Effects of Trace Metal Compositions of Igneous Intrusions on Public Health in Ishiagu Area of the Southern Benue Trough, Southern Nigeria

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ABSTRACT

Public health implications of structurally-controlled igneous intrusions in the Ishiagu area of southern Benue Trough were studied using the field expressions, trace element geochemistry, and geostatistical studies of some of the igneous rocks and the surrounding water and edible vegetables. Results of the study revealed that the average concentrations of these trace metals in the igneous rocks decreased from Mn to Mg as follows: Mn (1431ppm), Sr (419.5ppm), Ba (58.11 ppm), Cu (45.63 ppm), Pb (5.48 ppm), As ((1.20ppm), Mo (3.270ppm), Cd (0.960ppm) and Mg (0.940ppm); in water decreased from Mg to Cd as follows: Mg (5.840mg/l), Sr (1.270mg/l), Fe (0.3mg/l), Mo (.013mg/l), Mn (0.002mg/l), Ni (0.001mg/l), As (0.0004mg/l), Ni (0.001mg/l), Co (0.0001mg/l), and Cd (0.0001mg/l), and in the edible vegetables decreased from Fe-Ni as follows: Fe (8540 mg/kg), Mg (4085 mg/kg), Al (2352.1 mg/kg), Pb (360.76 mg/kg), Sr (182 mg/kg), Zn (53.38 mg/kg), Ba (46.3mg/kg) Cu (21.75 mg/kg), Mo (8.97 mg/kg), and Ni (4.92 mg/kg).

Geostatistical analysis of the edible vegetables showed that the bioaccumulation factor of the vegetation with respect to the rock decreased from Pb to Ni as follows: Pb> Mo >Cd >As> Fe > Cr > Cu > Zn>Sr>Mg>Ni. The concentrations of Fe, Ni, Cu, Cr, Mn, Cd, Pb and Zn in water and edible vegetables are higher than the permissible levels recommended by World Health Organization. Thus, the inhabitants of the study area are at risk of myocardial infarction, insulin alteration, anemia, neurodegenerative conditions in humans, renal dysfunction, metal fumes fever, hair and skin discoloration, respiratory tract diseases, carcinogenic diseases, kidney disease, Fanconi syndrome, lipid peroxidation of the heart, liver and spleen, hypertension, anemia, colic, headache, brain damage and central nervous system disorder, oesteomalacia, renal dysfunction, learning disabilities, hyperactivity, loss of vision, heart and liver failures, skin irritation, and hazardous effects on lungs and brains. The outcome of this study has provided a data base for intervention endeavors for health practitioners to comprehensively monitor and control health issues arising from geologic processes in Ishiagu area of Ebonyi State. The area is in dire need of standard medical facilities, which will, among other things, offer medical aids, document such health matters and keep surveillance in order to reduce the chronic impact of the trace metals on the health of the inhabitants of the study area.

(Keywords: geochemistry, geostatistical studies, environmental chemistry, bioaccumulation, health effects, trace metals)

INTRODUCTION

The Benue Trough is an intracratonic rift structure developed from an extensive block faulting in the early Cretaceous during the separation of South America from Africa (Ukaegbu 2008). It is characterized by multiple tectonism, magmatism and repeated cycles of sedimentation (Olade 1975, Wright et al., 1985, Akande et al., 2011). It has been described as the failed arm of a radial rift system which spans from the northern parts of the Niger Delta to the fringes of the Chad Basin (Burke 1972, Akande et al., 2011, Odigi and Soronnadi 2014).

The length of the Trough is about 700km and it bifurcates at the northeastern end with its width ranging from 100 km to 150 km (Wright et al 1985, Okiwelu et al., 2014) Thick sedimentation accompanied by basement faulting, rifting, subsistence, and opening of the South Atlantic Ocean gave rise to cycles of transgression and regression producing thicknesses ranging from 7000 – 10000 meters (Wright et al., 1985, Okiwelu et al., 2014.

The Trough has been distinctly divided by authors into the Lower, Middle and Upper (Akande et al., 2011, Fatoye and Gideon 2013, Okiwelu et al., 2014, Odigi and Soronnadi 2014). Outstanding deformational structures as a result of tectonism in the Trough include: Abakiliki Anticline, Anambra and Afikpo Synclines (Lower Benue), Keana Anticline, Awe Syncline (Middle Benue), Zambuk Ridge (Upper Benue) (Wright et al., 1985, Akande et al., 2011, Ibe et al., 2013.).

Aptian-Cenomanian depositional cycles show the Asu River Group dominated by shales described as blue-black shales by Wright et al., (1985) with localized development of limestone facies, sandstone, siltstone and volcano clastics (Ofoegbu and Amajor 1987, Akande et al., 2011). It has been described as pyroclastic, paralic shallow marine and fluviatile sequence (Petters 1978). Asu River Group lies unconformably on the Precambrian Basement Complex (Fatoye and Gideon 2013). Turonian to Conacian depositional cycle shows the Ezeaku Formation and the Agwu shales. The Turonian Conacian cycle is represented as paralic marine and fluviatile sequence (Petters 1978). The Ezeaku Formation is mainly calcareous shales with calcareous siltstones, limestones and sandstones. The lateral equivalents of Ezeaku Formation are Wukari Formation (Middle Benue), Jessu Formation (Upper Benue) (Reyment 1965, Wright et al., 1985 and Akande et al., 2011).

The Santonian was a period of compressional deformation episode and non-deposition (Akande et al., 2011, Fatoye and Gideon 2013 and Okiwelu et al., 2014). Campanian to Maastrichtian depositional cycle shows the Nkporo Shales, Oweli Sandstones, Afikpo Sandstones and Enugu Shales (Wright et al., 1985). These are overlain by deltaic sessions of Mamu Formation, Ajali Sandstone and Nsukka Formation (Wright et al., 1985 and Akande et al., 2011). They have been described as paralic marine and fluviatile off lap sequence (Petters 1978). The Upper Cretaceous sediments are overlain by transgressive Paleocene – Eocene shales, sandstones and siltstones which are the Imo Shales and the Ameki Formation of the Proto Niger Delta (Akande et al., 2011).

