BASELINE CONCENTRATIONS OF HEAVY METALS IN NATIVE FOREST SURFACE SOILS OF KOGI STATE, NIGERIA AS A GUIDELINE FOR SOIL QUALITY DETERMINATION

Supported by tetfund

A. A. Azeez[1]*, Y. A. Iyaka[2] and M. M. Ndamitso[2]
[1]Department of Chemistry, Kogi State College of Education, Ankpa, PMB 1033, Nigeria
[2]Department of Chemistry, Federal University of Technology, PMB 65, Minna, Niger State, Nigeria
*Correspondence address: Azeezakeem25974@gmail.com

Received: June 11, 2020 **Accepted:** October 02, 2020

Abstract: The potential threat of heavy metals to soil quality and human health has led to many studies on baseline concentrations of these metals in soils; because, knowledge of baseline concentration of heavy metals in soils has become a tool for soil quality determination in the world today. On this note, forty composite surface soil samples were collected from areas of native forest with no apparent anthropogenic influence in Kogi state. The soil samples were randomly collected at the depths of 0–20 cm, air-dried, crushed and sieved with 2 mm mesh sieve. The concentrations of five heavy metals (Cd, Pb, Ni, Cu, and Zn) were quantified using Atomic Absorption Spectrophotometer with model, AA280FS after digestion with HNO_3^- $H_2O_2^-$ HCI mixture (USEPA method 3050B). Data analysis was performed using mean and range to obtain heavy metal concentrations in the soil. Geo-accumulation indices were calculated to determine the levels of heavy metal contamination in the soil. To establish the accuracy of the method used, standard reference material (WEPAL sample 989) was used and the recovery ranged from 81 to 91%. These values were within the acceptable range of 80 to 120% expected for the metals indicating good accuracy for the analysis procedure. The results obtained revealed that the mean heavy metal concentrations ($mgkg^{-1}$) were: Cd, 0.44±0.28; Pb, 23.06±7.29; Ni, 17.49±8.13; Cu, 6.34±5.38 and Zn, 18.72±15.84, respectively. This study has clearly indicated that, all of the mean concentrations are within the normal range for uncontaminated soils. Also, results for the geo-accumulation index were -0.38 for Pb,-0.03 for Cd, -2.54 for Ni,-3.41 for Cu and -2.93 for Zn. All the geo-accumulation indices were less than zero ($I_{geo} < 0$) which indicated no heavy metal contamination in the soil. Apparently, these forest soils pose no health threat to humans or ecosystems. The concentrations of the studied heavy metals can be taken as the baseline which could be useful as soil quality guideline in Kogi state, Nigeria.

Keywords: Baseline concentration, geo-accumulation index, heavy metal, wet digestion

Introduction

Soil contamination and accumulation with heavy metals has become a serious problem around the world due to the potential threat to food safety and its detrimental effects on humans and animals health (Schneider *et al.*, 2016). Contamination of the soil ecosystem by heavy metals is a critical environmental challenge because the metals persist in the environment (Babatunde *et al*., 2014). Heavy metals are defined as metals and metalloids having density greater than 5 g/cm^3 (Tutic *et al.,* 2015). Heavy metals are natural components of the earth's crust, and cannot be destroyed (Njar *et al*., 2012). Boran and Altynok (2010) described heavy metals as one of the most harmful pollutants because of its toxicity. High concentrations of heavy metals impair the quality of the environment which affects human and animal life (Inertia *et al*., 2010). The accumulation of heavy metals in soil poses risk to human and the ecosystem's health (Odoh *et al*., 2011). Increased heavy metal levels in soils may also result in increased plant uptake. Such uptakes usually depend on the heavy metal content of the soils, chemical and final forms of the metals (Kaplan *et al*., 2011).

Heavy metals can enter the soil environment as a result of both pedogenic and anthropogenic processes (Bolan *et al.*, 2014). Heavy metals occur naturally in soils, which are formed by geological processes, such as alteration and erosion of the geological underground materials (Kabir *et al.,* 2012). A portion of metals in the atmosphere may be transferred to soils by atmospheric deposition (Lu *et al*., 2010). Although, Heavy metal concentrations in soils without anthropogenic influences are usually low and do not pose risks to humans or ecosystems (Lu *et al*., 2012). Environmental heavy metal pollution is mainly of anthropogenic origin and results from activities such as fossil fuels, vehicular emissions, industrial emissions, metalliferous mining and smelting, landfill leachates, fertilizers, sewage and municipal wastes (Sekabira *et al*., 2010). For instance, Morgan (2013) ascertained that contamination of soils by heavy metals, such as Cd, Ni, Zn, Pb and Cu is due to mining, smelting, manufacturing, use of agricultural fertilizers and pesticides, municipal waste, traffic emissions, and industrial effluents. In addition, cadmium, copper, lead and zinc are the most widespread anthropogenic contaminant elements in urban soil (Hu *et al*., 2013). Heavy metals such as chromium, nickel, arsenic, cadmium and lead have been considered as the most toxic elements in the environment by the US Environment Protection Agency (EPA) (Lei *et al*., 2010).

