

# Geochemical Spread of Trace Metals in Soils Around Cassava Processing Plants in Oyo, Southwestern Nigeria

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**Abstract-** The study was conducted to determine the level of metal contamination and access the spread of these metals in soils around some cassava processing plants in Oyo town. Cassava processing involves peeling off of the outer layers, crushing the cassava, compressing the crushed cassava under machine to drain off the effluents which could be a potential source of contamination to soil and underground water in the area. The location of the study falls within latitude 7° 15' N and 7° 18' N and longitude 3° 54' E and 4° 00' E

Twelve (12) soil samples were collected and analyzed for heavy metal contents using Inductive Coupled Plasma Atomic Absorption Spectrometry (ICP-MS) method from Activation Laboratory, Canada. The geochemical Analysis of the soil for Manganese (Mn), Strontium (Sr), Zinc (Zn), Vanadium (V), Lead (Pb), Chromium (Cr), Copper (Cu), Nickel (Ni) and Cadmium (Cd) were made and results statistically analyzed. The level of contamination of these metals in the soils were assessed using Geo-accumulation Index (I<sub>geo</sub>), Contamination Factor (C<sub>f</sub>) and Degree of Contamination (C<sub>d</sub>). Factor analysis indicated two factors where Factor 1 has Cu, Co, Mn, Cr, Sr and V and Factor 2 included Cu, Pb, Mn, Cd and Sr. Elemental association was determined and the influence of lithology, geochemical affinity and anthropogenic activities were suspected. The geoaccumulation index showed that the soils were uncontaminated with Cu, Ni, Co, Cd, V and Cr, uncontaminated to moderately contaminated by Sr, uncontaminated to strongly contaminated by Zn and moderately to strongly contaminated by Pb. The spread of the geoaccumulation index around sample points indicated that the soils are considerably contaminated by Pb, moderately contaminated by Zn and low to non-contamination by Cu, Ni, Co, Cd, V, Cr and Sr. These results revealed that Pb is a potential source of health risk in the area.

**Index Terms-** Geo-accumulation Index, Contamination Factor, Geochemical Affinity, Anthropogenic Activities,

## I. INTRODUCTION

The concentration of heavy metals in urban soils and street dusts emanating from particulate emission, had been the focus of many studies in developed and developing nations of the world. The presence of heavy metals in soil is expected because of the advancement in technology, urbanization and industrialization which could directly supply these metals into the environment in form of industrial effluents, auto-vehicle emission, fertilizer application in soils, indiscriminate refuse disposal and domestic wastes in urban cities (Olukanmi and Adeoye, 2012).

Vandenabeele and Wood (1972) discovered from studies that, though Pb contamination is limited to a narrow zone along highways in the studied area, it is not limited to surface soils but contamination can be as deep as 10cm down.

