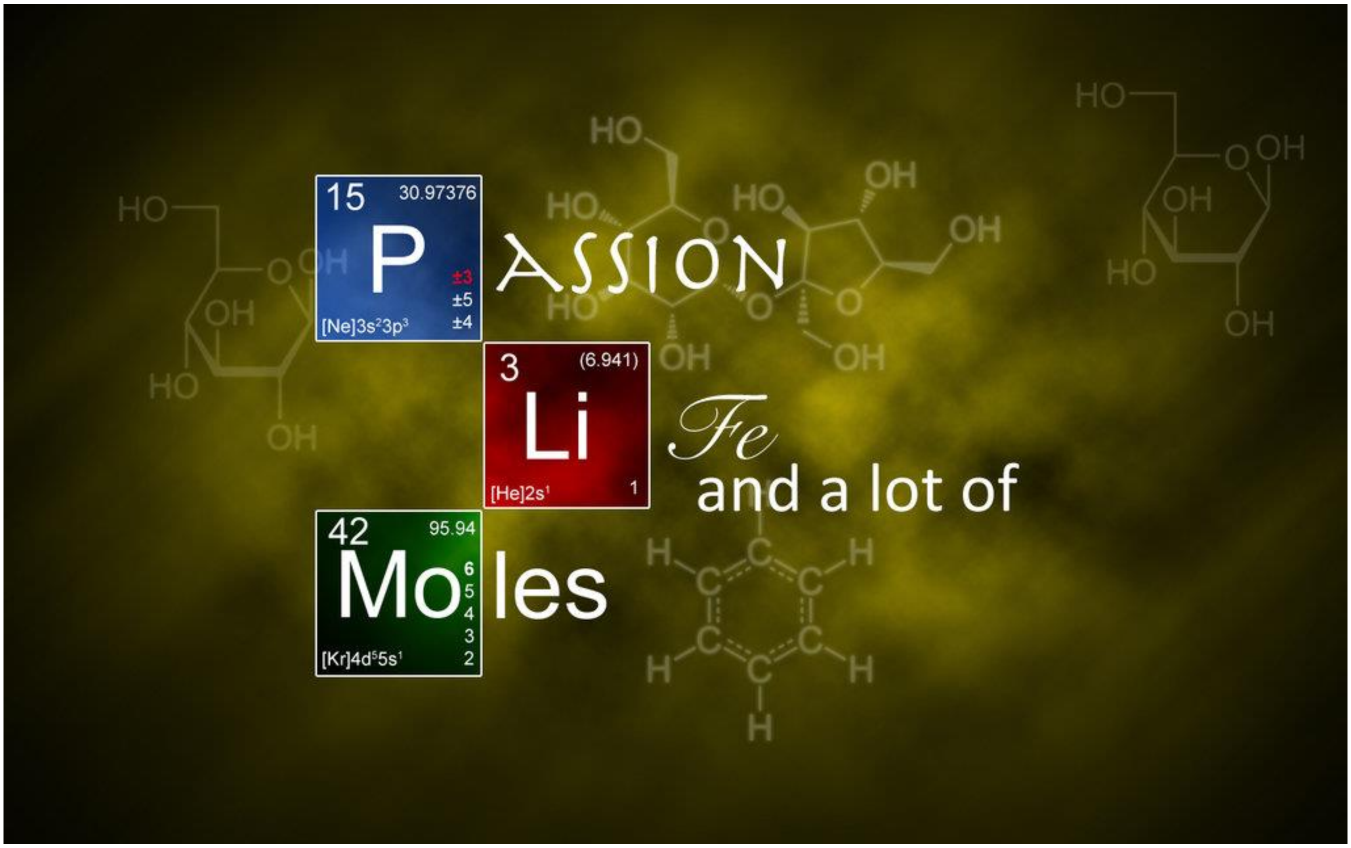

Volume 2 Issue.1:2016

INTERNATIONAL JOURNAL OF CHEMISTRY AND AQUATIC SCIENCES (IJCA)