In a similar research, Mico *et al*. (2006) reported that excess use of agro-chemicals, manures and sewage sludge disposal increased the heavy metal concentrations in soil. Further more, Ajayi *et al*. (2012) revealed that levels of Cd, Zn, Cu and As contents in soil can increase as they are found in most of the synthetic fertilizers and agrochemicals such as pesticides and herbicides as an impurity or active ingredient. Although, metals like copper, zinc and nickel are essential metals since they play an important role in biological systems, while some others such as cadmium and lead are non essential metals; as they have no known role in biological systems (Norouzi *et al*., 2012). Pb and Cd are relatively rare metals and no essential biological functions and are highly toxic to plants and animals (Nogueirol and Alleoni, 2013).

These non-essential metals can cause serious dysfunctions in organisms, including human beings (Recatala *et al*., 2010). Also, they can be toxic, neurotoxic, carcinogenic and teratogenic effect in human even at low concentration (Kanankes *et al*., 2014). However, the exposure to high dose of these heavy metals may cause renal, pulmonary, hepatic, skeletal, diarrhea, stomatitis, tremor, hemoglobinuria and cancer (Wang *et al*., 2012). Most especially, excessive intake of the Pb to human body can damage the nervous, skeletal, endocrine, enzymatic, circulatory, and immune system (Pareja

Carrera *et a*l., 2014). The chronic effects of Cd consist of lung cancer, pulmonary adenocarcinomas, prostatic prolifeative lesions, kidney dysfunction, bone fractures, and hypertension (Brevik *et al*., 2015).

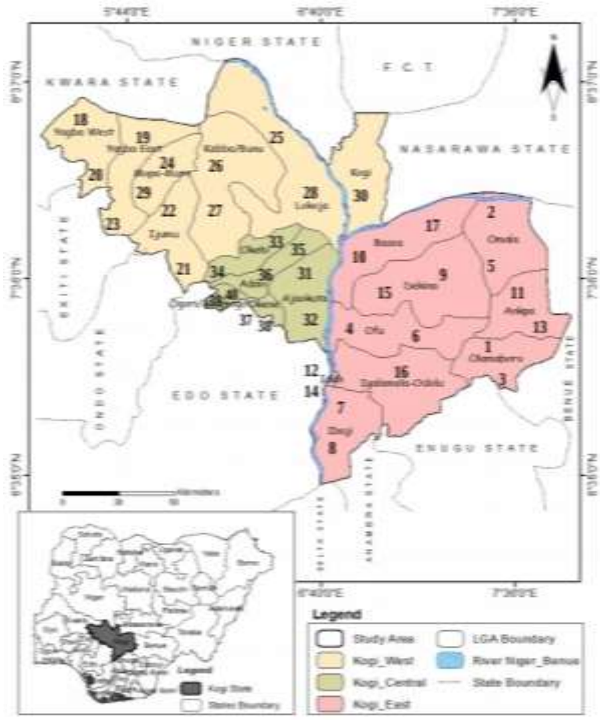
Globally, toxic heavy metals in soils and their consequent risks to ecosystems and human health has been a growing concern. This concern has given rise to regional scope, which provides tools for monitoring soil quality (Alfaro *et al*., 2015). For this reason, different countries have proposed and established baseline concentration that is adapted to soil of different geographical areas. This is because, baseline concentration of heavy metals is important in deciding contamination level for soil quality protection. These baseline concentrations of heavy metals can be used as a reference to determine if a soil has been impacted by anthropogenic activities (Gil *et al*., 2010). In this regard, numerous studies on baseline concentrations of heavy metals in natural, uncontaminated or forest soils have been conducted, established, documented and made official in different countries (Nuria, 2015; Alfaro *et al*., 2015; Roca *et al*., 2012; Olatunji and Osibanjo, 2012; Jimenez-Ballesta *et al.*, 2010; Brus *et al.*, 2009; Mico *et al.*, 2007; Herselman *et al*., 2005; and Jaume *et al.*, 2005). it obvious that these baseline concentrations in different countries are to establish guidelines values that will serve as monitoring benchmark for preserving soil quality.

Like many cities in Nigeria, Kogi and its environs has been subject to intense anthropogenic activities resulting in a vulnerable and often fragile soil ecosystem. Such activities include unsuitable use of heavy metal-enriched materials in agriculture (chemical fertilizers and pesticides), huge refuse dumpsites within residential areas, industrial emission (from cements plant and coal combustion chemical plants), sewage sludge, vehicular emissions among other. These activities could increase the risk of soil contamination and may subsequently lead to build up of heavy metals to toxic levels in ecosystem. Therefore, the objective of this paper is to determine the concentration of heavy metals; lead, cadmium, nickel, copper and zinc using native forest soil samples with no apparent human influence in Kogi State which will serve as baseline concentrations for soil quality determination.

Materials and Methods

Study area

The capital of Kogi state (Lokoja) is located on the confluence of Rivers Niger and Benue at Lokoja on Latitude 6° 44' North and Longitude 7° 44' East (Fig. 1). Going by the present composition of the state, Kogi State is quintessentially Nigeria, with three dominant ethnic groups namely; Igala, Ebira and Okun (Yoruba) and several minorities. Kogi state has a total land area of 28,313.53 square kilometres and on the basis of the 1991 Nigerian national population census, the total population of Kogi state was 2,141,756 (Ali *et al*., 2012). The climate of the Kogi state is a tropical climate with two distinct seasons (rainy season from March – October and dry season from November – March). Kogi state just as many other states in Nigeria is blessed with natural resources. It has expensive fertile land for agriculture all over the state, coal at Okobo, Ankpa, huge deposits of iron ore at Ajaokuta and limestone at Obajana. The state is known for cultivation of arable crops such as yam, cassava, maize, groundnut, cowpea among others (Omotola, 2008).



