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Petrography and Geochemical Evaluation of Major and Trace Elements Concentrations in the Stream Sediments of Itagunmodi and its Environs, Southwestern Nigeria

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Abstract

Accumulation of major and trace elements in the stream sediments of the Itagunmodi area southwestern Nigeria was investigated with a view to ascertain the levels of the elements that occur as contaminants in the study area. A total of nine stream sediments and a soil sample from the mining site were collected from the study area. The samples were geochemically analyzed, using the ICP-AES instrumentation techniques. From the result, some major and trace elements were selected for study, and they include; Aluminum (Al), Manganese (Mn), and Iron (Fe) with mean concentration values of {2.02 %, 1226.6% and 4.70%} respectively; They are known to have high anomalous value in all the locations in the order; Mn > Fe> Al. Cobalt(Co),Copper(Cu),Vanadium(V) , and Chromium(Cr) with mean concentration values of {23.13ppm, 71.61ppm, 133.80ppm and 108.24ppm} respectively amongst others are known to be the most distributed trace elements contaminants in the area The result of the contamination factor shows that Co, Cu, V and Cr have high contamination values of 60.55, 74.99, 53.89 and 56.68 respectively. It can therefore be concluded that some major part of the area are highly contaminated with these elements

Keywords: Geogenic, Mining, Biotite, Hornblende and Venadium

1 Introduction

Within the last quarter of the last century, there were much interest on environmental pollution and in particular about geochemical distribution and fate of heavy metals in both water and sediment phases of urban drainage system. Though significant advances had been made in the developed regions of the world, there are still increasing concerns about

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the impacts of urbanization, agricultural, mining and industrial activities on drainage networks in the developing regions of the world, especially in areas with inadequate land use planning and proper waste disposal and management systems *(*Mombeshora *et al.,* 1990). Though sediments are said to represent the ultimate sinks for heavy metals in the environment (Gibbs *et al.,* 1977), changing physio-chemical and environ-mental conditions may lead to remobilization and release of sediment-bound metal pollutants into the water column and consequently into the trophic levels of the food chain within an aquatic environment with serious health and environmental consequences. The environment impact of mining includes erosion, digging of sinkholes, loss of biodiversity, and contamination of soil, groundwater and surface water by chemicals from mining processes. In some cases, additional forest logging is done in the vicinity of mines to increase the available room for the storage debris and soil. Besides creating environmental damage, the contaminations resulting from leakage of chemicals also affect the health of the local population. Mining companies in some countries are required to adhere to environmental and rehabilitation codes, ensuring the area mined is returned to its original state. Some mining methods may have significant environmental and public health effects. The mining sector is responsible for some of the largest releases of heavy metals into the environment of any industry. It also releases other air pollutants including sulfur oxides in addition to leaving behind tons of waste tailings, slag, and acidic materials. Occupational and environmental exposure to heavy metals, silica, and asbestos can occur during mining and milling operations. The smelting process (extracting the metal from the ore) is associated with the highest exposures and environment releases. Erosion of exposed hillsides, mine dumps tailings dams and resultant siltation of drainage, creeks and rivers can significantly impact the surrounding areas, a prime example being the giant ok Tedi Mine in Papua New Guinea. In areas of wilderness, mining may cause destruction and disturbance of ecosystem and habitats in areas of farming it may disturb or destroy productive grazing and croplands, in urbanized environments mining may produce noise pollution, dust pollution and visual pollution. This research work is to investigate the geochemical assessment of major and trace element profiles of urban drainage network involving stream sediment samples within Osun metropolis, Southwestern Nigeria. The overall evaluation is expected to give an insight into vulnerability of urban drainage networks in a typical developing region in response to poor sanitation and waste disposal facilities and other anthropogenic activities within the populated urban catchment of a developing country. The study area lies approximately on latitude $7^0$34’N and Longitude 4^0 37’E (Fig.1) within the basement complex of south western Nigeria. The study area is easily accessible by complex road networks of major and minor roads as well as footpath linking one sampling point to the other and the study area is very close to towns such as Ile-Ife, Ilesa and Modakeke all in Southwestern, Nigeria.The climate is sub-humid tropical with average annual rainfall 1348.4mm. The area is well drained by rivers Awoyaya and Erele which flow in an approximately N-S direction. The drainage pattern is dendritic. The tributary streams take their courses from the surrounding hills

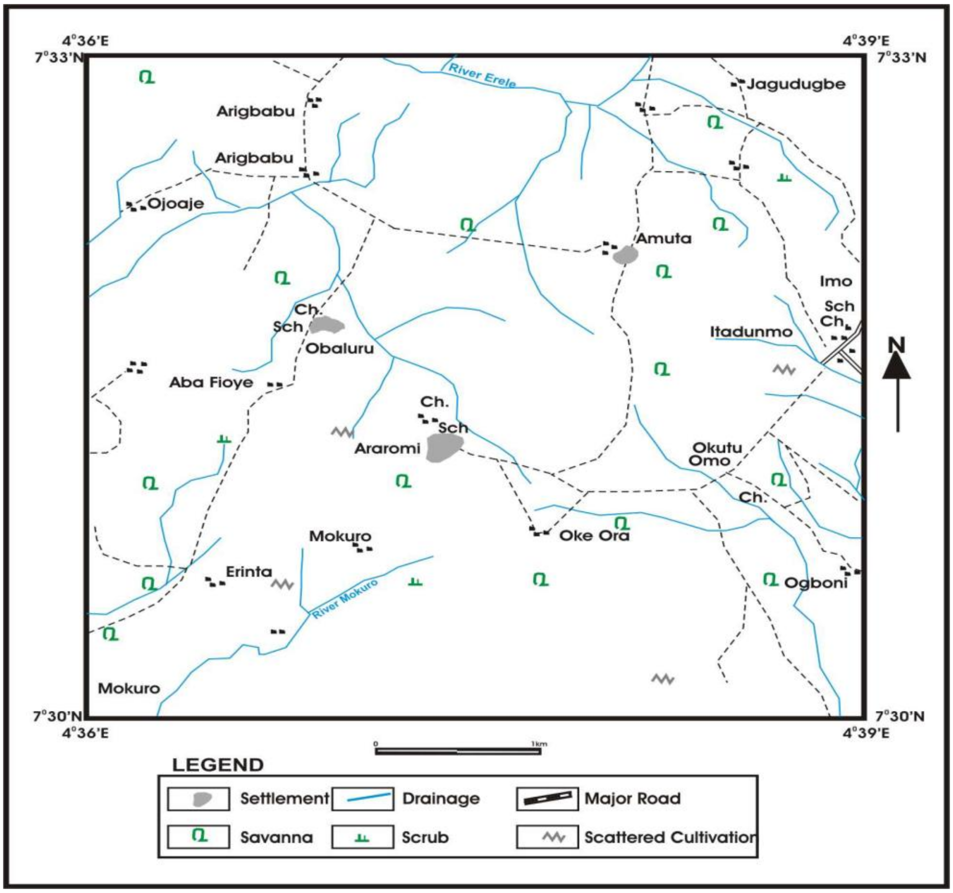

Figure 1: Location and drainage map of the study area.

2 Methodology of Study

Systematic geological mapping and stream sediment sampling of first order streams in other to represent weathered rocks in the drainage system was carried out followed by thin section Petrographic studies of fresh whole rock samples was carried out. Ten stream sediments samples were then analyzed for major and trace elements using inductively-coupled plasma atomic emission spectrophotometry (ICP-AES), at ACME Laboratory Vancouver Canada. The geochemical analytical procedure involves addition of 5ml of Perchloric acid (HClO4), Trioxonitrate (V) $HN0_3$ and 15ml Hydrofluoric acid (Hf) to 0.5gm of sample. The solution was stirred properly and allowed to evaporate to dryness after it was warmed at a low temperature for some hours. 4ml hydrochloric acid (HCl) was then added to the cooled solution and warmed to dissolve the salts. The solution was cooled; and then diluted to 50ml with distilled water. The solution is then introduced into the ICP torch as aqueous - aerosol. The emitted light by the ions in the ICP was converted to an electrical signal by a photo multiplier in the spectrometer, the intensity of the electrical signal produced by emitted light from the ions were compared to a standard (a previously measured intensity of a known concentration of the elements) and the concentration then computed.

3 Geological Setting, Field Description and Petrography

Nigeria is underlain by Precambrian basement complex rocks, younger granites of Jurassic age and Cretaceous to Recent sediments. The basement rocks occupy about half of the land mass of the country, and is a part of the Pan-African mobile belt lying between the West African and Congo cratons (Black,1980). There are however contrasting documentation of the evolution of the basement rocks. However loosely, the basement is grouped into three major groups lithostratigraphically viz: the Migmatite-Gneiss Quartzite Complex: comprising biotite and biotite hornblende gneisses, quartzites and quartz schist. Schist Belts, comprising paraschists and meta igneous rocks, which include schists, amphibolites, amphibole schists, talcose rocks, epidote rocks, marble and calc-silicate rocks. They are mainly N-S to NNE-SSW trending belts of low grade supracrustal (and minor volcanic) assemblages. Other secondary rocks used in delineating them are carbonates, calc gneiss and banded iron formation (BIF) and Older granites, which include granite, granodiorite, diorite charnockite, pegmatites and aplites. The Itagunmodi study area is generally underlain by four main crystalline rocks which includes Amphibolite, Granite gneiss, Granite and Quartzite (Fig. 2a). The Amphibolite is one of the major rocks found in the study area. It is a name given to a metamorphic rock consisting mainly of amphibole, especially hornblende and actinolite . Amphibolites found in this area is typically dark-green to black in colour with a weakly foliated or schistose (flaky) structure. It is a group of rocks composed mainly of amphibole, plagioclase feldspars, microcline, quartz, hornblende and with little or no quartz, as observed under the thin section (Fig.2b [i-ii]), with the hornblende having the highest percentage in all . The amphibolites occupy a small portion in the Northwestern part of the study area and it occurs as low lying outcrops within the riverbeds making geologic structures invisible. The Granite gneiss in the study area displays a structure where the minerals are arranged into bands of mafic minerals and more felsic minerals and it occupies a little portion in the Northwestern part of the study area. The rock is coarse in texture, having a mixture of light and dark coloured minerals. The light coloured mineral being predominant and it is mostly composed of quartz, biotite, plagioclase, Microcline, K-feldspar with quartz having the highest percentage under the thin section. (Fig 2b [iii-iv]) The Granitic rock is widely distributed throughout the study area. It is a common type of intrusive, felsic, igneous rock which is granular and phaneritic in nature. The granite rock in the study area consists of quartz, mica, and feldspar (rich in potassium) and can be pink to grey in colour, depending on their chemistry and mineralogy. Granite in this area are generally grey in colour and very massive (lacking internal structure), the granite in the study area has gained widespread use as a construction stone. The *quartzite* samples are mostly white in color but some ferruginized varieties display reddish bands. They consist mainly of quartz which occurs as irregular fine to medium grained crystals with interlocking grains of muscovite. The quartzite occurs as low-lying outcrops, it occupies the Southwestern portion of the study area and they are fine to medium grained, display incipient schistocity and contain quartz, microcline, and muscovite with accessory haematite.