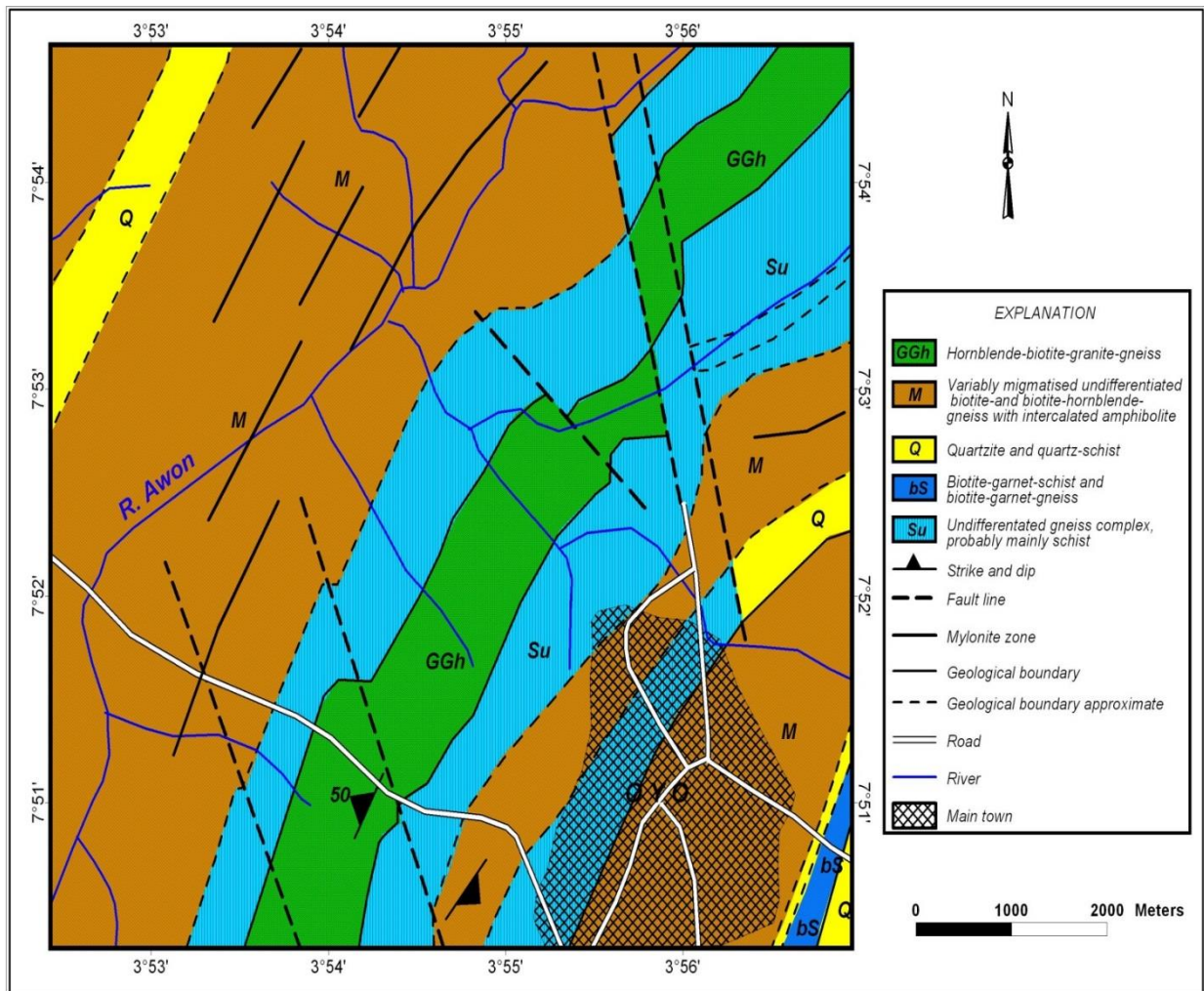
There have been numerous other studies that included other metallic ions such as Zn, Cd, Cu, As, etc. Shacklette and Conner (1973) from their studies found that Sn could be detected in Spanish moss up to 50 miles from the only tin smelter in the United States. Gibson and Farmer, (1984) in their studies to understand environmental mobility and bioavailability of Pb, Zn, Cu and Cd, revealed that the exchangeable fraction of these metals was significantly greater in street dust than in soils. Workers like Hamilton et al., (1984); Hewit and Candy, (1990); Onianwa, (2001); Fayode and Olu-Owolabi, (2003) showed that the amount of contamination increases as traffic density increases and that metal concentrations for the urban environment were considerably elevated. Onianwa, (1993) investigated the concentration of metallic ions in mosses of Ibadan and environs and concluded that Pb level in mosses within the city were higher than those in sub urban village but lesser than what is obtainable in industrialized countries and Fakayode and Olu-Owolabi (2003) linked the source of Pb in urban street dusts to gasoline from vehicular emission.

Oguntimehin and Ipinmoroti, (2008) studied heavy metal profile from five Auto-mobile Workshops in Akure, Nigeria and reported the variation in the concentration of Ba, Ni, Cr, Pb, Cu, Fe, Cd, Co and Zn metals in soils investigated and concluded that the degree of heavy metal pollution in the areas studied was in the order of Ijapo>Ilesha garage>Ondo road>Oyemekun>Oke-Ijebu. The distribution of metallic ions in urban soils and their relationship to soil pollution, bedrock composition, mining activities and land-use were assessed by Elueze et al., 2001; Zhai et al., 2003 and Teng et al., 2004). They concluded that urban soils in old urban commercial districts and industrial areas have elevated concentrations of Cd, Cu, Pb and Zn,

