Plausible Geo-Medical and Environmental Consequence of Mining Economic Deposits Associated with some Major and Trace Elements: A Case Study of Limestone Mapped within the Albian-Turonian Awe Formation around Abuni and Environs in Nasarawa State.

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ABSTRACT

Geochemical data has shown that the area under study is economically viable and promising. Ternary diagrams (SCM), point/contour maps, and bar charts were used to interpret the major and trace elements. The point/contour maps show areas of high and low concentration so as to enable investors to have excellent and direct access to valuable concentrates and or areas with crustal anomalies otherwise interpreted as economic deposits (ore). The geochemical data obtained serves as a baseline data for mineral exploration and environmental purposes.

(Keywords: geochemical analysis, mineral exploration, heath and environmental effects)

INTRODUCTION

It is often said than good processes proceeds good health and wealth creation for human benefit. It is therefore paramount to integrate and proffer world class standard measures to mitigate health, safety, and environmental challenges associated with scientific research, techniques and processes while exploring and exploiting for economic and viable deposits and or reserves.

The geology of Nigeria is fundamentally made up of the Basement Complex, the Younger Granite, and the Sedimentary Basins. The Basement Complex, which is Precambrian in age, consists of the Migmatite-Gneiss Complex, the Schist Belts, the Older Granites and the Undeformed basic and acidic dykes. The Younger Granites comprise several Jurassic magmatic ring complexes centered around Jos and other parts of North Central Nigeria (Obaje *et al.,* 2007). The Sedimentary Basins, containing sediment fill of Cretaceous to Tertiary ages, comprising of the Niger Delta, the Anambra Basin, the Benue Trough (Lower, Middle and Upper), the Chad Basin, the Sokoto Basin, the Mid-Niger (Nupe/Bida) Basin and the Dahomey Embayment.

The study area covered Abuni and its environs in Awe Local Government area of Nasarawa State. The area is part of the Middle Benue Trough of Nigeria and the area is composed of the Late Albian-Cenomanian Awe and Keana Formations (consisting essentially of sandstones with intercalations of bands of shales and clays) and Cenozoic volcanics (Patrick *et al.,* 2013).

GEOLOGICAL SETTING

Nigeria lies within the mobile belt affected by the Pan African Orogeny and is sandwiched between the geologically more stable and Older West African Craton and the Congo Craton (Turner*,* 1983) as seen in Figure 1.

Genetical considerations reveal three lithologic units in Nigeria namely; The Precambrian-Lower Paleozoic rocks of the crystalline Basement Complex occupying roughly 50% of the total surface area of Nigeria. The Jurassic Younger Granite and the Cenozoic Volcanism, which occurred within the Basement Complex occupying less than 10% of the total surface area of Nigeria and the Cretaceous-Recent Sediments constituting the six major Sedimentary Basins of the country namely; Anambra Basin, Benue Trough, Bida Basin, Chad Basin, Niger Delta Basin, Sokoto Basin and Darrhomy Embayment. All found occupying about 40% of the total surface area of Nigeria.

The study area is situated in the Middle Benue Trough of Nigeria, lying within latitudes $08^0$10'31.6" N and $08^0$13'31.6" N and between longitudes $009^0$02'25.3" E and $009^0$05'12.6" E (Figure 2).

BRIEF GEOLOGY OF NASARAWA STATE

Nasarawa State is underlain by the three geologic components that makes up the geology of Nigeria as earlier pointed out. The Precambrian rocks of the Basement Complex comprise the Migmatite-Gneiss Complex, the Schist Belt, the Older Granites and the Undeformed Basic and Acidic Dykes covering areas of Akwanga, Keffi, Nasarawa-Eggon and Wamba; the Jurassic Younger Granites are exposed around Afu, Andaha (Mada) and Farin-Ruwa (Shakaleri) Complexes; and the Cretaceous sedimentary rocks covering the greater part of the state in the south and east, running from Lafia through Obi, Jangwa, Jangerigeri, Awe and Keana (Figure 3).

The state is blessed with a great deal of solid minerals of economic importance and that is why it is tagged, "Home of Solid Minerals".

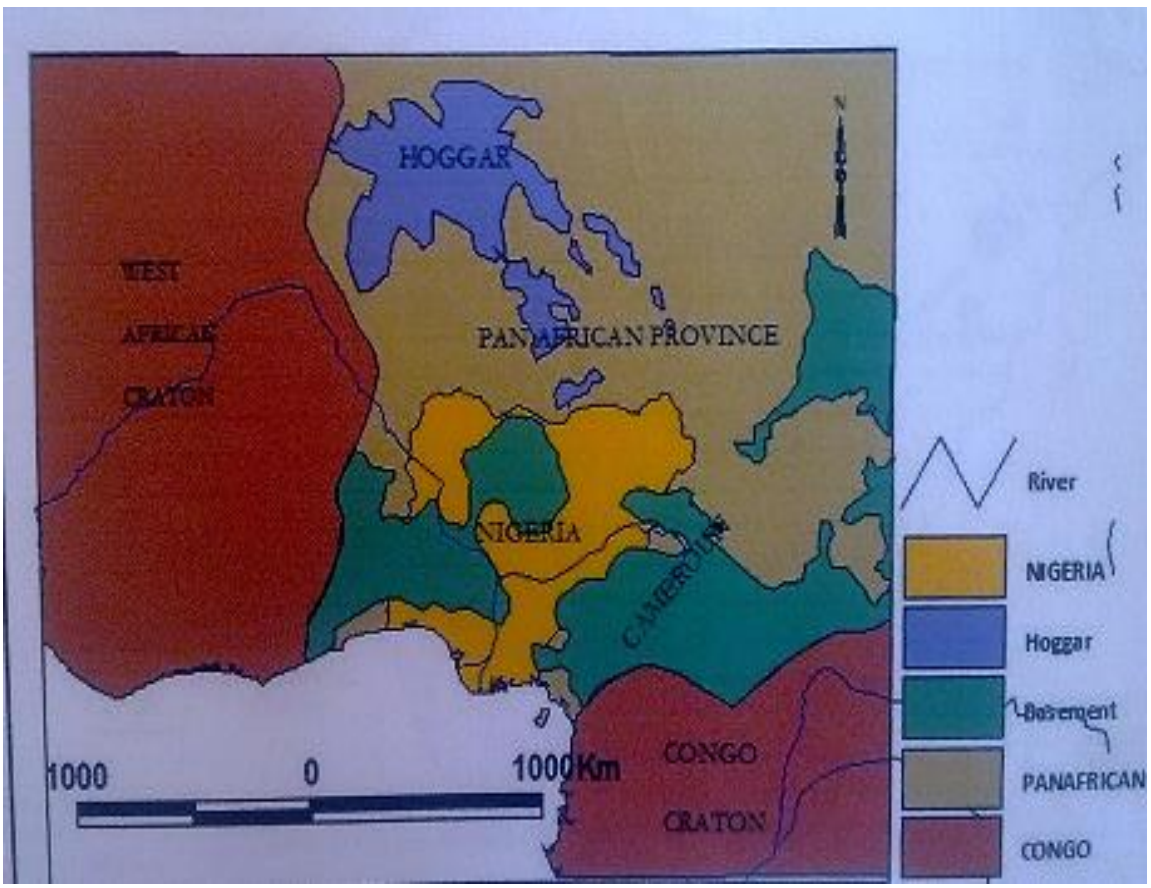

Figure 1: Location of Nigerian Sector of the Pan-African Province of West Africa (Turner, 1983).