Source: https://researchgate.net/figure/map-ofKogi-State-Nigeria

Fig. 1: Map of the study area showing sampling locations

Sample collection and pretreament

Forty randomly sampled composites of native forest surface soils with no apparent anthropogenic influence were collected from November, 2017 to February, 2018 across Kogi state (Fig. 1) and used for this study. These forests have been in existence for more 50 years, uncultivated and comprise of shrubs, woodlands and deciduous trees without the protection of the Kogi state forest reserve agency. From each forest site, five soil samples were randomly collected in different points at a location and pooled together to form a composite sample. They were collected from surface at the depths of 0–20 cm using stainless steel auger. After collection, each composite was then labelled, stored and transported to the laboratory. Prior to analysis, the soil samples were air- dried at room temperature for two weeks in the laboratory, dried, gently crushed, sieved in a 2 mm mesh sieve and stored for laboratory analysis.

Chemicals and reagents

All reagents and chemicals were of high analytical grade and high purity distilled water was used for all dilutions. These reagents included 65% nitric acid (HNO_3) and HCl (37%) by Sigma–Aldrich Company and 30% hydrogen peroxide (H_2O_2) by Merck, Germany were used for digestion purpose.

Instrumentation

A temperature control digestion block (Hover Lab) and a reflux flask with heating mantle were used for digestion purposes while Atomic Absorption Spectrophotometer with a model AAS 280 FS (Agilent Technology, USA) in Chemistry laboratory ABU Zaria, Nigeria was used for analyzing the aforementioned heavy metals.

Determination of heavy metals concentration

1.0 g of air- dried and sieved soil samples was weighed accurately into 100 cm^3 beaker and digested first with 10.0 cm^3 1:1 nitric acid (50%) on a hot plate at 95^0C without boiling, refluxed for 15 min without boiling and allowed to cool. Then 5.0 cm^3 of 65% nitric acid was added into the digestate and refluxed again for 30 minutes. This step was repeated until no brown fumes appeared. The digestate was then concentrated to 5.0 cm^3, allowed to cool and 10.0 cm^3 of 30% hydrogen peroxide was added slowly to the digestate and heated at 95^0C until its appearance remains unchanged. Subsequently, 10.0 cm^3 of 37% hydrochloric acid and 10.0 cm^3 of distilled water were added to digestate and refluxed for 15 min without boiling.

The resulting solution was allowed to cool and then filtered using Whatman's filter papers No 2 into 50 cm^3 calibrated plastic containers and made up to mark with distilled water. This was stored at 4^0C for analysis (USEPA, 1996). The filtrates were then analyze for heavy metals (Pb, Cd, Ni, Cu and Zn) using atomic absorption spectrophotometer (Agilent technology, USA with 280 FS model). Calculations of concentration of heavy metals (mg/kg) were done using;

$$Final\ conc.\left(\frac{mg}{kg}\right) = \frac{conc.(ppm)x\ volume\ of\ dilution\ (cm^3)}{weight\ of\ air-dried\ soil\ (g)}$$

Assessment of soil contamination using geoaccumulation index (Igeo)

Geo-accumulation (Igeo) has been used widely to evaluate the degree of metal contamination in soils (Tijani and Onodera, 2009). The index of geoaccumulation (Igeo) is widely used in the assessment of contamination by comparing the levels of heavy metals obtained to background levels originally used with soils (Muller, 1969). It is calculated using the equation:

$$Igeo = \log_2\left(\frac{Cn}{1.5\,Cb}\right)$$

Where Cn is the measured concentration of heavy metals in soil and Cb is geochemical background value of concentration of heavy metals in soils which is the average concentrations of the metals in the shale which are; Cd = 0.3, Pb = 20, Ni = 68, Cu = 45 and Zn = 95 mg/kg (Turekian and Wedepohl, 1961). The constant 1.5 is used for the possible variations of the background data due to the lithogenic effects. Igeo values are helpful to divide soil into quality classes (Nowrouzi and Pourhabbaz, 2014). The Igeo interpretation according to Lu *et al*. (2015) was adopted for this study; Igeo< 0 = practically uncontaminated; 0 < Igeo<1 = uncontaminated to moderately contaminated; 1 < Igeo < 2 = moderately contaminated; 2 < Igeo < 3 = moderately to strongly contaminated; 3 < Igeo < 4 = strongly contaminated; 4 < Igeo < 5 = strongly to extremely contaminated and Igeo > 5 = extremely contaminated.

Quality control and quality assurance

To minimize the chances of interferences, all glass wares were soaked in 10% v/v HNO_3 solution overnight (Onianwa, 2001), washed with high purity distilled water and rinsed thoroughly with distilled water before used. In the stage of digestion, three quality-assurance samples (a blank, a duplicate and a standard reference material) were included. A blank sample was analyzed at interval of 5th samples to check for interference and cross contamination. In addition, a duplicate sample was carried at intervals of 5th sample to check for precision of the instrument and method used. Finally, to check for the quality of the analytical method adopted for this analysis, the accuracy was checked by using Standard Reference Material (WEPAL Sample, 989).

