International Journal of
Advances in Scientific Research and Engineering (ijasre)

E-ISSN : 2454-8006

DOI: http://dx.doi.org/10.31695/IJASRE.2018.32758

Volume 4, Issue 6
June - 2018

Index Model Assessment of Heavy Metal Pollution in Soils Selected from Three Irrigated Farm Sites in Fct Abuja, Nigeria

Eze O C[1]*, Tukura B W.[2], Atolaiye B O.[3], Opaluwa O D[4]

Research scholar[1], [4]Doctor and [2-3]Associate Professors

Department of Chemistry

Faculty of Natural and Applied Sciences

Nasarawa State University,

PMB 1022, Keffi

Nigeria

ABSTRACT

The study was undertaken to examine the concentrations and health risk of heavy metals in soil from selected irrigated sites within Mpape River in FCT, Abuja. The study was carried out in dry seasons between 2015 and 2017 simultaneously from three irrigated farm sites. Heavy metal levels were quantified using Atomic Absorption Spectrophotometer (AAS). Other parameters were determined using standard methods. The levels of heavy metals in soils varied according to sites. The mean levels of Fe (24.82±0.89), Pb (3.34±0.65) and Zn (2.23±0.27) were significantly higher (P≤0.05) while Ni (0.39±0.19) was generally low. These values did not exceed the WHO/FAO, EU and USEPA permissible limits. However, soil bioavailable form recorded considerably higher concentrations in Fe (22.30±0.84), Zn (0.79±0.25) and Pb (0.79±0.28) while Ni (0.09±0.05) was lowest. Using contamination factor (CF) classifications; showed that soils from different irrigated farm sites along Mpape River were not contaminated by Fe, Zn, Ni and Pb. Pollution index was also (PLI = 0) indicating no pollution of the soil by heavy metals. Geo-accumulation index (igeo) values exhibited a zero category which shows that soils from various irrigated farm sites were unpolluted. Enrichment factor indicated extremely severe enrichment with respect to Pb (66-68.05), very severe enrichment was recorded for Zn (26.5) in farm B while Ni was found to be at very severe enrichment status in all the farms. The pollution index from all the farms were found to be in the low potential risk categories (<40) which suggested that the soils from all the farms do not pose any ecological health risk to the environment. The correlation results showed strong and positive relationship with Zn/Fe (0.959), Ni/Zn (0.978), Pb/Fe (0.970) and Pb/ Ni (0.990) and strong and negative relationship with Ni/ Fe (-0.988) and Pb/Zn (-0.976). The strong positive correlations in the soil samples is an indication that they have common source of pollution while the strong negative correlations observed is an attribute of different origin and sources of pollution load.

Key Words: Soil, Contamination Factor, Pollution Index, Geo-accumulation Index, Enrichment Factor.

1. INTRODUCTION

Soil is the primary reservoir of heavy metals in the overall metal cycle in nature [6], [7]. It is also a loose covering of fine rock particles that covers the earth. It naturally composed of minerals, water, organic matters and air. As a result of weathering of rocks, heavy metals naturally occurs in soil usually at low concentrations. Soil is the primary recipient of solid wastes [8]. Several tons of wastes find their ways into the soil from different sources such as agricultural, industrial and domestic. These wastes end up interacting with the soil system thereby altering the physical and chemical properties [9]. Heavy metals in soil pose potential threats to the environment and can damage human health through various absorption pathways such as direct ingestion, dermal contact and diet through the soil-food chain, inhalation and oral intake [10]. Metals may be retained in soil in form of oxides, hydroxides, carbonates, exchangeable cations, and /or bound to organic matter in soil [11]. Excessive accumulation of heavy metals in agricultural soil through wastewater irrigation may not only result in soil contamination, but also lead to elevated heavy metal uptake by crops and hence affects food quality and safety [12], [13]. There has long been concern about the issue of pollution by heavy metals because of their toxicity on plants, animals and human beings and their lack of biodegradability [14], [15]. Most of these pollutants are discharged into the environment every day to include heavy metals such as Pb, Cr, Cd, Ar and Zn which are regarded as one of the most serious pollutants of the aquatic environment because of their environmental persistence and tendency to accumulate in aquatic organisms [16], [17]. Chronic exposure to these metals can have serious health consequences such as including reduced growth and development, cancer, organ damage, nervous system damage, and in extreme cases death [18]. Humans are exposed to heavy metals through inhalation of air pollutants, consumption of contaminated drinking water, exposure to contaminated soils or industrial waste or consumption of contaminated food grown on contaminated land [19], [20]. The food chain contamination is one of the major pathways for the entry of these toxic pollutants into the human body.

Agriculture which is the backbone of most economy has also been adversely affected by upsurge in the indiscriminate dumping and disposal of wastes into the land and water courses [21]. The continuous pollution of both surface and underground water sources has reduced the quality and quantity of water needed for general agricultural requirements such as meeting crop water requirement during insufficient rainfall. Nonetheless, urban agriculture using waste water for irrigation provides for food, incomes and employment of thousands for people in the cities in Nigeria [21], [22]. Most of the studies show that the use of waste water contaminated with heavy metals for irrigation over long period of time increases the heavy metal contents of soils above the permissible limit [21], [22]. Ultimately increasing the heavy metal contents in soil also increases the uptake of heavy metals by plants depending upon the soil type, plant growth stages and plant species [23], [24]. The effects of pH on heavy metal availability to plants has been reported by many researchers and it is acceptable that as pH decreases, the solubility of cations form of metals in the soil solution increases, and therefore, they become more readily available to plants [23], and also explained that pH has a major effect on metal dynamics because it controls adsorption and precipitation which are the main mechanisms of metal retention to soil. Metal solubility in the solution depends on the solubility product of the solid phase (precipitate) containing the metal and that application of sludge increased the CEC value of the soil i.e the ability of the soil to retain metals [23]. Mpape Village, Wuse Zone 5 and Wuye Village areas are agricultural sites located in Abuja Metropolis, FCT, Nigeria, along the bank of Mpape River. Process water from municipal waste and sewage sludge located near the river contains large amount of heavy metals. The contaminated wastes from Mpape River are used extensively for irrigation of vegetables on soil particularly at the agricultural sites during dry seasons [22]. Hence, these pose significant effects on the soil and vegetable crops thereby exposing consumers of these vegetable crops to bioaccumulation of trace metals and anions with time. Therefore, this study is aimed at examining the index models assessment of heavy metals pollution in soils selected on irrigated farm sites along Mpape River, in FCT Abuja.