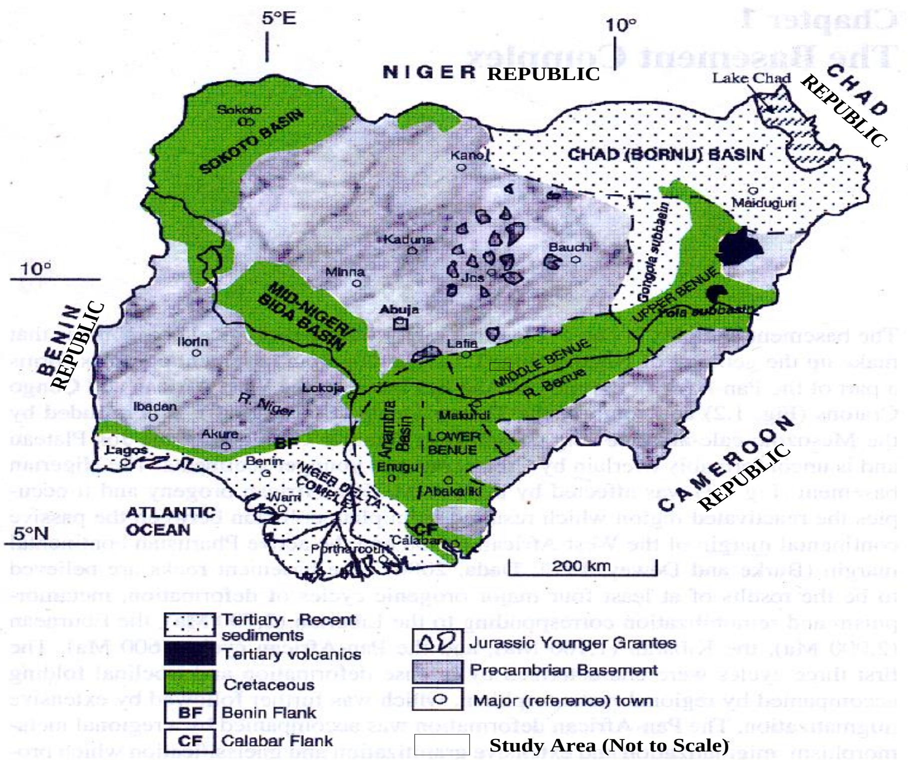

Figure 2: Outline Geological Map of Nigeria Showing Study Area (Modified after Obaje *et al.,* 1996).

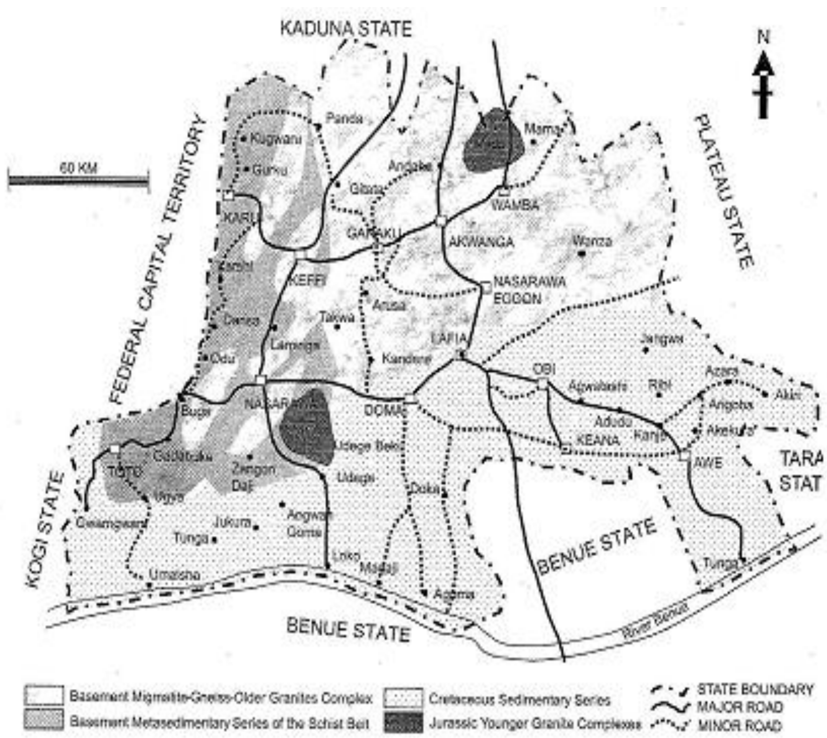

Figure 3: Outline Geological map of Nasarawa State (Obaje *et al.,* 2007).

The Benue Trough of Nigeria is conventionally subdivided into a “Lower Benue Trough”, “Abakaliki Trough” of Murat (1972) and Whiteman (1982), a “Middle Benue Trough” and an “Upper Benue Trough” (“Benue valley” respectively of Whiteman (1982). The Benue Trough was terminated by a Late Santonian episode of compressional folding. Subsequent sedimentation was centered on basins developed on the North-Western flank of the resultant deformed sediments. The stratigraphic succession of the Benue Trough is shown below (Figure 4).

