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ASSESSMENT OF SOLID MINERALS AND SOME ELEMENTAL OXIDES IN SOIL OF KWAYA KUSAR LOCAL GOVERNMENT AREA OF BORNO STATE, NORTHEASTERN NIGERIA.

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ABSTRACT

Soil samples were collected from from (5) locations, wandali, kwaya kusar, gashina, kubagaya and guwal in kwaya kusar Local Government Areas, Borno State Northeastern Nigeria using Complete Randomized Block Design (CRBD). The coordinate of each location were taken, the soil samples were homogenized and dry at 500^{o}C for 12Hrs, then crushed using iron pestle and mortar and sieved using 150micro meshes, the samples were analyzed analytically using X-Ray Diffraction (XRD) for minerals, the results reveals the presence of Kaolinte, Microcline, Quartz, Albite, Biotite, Heamatite, Chlonlcore and Montmorillonite with Quartz been dominant across all the area studied. Major elemental oxides such as SiO_2, Fe_2O_3, Al_2O_3, CaO, TiO_2, MgO, K_2O, Na_2O, MnO and SO_3. Were also analyzed using X-Ray Fluorescence (XRF) Spectroscopy. SiO_2 was observed to be dominant followed by Al_2O_3 and Fe_2O_3 across all the areas studied.

***Keywords**: Assessment, Soil, Solid Mineral, XRD, XRF*

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INTRODUCTION

Geological composition of Biu plateau varies greatly, which provides great varieties of topographical forms, featuring rugged hills of granite, sandstone and volcanic plugs. The plateau developed on sedimentary and volcanic rocks [1]. The breaking down of rocks into smaller pieces under some condition is known as weathering, which leads to the breaking down of the minerals into their various elemental forms and that lead to an increase in the concentration of these elements in the soil [2]. According to Nelson [3], each rock or mineral have a particular chemical makeup, which is combination of two or more elements? Eg Calcite ($CaCO_3$), Bouxite ($Al(OH)_3$), etc, while some minerals are made up of single elements, eg gold (Au), Diamond (C) and silver (Ag) [4]. Some elements that are found in combined state in the earth crust and mantle are listed below in their predominantly order, Oxygen 46.6%, Silicon 27.7%, Aluminium 8.1%, Iron 5.0%, Calcium 3.6%, Sodium 2.8%, Potassium 2.6 % Magnesium 2.1% and all others put together 1.5%. [3]. The elements are combined in various proportions to form the rocks of the earth which are the parent materials with differences in their structure, composition and rate of decomposition [5]. It was also observed by Badmus. [6] that deep chemical weathering of rocks in hot humid and tropical climate promote mineral enrichment. It was also observed that dissolution of minerals by weathering process lead to the apparent enrichment of these elements in soil [7]. Some of these oxides have strong oxygen to other elements bond over a wide range of conditions e.g SiO which make their compound very strong and stable [8].

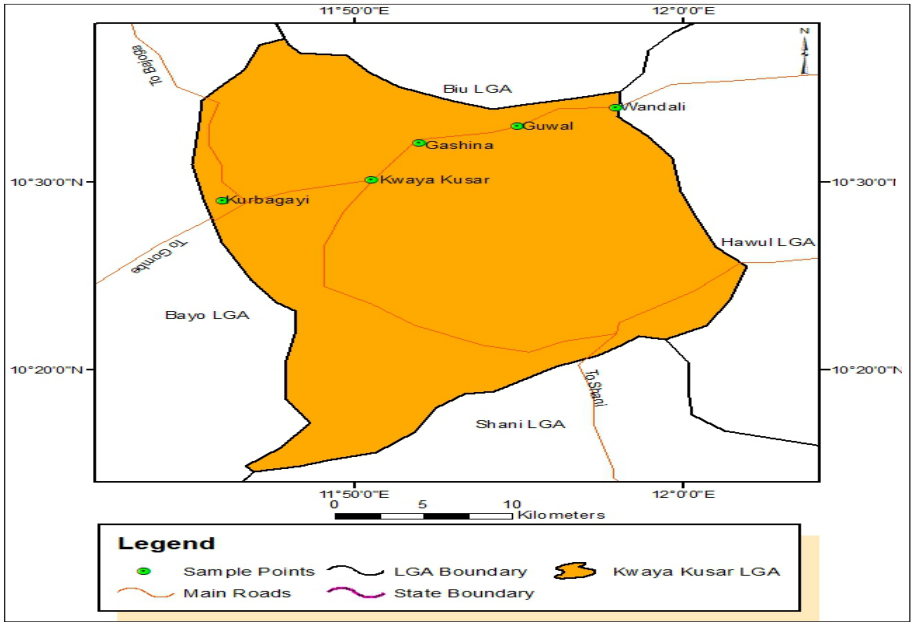
The mineral oxides typically present in soil comprises oxide, hydroxide, oxyhydroxide and hydrated oxides of Si, Fe, Mn, Al and Ti which are predominantly inherited from primary rocks minerals. Most oxide form in soil are metal cations Fe^{2+}, Mn^{2+}, Ti^{4+}, Al^{+3} and Si^{4+} are release from silicate by weathering. The divalent cation Mn and Fe oxide hydrolyze and precipitate almost exclusively and oxides mineral Al^{3+} and Si^{4+} have strong tendency to form secondary alumino-silicate clay minerals. The formation of Al and Si oxide requires special condition [9]. All oxides have very low solubility at common soil PH, and are therefore enriched during pedogenesis. Highly weathered soil which has lost a substantial part of the alkali such as Si may contain as much as 50% metal oxide. Mn, Fe and Al may exhibit a high surface area with reactive surface site which strongly bind oxyanion and metal cation, thereby impacting the availability and mobility of plant and toxic metals [10]. The basic structural unit of Fe, Mn, Al and Ti oxides are cationic metal centers bound to six oxygen in relation to the metal cation.