2.0 MATERIALS AND METHODS

2.1 Study Area

The study was conducted at three different irrigation sites; Mpape Village, Wuse Zone 5 and Wuye Village areas along Mpape River in Abuja Municipal Area Council in the Federal Capital Territory, Nigeria. Mpape River is located at latitude 9 ^{0} 5'N and longitude 7 ^{o} 29 ' E and originates from Mpape Rock in the Federal Capital Territory, Abuja, Nigeria. The River experiences large influx of wastes especially during the wet season from both points and non-point sources. It is used majorly as source of water for irrigation purposes in the area during dry seasons. Inhabitants in these areas, however, depend on the rivers source of water for domestic purposes as well as fishery activities. There are lots of activities engaged in such areas such as industrial activities comprising block moulding industries, mechanic workshops, car wash shops take place along the bank of the river. Domestic sewage, agricultural runoffs and domestic wastes are often emptied into the river.

DOI: 10.31695/IJASRE.2018.32758

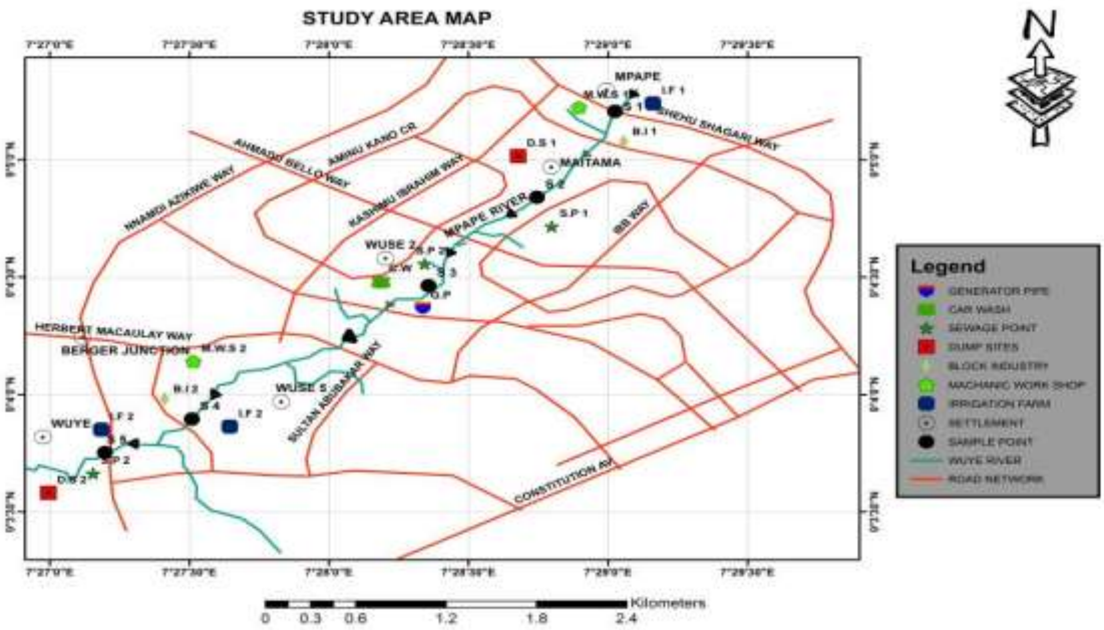

Figure 1: Mpape River showing sampling location

2.2 Sample Collection and Preparations

Soil samples (4 kg) were collected randomly at the depth of 10 cm using soil auger from six different locations in the area of the irrigated farm to form a composite sample. Soil samples were taken to the laboratory and air- dried on a table surface for 3 days and was ground using pestle and mortar. They were sieved using 2 mm mesh to obtain more homogenous samples. They were sealed in cellophane bags for metal analysis [25].

2.3 Sample Digestion Soil

Three replicate samples of soil (5 g) were weighed and placed in 100 cm^3 beaker. The samples were digested with 20 cm^3 aqua regia (3HCl: $1HNO_3^-$) for 2 hrs on a hot plate. The digest was diluted with 50 cm^3 of deionized water and allowed to cool, then filtered into a 100 cm^3 volumetric flask using Whatman 541 filter paper. The solution was made up to mark with distilled water and stored in a high density plastic bottle for metal analysis [25].

2.4 Determination of Bioavailable Form of Metals in Soil

Soil samples were extracted using Ethylenediamineteraacetic Acid (EDTA) than other chelating agents such as Diethylenetriaminepentaacetic Acid (DTPA) due to its high chelating ability to remove greater amount of heavy metals from the soil and also shows good correlation with acidic soils and acts more aggressively than other metal chelates under acidic conditions. Dried soil samples (10 g) were placed in 50 cm^3 extraction vessel (beaker) and 20 cm^3 of (EDTA) extraction agent was added. Samples were shaken for 2 hrs and then filtered into a 100 cm^3 volumetric flask using Whatman 541 filter paper for metal analysis [26].

2.5 Pollution Indexes Model in Soil Samples

2.5.1 Pollution Load Index (PLI)

Pollution Load Index is a measure of the degree of overall contamination in a sample station. In order to ascertain the pollution load index of heavy metals, contamination factors were calculated. Contamination factor is the ratio of the concentration of the heavy metal to the background value. Contamination factor (CF) is used to ascertain the levels of soil contamination and is obtained as given in the equation [27]:

$$\text{Contamination Factor (CF)} = C_m / C_b \qquad (2.1)$$

Where; C_m, is the concentrations of the metals, C_b, is the background value or control value. The background values for heavy metals are Fe ; 38000, Zn ; 140, Pb ; 85, Cu ; 36, Cr ; 100, Ni ; 35, Mn ; 850, Cd ; 0.8 (mg/kg) [28], [29].