Age	Anambra basin	Lower Benue–Middle Benue	Upper Benue Basin: Dadiya–Numanha	Upper Benue Basin: Zambuk–Gulani	Upper Benue Basin: Gombe–Pindiga	Southern Chad Basin
Palaeocene and younger	Imo Formation	Volcanics	Lamja sandstones		Kerri-Kerri Fm.	Kerri-Kerri Fm.
Maastrichtian	Nsukka Formation Ajali Sandstone Mamu Formation Nkpora Formation	Lafia Formation			Pindiga Formation; Gombe sandstones	Gombe sandstones
Senonian: Campanian			Numanha shales	Gulani sandstones		
Senonian: Santonian			Sekule Fm.			
Senonian: Coniacian	Agwu Formation	Agwu Formation				Fika shales
Turonian Upper Middle			Jessu Fm.			
Turonian Lower	Eze-Aku Formation	Eze-Aku Fm. / Makurdi Fm., Keana Fm., Awe Fm.	Dukul Fm.			Gongila Fm.
Cenomanian	Asu River Group: Okposi Fm. Sandstone and shale	Asu River Group	Yolde Fm.		Yolde Fm.	
Mid–Late Albian	Asu River Group: Abakaliki shales		Bima sandstones	Bima sandstones	Bima sandstones	Bima sandstones
Pre-Cambrian	Basement Complex					

-------------- = Unconformity.

Figure 4: Stratigraphic Succession in the Benue Trough and the Nigerian sector of the Chad Basin (Cratchley and Jones, 1965).

METHODOLOGY

A hand auger was used for boring holes to collect soil samples between 15-30cm depth along transverses (based on the nature of soil). Of the 25 samples collected on the field, 11 were selected at random and taken for analysis at the National Metallurgical Development Centre (NMDC),Jos. Sample collection points are shown below and the acronym ADE 1-11 are adopted for label and identification (Figure 5 and Table1).

Selected samples were duly crushed and pulverized to pass through a 200-250 mesh sieve and are mechanically split to obtain a representative sample. The crusher and collection material were vacuum cleaned with acetone after each sample to avoid inter sample contamination. The pulverized samples were stored in sealed and labeled polythene sachets. And the powdered samples were finally sent to the ED-XRF laboratory of NMDC, Jos for geochemical analysis of the major and trace elements using Energy Dispersive X-ray Fluorescence (ED-XRF).

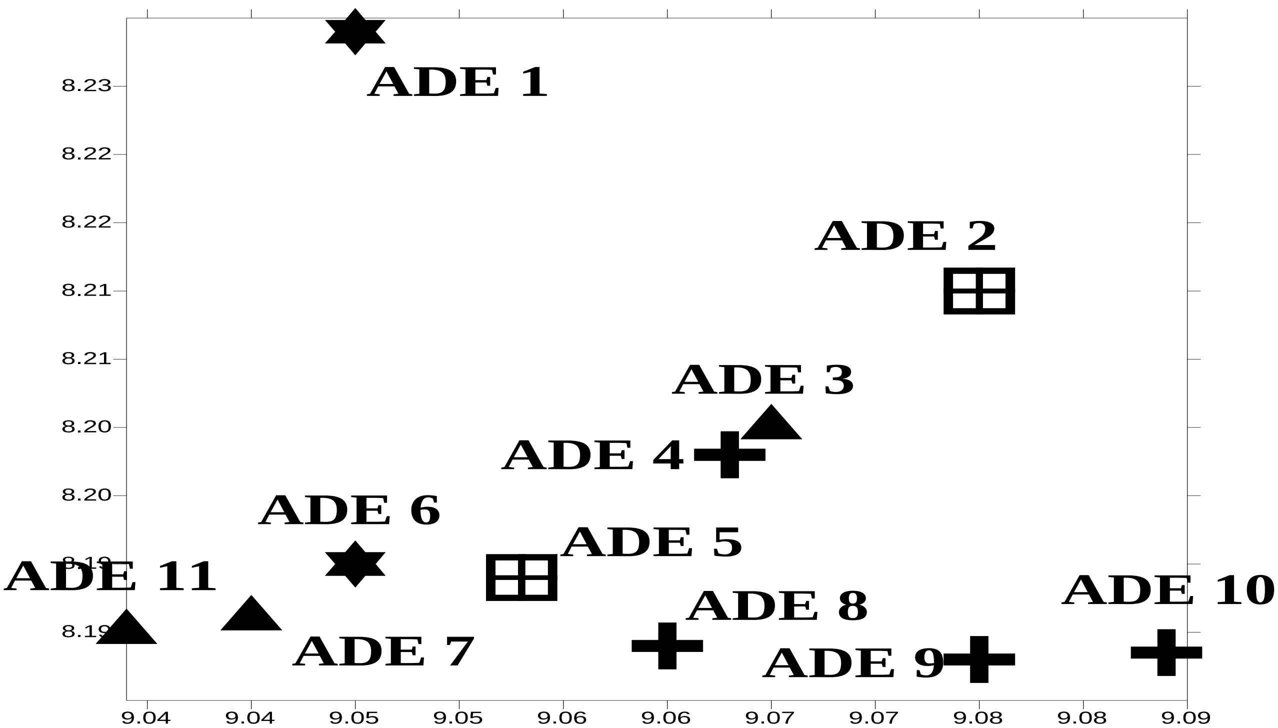

Figure 5: Soil Samples Location Map (Coordinates in decimal degrees).

Table 1: Sample Points and Rock Type.

S/N	Sample Name	Co-ordinates	Rock Type
1	**ADE 1**	N08°13'23.9" E09°02'48.9"	Shale
2	**ADE 2**	N08°12'51.8" E09°04'45.7"	silty Sandstone
3	**ADE 3**	N08°12'18.4" E09°04'07.0"	silty Sandstone
4	**ADE 4**	N08°12'03.9" E09°03'35.1"	sandy Claystone
5	**ADE 5**	N08°11'32.9" E09°03'28.0"	Limestone
6	**ADE 6**	N08°11'27.3" E09°02'58.3"	Shale
7	**ADE 7**	N08°11'24.2" E09°02'44.5"	Sandstone
8	**ADE 8**	N08°11'06.2" E09°03'53.5"	Volcanics (Basalt)
9	**ADE 9**	N08°10'49.0" E09°04'38.0"	Sandstone
10	**ADE 10**	N08°10'58.3" E09°05'15.7"	Shale
11	**ADE 11**	N08°11'13.9" E09°02'30.3"	Volcanics (Basalt)

ANALYTICAL TECHNIQUE

Energy Dispersive X-ray Fluorescence (ED-XRF) was employed for the analysis of the various soil samples. A finely ground 20.00g of the samples that have pass through a 200-250 mesh sieve were dried in an oven at 105^0 for 1 hour and allowed to cool. Thereafter, the samples were intimately mixed with a binder, in the ratio of 5.0g samples to 1.0g cellulose flakes binder and pelletized at a pressure of 10-15 tons/inch^2 in a pelletizing machine. At this stage the pelletized samples were stored ina desiccators for analysis.