Many oxide minerals such as geothnite. Silicon is bounded to four oxygen forming a tetrahedron; these tetrahedrous are connecting viacorner only [11].

Geologist defined mineral as crystalline solid which occurs naturally with specific chemical composition, structural arrangement of component atom and physical properties [12]. According to Pidwirny [13], there are specific element or combination of elements which are known to be associated with specific type of mineral, therefore it is possible to evaluate the elements which are found in a given area [14]. Considering the diversity of minerals group in nature, the initial mineralogical and chemical examination of minerals ore can be used to indicate the suitability of minerals for different application [15]. According to Pipkin and Trend [14]. Minerals are originated through the process of rock formation occurring in nature. A common phenomenon occurring for the origin is the cooling of molten magma (rock materials) from the earth crust. The magma that reaches the surface is called lava, as this material crystallized and grow into rock [16].

According to Alexander *et al*. [2], the mineral resource potential of an area is a measurement of the likelihood of occurrence of valuable mineral or minerals that are valuable in feature. It is against this background that the research is motivated to investigate quantity and quality of minerals and elemental composition in soil of Kwaya kusar local government area. Biu plateau has not been extensively studied but some geologists have made an appreciable attempt in identifying the types of rocks and soil in the study area. This work investigates the types of minerals and elemental composition in soil of Kwaya kusar local government area which is part of Biu plateau using some analytical techniques

Study area



Map of kwaya kusar local government area

Soil sampling

Surface soil was taken from 0 cm to 50 cm depths. A soil probe was used for collecting soil samples as described by Alexander *et al.* [17]. A spade was used to dig down the soil profiles. Composite sample of five (5) samples across the study area was obtained. The soils collected was mixed thoroughly and put into well label polythene bags, the soil samples were homogenized and dry at 500^0 C for 12 hours. The soil samples were crushed using iron pestle and mortar then sieve by using 150 micro meshes and ready for analytical assessment of the in the laboratory.

Determination of Major Elemental oxides from Soils Samples using X-Ray Fluorescence (XRF) Spectroscopy

Major elemental oxides in soil were determined using X-ray fluorescence spectroscopic method Axion cement Pan Analytical model. 20g of each powder soil was fuse with 0.40g of stearic acid in 20ml platinum crucibles and pass with Herzog D4500 model hydraulic press to form pellet. These fused buttons was X- rayed and counted, and the major elemental oxides was determined (Swanson and Huffman, 1976)[18]. An annular 25 mCi 109Cd was used as an excitation source, which emit Ag-K X-ray (22.1KeV) in which case, the element with lower characteristics excitation energies was accessible for detection in the samples.

Quantitative analysis of samples was carried out using the emission transmission (E – T) method, for which a number of quantifications was developed and apply; these quantification methods provide different approaches to correct the matrix absorption as well as enhancement effect. In this work, quantification was carry out using a modified version of Emission-Transmission (E-T) method and the use of pure target material (Mo) was employ to measure the absorption factor in the samples. The (Mo) target served as monochromatic X-ray which was excited through the sample by primary radiation and penetrate the sample on the way to detector. The absorption factor was experimentally determined which was used by the program in the quantification of concentration of the elements. In addition, the contribution to the Mo-K peak intensity by the Zr-K was subtracted from each sample. The spectra for the sample were collected for 3000s with the 109 Cd source and the spectra were evaluated using the AXIL-QXAS program. 109Cd was used for analysis of the metal oxides.

Statistical analysis

All analysis was performed in triplicates. Result was presented as mean ± SD. Statistical significant Figure were establish using one-way analysis of variance. (ANOVA). Mean was separated according to Duncans Multiple Range Analysis. $P \leq 0.05$ was considered statistical significant