The procedures of [30] were used to calculate the pollution index for each site from the equation;

$$(PLI) = (C_f1 \text{ X } C_f2 \text{ X } C_f3 \text{ X} \ldots\ldots.. C_fn)^{1/n} \qquad (2.2)$$

Where, n is the number of metals and C_f is the contamination factor which is the metal concentration in soil / background values of the metals. PLI is a potent tool use in heavy metal pollution assessment [30].

2.5.2 Geo-accumulation Index (lgeo)

The formula proposed by [31] was adopted to calculate the geo-accumulation index (lgeo). Geo-accumulation index assesses the pollution level in soils or sediments with respect to the toxic metals as shown in the equation thus;

$$lgeo = \log2 (Cn / 1.5Bn) \quad (2.3)$$

Where, Cn is the concentration of the element in the soil, Bn is the geochemical background reference value for the element or world average of the element in shale /or control soil. The constant 1.5 is introduced in the equation arbitrarily to account for the natural fluctuations that may have occurred throughout the years in the environment. The background value taken is considered from the world average shale values (mg/kg) of the metals determined in the study. The values are Fe = 47200, Zn = 95, Pb = 20, Cu = 45, Cr = 90, Ni = 68, Mn = 850, Cd = 0.3 [32].

2.5.3 Enrichment Factor (EF)

EF is used to assess the relative contributions or the degree of pollution caused by natural and anthropogenic heavy metal inputs to soils. It can also be said to be used to evaluate the magnitude of contamination in the environment. In the study, the background concentrations (reference earth's crust) for Fe, Mn, Zn, Cu, Cr, Ni, Pb and Cd were 46700, 950, 95, 40, 90, 68, 20 and 0.3) and these were taken from [33]. The enrichment factor (EF) was calculated for each metal in the soil using the equation thus;

$$EF = C_x / C_{Fe})_{soil} / C_x / C_{Fe})_{background} \quad (2.4)$$

Where, C_x / $C_{Fe})_{soil}$ refer to the concentration of the element X to Fe in the soil (s) from the farm sites and C_x / $C_{Fe})_{background}$ is the background value of the metal- Fe ratio respectively. Iron was used as reference element [33] and the metal concentrations were normalized to the textural characteristics of soils with respect to Fe.

2.5.4 Ecological Risk Index Factor (RI)

RI was suggested by Wang *et al.(*2011) in order to express the ratio of the toxic response factor for a given contaminant / pollutant and to assess soils quality of an environment contaminated by heavy metal and also to evaluate the contamination degree of the soils considering the effect of multiple metals.

$$Ri = \Sigma E^i_r \quad (2.5)$$

$$E^i_r = T_i C_i / C_o \quad (2.6)$$

$$CF = C_i / C_o \quad (2.7)$$

T_i is the toxic response factor for the metals and the values for Pb, Ni and Zn are 5, 5, 1 respectively [34], [28]. C_i is the concentration of metals in the soil and C_o, is a reference value for metals.

2.6 Elemental Analysis of Samples

Qualification of Pb, Fe, Zn and Ni was carried out in triplicates using Atomic Absorption Spectrometry (Model AA6800 Shimadzu-automated) at Sheda Science and Technology Institute (SHEDTSCO) Kwali, FCT, Abuja.

2.7 Quality Control

Appropriate safety measures and quality assurance procedures were taken to ensure the reliability of the results. Samples were carefully handled to avoid cross-contamination. Glass wares were properly cleaned and reagents used were of analytical grade. Deionized water was used throughout the studies. Standards were prepared for each metal from their stock solution to calibrate the instruments and also to know the actual concentrations. Reagent blank determinations were used to apply corrections to the instrument readings. For validation (precisions/ Accuracy) of analytical results, replicate analyses of the samples were done for water, sediments, soils and vegetables.

2.8 Statistical Analysis

Two- way ANOVA for the data was carried out using Micro Soft Office Excel 2010 and Tukey Multiple Honestly Significant Difference (HSD) was used to evaluate the significant difference in the concentration of different studied metals in soil

DOI: 10.31695/IJASRE.2018.32758

samples from three farm sites at 95% confidence interval. Correlations of heavy metal in the soil samples from different farm sites were also carried out ($P \leq 0.05$) level of significance.

3.0 RESULTS AND DISCUSSIONS

Results for the concentrations of heavy metals, Bioavailable form of metals in soil, Pollution Indexes Models and Correlation Coefficients of values in soil samples are presented in Tables 1 to 7 respectively

3.1 Concentrations of Heavy Metals in Soil Samples

Concentrations of Heavy Metals in Soil Samples are presented in Table 1 respectively. The concentration of metals in the soil from the three farm sites (A, B and C) studied ranged from 24.76 ± 0.84 to 24.87 ± 0.94 mg/kg for Fe, 1.82 ± 0.32 to 2.63 ± 0.22 mg/kg for Zn, 3.27 ± 0.62 to 3.39 ± 0.81 mg/kg for Pb and 0.30 ± 0.19 to 0.44 ± 0.20 mg/kg for Ni. Fe, Zn and Pb recorded higher concentrations in farm B while Ni was generally low in all the farm sites. However, highest accumulation of metal was recorded for Fe in all the farm sites.

Table 1: Concentrations of Heavy Metals in Soil Samples

	Farms			
Metals	A	B	C	**Mean ±SD**
Fe	24.84 ± 0.89^b	24.87±0.94b	24.76 ± 0.84^b	24.82 ± 0.89
Zn	2.24 ± 0.26^a	2.63±0.22a	1.82 ± 0.32^b	2.23 ± 0.27
Ni	0.44 ± 0.20^a	0.44±0.17a	0.30±0.19a	0.39 ± 0.19
Pb	3.27 ± 0.62^b	3.39 ± 0.81^b	3.37 ± 0.52^b	3.34 ± 0.65

Means levels with the same alphabets within the same row are not statistically different ($P\leq0.05$)