The pelletized samples were analysed by ED-XRF using a MiniPal 4 ED-XRF Model. The appropriate programs for the various elements of choice were employed to analyze the soil samples for their presence or absence, the result is reported in percentage (%) for major elements and in parts per million (ppm) for trace elements. The advantages of this analytical method include the following; It is currently the most widely used analytical technique in the determination of both the major and trace element chemistry of sample materials, it is versatile and can analyze up to 80 elements over a wide range of sensitivities, It provides detection concentrations from 100% down to a few parts per million (ppm) and it is a rapid method for large numbers of precise analyses within a relatively short period of time.

INSTRUMENTATION

ED-XRFS is a non-destructive analytical method of quantitative and elements (Figure 6).

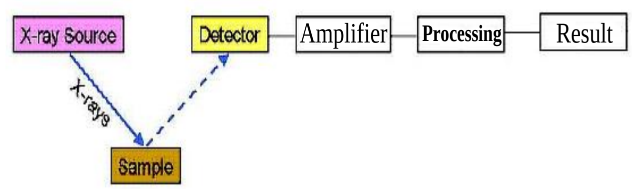

Figure 6: Operation Principle of ED-XRFS.

RESULTS AND DISCUSSIONS

Table 2: Result of X-ray Fluorescence Analysis (Major Elements).

S/N	Sample Name	Major Elements (%)										
		Al_2O_3	SiO_2	P_2O_5	SO_3	K_2O	CaO	TiO_2	MnO	Fe_2O_3	Na_2O	MgO
1	**ADE 1**	10.50	26.70	0.66	ND	1.49	3.77	2.94	0.93	46.26	NF	NF
2	**ADE 2**	4.31	66.10	ND	ND	2.16	0.94	3.45	0.18	19.53	030	1.08
3	**ADE 3**	3.45	76.60	ND	ND	2.64	0.42	3.12	0.11	4.88	NF	NF
4	**ADE 4**	14.00	59.40	0.51	0.11	4.60	ND	3.55	0.06	8.88	NF	NF
5	**ADE 5**	12.70	37.90	ND	ND	1.40	1.86	6.93	0.77	28.66	0.88	1.21
6	**ADE 6**	16.50	36.20	0.35	0.05	1.70	1.32	6.18	0.41	27.25	0.43	1.33
7	**ADE 7**	10.00	64.70	0.56	ND	5.93	0.20	2.66	0.09	8.04	ND	1.01
8	**ADE 8**	14.00	55.30	0.49	ND	0.62	1.13	6.09	0.31	13.53	NF	NF
9	**ADE 9**	9.10	63.30	0.53	ND	1.44	0.77	6.83	0.29	14.04	NF	NF
10	**ADE 10**	8.90	71.00	ND	ND	4.08	1.18	4.52	0.15	6.92	ND	1.38
11	**ADE 11**	12.40	64.00	0.93	ND	6.13	1.91	1.82	0.12	5.53	NF	NF

Table 3: Result of X-ray Fluorescence Analysis (Converted, Trace Elements).

S/N	Sample Name	Trace Elements (ppm)										
		Cr	Ni	Cu	Zn	Sr	Zr	Ba	Rb	Au	Pb	As
1	**ADE 1**	900	600	400	200	1,100	700	ND	500	ND	ND	ND
2	**ADE 2**	400	100	100	ND	300	4,700	ND	300	ND	ND	ND
3	**ADE 3**	200	200	200	100	ND	2,700	ND	ND	500	ND	ND
4	**ADE 4**	300	200	200	ND	300	2,000	ND	300	300	ND	ND
5	**ADE 5**	700	400	400	200	800	2,400	ND	400	ND	ND	ND
6	**ADE 6**	1200	900	600	200	400	1,500	ND	400	ND	1,900	ND
7	**ADE 7**	200	100	400	ND	5,100	2,700	ND	500	400	ND	ND
8	**ADE 8**	300	200	500	100	ND	4,600	ND	200	ND	ND	ND
9	**ADE 9**	300	200	900	200	300	3,800	ND	200	ND	1,200	ND
10	**ADE 10**	300	200	700	100	300	2,900	ND	300	300	ND	ND
11	**ADE 11**	200	100	500	100	500	2,800	ND	500	400	1,500	40

ND: Not Detectable
NF: Not Analysed For

Table 4: Reported Average Global Concentration of some Elements in World's Soil (Bowen, 1979 and Webber *et al.,* 1984).

S/N	Element	Average Concentration (ppm)
1	Cr	200
2	Ni	50
3	Cu	20-30
4	Zn	50
5	Sr	340
6	Pb	30

The average concentration of Zirconium (2800ppm) and Rubidium (300ppm) in the soils of the area were used as mean on the histogram and these were obtained using the relation:

$$\overline{X} = \sum f / N$$

Where $\overline{X}$ = Mean
$\sum$ = Summation
f = Frequency
N = Number of Samples

INTERPRETATION

The proportions of elements in any naturally occurring easily sampled material (e.g. soil) is a fundamental property used for comparison and classification, therefore to have a better understanding of the study, SCM ternary diagram, point/contour maps and bar charts were plotted.

From the SCM diagram above (Figure 7), it can be observed that the limestone bed is rich in MgO relative to SiO_2 and CaO and there is a higher SiO_2/MgO ratio in the rock than the calcic rich minerals (CaO). Comparing this with the standard SCM diagram, where the plot fall shows that the carbonate rock is Mg-rich and the magnesian mineral could be magnesite which is a magnesian carbonate ($MgCO_3$) since the sample was obtained around limestone which is a calcium carbonate rock.

DISCUSSION

The health and environmental effect of each selected trace elements are discussed below;

<u>Chromium</u>

Health Effect: Exposure to chromium may be through breathing, eating or drinking and through skin contact with chromium or chromium compounds. Eating of food that contains chromium (III) is the main route of chromium uptake, as chromium (III) occurs naturally in many vegetables, fruits, meats, yeasts and grains. Chromium (III) is an essential nutrient for humans and shortages may cause heart conditions, disruptions of metabolisms and diabetes. But the uptake of too much chromium(III) can cause health effects as well, for instance skin rashes, upset stomachs and ulcers, respiratory problems, kidney and liver damage, lung cancer and death. In animals chromium can cause respiratory problems, a lower ability to fight disease, birth defects, infertility and tumor formation.

Environmental Effect: When concentrations of chromium exceed a certain value in plants, negative effects can still occur. Areas within ADE 1, 2, 4, 5, 6, 8, 9 and 10 are prone to suffer from the effects of chromium due to their high concentration in chromium while ADE 3, 7 and 11 are not prone.