The percentage recoveries of Cd, Pb, Ni, Cu and Zn are 81, 80, 89, 86 and 91% are presented in Table 1. The recoveries of five studied heavy metals ranged from 80% to 91%. These values were within the acceptable range of 80 to 120% expected for the metals indicating good accuracy for the analysis procedure (Duan *et al*., 2012).

Table 1: Recovery of heavy metals in the standard reference material (WEPAL 989) by USEPA method 3050B

Heavy metal	Certified value (mg/kg)	Determined value (mg/kg)	Recovery (%)
Cd	8.21	6.65	81
Pb	281	224.8	80
Ni	53.9	48.0	89
Cu	153	132.23	86
Zn	1020	928.2	91

The percentage recovery of each metal was calculated as:

$$Recovery\ (\%) = \frac{determined\ conc.\ of\ a\ heavy\ metal\ (mg/kg)}{conc.of\ certified\ of\ the\ same\ heavy\ metal}$$

Statistical analysis

The range, mean and standard deviation were calculated for descriptive statistical analysis using SPSS 21 (IBM Statistics, 2012).

Results and Discussions

The results of heavy metal concentrations in the Kogi State forest surface soils are presented in Table 2. In this study, the mean concentration of each heavy metal was compared with the baseline values and standard limit of heavy metals reported in the literature.

Lead

Lead rarely exist in nature and could be found in different forms such as organic and inorganic compounds (Moyo *et al*., 2013). Lead accumulation in the body organs (such as brain) may lead to poisoning (plumbism) or even death. The presence of Pb may also affect the gastrointestinal tract, kidneys and the central nervous system **(**Tirkey *et al*., 2012). The examined concentration lead in the forest surface soils ranged from 9.13 - 43.05 mg/kg with a mean of 23.06±7.29 mg/kg (Tables 2 and 3). This mean concentration of Pb was observed to be within the standard limit of 30-300, 50-300, 2-300, 100, 300 and 70 mg/kg of Pb concentration in soil set out set out by USEPA(1986), EEC(1993), Alloway (1995), WHO/FAO (2001), EU(2002) and CCME(2014). Also, mean concentration of Pb is far less than the baseline values of 50 mg/kg reported by Alfaro *et al*. (2015); 44.2 mg/kg by Jimenez- Ballesta *et al*. (2010); 85 mg/kg by Brus *et al*. (2009) and 28 mg/kg by Mico *et al.* (2007).

Cadmium

Cadmium is an element found naturally in the environment. It is a toxic metal even at low levels (Jain *et al*., 2007). It can cause many toxic symptoms, such as inhibition of growth and photosynthesis, deactivation or inhibition of enzymes, disturbances in plant water relationships, ion metabolism, and formation of free radicals (Kumars *et al*., 2008). The concentration of cadmium in the forest surface soils ranged from 0.00 – 0.95 mg/kg with a mean value of 0.44±0.28 mg/kg. Mean of Cd concentration recorded in these soils is within the standard limit of 3, 1-3, 0.01–2.0, 3.0, 3.0 and 1.4 mg/kg of Cd concentration in soil set out by USEPA(1986), EEC(1993), Alloway (1995), WHO/FAO (2001) , EU(2002) and CCME(2014). Also, mean concentration of Cd is within the baseline values of 0.6 mg/kg reported by Alfaro *et al*. (2015); 4.4 mg/kg by Jimenez- Ballesta *et al*. (2010); 0.80 mg/kg by Brus *et al*. (2009) and 0.70 mg/kg by Mico *et al.* (2007).

Nickel

Nickel is an element that occurs in the environment only at very low levels and is essential in small doses. It could be dangerous when the maximum tolerable amounts are exceeded (Wuana and Okieimen, 2011). Nickel can result in lung, liver and kidney damage. In high quantities Ni can also cause cancer, respiratory failure, birth defects, allergies, dermatitis, eczema, nervous system and heart failure (Adelekan and Abegunde, 2011). The concentration values recorded in respect of Ni at forest surface soils revealed the range of 0.00 - 32.75 mg/kg with a mean of 17.49±8.13 mg/kg. This mean concentration of Ni is less than the standard limit of 150, 75, 2-750, 50, 75 and 50 mg/kg of Ni concentration in soil set out set out by USEPA (1986), EEC (1993), Alloway (1995), WHO/FAO (2001), EU (2002) and CCME (2014). Also, mean concentration of Ni is far less than the baseline values of 170 mg/kg reported by Alfaro *et al*. (2015); 42.6 mg/kg Jimenez- Ballesta *et al*. (2010); 35 mg/kg by Brus *et al*. (2009) and 31 mg/kg by Mico *et al.* (2007).