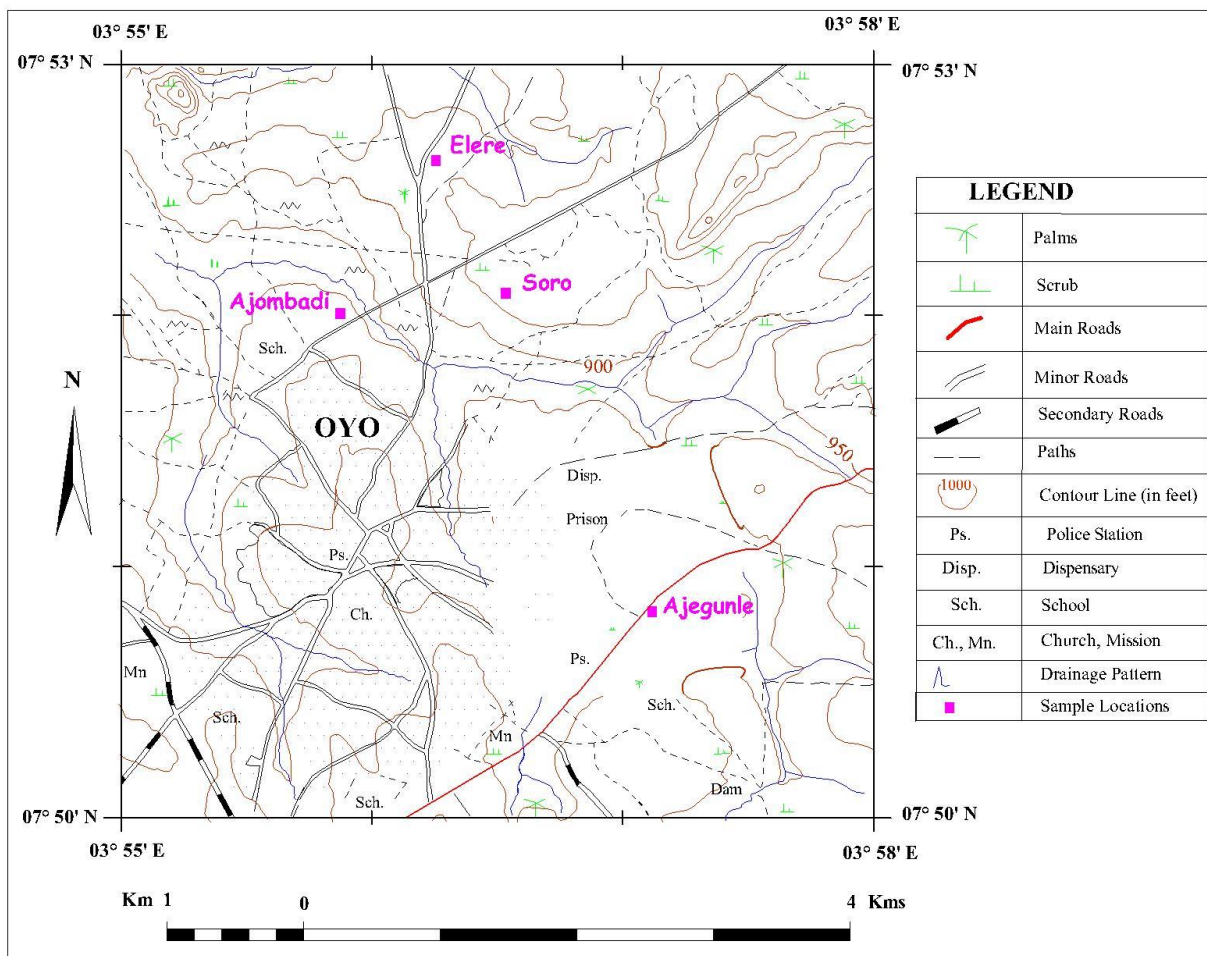
The Nigeria Basement Complex forms a part of the Pan-African mobile belt and lies between the West African and Congo cratons and South of the Touareg Shield (Black, 1980). The Basement rocks are believed to be the result of at least four major Orogenic cycles of deformation, metamorphism and re-mobilization corresponding to the Liberian (2700 Ma), the Eburnean (2000 Ma), the Kiberian

(1100 Ma) and the Pan-African cycle (600 Ma) (Rahaman, 1988; Obaje,2009; Olayinka, 1992).The Nigerian Basement Complex comprises the Migmatite-Gneiss –Quartzite complex; the metavolcanic and metasedimentary rocks (Schist Belt); the Pan-African granitoids and the undeformed acid and basic dykes (Rahaman,1976; Jones and Hockey 1964;Dada,2006).

The study area is located within the southwestern portion of the Nigerian Precambrian Basement Complex (Fig.1). Metals in soils are products of the weathering of underlying rocks constituting the primary or lithogenic sources of the metals in soils. However, soils in urban cities can also be contaminated by metals from anthropogenic sources such as vehicular and industrial emissions, wastes and indiscriminate refuse dumping and uncontrolled disposal of agricultural wastes. In cassava processing areas, the discharge of the affluent can contaminate the soil and even infiltrate through the soil to contaminate the groundwater within the area. This study is therefore aimed at accessing the level of metal contamination around cassava processing plants in the study area.



**Fig. 1: Geological Map of Oyo Town and Its Environs  
(Extracted From Topomap-Sheet 241 1<sup>ST</sup> Edition)**



**Fig 2: Accessibility and sample Location Map**

**II. MATERIALS AND METHODOLOGY**

**Sampling and Sample Preparation**

The study area is located within Latitude N07°50' and N 07 ° 53' and longitude E003°55' and E 003° 57' where four cassava processing factories located in Ajegunle, Ajombadi, Elere, and Soro were identified and captured for the study (Fig.2). These areas are within medium density population in the town. Three soil samples at a depth of 0 to 15cm were taken from each location at an intervals of 20m, 40m and 60m to the center of the factory site. A total of 21 samples were collected in this way and stored in well labeled sample bags.