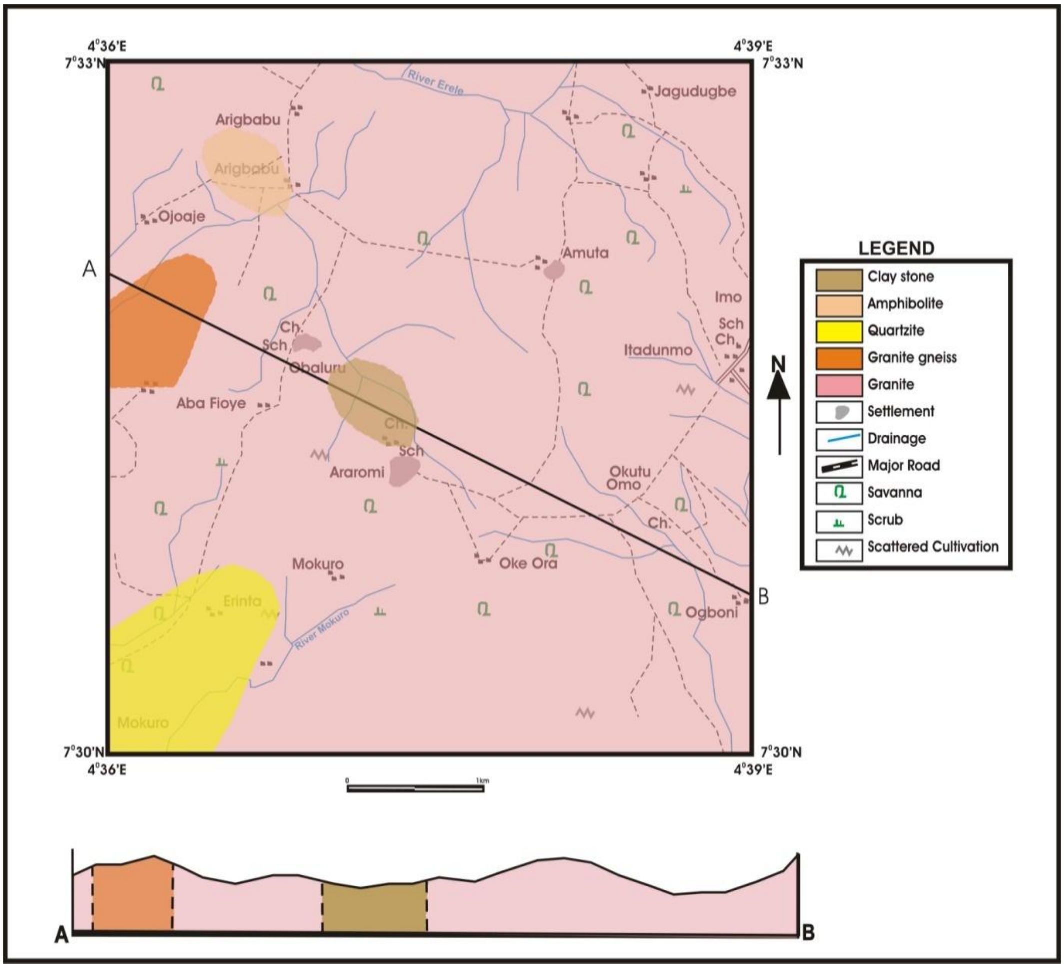

Figure 2a: Geological Map of Itagunmodi study area

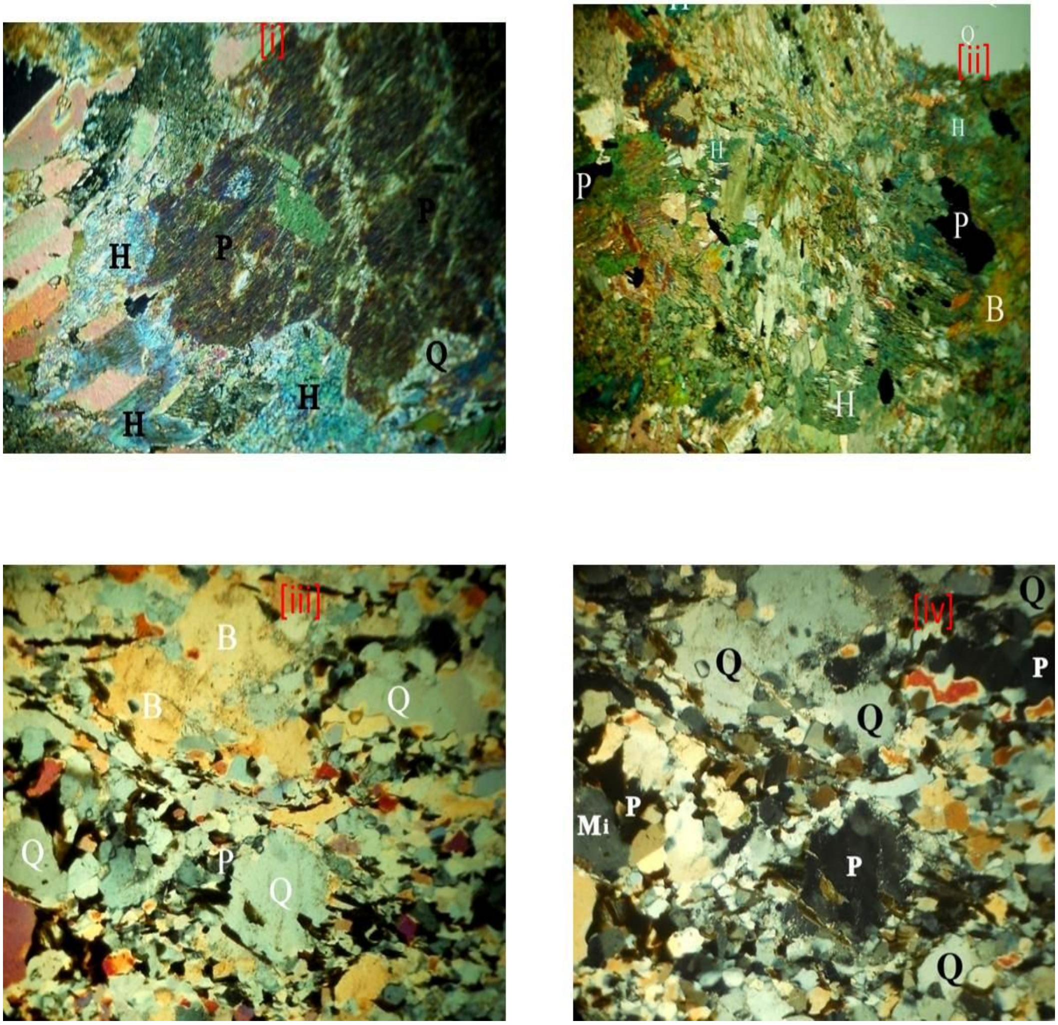

Figure 2b: [i] Photomicrograph of Amphibolite under the transmitted light showing Hornblende(H), Plagioclase (P), Biotite (B), Microcline(Mi). [ii] Photomicrograh of Amphibolite under the transmitted light showing Plagioclase (P), Hornblende(H) and Biotite (B). [iii] Photomicrograph of Granite Gneiss under the transmitted light showing Microcline (Mi), Quartz, (Q) and Plagioclase (P.) [iv] Photomicrograph of Granite Gneiss under the transmitted light showing Quartz (Q), and Biotite (B).

4 Result and Discussion

The analytical results for the Major elements are presented in Tables1 [a-b]. Table.1a shows the major elements concentration and Table.1b shows the statistical summary of major elements with respect to their average shale content respectively. From the analytical data and the various statistical plots, the graphs below show the distribution of the major elements in different locations for instance the Location- ITA-S7 where the Amphibolites rock occur was found to have the highest concentration of most of the major elements (Fig. 3a and 3b) . Iron oxide {FeO} ranges from (0.35% - 12.80 %) in concentration having mean concentrations of (4.7070 %). MgO has concentrations ranging from (0.02% - 0.61 %) and a mean concentration of (0.2690%). It can be suggested that the FeO and MgO present in the stream sediment may have originated through erosion, leaching and other related weathering activities, of the ferromagnesian minerals present in the Amphibolites. Calcium oxide {CaO} is one of the numerous elements that may probably have originated from the calcium rich Amphibole mineral i.e hornblende with the chemical formulae {Ca_2 (Mg_4Al) (Si_7Al)} contained in the Amphibolite rocks at the Location-ITA-S7 of the study area. It ranges from (0.03% - 0.87%) with a mean value of (0.279%). It has its highest and lowest value at Location-ITA-S7 and Location-ITA-S8 respectively. Titanium {Ti}, has maximum concentration of (0.154%) at Location-ITA-S7 and minimum concentration of (0.03%) at Location-ITA-S8. Titanium {Ti} is of interest because it can normalize trace element data in soil profile reconstruction and it readily forms insoluble complexes and it is not lost during weathering process that transported it to where it was distributed . The phosphorus content shows a very high value of (0.28%) at the Location-ITA –S7 and a low value of (0.016%) at the Location-ITA-S8 location with a mean value of (0.2310%). Generally, It is observed that the aforementioned elements (FeO, MgO, TiO_2, P_2O_5 and CaO) have their highest and lowest distribution at Location-,ITA-S7 and Location- ITA-S8 respectively while Mn_2O_3 and Al_2O_3 in contrast record the highest amount of concentration at Location- ITA-9 (Fig 3c and 3d), both having values of (5074% and 4.29%). Manganese {Mn} concentrations range from {87.65% -5074 %) with a mean concentration of (1226%). having the highest value at the Location- ITA-9 and the lowest value at Location-ITA-S8. Its origin could be from the weathering of manganese bearing rocks such as the Amphibolites, ferromagnesian micas and iron clay minerals in the area. Aluminum {Al} ranges from (1.08% - 4.29%) with a mean value of (0.020%), The presence of this element in the study area may also have contributed to the accumulation of clay mineral in the central part of the study area, Aluminum is a conservative element and a major constituent of the clay minerals, present in the clay stone in the Northwestern part of the area.

