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Assessment of Some Physicochemical Parameters of Soil And Heavy Metals In Vegetables Cultivated On Irrigated SitesAlong The Bank of Mpape River In FCT, Abuja, Nigeria

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Abstract: *The purpose of the study was to assess some physicochemical parameters of soil and the heavy metal concentrations in soil and vegetables along the bank of Mpape River in FCT, Abuja. The study was carried out in dry season between 2016 and 2017. Soil and vegetables samples were collected 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 physicochemical characteristics in soil and the heavy metals in soil and vegetables varied significantly according to sites without adhering to any significant trend. Soil pH (5.62±0.72) was slightly acidic, soil temperature (27.37±0.60 ^{0}C) and OM content (3.31±0.37 %)were significantly higher and within WHO/FAO[1] permissible limits.Levels of Cr and Cd were below detectable limits while Mn (7.61±0.76) and Cu (0.65±0.016) in soil were below EU[2] permissible limits. The levels of Cr (0.17±0.08),Mn (7.22±0.59), Cd (0.02±0.01) and Cu (0.80±0.26) in Lagos Spinach were significantly higher than the levels of Cr (0.29±0.16), Mn (3.92±0.53), Cd (0.01±0.03) and Cu (0.67±0.28) in African Egg-plant which were below FAO/WHO[1] and EU[2] permissible limits. Transfer factors (TF) values for Mn and Cu surpass 0.5 showing that the vegetables were largely contaminated by Mn and Cu while Cr and Cd were below 0.5 in the two vegetables. Daily intakes value (DIM) calculated for Cr, Cd and Cu in vegetables were generally below the WHO/EU[2, 3] and SEPA[5] maximum limits except for Mn that was higher than the limits indicating that people who consumed these vegetables may accumulate more of the Mn. Health Risk Index in both vegetables from all the farms was less than 1, indicating that no significant potential health risk associated with the consumption of these vegetables. All the metals were significantly different (<0.05). The correlation analysis showed that the metals in these farms have varying correlations. All the metals in all the farms were strong and positively correlated which is an indication that they have common source of pollution.*

Keywords: *Assessment, Physico-chemicals, metals, Soil, Sites, Vegetables*

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I. Introduction

Water is an essential natural resource for sustainability of life on earth. It is used for domestic, industrial and agricultural purposes[5].Rivers serve as sinks for wastes from different sources, mainly from anthropogenic activities which include various toxic chemicals, acids, alkalis, detergents and agrochemicals which greatly affect the physicochemical properties of water used for irrigation[6]. Some of these parameters include pH, temperature, organic matter and solids and also heavy metals such as chromium, manganese, cadmium and copper which may be affected by seasonal variations[7].Accumulation of heavy metals in crop plants is of great concern due to the probability of foodcontamination through the soil-root interface due to the pollution of metals which are reported to cause many types of diseases such as cancer, nervous diseases and also various diseases affecting different organs of the body[7].

Soil is the primary reservoir of heavy metals in the overall metal cycle in nature[8,9]. The heavy metals which are the natural components of the environment mainly in combined forms are being added to the soil through direct or indirect consequences of anthropogenic activities such as disposal of urban and industrial wastes; mining and smelting of non-ferrous metals and metallurgical, additions of manures, sewage sludge, fertilizers and pesticides, spent engine oil[6].

Vegetables play important roles in our daily diet and as economic crops, they take up heavy metals by absorbing them from contaminated soils, as well as from deposits on parts of the vegetables exposed to the air from polluted environments[10]. Heavy metal accumulation in plants depends upon plant species, and the efficiency of different plants in absorbing metals is evaluated by either plant uptake or soil to plant transfer factors of the metals[11]. Several studies have indicated that vegetables, particularly, the leafy ones, grown in heavy metal contaminated soil have higher concentrations of these metals than those in an uncontaminated soil and these metal sources in vegetables is the growth media (soil, air, nutrients solutions) and are taken up through the roots and foliage[10].

There has always been a number of studies which have investigated vegetables growing on soil irrigated areas with wastewater which indicated high concentrations of heavy metals in the leaves than the roots of vegetables grown on these areas and identified leafy vegetables at greater risk of accumulating elevated concentration. Some researchers[12, 13]have reported heavy metal pollution assessment of soil and vegetables from irrigated farmlands in FCT Abuja, but there is limited information on the pollution status of soil and vegetables along the bank of Mpape River. The objective of this study, therefore, is to assess some physicochemical parameters of soil and heavy metal pollution of soil and vegetables cultivated along the bank of Mpape River in Federal Capital Territory (F.C.T.) Abuja, Nigeria, during dry seasons. Information from this study would be a useful tool for further assessment and monitoring of the river quality.

II. Materials And Methods

Study Area

The study was conducted at three different irrigation sites; Mpape, Wuse Zone 5 and Wuye 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 Federal Capital Territory, Abuja, Nigeria (Figure 3.1). The River experiences large influx of wastes from both points and non-point sources, especially during the rainy season. It is used majorly during dry seasons as source of water for irrigation purposes in the area. Inhabitants of this area, however, depend on the river for fishery activities and as well as source of water for domestic purposes. Some industrial activities such as 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.