WWW.CHEMISTRYJOURNAL.KYPUBLICATIONS.COM

ISSN:2455-040X

www.kypublications.com

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SURVEY OF HEAVY METAL CONTAMINATION OF SOIL FROM OTUKPO URBAN AGRICULTURAL FARM LAND WITHIN OTUKPO LOCAL GOVERNMENT AREA OF BENUE STATE

RESEARCH ARTICLE

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ABSTRACT

The determination of Cd, Co, Cu, Mn, Ni, Pb and Zn in soils from urban farmland in Otukpo local government area of Benue state was carried out with Flame Atomic Absorption spectrophotometric technique. The method developed by the United State Environmental Protection Agency for (total sobbed) heavy metals in soils, sediments and sludges was used in the preparation of the soil samples for the determination of total metal content in this study. Generally, the overall results (mg/Kg) ranged from 7.250-9.850, 2.200-5.550, 42.560-95.540, 86.980-125.550, 245.650-323.540, 39.650-55.650, 280.890-389.760 and 133.350-187.780 for Cd, Co, Cr, Cu, Mn, Ni, Pb and Zn respectively. The concentration of Pb was the highest. The degree of contamination by each metal was estimated by the enrichment factors. The enrichment factors obtained for Cd, Co, Cu, Mn, Ni, Pb and Zn in soil samples were 8.699, 5.867, 8.674, 6.170, 2.272, 4.888, 67.370 and 13.946 respectively. The inter-element correlation was found among metals in the soils studied using Pearson's correlation co-efficient. There were positive correlations among the metals determined such as Pb, Zn ,Cd and Cr. Heavy metals such as Pb, Zn, Cd, Cr, Cu, and Co shows high degree of contamination, while Mn and Ni shows low degree of contamination in the study sites.

Keywords: Soils, Heavy Metals, Contamination, Urban farm land.

INTRODUCTION

Soil as a natural resources, is more valuable than is general thought, yet it remains very basic to human existence and the foundation of our food chain [1]. Factors such as rapid increase in human population, dearth in arable land, increase in urbanization, and the intensive cultivation of the limited arable land have led to decline in productivity. Again, vast areas of land in the tropics that were once fertile have now been rendered unproductive due to erosion–induced soil degradation, loss of soil organic matter and decrease CEC and increase metal toxicity [2]. Great civilizations have almost invariably had good soils as one of their chief natural resources and these civilizations have remained great only so long as they properly cared for the soils. Shifting of settlements and cultivation in most cases always accompanied declined in soil fertility after many years of cultivation [3]. Over some years ago agriculture has moved to urban and peril–urban area in attempt to increase food production.

There has been increasing recognition amongst the scientist and developing countries of the rising importance of food production in city area, particularly in those parts of the world that have been characterized by economic collapse [4]. Urban and peri–urban agriculture offer wide–range benefits. It, can contribute substantial amounts to the proportion of food consumed in the city; [5], for example, has estimated that 15–20% of the world's supply of vegetables and meat is produced in urban areas, and FAO (1999) estimates that 800 million urban dwellers are actively engaged in urban agricultural activities, while 200 million providing food for markets.

Traditional farming system before, the advert of chemical fertilizer employed shifting cultivation, rotational fallowing and ploughing back crop residues. This is because farmers associated soil fertility with organic matter [6]. However, with a growing population and the expansion of markets, fallow periods have become shorter and cultivation periods longer. This situation is worsened by incessant uncontrolled bush fires, poor cropping systems and unfavourable weather [7].