Iron is present in natural waters in varying quantities. It is an essential element in human nutrition and is generally not considered hazardous metal pollutant [35]. The minimum daily requirement of iron is dependent on sex, age, iron bioavailability and the physiology of the individual [35]. Iron is an essential part of haemoglobin in human blood and is needed in transporting oxygen and carbon dioxide in human and its deficiency can lead to anaemia and impairment to enzymes in plants [36]. Iron in excess above 48 mg/day may cause gastrointestinal side effects [37]. Investigations carried out by [38] on irrigated soil in Kaduna State, and [39] on sewage soil farm site in Karachi in Pakistan on heavy metals reported higher levels of Fe (1808.4 to 1871.2 mg/kg) than the mean concentration of 24.82±0.89 mg/kg in the present study (Table 1). Fe levels were lower than the 99.40 mg/kg permissible limits WHO/FAO [1] for agricultural soils. At neutral to alkaline pH, Fe is not known to cause toxicity [40]. Fe levels did not vary significantly ($P\leq0.05$) in the three farm sites

Zinc (Zn) is an essential trace element for humans, animals and higher plants. Higher plants predominately absorb Zn as a divalent cation (Zn^{2+}), which acts as a metal component of enzyme or as a functional, structural or regulatory cofactor of large number of enzymes [41]. Zn tends to have strongest sorption at pH above 7, changing its species depending on soil pH [41]. The present study recorded mean concentration of Zn (2.23±0.27 mg/kg) (Table 1) which was lower than the concentration of 4.2±2.4 mg/kg reported by [41] for agricultural soil close to tannery-affected areas of Pakistan, 8.94 to 15.97 mg/Kg on agricultural soils in copper mining areas of Singhbhum Shear zone in India [42]. However, concentration of Zn in the present study was lower than the 300 mg/kg EU/WHO [3], [2] and 100 mg/kg SEPA [5] allowable limits for agricultural soils. ANOVA revealed that levels of Zn varied significantly ($P\leq0.05$) in farm C.

Nickel (Ni) is essential for growth and reproduction in livestock and man, however, could be carcinogenic in higher amounts in the body [43]. Mean concentration of Ni in soil (0.39±0.19 mg/kg) was in agreement with 0.41 mg/kg reported for Ni in agricultural site along Jabi Lake in FCT, Abuja [44], however, above the 0.98 to 1.22 mg/kg reported for soil from agricultural sites in Maiduguri, Borno State [45], however, lower than the 50 mg/kg EU [3] and 10 mg/kg SEPA [5] allowable limits for agricultural soils. Ni level varied significantly ($P\leq0.05$) in farm C.

Lead (Pb) is neither an essential nor a beneficial element for plants or animals. When lead is released into the environment, it has a long residence time compared with most other pollutants [46]. Lead and its compounds tend to accumulate in soils and sediments, due to their low solubility and microbiological degradation. The mean concentration of Pb (3.34±0.65 mg/kg) was in agreement with the results (0.28 to 4.49 mg/kg) obtained from similar study by [46] for soils from irrigated farm site along South Bank of River Benue, Makurdi, however was contrary to concentrations (6.75 to 14.54 mg/kg) reported by [45] on soils from agricultural sites in Maiduguri, Borno State. The concentrations of Pb in soils from both areas could be attributed to its sources from automobile exhausted fumes as well as dry cell batteries, sewage effluents, runoffs of wastes and atmospheric depositions owing to the close proximity of the sites to high vehicular traffic [45]. The concentrations obtained from the present study were lower than the 84 to 100 mg/kg WHO/EU [2], [3] and 300 mg/kg EU [4] maximum tolerable limits proposed for agricultural soils. In the entire farm, Fe had the highest level of accumulation; Zn and Pb were considerably higher levels while Ni was generally low. Polluted river channels from mechanic workshops and block moulding industries, solid wastes discharges, effluents discharged from generators into the river may have contributed to the pollution load at different sites which may have generated to higher concentrations of some metals [47]. However, in all the farm sites, heavy metal concentrations decreased in the order of Fe>Pb>Zn>Ni respectively. Pb did not vary significantly (P≤0.05) in all the farm sites.

Generally, concentrations of metals in this study did not exceed the standard permissible limits. Though these metal levels fell below the allowable limits, their persistence in the soil for a long period of time may lead to an increase in their uptake by plants. The concentration of heavy metals in the soil samples showed spatial variations which may be ascribed to the variations in heavy metal sources and the quantity of heavy metals in irrigation water [48]. Statistically, ANOVA revealed significant difference (P≤0.05) in the mean levels of soil collected at the three farm sites

3.2 Bioavailable Form of Heavy Metals in Soil Samples

Results for the bioavailable form of metals in soil samples are presented in Table 2 respectively. Study on the bioavailability of heavy metals in soils was conducted using Ethylene Diamine Tetra acetic Acid (EDTA) due to its ability to act more aggressively than other chelating agents in removing heavy metals from the soil under acidic conditions and also its ability to enhance the metal solubility from the soil solid phase [49]. The bioavailable form of metals in soil samples from irrigated farms were lower compared to the total metal concentrations. Highest bioavailable form of metal from the sites were recorded for Fe (23.19± 0.87 mg/kg), Zn (1.06± 0.32 mg/kg and Pb (1.03± 0.03 mg/kg) mg/kg in farm B respectively while Ni was generally low in all the farm sites.

Table 2: Bioavailable Form of Heavy Metal Content (mg/Kg) in Soil Samples

	Farms			
Metals	**A**	**B**	**C**	**Mean ± SD**
Fe	22.70±0.92^{b}	23.19±0.87^{b}	21.02±0.74^{b}	22.30 ± 0.84
Zn	0.85±0.41^{b}	1.06±0.32^{b}	0.46±0.02^{a}	0.79 ± 0.25
Ni	0.12±0.10^{b}	0.14±0.05^{a}	0.00±0.00^{a}	0.09 ± 0.05
Pb	0.49±0.74^{b}	1.03±0.03^{a}	0.85±0.08^{a}	0.79 ± 0.28

Means levels with the same alphabets within the same row are not statistically different (P≤0.05)

The relatively high mean concentrations recorded for Fe (22.30 ± 0.84 mg/kg) may imply higher mobilization, availability of these metals for plant uptake while lower mean levels of 0.09 ± 0.05 mg/kg, 0.79 ± 0.25 mg/kg and 0.79 ± 0.28 mg/kg for Ni, Zn and Pb respectively suggested immobilization of heavy metals into soil by formation of complexes with soil particles [49]. A similar work reported by [50] on bioavailable form of metals in irrigated soil from Meerut City College, had relatively higher extractable levels of 55.35 mg/kg for Pb, 74.45 mg/kg for Zn; and 26.45 mg/kg for Ni than the present recorded levels. At (P≤0.005), metals from different farm sites were not statistically different.

