.34 | 0.32 |
| Sickle wild | 0.05 | 0.31 | 0.33 | 0.97 |
| Coffee senna | 14.55 | 0.31 | 0.31 | 0.61 |
| Rice flatsedge | 1.05 | 1.05 | 0.38 | 0.69 |

Variations in transfer factor among different herbs may be attributed to differences in the concentration of metals in the soil and differences in element uptake by different herbs as postulated by Cui *et al*. (2004) and Zheng *et al*. (2007). The results from this study indicated that the uptake of each metal differs from one site to another and from one plant to another and the TF for the herbs in all sites ranged differently. The TF value of (1) unity, indicated that the concentration of the metal in the plant was equal to that of the soil while the TF value greater than unity indicates a higher concentration of the metal in the plants than in the soil. This indicated that plant uptake of this metal at the sites was not restricted by pH or other parameters (Amusan *et al,* 2005).

Generally most of the heavy metals are less available to plants under alkaline conditions than under acid conditions (Hess and Schmid, 2002). The high level of these metals in the plant at these sites might be due to direct deposition and foliar absorption in addition to the translocation from roots to the upper part of the plant.

**Metal pollution index (MPI) of heavy metal in herbs**

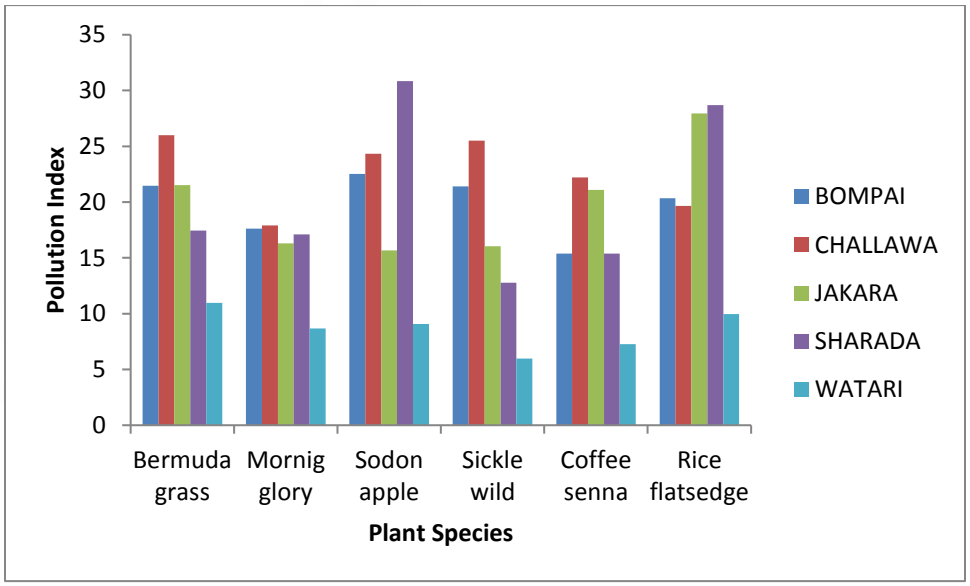


**Figure 7** Metal Pollution Index of various Herbs for all Areas

Metal pollution index (MPI) was applied to examine the overall metal contents of the different herbs from the five sampling areas in order to compare and monitor the metal pollution due to aggregate effects of all the metals in the analyesd samples. Metal

pollution index was computed by calculating the geometrical mean of the concentration of all the metals in the herbs using the relation according to Ghosh et al, (2013):

$$MPI = (CF1*CF2*CF3.....*CFn)^{1/n}$$

Where CF1, CF2, CF3....CFn = concentrations of the studied metals 1, 2, 3 upto n metal in the sample.

Figure 7 indicates the metal Pollution Index (PI) of various herbs for the five sampling areas.

The high mean pollution index obtained indicated that herbs at these sites receive loads of heavy metals which accumulated more than those from other sampling areas; hence, Challawa could be described as higher risk site compared to other areas. The mean pollution index is in order Challawa>Bompai>Jakara>Sharada>>Watari. Among the different herbs examined P3 showed the highest value of pollution index (7.46) while lowest PI value was observed in P9 (4.00). Chris and Leo (2011) reported higher pollution index value in Ready-to-use Herbal Remedies in South Eastern Nigeria; H-Nal (30.3), Virgy-virgy worm expeller (26.4) and sekin powder (24). Value of PI < 1 indicates that the plant material is not yet contaminated whereas PI > 1 indicates pollution. On the other hand, PI = 1 reveals a critical state which makes the involved plant useful for environmental monitoring (Chukwuma, 1993; OTI, 2015).