Many of the farmers within and around Otukpo believe that the soils in the area are declining in productivity as a result of annual application of mineral fertilizers. It has been noted that some of the mineral fertilizers are increasingly being applied have acidifying effects on the soils. Therefore organic fertilizers are increasingly being used to provide a useful supplement to inorganic ones [8]. Presently, there are some areas where farmers apply urban waste in combination with mineral fertilizers, and sometimes with poultry droppings and or cow dung. Urban waste has great potential because it can be exceedingly nutrient rich and so can be used as fertilizing material while at the same time its utilization in this way can also assist in alleviating the waste disposal problems in some of our towns and cities [6, 8]. But unfortunately, most municipal waste sludge can be laden with microbiological agents and more seriously with heavy metals. There is a growing concern about the possibility of soil contamination resulting in uptake by plants and the introduction of the elements in vital food chains affecting food safety. Thus knowledge of build up of metals in the soils of cultivated areas is important to recognize potential ecological problems [8].

Although there have been considerable number of studies on the concentrations of heavy metals in soils and plants, the vast majority have been carried out in developed countries with long histories of industrialization and extensive use of chemical fertilizers. Very few were carried out in developing countries such as Nigeria and data on pollutant metal concentrations and distribution in the most of urban farms, especially on edible food crops like vegetables are extremely scarce. Therefore, this study was initiated to assess the level of contamination of crops especially vegetables grown in urban area by some heavy metals within Otukpo urban area in Otukpo local government of Benue, since there have been no studies about the extent of contamination of the soil and food crops grown in the area by trace metal pollutants.

Study Area

Otukpo Local Government Area (LGA) is one of the oldest LGA in Benue State, but also the traditional headquarters of Idoma people where its paramount Chief the Och'Idoma has his palace. The LGA came into existence in 1923, with its headquarters at Otukpo. In addition to metropolitan Otukpo town other prominent places in the local government area include Ogobia, Upu, Otukpoicho, Otobi, Adoka, Oyagede and Akpa-Igede. It is located on $7^{0}13^{1}$N & $8^{0}9^{1}$E, and $7^{0}21^{1}$N & $8^{0}15^{1}$E. It is equally is bounded in the North by Apa and Ohimini local government areas in the Southeast, Ado local government in the South and Olamaboro local government area in Kogi state in the West. It has an estimated landmass of about 390 sq. km, and with an estimated population of 266,411 (2006, Census) [9]. LGA has a tropical sub-humid climate, with two distinct seasons, namely a wet and dry season. The wet season this lasts for seven months starts from April and ends in October. The annual rainfall total ranges from 1,200mm to 1,500mm. Temperatures are generally very high during the day, particularly in the months of March and April. Along the river valleys, these high temperatures plus high relative humidity produce inclement/debilitating weather conditions.

Materials and Methods

Collection of sample

All soil samples (0 to 15 cm) used in this study was collected from different farm locations of Otukpo area and the crops and vegetables samples were collected from the particular farm land in the study area).

Preparation of sample

Sampling spots of about 20-30 m apart from each other were mapped out for soil sample collection within each sampling sites. Samples were collected using clean stainless steel trowel from about 0-15 cm depth. A soil sample for each control sites were also collected from where farming, mining and industrial activities were absent. The collected soil sub-samples were thoroughly mixed, pooled together to make a composite of each soil sample. The collected soil samples were air-dried for some weeks to remove excess moisture. Large soil clods were also crushed to facilitate the drying. The dried soil samples were crushed in a porcelain mortar with a pestle. The crushed soil sample were sieved through a 2.mm sieve made of stainless steel, for analyzing soil pH and particle size, some portion of the individual sieved soil samples were further pulverized to a fine powder and passed through a 0.5 mm sieve for analyzing organic carbon and total metal content. The pH of the soil samples was determined with pH meter Hanna (Model H1991000) according to standard analytical methods. Organic matter was determined using the chromic acid oxidation method [10]. Particle size distribution was determined by the hydrometer method as described by Bauyocos [11]. The exchangeable cation was determined by the method described by Hendershot [12].