The chart shown in Figure 8 is plotted using the various concentration of chromium in soils of the study area and also using its reported global average concentration in the world's soils, 200ppm (Bowen, 1979 and Webber *et al.,* 1984).
From Figure 8, soil samples ADE 1, 2, 4, 5, 6, 8, 9 and 10 have concentration of chromium above average while ADE 3, 7 and 11 have concentration below average. ADE 6 tends to have more chromium concentration above average compared to others.

Nickel

Health Effect: Nickel uptake increase with increased consumption of large quantity of vegetables from polluted soils, because plants are known to accumulate nickel. An uptake of too large quantities of nickel has the following consequences: higher chances of development of lung cancer, nose cancer, larynx cancer and prostate cancer, sickness and dizziness, lung embolism, respiratory failure, birth defects, asthma and chronic bronchitis, skin rashes and Heart disorders. For animals, nickel is an essential foodstuff in small amounts. But nickel is not only favorable as an essential element; it can also be dangerous when the maximum tolerable amounts are exceeded. This can cause various kinds of cancer on different sites within the bodies of animals.

Environmental Effect: In plants, negative effect may occur when concentration of nickel is above normal. When nickel is present in a toxic level in plants, the plant usually develops white dead patches on leaves. The entire mapped area is prone to suffer from the effects of nickel due to obvious high concentration as shown from elemental data/histogram plots obtained.

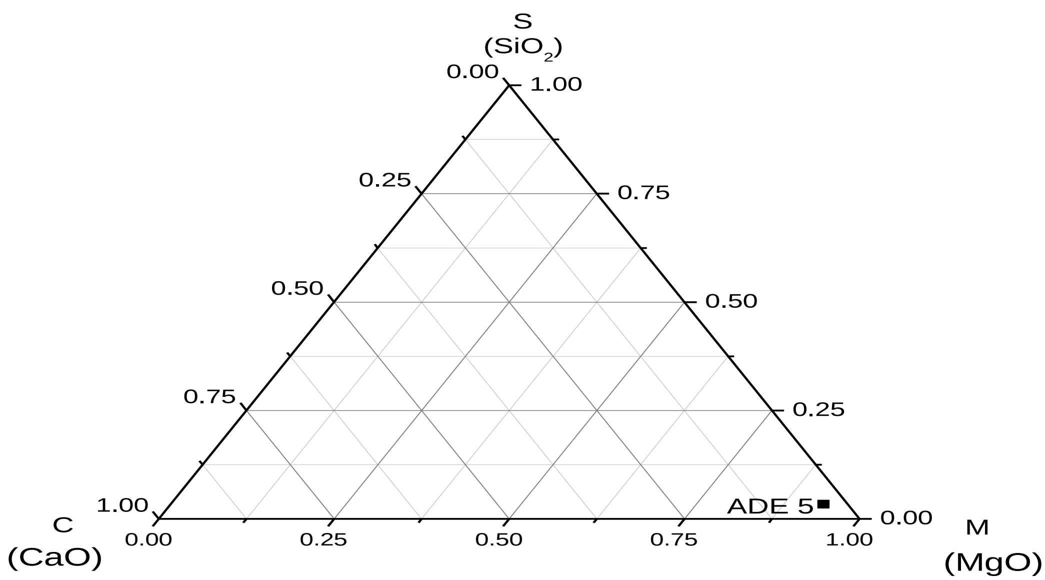

Figure 7: SCM Diagram for Soil of Abuni and its Environs (Limestone Deposit region).

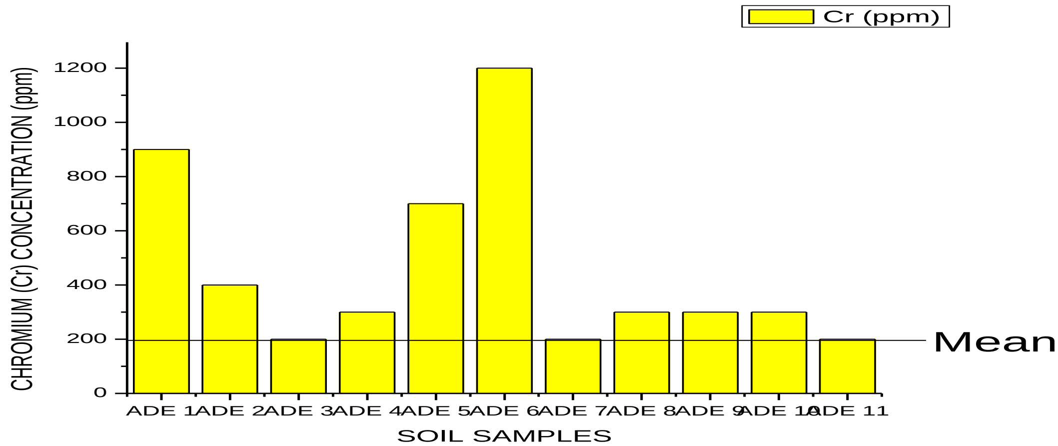

Figure 8: Bar Chart showing the Concentration (ppm) of Chromium (Cr) in soils of Abuni and its Environs.

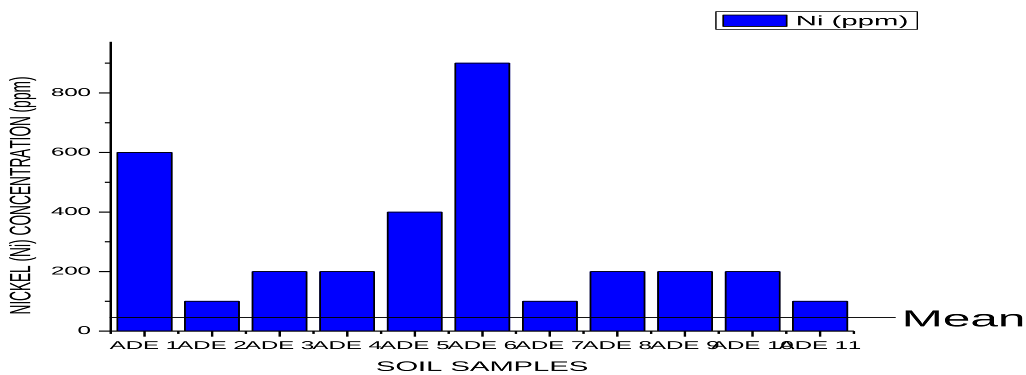

Figure 9: Bar Chart showing the Concentration (ppm) of Nickel (Ni) in Soils of Abuni and its Environs.