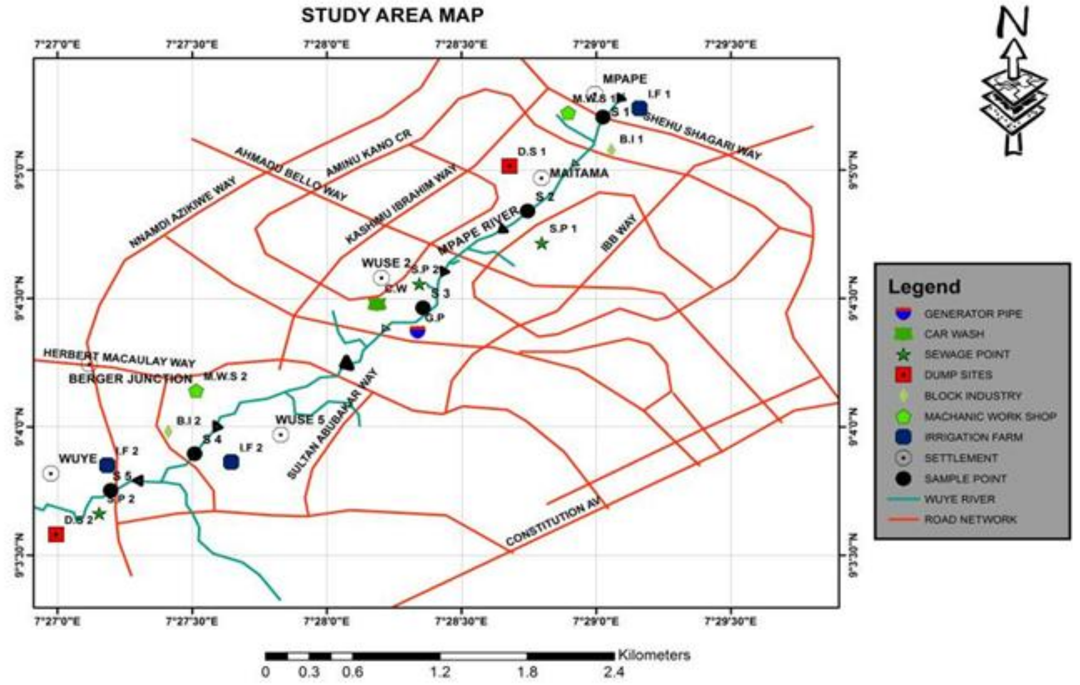

Figure1: Mpape River Showing Sampling Location Sample Collections and PreparationsSoil

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[14].

Vegetables

Samples (4 kg) each of Lagos Spinach (*Celosia argentea)* and African Egg- Plant (*Solanum macrocarpon)* leaves were collected randomly from six different locations in the irrigated farmland to form a composite sample by uprooting manually with hands and packaged inside cellophane bags. Vegetable samples were taken to the laboratory and were washed thoroughly three times with deionized water in order to remove soil particles. Vegetables were spread on a tray and air - dried for 3 days. The vegetables were separated into roots, stems and leaves. The leaves were ground to powder using mortar and pestle. The ground samples were sieved with 125 µm mesh in order to obtain more homogenous samples. The sieved samples were packaged in cellophane bags for metal analysis[15].

Sample DigestionSoil

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[14].

Vegetables

Three replicate samples of each vegetable (5 g) were weighed separately into porcelain crucible and digested with 10 cm^3 of 98 % concentrated HNO_3. The mixture was heated to complete dissolution in a water bath for 1 hr at temperature of 150 ^oC until light coloured solution was obtained. The solution was made up to 25 cm^3 with distilled water and filtered through Whatman No.1filter paper. The filtrate was stored in a plastic bottle for metal analysis[15].

Determination of the Physicochemical Properties of Soil

pH

Soil pH was determined by shaking 5 g of sample with 5 cm^3 of water. The soil solution was allowed to stand overnight. pH meter was inserted inside the solution and the value was read and recorded[16].

Temperature

Temperature was measured using thermometer (0 – 50 ^0C). Temperature probe was inserted into the soil sample solution containing 5 cm^3 of deionized water. The temperature value was read and recorded[16.].

Organic Matter

Organic matter was determined using acid extraction method by weighing 100 g of the sample into a beaker and 50 cm^3 of 30 % H_2O_2 was added. The solution was heated at 450 ^0C for 1 hr. The calculation of the amount of OM was done by the difference in mass of dry sample before and after extraction[17].

OM % = Initial mass of dry sample before extraction–Final mass of dry sample after extraction (2.1)

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[18] (Amacher *et al.*, 2003).

Risk Assessment of Heavy Metals in Vegetable Samples

Health Risk Index (HRI)

The health risk index through the consumption of contaminated vegetables from the farm sites was assessed based on the food chain and the reference oral dose (RFD) for each vegetable. Values of HRI depend upon the daily intake of metals (DIM) and oral reference dose (RFD) which was estimated per day exposure of metals to the human body[10].

The DIM in this study was calculated using the average adult vegetable intake rate of 0.345 kg / person / day based on the formula proposed by[10, 19]. Average body weight of adult consumers (57.9 kg) was obtained through a formal survey conducted in the study area by interviewing about 30 persons (15 males and 15 females) between the ages of 30 - 45 years and their average body weights taken using a weighing balance scale at each irrigation site.

DIM = Metal Concentration in plants (mg / kg) X Daily Food Intake of vegetables (Kg /person / day) / Average body weight (ABW) (kg). (2.2)

The health risk index for heavy metals was calculated thus;

HRI = DIM / RFD. (2.3)

RFD for Cd = 0.001, Cr = 0.003, Cu = 0.04 and Mn = 0.014 (mg / kg bw / day)[20, 21].
In this work, if the health risk index value is < 1, then the exposed population is considered to be safe but where HIR is equal or greater than 1, the exposed population is considered to be very unsafe[17].

Transfer Factor (TF)
The transfer factors of heavy metals from soil to vegetables, is one of the key components of human exposure to metals through the food chain. Transfer factor in this study was calculated based on the total metal content of the vegetable leaves according to[19].
TF = Concentrations of metals in edible parts / Concentrations of metals in the soil (2.4)

Elemental Analysis of Samples
Qualification of Cu, Cd, Mn and Cr were carried out in triplicates using Atomic Absorption Spectrometry (Model 180-30) Hitach.

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 soils and vegetables.

Statistical Analysis

Two- way ANOVA test was carried out using Micro Soft Office Excel 2010 to evaluate the significant difference in the concentration of the four studied metals in the vegetable and soil samples and at the various farm sites at 5% confidence interval. Correlation test was done using R- 3.50 statistical package program to check for correlations between heavy metals in soil and vegetable samples at ($P < 0.05$) = is significantly different and ($P \leq 0.05$) = is not significantly different.