3.3 Pollution Indexes Models in Soil Samples

3.3.1 Pollution Load Index

Pollution Load Index for soils is presented in Table 3a respectively. To appraise the pollution load index of the metals in the soil, contamination factors (CF) were calculated (Table 3a). Contamination factor expresses the level of pollution of the soil by metals. CF ranged from 0.013 to 0.019 for Zn, 0.009 to 0.013 for Ni, 0.039 to 0.04 for Pb and 0.001 for Fe. The highest value was recorded for Pb in all the farm sites.

DOI: 10.31695/IJASRE.2018.32758

Table 3a: Contamination Factor of Heavy Metals in Soil Samples

	Farms		
Metals	A	B	C
Fe	0.001	0.001	0.001
Zn	0.016	0.019	0.013
Ni	0.013	0.013	0.009
Pb	0.039	0.040	0.040
PLI	0.0000002	0.0000002	0.0000001

Table 3b: Pollution Load Index (PLI) Classification Categories

Pollution Class	PLI – Values	Soil Quality
Class 1	PLI = 0	Perfection
Class 2	PLI < 1	Low Contamination
Class 3	1 <PLI < 3	Moderate Contamination
Class 4	3< PLI < 6	Considerable Contamination
Class 5	6 < PLI	Very High Contamination

Source: [30]

Table 3c: Contamination Factor (CF) Classification Categories

Contamination Class	CF – Values	Soil Quality
Class 1	< 0.1	No Contamination
Class 2	0.10 - 0.25	Slight Contamination
Class 3	0.26 - 0.5	Moderately Contamination
Class 4	0.51 - 0.75	Severe Contamination
Class 5	0.76 - 1.00	Very Severe Contamination
Class 6	1.1 - 2.0	Slight Pollution
Class 7	2.1 - 4.00	Moderate Pollution
Class 8	4.1 - 8.0	Severe Pollution
Class 9	8.1 - 16.00	Very Severe Pollution
Class 10	> 16.0	Excessive Pollution

Source: [51], [27]

Applying the contamination factors as categorized to interpret the data (Table 3c) [51], [27], showed that soils from different farm sites along Mpape River were not contaminated by any of the heavy metals studied. The Pollution Load Index (PLI) was used and measured based on the pollution index classification categories (Table 3b) [30]. From the results, the PLI for soil from the three farm sites varied from 0.0000001 to 0.0000002, which were generally far below 1. This indicated no pollution of the soils from Mpape, Wuse and Wuye farm sites by heavy metals.

3.3.2 Geo-accumulation Factors (Igeo-Index)

Geo-accumulation factors for metals in soil are presented in Table 4a respectively. This is used to quantify the extent of heavy metal contaminations associating with the soils. Seven categories of metal classification degrees of pollutions were adopted ranging from background concentrations to very heavily polluted (0-6) as described by [52] (Table 4b). Geo-accumulation factors ranged from 0.004 t0 0.006 for Zn, 0.001 for Fe and Ni and 0.003 for Pb.

Table 4a: Geo-accumulation Index of Heavy Metals in Soil Samples

Metals	Farms		
	A	**B**	**C**
Fe	0.001	0.001	0.001
Zn	0.005	0.006	0.004
Ni	0.001	0.001	0.010
Pb	0.003	0.003	0.003

Table 4b: Geo-accumulation Index Factor Classification Categories (Igeo)

Igeo- classe	Igeo – Valu(	Soil Quality
Class 0	Igeo ≤ 0	Practically Unpolluted
Class 1	0 <Igeo< 1	Unpolluted to Moderately Polluted
Class 2	1 <Igeo< 2	Moderately Polluted
Class 3	2 <Igeo< 3	Moderately Polluted to Highly Polluted
Class 4	3 <Igeo< 4	Highly Polluted
Class 5	4 <Igeo< 5	Highly to Very Highly Polluted
Class 6	5 <Igeo> 6	Extremely Polluted

Source: [52]

From the present study, geo-accumulation values calculated for various metals in all the farm sites were in the zero categories indicating that the soils from all the various farm sites were unpolluted.

3.3.3 Risk Index (RI) in Soil Sample.

In order to assess the risk index of metals, enrichment factor was calculated (Table 5a). Enrichment factor (EF) is used to assess the relative contributions of natural and anthropogenic sources of heavy metal inputs to soil. EF ranged from 18.38 to 26.5 for Zn with higher value recorded in farm B and lower value in farm C, 13.46 to 22.22 for Ni indicating highest and lowest values in farms A and C and 66 to 68.05 for Pb. Farm C recorded the highest value while farm A lowest respectively.

Table 5a: Enrichment Factor for Soil Samples

Metals	Farms		
	A	**B**	**C**
Zn	22.5	26.5	18.38
Ni	22.22	19.66	13.46
Pb	66	68	68.05

The degree of pollution/ contaminations were calculated for each soil sample relative to the background values of abundance of chemical element in the earth’s crust; choosing Fe as the reference element/ normalizer due to its conservative and more abundance in nature [33]. A five categories ranking system was used in this study (Table 5b) to denote the degree of anthropogenic contamination adopted by [53]. Enrichment factor analysis indicated severe to extremely severe enrichment of metals in the agricultural soil in the study area (Table 5a).