## 4. CONCLUSION

Medicinal plants are sources of a large number of active ingredients of herbal and modern medicine. This study confirms that herbs analyzed contain the essential metals like Iron, Calciume.t.c., which support the treatment of various diseases. Therefore, these herbs may be a good source of minerals to treat number of diseases that are mainly caused due to the deficiency of those minerals. However, continuous increase in environmental pollution is leading to the buildup of pollutants including heavy metals in the plant parts which eventually enter in to human food chain. The present investigation clearly demonstrated the variation in heavy metal concentration depending upon the collection sites. The need to screen medicinal plants for their elemental composition is highly desirable.

## REFERENCE


1. Abechi, E.S.; Okunola O.J.; Zubairu, S.M.J.; Usman A.A. and Apene E. (2010). Evaluation of heavy metals in roadside soils of major streets in Jos metropolis. Nigeria. *Journal of Environmental Chemistry and Ecotoxicology*. 2(6): 98-102.
2. Adamu, C. I.; Nganje, T. N.; Ukwang, E.E.; IBE, K. A. and Peter, N. (2011). A Study of the Distribution pattern of Heavy metals in surface soils around ArufuPb-Zn mine, Northeastern Nigeria, Using Factor Analysis. *Research Journal of Chemical Sciences.1 (2): 70-80*
3. Adriano, D.C. (1986). Trace Elements in the Terrestrial Environment. Springer-Verlag Inc.: New York, pp. 1- 45.
4. Ajasa, A.O..; Bello, M.O.; Ibrahim, A.O.; Ogunwande, I.A. and Olawore, N.O. (2004). Heavy trace metal and macronutrients status in herbal plants of Nigeria.*Food Chem.* 85:67-71.
5. Akubugwo, I. E.; Obasi, N. A. Chinyere, G. C. and Ugbogu, A. E. (2007). Nutritional and chemical value of *Amaranthushybridus*L. leaves from Afikpo, Nigeria. *African Journalof Biotechnology,* 6 (24): 2833-2839
6. Alloway, B.J. (1995). Heavy Metals in Soils. Blackie Academic and Professional: First edition, London, pp. 7 - 39.
7. Anita, S.; Rajesh, K.S.; Madhoolika, A. and Fiona, M.M. (2010) Risk assessment of heavy metal toxicity through contaminated vegetables from waste water irrigated area of Varanasi, India, *Tropical Ecology,* (51):25: 375-387.
8. Arpadjan, S.; Celik, G.; Taskesen, S. and Gücer, S. (2008). Arsenic, cadmium and lead in medicinal herbs and their fractionation. *Food ChemToxicol,* 48:2871-5.
9. Ayoola, P.B. and Adeyeye, A.(2010). Phytochemical and nutrient evaluation of *Carica papaya* (Pawpaw) leaves. *International Journal of Res. Rev. Appl. Sci*. 5: 325-328.
10. Bandita, D.; Gayatri, N. and Sahu, R.K. (2011). Studies on the uptake of heavy metals by selected plant species growing on coal mine spoils in sub-tropical regions of India. *Journal of American Science. 7(1): 26- 34.*
11. BBC News (2006). Can herbal medicine combat Aids? Wednesday, 15 March, 13:10 GMT. http://newsvote.bbc.co.uk/mpapps/pagetools/print/news.bbc.co.uk/2/hi/Africa/4793106.stm; Accessed 2011 April 16.
12. Chris O. N. and Leo M. (2011). Heavy Metal Contamination of Ready-to-use Herbal Remedies in South Eastern Nigeria Pakistan. Journal of Nutrition 10 (10): 959-964.
13. Chukwuma, S.C. (1994). Evaluating Baseline Data for Lead (Pb) and Cadmium (Cd) in Rice, Yam, Cassava, and Guinea Grass from Cultivated Soils in Nigeria, *Toxicological and Environmental Chemistry*, 45: 45-56.