Results

The results of some major elemental oxides in soil samples of kwaya kusar local government area is shown in table 1 bellow. The quantitative analysis reveals that SiO_2 is present in the samples of all locations with relatively high concentration than any other metal oxide, with concentration ranges from 35.72 ± 26.6 % in guwal to 60.62 ± 1.70 % in kwaya kusar with the total mean of 46.32 % across the study area, Fe_2O_3 and Al_2O_3 was observed across all the areas studied with concentration ranges from 8.78 ± 1.52 % in kwaya kusar and 16.64 ± 0.42 % in Gashina to 27.50 ± 1.09 % in kubagaya and 20.46 ± 0.24 % in Kubagaya respectively. CaO was observed across all the areas studied with concentration ranges from 1.96 ± 1.05 % in wandali to 7.46 ± 1.55 % in Guwal with the mean concentration of 3.99 %. TiO_2, MgO and K_2O occurs

across all the areas studied with concentration ranging from2.31 ± 0.71 % in guwal, 1.60 ± 0.19 % in Gashina and 1.45 ± 0.36 % in Kubagaya respectively to 4.41± 0.36 % in Gashina 2.53 ± 0.25 % in kubagaya and 7.13 ± 1.89 % in kwaya kusar respectively. Na_2O was observed only in wandali with the concentration of 0.23 ± 0.21 %, MnO and $S0_3$ was detected across all the area studied with relatively low concentration. the concentration ranging from 0.23 ± 0.02 % in kwaya kusar and 0.43 ± 0.27 % in wandali to 0.54 ± 0.12 % in kubagaya and 0.82 ± 0.27 % respectively. Lol was observed to vary from one location to another with relatively low concentration of less than 2% across the areas studied.

Table 1: Present the mean Percentage Concentration of Some Major Elemental Oxides in Soils of Kwaya Kusar Local Government Area

Location	SiO_2	Fe_2O_3	AL_2O_3	CaO	TiO_2	MgO	K_2O	Na_2O	MnO	SO_3	LOI
Wandali	41.75 ± 0.72^{ab}	19.56 ± 1.30^{b}	19.26 ± 2.11^{ab}	1.96 ± 1.05^{a}	3.31 ± 1.04^{ab}	1.67 ± 0.59^{a}	5.23 ± 1.02^{bc}	0.23 ± 0.21^{b}	0.49 ± 0.40^{a}	0.43 ± 0.27^{a}	0.17
KwayaKusar	60.62 ± 1.70^{b}	8.79 ± 1.52^{a}	18.99 ± 2.06^{ab}	2.88 ± 1.51^{a}	2.63 ± 0.74^{a}	2.31 ± 1.29^{a}	7.13 ± 1.89^{c}	0.00 ± 0.00^{a}	0.23 ± 0.07^{a}	0.47 ± 0.20^{a}	1.11
Gashina	54.06 ± 0.32^{ab}	17.73 ± 0.49^{b}	16.64 ± 0.42^{a}	1.96 ± 0.10^{a}	4.41 ± 0.36^{b}	1.60 ± 0.19^{a}	2.93 ± 0.15^{ab}	0.00 ± 0.00^{a}	0.44 ± 0.07^{a}	0.60 ± 0.17^{a}	1.19
Guwal	35.72 ± 26.6^{a}	17.55 ± 1.42^{b}	19.48 ± 1.41^{ab}	7.46 ± 1.55^{b}	2.31 ± 0.71^{a}	1.67 ± 0.61^{a}	7.60 ± 2.16^{c}	0.00 ± 0.00^{a}	0.39 ± 0.12^{a}	0.82 ± 0.27^{a}	1.07
kubagaya	38.99 ± 0.22^{ab}	27.50 ± 1.09^{c}	20.46 ± 0.24^{b}	5.70 ± 0.60^{b}	3.45 ± 0.38^{ab}	2.53 ± 0.25^{a}	1.45 ± 0.17^{a}	0.00 ± 0.00^{a}	0.54 ± 0.12^{a}	0.48 ± 0.15^{a}	10.92
Range	4.92 .62.17	7.13-28.40	16.16-21.3	1.17-9.13	1.74-4.82	1.00-3.80	1.30-9.28	0.00-0.41	0.17-0.94	0.19-1.02	0.28
Total Mean	46.23	18.22	18.97	3.99	3.22	1.95	4.69	0.13	0.42	0.56	0.12
Standard Deviation	14.11	6.25	1.81	2.47	0.95	0.72	2.64	0.05	0.20	0.24	0.49
C.V. (%)	30.52	34.30	9.54	61.90	29.5	36.92	56.29	38.46	47.62	42.86	2.14

Mean ± Standard Deviation within a column with different superscript letters are significantly different at $P \leq 0.05$ according to Duncan Multiple Range Test. CV = Co-efficient of Variation

Mineral Identified in Soil of Kwaya Kusar Using X – Ray Diffraction Ppectroscopy (XRD)

The mineral identified in soil of kwaya kusar Local Government Area are presented in Table 2. The result from Kubagaya revealed the presence of Chlinochlore, Hematite and montmorillonite with the percentage composition of 3 %, 86 % and 11 % respectively as shown in Figure 1. The sample of wandali showed the presence of 30 % Augite, 36 % quarts, 12 % Hematite and 22 % kaolinite as shown in the Figure 2 bellow. The mineral recorded in the soil of Guwal were 33 % Ablite, 41 % microcline, 10 % Biotite and 16 % Quarts as shown in the Figure 3: The soils of Gashina contain microcline and Quarts with percentage composition of 21 % and 79% respectively as shown in the Figure 4 below. The mineral identified in the soil of kwaya kusar were kaolinite, microcline and Quarts with the percentage composition of 13 %, 44 % and 43 % respectively as show on Figure 5.