Table 1a: Major element concentration of stream sediments of the study area (Wt. %).

Location	Mn_20_3	FeO	CaO	P_2O_5	MgO	TiO_2	Al_2O_3	NaO	K_2O	SO_3
ITA-S1	346.3	1.92	0.14	0.06	0.4	0.14	1.45	0.0067	0.34	<0.0004
ITA-S2	1593.6	3.99	0.15	0.07	0.17	0.08	1.49	0.008	0.13	<0.0004
ITA-S3	244.29	2.57	0.08	0.08	0.15	0.12	1.08	0.004	0.08	<0.0004
ITA-S4	1217.1	7.54	0.14	0.17	0.02	0.1	1.93	0.001	0.05	<0.0004
ITA-S5	293	2.77	0.08	0.06	0.25	0.11	1.53	0.0067	0.2	<0.0004
ITA-S6	1039	7.88	0.22	0.19	0.13	0.11	2.27	0.04	0.05	<0.0004
ITA-S7	1534.7	12.8	0.87	0.64	0.61	0.26	2.84	0.01	0.22	<0.0004
ITA-S8	87.65	1.15	0.03	0.04	0.07	0.05	1.15	0.001	0.04	<0.0004
ITA-S9	5074	0.35	0.55	0.6	0.35	0.22	4.29	0.003	0.08	<0.0004
ITA-S10	836.3	6.1	0.53	0.4	0.54	0.14	2.17	0.008	0.22	<0.0004

Table 1b: Statistical data of major elements concentration

	N	Minimum	Maximum	Mean	Standard deviation	Average shale
Mn_2O_3	10	87.65	5074.00	1226.5890	1457.86813	0.07
FeO	10	0.35	12.80	4.7070	3.85525	0.047
CaO	10	0.03	0.87	0.2790	0.27602	0.025
P_2O_5	10	0.04	0.64	0.2310	0.23120	0.6
MgO	10	0.02	0.61	0.2690	0.19964	0.074
TiO_2	10	0.05	0.26	0.1330	0.06308	0.0045
Al_2O_3	10	1.08	4.29	2.0200	0.96637	0.02
Na_2O	10	0.00	0.04	0.0088	0.01137	0.009
K_2O	10	0.04	0.34	0.1410	0.09994	0.025
SO_3	0	*	*	*	*	

*****= below detection limit

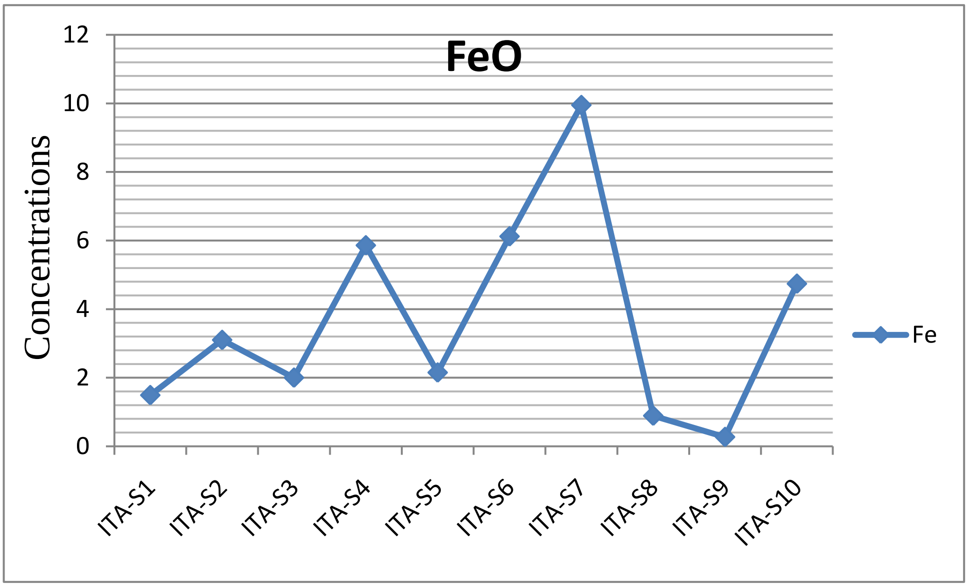

Figure 3a: Line diagram of FeO concentration

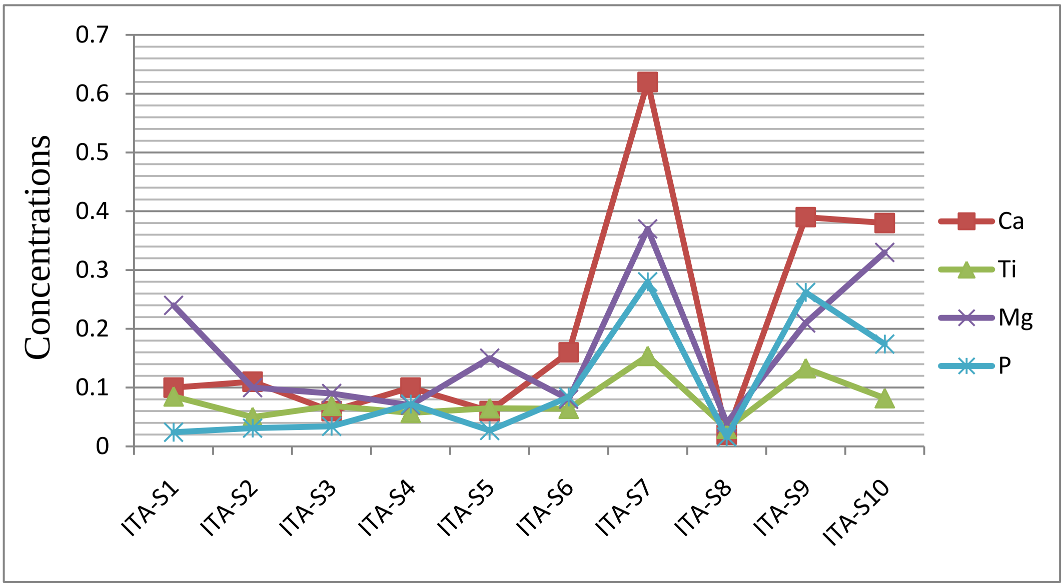

Figure 3b: Line diagram of CaO, TiO_2, MgO and P_2O_5

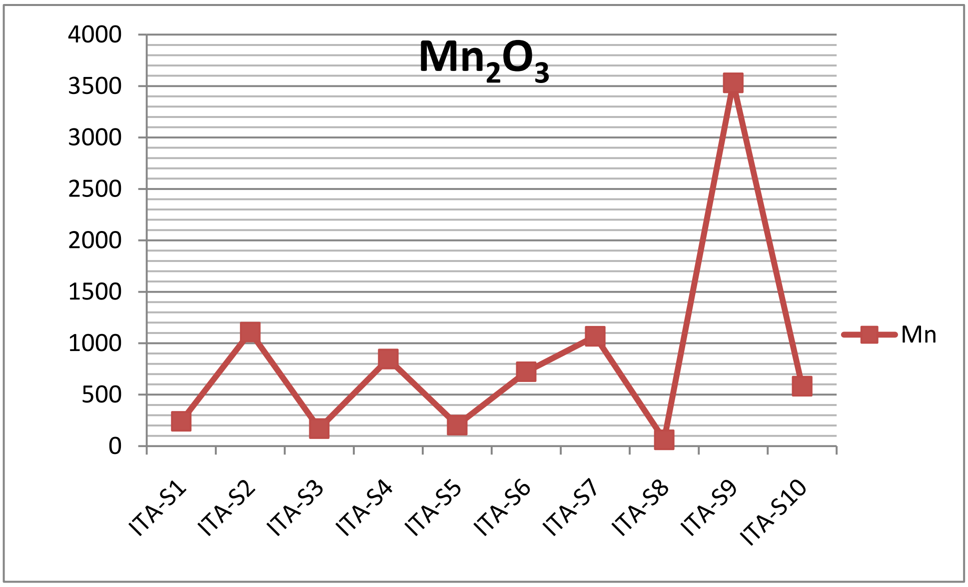

Figure 3c: Line diagram of Mn_2O_3 concentration distribution

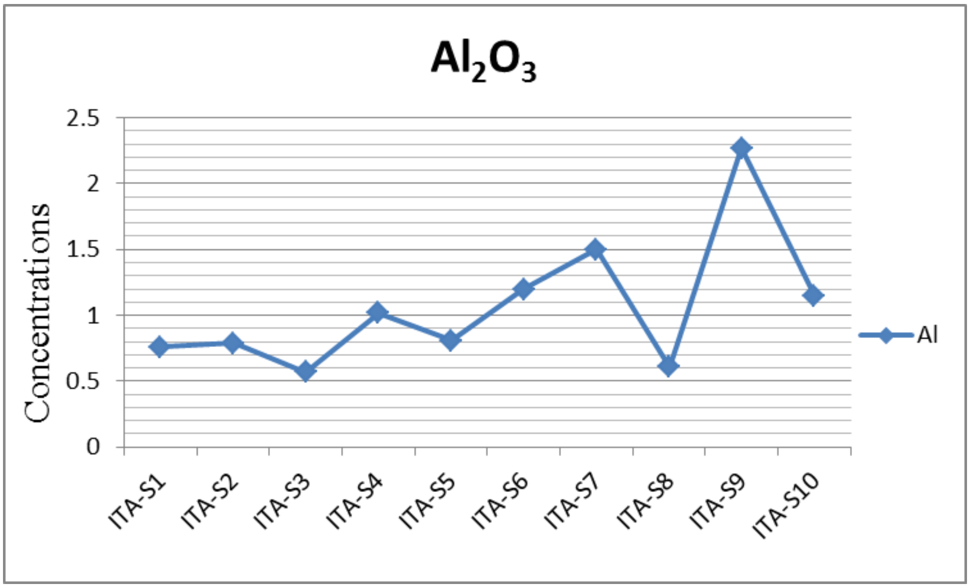

Figure 3d: Line diagram of Al_2O_3 concentration distribution

While the analytical results for the Trace elements geochemistry are presented in Tables [2a-2b]. The selected trace elements analyzed for include; Vanadium (V), Chromium (Cr), Manganese (Mn), Cobalt(Co), Nickel(Ni), Copper(Cu), Zinc(Zn), Gallium(Ga), Arsenic(As), Rubidium (Rb), Strontium(Sr), Zirconium(Zr), molybdenum (Mo),lead (Pb) and Tungsten (Y). The results of trace element analysis of the samples, the statistical summary of the concentration of the element and the distribution of trace elements in the study area are represented in Table. 2a and 2b respectively