From the chart shown above in Figure 9 plots using the various concentration of nickel in soils of the study area and also using its reported global average concentration in the world's soils, 50ppm (Bowen, 1979 and Webber *et al.,* 1984).

All the soil samples have concentration of nickel above average. ADE 6 tends to have more nickel concentration above average compared to others.

Copper

Health Effect: We absorb eminent quantities of copper each day by eating, drinking and breathing. The absorption of copper is necessary, because copper is a trace element that is essential for human health. Long-term exposure to copper can cause irritation of the nose, mouth and eyes and it causes headaches, stomachaches, dizziness, vomiting, diarrhea and decline in intelligence with young adolescents. A good example is that of Zamfara State Lead poisoning caused by the wildcat extraction of gold from Pb-Zn-Cu sulphides.

Environmental Effect: Only a limited number of plants have a chance of survival on copper-rich soils. When the soils of farmland are polluted with copper, animals will absorb concentrations that are damaging to their health. When copper is present in a toxic level in plants the following symptoms are usually observed; dead patches on lower leaves from tips, purple stems, whitened leaves with green veins, stunted roots, creeping sterile forms in some species. Mainly sheep suffer a great deal from copper poisoning, because the effects of copper are manifesting at fairly low concentrations. The entire mapped area is prone to suffer from the effects of copper due to their notable high concentration.

The chart shown in Figure 10 is plotted using the various concentration of copper in soils of the study area and also using its reported global average concentration in the world's soils, 30ppm (Bowen, 1979 and Webber *et al.,* 1984). From the plot, all the soil samples have concentration of copper above average. ADE 9 tends to have more copper concentration above average compared to others.

Zinc

Health Effect: Zinc is a trace element that is essential for human health. When people absorb too little zinc they can experience a loss of appetite, decreased sense of taste and smell, slow wound healing and skin sores. Zinc-shortages can even cause birth defects. Too much zinc can cause eminent health problems, such as stomach cramps, skin irritations, vomiting, nausea, anemia, damage the pancreas and disturb the protein metabolism, and cause arteriosclerosis, and respiratory disorder. A good example is that of Zamfara State Lead poisoning caused by the wildcat extraction of gold from Pb-Zn-Cu sulphides.

Environmental Effect: Large quantities of zinc can be found in soils. When the soils of farmland are polluted with zinc, animals will absorb concentrations that are damaging to their health. Water-soluble zinc that is located in soils can contaminate groundwater. Zinc cannot only be a threat to cattle, but also to plant species. Plants often have a zinc uptake that their systems cannot handle, due to the accumulation of zinc in soils. When zinc is present in a toxic level in plants the following symptoms are usually observed; whitened leaves with green veins, dead areas on leaf tips, purple stems, whitened leaves with green veins, stunted roots and white dwarfed forms.

Areas within the vicinity of soil samples ADE 1, 3, 5, 6, 8, 9 10 and 11 are prone to the effects of zinc due to their high concentration in zinc while areas within the vicinity of samples ADE 2, 4 and 7 are not prone to. When is present in a toxic level in plants the following symptoms are usually observed; dead patches on lower leaves from tips, purple stems, whitened leaves with green veins, stunted roots, creeping sterile forms in some species.

The chart shown in Figure 11 is plotted using the various concentration of zinc in soils of the study area and also using its reported global average concentration in the world's soils, 50ppm (Bowen, 1979 and Webber *et al.,* 1984). From Figure 11, soil samples ADE 1, 3, 5, 6, 8, 9 10 and 11 have concentration of zinc above average while samples ADE 2, 4 and 7 are below average.

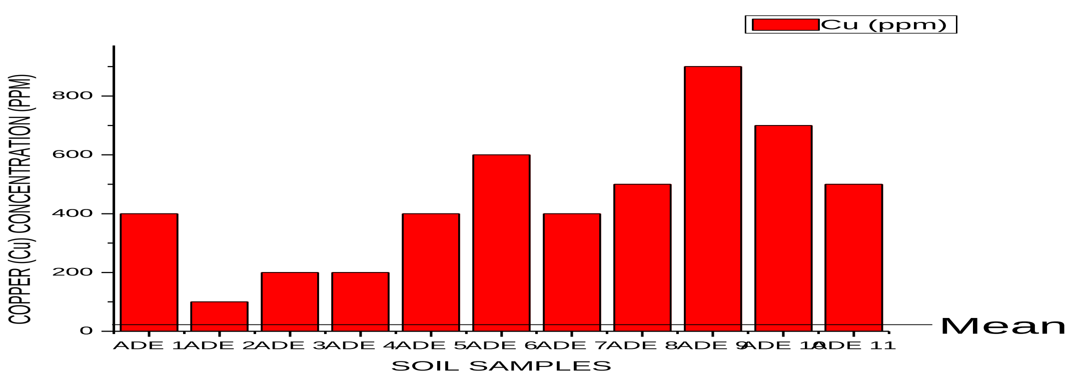

Figure 10: Bar Chart showing the Concentration (ppm) of Copper (Cu) in Soils of Abuni and its Environs.

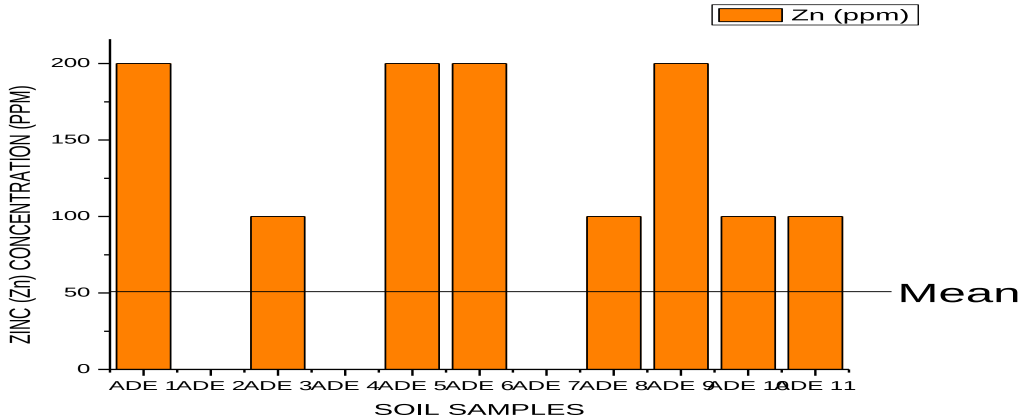

Figure 11: Bar chart showing the concentration (ppm) of Zinc (Zn) in soils of Abuni and it Environs.