Table 2: Concentrations of heavy metals in studied Kogi state forest surface soils (mg/kg)

Sampling Site	Lead	Cadmium	Nickel	Copper	Zinc
1	12.05	0.00	7.00	9.35	49.05
2	9.15	0.00	0.00	10.90	7.90
3	14.75	0.15	3.75	9.80	23.25
4	43.05	0.25	9.65	5.05	58.50
5	17.68	0.62	9.75	2.60	74.55
6	22.20	0.95	17.30	3.85	12.90
7	21.45	0.45	32.75	17.20	17.55
8	20.75	0.35	10.70	2.75	9.75
9	19.35	0.65	20.45	0.00	5.30
10	18.85	0.53	12.55	0.30	36.60
11	19.55	0.48	19.65	3.45	16.65
12	20.80	0.87	21.25	2.35	12.75
13	16.45	0.19	13.35	4.55	0.75
14	23.10	0.25	25.15	3.80	10.70
15	20.98	0.90	14.13	0.63	19.23
16	29.15	0.30	21.20	6.30	8.65
17	23.50	0.75	17.50	9.40	4.25
18	35.45	0.50	19.35	9.70	3.55
19	25.25	0.10	21.25	15.00	3.50
20	14.63	0.23	19.75	7.35	1.30
21	32.15	0.60	28.95	16.70	19.10
22	28.25	0.21	29.55	4.85	24.40
23	30.80	0.00	26.85	2.40	19.25
24	25.30	0.10	30.40	14.85	12.90
25	19.65	0.58	18.73	19.58	20.73
26	29.50	0.64	18.65	2.50	4.25
27	27.90	0.55	15.90	17.40	16.30
28	31.35	0.75	9.25	4.75	25.05
29	27.80	0.09	2.55	0.15	42.25
30	27.65	0.13	5.68	0.98	42.48
31	29.70	0.78	31.30	9.20	23.60
32	28.30	0.85	24.00	4.15	18.15
33	31.35	0.30	23.55	2.55	14.10
34	20.60	0.42	22.55	6.50	8.25
35	24.53	0.80	20.98	8.85	14.68
36	20.55	0.75	14.20	1.65	19.80
37	11.80	0.30	11.80	2.20	8.10
38	16.35	0.60	18.80	3.55	19.80
39	21.50	0.40	20.25	0.55	7.96
40	9.13	0.28	9.18	6.03	10.79
Mean±SD	**23.06±7.29**	**0.44±0.28**	**17.49±8.13**	**6.34±5.38**	**18.72±15.84**
Range	**9.13-43.05**	**0.00-0.95**	**0.00-32.75**	**0.00-19.58**	**0.75-74.55**

SD= Standard deviation

Table 3: Mean concentration, average shale and geo-accumulation index (Igeo) values of studied heavy metals in forest surface soils in Kogi State

Concentration (mg/kg)	Pb	Cd	Ni	Cu	Zn
Present study	23.06±7.29	0.44±0.28	17.49±8.13	6.34±5.38	18.72±15.84
Average shale	20	0.3	68	45	95
Igeo value	-0.38	-0.03	-2.54	-3.41	-2.93

Copper

Copper is an essential metal for normal plant growth and development, although it is also potentially toxic. Copper is considered as a micronutrient for plants (Kabir *et al*., 2009). Excess of Cu in soil plays a cytotoxic role, induces stress and causes injury to plants. This leads to plant growth retardation and leaf chlorosis (Jyotish *et al.*, 2015). Copper concentration levels in forest surface soils are in the range of 0.00 – 17.20 mg/kg with a mean of 6.34±5.38 mg/kg (Tables 2 and 3). The mean concentration of Cu from the soils is comparatively less than the standard limit of 250, 140-300, 2-250, 100, 140 and 63 mg/kg of Cu concentration in soil set out set out by USEPA (1986), EEC (1993), Alloway (1995), WHO/FAO (2001), EU (2002) and CCME (2014). Also, mean concentration of Cu is far less than the baseline values of 39.2 mg/kg reported by Nuria (2015); 83 mg/kg by Alfaro *et al*. (2015); 27.0 mg/kg by Jimenez- Ballesta *et al*. (2010); 36 mg/kg by Brus *et al*. (2009) and 19.82 mg/kg by Mico *et al.* (2007).

Zinc

Zinc is widely distributed in nature. It is a very common environmental contaminant (Finkelman, 2005). High levels of Zn could cause health problems such as stomach cramps, skin irritations, vomiting, nausea, anaemia, headaches, loss of appetite and some respiratory disorders (Rajappa *et al*., 2010). The concentration of Zn in the forest surface soils ranged from 0.75 - 74.55 mg/kg with a mean of 18.72±15.84 mg/kg (Tables 2 and 3). The mean concentration level of Zn recorded in the soils was observed to be far less than the standard limit of 300, 150-300, 1-900, 300, 300 and 200 mg/kg of Zn concentration in soil set out by USEPA (1986), EEC (1993), Alloway (1995), WHO/FAO (2001), EU (2002) and CCME (2014). Also, mean concentration of Zn is less than the baseline values 133.9 mg/kg reported by Nuria (2015); 86 mg/kg by Alfaro *et al*. (2015); 86.5 mg/kg Jimenez- Ballesta *et al*. (2010); 140 mg/kg by Brus *et al*. (2009) and 83 mg/kg by Mico *et al.* (2007).

The results obtained indicate that, the studied forest soils in Kogi State are practically uncontaminated based on Igeo < 0.

Conclusion

Generally, the mean concentrations (mg/kg) of heavy metals in forest surface soil samples were: Cd 0.44±0.28, Pb 23.06±7.29, Ni 17.49±8.13, Cu 6.34±5.38 and Zn 18.72±15.84, respectively. The obtained mean concentrations were all within normal range for normal soils set out by USEPA (1986), EEC (1993), Alloway (1995), WHO/FAO (2001), EU (2002) and CCME (2014). In addition, these mean concentrations fell within the baseline values of heavy metals of normal soils reported by Nuria (2015), Alfaro *et al*. (2015), Jimenez- Ballesta *et al*. (2010), Brus *et al*. (2009) and Mico *et al.* (2007). This is an indication that, the plants, microorganisms and animals are safe from the hazardous effects of these heavy metals in soils.