Table 2a: Trace elements (ppm) in the study area

	Mo	Zn	Ag	Ni	Co	Mn	As	U	Au	Th	Sr	Cd
ITA-S1	0.16	33.8	5	7.3	7.1	241	0.3	0.3	1.8	5.7	6.9	0.02
ITA-S2	0.56	61.4	14	9.9	13.4	1109	2.3	0.5	2.2	5.1	9.2	0.04
ITA-S3	0.43	63	2004	20.5	5.3	170	0.4	0.9	14719	11.6	8	0.04
ITA-S4	0.9	75.2	20	25.1	21.6	847	1.3	0.9	4.9	3.4	11.9	0.03
ITA-S5	0.29	34.1	16	11.8	10	204	0.9	0.6	1.6	4.1	5.5	<0.01
ITA-S6	0.82	44.1	23	21.2	24.4	723	1.3	0.9	1.8	3.9	18.3	<0.01
ITA-S7	0.49	92.2	37	55.5	35.3	1068	1.6	0.7	2.3	4.4	90.2	<0.01
ITA-S8	0.39	16.4	17	7	2.1	61	<0.1	1	2.8	6.4	2.5	<0.01
ITA-S9	0.59	74	36	50.6	89.8	3531	2.6	1.6	2.7	4	109.7	0.13
ITA-S10	0.18	42.5	11	24.8	22.3	582	0.6	0.5	1	4.4	53.2	<0.01

Table 2a: Continued

Sb	Bi	V	La	Cr	Ba	B	W	Sc	Ti	Hg	Se	Te	Ga	Cs	Ge
0.05	0.11	31	16.8	26.7	91.6	<20	0.2	3.3	0.12	10	<0.1	<0.02	2.9	0.89	<0.1
0.12	0.14	59	18	51.9	91.9	<20	0.1	5	0.14	16	<0.1	<0.02	4.3	1.1	<0.1
0.06	0.17	90	32.2	184.5	55.7	<20	0.2	9.5	0.07	16	<0.1	0.03	4.7	0.65	<0.1
0.11	0.16	161	11.7	193	78.4	<20	0.5	12.2	0.05	12	<0.1	0.06	7.8	0.91	<0.1
0.03	0.26	56	19.6	53.1	78.4	>20	0.2	6.4	0.16	34	<0.1	0.02	4	2.15	<0.1
0.11	0.27	151	12.4	110.2	100.7	<20	0.5	12.9	0.05	34	<0.1	<0.02	8.8	1.69	<0.1
0.3	0.24	287	28.5	207.3	345.6	<20	0.1	16.6	0.07	27	<0.1	0.03	11	1.36	0.2
0.04	0.14	58	23.9	69.4	40.7	<20	0.1	6	0.06	38	<0.1	<0.02	4.4	0.98	<0.1
0.23	0.16	293	48.4	100.5	282.7	<20	0.2	25	0.15	49	<0.1	0.04	13.8	2.81	0.1
0.07	0.03	152	23	86.8	117.5	<20	0.1	7.4	0.06	9	<0.1	<0.02	6.4	0.75	0.1

Table 2a: continued

Hf	Nb	Rb	Sn	Ta	Zr	Y	Ce	In	Re	Be	Li	Pd	Pt
0.02	0.85	24.5	2.6	<0.05	0.6	7.11	38.4	0.02	<1	<0.1	3.2	<10	<2
0.02	0.71	18.1	2	<0.05	1.1	9.87	62.5	0.04	<1	0.2	3.4	<10	<2
0.05	0.58	8	3	<0.05	2	15.22	70.3	0.09	<1	0.4	1.7	<10	<2
0.06	0.64	5.1	3.6	<0.05	2.7	10.44	51	0.05	<1	0.6	2.3	<10	2
0.02	0.7	23.7	1.1	<0.05	0.8	11.89	42.1	0.03	<1	0.3	6.5	<10	3
0.08	0.7	5	1.9	<0.05	2.9	11.05	48	0.06	<1	0.5	2.5	<10	3
0.09	0.37	13.1	3.4	<0.05	2.5	25.46	101.6	0.05	<1	0.8	3.8	<10	3
0.03	0.52	6.3	0.8	<0.05	1	13.32	67.1	0.04	<1	0.3	1.6	<10	<2
0.12	2.18	16.9	3.6	<0.05	3.7	22.89	158.6	0.1	<1	1	4	<10	7
<0.02	0.62	14.1	1.7	<0.05	1.2	11.79	57.8	0.03	<1	0.4	2.9	<10	<2

Table 2a: continued

Location	Cu	Pb	As	Co	Ga	Sr	Cr	V	Ni	Zn	Rb	Zr	Y	Au
ITA-S1	34.01	8.81	0.3	7.1	2.9	6.9	26.7	31	7.3	33.8	24.5	0.6	7.11	1.8
ITA-S2	59.29	15.21	2.3	13.4	4.3	9.2	51.9	59	9.9	61.4	18.1	1.1	9.87	2.2
ITA-S3	112.4	14.17	0.4	5.3	4.7	8	184.5	90	20.5	63	8	2	15.22	14719
ITA-S4	82.36	11.91	1.3	21.6	7.8	11.9	193	161	25.1	75.2	5.1	2.7	10.44	4.9
ITA-S5	40.24	7.17	0.9	10	4	5.5	52.1	56	11.8	34.1	23.7	0.8	11.89	1.6
ITA-S6	54.71	10.31	1.3	24.4	8.8	18.5	110.2	151	21.2	44.1	5	2.9	11.05	1.8
ITA-S7	101	8.77	1.6	35.3	11	90.2	207.3	287	55.5	92.2	13.1	2.5	25.46	2.3
ITA-S8	32.92	11.61	<0.1	2.1	4.4	2.5	69.4	58	7	16.4	6.3	1	13.32	2.8
ITA-S9	149.2	11.39	2.6	89.8	13.8	109.7	100.5	293	50.6	74	16.9	3.7	22.89	2.7
ITA-S10	50.03	6.62	0.6	22.3	6.4	53.2	86.8	152	24.8	42.5	14.1	1.2	11.79	1

Table 2b: Statistical data of Selected Trace Elements

ELEMENTS	N	Minimum	Maximum	Mean	Std. Deviation	Average shale
Cu(ppm)	10	32.92	149.20	71.6160	38.67415	116.28
Pb (ppm)	10	6.62	15.21	10.5970	2.82055	8.59
As(ppm)	9	0.30	2.60	1.2556	.80795	2.3
Co (ppm)	10	2.10	89.80	23.1300	25.56439	87.7
Ga (ppm)	10	2.90	13.80	6.8100	3.51614	10.9
Sr (ppm)	10	2.50	109.70	31.5600	39.09624	107.2
Cr (ppm)	10	26.70	207.30	108.2400	64.82400	180.6
V (ppm)	10	31.00	293.00	133.8000	94.31720	262
Ni (ppm)	10	7.00	55.50	23.3700	17.10530	48.5
Zn (ppm)	10	16.40	92.20	53.6700	23.31290	75.8
Rb (ppm)	10	5.00	24.50	13.4800	7.32709	19.5
Zr (ppm)	10	0.60	3.70	1.8500	1.05751	3.1
Y (ppm)	10	7.11	25.46	13.9040	5.84488	18.35

Table 2c: Showing the correlation co-efficient of the trace element

	Cu	Pb	As	Co	Ga	Sr	Cr	V	Ni	Zn	Rb	Zr	Y
Cu	1												
Pb	.343	1											
As	.514	.405	1										
Co	.757	.038	.712	1									
Ga	.756	.053	.648	.903	1								
Sr	.699	.238	.538	.879	.875	1							
Cr	.611	.195	.035	.176	.491	.312	1	.					
V	.757	.135	.551	.839	.969	.920	.590	1					
Ni	.795	.139	.494	.797	.917	.927	.623	.979	1				
Zn	.793	.262	.563	.542	.669	.609	.746	.746	.796	1			
Rb	-.174	.365	-.028	.070	-.249	.089	-.626	-.220	-.123	.142	1		
Zr	.805	.213	.558	.773	.906	.630	.625	.833	.770	.680	.474	1	
Y	.756	.032	.475	.674	.778	.844	.539	.839	.895	.637	.101	.609	1