III. Results

Table 1: Shows the levels of the physicochemical parameters of soil samples. Soil temperature from three farms varied according to sites and ranged from 27.20 ± 0.02 to 27.50 ± 0.92 ^{0}C indicating highest and lowest values at farms B and A respectively. Soil pH was generally acidic and ranged from 5.23 ± 0.87 to 5.94 ± 0.78. Farm A and B recorded the highest and lowest values respectively. Soil organic matter (SOM) varied from 2.42 ± 0.14 to 3.93 ± 0.76 %, recording the lowest and highest levels in farms A and C respectively.

Table 1: Shows Physicochemical Parameters of Soil Samples

		Farms		
Parameters	**A**	**B**	**C**	**Mean±SD**
Temperature (^{0}C)	27.20±0.02^a	27.50±0.92^b	27.40±0.87^b	27.37±0.60^b
Ph	5.94±0.78^b	5.23±0.87^b	5.68±0.52^b	5.62±0.72^b
Organic Matter(%)	2.42±0.14^a	3.59±0.26^a	3.93±0.76^b	3.31±0.37^b

Mean levels with the same alphabets within the same row are statistically different (<0.05)

Table 2: Presents the concentrations of heavy metals in soil samples. Concentration of Cr, Mn and Cu ranged from 1.36±0.11to 1.69±0.10, 10.10±0.85to 11.42±0.74and 0.09±0.07 to 1.01±0.07 respectively with the highest concentrations of Cr (1.69±0.10) and Mn (11.42±0.74) recorded in farm A while Cu (1.01±0.07) was highest in farm B and Cd concentration (0.01±0.04) was generally low in all the three farms.

Table 2: Shows Concentrations (mg/Kg) of Heavy Metals in Soil Samples

		Farms		
Metals	A	B	C	**Mean ±SD**
Cr	1.69±0.10^b	1.59±0.12^b	1.36±0.11^b	1.55 ± 0.11^b
Mn	11.42±0.74^b	11.03±0.62^b	10.10±0.85^b	10.85 ± 0.74^b
Cd	0.01±0.04^a	0.01±0.03^a	0.01±0.01^a	0.01 ± 0.03^a
Cu	0.091±0.07^a	1.01±0.07^a	0.63±0.06^a	0.85 ± 0.07^a

Mean levels with the same alphabets within the same row are statistically different (<0.05)

Table 3: Shows the bioavailable form of heavy metals in soil samples. Mn and Cu ranged from 6.13± 0.64to 8.63 ± 0.94and 0.31±0.02 to 0.97±0.41 respectively. Concentration of Mn (8.63± 0.94 mg/kg) was significantly

higher in farm A and lowest in farm C while higher concentration of Cu (0.97 ±0.41 mg/kg) was recorded in farm B and lowest in farm C. Cr and Cd levels were below detectable limits in all the farm sites.

Table 3: Shows Bioavailable Form of Heavy Metal Content (mg/Kg) in Soil Samples

		Farms		
Metals	**A**	**B**	**C**	**Mean ± SD**
Cr	BDL	BDL	BDL	BDL
Mn	8.63 ± 0.94^{b}	8.07 ± 0.71^{b}	6.13± 0.64^{b}	7.61 ± 0.76^{b}
Cd	BDL	BDL	BDL	BDL
Cu	0.68±0.06^{a}	0.97±0.41^{b}	0.31±0.02^{a}	0.65 ± 0.16^{b}

Means levels with the same alphabets were statistically different (<0.05)
BDL= Below Detectable Limit

Table 4: Shows the concentrations of heavy metals in the leaves of vegetables (Lagos spinach and African Egg-plant). In Lagos Spinach, the lowest and highest concentrations of Cr ((0.07±0.04 mg/Kg) and (0.25±0.10 mg/kg) were recorded in farms B and C and Mn recorded highest (10.07±0.91 mg/kg) and lowest (4.92±0.40 mg/Kg) concentration in farms B and C. Farm A recorded the highest concentration of Cu (0.87±0.26 mg/kg) and the lowest (0.74±0.31 mg/Kg) in farm C. Highest concentration of Cd was recorded in farm C while farm A was below detectable limits. In African Egg-plant, Cr indicated the highest (0.36±0.21 mg/kg) and lowest (0.22±0.1 mg/Kg) concentrations in farms B and C. Concentrations of Mn (6.22±0.79 mg/kg) was highest in farm C and lowest (2.38±0.47 mg/Kg) in farm B. Cu recorded highest concentrations (0.73±0.41 mg/kg) in farm C and the lowest (0.61±0.08 mg/Kg) in farm A. However, Cd concentrations (0.01±0.03 mg/kg) were the least and similar for all farms.

Table 4: Shows Concentrations (mg/Kg) of Heavy Metals in the Leaves of Vegetables Samples

		Farms		
Metals	**A**	**B**	**C**	**Mean ± SD**
Lagos Spinach (Celosia argentea)				
Cr	0.20 ± 0.11^{b}	0.07 ± 0.04^{a}	0.25 ± 0.10^{b}	0.17 ± 0.08^{b}
Mn	6.66 ± 0.46^{b}	10.07 ± 0.91^{b}	4.92 ± 0.40^{b}	7.22 ± 0.59^{b}
Cd	0.00 ± 0.00^{a}	0.01 ± 0.01^{a}	0.01 ± 0.02^{a}	0.017 ± 0.01^{a}
Cu	0.87 ± 0.26^{b}	0.80 ± 0.20^{b}	0.74 ± 0.31^{b}	0.80 ± 0.26^{b}
African egg -plant (Solanum macrocarpon)				
Cr	0.30 ± 0.12^{b}	0.36 ± 0.21^{b}	0.22 ± 0.14^{b}	0.29 ± 0.16^{b}
Mn	3.17 ± 0.34^{b}	2.38 ± 0.47^{b}	6.22 ± 0.79^{b}	3.92 ± 0.53^{b}
Cd	0.01 ± 0.03^{a}	0.01 ± 0.03^{a}	0.01 ± 0.03^{a}	0.01 ± 0.03^{a}
Cu	0.61 ± 0.08^{a}	0.66 ± 0.35^{b}	0.73 ± 0.41^{b}	0.67 ± 0.28^{b}

Means levels with the same alphabets were statistically different (<0.05).
BDL = Below Detectable Limit

Table 5: Shows the transfer Factors (TF) from soil to the leaves of vegetable samples. In the study, in Lagos Spinach, TF for Cu (1.28 to 2.39) was greater than 1except for Cu at farm B (0.82). TF for Mn (0.77 to 1.25) was relatively high. However, the TF for Mn (1.01) at farm C and Cu (0.68 to 2.35) were also observed to be greater than or equal to 1 in African egg-plant. Cd recorded the least and similar TF values (0.01) in farms B and C while it was below detectable limits in farm A.