DOI: 10.31695/IJASRE.2018.32758

Table 5b: Enrichment Factor (EF) Classification Categories

Classes	EF – Values	Soil Quality
Class 1	EF < 1	No Enrichment
Class 2	EF < 3	Minor Enrichment
Class 3	EF = 3 – 5	Moderate Enrichment
Class 4	EF = 5 – 10	Moderately Severe Enrichment
Class 5	EF = 10 – 25	Severe Enrichment
Class 6	EF = 25 – 50	Very Severe Enrichment
Class 7	EF > 50	Extremely Severe Enrichment

Source : [53]

The EFs indicated extremely severe enrichment with respect to Pb, very severe enrichment was recorded for Zn only in farm B. However, Ni was found to be at very severe enrichment status in all the farms. These results were contrary to those previously reported by [54], [40] for heavy metals in soil along major roadside areas in Botswana from moderate Ni to extremely enrichment for Pb. The high values and dissimilarities in EF reported by different authors may be ascribed to the different approaches used in enrichment factor calculation methods, such as choice of reference element. The variation in EF from site to site may also reflect the age of establishment of the various sites and indicative of the number of times the sites are used in planting, the type of farming practices performed at each farm site, and other anthropogenic causes such as the type of water used for irrigation and fertilizer applications [55]. Therefore, EF values from the present studies suggest that the sources are of anthropogenic origin

Table 6a: Ecological Risk Index (RI) of Heavy Metals in Soil Samples

	Farms		
Metals	**A**	**B**	**C**
Fe	NA	NA	NA
Zn	0.024	0.028	0.019
Ni	0.032	0.032	0.022
Pb	0.818	0.848	0.843
$\Sigma E_r^i =$	1.300	1.949	1.667

The potential ecological risk (E_r^i) assessments of heavy metals in soil samples are presented in Table 6a respectively. Zn ranged from 0.019 to 0.028, 0.022 to 0.032 for Ni and 0.818 to 0.848 for Pb respectively.

Table 6b: Ecological Risk Index (E_r) Classification Categories

Classes	Er- values	Soil Quality
Class 1	< 40	Low Potential Ecological Risk
Class 2	40 ≤ Er< 80	Moderately Potential Ecological Risk
Class 3	80 ≤ Er< 160	Considerable Potential Ecological Risk
Class 4	160 ≤ Er< 320	High Potential Ecological Risk
Class 5	Er> 320	Very High Ecological Risk

Source: [56]

The degree of E_r^i is classified into five categories (Table 6b) [56]. The potential ecological risk index (RI) values calculated from the present studies in all the farms were in the low potential risk category which may suggests that the soils from all the farms do not pose any ecological health risk to the environment [56].

3.4 Statistical Analysis

Correlation analysis in soil samples from the three farm lands are presented in Table 7 respectively.

The correlation results showed that the metals have varying correlations. The pairs of metals; Zn/Fe (0.959), Ni/Zn (0.978), Pb/Fe (0.970) and Pb/ Ni (0.990) were strong and positive while Ni/ Fe (-0.988) and Pb/Zn (-0.976) were strong and negative.

Table 7: Correlation Coefficient (r) values for Heavy Metal Concentrations in Soil Samples from three irrigated farm sites

	Fe	Zn	Ni	Pb
Fe	1***			
Zn	0.959**	1***		
Ni	-0.988*	0.978**	1***	
Pb	0.970**	-0.976*	0.990**	1***

Correlation is significant at (P≤0.05) level

The strong positive correlations in the soil samples is an indication that they have common source of pollution while the strong negative correlations observed is an attribute of different origin and sources of pollution load such as municipal and agricultural dumps, chemicals from irrigated farm lands and other small scale activities from the five sampling sites [27].

4.0 CONCLUSION

In a man's environment, the top soil quality is very paramount in order to ensure good healthy living. The results obtained for the heavy metals in the different irrigated farm sites along Mpape River indicated that the soils were generally uncontaminated by the these metals. Index model assessments applied to the results of the heavy metals obtained in this study revealed that the probable sources of contaminants in the soil from different irrigated farm sites were of anthropogenic origin. The index model assessment confirmed that the soils were unpolluted except the enrichment factor that indicated extremely severe enrichment with respect to Pb, very severe enrichment for Zn in farm B and Ni at very severe enrichment status in all the irrigated farms sites. However, the problem of pollution from these metals in these areas should be under routine check in order to avoid being polluted in the near future and excessive build-up in the food chain.

ACKNOWLEDGEMENT

We are grateful to Department of Chemistry, Nasarawa State University, Keffi for the use of their facilities for the research work.

REFERENCES

[1]. FAO/WHO (2001).Codex Alimentarius Commission. Food Additives and Contaminants. Joint FAO/WHO. Food Standard Programme.

[2]. WHO, (2006). Guidelines for the safe use of wastewater excreta and grey water. Waste Water use in agriculture, 2, pp. 2-219.

[3]. European Union.(2006). Commission Regulation. NO. 1881. Setting Maximum Levels for certain contaminants in food stuffs. *Office of Journal of European Union*, 364,pp. 5-24.

[4]. European Union.(2002). Heavy Metals in Wastes. European Commission on Environment.

[5]. State Environmental Protection Administration –SEPA (2005). The limits of Pollutants in Food in China. GB2762.

[6]. Cui, Y.J., Zhu, Y.G., Zhai, R.H., Chem., D.Y., Huang, Y.Z., Qui, Y., & Liang, J.Z. (2004). Transfer of Metals from Soil to vegetables in an area near a smelter in Nanming, China, 30 (6), pp. 785-91.

[7]. Cui, Y.J., Zhu, Y.G., Zhai, R., Huang, Y., Qui, Y., & Liang, J. (2005). Exposure to Metal Mixtures and Human Health Impacts in a Contaminated Area in Nanning, China. *Environ. Int.,* 31, pp. 784-790.

[8]. Nyles, C.B., & Ray, R.N. (1999). The nature and properties of soil: 12th ed. United States of America, pp. 743-785.

[9]. Kabata- Pendias, A. (2004). Soil-plant Transfer of Trace Elements: An Environmental Issue. Geoderma, 122, pp. 143-149.

DOI: 10.31695/IJASRE.2018.32758

[10]. Sajjad, K., Robina, F., Shagufta, S., Mohammad, A.K., & Maria, S. (2009). Health Risk Assessment of Heavy Metals for Population via consumption of vegetables. *World Applied Science Journal*, 6 (12), pp. 1602-1606.