Strontium

Health Effect: We are most likely to come in contact with strontium by eating, drinking or by direct contact with soil that contains strontium. Foodstuffs with significantly high concentrations of strontium are grains, leafy vegetables and dairy products. Radioactive strontium is much more of a health risk than stable strontium. When the uptake is very high, it may cause anemia and oxygen shortages, and at extremely high concentrations it is even known to cause cancer as a result of damage to the genetic materials in cells.

Environmental Effect: Strontium in its elemental form occurs naturally in many compartments of the environment. Strontium compounds can move through the environment fairly easily, because many of the compounds are water-soluble. Strontium does not bio magnify up the food chain. Areas within the vicinity of soil samples ADE 1, 5, 6, 7 and 11 are prone to the effects of strontium due to their high concentration in strontium while the other areas are not.

The chart shown in Figure 12 is plotted using the various concentration of strontium in soils of the study area and also using its reported global average concentration in the world's soils, 340ppm (Bowen, 1979 and Webber *et al.,* 1984). From Figure 12, soil samples ADE 1, 5, 6, 7 and 11 have concentration of strontium above average while samples ADE 2, 3, 4, 8, 9 and 10 are below average. ADE 7 tends to have more strontium concentration above average compared to others.

Zirconium

Health Effect: Zirconium 95 is among the long-lived radionuclides and will continue to produce increased cancers risk for decades and centuries to come.

Environmental Effect: Zirconium is unlikely to present a hazard to the environment. While aquatic plants have a rapid uptake of soluble zirconium, land plants have little tendency to adsorb it, and indeed 70% of plants that have been tested showed no zirconium to be present at all. Areas within the vicinity of soil samples ADE 2, 8, 9 and 10 are prone to the effects of zirconium due to their high concentration in zirconium while the other areas are not.

The chart shown in Figure 13 is plotted using the various concentration of zirconium in soils of the study area and also using its average concentration in the soils of the area (2800ppm). From Figure 13, soil samples ADE 2, 8, 9 and 10 have concentration of zirconium above average while samples ADE 1, 3, 4, 5, 6, 7 and 11 are below average. ADE 2 tends to have more zirconium concentration above average compared to others.

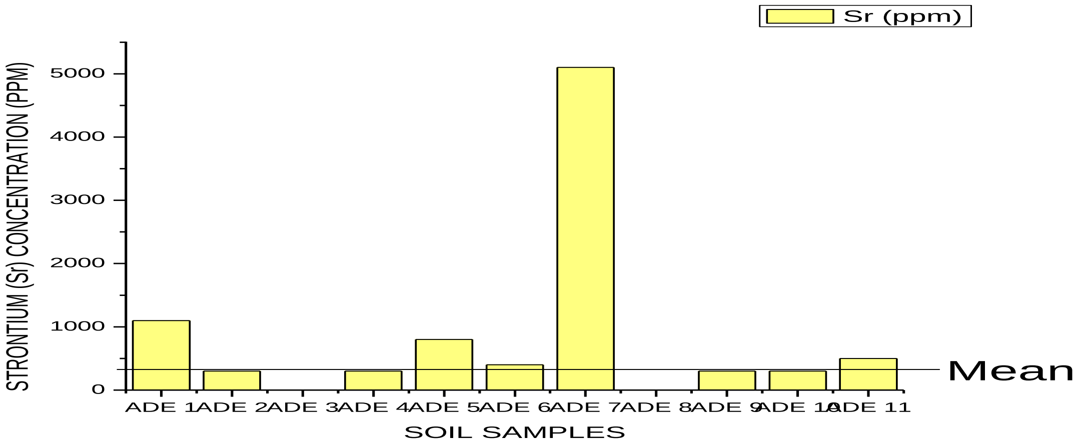

Figure 12: Bar Chart showing the Concentration (ppm) of Strontium (Sr) in Soils of Abuni and its Environs.

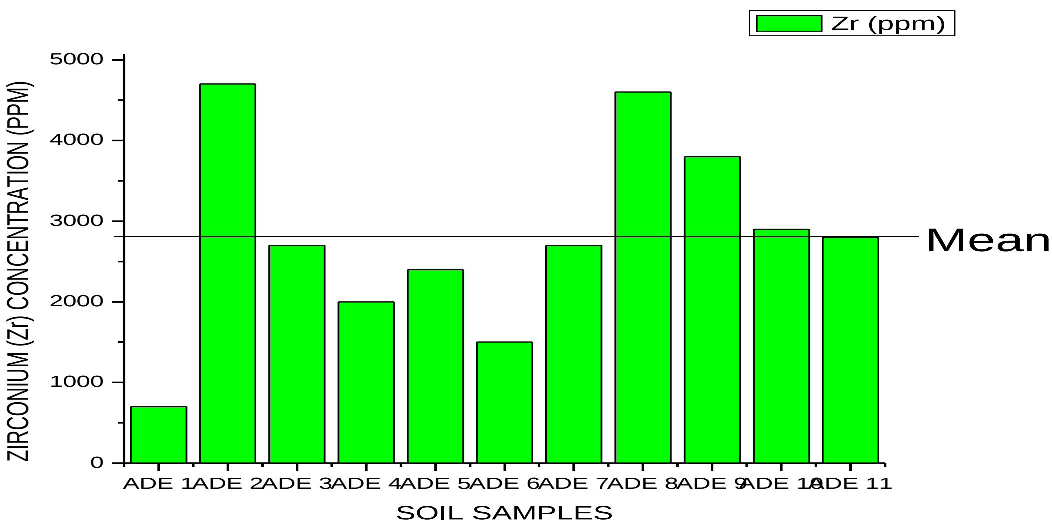

Figure 13: Bar Chart showing the Concentration (ppm) of Zirconium (Zr) in Soils of Abuni and its Environs.

Rubidium

Health Effect: Signs and symptoms of too much of rubidium in patients include; skin and eye burns, failure to gain weight, ataxia, hyper irritation, skin ulcers, and extreme nervousness.

Environmental Effect: Rubidium has no known biological role but has a slight stimulatory effect on metabolism, probably because it is like potassium. No negative environmental effects of rubidium have been reported.

Areas within the vicinity of soil samples ADE 1, 5, 6, 7 and 11 are prone to the effects of rubidium due to their high concentration in rubidium while the other areas are not.

The chart shown in Figure 14 is plotted using the various concentration of rubidium in soils of the study area and also using its average concentration in the soils of the area (300ppm).

From Figure 14, soil samples ADE 1, 5, 6, 7 and 11 have concentration of rubidium above average while samples ADE 2, 3, 4, 8, 9, and 10 are below average.