Table 5: Shows Transfer Factor of Heavy Metals from soil to the Leaves of Vegetables Samples

			Metals	
Farms	Cr	Mn	Cd	Cu
Lagos Spinach (Celosia argentea)				
A	0.20	0.77	0.00	1.28
B	0.07	1.25	0.01	0.82
C	0.25	0.80	0.01	2.39
Mean	0.17	0.94	0.00	1.50
African egg- plant (Solanum macrocarpon)				
A	0.30	0.37	0.01	0.90
B	0.30	0.29	0.01	0.68

C	0.22	1.01	0.01	2.35	
Mean	0.29	0.56	0.01	1.31	

Table 6: Shows the results for daily intake of metals in vegetable. The highest values for the daily intake of metals in both vegetables were recorded for Mn (0.040) in farm A in Lagos Spinach and Mn (0.037) in Farm C in African Egg- plant.

Table 6: Presents Daily Intake of Metals (DIM) (mg/ Kg/ person / day)

			Metals	
Farms	Cr	Mn	Cd	Cu
Lagos Spinach (Celosia argentea)				
A	0.001	0.040	0.000	0.005
B	0.001	0.060	0.001	0.005
C	0.002	0.029	0.006	0.004
Mean	0.001	0.043	0.002	0.005
African egg -plant (Solanum macrocarpon)				
A	0.004	0.019	0.006	0.004
B	0.002	0.014	0.001	0.004
C	0.001	0.037	0.001	0.004
Mean	0.002	0.023	0.003	0.004

Table 7: Shows health risk index of heavy metals in vegetable leaves. The highest HRI values were recorded for Mn (0.429) in farm B in Lagos Spinach and Mn ((0.429) in farm C in African Egg-plant.

Table 7: Shows Health Risk Index (HRI) of Heavy Metals in Vegetable Leaves Samples

		Metals		
Farms	Cr	Mn	Cd	Cu
Lagos Spinach (Celosia argentea)				
A	0.033	0.286	0.001	0.125
B	0.033	0.429	0.010	0.125
C	0.067	0.207	0.060	0.100
Mean	0.044	0.307	0.023	0.117
African egg -plant (Solanum macrocarpon)				
A	0.133	0.136	0.060	0.100
B	0.067	0.100	0.010	0.100
C	0.033	0.264	0.010	0.100
Mean	0.078	0.167	0.027	0.100

Table 8: Shows the correlation coefficient between the bioavailable form of metals in soil and Lagos Spinach leaves from the three farm sites. From the results, Mn/Cr (0.953), Cd/Cr (0.987), Cd/Mn (0.985), Cu/Cr (0.883), Cu/Mn (0.775) and Cu/Cd (0.780) showed strong and positive correlations.

Table 8: Shows Correlation Coefficient between the Bioavailable form of Metals in the Soil and Lagos Spinach leaves from the three farm sites

	Cr	Mn	Cd	Cu
Cr	1***			
Mn	0.953**	1***		
Cd	0.987**	0.985**	1***	
Cu	0.883**	0.775**	0.780**	1***

*Correlation is significant at ($P<0.05$) level
*Correlation is not significant at ($P\leq0.05$) level

Table 9: shows the correlation coefficient between the bioavailable form of metals in the soil and African Egg-plant leaves from the three farm sites. From the results, Mn/Cr (0.964), Cd/Cr (0.860), Cd/Mn (0.971), Cu/Cr (0.870), Cu/Mn (0.675) and Cu/Cd (0.790) showed strong and positive correlations.

Table 9: Shows Correlation Coefficient between the Bioavailable form of Metals in the Soil and African Egg-plant leaves from the three farm sites

	Cr	Mn	Cd	Cu
Cr	1***			
Mn	0.964**	1***		

Cd	0.960**	0.971**	1***	
Cu	0.970**	0.976**	0.990**	1***

*Correlation is significant at ($P<0.05$) level
*Correlation is not significant at ($P\leq0.05$) level

IV. Discussions

Physicochemical parameters of Soil Samples

The mean temperature value (27.37 ± 0.60 ^{0}C) (Table 1) was less than 45 ^{0}C, thus within FAO/WHO[22] permissible limits for irrigation soil. Variation in temperature might be due to the time of sampling and season.pH affects the mobility of heavy metals in soil. It has been found that soil pH correlated with the availability and transport of nutrients to the plants[23]. As pH decreases, solubility of metal elements in the soil increases and they become more readily available to plants[24]. Heavy metal mobility and uptake decreases with increasing soil pH due to precipitation of hydroxides, carbonates or formation of insoluble organic complexes[24]. Soil mean pH value (5.62 ± 0.72) (Table 1) obtained from the three farms were lower than the 7.30 to 8.60 reported for soil pH from irrigated dumpsites in Port Harcourt[25] and (7.84 to 8.26) for soil pH from irrigated dumpsites in Kano[26]. The values obtained from the present study were below the 7.1 to 8.2 WHO/FAO[22] permissible limits. This suggests that low pH would favour the increased micro nutrient availability, mobility, redistribution and solubility in acidic medium[26]. Heavy metals are generally more mobile at pH < 7 than at pH $>$ 7.Soil organic matter (**S**OM) is important for the retention of metals in the soil thereby decreasing mobility, bioavailability and enhances the usefulness of soil for agricultural purposes[27]. Higher values recorded in farm C might be due to higher anthropogenic activities such as indiscriminate dumping of refuse and decompositions of dead plants. This was supported by[28]who reported that dumpsites had higher soil organic matter contents. The mean value (3.31 ± 0.39 %) recorded for SOM (Table 1) in the present study may be responsible for the increase in soil pH as was observed by[28]. This was lower than 5.8 to 7.8% reported for soils from irrigated dumpsites[29], and also 3.88 to 7.39 % reported in different farms in Port Harcourt[25]. Nevertheless, the values were within the 1.3 to 4.76% WHO/FAO[22] permissible limits for irrigation soil. When SOM is decomposed by micro-organisms, weak acids such as organic acids in humus are released to form humid acid such as oxalic; fumic, malic, maleic[25].