Table 16: Mineral Identified in Soil of Kwaya Kusar Local Government Area Using X – Ray Diffraction Spectroscopy (XRD)

Location	Minerals	Compound name	Chemical formula	Crystal system
Kwayakusar	Kaolinite	Aluminium Silicate Hydroxide	$Al_2Si_2O_5(0H)_4$	Anorthic
	Microchine	Potassium Aluminum silicate	$KAlSi_3O_8$	Anorthic
	Quartz	Silicon Oxide	SiO_2	Hexagonal
Gashina	Microchine	Aluminium Silicate Hydroxide	$KAlSi_3O_8$	Anorthic
	Quartz	Silicon Oxide	SiO_2	Hexagonal
Guwal	Albite	Sodium Aluminium Silicate	$NaAlSi_3O_8$	Anorthic
	Biotite	Potassium ironAluminiumMagnesium Silicate	$K(Mg,Fe)3(AlSiO_{810})$	Anorthic
	Microchine	Potassium Aluminium Silicate	$KAlSi_3O_8$	Anorthic
	Quartz	Silicon Oxide	SiO_2	Hexagonal
Wandali	Augite	Calcium iron magnesium silicate	$Ca(Mg,Fe)Si_2O_6$	Monochinic
	Hematite	Iron oxide	Fe_2O_3	Hexagonal
	Kaolinite	Aluminium Silicate Hydroxide	$Al_2Si_2O_5(0H)_4$	Hexagonal
	Quartz	Silicon Oxide	SiO_2	Hexagonal
Kubagaya	Chinochore			Anorthic
	Hematite	Iron oxide	Fe_2O_3	Hexagonal
	Montmorillonite	Sodium magnesium Aluminium Silicate Hydroxide Hydrate	$Na_2(AlMg)_2Si_4O10OH_2.6H_2O$	Monochinic