METHODOLOGY

Field study was carried out in the study area (Ishiagu) using visual observations, measurements of sample locations and sampling. Six samples of rocks, six samples of edible vegetation and six samples of water were collected from the study area (see Figure 1 sample location map). These 18 samples were analyzed using Inductively Coupled Mass Spectrometry (ICP-MS) method. The results from the laboratory were converted element by element to the same units in order to see the geo-accumulation tendencies such as Geo-Accumulation factor, Contamination factor and Bio-Concentration Factor.

RESULTS

Table 1 represents the statistical description of elements composition in the rock samples. However, for this study we are considering a few of them listed below:

Magnesium (Mg): The average concentration of Mg in the rock samples is 0.083 ppm, their values range from 0.47 to 2.78 ppm, with the maximum value of 2.78 ppm in (R 4). The average value of Mg in the study area is less than the average crustal value given by Taylor and McLennan (1995). The maximum concentration of Mg in the study area is 2 times higher than the average crustal value used for the comparison

Zinc (Zn): The average concentration of Zn in the rock samples is 125ppm, with values ranging from 4.5ppm to 161 ppm. The average value of Zn in the study area is 2 times higher than the average crustal value (Rudnick and Gao 2003).

Manganese (Mn): The average concentration of Mn in the rock samples is 1431 ppm, with values ranging from 639 to 4610 ppm. The average value of Mn in the study area is higher than the average crustal values given by Taylor and McLennan (1995).

Iron (Fe): The average concentration of Fe in the rock samples is 5.64 ppm, with values ranging from 1.38 to 9.25 ppm. The average value of Fe in the study area is higher than the average crustal values given by Taylor and McLennan (1995).

Lead (Pb): The average concentration of Pb in the rock samples is 5.48 ppm, with values ranging from 2.08 to 13.5 ppm.

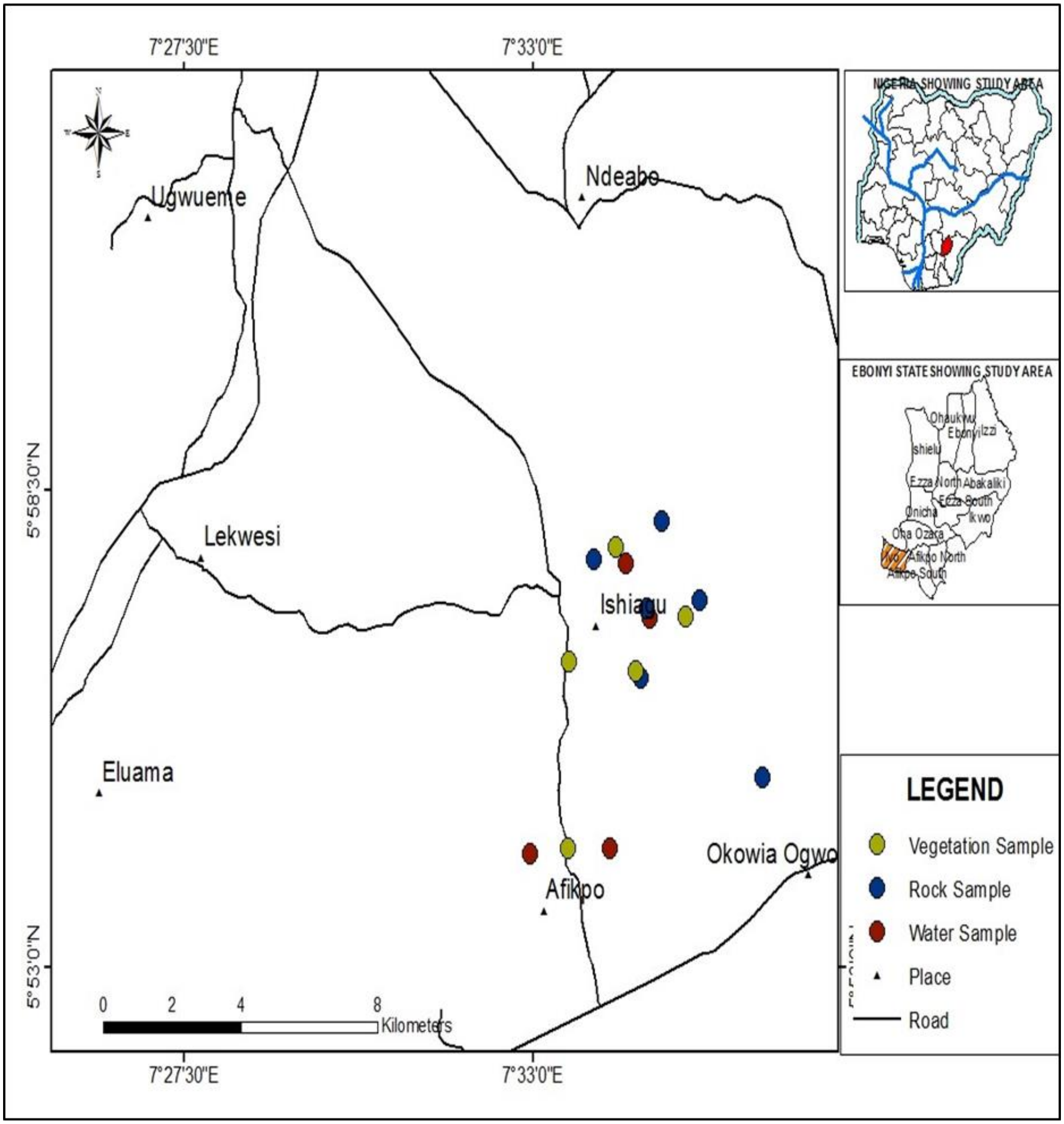

Figure 1: Sample Location Map.

The average value of Pb in the study area is lower than the average crustal values given by Taylor and McLennan (1995), Wedepohl (1995) and Rudnick and Gao (2003).

Chromium (Cr): The average concentration of Cr in the rock samples is 4.83 ppm, with values ranging from 1.0 to 12.0 ppm. The average value of Cr in the study area is lower than the average crustal values given by Taylor and McLennan (1995), Wedepohl (1995) and Rudnick and Gao (2003).

Nickel (Ni): The average concentration of Ni in the rock samples is 19.2 ppm, with values ranging from < 0.1 to 79.6 ppm. The average value of Ni in the study area is lower than the average crustal values given by Taylor and McLennan (1995) and Rudnick and Gao (2003).