Lead

Health Effect: Lead is one out of four metals that have the most damaging effects on human health. It can enter the human body through uptake of food (65%), water (20%), and air (15%). Foods such as fruit, vegetables, meats, grains, seafood, soft drinks and wine may contain significant amounts of lead. For as far as we know, lead fulfils no essential function in the human body, it can merely do harm after uptake from food, air or water. Lead can cause several unwanted effects, such as; Disruption of the biosynthesis of hemoglobin and anemia, A rise in blood pressure, Kidney damage, Miscarriages and subtle abortions, Disruption of nervous systems, Brain damage, Declined fertility of men through sperm damage, Diminished learning abilities of children, Behavioral disruptions of children, such as aggression, impulsive Lead can enter a fetus through the placenta of the mother. Because of this, it can cause serious damage to the nervous system and the brains of unborn children, vomiting, muscle weakness and sometimes leads to death. A good example is that of Zamfara State Lead poisoning caused by the wildcat extraction of gold from Pb-Zn-Cu sulphides.

Environmental Effect: Lead accumulates in the bodies of water organisms and soil organisms. These will experience health effects from lead poisoning. Health effects on shellfish can take place even when only very small concentrations of lead are present. Body functions of phytoplankton can be disturbed when lead interferes. Soil functions are disturbed by lead intervention, especially near highways and farmlands, where extreme concentrations may be present. Soil organisms can suffer from lead poisoning, too. Lead is a particularly dangerous chemical, as it can accumulate in individual organisms, but also in entire food chains.

Areas within the vicinity of soil samples ADE 6, 9 and 11 are prone to the effects of lead due to their high concentration in lead while the other areas are not.

The chart shown in Figure 15 is plotted using the various concentration of lead in soils of the study area and also using its reported global average concentration in the world's soil, 30ppm (Bowen, 1979 and Webber *et al.,* 1984).

From Figure 15, soil samples ADE 6, 9 and 11 have concentration of lead above average while samples ADE 1, 2, 3, 4, 5, 7, 8, and 10 are below average. ADE 6 tends to have more lead concentration above average compared to others.

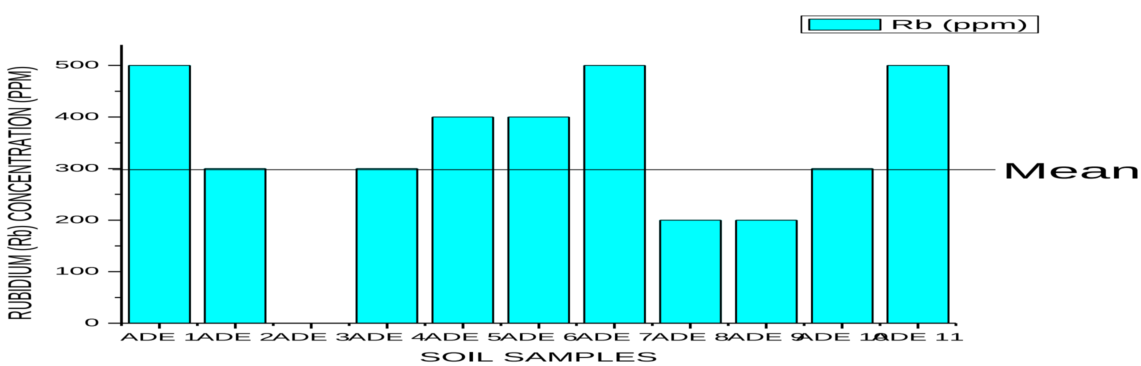

Figure 14: Bar Chart showing the Concentration (ppm) of Rubidium (Rb) in soils of Abuni and its Environs.

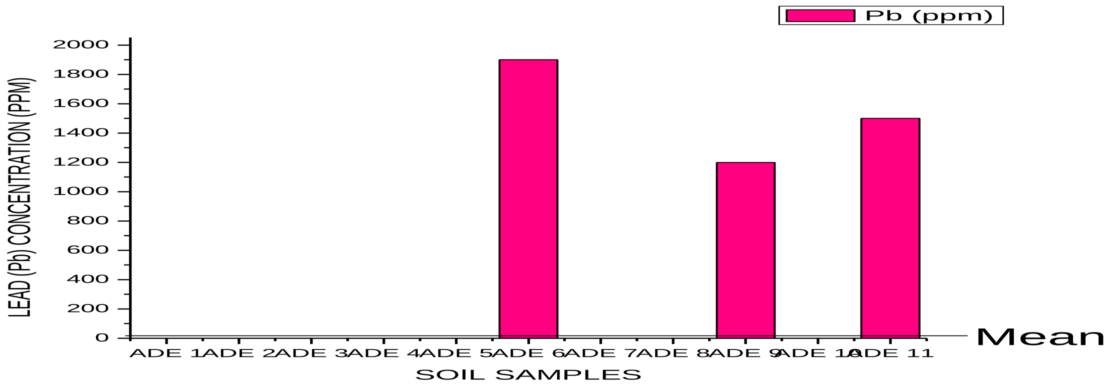

Figure 15: Bar Chart showing the Concentration (ppm) of Lead (Pb) in soils of Abuni and its Environs.

The SCM (SiO_2, CaO and MgO) ternary diagram (Figure 7) shows the relative variation of three major oxides in the soils of Abuni and its environs by showing the change of inter element ratio which do not necessarily show up clearly on two oxide correlation plots.

The point/contour maps and bar charts (Figures 8-15) reveal concentration of trace elements in each sample collected and also shows variation in concentrations of each sample relative to one another in the whole study area. The point/contour maps shows area of high and low concentration so that when an explorer sees it he or she will know where to concentrate his search for mineral deposits.

CONCLUSIONS

Petrographical and geochemical evidences obtained from this study, are: similarity observed in most of the sedimentary rock, suggesting that the sedimentary rocks were deposited under almost similar geological processes but not at the same time while the dissimilarity observed in the volcanics is due to the fact that they are relatively the youngest as they can be seen to intrude the Late Albian-Cenomanian Awe and Keana Formations.

The elemental concentration in the soils is influenced by the Awe and Keana Formations and the volcanics which serve as their parent material. This enrichment is as a result of weathering of these rocks and the subsequent redistribution and accumulation in the soils and streams.

Almost all elements plotted on the point/contour map and bar chart shows concentration above their crustal abundance (normal background value).

The trace element data obtained from this research may serve as a geochemical database of Abuni and its Environs for environmental related issues such as health and agriculture.

The geochemical data of major and trace elements obtained from this research may also serve as a geochemical baseline of Abuni and its Environs for application in detailed mineral exploration and exploitation.

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