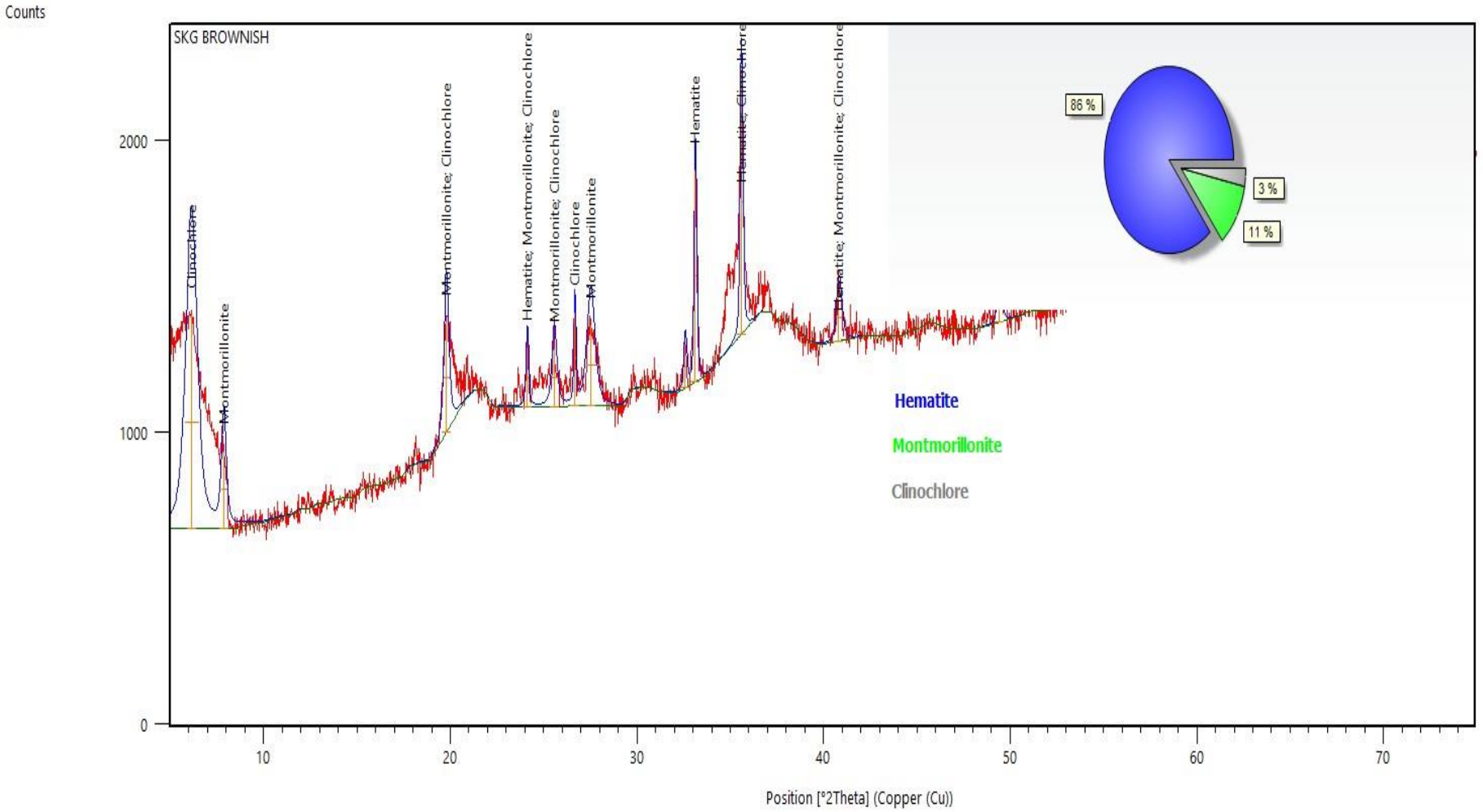


Figure. 1 Percentage composition of minerals in Soil of Kubagaya

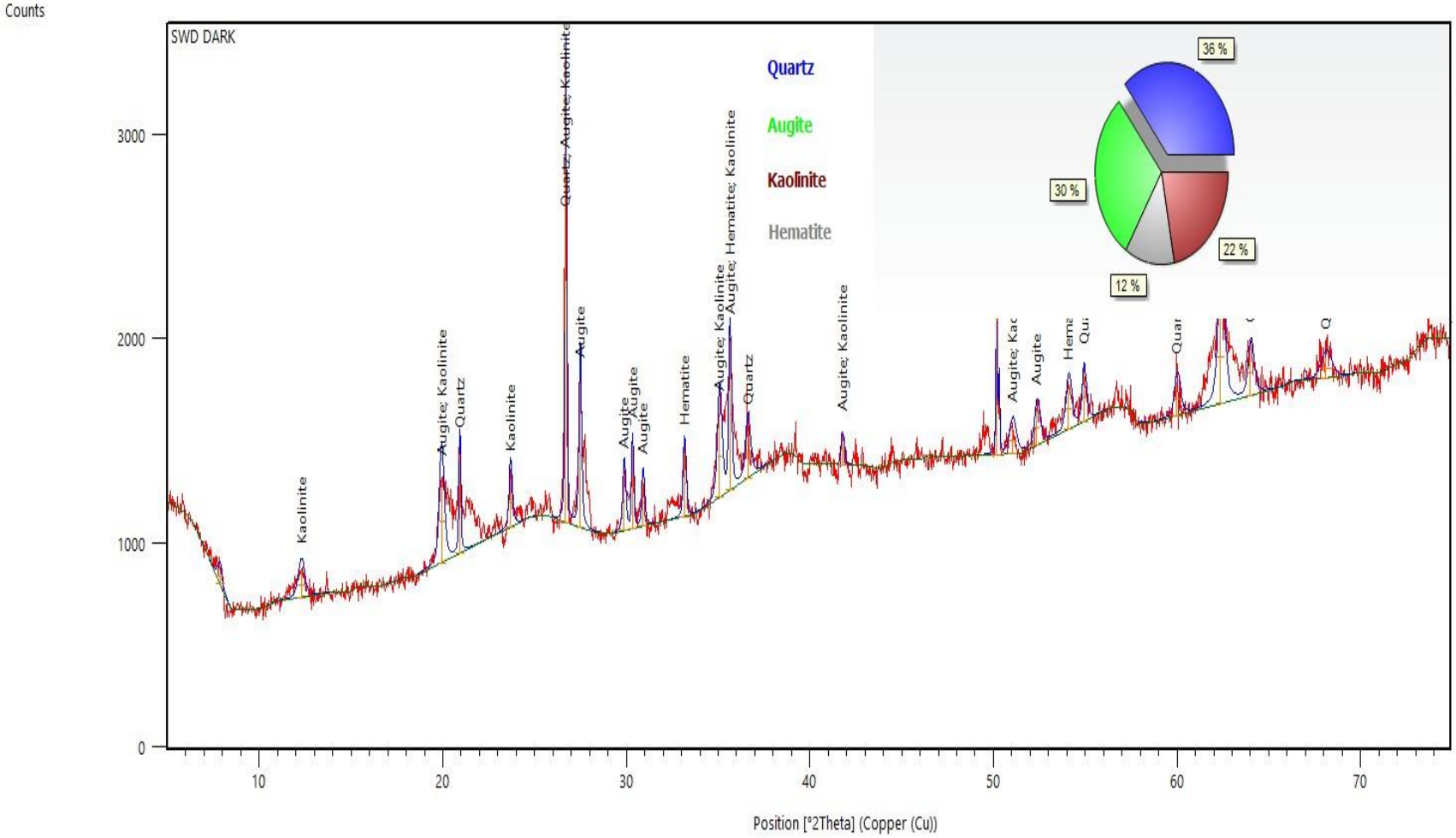


Figure. 2 Percentage compositions of minerals in Soil of Wandali.