Copper (Cu): The average concentration of Cu in the rock samples is 45.63 ppm, with values ranging from 23.9 to 91 ppm. The average value of Cu in the study area is higher than the average crustal values given by Taylor and McLennan (1995), Wedepohl (1995), and Rudnick and Gao (2003).

Strontium (Sr): The average concentration of Sr in the rock samples is 419.5 ppm, with values ranging from 48.5 to 2060 ppm. The average value of Sr in the study area is 1.3 times higher than the average crustal values given by Taylor and McLennan (1995), Wedepohl (1995) and Rudnick and Gao (2003).

Cadmium (Cd): The average concentration of Cd in the rock samples is 0.96 ppm, with values ranging from 0.23 to 2.38 ppm. The average value of Cd in the study area is 10 times higher than the average crustal values given by Wedepohl (1995) and Rudnick and Gao (2003).

Table 1a: Statistical Description of Elements Composition in Rock Sample

ELEMENT	MINIMUM	MAXIMUM	S.D.	ROCK STUDY MEAN	CRUST (Taylor and Mclennan 1995)	CRUST (Wedepohl 1995)	CRUST (Rudnick and Gao 2003)
Mo	0.29	5.37	2.07	3.27	1.5	1.4	1.1
Ag	0.033	0.162	0.05	0.089	0.05	55	53
In	< 0.02	0.11	0.0434	0.06	0.05	0.061	0.056
Sn	0.7	5.51	1.96	3.47	5.5	2.5	2.1
Sb	0.06	0.25	0.036	0.15	0.2	0.31	0.4
Cs	0.03	0.29	0.093	0.4	4.8	5.8	4.9
Ba	25.6	83.8	22.33	58.11	550	668	624
La	3.9	60.1	21.55	40.71	30	32.3	31
Ce	8.83	132	46.85	90.22	64	65.7	63
Cd	0.23	2.38	0.74	0.96	0.098	0.102	0.09
Pr	1.2	15.2	5.34	10.83	7.1	6.3	7.1
Nd	5.49	63.7	22.14	46.57	26		27
Sm	2.2	14.2	4.45	10.48	4.5	4.7	4.7
Eu	1.9	3.4	0.61	2.86	0.88	0.95	1
Gd	3.1	11.1	3.16	8.98	3.8	2.8	4
Tb	0.6	1.6	0.37	1.28	0.64	0.5	0.7
Dy	3.2	8.5	2.1	6.88	3.5	2.9	3.9
Ho	0.5	1.5	0.4	1.23	0.8	0.62	0.83
Er	1	3.6	1.02	2.89	2.3		2.3
Tm	0.1	0.4	0.12	0.33	0.33		0.3
Yb	0.6	2.6	0.75	2	2.2	1.5	2
Lu	< 0.1	0.3	0.09	0.23	0.32	0.27	0.31
W	< 0.1	0.7	0.26	0.33	2	1.4	1.9
Pb	2.08	13.5	4.23	5.48	16	17	17
Th	0.2	7.6	3	4.37	10.7	10.3	10.5
U	< 0.1	1.3	0.53	0.81	2.8	2.5	2.7

Table 1b: Statistical Description of Elements Composition in Rock Sample.

ELEMENT	R1	Igeo	R2	Igeo	R3	Igeo	R4	Igeo	R5	Igeo	R6	Igeo	Mean	Crust	highest conc.
Mo	4.67	0.62	5.37	0.72	0.29	-	1.86	0.25	5.08	0.68	2.36	0.31	3.27	1.5	5.37
Ag	0.162	0.65	0.109	0.44	0.033	0.13	0.054	0.22	0.133	0.53	0.042	0.17	0.089	0.05	0.162
In	0.11	0.44	0.05	0.2	< 0.02	-	0.04	0.16	0.06	0.24	0.08	0.32	0.06	0.05	0.44
Sn	4.98	0.18	4.85	0.17	0.7	0.03	1.79	0.07	5.51	0.2	2.79	0.1	3.47	5.5	5.51
Sb	0.25	0.25	0.21	0.21	0.06	0.06	0.23	0.23	0.07	0.07	0.1	0.1	0.15	0.2	0.25
Cs	0.1	-	0.12	-	0.03	-	0.2	0.01	0.29	0.01	0.09	-	0.4	4.8	0.29
Ba	62.2	0.02	83.8	0.03	25.6	0.01	71.2	0.03	69.4	0.03	36.5	0.01	58.11	550	83.8
La	50.2	0.34	55.7	0.37	3.9	0.03	26	0.17	60.1	0.4	48.4	0.32	40.71	30	60.1
Ce	111	0.35	122	0.38	8.83	0.03	60.5	0.19	132	0.41	107	0.33	90.22	64	132
Cd	0.98	0.2	2.38	0.49	0.23	0.05	0.72	0.15	0.62	0.13	0.84	0.17	0.96	0.098	2.38
Pr	13.3	0.38	14.5	0.41	1.2	0.03	8.1	0.23	15.2	0.43	12.7	0.36	10.83	7.1	15.2
Nd	56.9	0.44	60.4	0.47	5.49	0.04	37.2	0.29	63.7	0.49	55.8	0.43	46.57	26	63.7
Sm	12.6	0.56	12.9	0.56	2.2	0.9	8.7	0.39	14.2	0.63	12.3	0.54	10.48	4.5	14.2
Eu	3.1	0.71	3.4	0.77	1.9	0.43	2.3	0.52	3.2	0.72	3.3	0.75	2.86	0.88	3.3
Gd	10.6	0.56	11	0.58	3.1	0.16	7.6	0.4	11.1	0.59	10.5	0.56	8.98	3.8	11.1
Tb	1.5	0.47	1.5	0.47	0.6	0.19	1.1	0.34	1.6	0.5	1.4	0.44	1.28	0.64	1.6
Dy	8.2	0.47	8.2	0.47	3.2	0.18	5.5	0.32	8.5	0.49	7.7	0.44	6.88	3.5	8.5
Ho	1.5	0.38	1.5	0.38	0.5	0.12	1	0.25	1.5	0.38	1.4	0.35	1.23	0.8	1.5
Er	3.6	0.31	3.5	0.31	1	0.09	2.4	0.21	3.5	0.31	3.3	0.29	2.89	2.3	3.6
Tm	0.4	0.24	0.4	0.24	0.1	0.06	0.3	0.18	0.4	0.24	0.4	0.24	0.33	0.33	0.4
Yb	2.6	0.24	2.4	0.22	0.6	0.05	1.7	0.16	2.4	0.22	2.3	0.21	2	2.2	2.6
Lu	0.3	0.19	0.3	0.19	< 0.1	-	0.2	0.13	0.3	0.19	0.3	0.19	0.23	0.32	0.3
W	0.5	0.5	0.7	0.7	< 0.1	-	0.1	0.1	0.6	0.6	0.1	0.1	0.33	2	0.7
Pb	3.74	0.05	4.56	0.06	13.5	0.17	2.08	0.03	6.53	0.08	2.52	0.03	5.48	16	13.5
Th	5.9	0.11	6.7	0.13	0.2	-	1.3	0.02	7.6	0.14	4.5	0.08	4.37	10.7	7.6
U	1.2	0.09	1.3	0.09	< 0.1	-	0.2	0.01	1.3	0.09	0.9	0.06	0.81	2.8	1.3