These soil samples were air dried at room temperature and samples clustered together were disaggregated using porcelain mortar and pestle before sieving. The sieves were stacked in the mechanical shaker in descending order of sizes and operated for 5mins each. The fraction contained in the pan (<0.075mm) were packed in air-tight polythene bags and later sent to Activation Laboratories, Verancouver, Canada for geochemical analysis.

The samples were digested using Aqua Regia Digestion Method. The method involves measuring 0.5g of each sample and digesting it in 0.5mils of H<sub>2</sub>O, 0.6mils of concentrated HNO<sub>3</sub> and gently mixing the solution with 1.8mils of concentrated HCL for 2hours at 75°C. This solution is then cooled and diluted to 10mil with de-ionized water and thereafter used for trace element determination.

**Sample Analysis**

The samples were analyzed using the Inductive Plasma Mass Spectrometry (ICP-MS) method. The inductively coupled plasma ionizes the sample and the spectrometer separates and quantifies the ions. The plasma in the inductively coupled plasma is energized by inductively heating the gas with an electric coil. The concentration of elements in each sample were determined through calibration with certified reference material such as single or multi element reference standard. Quality control and quality assurance measures were taken to ensure high level dependability of geochemical analysis and reliability of the instrument. Sets of geochemical standards whose concentration had been preciously determined is to ensure the quality of the analysis. The United State Geological Survey (USGS)

geochemical standards GXR-6, GXR-4, GXR-2 and GXR -1 were used for this analysis and this ensures the accuracy of the analytical instrument. Blank samples were also analyzed at regular intervals during sample analysis.

### III. STATISTICAL ANALYSIS OF THE SOIL SAMPLES

#### Descriptive Statistics

The mean , mode , media and standard deviation of the geochemical results were calculated and reported.

#### Correlation Factor.

The degree of correlation between two variables is usually obtained from the coefficient of correlation on data containing the two variables . The correlation between two variables can be perfectly positively correlated (+1), perfectly negatively correlated (-1) or a total absence of correlation (0) and intermediate values between +1 ,0 and -1 can also be interpretation. When the correlation coefficient is +0.97, this is interpreted as high positive correlation, -0.85 as high negative correlation and 0.09 as low positive correlation.

### IV. CONTAMINATION INDEX

#### Geo-accumulation Index (*I<sub>geo</sub>*)

The Index of geo-accumulation (*I<sub>geo</sub>*) was used in accessing the soil contamination. This is calculated using the equation developed by Muller, (1969), expressed as

$$I_{geo} = \log_2 C_n / 1.5 B_n$$

Where  $C_n$  represents the measured concentration of the element in the soil sample fraction

$B_n$  is the geochemical background value obtained from controlled sample of a neutral location free from anthropogenic influence The 1.5 constant allows for analysis of natural fluctuation in the content of a given substance in an environment where there are small anthropogenic influence. Table 1 below gives soil quality and specific *I<sub>geo</sub>* value according to Muller, (1969)

**Table 1: Classes of Geoaccumulation Index (*I<sub>geo</sub>*) after Muller, 1969**

Class	<i>I<sub>geo</sub></i> Value	Soil Quality
0	$I_{geo} < 0$	Practically Uncontaminated
1	$0 < I_{geo} < 1$	Uncontaminated to Moderately Contaminated
2	$1 < I_{geo} < 2$	Moderately Contaminated
3	$2 < I_{geo} < 3$	Moderately to Heavily Contaminated
4	$3 < I_{geo} < 4$	Heavily Contaminated
5	$4 < I_{geo} < 5$	Heavy to Extremely Contaminated
6	$I_{geo} > 5$	Extremely Contaminated

#### Contamination Factor and Degree of Contamination ( $C_{deg}$ ).

The Contamination Factor and Degree of Contamination ( $C_{deg}$ ) is another parameter for accessing the contamination of soils. This is according to Hakanson (1980) where soil contamination was compared with the observed concentration with pre-industrialized levels (the average shale concentration). In the table below (Table 2), the categories of contamination factor and class of contamination is explained.

**Table 2: Hakanson's Categories of Contamination degree**

Class of Contamination degree	Soil Category
$C_{deg} < 8$	Low degree of contamination
$8 \leq C_{deg} < 16$	Moderate degree of contamination
$16 \leq C_{deg} < 32$	Considerable degree of contamination
$32 \leq C_{deg}$	Very high degree of contamination

$C_f < 1$ : Low contamination factor

$1 \leq C_f < 3$ : Moderate contamination factor

$3 \leq C_f < 6$ : Considerable contamination factor

$C_f \geq 6$ : Very high contamination factor



V. RESULTS AND DISCUSSION

**Elemental concentration and interrelationship**

The analytical results of the soils from the cassava processing factory areas is presented in table 3 and table 4 is the average, range and standard deviation results the descriptive statistics. The range and average values of metals (ppm) in the soils were Mn (1785.00 -494.00, 992.08); Sr (854.00 – 30.00, 319.46); Zn (793.00 – 62.00, 240.77); V (98.00 - 28.00, 51.54) ; Pb (111.00 – 15.00, 41.31); Cr (56.00 – 22.00, 33.38); Cu (42.00 – 14.00, 41.31); Co (36.00 – 7.00, 17.31); Ni (29.00 – 5.00, 14.46)and Cd (0.60 – 0.40, 0.45). This results shows that the average concentration increased in the order of Mn>Sr>Zn>V>Pb>Cr>Cu>Co>Ni>Cd.