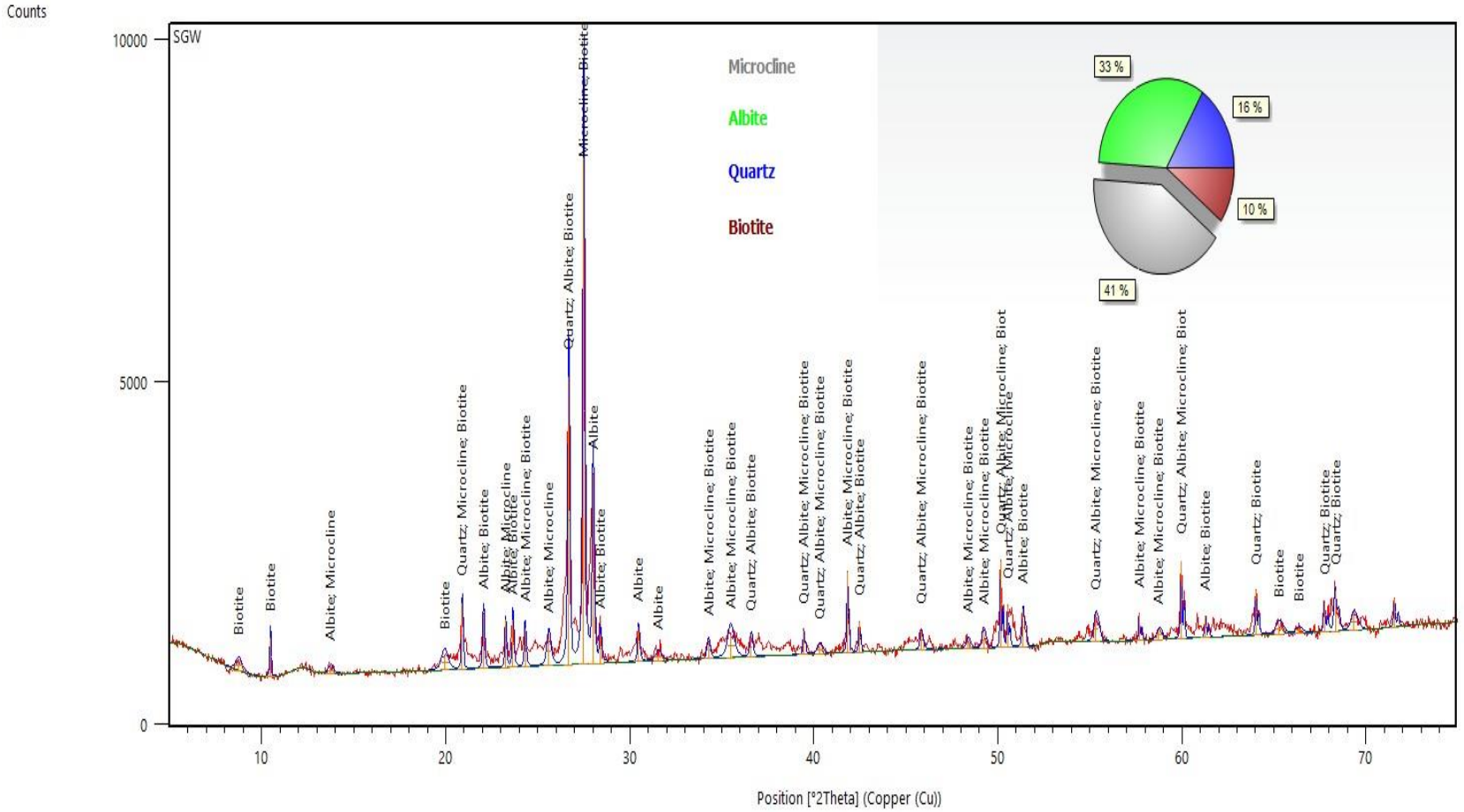


Figure. 3: Percentage composition of minerals in Soil of Guwal.