The method developed by the United States Environmental Protection Agency for (total sobbed) heavy metals in soil, sediments and sludged (USEPA SW-846, method 3050) [13], was used in the preparation of the soil samples for the determination of total metal content in this study. One gram (1g) of the soil sample was weighed into a beaker for acid digestion. Analar grade nitric acid, hydrogen peroxide (about 30%) and concentrated hydrochloric acid were used for the digestion. The digest was filtered through whatman filter paper. Each filtrate was collected in 100 ml volumetric flask and deionized water was used to rinse the filter paper into volumetric flask. Each filterate was later made up to 100 ml with deionized water. Standards were prepared with serial dilution techniques within the range of each metal determined. The standards used were Analar grade; the instrument was first calibrated with stock solutions of the prepared standards before analyzed using Flame Atomic Absorption Spectrophotometer. After every five samples analyzed using FAAS, the first sample was repeated for quality check. Only when the result was within 10% of earlier readings did the analysis proceed further. The data obtained in the study were analyzed using Pearson correlation analysis. The enrichment factors for soils were calculated according to the following equation

EFc = (Cx/CFe)soil/(Cx/CFe)Earth's crust

Where (Cx/CFe) soil is the ratio of concentration of the element being determined (Cx) to that of Fe (CFe) in the soil sample and (Cx/CFe) earth's crust is the ratio in the reference Earth's crust [14, 15, 16]. Enrichment factors were calculated for each sample relative to the abundance of the elements in the Earth's crust [17], choosing Fe the reference element due to the crust-dominated element. The iron content of soils does not change owing to its high levels in the Earth's crust, example; 0.5-10%, unless there is a large point source around a specific environment. An enrichment factor of unity would indicate that the relative concentration of a given metal is identical to that which is present in unpolluted soil.

For heavy metal extractions of crops and vegetables, 1 g of dried fruits and vegetables samples were weighed into conical flask using the US EPA 3050 method. The 10 cm^3 of HNO_3 was added and mixture was heated for 15 min on a hot plate at 100 °C. The digest was allowed to cool and another 5 cm^3 of HNO_3 was added and heating continued for 30 min at 100 °C. The volume of the digest was reduced by boiling and allowed to cool. The 5 cm^3 of de-ionized water was added when effervescence subsided 10 cm^3 of H_2O_2 (60%) was added and heating continued for another 15 min. The final digest was allowed to cool and filtered. The final volume of digest was made up to 50 cm^3 with de-ionized distilled water and was analyzed for the required heavy metal by flame atomic absorption spectrophotometer. Standards were prepared with serial dilution techniques within the range of each metal determined. The standards used were analar grade. The instrument was first calibrated with stock solutions of the prepared standards before analyzed using flame atomic absorption spectrophotometer. After every five samples analyzed using AAS, the first sample was repeated for quality cheek. Only when the result was within 10% of earlier readings did the analysis proceed further. The data obtained in the study were analyzed using Pearson correlation analysis.

RESULTS AND DISCUSSION

Soil Characteristics

The result of soil characteristics from Otukpo urban farm land are presented in Table 1 and the summary of the results are presented in Table 2. The pH values ranged from 6.600-7.500, for Otukpo urban soil samples. All the soils studied from the urban farm either weakly acid or neutral. The soil organic carbon concentrations ranged from 2.860-3.980. The soils from the study areas were generally moderate to high in organic carbon contents. Most of the soil samples studied from Otukpo urban soil samples has organic carbon values of more than 2.00%. The clay contents ranged from 10.200-16.600%. The cation exchange capacity ranged from 13.800-19.800 meq/100g, for Otukpo urban soil samples.