**Table 3: Analytical Results of the sampled soils from study area**

*Location	Cu	Pb	Zn	Ni	Co	Mn	Sr	Cd	V	Cr	Ba	As	Mo
L 1A	33	111	377	13	12	838	604	0.6	41	38	580	3	<1
L 1B	22	36	128	9	7	639	551	0.5	28	24	584	<2	<1
L 1C	20	55	148	10	29	1047	265	0.5	65	31	298	<2	1
L 2A	38	33	75	25	32	1571	34	0.5	96	50	349	2	1
L 2B	31	45	444	10	9	780	555	0.6	33	22	497	2	<1
L 2C	37	31	73	29	36	1785	30	0.5	98	56	353	2	1
L 3A	22	23	123	8	10	857	99	0.5	32	29	190	<2	<1
L 3B	17	16	113	6	7	494	88	0.5	31	30	153	<2	<1
L 3C	14	15	62	5	10	597	55	0.5	31	23	124	<2	<1
L 4A	42	52	793	24	15	931	854	0.6	44	33	734	<2	1
L 4B	22	24	137	9	15	945	267	0.5	38	23	245	<2	<1
L 4C	35	69	584	15	11	893	720	0.5	39	27	688	<2	1
<b>AVERAGE</b>	29	41	241	14	17	992	319	0.5	52	33	395	2	1

- The A, B and C represents the three sample points in each location

**Table 4: Descriptive Statistics showing range, average of values and standard deviation**

	Range (ppm)	Average(ppm)	Std. Deviation
<b>Cu</b>	42.00 14.00	28.54	9.33
<b>Pb</b>	111.00 15.00	41.31	26.32
<b>Zn</b>	793.00 62.00	240.77	234.63
<b>Ni</b>	29.00 5.00	14.46	8.31
<b>Co</b>	36.00 7.00	17.31	10.74
<b>Mn</b>	1785.00 494.00	992.07	395.51
<b>Cd</b>	.60 .40	.446	.08
<b>V</b>	98.00 28.00	51.54	27.005
<b>Cr</b>	56.00 22.00	33.38	11.30
<b>Sr</b>	854.00 30.00	319.46	297.56

The inter-elemental relationship as revealed in the correlation matrix as very strong, strong and fairly strong (Table 5). A very strong relationship is exhibited between Ni-Cu, V- Co and Cr-V and strong relationship between Ni- Cu, Co -Ni, Mn-Ni, Mn - Co, Cd - Zn and V - Ni whereas, a fairly strongly relationship exists between Zn and Cu.

**Table 5: Correlation Matrix of the Results of the Geochemical Analysis**

	Cu	Pb	Zn	Ni	Co	Mn	Cd	V	Cr	Sr
Cu	1.000									
Pb	.396	1.000								
Zn	<b>.504</b>	<b>.572</b>	1.000							
Ni	<b>.885</b>	.097	.150	1.000						
Co	.479	-.083	-.333	<b>.766</b>	1.000					
Mn	<b>.655</b>	-.052	-.233	<b>.874</b>	<b>.938</b>	1.000				
Cd	.415	<b>.607</b>	<b>.722</b>	.083	-.282	-.205	1.000			
V	<b>.572</b>	-.085	-.323	<b>.834</b>	<b>.973</b>	<b>.959</b>	-.258	1.000		

Cr	.633	.043	-.249	.859	.843	.889	-.120	.915	1.000	
Sr	.330	.668	.896	-.042	-.470	-.387	.673	-.475	-.412	1.000

### VI. FACTOR ANALYSIS

The varimax-rotation analysis of the data is done to separate between the different components of the soil and their distribution over the study area. The possible sources of metals in the study area is also evaluated from the varimax-rotation results. Two factor components were revealed from Eigen values. The elemental loading in this factors is shown in table 6 with factor loading greater than 0.50 being significant for the interpretation of the data and the total system variance of the metals presented in table 7.

#### Factor 1: Cu, Co, Mn, Cr, Sr and V

From table 7, factor 1 accounts 51.47% of the system variance indicating a high +ve factor loading on Cu, Co, Mn, Cr, Sr and V. According to Goldschmidt, Cu is classified as chalcophile element, Co is siderophile and Mn, V and Cr as lithophile element. The elemental association of Cu, Co, Mn and V in factor 1 is an indication of mafic and intermediate lithologic environment even though anthropogenic and geochemical behavior of the metals could also be a factor.