Heavy Metal Concentrations in Soil Samples

Chromium is a less mobile element at neutral pH[30]. Cr^{+6} adsorption decreases with increasing pH while Cr^{+3} adsorption increases with increasing pH[31]. Owing to low solubility and mobility of Cr, only small amount of Cr is bioavailable. Mn is an essential metal for both plants and animals but higher accumulation can have adverse effects on the central nervous system of humans[32]. Cadmium (Cd) has no essential biological function and is highly toxic to plants and animals[32]. Copper (Cu) is one of the most essential elements for plants and animals. Mean concentration of Cr (1.55±0.11 mg/kg) from the three farms (Table 2) was similar to the concentration (1.36 to 1.65 mg/kg) reported for agricultural soils in copper mining areas of Singhbhum shear zone in India[33], which was below the 100 mg/kg EU[34] and the 150 mg/kg WHO[17] recommended limits. Mean concentration of Mn (10.85±0.74 mg/kg) increased significantly ($P<0.05$) in the present study and was higher than the concentrations (6.53 mg/kg) reported by[35] from irrigated farms in Sindh Industrial Trading Estate, Karachi, Pakistan and the (2.17±0.11 mg/kg) reported by[36] for soils within abattoirs farm sites in Rivers State, however did not exceed the 500 mg/kg SEPA[37] and the 200 mg/kg EU[34] allowable limits recommended for agricultural soils.[38]investigated heavy metal concentrations of soils from irrigated farmland in Makera Area of Kaduna State and reported relatively higher concentrations of Cd (3.05 to 8.02 mg/kg) compared to the very low mean concentration (0.01±0.03 mg/kg) obtained in the present study (Table 2). Levels of Cd in this study were lower than the 0.2 mg/kg SEPA[37] and the 3 mg/kg EU[34]allowable limits for agricultural soil. Mean concentration of Cu (0.85±0.07 mg/kg) was lower than the levels (3.96±0.71 mg/kg) reported by[13] for soil from farms along Jabi Lake, FCT, Abuja. The reported concentration of Cu in the present study was far below the 100 mg/kg EU/WHO[34, 17] permissible limits for agricultural soils. Thus an indication that anthropogenic practices on the farm sites, did not pose any health hazard risk due to Cr, Mn, Cu and Cd in the soil. The mean heavy metal concentrations decreased in the order of Mn > Cr > Cu > Cd respectively. These metals varied significantly in different farms ($P<0.05$), however, their levels were significantly higher than the bioavailable form of metals. Higher concentrations of some metals at different sites may be attributed to contributions from irrigated water from Mpape and other adjoining rivers, and polluted river channels from mechanic workshops and block moulding industries, and also from effluents discharged from generators into the river.The mean metal levels from different farm sites varied significantly ($P<0.05$) level of significance.

Bioavailable form of Heavy Metals in Soil Samples

Higher metal concentration in soils is one of the important environmental concerns[39, 27.] Sufficient information is not obtained in the use of total concentration of metals as criteria to assess potential effects of soil contamination[40], therefore, total metal concentrations may not predict best metal bioavailability in soils. 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[40]. The bioavailable form of metals in soil samples (Table 3) from irrigated farms were lower compared to the total metal concentrations. The relatively high mean concentrations recorded for Mn (7.61 ± 0.79 mg/kg) may imply higher mobilization, availability of these metals for plant uptake while lower mean level of 0.65 ± 0.16 mg/kg for Cu suggested immobilization of heavy metals into soil by formation of complexes with soil particles[40]. A similar work was done by[41] on bioavailable form of metals in irrigated soil from Meerut City College, which relatively reported higher extractable levels of 37.32 mg/kg for Cr and 34.01 mg/kg for Cd. From the result, mean metal concentrationsfrom different farm sites varied significantly (<0.05) level of significance.

Concentrations of Heavy Metals in the Leaves of Vegetable Samples

Studies conducted by [42, 42] reported higher levels of Cr (0.51 to 38.18 mg/kg) and (1.72 to 2.80 mg/kg) in leafy vegetables on irrigated farmlands of Chandi Garh in India and Makera area of Kaduna State compared to the mean levels (0.17±0.08 to 0.29±0.16) recorded for the two vegetables in the present study (Table 4). The values recorded in the present study were within the 0.3 mg/kg EU[34] and the 1.2 - 2.3 mg/kg FAO/WHO[43 44] permissible limits, hence eating the vegetables from these farms may not constitute potential health hazards to the consumers.Manganese enhances and improves bone and teeth formation, but in excess can lead to cancer[89]. The mean concentrations of Mn in both vegetables ranged from (3.92±0.53 to 7.22±0.59 mg/kg) which were similar to the levels (4.12 ±0.60 to 7.32±1.56 mg/kg) reported for vegetable leaves on irrigated farm in mining areas of Banat in Romania [45]. Studies carried out by [46, 43=7] reported lower levels of Mn (0.16 to 1.67 mg/kg) and (0.23 to 3.45 mg/kg) on leafy vegetables from different irrigation farms in Lagos State and Biu Local Government Area of Borno State respectively. The values recorded in the present study were within the 5.0 mg/kg WHO/FAO[43] permissible limits; therefore, consumption of these vegetables from farm sites poses no deleterious effects to the users. [46, 47] reported levels of Cd (0.06 to 0.07 mg/kg) and (0.05 to 0.08 mg/kg) in vegetables from Lagos Streets and irrigated farms in Port Harcourt which were higher than the mean Cd levels (0.001±0.03 to 0.02±0.01 mg/kg) in the present study which were below the 0.2 mg/kg FAO/WHO[48, 44]and the 20 mg/kg EU[34] permissible limits, suggesting that no potential health risk is significant in the intake of these vegetable. Mean levels of Cu ranged from (0.67±0.28 to 0.80±0.26) which were within the levels (0.70±0.09 mg/kg) reported for vegetables from irrigation farmlands of Tanda Dam Kohat in Pakistan[49], but higher than (0.01 to 0.07 mg/kg) reported for vegetables from different farm lands in Lagos State[46]. The concentrations recorded in the present study were below the 20 - 40 mg/kg FAO/WHO[44] (2011) and EU[34] permissible limits suggesting safety in the consumption of vegetables despite the anthropogenic activities in the study area. In the two vegetables studied, Cr and Mn had the highest concentrations in farms B while Cu concentrated higher in farms A. Cd concentrations were consistently low in all the vegetables. In all the farm sites, heavy metal concentrations from the two vegetables decreased in the order of Mn>Cu>Cr>Cd. From the results, the mean metal concentrations from different farm sites were significantly different ($P< 0.05$) level of significance.