From the analytical results and the line diagrams shown, Cu ranges from (32.92 ppm - 149.20 ppm) with mean concentration of (71.616ppm), Co ranges from (2.10ppm -89.80 ppm) with a mean concentration of (23.13ppm), Sr ranges from (2.50ppm -109.7 ppm) with a mean concentration of (31.56ppm)and V ranges from (31ppm - 293 ppm) with a mean concentration of (133.8ppm) . They have their highest distribution at Location-ITA-S9, in the South-Eastern part of the study area (Fig. 5a and 5c). The major sources of these elements are from the mining operations. In the absence of specific industrial sources, runoff is the major factor contributing to elevated copper levels in river water *(*Nonnotte *et al., 1988)* Domestic waste water is also another major anthropogenic source of copper in waterways (*Isaac .,1997)* and the copper is released to the water as a result of natural weathering of soil in the area. As, Zr, Ga display the highest concentration values at the Location-ITA-S9 with values ranging from (0.3ppm - 2.6ppm, 0.6ppm -3.7ppm, 2.9ppm -13.80ppm) and mean concentrations (1.2556ppm , 1.8500ppm, 6.8100ppm) respectively (Fig 5b) , Arsenic {As} is a by-product from the mining of Au, Cu, Pb and Zn its presence was noted in all the analyzed samples from the study area, though at a moderately- low level. Variation in the overlying parent material may be the cause of the wide differences in the concentration between these classes of elements mentioned (As, Zr, Ga). Vanadium also has its concentration mainly distributed at the Northwestern part of the study area (Fig.5c). The various concentrations of elements Nickel {Ni}, Zinc {Zn}, Yttrium {Y} and Chromium {Cr} are graphically represented in the line diagram (Fig. 5d) they all seems to have their highest values at Location- ITA-7 .Au is an exceptional element in all. It is exceptional because it has the highest anomaly value of concentration at Location- ITA-3 with values ranging from (1ppm -14719ppm) in concentration. This element is highly abundant in the soil sample in this location but has a low concentration in the stream sediments of all other locations and its abundance in the soil may be as a result of the mining activities in the study area (Fig. 5e). *Fig 4[i,ii,iii,iv,v,vi,vii,viii ix,x,xi,xii]* Show the 2D geochemical maps for trace elements (Cu), (Pb), (As) , (Co) , (Ga), (Sr), (Cr) (V),(Ni), (Rb), (Zr) and (Y) respectively**.** It is observed from Table 2c and Figs 6{a-e} that a very strong correlation exist between the elements: Co and Cu, Ga and Co, V and Ga, Zr and Ga, Ni and Cu, Zn and Cu. This suggests that these correlated elements must have originated from the same source (whether an anthropogenic or natural activities

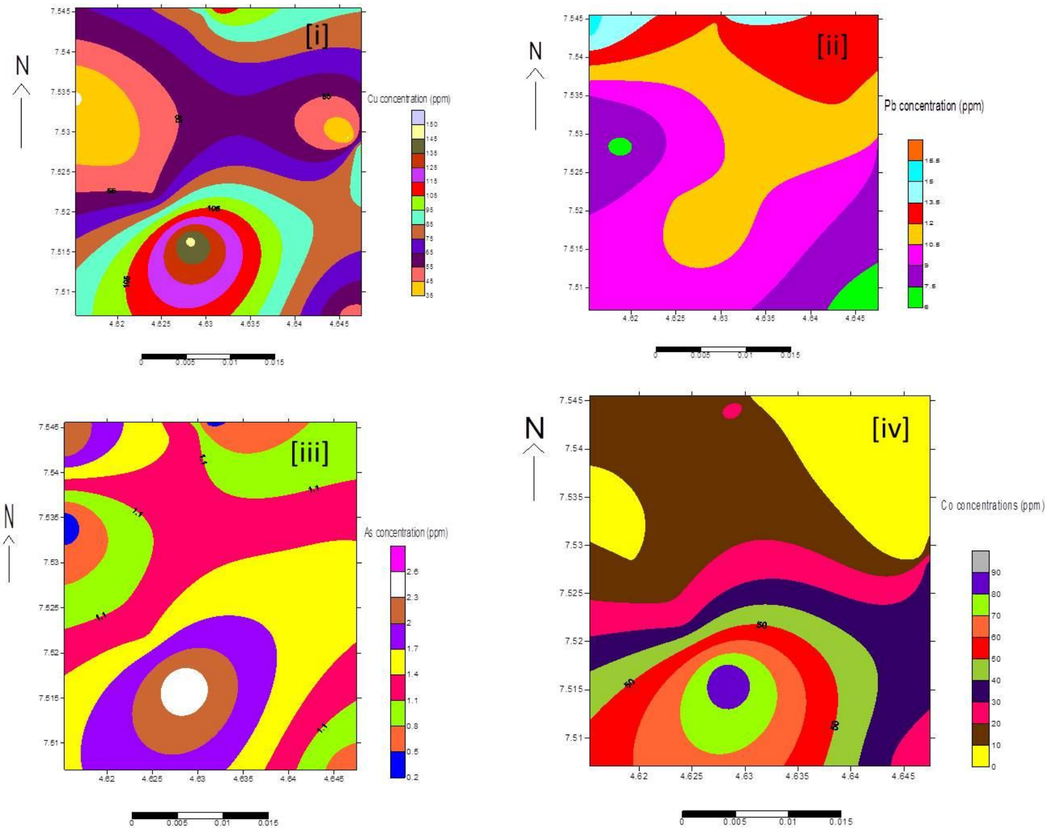

Figure 4[i,ii,iii,iv]: Showing the 2D geochemical maps for trace elements (Cu), (Pb), (As) and (Co) respectively.

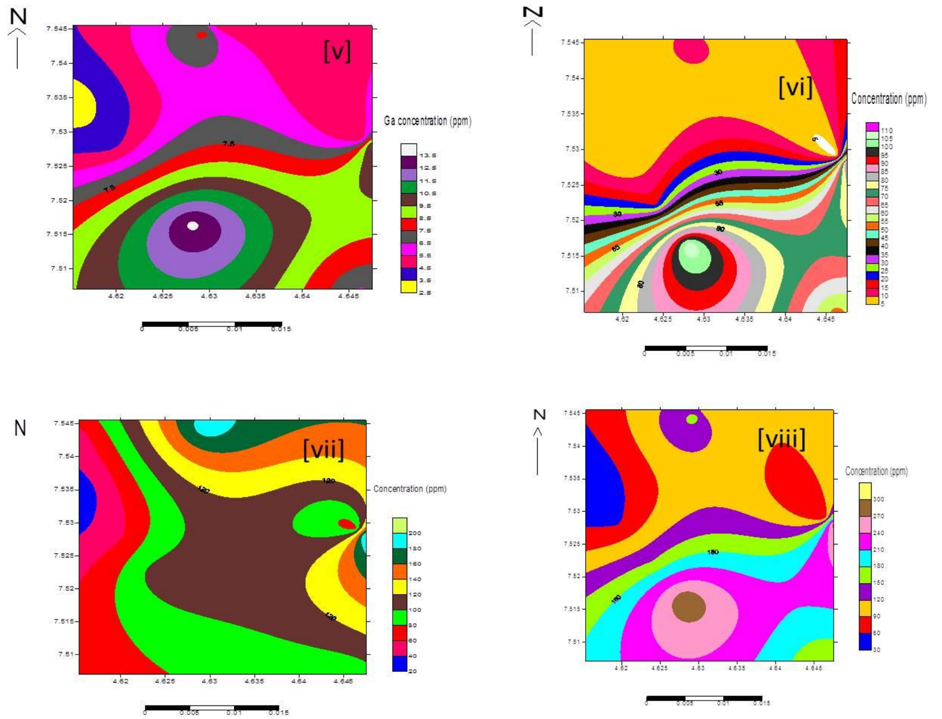

Figure 4[v,vi,vii,viii]: Showing the 2D geochemical maps for trace elements (Ga), (Sr), (Cr) and (V) respectively.

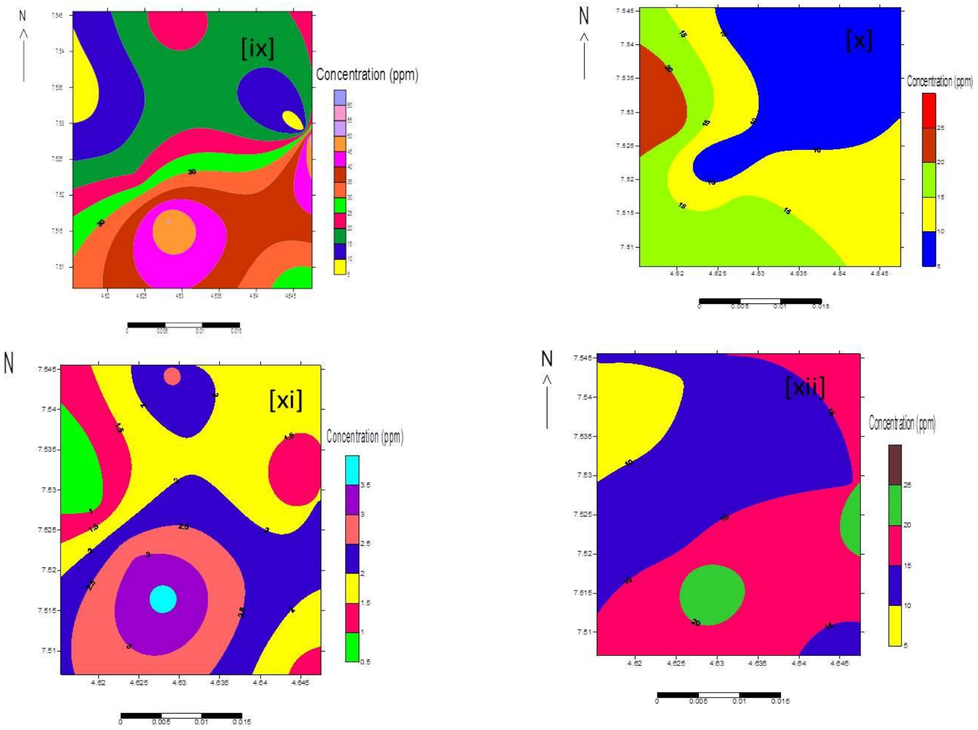

Figure 4[ix,x,xi,xii]: Showing the 2D geochemical maps for trace elements (Ni), (Rb), (Zr) and (Y) respectively.