The study using geo-statistical method of Geo-Accumulation shows that most of element concentrations fall between >0<1 indicating slight pollution. However, a few elements showed more elevated levels:

- Ca showed >2<3 , moderately polluted
- Mn showed >1-<2 indicating moderate pollution.
- Sr showed >1-<2 indicating moderate pollution.

These values are also graphically represented in Figures 2a, 2b, 2c, and 2d.

The Contamination factor of: Ti, Li, Be, B, Na, Mg, Al, K, Ca, Sc ,V, Cr, Co, Ni, Ga, As, Rb, Zr, Nb, Sn, Sb, Cs, Ba, Yb, Lu, W, Pb, Th ,and U is less than 1 which implies that they fall into the category of low contamination

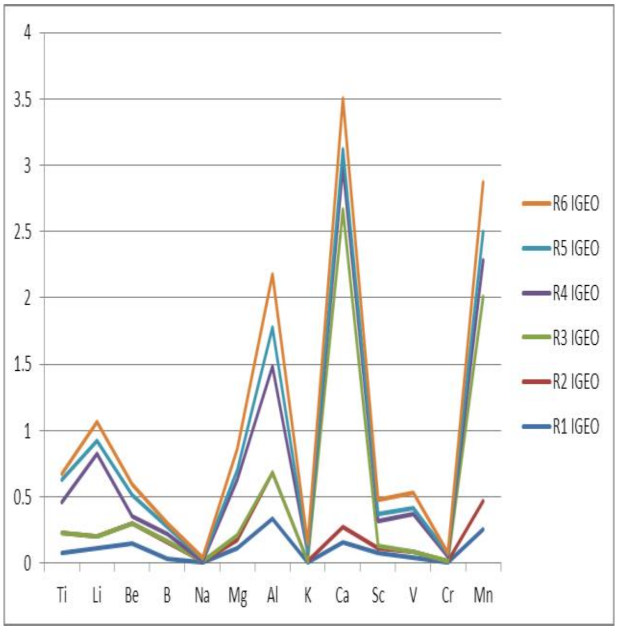

Figure 2a

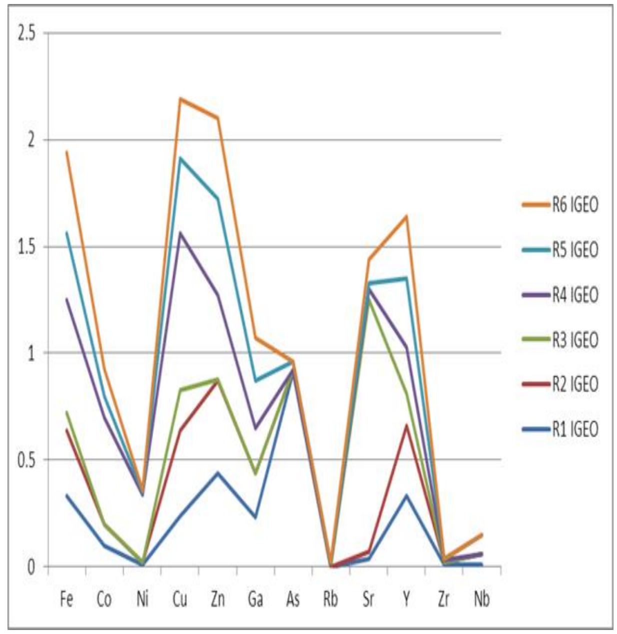

Figure 2b

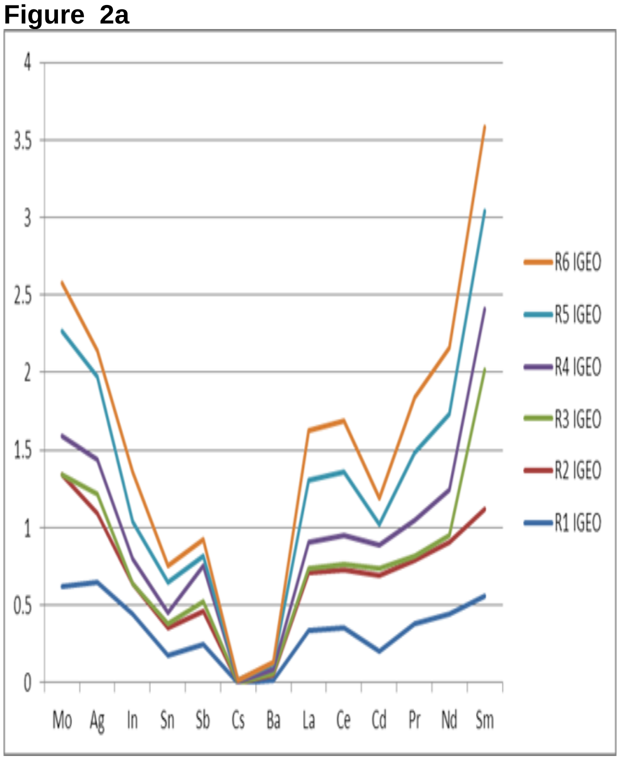

Figure 2c

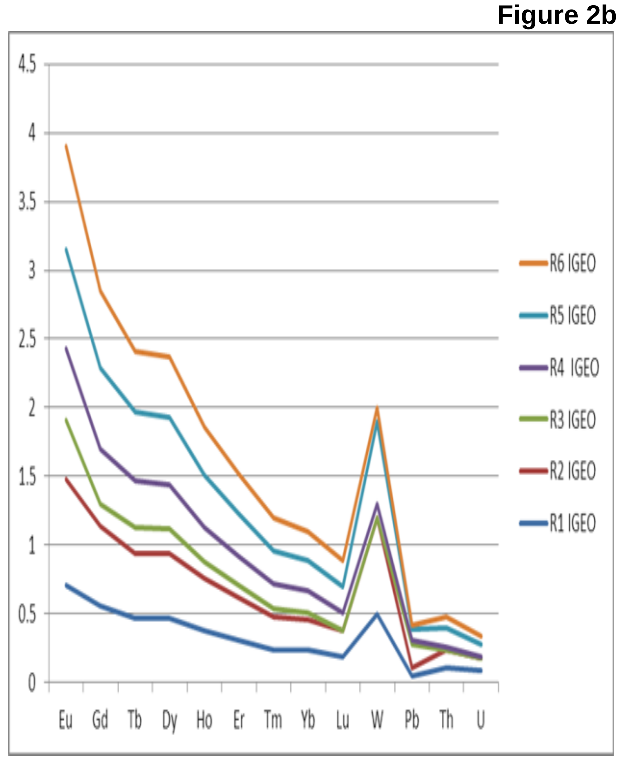

Figure 2d

The Contamination factor of Fe, Cu, Zn, Sr, Y, Ag, In, La, Ce, Pr, Nd, Dy, Ho, Er, Sr, Tm, Ca, Mn, Mo, Sm, Gd and Tb fall into CF>1<3 which shows moderate contamination factor. Er Shows 3 ≥ Cf< 6 which is considerable contamination factor.

Cd Shows CF > 6 which is very high contamination factor (Table 2).The graphical illustration of these contamination factors are shown in Figures 3a,3b,3c. and 3d.

Table 2: Contamination Factors.

ELEMENT	Mean	Crust(Taylor and Mc lennan 1995	Contamination factor
Ti	0.217	0.39	0.56
Li	17.62	20	0.88
Be	1.76	3	0.59
B	3.83	15	0.26
Na	0.088	2.89	0.03
Mg	0.94	1.33	0.71
Al	1.52	8.04	0.19
K	0.083	2.8	0.03
Ca	8.78	3	2.93
Sc	5.25	13	0.4
V	58.4	110	0.53
Cr	4.83	85	0.07
Mn	1431	600	2.39
Fe	5.64	3.5	1.61
Co	15.54	17	0.91
Ni	19.2	50	0.38
Cu	45.63	25	1.83