[11]. Singh, A.K., Rattan, R. K., Datta, S.P., Chhon-Kar, P.K., & Suribabu, K. (2010).Long-term impact of irrigation with sewage effluents on heavy metal content in soils, crops and ground water- A case study.*Agriculture, Ecosystem & Environment.* 109, pp. 310-322.

[12]. Muchuweti, M., Birkett, J.W., Chinyanga, E., Zvauya, R., Scrimshaw, M.D., & Lester, J.N. (2006). Heavy metal content of vegetables irrigated with mixture of waste water and severe sludge in Zimbabwe. Implications for human health. *Journal of Agriculture, Ecosystem and Environment*, 112, pp. 41-48.

[13]. Abreu, M.G.M., & Tokunaga, E. (2006).Chemical extraction of arsenic from contaminated soil.*Journal of Environmental Science & Health*, 41(4), pp. 631-643.

[14]. Chipo, M. (2011). Assessment of Heavy Metal Accumulation in Wastewater Irrigated Soil and Uptake by maize plants (Zea Mays) at firle Farm in Harare. *Journal of Sustainable Development*, 4 (6), pp. 132-137. Published by Canadian Centre of Science and Education.

[15]. Zhuang, P., Murray, B.M., Hanping, X., Li, N., & Li, Z. (2009). Health Risk from Heavy Metals via Consumption of Food Crops in the vicinity of Dabaoshan mine, South, China. *Science of the Total Environment*, 407, pp. 1551-1561.

[16].Sharma, R., Sigh, A., K, Agrawal, M., & Marshal, F. A. (2008a). Risk assessment of heavy metal toxicity through contaminated vegetables from waste water irrigated area of Varanasi, India. *Journal of Tropical Ecology*, 51 (25), pp. 375 – 387.

[17]. Sharma, R.K., Agrawal, M., & Marshall, F.M. (2009). Heavy Metals in vegetables collected from production and Market Sites of Tropical Urban Areas of India. *Food and Chemical Toxicology*, 47, pp. 583-591.

[18]. Ubani, N., Lamali, M. K., Kazi, T. G., Arain, M. B., Afridi, H. l., Memon, A.R., & Shah, A. (2007).Heavy metals from soil and domestic sewage sludge and their transfer to sorghum plants. *Journal of Environmental Chemistry*, 5, pp. 29-218.

[19].Wilson, B., & Pyatt, F.B. (2005). Heavy Metal Dispersion, Persistence, and Bio-accumulation around an ancient Mine situated in Anglesey. UK. *Ecology and Environmental safety*, 66, pp. 224-231.

[20]. Soylak, M., Duran, A., & Tuzen, M. (2007). Trace element levels in some dried fruit samples from Turkey. *International Journal of Food Science & Nutrition*, 59, pp. 581-589.

[21]. Samaila, k.L., Marcus, N.D., & Kukwi, J.I. (2011). The Influence of Waste Water on Soil Chemical Properties on IUrrigated Fields in Kaduna, South- Township, North Central Nigeria. *J. Sustain. Dev. Afri*, 13 (6), pp. 1520-5509.

[22]. Eze, O.C., Tukura B.W., Atolaiye B.O. and Opaluwa, O.D.(2018). Pollution Assessment of Heavy Metals in Water and Sediment from Mpape River in FCT, Abuja, Nigeria, 3 (2), pp.66-77.

[23]. Zhang, F.S., Yamasaki, S., & Nanzyo, M. (2002). Waste ashes for use in agricultural production: limiting effects of some metals. *Sci. Total environ.*, 284, pp. 215-225.

[24]. Naser, H.M., Shil, N.C., Mahmud, N.U., Rushid, M.H., & Hossain, K.M. (2009). Lead, Cadmium and Nickel conctents of vegetables grown in industrially polluted and non-polluted areas of Bangladesh. *Bangladesh J. Agric. Res.*, 34, pp. 545-554.

[25]. Awode, U.A., Uzairu, A., Balarabe, M.L., Harrison, G.F. & Okunola, O.J. (2008). Assessment of Peppers and Soils for some heavy metals from irrigated farmlands on the Bank of River Challawa, Northern Nigeria. *Pakistan Journal of Nutrition*, 7 (2), pp. 244-248.

[26]. Amacher, M.C., O'Neill, K.P.,Dresbachand, R., & Palmer, C. (2003). Forest Inventory and Analysis Manual of Soil Analysis Method. Soils Lab. Manual.

[27]. Lacatusu, R. 2000. Appraising levels of soil contamination and pollution with heavy metals. *European Soil Bureau Research Report*, Number 4. of Upper Warri River, Niger Delta, Nigeria. *Journal of Science and Environment*., 2, pp. 75 – 86.

[28]. Wang, Y., Yang, Z., Shen, Z., Tang, Z., Niu, T., &Gao, F. (2011). Assessment of Heavy Metals in Sediments from a Typical Catchment of the Yangtze, River, China.*Environ. Monit.Assess.*,172, pp. 407-417.

[29]. DPR 2002. Environmental guidelines and standards for the petroleum industry in Nigera. Department of Petroleum Resources, Lagos, Nigera.

[30]. Hari-Kumar, P.S., Nasir, U.P., & Mujeebu, R.P (2009).Distrinution of Heavy Metals in the Core Sediments of a Tropical Wetland System.*International Journal of Environmental sciences and Technology*, 6, pp. 225-232.

[31]. Christophoridis, c., Dedepsidis, D., & Fytianos, K. (2009).Occurrence and Distribution of Selected Toxic Metals in the Surface Sediments of Thermaikos.Gulf. Greece: Assessment using Pollution Indication. *J. Hazard Matters*, 168, pp. 1082-1091.

[32]. Liao, G.O., & Chao, W. (2004). Assessment of Heavy Metalic ions pollutions for a river near a metal mine. *J. Mining and Metallurgy*, 13 (1), pp. 86-90.

[33]. Adamo, P., Arienzo, M., Imoperato., M., Naimo, D., Nardi, G., & Stanzione, D. (2005). Distribution and Partitioning of Heavy Metals in Surface and Sub-surface sediemnts of Naples City Port.*Chemosphere*, 61, pp. 800-809.