Transfer Factor of Heavy Metals from Soil to Vegetables

The metal transfer factor is a function of different factors such as the soil pH, soil organic matter, metals availability and soil particle size[50]. The metal transfer factor from soil to plants is a key module of human exposure to heavy metals through food chain. Transfer factor of metals is essential to investigate the human health risk index[50]. TF values close to or above 1 are considered to be high[19]. This may indicate contaminations from anthropogenic sources and also increased bioaccumulation of heavy metals in the vegetables[19]. The TF values for Mn (0.77-1.25) and (1.01) (Table 5) were relatively high and similar to the 0.52 to 0.87 reported for vegetables from irrigated areas in Makera, Kaduna State. The considerably high TF values showed by Mn and Cu in both vegetables with almost all values surpassing 0.5 showed that vegetables were largely contaminated with these metals[19, 51]. TF for Cr was lower than the values 0.005 to 0.027 reported for vegetables grown on farmlands in Yargalma of Northern Nigeria[52]. The low TF recorded in Cd may be due to its strong adsorption unto the organic matter which renders it less bioavailable to plants[53]. However, high TF implies low retention of metals in soil while lower TF implies that the metals binds more to the soil and becomes unavailable for plants[51, 52]. Transfer factors of metals in both vegetables were in the decreasing order of Cu>Mn>Cr>Cd. The variation seen, however, is a function of metal availability, different vegetables exhibiting different absorption and higher transfer capacity exhibited by some vegetable species than others[451, 52].

Daily Intake of Metals (DIM) in Vegetables

Daily vegetable consumption was obtained through a formal survey conducted in the study area. An interview of about 20 persons between the ages 30-45 years age group was conducted at each irrigation site and an average mean body weight of 57.90 kg was recorded. The results (Table 6) revealed higher mean values of daily intake for Mn (0.043) and (0.023) in Lagos spinach, and African egg-plant respectively. However, lower DIM values (0.001 – 0.002, 0.002 – 0.003 and 0.004 – 0.005) were observed for Cr, Cd and Cu in both vegetables respectively. These values were lower than the daily intake values of 0.064, 1.00 and 10.00 for Cd, Mn, and Cu recorded for leafy vegetables (Amaranthus) from irrigated farm lands[10, 54]. DIM recorded in this study were far below the 0.060, 3.00 and 0.05 to 0.2 for Cd, Cu and Cr WHO/FAO[22] permissible limits respectively, except Mn that was higher than the 0.014 mg/kg allowable limits. The DIM of each metal through consumption of vegetables decreased in the order; of Mn>Cu>Cd>Cr in Lagos Spinach, and Mn>Cu>Cr>Cd in African egg-plant. Therefore, it may be concluded that the local population will accumulate higher levels of Mn.

Health Risk Index (HRI) of Heavy Metals in the Leaves of Vegetables (Lagos Spinach and African Egg-plant)

If the health risk index of metals are equal to or greater than 1, then population is considered to be unsafe and will experience potential health hazards through consumption of vegetables, and when is less than 1, then exposure to any significant potential health risks to the population will not be of any great concern from the intake of vegetables[19, 38]. HRI for metals in all the farms and in both vegetables (Table 7) were < 1. However, continuous accumulation of these metals over time may have a negative impact on the environment. This study indicates that those that consume these vegetables from farmlands might not have been exposed to any significant potential health risks. HRI in Lagos Spinach and African egg- plant varied in the order of Mn>Cu>Cr>Cd respectively. There are other sources of metals exposures, such as consumption of other food stuffs and dust inhalation.

Correlation Coefficient between the Bioavailable form of Metals in the Soil and Vegetable Leaves (Lagos Spinach and African Egg-plant)from the three farm sites

The correlation analysis (Tables 8 and 9) showed that the metals in these farms have varying correlations. All the metals in the farms were strong and positively correlated which is an indication that they have common source of pollution[55].

Correlation rating: > 0.91= very strong, 0.90-0.81= strong, 0.81-0.5= moderate, <0.5= weak (Lacatusu, 2000)

V. Conclusion

Physicochemical characteristics of soil and the current levels of metals in soil and vegetablesvaried according to farm sites. These variations according to sites have no specific trend. Soil pH, temperature and OM contents were higherin Farms A, B and C respectively but were within the WHO/FAO permissible limits. Levels of Mn and Cu in soil samples were higher in A and B respectively while Cr and Cd levels were below detectable limits in all farm sites and these values were below the EU/WHO and SEPA permissible limits for agricultural soils. In vegetable samples, Lagos Spinach recorded higher levels of Cu, Mn and Cr in farms A, B and C respectively and in African Egg-plant, the levels of Cr, Mn and Cu were higher in Farms B and C respectively while Cd levels was similar in both vegetables. These values obtained were below the FAO/WHO and EU permissible limits for vegetable samples. Metal transfer factor values (TF) for Mn, Cr and Cu were higher in Farms B and C in Lagos Spinach and Cr, Mn and Cu were higher in farms A,B and C in African Egg-plant respectively while Cd value was similar in all the farm sites. However, Mn and Cu surpasses 0.5 showing that vegetables were largely contaminated by these metals from anthropogenic sources, while Cr and Cd were below 0.5 showing that the vegetables were not contaminated by these metals. DIM recorded moderate value for Mn in both vegetables indicating that people who consumed these vegetables may accumulate more of the Mn.The DIM values in both vegetables were below the WHO/FAO permissible limits except for Mn that was higher than the limits. Health Risk Index (HRI) for metals in all the farms and in both vegetables were less than 1, indicating that no significant potential health risk associated with the consumption of these vegetables.The mean metal levels from different farm sites varied significantly (<0.05) level of significance.