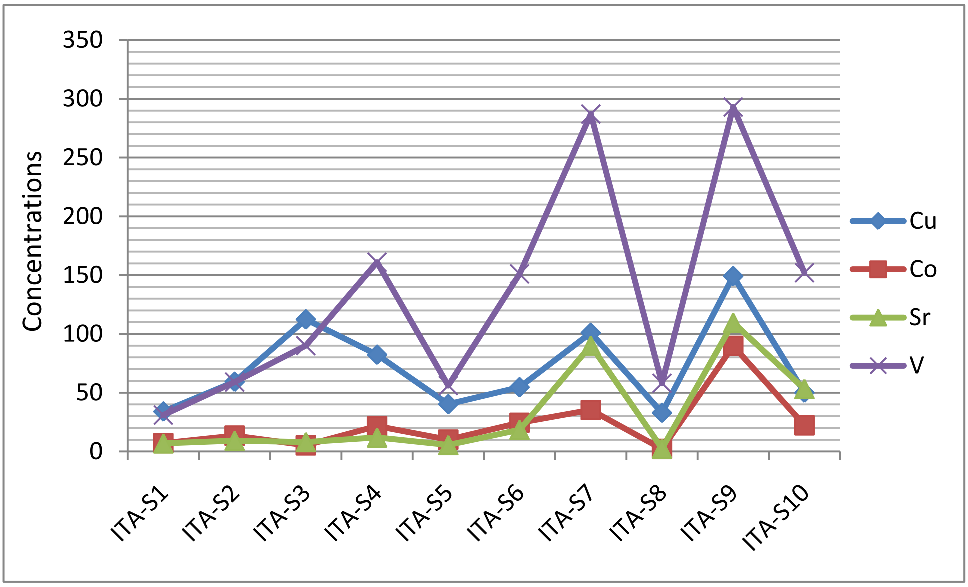

Figure 5a: Line diagram of Cu, Co, Sr, V

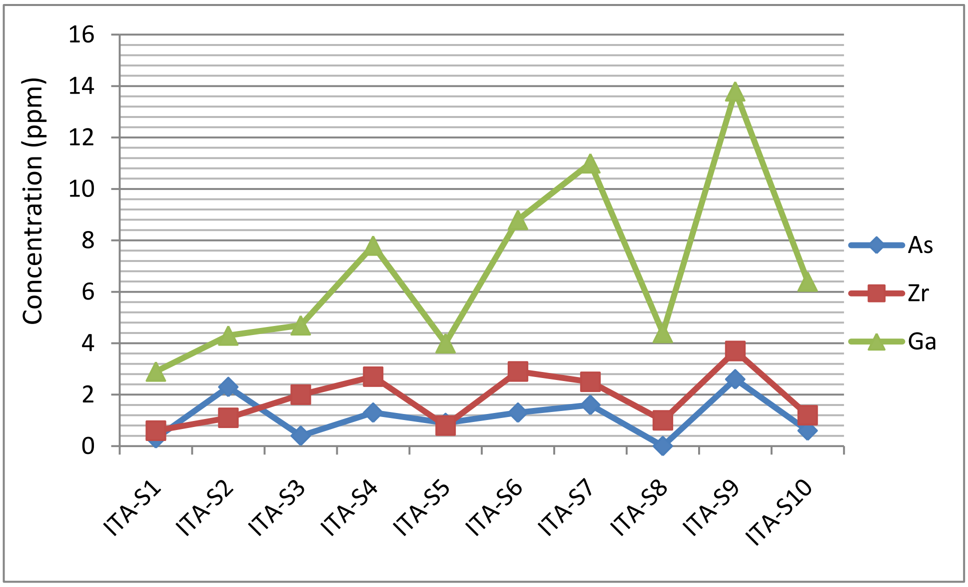

Figure 5b: Line diagram of As, Zr and Ga

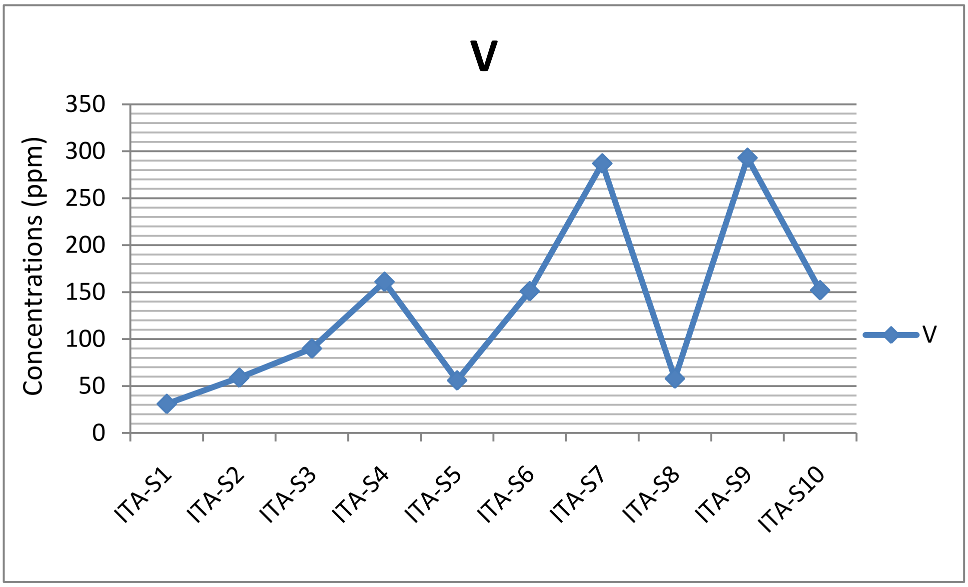

Figure 5c: Line diagram showing Vanadium concentration.