**Table 6: Factor Analysis showing the Rotated Component Matrix of the Study Area**

	Component	
	1	2
Cu	.762	.588
Pb	.065	.773
Zn	-.099	.931
Ni	.045	.210
Co	.914	-.265
Mn	.969	-.149
Cd	-.068	.846
Cr	.960	-.236
Sr	.941	-.115
V	-.275	.910

Extraction Method: Principal Component Analysis.

**Table 7: Total variance of metals in soils of the study area**

Component	Initial Eigenvalues			Extraction Loadings	Sums of Squared			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %		Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.253	52.529	52.529	5.253	52.529	52.529	5.147	51.467	51.467	
2	3.454	34.536	87.065	3.454	34.536	87.065	3.560	35.598	87.065	
3	.566	5.665	92.729							
4	.373	3.734	96.464							
5	.186	1.857	98.321							
6	.078	.780	99.101							
7	.058	.581	99.683							
8	.026	.261	99.943							
9	.004	.041	99.984							

**10 .002 .015 100.000**

**Extraction Method: Principal Component Analysis.**

**Factor 2: Cu, Pb , Zn, Cd and V**

Factor 2 accounts for 35.59% of the system variance having a high +ve factor loading on Pb , Zn, Cd and Cu moderately +ve. In Goldschmidt classification scheme, Cu, Pb , Zn and Cd are siderophile and Sr lithophile. Cd is strongly associated with Zn in it's geochemistry and the chemical composition of parent rock influence it's content in soil.

**VII. CONTAMINATION INDEX**

**Geo-accumulation Index(I<sub>geo</sub>).**

The assessment of the level of contamination of soils from the study area were determined by comparing the calculated Igeo values of the soil samples with standard values according to Muller (1969) and Hakanson (1980). Table 8 indicates the range of Geo-Accumulation Index(I<sub>geo</sub>) of Soils from study area and inferred soil quality. The sampled soils are generally uncontaminated by Cu, Ni, Co, Mn, Cd, V and Cr but moderately to strongly contaminated by Pb, uncontaminated to strongly contaminated by Zn and uncontaminated to moderately contaminated by Zr.

**Table 8: Range of Geo-accumulation Index(I<sub>geo</sub>) of Soils from Study Area and Inferred Soil quality**

Metals	Range of Values		Soil Quality
	Max	Min	
Cu	-1	-2	Uncontaminated
Pb	3	0	Moderately to strongly contaminated
Zn	3	-1	Uncontaminated to strongly contaminated
Ni	-2	-4	Uncontaminated
Co	0	-2	Uncontaminated
Mn	0	-2	Uncontaminated
Cd	-0.8	-1.4	Uncontaminated
V	-1	-3	Uncontaminated
Cr	-1	-3	Uncontaminated
Sr	0.6	-4.2	Uncontaminated to moderately contaminated

**Table 8: Percentage of Metals in each class of Geoaccumulation Index**

Class	Igeo Value	Soil Quality											
			% Cu	% Pb	% Zn	% Ni	% Co	% Mn	% Cd	% V	% Cr	% Sr	
0	Igeo < 0	Practically Uncontaminated	100	31	69	100	100	100	100	100	100	100	77
1	0 < Igeo < 1	Uncontaminated to Moderately Contaminated	nil	46	nil	nil	nil	nil	nil	nil	nil	nil	23
2	1 < Igeo < 2	Moderately Contaminated	nil	15	23	nil	nil	nil	nil	nil	nil	nil	nil
3	2 < Igeo < 3	Moderate to Heavily Contaminated	nil	8	8	nil	nil	nil	nil	nil	nil	nil	nil
4	3 < Igeo < 4	Heavily Contaminated	nil	nil	-	nil	nil	nil	nil	nil	nil	nil	nil

5	$4 < I_{geo} < 5$	Heavily Extremely Contaminated	to	nil	nil	-	nil	nil	nil	nil	nil	nil	nil
6	$5 < I_{geo}$	Extremely Contaminated		nil	nil	-	nil	nil	nil	nil	nil	nil	nil

From Table 9 below, A,B,C represents sample points at 20m interval in each location. The spread shows that location 1 has considerable contamination level for Pb and moderately contaminated with Zn. A general trend from this table is that the contamination level falls within low to uncontamination with Cu, Ni, Co, Cd, V, Cr and Sr across the sampled area.