Zn	125	71	1.76
Ga	15.2	17	0.89
As	1.2	1.5	0.8
Rb	2.87	112	0.03
Sr	419.5	350	1.2
Y	30.2	22	1.37
Zr	5.6	190	0.03
Nb	1.8	12.5	0.14

ELEMENT	Mean	Crust(Taylor and Mc lennan 1995)	Contamination factor
Mo	3.27	1.5	2.18
Ag	0.089	0.05	1.78
In	0.06	0.05	1.2
Sn	3.47	5.5	0.063
Sb	0.15	0.2	0.75
Cs	0.4	0.48	0.83
Ba	58.11	550	0.11
La	40.71	30	1.36
Ce	90.22	64	1.41
Cd	0.96	0.098	9.8
Pr	10.83	7.1	1.53
Nd	46.57	26	1.79
Sm	10.48	4.5	2.33
Eu	2.86	0.88	3.25
Gd	8.98	3.8	2.36
Tb	1.28	0.64	2
Dy	6.88	3.5	1.97
Ho	1.23	0.8	1.54
Er	2.89	2.3	1.26
Tm	0.33	0.33	1
Yb	2	2.2	0.91
Lu	0.23	0.32	0.72
W	0.33	2	0.17
Pb	5.48	16	0.34
Th	4.37	10.7	0.41
U	0.81	2.8	0.29

DISCUSSION

Metallic pollutants in environmental samples portend a great risk to human wellbeing. Heavy metal contamination has devastating effects on terrestrial ecological balance as well as diversity of aquatic organisms (Matoka *et al.,* 2014). Agriculture which is the main stay of the people in the study area plays a major role in the socio-economic empowerment among inhabitants.

The detection of high concentration of some metals in some samples of edible vegetation consumed by people in the study area present a health risk. Concerns regarding nutritional provision while guarding against bio concentration of heavy metals have been expressed by some authors (Matoka *et al.,* 2014).

Heavy metals are bio-concentrators and transferred to humans by natural processes (Ruqia *et al*., 2015). Vegetation contains both essential and non-essential toxic elements with various levels of contamination posing a major threat to human health. Some of the metallic pollutants are explained below:

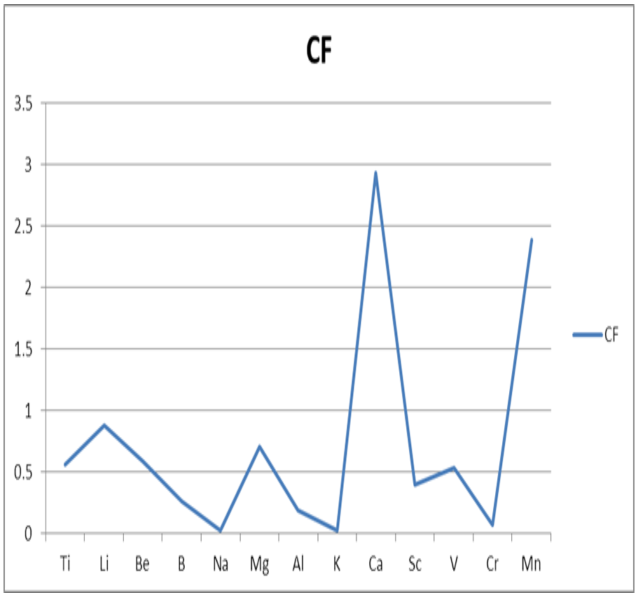

Figure 3a

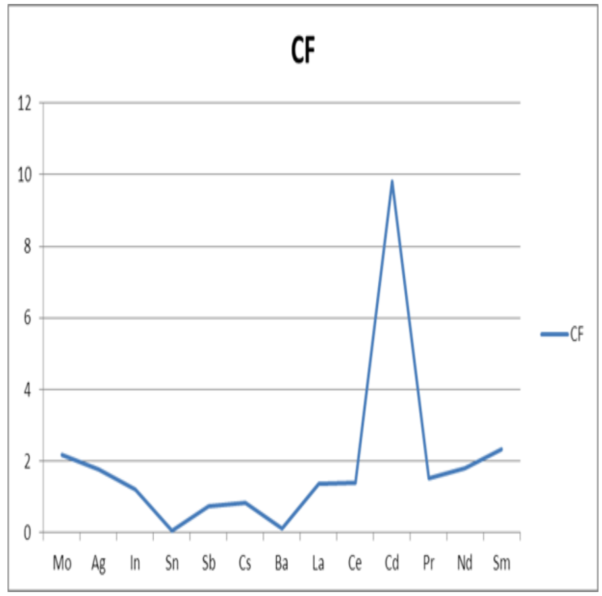

Figure 3b

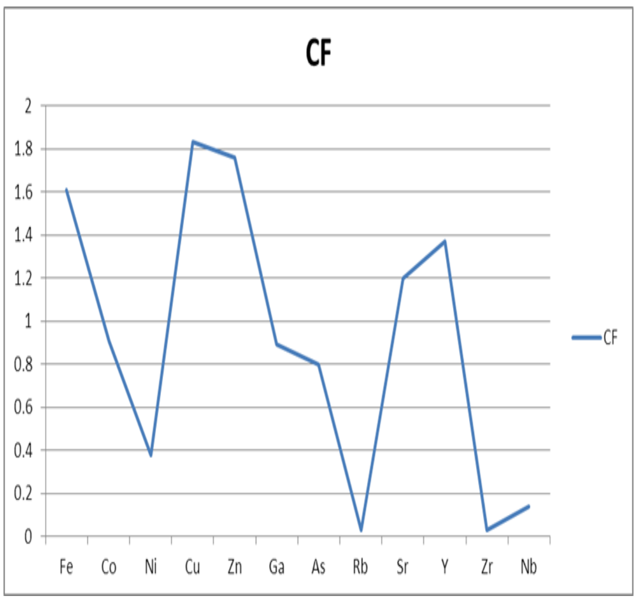

Figure 3c

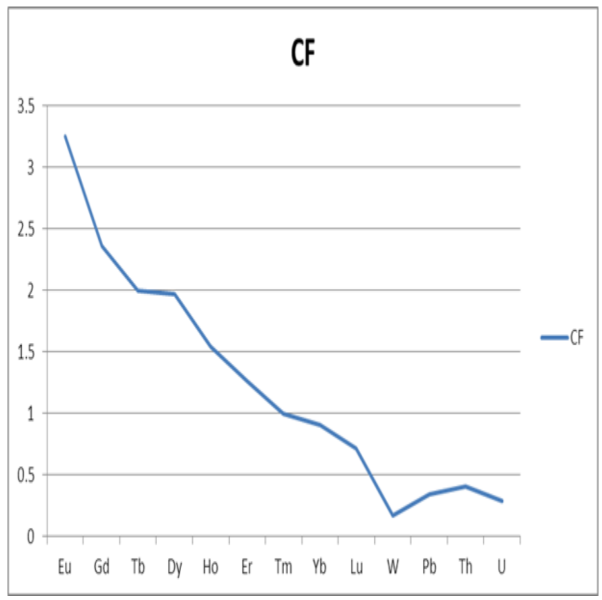

Figure 3d

Manganese: The values from geochemical data of the rock samples in the study area for Mn range from 639ppm to 4610ppm (R3) with an average concentration of 1431ppm. The average concentration of Mn in the study area is 2 ½ times higher than average crustal values (Taylor and Mclennan (1995). Comparison between the average value of Mn and some elements illustrated that concentration decreased from Mn>Sr>Ba> Cu >Pb> As > Mo > Cd > Mg. The geo-accumulation index of Mn in the rock samples range from (0.21 – 1.54), thereby categorizing it as moderately polluted. However, the contamination factor (2.39) illustrates that it has a moderate contamination factor. The concentrations of Mn observed in the water samples range from 0.0001mg/l to 0.0044mg/l, which are lower than WHO permissible limits (Table 3). The concentrations of Mn in the vegetation samples observed range from 16.8mg/kg to 306 mg/kg, with an average value of 209.25 mg/kg (Table 4). The bio concentration factor of Mn with respect to rock is 0.14, thereby categorizing it to have a low bio concentration factor. However due to its abundance in the rock substrate the values observed in the vegetation samples were significant. A comparison with WHO permissible limit (200mg/kg) indicated that three vegetation samples were higher than the permissible limits.

The element Mn is an essential element, activating some of the enzymes involved in the tricarboxylic acid cycle and a center for manganese cluster complexes in the oxidation of water to oxygen. Deficiency in Mn can be noticed in the vegetation from concentration levels less than 10mg/kg. It is required in trace amounts by all known living organisms. However, it is a neurotoxin. Toxic levels of Mn observed in some of the vegetation samples in the study area imply that the inhabitants are at risk of kidney disease and neurological damage.

Strontium: The values from the geochemical analysis of the rock samples for Sr range from 48.5 ppm to 2060 ppm (R3) with an average of 419.5 ppm. The average value of Sr (rock) in the study area is 1 1/3 times higher than the average crustal values (Taylor and Mclennan 1995, Wedepohl 1995, Rudnick and Gao 2003). A comparison of the average concentrations of some elements show Mn>Sr> BA > Cu >Pb> As > Mo > Cd. Geo-accumulation values of Sr range from 0.03 to 1.18, thereby categorizing it as slightly polluted. However, the contamination factor (1.2) is moderate contamination factor. The concentrations of Sr in the water samples range from 0.00004 mg/l to 5 mg/l which are all bellow the permissible limits set by WHO (Table 3). The concentrations of Sr observed in the vegetation samples range from 51.5mg/kg to 515mg/kg, the average value is 182 mg/kg which are all bellow the required permissible limits by WHO (Table 4). Stable isotopes of Sr usually don't pose a significant health threat. However, radioactive Sr can cause various bone disorders and cancers.

Table 3: WHO Permissible Limits.