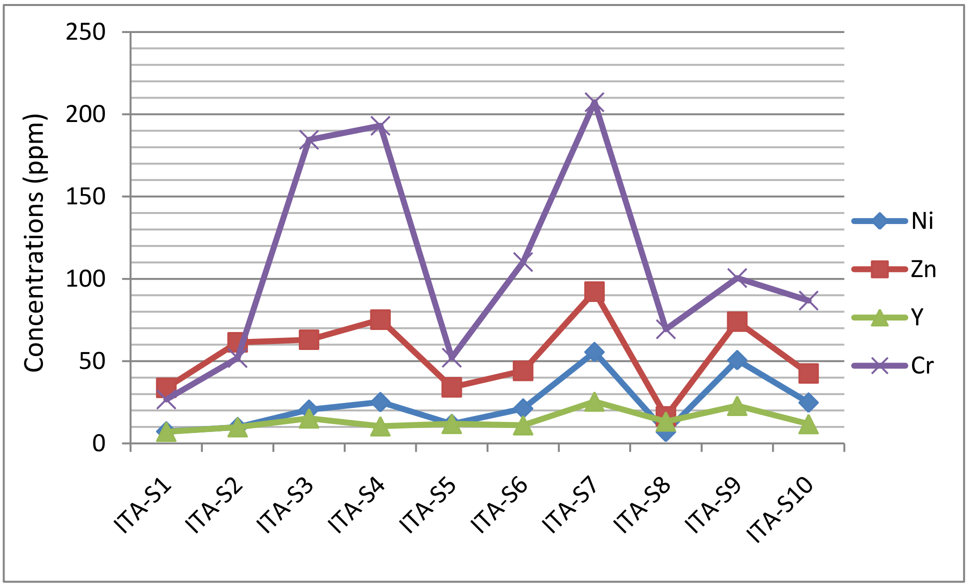

Figure 5d: Line diagram between Ni, Zn, Y, Cr

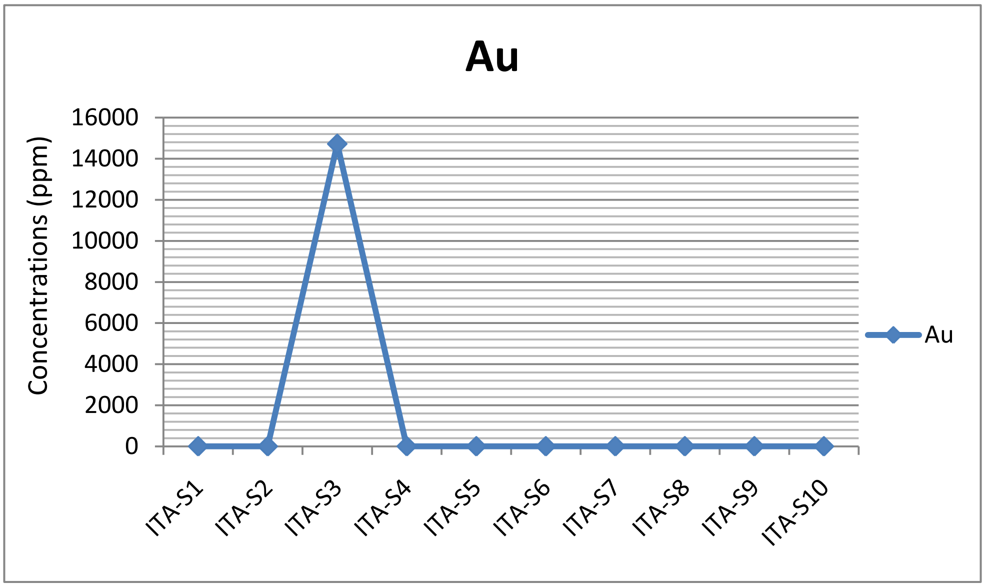

Figure 5e: Line diagram of Au present in the soil and stream sediment sample

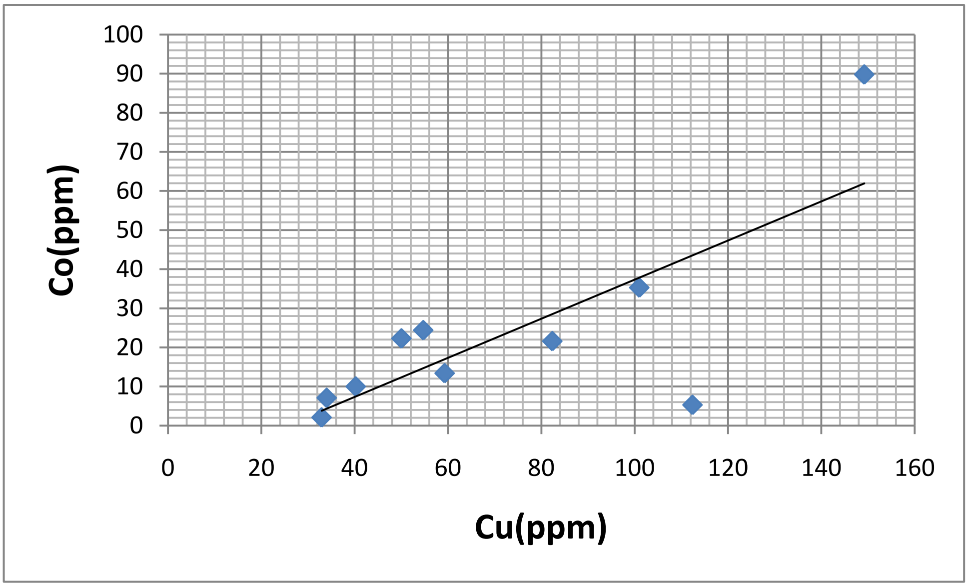

Figure 6a: Scatter diagram between Co and Cu

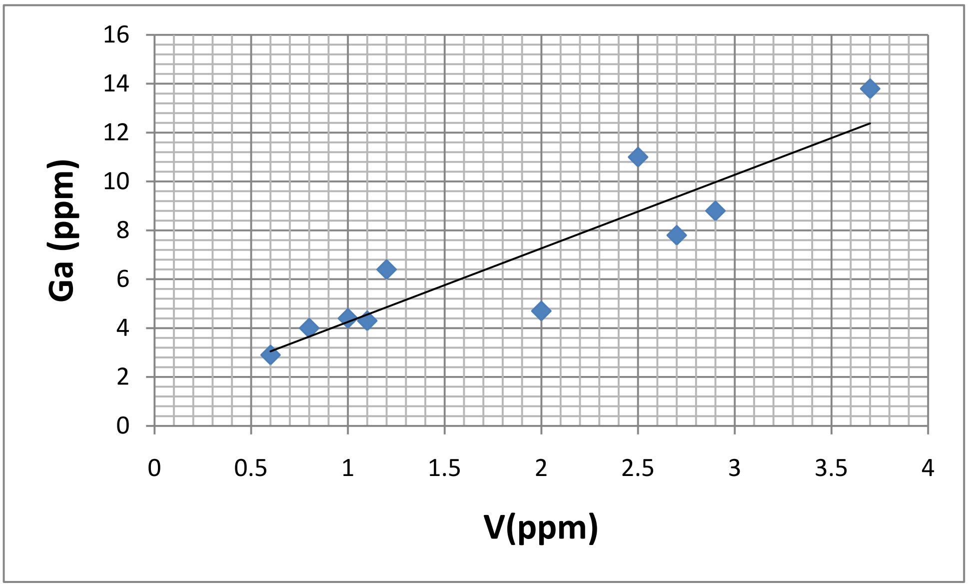

Figure 6b: Scatter diagram between Ga and V

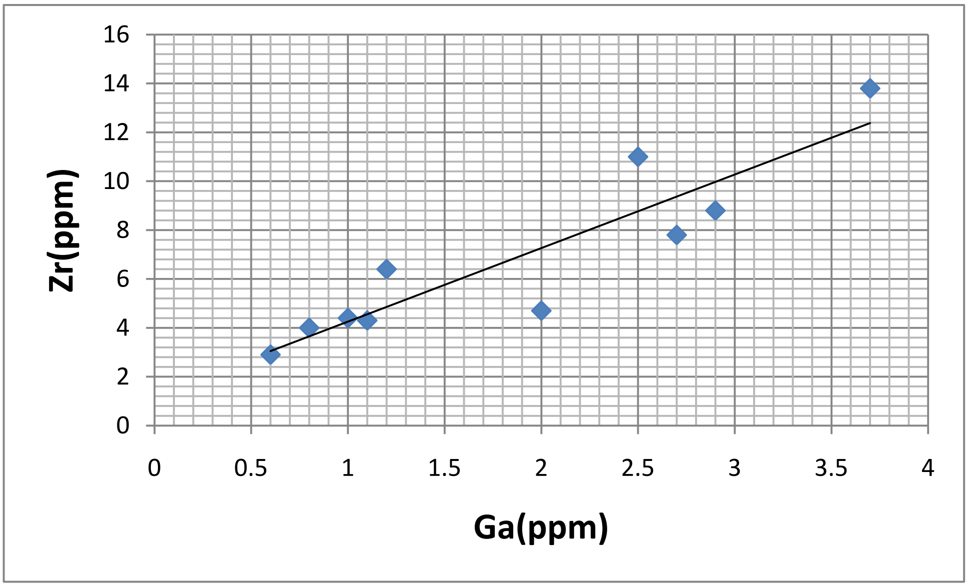

Figure 6c: Scatter diagram between Zr and Ga

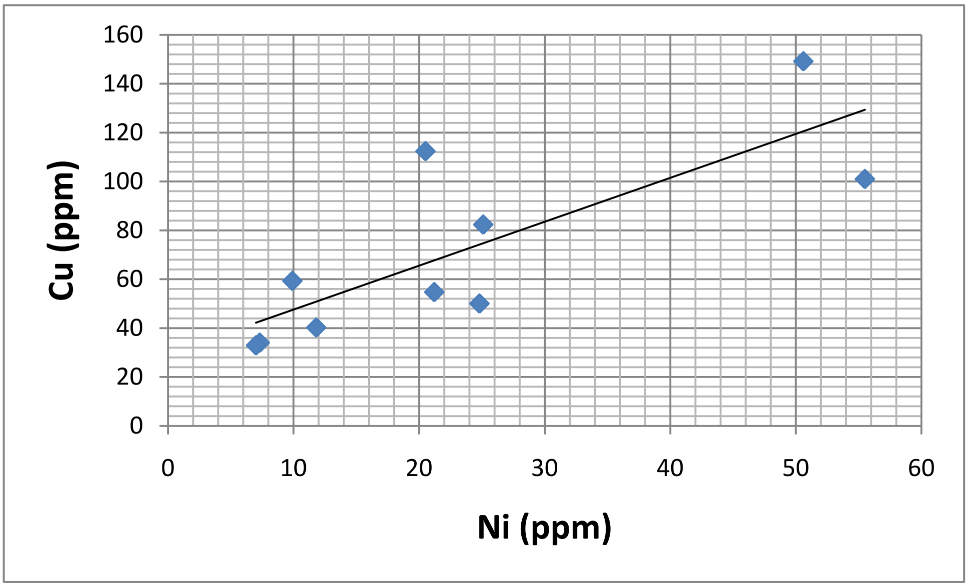

Figure 6d: Scatter diagram between Cu and Ni

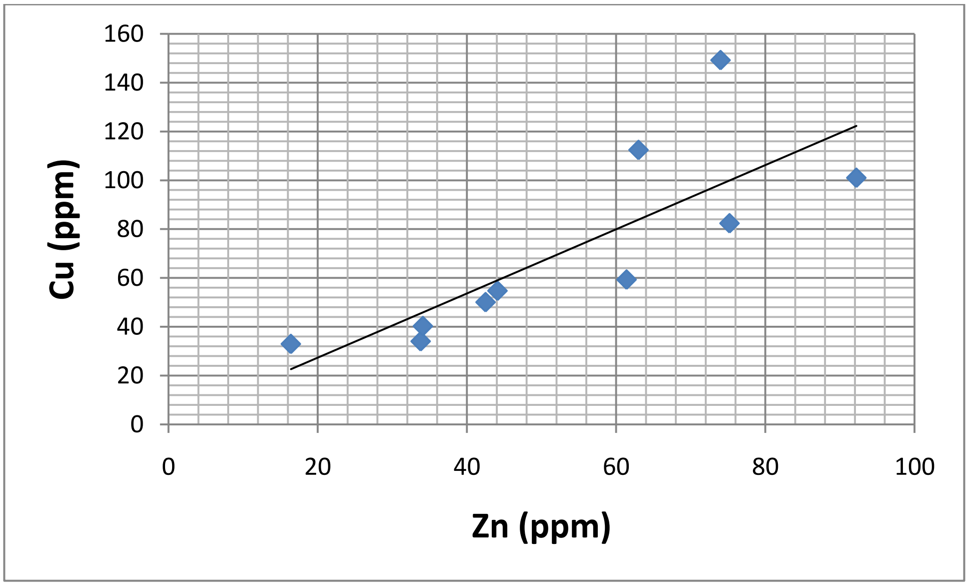

Figure 6e: Scatter diagram between Zn and Cu

5 Enviromental Geology

In order to ascertain the degree of contamination and distinguish between natural and anthropogenic pollution sources, the Metal ratio, index of Geo accumulation (Muller, 1969); cumulative metal enrichment and contamination factor/degree of contamination was used to determine the environmental implication of trace element distribution in the stream sediments of the Ede study area and this was achieved using the afore listed geochemical parameters. Several approaches to the study of pollution were employed in this study as listed above, and they lead us to conclude that the interpretation of the pollution intensity in Itagunmodi is more dependent on the background values.

5.1 Metal Ratio

Metal ratio is usually expressed with respect to average shale content to qualify the degree of pollution (Forstner and Wittman 1983). Table 3a; shows the computed values of metal ratio.

It is calculated thus; **Cn/Cb**

Where **Cn** – obtained concentration in ppm.

Cb – Average shale concentration in ppm.

From (Table 3a) below, it is observed that all the elements except Cu, Co, Cr and V have metal ratios less than 1 at some locations. This implies that these aforementioned elements are the major contaminants of the sediments in these locations because they have greater enrichment. This is attributed to the fact that they have metal ratio values greater than 1, and their abundance is attributed to mining operations and natural weathering of soil in the area.

Table 3a: Metal Ratio for Selected Element

	Cu	Pb	As	Co	Ga	Sr	Cr	V	Ni	Zn	Rb	Zr	Y
ITA-S1	0.6802	0.4405	0.03	0.355	0.116	0.01725	0.267	0.238462	0.09125	0.375556	0.49	0.003333	0.054692
ITA-S2	1.1858	0.7605	0.23	0.67	0.172	0.023	0.519	0.453846	0.12375	0.682222	0.362	0.006111	0.075923
ITA-S3	2.248	0.7085	0.04	0.265	0.188	0.02	1.845	0.692308	0.25625	0.7	0.16	0.011111	0.117077
ITA-S4	1.6472	0.5955	0.13	1.08	0.312	0.02975	1.93	1.238462	0.31375	0.835556	0.102	0.015	0.080308
ITA-S5	0.8048	0.3585	0.09	0.5	0.16	0.01375	0.521	0.430769	0.1475	0.378889	0.474	0.004444	0.091462
ITA-S6	1.0942	0.5155	0.13	1.22	0.352	0.04625	1.102	1.161538	0.265	0.49	0.1	0.016111	0.085
ITA-S7	2.02	0.4385	0.16	1.765	0.44	0.2255	2.073	2.207692	0.69375	1.024444	0.262	0.013889	0.195846
ITA-S8	0.6584	0.5805	0.01	0.105	0.176	0.00625	0.694	0.446154	0.0875	0.182222	0.126	0.005556	0.102462
ITA-S9	2.984	0.5695	0.26	4.49	0.552	0.27425	1.005	2.253846	0.6325	0.822222	0.338	0.020556	0.176077
ITA-S10	1.0006	0.331	0.06	1.115	0.256	0.133	0.868	1.169231	0.31	0.472222	0.282	0.006667	0.090692

5.2 Contamination Factor and Degree of Contamination

The assessment of sediment contamination was also carried out using the contamination factor and degree of contamination. This enables an assessment of contamination through making reference of the concentration of the surface, to the background values (average shale content); Hakanson (1980). The contamination factor is calculated using the formula Cf=C-1/Mn, Where C-1; is the obtained mean concentration in (ppm) and Mn is the average background value of the elements. Contamination index is employed to determine the degree of contamination in the stream sediments. The assessment of the overall contamination of sediment was based on the degree of contamination index. The contamination factor is a single element index. The sum of the contamination factors for all element examined represents the degree of contamination (Cdeg) of the environment and four classes are recognized (Table 3b).