14. Cui, Y.J.; Zhu, Y.G.; Zhai R.H.; Chen D.Y.; Huang Z.H. and Qiu Y. (2004). Transfer of metals from soil to vegetables in an area near a smelter in Nanning, China. *Environ. Int*., 30: 785-91.
15. Dawaki, M.U.; Abubakar, U. Dikko, A.U.;Noma, S.S. and Umar, A.A. (2013). Pollution as a threat factor to urban food security in metropolitan Kano, Nigeria. *Food and Energy Security*. 2(1): 20–33.
16. Dickson, A. G. and Goyet, C. (1994). Handbook of method for the analysis of the various parameters of the carbon dioxide system in sea water, version 2. ORNL/CDIAC Pp74.
17. Emsley, J. (2001). Manganese. Nature's Building Blocks: An A-Z Guide to the Elements. First edition. Oxford, UK: Oxford University Press. pp. 249–253.
18. Fagbote E.O. and Olanipekun E.O. (2010). Evaluation of the status of Heavy Metal pollution of soil and plant *(Chromolaena Odorata)* of Agbadu Bitumen Deport Area, Nigeria. *American- Eurasian J. Sci. Res*, 5(4):241-248.
19. Gomez, R.M.; Cerutti, S.; Sombra, L.; Silva, F.M. and Martinez, D.L. (2007). Determination of heavy metals for the quality contril in argentinian herbal medicines by ETAAS and ICP-OES. *Food ChemToxicol,* 45:1060-4.
20. Hernberg, S. (2000). Lead poisoning in a historical perspective. *American journal of industrial Medicine,* 38 (3): 244–254.
21. Hess, R. and Schmid, B. (2002). Supplement overdose can have toxic effects. *J. Pediat.Heamatol. Oncol.* 24: 582–584.
22. Ibrahim, G. and Jimoh, W.L.O. (2015). Evaluation of Heavy Metal And Macro-Elements In Irrigated Vegetables From Challawa-Yandanko And Kano River Basin Project, In Nigeria. *International Journal of Scientific Research and Engineering Studies (IJSRES),* 2(2): 35-41.
23. Iwu, M.M., (1994). African Medicinal Plants in the Search for New Drugs Based on Ethnobotanical Leads. Ethnobotany and Search for New Drugs. Wiley, Chichester, pp. 116–129.
24. John, W. M. and Edward, A. (1980). Chemical composition of Earth, Venus, and Mercury. *Proc. Nat. Acad. Sci.* 77 (12): 6973 –6977.
25. Jung M.C. (2008). Heavy metal concentrations in soils and factors affecting metal uptake by plants in the vicinity of a Korean Cu-W Mine. Sensors. 8:2413–2423.
26. Kirmani, M.Z.; Mohiuddin, S.; Naz F.; Naqvi, I. and Zahir, E. (2011). Determination of some toxic and essential trace metals in some medicinal and edible plants of Karachi city. *J. Basic ApplSci*, 7(2): 89-95. ).
27. Lyons, T. W. andReinhard, C.T. (2009). Early Earth: Oxygen for heavy-metal fans. *Nature*, 461 (7261):179–181.
28. Mielke, H. (1999). Determination of lead in soil by Atomic Absorption Spectroscopy. *American Scientist,* 8 (1): 62-73
29. Nganje, T.N.; Adamu, C.I.; Agbor, E.E.; Besong, E. and Atanga, S.M.B. (2013). Accumulation of Essential and Non-Essential Trace Metals in Soil-Plant System in Parts of Southeastern Nigeria. *Journal of Earth Science Research,* 1 (2): 60-67.
30. Nriagu, J.O. and Pacyna, J.M. (1988). Quantitative assessment of worldwide contamination of air, water and soils by trace metals. *Nature, 333*: 134 - 139.
31. Oti, W.J.O. (2015). Pollution Indices and Bioaccumulation Factors of Heavy Metals in Selected Fruits and Vegetables from a Derelict Mine and their Associated Health Implications. *International Journal of Environmental Science and Toxicology Research*, 3(1): 9-15.
32. Umoru P.E. (2013). Concentration of Heavy Metals in Soil from an Irrigated Farmland in Kaduna Metropolis, Nigeria. *International Journal of Advancements in Research & Technology*. 2 (1): 1 - 9
33. Wilkes, C. E.; Summers, J. W.; Daniels, C. A.; Berard, M. T. (2005). PVC handbook. Hanser. ISBN 978-1-56990-379-7. p106.
34. World Health Organization (2003). Traditional Medicine, Fact sheet No. 134. Available at: [Link] [Accessed on: 07/01/2013].
35. WHO. (2008). Traditional Medicine. WHO Fact sheet No.134. Revised. December 2008.pp93-112.
36. Yarnell, A. (2006). Atomic Absorption Determination of Lead in Soil. Chemical and Engineering News. 47-49.
37. Zheng, N.; Wang, Q.C. and Zheng, D.M. (2007). Health risk of Hg, Pb, Cd, Zn and Cu to the inhabitants around Huludao zinc plant in China via consumption of vegetables. *Science of the Total Environment* 383: 81-89.
38. Zweifel, H. (2009). Plastics Additives Handbook. HanserVerlag. ISBN 978-3-446-40801-2. pp438.