Element	Range of conc. of water samples	Max . Conc in Water samples	WHO permissible limit
Nickel	<0.0003 to 0.001 mg/l	0.001mg/l	0.2 mg/l
Chromium	<0.0005 to 0.0005mg/l	0.00005mg/l	0.1 mg/l
Cadmium	<0.00001 to 0.0001mg/l	0.0001mg/l	0.01 mg/l
Copper	0.0005 to 0.0017 mg/l	0.0017 mg/l	2 mg/l
Lead	< 0.00001 to 0.0112mg/l	0.0112mg/l	0.1 mg/l
Iron	< 0.01 - 0.69 mg/l	0.69 mg/l	0.1 mg/l

Table 4: Bio-Concentration/WHO Permissible Limits.

Element	Range of conc. in vegetation samples	Max . Conc in vegetation samples	WHO permissible limit
Nickel	0.81 to 17 mg/kg.	17 mg/kg.	10mg/kg
Chromium	0.59 to 7.64 mg/kg	7.64 mg/kg	1.3mg/kg
Cadmium	0.2 to 4.42 mg/kg	4.42 mg/kg	0.3mg/kg
Copper	12 to 36.4 mg/kg	36.4 mg/kg	10mg/kg
Lead	4.23 to 964 mg/kg	964 mg/kg	10mg/kg
Iron	165 to 29,100 mg/kg.	29,100 mg/kg	50mg/kg
Selenium	<0.01 to 2.26 mg/kg	2.26 mg/kg	0.04ug/kg
Zinc	6.9 to 86.6 mg/kg	86.6 mg/kg	50mg/kg
Manganese	16.8 to 306 mg/kg	306mg/kg	200mg/kg

Copper: The values from rock samples geochemical analysis for Cu in the study area range from 23.9 ppm to 91 ppm, with an average value of 45.63ppm. The average value of Cu in the study area is higher than average crustal values (Taylor and Mclennan 1995, Wedepohl 1995, Rudnick and Gao 2003). The geo-accumulation index of Cu in the rock samples range from 0.19 to 0.73 thereby categorizing it as slightly polluted. However, the contamination factor 1.83 illustrates that it has a moderate contamination factor. The concentrations of Cu in the water samples range from 0.002mg/l to 0.0017mg/l, which are all lower than permissible levels recommended by WHO (Table 3). The bio-concentration factor of Cu with respect to rock in the vegetation samples was 0.48 thereby categorizing it to have low bio concentration factor. The abundance of Cu in the rock when compared to average crustal values, slightly polluted and moderate contamination factors accounted for the significant concentrations of Cu in the vegetation samples in spite of having a low bio concentration value. The concentrations of Cu in the vegetation samples range from 12mg/kg to 36.4mg/kg. All the vegetation samples in the study area were observed to be higher than WHO permissible limits.

Cu is an essential micronutrient required for the growth of plants and animals. The presence of copper in plants is important for seed production, disease resistance and regulation of water. However, high concentrations of Cu may have adverse effects on humans that consume the plants and animals. High concentrations of Cu above permissible limits recommended by WHO indicate that the inhabitants of the study are at risk of renal dysfunction, metal fumes fever, hair and skin discoloration, dermatitis and respiratory tract diseases.

Chromium: The values from geochemical analysis of rock samples for Cr range from 1 ppm to 12ppm, with an average concentration of 4.83ppm. The average concentration of Cr in the study area is lower than average crustal values (Taylor and Mclennan 1995, Wedepohl 1995, Rudnick and Gao 2003). The geo-accumulation values of Cr of the rock samples range from 0.01 to 0.03 which is categorized slightly polluted, also it indicated low contamination value. The concentrations of Chromium in the water samples range from 0.0005 mg/l to 0.005mg/l which were all below the WHO permissible limits (Table 3). The concentrations of Cr in the vegetation samples range from 0.59mg/kg to 7.64mg/kg, with an average of 1.3mg/kg. The bio-concentration factor of Cr in the edible vegetation samples with respect to rock is 0.93 indicating a low accumulation factor. The concentrations of four vegetation samples were observed to be higher than the WHO permissible limits(Table 4).

Toxic levels of Cr observed in some vegetation samples in the study area indicate that the inhabitants of the study area are at risk of carcinogenic diseases, kidney disease, Fanconi syndrome, lipid peroxidation of the heart, liver and spleen.

Lead: The values from geochemical analysis of rock samples for Pb range from 2.08 ppm to 13.5 ppm, with an average value of 5.48 ppm. The average concentration of Pb in the study area is lower than average crustal values (Taylor and Mclennan 1995, Wedepohl 1995, Rudnick and Gao 2003). The geo-accumulation values of Pb of the rock samples range from 0.03 to 0.17, thereby categorizing it as slightly polluted, also has a low contamination factors (0.34).The concentrations of Pb obtained from the water samples range from 0.00001mg/l to 0.0112 mg/l which are less than WHO permissible values (Table 3). The concentration of Pb in the vegetation samples range from 4.23 mg/kg to 964 mg/kg having an average value of 360.76 mg/kg. The bio- concentration value of the vegetation samples with respect to rock is 65.83 which are very high; this is shown in the significant concentrations seen in the edible vegetation samples. The concentrations of five of the vegetation samples were observed to be higher than the WHO permissible limits (Table 4).

Pb is a toxic metal which interferes with a variety of body processes and is toxic to many organs and tissues including; heart, bones, intestines, kidneys, reproductive system and nervous system. Pb poisoning is one of the oldest known work and environmental hazard. Toxic levels of Pb above WHO permissible limits indicate that the inhabitants of the study area are at risk of hypertension, Fanconani syndrome brain damage and central nervous disorder .

Zinc: The values from geochemical analysis of rock samples for Zn range from 4.5ppm to 161 ppm with an average of 125ppm. The average concentration of Zn was observed to be higher than average crustal values ((Taylor and Mclennan 1995, Wedepohl 1995, Rudnick and

Gao 2003) The geo-accumulation values of Zn range from 0.01 to 0.45 thereby categorizing it as slightly polluted. However, the contamination factor (1.73) indicated moderate contamination factor. The concentrations of Zn in water samples range from 0.0005mg/l to 0.062mg/l, and they were observed to be below WHO permissible limits (Table 3). The concentrations of Zn in the edible vegetation samples range from 6.9mg/kg to 86.8mg/kg, with an average of 53.38mg/kg. The bio- concentration factor of Zn with respect to rock is 0.43 which categorized Zn in the vegetation samples as low bio-concentration factor. Four vegetation samples were observed to be above WHO permissible limits (Table 4) .