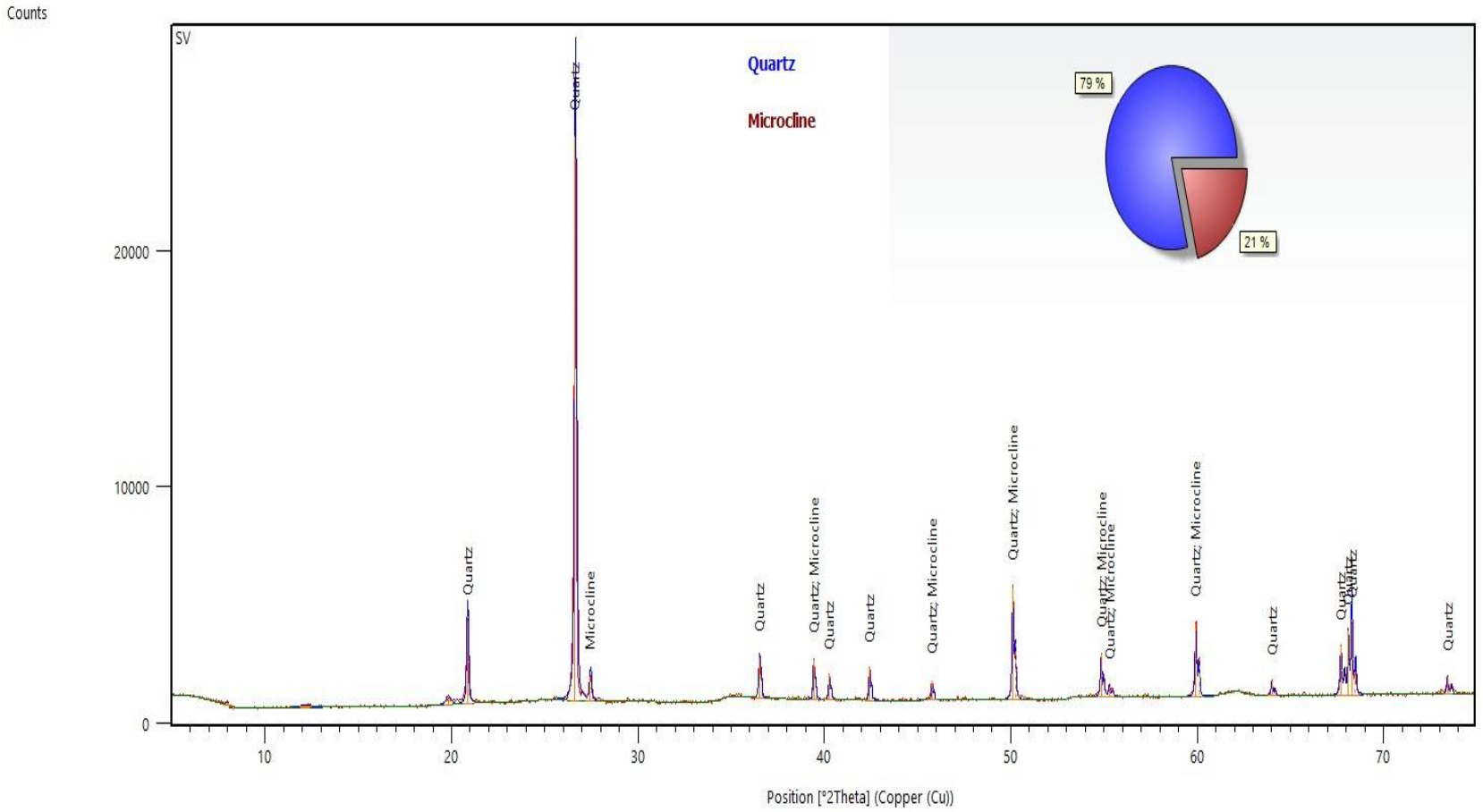


Figure. 4: Percentage composition of minerals in Soil of Gashina.