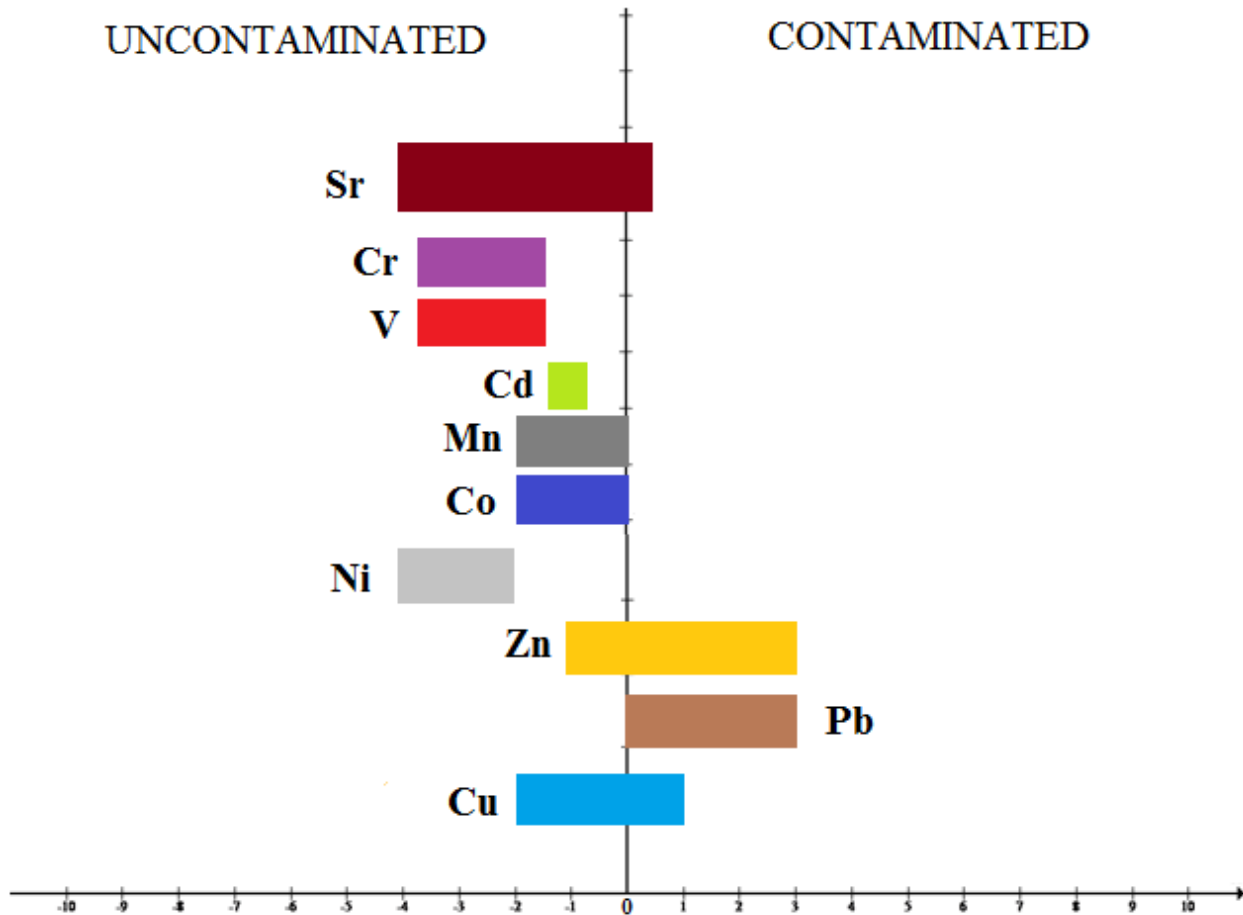


Fig 4 :- Geo-accumulation ( $I_{geo}$ ) Index for metals of the study area.

Table 9 : Spread of geo-accumulation ( $I_{geo}$ ) index the study area

Metals	Location 1			Location 2			Location 3			Location 4		
	A	B	C	A	B	C	A	B	C	A	B	C
<b>Cu</b>	-1	-2	-2	-2	-2	-2	-1	-1	-1	-1	-2	-1