The results of heavy metal concentrations in the Otukpo urban soil samples are presented in Table 3, and the summary of the results are presented in Table 4. The soil samples from Otukpo urban farm land revealed a clear elevated level of these heavy metals (Cd, Co, Cr, Cu, Mn, Ni, Pb and Zn). The mean concentrations of heavy metals obtained from the control sites were much lower than those obtained from the soils of the urban farm land under consideration. This reflects a general and diffuse contamination of soils of this urban farm land by heavy metals investigated. Out of the heavy metals considered, lead shows the highest pollution in the sites studied. The overall results ranged from 7.250-9.850, 2.200-5.550, 42.560-95.540, 86.980-125.550, 245.650-323.540, 39.650-55.650, 280.890-389.760 and 133.350-187.780 mg/Kg for Cd, Co, Cr, Cu, Mn, Ni, Pb and Zn respectively.

Table 1: Soil properties of Urban Agricultural farmland Otukpo

Sites	PH	O.C	Sand%	Silt%	Clay%	C.E.C meq/100g
1	6.900	3.970	70.100	16.700	13.200	15.500
2	7.300	3.080	72.100	14.700	14.200	14.700
3	7.400	3.880	72.100	15.700	12.200	16.800
4	6.700	3.870	72.100	17.700	10.200	17.200
5	7.200	3.020	73.100	15.700	11.200	15.800
6	6.800	2.950	71.700	14.900	13.400	13.800
7	7.000	3.910	72.700	14.700	12.600	15.090
8	7.200	2.890	73.700	12.700	13.600	14.200
9	6.600	3.050	70.900	13.500	15.600	15.500
10	7.400	3.110	70.700	14.700	14.600	16.200
11	6.900	3.030	72.700	13.900	13.400	16.080
12	7.100	3.210	70.700	15.900	13.400	16.600
13	7.300	3.980	72.700	10.700	16.600	18.200
14	7.200	3.050	70.700	14.700	14.600	17.500
15	7.500	2.860	72.700	12.700	13.600	19.800
16	7.200	2.890	72.100	15.700	12.200	13.900
17	6.600	3.050	73.700	12.700	13.600	13.800
18	7.400	3.110	70.900	13.500	15.600	15.600
19	6.900	3.030	70.700	14.700	14.600	14.300
20	7.100	3.210	72.700	13.900	13.400	15.600
Mean	7.085	3.258	71.940	14.470	13.590	15.809
STD	0.274	0.405	1.083	1.599	1.503	1.571
MIN	6.600	2.860	70.100	10.700	10.200	13.800
MAX	7.500	3.980	73.700	17.700	16.600	19.800

Table 2: The summary Results of Soil Properties of the Study Area (Otukpo Urban farm.)

	PH	O.C	Sand (%)	Silt (%)	Clay(%)	C.E.C(meq/100)
Mean	7.085	3.258	71.940	14.470	13.590	15.809
Std	0.274	0.405	1.083	1.599	1.503	1.571
Range	6.600	2.860	70.100	10.700	10.200	13.800
	7.500	3.980	73.700	17.700	16.600	19.800
Control						
Mean	6.833	1.643	73.333	11.667	16.000	15.167
Std	0.351	0.153	2.466	0.289	0.866	2.082
Range	6.500	1.550	70.500	11.500	15.000	13.500
	7.200	1.820	75.000	12.000	16.500	17.500