Zn is an essential element perceived by the public today as being of exceptional biologic and public health importance. Zn deficiency causes growth retardation and many diseases, while excessive consumption can cause axtaxia, legarthy, and copper deficiency. High concentrations of Zn in some of the vegetation samples above permissible limits indicate that the inhabitants of the study area are at risk of kidney disease and neurotoxins.

Cadmium: The values from geochemical analysis of rock samples for Cd range from 0.23ppm to 2.38 ppm, having an average value of 0.96ppm. The average concentration of Cd was observed to be higher than crustal values (Taylor and Mclenann 1995, Rudnick and Gao 2003) The geo-accumulation values of Cd range from 0.05 to 0.49 which categorized it as slightly polluted. However, the contamination factor of Cd (9.8) showed a high contamination factor. The concentrations of Cd in the water samples range from 0.00001 mg/l to 0.00002 mg/l which were observed to be below WHO permissible limits (Table 3). The concentrations of Cd in the vegetation samples range from 0.2mg/kg to 4.42 mg/kg, with an average value of 1.72 mg/kg. The bio accumulation of Cd (1.79) showed a high accumulation factor. The abundance of Cd when compared with crustal values, high contamination factor and high bio-concentration factor all account for the significant amount of Cd observed in the edible vegetation. The concentrations of Cd in all the vegetation samples were observed to be higher than WHO permissible limits (Table 4).

Cd is an extremely toxic industrial and environmental pollutant classified as human carcinogen(group 1) –Wikipedia.org 19th September 2016. Toxic levels of Cd in the vegetation samples in the study area imply that the inhabitants are at risk of kidney disease, lipid peroxidation in the heart, liver and spleen, hypertension, and renal dysfunction

Nickel: The values from geochemical analysis of rock samples for Ni range from 0.1 ppm to 79.6ppm with an average of 19.2 ppm. The average value of Nickel is lower than crustal averages (Taylor and McLennan 1995, Rudnick and Gao 2003). The geo-accumulation index ranges from 0.1 to 0.32 thereby categorizing it as slightly polluted, also the contamination factor of Ni (0.38) indicates low contamination. The concentration of Ni in water samples range from 0.0003 mg/l to 0.001 mg/l which were observed to be lower than WHO permissible limits(Table 3). The concentrations of Ni in edible vegetation samples range from 0.81 to 17 mg/kg with an average of 4.92 mg/kg. The bio concentration of nickel (0.31) shows low concentration (Table 4).

The low concentration of Ni when compared with crustal values, low contamination factor and low bio-concentration resulted in the not very significant amounts detected in the vegetation. Consequently, only one vegetation sample was observed to be higher than permissible levels of Ni. Toxic levels of Observed in the study area indicate that the inhabitants of the study area are at risk of loss of vision, skin irritation, and heart and lung failure.

Iron: The values of geochemical analysis of rock samples for Fe range from 1.38 ppm to 9.25 ppm with an average of 5.64 ppm. The average value of Fe is above crustal values (Taylor and Mclennan 1995) .The geo accumulation index of Fe range from 0.08 to 0.38) thereby categorizing it as slightly polluted, also the contamination factor (1.61) indicates it has moderate contamination factor. The concentration of Fe in water samples range from 0.01mg/l to 0.69mg/l , only one sample of Fe was seen to be higher than WHO permissible limits (Table 3). The concentrations of Fe in vegetation samples range from 165 mg/kg to 29,100 mg/kg. The bio-concentration factor of Fe shows high concentration. All the vegetation samples were observed to have Fe values higher than WHO permissible limits

Fe is the most abundant essential constituent for plants and animals However at high concentrations, it causes anemia and neurodegenerative conditions in humans. High concentrations of Fe above WHO permissible limits indicate that the inhabitants of the study area are at risk of lipid oxidation, myocardial infarction, renal decline .

These elements which have bio-accumulated on the vegetation and water usually end up being consumed by the inhabitants of the study area.

CONCLUSION

The geochemical results obtained from the rock samples in the study area concentration show that Mn (4610 ppm) has the highest concentration in the rock samples collected. According to their decreasing order of concentration, the results showed Mn>Sr>Cu>Ba>Ni > Co > Fe >Pb> As> Mo > Cd > Mg. The results obtained for heavy metals concentration in water samples collected showed that Sr (> 5000 ug/l) showed the highest concentration. The results obtained for heavy metals concentration in vegetation samples collected showed Mn (5690 ppm) the highest accumulation. The Heavy metal showing the highest bio accumulation factor with respect to rock is Pb (63.53). The order of the decreasing Bio concentration factors is Pb> B > Mo > Cd > As >> Cr > Cu > Mg > Ni >Sr> Zn > Fe.

A comparison of the average element concentrations in the rock samples and crustal averages illustrates that some elements have high enrichment. Some edible vegetation samples concentrations for Ni, Cr, Cd, Cu, Pb, Fe, Se, Zn, and Mn were above permissible limits recommended by WHO .The health implications on the inhabitants off the study area are shown.

The Study area is known for agriculture, the soils that are used for this are mainly formed from weathered rock which although they disintegrate will still bear a remarkable chemical resemblance with the source rocks. These heavy and trace element rich soils would only result in bio-concentration of these elements in the agricultural produce which in turn would be consumed by animals and humans thereby posing a health risk.

The study showed that the area has a high potential of bio accumulation of certain elements in the vegetation. The effects of the elemental concentrations were detected in water and vegetation increase by bio accumulation. However, visits to the medical facilities in the study area could not highlight major ailments that could be associated with chronic trace element accumulation disorder. The diseases reported were high blood pressure, chest pains, very cases of liver and kidney failures. The authors are of the view that due to the non-existence of any standard health facility in the area, cases of the potential health issues as identified in this work could not have been treated in the study area, and that could account to lack of records of such cases.

Medical evaluations from health records of the area through medical practitioners could not be retrieved because the standard hospitals are not available in the study area. It is recommended that further studies using geochemical analysis of soil and blood samples of inhabitants of the area will provide a well-coordinated toxicity level monitoring in order to reduce the chronic impact on the health of the inhabitants of the study area. It is also recommended that well equipped health facilities to manage the potential health hazards in the study area should be constructed.

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