[34]. Hilton, J., Davison, W., & Ochesenbein, U. (1985).Mathematical Model for Analysis of Sediment Coke Data.*Chem. Geol*., pp. 281-291.

[35]. JECFA, (2005).Joint FAO/WHO ExpertCommitte on Food Additives, 64th meeting, JECFA/64/SC, Codex standard, 47, pp. 193-1995.

[36]. Bhagura, G.R., & Miragane, S.R. (2011). Heavy metal concentration in ground water and soils of Thane Region of Maharashtra, India. *Environmental Monitoring & Assessment*, 173, pp. 643-652.

[37]. Driskell, J.A. (2009). Upper Safe levels of Intake for adults: Vitamins and |Minerals. University of Nebrska, Lincoln.Extension.Publication, Institute of agriculture and Natural resources.

[38]. Mohammed, S.A., & Folorunsho, J.O. (2015). Heavy Metal Concentration in Soil and Amaranthus retroflexus grown in irrigated Farmlands in Markera area, Kaduna, Nigeria. *Journal of Geography and regional Planning,* 8 (98), pp. 210-217.

[39]. Farooq, A., & Ishretullah, S. (2000). Determination of Heavy Metals in vegetables and soils at sewage farm in Sindh Industrial Trading Estate, Karachi. *Jour. Chem. Soc. Pak.* 23, pp. 1.

[40]. Mmolawa, K. B., Likuku, A.S., & Gaboutioeloe, G.K. (2011).Assessment of Heavy Metals Pollution in Soils along major roadside areas in Botswana.*African Journal of Environmental science and Technology.* 14, pp. 245-301.

[41]. Ali, Z., Malik, R.N., Shinwari, Z.K., & Qadir, A. (2015). Environmental risk Assessment and Statistical Appointment of Heavy Metals in Tannery-affected areas. *Int. J. Environ. Sci. Technol.*, 12, pp. 537-550.

[42]. Soma, G., Abhay, K.S., & Mukesh, K.M. (2016).Metal Contamination of Agricultural Soils in the Copper Mining Areas of Singhbhum Shear Zone in India.*J. Earth Syst. Sci., pp.* 126:49.

[43]. Iwegbue, C.M. (2010). Composition and Daily Intakes of Some Trace Metals from Canned Beers in Nigeria.*Journal of the Institute of Brewing and Distilling*, 116 (3), pp. 312-315).

[44]. Umar, M.A., & Ebong, M.C. (2013).Determination of Heavy Metals in soil, water, sediment, fish and cray fish of Jabi Lake in the Federal Capital Territory, FCT, Abuja, Nigeria.*International Journal of Research in Pure and Applied Chemistry*, 2 (1), pp. 5-9.

[45]. Alex, Van Herk (2012). Physicochemical parameters in soil and vegetable samples from Gongulon Agricultural sites, Maiduguri, Borno State, Nigeria.*International Journal of Chemistry 4 (4), pp. 222-229.*

[46]. Adah, C.a., Abah, J., Ubwa, S.T., & Ekele, S. (2013). Soil availability and uptake of some Heavy Metals by three staple vegetables commonly cultivated along the South Bank of River Benue, Makurdi, Nigeria.*Int. J. Environ. Bioe.*, 8 (20), pp. 56-67.

[47]. Zhuang, P., Murray, B.M., Hanping, X., Li, N., & Li, Z. (2009). Health Risk from Heavy Metals via Consumption of Food Crops in the vicinity of Dabaoshan mine, South, China. *Science of the Total Environment*, 407, pp. 1551-1561.

[48]. Liu, X., Song, Q., Tang, Y., Li, W., Xu, J., Wu, J., Wang, F., & Brookes, P.C. (2013). Human Health Risk Assessment of Heavy Metals in Soil- vegetable System: A Multi-medium analysis. *Sci. Total Environ., 463, pp. 530-540.*

[49]. Gryoschko, R., Kuhnle, R., Terytze, K., Breuerand, I., & Stahr, K. (2004). Soil Extraction of readily soluble heavy metals and As with IM N114N03- Solution: Evaluation of DEN 19730.1. *Soils Sediments*, 5, pp. 101-106.

DOI: 10.31695/IJASRE.2018.32758

[50]. Deepak, S., & Shukla, A.K. (2013). Analysis of Heavy Metals in Soil and Vegetables irrigated with Wastewater in Meerut City Region, Int. J. Adv. Life Sci, 6, pp. 287-292.

[51]. Gong, Q., & Deng, J. (2008).Calculating pollution Indices by heavy metals in Ecological Geochemistry Assessment and a case study in Parks of Beijing.*Journal of China University of Geosciences,* 19 (3), pp. 230-241.

[52]. Charkaravarty, M., & Patgiri, A.D. (2009).Metal Pollution assessment in Sediments of the Dikrong River, India. *J. Hum. Ecl.*, 27 (1), pp. 63-67.

[53]. Giri, S., Singh, A.K., & Tewary, B.K. (2013).Source and Distribution of Metals in Bed Sediments of Subarnarekha, River, India. *Environ. Earth Sci.*, 70 (97), pp. 338-3392.

[54]. Mmolawa, K. B., Likuku, A.S., & Gaboutloeloe, G.K. (2010). . Heavy Metal Distribution and Enrichment anround Botswana.Fifth International Conference of Environmental science and Technology, Houson, Texas, USA.

[55]. Sucharova, J., Suchara, I., Hola, M., Marikova, S., Reimann, C., Boyd, R., Filzmoser, P., & Englmaier, P. (2012). Top/ Bottom-Soil Ratios and Enrichment Factors: *Applied Geochemistry.* 27, pp. 138-145.

[56]. Wu, Q., Leung, J.Y., Geng, X., Chen, S., Huang, X., Li, H., Huang, Z., Zhu, L., Chen, J., & Lu, Y. (2015).Heavy Metal Contamination of Soil and Water in the vicinity of an abandoned e-waste recycling site.Implications for Dissemination of Heavy Metals. *Sci. Total Environ.* 506-507, pp. 217-225.