Recommendation

Generally, the physicochemical parameters of soil and heavy metal concentrations of soil and vegetables have significant differences between them on different farm sites which may arise from different factors such as rain fall and changes in anthropogenic activities, e.g agricultural practices and sewage effluence, urban and municipal wastes and also from different domestic activities which led to loading the river used in irrigation of vegetables with different pollutants during the period of sampling and analysis, more so, if discharges are not minimised by using proper waste disposal of the city dwellers, then the water is thus not potable for domestic and irrigation purposes without some forms of treatment. Therefore, it is recommended that effective and continuous monitoring management of Mpape River is required in order to minimise pollution in order to ensure proper wellbeing of the populace.

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References

[1]. WHO/FAO Guidelines for irrigation water, Geneva. 2008.

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

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

[4]. SEPA, The limits of Pollutants in Food. State environmental Protection Administration, china. 2005; 2762.

[5]. Tukura BW, Gimba CE, Ndukwe IG, Kim BC. Physicochemical characteristics of water and sediment in Mada river, Nasarawa State, Nigeria: *Journal of Environmental and Bioenergy*. 2012; 1(3), 170 – 178.

[6]. Iniobong EW, Okon B, Edidiong EU. Response of Telfairia Occidentalis (Hook) to Arbuscular Mycorrhiza fungi and Gliri cidia sepium leaves manure in spent engine oil contaminated soil. *World agric. Sci.* 2005;8, 20-25.

[7]. Guveni DE, & Akinci G. Comparison of acid digestion techniques to determine heavy metals in sediments and soil sample. Gazi University. *Journal of Sciences.* 2011; 24 (1), 29-34.

[8]. Cui YJ, Zhu YG, Zhai RH, Chem, DY, Huang YZ, Qui Y, Liang JZ. Transfer of Metals from Soil to vegetables in an area near a smelter in Nanming, China. 2004; 30 (6), 785-91.

[9]. Cui YJ, Zhu, YG, Zhai R, Huang Y, Qui Y, Liang J. Exposure to Metal Mixtures and Human Health Impacts in a Contaminated Area in Nanning, China. *Environ. Int.* 2005; 31, 784-790.

[10]. Wang X, Sato T, Xing B, Tao S. Health Risks of Heavy Metals to the general public in Tianjin, China via consumption of vegetables and Fish. *Sci. Total Environ*. 2005; *350, (1-3), 28-37.*

[11]. Van Ginneken L, Meers E, Guisson R. Phytoremediation for Heavy Metals Contaminated Soils Combined with Bioenergy Production. *Journal of Environmental Engineering and Land scape Management.* 2007; 15 (4), 227-236..

[12]. Tukura BW, Etonihu AC, Ambo IA, Iboro IF. Accumulation of Heavy Metals in Vegetables grown on farmlands irrigated with treated sewage effluent. *Journal of FUW in Science and Technology.* 2016; *1 (1), 168 – 172.*

[13]. Umar MA, Ebong MC. 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* 2013;2 (1) :5-9.

[14]. Awode UA, Uzairu A, Balarabe ML, Harrison GF, Okunola OJ. Assessment of Peppers and Soils for some heavy metals from irrigated farmlands on the Bank of River Challawa, Northern Nigeria. *Pakistan Journal of Nutrition.* 2008;7 (2): 244-248.

[15]. Ladipo MK, Doherty VF. Heavy Metals levels in vegetables from selected Markets in Lagos, Nigeria. *Afri. J. Food Sci. Technol.* 2011; 2 (1):18-21.

[16]. AOAC, Association of Oficial Analytical Chemist 16th edition, Washington DC. 2000: 42, 13-26.

[17]. Amacher MC, O'Neill KP, Dresbachand R, Palmer C. Forest Inventory and Analysis Manual of Soil Analysis Method. Soils Lab. Manual 2003.

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

[19]. USEPA. Environmental Protection Agency. Region 9, Preliminary Remediation Goals. , 2002.

[20]. USEPA IRIS. United States Environmental Protection Agency Integrated Risk Information System. 2006.

[21]. Gray CW, Mclaren RG, Roberts AH, Condron LM. Sorption and desorption of Cadmium from some New Zealand Soils. Effects of pH and contact time. *Aust. J. Soil Res.*1998; 36: 199-216.

[22]. Wu Q, Leung JY, Geng X, Chen S, Huang X, Li H, Huang Z, Zhu L, Chen J, Lu Y. 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.* 2015; 506-507, 217-225.

[23]. Obasi NA, Akubugwo EI, Ugbogu OC, Glory O. Assessment of Physicochemical properties and Heavy Metals bioavailability in dumpsites along Enugu- Port Harcourt Express ways, South-East, Nigeria. *Asian J. Appl. Sci.* 2012; 5(6): 342-356.

[24]. Chukwulobe, E.E., & Saeed, M.D. Assessment of some Physicochemical properties and levels of Pb, Cu and Zn in soils of selected dumpsites in Kano Metropolis, North-West, Nigeria. *Int. Jour. Biol. Chem. Sci.* 2014;8 (2): 717-726.

[25]. Wu Y, You-ning XU, Zhang J, Hu SI. Evaluation of Ecological risk and primary empirical Research on Heavy Metals in Polluted Soil over Xiaoqinling gold Mining Region, Shaaxi, China. Trans. *Nonferrous Met. Soc. China.* 2010; 20: 688-694.