Table 3: Total Metal Contents (mg/Kg) of Soil from Otukpo Urban Farm Land

Metals	Cd	Co	Cr	Cu	Mn	Ni	Pb	Zn
1	7.890	2.200	55.480	112.340	320.870	50.540	350.450	152.890
2	9.750	2.850	78.580	103.550	250.980	49.780	389.760	165.780
3	8.250	2.550	95.540	124.670	275.250	39.650	354.880	134.350
4	8.520	2.540	45.670	99.560	290.550	45.670	312.230	155.680
5	7.540	3.270	67.970	115.860	267.560	55.650	355.450	166.560
6	9.720	5.550	86.750	86.980	312.550	48.880	311.540	145.550
7	8.510	4.540	89.650	95.890	255.060	54.550	324.650	177.560
8	7.550	3.350	55.650	125.550	310.550	48.880	287.560	187.780
9	7.250	5.550	42.560	97.540	260.650	53.440	295.880	167.780
10	8.250	4.650	77.870	110.780	312.770	54.550	315.450	155.650
11	7.750	4.330	67.550	113.880	278.570	51.550	289.470	166.890
12	9.770	5.120	82.880	120.980	321.550	43.660	321.670	145.550
13	7.740	3.560	70.530	98.550	255.670	45.530	288.670	134.790
14	8.150	5.510	54.550	105.650	323.540	53.250	314.250	133.350
15	9.850	3.330	45.670	111.550	245.650	43.560	280.890	178.560
16	8.510	4.540	89.650	95.890	255.060	54.550	324.650	177.560
17	7.550	3.350	55.650	125.550	310.550	48.880	287.560	187.780
18	7.250	5.550	42.560	97.540	260.650	53.440	295.880	167.780
19	8.250	4.650	77.870	110.780	312.770	54.550	315.450	155.650
20	7.750	4.330	67.550	113.880	278.570	51.550	289.470	166.890
Mean	8.290	4.066	67.509	108.349	284.969	50.106	315.291	161.219
STD	0.854	1.103	17.032	11.186	27.883	4.502	28.763	16.695
MIN	7.250	2.200	42.560	86.980	245.650	39.650	280.890	133.350
MAX	9.850	5.550	95.540	125.550	323.540	55.650	389.760	187.780

Table 4: Summary results of total metal contents (mg/Kg) in the Soils of the Study Area (Otukpo Urban Farm Land)

metals	Cd	Co	Cr	Cu	Mn	Ni	Pb	Zn
Mean	8.290	4.066	67.509	108.349	284.989	50.106	315.291	161.219
S.D	0.854	1.103	17.032	11.186	27.883	4.502	28.763	16.695
Range	7.250	2.200	42.560	86.980	245.650	39.650	280.890	133.350
	9.850	5.550	95.540	125.550	323.540	55.650	389.760	187.780
Control								
Mean	0.953	0.693	7.783	17.560	125.400	10.250	4.680	11.560
Std	0.085	0.045	0.516	0.894	4.472	0.894	0.511	0.894
Range	0.860	0.640	7.450	16.560	120.400	9.250	4.350	10.560
	1.050	0.740	8.450	18.560	130.400	11.250	5.340	12.560
E.F	8.699	5.867	8.674	6.170	2.272	4.888	67.370	13.946

Generally, in the area studied (Otukpo urban farmland), the concentrations of the heavy metals were extremely high especially Pb, Zn, Cd, Cr, Cu and Co. This is an indication that these heavy metals are the primary contaminant in the soil of the farm land which was also reflected in the low level of these heavy metals obtained from the control sites in comparison with those obtained from the study sites. Also, the degrees of heavy metals pollution in urban farm soils which were determined by its enrichment factors were also high.

The trace heavy metal concentrations of the soil samples show that the soils contain sufficient amounts of Pb, Zn, Cd , Cr, Cu and Co (all results in mg/Kg) (Table 4). These trace elements are introduced into soils from various sources, including atmospheric deposition of metal/metalloid-bearing particles, application of sewage sludge, phosphate fertiliser, pig slurry and pesticides, where they exist in several chemical forms.