Also, further study was carried out to assess the potential ecological risk caused by the heavy metal contamination in the studied forest soils through the calculation of geoaccumulation index (Igeo). The study focused on the evaluation of the contamination with heavy metal. The Igeo values of < 0 present in this study have demonstrated that the studied forest ecosystems are practically uncontaminated. The low concentration level of all studied heavy metals in these soils showed the impact lithogenic one rather the contaminated from anthropogenic activities.

Finally, since the concentrations of cadmium lead, nickel, copper and zinc are within the normal range of normal soils and found uncontaminated, these concentrations could probably be used as baseline concentrations for these heavy metals in Kogi State soils for soil protection guidelines.

Conflicts of Interest

The authors declare no conflict of interest related to this study.

Acknowledgements

This work was part of M.Tech thesis in the Department of Chemistry, Federal University of Technology, Minna, Niger State. First, our profound appreciation goes to Almighty Allah for the successful completion of this study. Secondly, special gratitude goes to the laboratory technologists in the Department of Chemistry, Kogi State College of Education for their technical and analytical supports during the course of the laboratory work. Finally, the authors would also acknowledge the analysts at central laboratory, Ahmadu Bello University (ABU) Zaria where the Atomic Absorption Spectrophotometry (AAS) of heavy metals were carried out.

Conflict of Interest

Authors have declared that there is no conflict of interest reported in this work.

References

Adelekan BA & Abegunde KD 2011. Heavy metals contamination of soil and groundwater at automobile mechanic villages in Ibadan, Nigeria. *Int. J. Physical Sci.*, 6(5): 1045–1058.

Alfaro MR, Montero A, Ugarte OM, Do Nascimento CWA, De Aguiar Accioly AM, Biondi, CM & Da Silva YJAB 2015. Background concentrations and reference values for heavy metals in soils of Cuba. *Envtal. Monitoring Assessment*, 187: 4198–4208.

Ajayi SO, Odesanya BO, Avwioroko AO, Adebambo GS & Okafor B 2012. Effects of long term fertilizer use on trace metal levels of soils in a farm settlement. *J. Agric. Res. and Devt.*, 2: 44–51.

Ali S, Yusufu B, Moses SE & Abu M 2012. The scramble for lugard house: Ethnic identity politics and recurring tensions in Kogi State, Nigeria. *Canadian Social Science*, 8(1): 130–135.

Alloway BJ 1995. *Heavy Metals in Soils.* (2nd edition), Blackie academic and Professional, Glasgow. Page 122–151. ISBN 0-7514-0198-6.

Ayeni LS & Adeleye E.O. (2011). Soil nutrient status and nutrient interactions as influenced by agro wastes and mineral fertilizer in an incubation study in the Southwest Nigeria. *Int. J. Soil Sci.*, 6(1): 60–68.

Babatunde O, Oyewale A & Steve P 2014. Bioavailable trace elements in soils around NNPC Oil Depot Jos, Nigeria. *J. Envtal. Sci., Toxicol. and Food Techn.*, 8(1): 47–56.

Bolan N, Kunhikrishnan A, Thangarajan R, Kumpiene J, Park J, Makino T & Scheckel K 2014. Remediation of heavy metal (loid) s contaminated soils–to mobilize or to immobilize. *J. Hazardous Materials*, 266: 141–166.

Boran M & Altynok I 2010. A review of heavy metals in water, sediment and living organisms in the Black Sea. *Turkish J. Fisheries and Aqu. Sci.*, 10: 565–572.

Brevik EC, Cerda A, Mataix-Solera J, Pereg L, Quinton JN, Six J & Van Oost K 2015. The interdisciplinary nature of soil. *SOIL*, 1: 117–129.

Brus DJ, Lame FPJ & Nieuwenhuis RH 2009. National baseline survey of soil quality in the Netherlands. *Environmental Pollution*, 157: 2043-2052.

CCME 2014. Canadian environmental soil quality guidelines. Canadian Council of Ministers of the Environment. Available at www.ccme.ca/en/resources/canaidanenvironmental-quality-guidelines.

Dan-Azumi Bichi MH 2010. Industrial pollution and heavy metals profile of Challawa River in Kano, Nigeria. *J. Appl. Sci. in Envtal. Sanitation*, 5(1): 23–29.

Duan J, Tan J, Wang S, Hao J & Chai F 2012. Size distributions and sources of elements in particulate matter at curbside, urban and rural sites in Beijing. *J. Envtal. Sci.*, 24(1): 87–94.

EEC 1993. Agricultural soil and the environment. Archieved from www.ec.europa.eu/agriculture/publi/fact/envir/2003_en pdf on July 26, 2004.

European Union 2002. Heavy metals in wastes. European Commission on environment.http://ec.europa.eu/ environment/waste/studies/pdf/heavy.metals.report.pdf.

Finkelman RB 2005. Sources and health effects of metals and trace elements in our environment: An overview. In: Moor TA, Black A, Centeno J, Harding J & Trumm DA (Eds.), *Metal Contaminants in New Zealand*. Resolution Press, Christchurch, New Zealand, pp. 25–46.