5.3 Contamination Degree (Cdeg)

Contamination degree is the sum total of all contamination factors of all metals examined. It gives the overall contamination in the study area four classes are recognized (Table 3c)

Table 3b: Descriptive classes of contamination factor (Hakanson, 1980)

Class	Indication
Cf<1	Low contamination
1<Cf<3	Moderate contamination factor
3<Cf<6	Considerable contamination factor
6<Cf	Very high contamination

Table 3c: Degree of contamination Hakanson (1980)

Classes	Contamination degree(C deg)
Cdeg<8	low degree of contamination
8≤Cdeg<16	Moderate degree of contamination
16≤Cdeg<32	Considerable degree of contamination
32≤Cdeg	Very high degree of contamination

Table 3d: showing the degree of contamination of the trace metals

	Mean	Av, shale content	contamination factor	overall Degree of contamination
Cu	71.61	50	1.4322	74.99108776
Pb	10.597	20	0.52985	27.74335138
As	1.2556	10	0.12556	6.574417665
Co	23.13	20	1.1565	60.55522483
Ga	6.81	25	0.2724	14.26307241
Sr	31.56	400	0.0789	4.131264366
Cr	108.24	100	1.0824	56.67529213
V	133.8	130	1.029230769	53.89131053
Ni	23.37	80	0.292125	15.2958885
Zn	53.67	90	0.596333333	31.22446958
Rb	13.48	50	0.2696	14.11646227
Zr	1.85	180	0.010277778	0.538152308
			6.875377	

From the value obtained for the contamination degree (Table 3d). It is established that the study area is highly contaminated with elements; Cr, V, Co and Cu, with values; 56.67, 53.89, 60.55 and 74.99

5.4 Index of Geoaccumulation

The geoaccumulation index (Igeo) was originally defined by Muller (1969) for metal concentrations in the <2µm fraction and developed for the global standard shale values which is expressed as

$\text{Igeo}=\log_{2}\text{Cn} /1.5*\text{Bn}$

Where Bn is the measured concentration in the sediment for the metal n, Bn the background value for the metal n and the factor 1.5 is used because of possible variations of the background data due to lithological variations.

The index of geoaccumulation consists of seven grades with Igeo of 6 (Table 3e) indicating almost a100 fold enrichment above background values (Muller, 1969)

Table 3e: Geo-accumulation index classes

I-geo class	Class	Pollution intensity
>5	6	Very strong polluted
4-5	5	Strong to very strong
3-4	4	Strongly polluted
2-3	3	Moderately to strongly
1-2	2	Moderately polluted
0-1	1	Unpolluted to moderately polluted
0	0	Unpolluted

Table 3f: Showing the Geoaccumulation Index of the Selected Trace Metal

	Cu	Pb	As	Co	Ga	Sr	Cr	V	Ni	Zn	Rb	Zr	Y
ITA-S1	0.027	0.0044	0.0006	0.005	0.00093	0.0000085	0.00054	0.00037	0.00022	0.00084	0.001`9	0.0000055	0.00031
ITA-S2	0.048	0.0076	0.0046	0.01	0.0014	0.00001	0.001	0.0007	0.0003	0.0015	0.0015	0.0000068	0.00044
ITA-S3	0.009	0.0071	0.0008	0.004	0.0015	0.00001	0.004	0.0011	0.00064	0.0016	0.00064	0.000012	0.00067
ITA-S4	0.0066	0.006	0.0026	0.0019	0.0025	0.000015	0.0039	0.0019	0.0031	0.0019	0.00041	0.000017	0.00046
ITA-S5	0.0032	0.0036	0.0018	0.0014	0.0013	0.000007	0.001	0.00067	0.00037	0.00085	0.0019	0.0000049	0.00052
ITA-S6	0.0044	0.005	0.0026	0.018	0.0028	0.00023	0.0022	0.0018	0.00066	0.0011	0.0004	0.000018	0.00049
ITA-S7	0.008	0.0044	0.0032	0.0024	0.0038	0.00011	0.004	0.0034	0.0017	0.0023	0.0011	0.000015	0.0011
ITA-S8	0.0026	0.0058	0.0002	0.00015	0.0014	0.0000031	0.0014	0.00069	0.0002	0.00041	0.0005	0.0000062	0.00058
ITA-S9	0.012	0.0057	0.0052	0.0039	0.0044	0.00014	0.002	0.0035	0.0016	0.0018	0.0014	0.000023	0.001
ITA-S10	0.004	0.0033	0.0012	0.009	0.002	0.0000067	0.0017	0.0018	0.00078	0.0011	0.0011	0.0000075	0.0005

The (Table 3f) above shows that the values of the elements are all less than 1. In order to determine the pollution status of the study area, the values of the elements when compared to the Muller classes of geoaccumulation (1969), suggests that the study area is unpolluted to moderately polluted with the selected trace metals

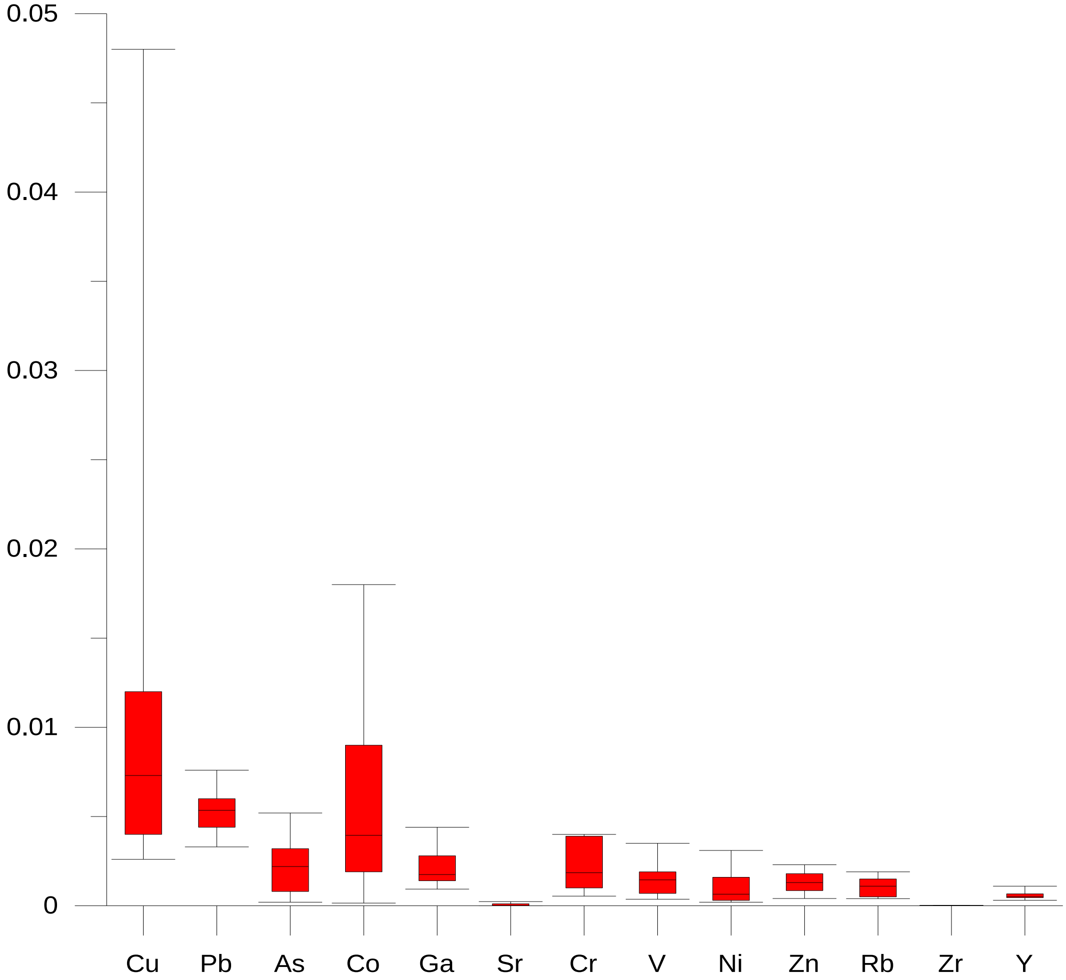

Figure 7: Box plot of the Selected Trace Elements

From the box plot shown above, (Fig 7) the elements fall into the class 0 to 1(i.e. unpolluted to moderately polluted) from the Muller table of (1969) except for Au which is not included in the plot due to its high anomalous concentration value in the soil sample.

6 Summary and Conclusion

The result of major elements concentration shows that there are natural concentrations of Mn, Na, Fe, Mg, Al, Ca and k in some locations of the study area which indicates an abundance of Ferro-magnesian and Al-rich minerals present in the Amphibolite and Granite rocks in the area. The result of the correlation co-efficient suggests a common source between them. It can be inferred from this study that there are natural concentrations of Cu, Co, V in the stream sediment which has been linked to the presence of rocks rich in this elements, it also identified the presence of gold {Au} as the major contaminant of the soil in the study area, which is related to the Gold mining activities in most part of the study area. The result has shown the level of pollution and contamination in the area. It is therefore suggested that regular geochemical research work should be carried out in this study area to determine further rise in contamination level as a result of mining activities going on in this environment in addition; Mining activities in the area should be controlled to reduce the amount of pollutants released into the streams and water bodies within the study area for the good health of the residents.

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