The mean concentration of Pb, Zn, Cd, Cr, Cu and Co in the soil samples are 315.291±28.763, 161.219±16.695, 8.290±0.854, 67.509±17.032, 108.349±11.186 and 4.066±1.103 mg/Kg respectively. Pb and Zn in soils could be derived from organic and inorganic fertilizers, industrial sources as well as from abrasion from tyres of motor vehicles and other activities [18, 19]. The concentrations of Pb and Zn were found be high in the all samples from urban farm land while the concentrations of Pb and Zn were found to be low in the soils from control area. The Pb and Zn content of Otukpo urban agricultural soils have been found to enrich by a factor of 67.370 and 13.946. This could be attributed to the application of organic and inorganic manures and chemical additive on the farmland [20, 21].The high levels of Zn in the top soils of the study area could be fertilizer applications. Cadmium, Chromium and Copper also show a similar distribution pattern in the soils studied with relatively higher concentrations in the site i.e. 7.250-9.850, 42.560-95.540 and 86.980-125.550 mg/Kg as opposed to soils sampled from control areas. Cd may be derived from the same source i.e. fertilizer application [21]. The concentration of chromium in the rice mill soil varies from 42.560-95.540 mg/Kg with a mean value of 67.509±17.032. The highest concentrations of chromium are recorded in the samples near rice mill industry, which could be attributed to wear, friction and emission source of chromium from the plants [20].

Mutual correlations between the elements done at 95% significance level shows positive correlation between Pb and Zn (r = 0.624) suggesting a possible common origin for them (Table 5). Cd and Cr show a very high positive correlation (0.892) between as compared to the other heavy metals. Hence it can be accounted for their similar source, probably coal as coal contains Cd and Cr in its trace element composition. Coal combustion releases these trace elements which can get incorporated in the dust along with the other particulates and gets deposited on the top soil of the surrounding area. Cr also shows good positive correlation with Zn (r =0.588) confirming further their common source (Table 5).

Table 5: Inter–elemental Correlation in the Study Area

Metals	Cd	Co	Cr	Cu	Mn	Ni	Pb	Zn
		-0.015	0.395	0.892	-0.005	-0.410	0.302	-0.169
			0.045	-0.432	0.112	0.452	-0.377	-0.089
				-0.027	0.001	-0.058	0.467	0.588
					0.357	-0.328	0.003	0.147
						-0.005	-0.055	-0.297
							0.028	0.323
								0.624

The present study shows that the metal concentrations of top soils can be used as a powerful geochemical tool for monitoring the impact of anthropogenic activity. Soil samples show higher concentrations of the heavy metal determined as compared to the heavy metals from control areas indicating the presence of contaminants particles in the area. Excess of these heavy metals in the soils from the urban farm land, as opposed to the average levels of heavy metals in control soils account for incorporation of agricultural activities in the studied areas. Mutual correlation of the heavy metals in the soils suggests a common origin for Pb, Zn, Cd and Cr. The distribution of the metal concentration of the soil in the study area indicated that this area has been affected by anthropogenic activity, in particular the farm land, leading to a high accumulation of heavy metals in the soils located within urban farm land as compared with the soils from control areas.

CONCLUSIONS

The results obtained from the analysis of soil's collected from urban agricultural farm land in various locations in Otukpo local government, of Benue state in Nigeria indicated that the concentrations of Cd, Co, Cu, Mn, Ni, Pb and Zn were higher than those of control soil metals contents. The degree of contamination of Pb and Zn were the highest. Cd, Cr, Cu, and Co also showed high degree of contamination in urban agricultural soil samples. From this reason, it could be predicted that the contaminations of Pb, Zn, Cd, Cr, Cu, and Co are probably from anthropogenic activities from various sources, including atmospheric deposition of metal/metalloid-bearing particles, application of sewage sludge, phosphate fertiliser, pig slurry and pesticides, where they exist in several chemical forms. While those of Ni and Mn may be from parent material in the soil. The observed contaminants were Pb, Zn, Cd, Cr, Cu, and Co and their concentrations and enrichment factors were high in all the soils studied. The results do not provide information about changes in the levels of inorganic soil contaminants over time, but they do provide baseline data for comparisons in the future. Hence, overall, levels of Pb, Zn, Cd, Cr, Cu, and Co contaminations are those which call for closer monitoring in sites under considerations. Further study is needed not only to assess the distribution of metals in soil but also to examine variation on small scale. More intensive work is necessary to show any change or increase of metals in the investigated area over time.

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