Gil C, Ramos-Miras J, Roca-Perez L & Boluda R 2010. Determination and assessment of mercury content in calcareous soils. *Chemosphere*, 78: 409–415.

Herselmana JE, Steynb CE & Fey MV 2005. Baseline concentration of Cd, Co, Cr, Cu, Pb, Ni and Zn in surface soils of South Africa. *South Afr. J. Sc.*, 101: 509–512.

Hu Y, Liu X, Bai J, Shih K, Zeng EY & Cheng H 2013. Assessing heavy metal pollution in the surface soils of a region that had undergone three decades of intense industrialization and urbanization. *Envtal. Sci. and Poll. Res.*, 20(9): 6150–6159.

Jain M, Pal M, Gupta P & Gadre R 2007. Effect of cadmium on chlorophyll biosynthesis and enzymes of nitrogen assimilation in greening maize leaf segments: Role of 2-oxoglutarate. *Indian J. Experi. Bio.*, 45(4): 385–389.

Jaume B, Pedro T, Lluis L & Ferrran R 2005. Baseline concentrations of soils of the Torrreles and sant climent municipal districts (Catalonia, Spain). *Envtal. Monitoring Asses.*, 108(1-3): 302–322.

Jimenez-Ballesta R, Paz CB, Martin-Rubi JA & Rosario GG 2010. Pedo-geochemical baseline content levels and soil quality reference values of trace elements in soils from the Mediterranean (Castilla La Mancha, Spain). *Central Eur. J. Geosci.*, 2(4): 441–454.

Jyotish K, Mohnish P & Kumar N 2015. Effect of different mining dust on the vegetation of district balaghat, M.P – A Critical Review. *Int. J. Sci. and Res. (IJSR)*, 4: 603– 607.

Kabir M, Iqbal MZ & Shafiq M 2009. Effects of lead on seedling growth of *Thespesia populnea* L. *Advances in Environmental Biology*, 3(2): 184–190.

Kabir E, Ray S, Kim KH, Yoon HO, Jeon EH, Kim YS, Cho YS, Yun, ST & Brown RJC 2012. Current status of trace metal pollution in soils affected by industrial activities. *Sci. World Journal*, 1–18.

Kananke T, Wansapala J & Gunaratne A 2014. Heavy metal contamination in green leafy vegetables collected from selected market sites of Piliyandala area, Colombo district, Sri Lanka. *Am. J. Food Sci. and Techn.*, 2(5): 139-144.

Kaplan O, Kaya G & Yaman M 2011. Sequential and selective extraction of copper in different soil phases and plant parts from former industrialised areas. *Commun. Soil Science Plant Anal*., 42(19): 2391–2401.

Kumar Y, King PP & Prasad VSRK 2008. Removal of copper from aqueous solution using Ulva fscata sp.A marine green algae. *J. Hazardous Materials*, 137: 367–368.

Lei M, Zhang Y, Khan S, Qin PF & Liao BH 2010. Pollution, fractionation and mobility of Pb, Cd, Cu, and Zn in garden and paddy soils from a Pb/Zn mining area. *Environmental Monitoring Assessment*, 168: 215–222.

Lu CA, Zhang JF, Jiang, HM, Yang JC, Zhang JT, Wang JZ & Shan HX 2010. Assessment of soil contamination with Cd, pb and Zn and source identification in the area around the Huludao Zinc plant. *J. Hazardous Materials*, 182: 743−748.

Lu Z, Cai, M, Wang J, Yang H & He J 2012. Baseline values for metals in soils on Fildes Peninsula, King George Island, Antarctica: the extent of anthropogenic pollution. *Envtal. Monitoring Assessment*, 184: 7013–7021.

Lu X, Wang L, Lei K, Huang J & Zhai Y 2015. Contamination assessment of copper, lead, zinc, manganese and nickel in street dust of Boaji, NW China. *J. Hazardous Materials*, 161(2–3): 1058–1062.

Map of Kogi State, Nigeria showing the study areas. Available at https://researchgate.net/figure/map-of Kogi - State-Nigeria.

Mico C, Recatala L, Peris M & Sanchez J 2006. Assessing heavy metal sources in agricultural soils of an European Mediterranean area by multivariate analysis. *Chemosphere*, 65: 863–872.

Mico C, Peris M, Recatala L & Sanchez J 2007. Baseline values for heavy metals in agricultural soils in an European Mediterranean region. *Science of the Total Environment*, 378(1-2): 13–17.

Morgan R 2013. *Soil, Heavy Metals, and Human Health. In: Soils and Human Health.* Edited by: Brevik, E. C. and Burgess, L. C., Boca Raton, FL, USA, CRC Press, pp. 59–82.

Moyo M, Amoo S, Ncube B, Ndhlala A, Finnie J et al. 2013. Phytochemical and antioxidant properties of unconventional leafy vegetables consumed in southern Africa. *South African Journal of Botany*, 84: 65–71.

Muller G 1969. Index of geo-accumulation in sediments of the Rihne River. *Geojournal*, 2: 108–118.

Njar GN, Iwara AI, Offiong RA & Deekor TN 2012. Assessment of heavy metal status of boreholes in Calabar South Local Government Area, Cross River State, Nigeria. *Ethiopian J. Envtal. Stu. and Mgt.*, 5(1): 86-91.

Nogueirol RC & Alleoni LRF 2013. Sequential extraction and speciation of Ba, Cu, Ni, Pb and Zn in soil contaminated with automotive industry waste. *Chem. Speciat. Bioavailability*, 25(1): 34–42.