[26]. Oyedele D, Gasu MB, Awotoye OO. Changes in soil properties and plant uptake of heavy metals on selected municipal solid waste dump sites in Ile-Ife, Nigeria. *Journal of Environ. Sci. Technol.* 2008; 3 (5): 107-115

[27]. Akpoveta OV, Osakwe SA, Okoh BE, Otuya BO. Physicochemical Characteristics and Levels of Some Heavy Metals in Soils around Metals Scrap Dumps in some parts of Delta state, Nigeria. *J. Applied Sci. Environ. Manag.* 2010. 14: 57-60.

[28]. Qadir A, Malik RN, Husain, SZ. Spatio-Temporal variations in water quality of Nullah Aik-tributary of the River Chenab, Pakistan. *Environ. Monit. Assess.* 2008;140: 43-59.

[29]. Gowd SS, Reddy MR, Govil PK. Assessment of Heavy Metal Contamination in Soils at Jalmau (Kanpur) and Unao Industrial Areas of the Ganga Plain Uttar Pradesh, India. *J. Hazard Matter.* 2010; 174: 113-121.

[30]. Crossgrove JS, Yokee RA. Management Distribution across the blood –brain barrier 111. The Divalent Metal Transporter-1 is not the major mechanism mediating brain management uptake. *Neurotoxicity*. 2004; 25 (3): 451-460.

[31]. Soma G, Abhay KS, Mukesh KM. Metal Contamination of Agricultural Soils in the Copper Mining Areas of Singhbhum Shear Zone in India. *J. Earth Syst. Sci.* 20117;126:49.

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

[33]. Edori OS, Kpee F. Index Models assessment of Heavy Metal Pollution in Soils within selected Abattoirs in Port Harcourt, Rivers state, Nigeria. *J.Sci. Res.* 2016;7: 9-15.

[34]. Mohammed SA, Folorunsho JO. Heavy Metal Concentration in Soil and Amaranthus retroflexus grown in irrigated Farmlands in Markera area, Kaduna, Nigeria. *Journal of Geography and regional Planning.* 2015; 8 (98): 210-217.

[35]. Smith CJ, Hopmans P, Cook FJ. Accumulation of Cr, Pb, Cu, Ni, Zn and Cd in soil following irrigation with treated urban effluent in Australia. *Envir. Poll.* 1995;94 (3): 317-323.

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

[37]. Deepak S, Shukla AK. Analysis of Heavy Metals in Soil and Vegetables irrigated with Wastewater in Meerut City Region.*Int. J. Adv. Life Sci*. 2013; 6: 287-292.

[38]. Neclam S, Madhuri R, Samriddhi C. Risk assessment of Heavy Metal distribution and Contamination of vegetables irrigated with storm water in the vicinity of Chandigarh, India. *Jour. Natur. Sci. Res.* 2014; 4: 16.

[39]. FAO/ WHO. Joint Experts Committee on Food Additives, Summary and Conclusion. In proceedings of the 53rd Meeting of Joint FAO/WHO. Expert Committee on Food Additives Rome, Italy. 1999.

[40]. FAO/WHO. Joint FAO/WHO Food Standard Programme Codex Committee on contaminants in foods, Fifth session. 2011; 64-89.

[41]. Monica H, Liana MA, Despina MB, Loan G, Losif G. Heavy Metals Health risk assessment for Population via Consumption of vegetables grown in old mining area in Banat, Romania. *Chemistry central Journal.* 2011;5:54.

[42]. Ogukunle AT, Bello OS, Ojofeitimi OS. Determination of Heavy Metals contamination of street vended fruits and vegetables in Lagos State, Nigeria. *International Food Research Journal.* 2014; 21 (6),:2115-2120.

[43]. Akpan G.E, Etim IU, Emmanuel EE. Soil quality studies for some Physicochemical parameters and concentrations of toxic metals in coastal areas in Akwa Ibom State. *International Journal of environmental and Bioenergy.* 2016;11 (92): 122-139.

[44]. Oladele AT, Fadare OO. Heavy Metals and Proximate Compositions of Forest Leafy vegetables in oil Producing Areas of Nigeria. *Ethiopian Jour. Environ. Studiesand Manag.* 2015; 8 (4): 451-463.

[45]. FAO/WHO. Joint FAO/WHO, Food Standard Programme. Codex Alimentarius Commission 13th Session. Report of the Thirty Eight Session of the Codex Committee on Food Hygiene, Houston, United States of America. 2007.

[46]. Ruqia N, Muslim MM, Hameed UR, Naveed UR, Surrya S, Nosheen A, Muhammad S, Mohib U, Muhammad R, Zeenat S. Accumulation of Heavy Metals (Cu, Ni, Cd, Cr, Pb, Zn and Fe) in the soils, water and plants and analysis of Physicochemical parameters of soil and water collected from Tanda Dam, Kohat, Pakistan. *Jour. Pharm. Sci. and Res.* 2015; *7 (93): 89-97.*

[47]. Doherty VF, Sogbanmu TO, Kanife UC, Wright O. Heavy Metals in vegetables collected from selected farm and Market sites in Lagos, Nigeria. Global Advanced Research. *Journal of Environmental Science and Toxicology.* 2012; 1 (6): 137-142.

[48]. Kloke A. Heavy Metals Contamination of Soils and Waters in and aroud the Imcheon Au- Ag. Mione. *Korea Appl. Jour. Geochem. Sci.* 1984;1 (6): 1369-1375.

[49]. Tsafe AI, Hassan LG, Sahabi DM, Alhassan Y, Bala BM. Evaluation of Heavy, Metal Uptake and Risk Assessement of vegetables grown in Yargalma of Northern, Nigeria. *J.Basic Appl. Sci. Res.* 2012; 2(7): 6708-6714.

[50]. Uwah EI. Concentrations of some Heavy Metal Pollutants in Soils and Carrot Obtained in Maiduguri, Nigeria. *Continental Jour. Appl. Sci*. 2009; 4: 76-88.

[51]. Chary NS, Kamala CT, Raj DSA. Assessing risk of heavy metals from consuming food grown on sewage irrigated soils and food chain transfer. *Ecotoxicol. Environ. Safety.* 2008; 69: 513-524.

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