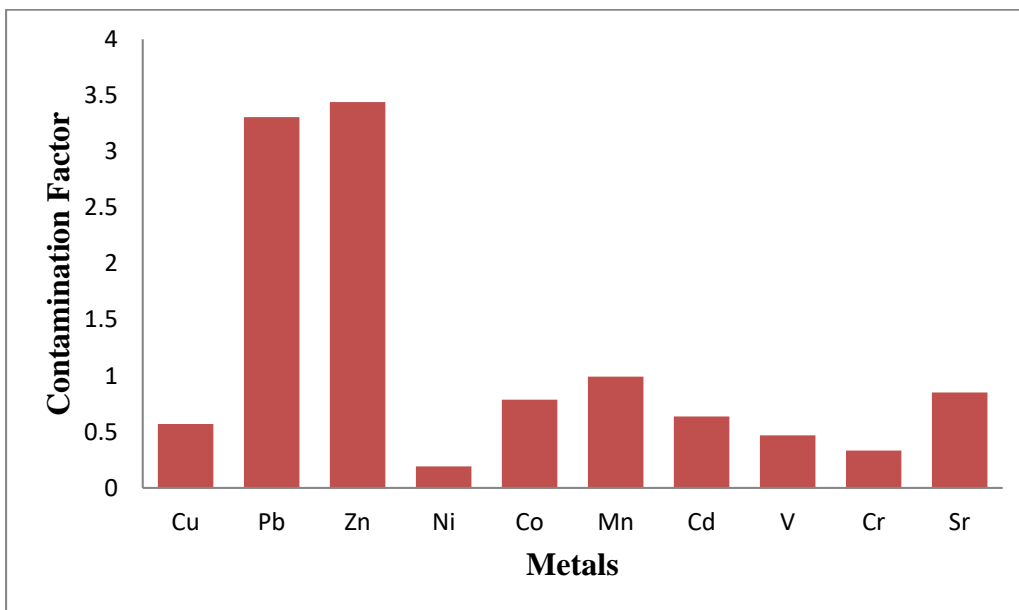


<b>Pb</b>	3	1	2	0	0	0	1	1	1	1	0	2
<b>Zn</b>	2	0	0	0	0	-1	0	2	-1	3	0	2
<b>Ni</b>	-3	-4	-3	-4	-4	-4	-2	-3	-2	-2	-4	-3
<b>Co</b>	-1	-2	0	-2	-2	-2	0	-2	0	-1	-1	-2
<b>Mn</b>	-1	-1	-1	-1	-2	-1	0	-1	0	-1	-1	-1
<b>Cd</b>	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
<b>V</b>	-2	-3	-1	-2	-2	-2	-1	-2	-1	-2	-2	-2
<b>Cr</b>	-2	-3	-2	-2	-2	-3	-2	-3	-1	-2	-3	-2
<b>Sr</b>	0	0	-1	-3	-3	-3	-4	0	-4	1	-1	0

**Contamination Factor ( $C_f^i$ ) and Degree of Contamination ( $C_a$ )**  
**Contamination Factor ( $C_f^i$ )**

**Table 10 : Contamination Factor for the Soil from study Area**

Categories		Cu	Pb	Zn	Ni	Co	Mn	V	Cr	Sr	Cd
$C_f^i < 1$	Low Contamination Factor	0.571			0.193	0.781	0.992	0.637	0.469	0.443	0.852
$1 \leq C_f^i < 3$	Moderate Contamination Factor										
$3 \leq C_f^i < 6$	Considerable Contamination Factor		3.305	3.460							
$C_f^i \geq 6$	Very High Contamination Factor										



**Figure 5:- Contamination Factor for Metals in the Study Area**

The soil around cassava processing factory in Oyo town showed low contamination factor for Cu, Ni, Co, Mn, Cd, V, Cr, Sr but moderate contamination factor for Pb and Zn. The contamination factors are Cu (0.571), Ni (0.193), Co (0.787), Mn (0.992), Cd (0.637), V (0.469), Cr (0.334), Sr (0.832), Pb (3.305) and Zn (3.460).

Degree of contamination gives an overall assessment of the soils as presented in table 11 below. The overall degree of contamination of the soils from the study area showed a moderate degree of contamination (11.58).

**Table 11 : Hakanson’s Categories of ContaminationDegree**

Class of Contamination Degree	Soil Categories	Degree of Contamination for the studied area
$C_{deg} < 8$	Low degree of contamination	
$8 \leq C_{deg} < 16$	Moderate degree of contamination	11.58
$16 \leq C_{deg} < 32$	Considerable degree of contamination	
$32 \leq C_{deg}$	Vey high degree of contamination	

VIII. CONCLUSION

This study revealed that the average value of metal concentration in soils around cassava processing plants in Oyo is increased in the order Mn>Sr>Zn>V>Pb>Cr>Cu>Co>Ni>Cd and factor analysis yields two Factor groupings where **Cu, Co, Mn, Cr, Sr and V are grouped as Factor 1**. The elemental association of Cu, Co, Mn and V in **Factor 1** is an indication of mafic and intermediate lithologic environment even though anthropogenic and geochemical sources could also be a factor. **Factor 2: Cu, Pb, Zn, Cd and V and these elements are siderophile** except Cd which could be strongly associated with Zn in it’s geochemistry and the chemical composition of parent rock in the area could also influence it’s content in the soils.

The Geoaccumulation index showed that the sampled soils are generally uncontaminated by Cu, Ni, Co, Mn, Cd, V and Cr but moderately to strongly contaminated by Pb, uncontaminated to strongly contaminated by Zn and uncontaminated to moderately contaminated by Zr. The soil around cassava processing factory in Oyo town showed low contamination factor for Cu, Ni, Co, Mn, Cd, V, Cr, Sr but moderately contaminated by Pb and Zn. The overall assessment of soils around cassava processing plants in Oyo from this study is that the soils are moderately contaminated (11.58). It is recommended that a regular assessment of soils around cassava processing plants in Oyo be made to monitor the level of metal contamination in soils of the area before it could become a health risk to residents and the numerous cassava consumers in the town.

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