Norouzi M, Mansouri B, Hamidian AH, Ebrahimi T & Kardoni F 2012. Comparison of the metal concentrations in the feathers of three bird species from southern Iran. *Bull. Environ. Contam. Toxicology*, 89(5): 1082–1086.

Nowrouzi M & Pourkhabbaz A 2014. Application of geoaccumulation index and enrichment factor for assessing metal contamination in the sediments of Hara Biosphere Reserve, Iran. *Chemical Speciation & Bioavailability*, 26: 99–106.

Nuria R 2015. Heavy metal background levels in rural soils: A case study in Pampean soils (Argentina). *Cienc Suelo* (Argentina), 33(2): 283–292.

Odoh R, Agbayi EB, Kagbu JA & Thomas SA 2011. Heavy metal speciation in agricultural farmland in some selected local government areas of Benue State, Nigeria. *Archaeol. and Appl. Sci. and Res.*, 3(3): 560-573.

Olatunji OS & Osibanjo O 2012. Baseline studies of some heavy metals in top soils around the iron-ore mining field Itakpe north central Nigeria. *Int. J. Mining Engr. and Mineral Processing*, 1(3): 107–114.

Omotola SJ 2008. Democratisation, identity transformation, and the rising ethnic conflict in Nigeria. *Philippine J. Third World Stu.*, 23(1): 71–90.

Onianwa PC 2001. Roadside topsoil concentrations of lead and other heavy metals in Ibadan, Nigeria. *Soil Sediment Contamination*, 10(6): 577–591.

Pareja Carrera J, Mateo R & Rodriguez Estival J 2014. Lead (Pb) in sheep exposed to mining pollution: Implications for animal and human health. *Ecotoxicol. Envtal. Safety*, 108: 210–216.

Rajappa B, Manjappa S & Puttaiah E 2010. Monitoring of heavy metal in groundwater of Hakinaka TaluK, India. *Contemporary Engr. and Sci.*, 3(4): 183–190.

Recatala L, Sanchez J, Arbelo C & Sacristan D 2010. Can be reference values of heavy metals useful as soil quality standards? Contributions from assays in representative Mediterranean agricultural soil. *19th World Congress of Soil Science, Soil Solutions for a Changing World*. 1– 6 August. Australia. Published on DVD, pp. 23–26.

Roca N, Pazos MS & Bech J 2012. Background levels of potentially toxic elements in soils: A case study in Catamarca (a Semiarid Region in Argentina). *Catena*, 92: 55–66.

Schneider AR, Morvan X, Saby NPA, Cances BE, Ponthieu M, Gommeaux M & Marin B 2016. Multivariate spatial analyses of the distribution and origin of trace and major elements in soils surrounding a secondary lead smelter. *Envtal. Sci. Poll. Res.*, 23: 1–11.

Sekabira K, Oryem-Origa H, Basamba TA, Mutumba G & Kakudidi E 2010. Assessment of heavy metal pollution in the urban stream sediments and its tributaries. *Int. J. Envtal. Sci. and Techn.*, 7(3): 435–446.

Tijani MN & Onodera S 2009. Hydro-geochemical assessment of metals contamination in an urban drainage system: A case study of Osogbo Township, SW-Nigeria. *Int. J. Water Resou. and Protec.*, 3: 164–173.

Tirkey A, Shrivastava P & Saxena A 2012. Bioaccumulation of heavy metals in different components of two Lakes ecosystem. *Current World Environment*, 7(2): 293–297.

Turekian KK & Wedepohl KH 1961. Distribution of the elements in some major units of the earth's crust. *Bull. Geol. Soc. Am.*, 72: 175–192.

Tutic A, Novakovic S, Lutovac M, Biocanin R, Ketin S & Omerovic N 2015. The heavy metals in agrosystems and impact on health and quality of life. *Macedonian J. Med. Sci.*, 3(2): 345–355.

United States Environmental Protection Agency 1986. *Test Methods of Evaluation of Solid Wastes*. In: Contaminated Land Policies In Some Industrialized Countries. Visser WJFG (ed.), TCB Report RO2 UK, pp. 38–41.

United States Environmental Protection Agency 1996. *Method 3050B Acid Digestion of Sediments, Sludges and Soils, Revision 2*. Environmental Protection Agency, Washington, USA, pp. 3–5.

Wang Y, Qiao M, Yunxia Liu Y & Zhu Y 2012. Health risk assessment of heavy metals in soils and vegetables from wastewater irrigated area, Beijing-Tianjin cycluster, China. *J. Envtal. Sci.*, 24(4): 690–698.

Wei B & Yang L 2010. A review of heavy metal contaminations in urban soils, urban road dusts and agriculture soils from China. *Microchemical Journal*, 94: 99–107.

WHO/FAO 2001. Codex Alimentarius Commission. Food Additives and Contaminants. Joint FAO/WHO Food standards Programme, ALINORM 10/12A: 1-289. Fertilizer and their efficient use. http://www.transpaktrading.com/static/pdf/research/achemistry/introTofertiliers.pdf.

Wuana RA & Okieimen FE 2011. Heavy metals in contaminated soils: A review of sources, chemistry, risks and best available strategies for remediation. *Commun. Soil Sci. and Plant Analysis*, 42: 111–122.