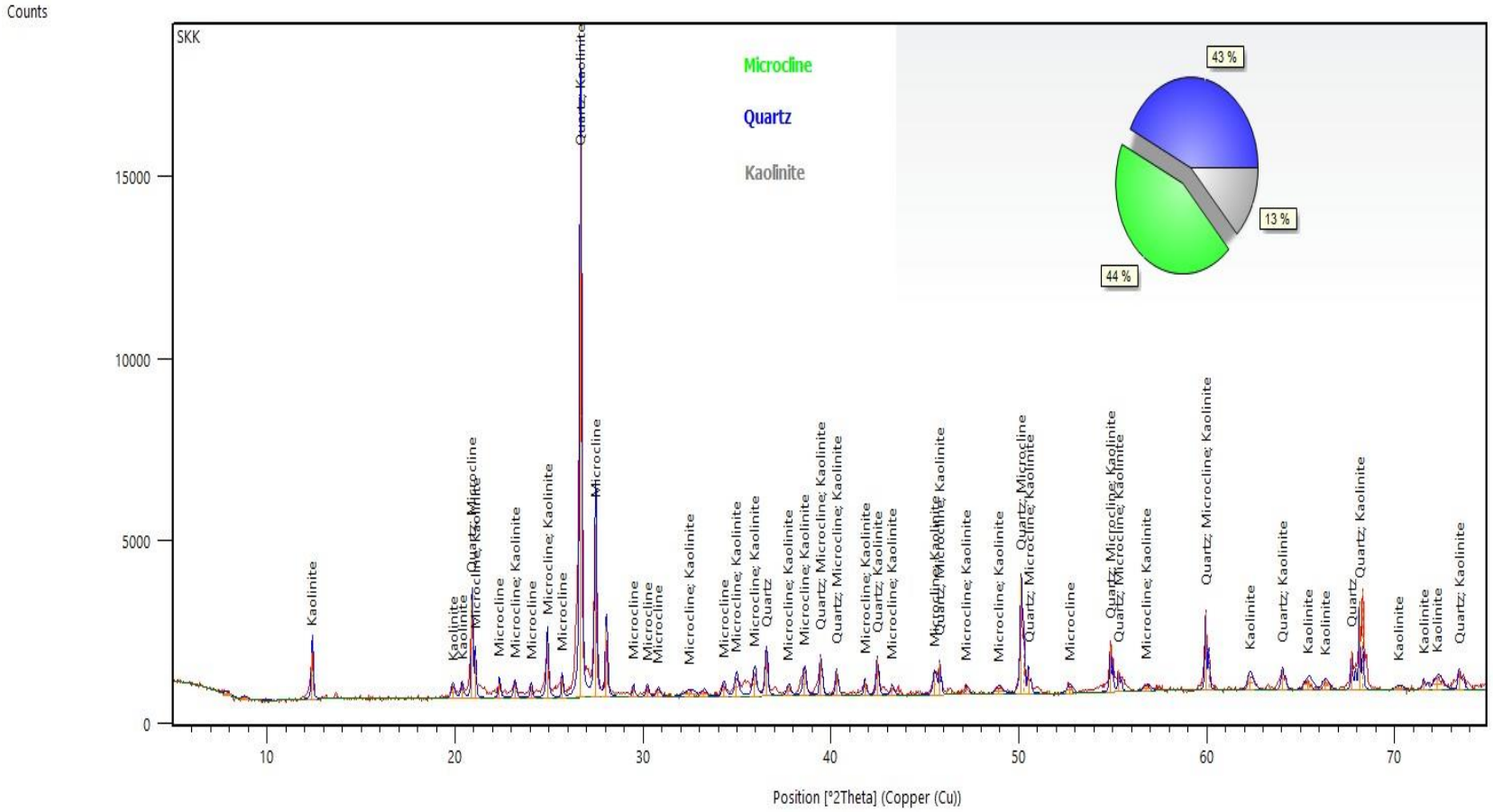


Figure. 5: Percentage composition of minerals in Soil of Kwaya kusar

DISCUSSION

Base on the information given in the table above, SiO_2 was observed to be relatively higher than Any other elemental oxides, similar results was obtained by Osemeahon *et al*. [19], in a research titled survey of solid minerals in rocks of Ditera and Waltadi in song local government area of Adamawa state. The high concentration of SiO_2 could be due to the fact that silicon and oxygen are the most abundant element in the earth crust and mantle, they are strongly bonded over a wide range of condition which make their compound to be stable, as recorded by Alexander *et al.* [2]. This study confirm that the soil of the study area have high percentage of silicate minerals such as quartz, biotite and microcline as reported by Tadzabia *et al*. [20]. Al_2O_3 was also observed to be relatively high in concentration; this study is in line with the research conducted by Ako *et al.* [21]. The high concentration could be due to the fact that Al_2O_3 are less mobile elements in soil in which they are lock up especially in alimino-silicate minerals as reported by Penuel *et al*. [22]. The relatively high concentration of Al_2O_3 signals the reason why bytownite, phlogopite, microcline, Kaolinite and chlinichlore was detected in the soil as reported by Magili and Maina, [4]. Fe_2O_3 was observed across all the area studied with relatively high concentration, similar results were also recorded by Alexander *et al.* [2] and Osemeahon *et al*. [19]. The high concentration of Fe_2O_3 across all location could be due to the fact that, Fe is relatively abundant in earth crust, the presence of Fe_2O_3 justify the existence of minerals hematite and albite in the study area as reported by Angus [23]. TiO_2 was observed across all the study area with relatively low concentration which could be due to leaching or due to ionic exchange or reaction that took place in the soil. The low concentration of TiO_2 justifies the absence of minerals such as Barite in the soil of the area studied. K_2O, MgO and MnO were observed in all the samples studied with relatively low concentration but the concentration varies from one location to another, the variation could be due to complex distribution of elements in the soil [24]. In Rubio *et al* [25] reported that the variation from one location to another could be due to instability of the carbonate and organic materials content of the soil samples. Na_2O and SO_3 were observed to have low concentration and does not occurs in all sample , it could be due to leaching in the soil and instability of their chemical bond.

Lol was observed to vary from one location to another with very low concentration of less than 1%, this indicate that the minerals does not contain decomposable organic matter such as carbonate etc.

Reference

1. Ikusemoran M, Abdullahi J, & Dami A. (2013). Terrain analysis of Biu plateau for road development, Borno State, Nigeria. *Journal of Geography and Geology*, 2013: 6 (**2)**, 29-35.
2. Alexander P, Maina HM & Barminas JT. Quality of Solid Minerals in Rocks and Soils of Mubi South Local Government Area of Adamawa State, Nigeria. *International Research Journal of Pure and Applied Chemistry*, 2016: 10(4): Pp 1-12.
3. Nelson SA (2016), Mineral Chemistry. Tulane University, file/MASTER/shared Does/mineral % 20 chemistry Liton. 2016.
4. Magili ST, & Maina, HM. Analysis of Guyuk limestone in Adamawa State, Nigeria using XRF Spectroscopy. *International Journal of Chemistry*, 2010: *2*(1), 84-92.
5. John F, & Steve P. The illustrated Encyclopedia of Minerals, Rocks and Fossils of the world. Annes Publishing Ltd. 2011: Pp. 145-256.
6. Badmus BS, Olurin OJ, Ganiyu SA, & Oduleye O. T (2013) Evaluation of Physical Parameters of Various Solid Minerals within Nigeria using Direct Experimental Laboratory Methods. *American International Journal of Contemporary Research* 2013: 3(**3)**: 153.
7. Amare K, & Koeberl C. Variation of chemical composition in Australasian tektites from different localities in Vietnam". *Meteoritics & Planetary Science*, 2006: 41(1), 107–123.
8. Churchman, G S, and Lowe D J. (2012) Alteration, formation and occurrence of minerals in soil: Hand book of soil science 2nd Edition Vol 1: properties and process" CRC Press. 2012: Pp 90-98.
9. Lawrence LB. Description of Some of Oregon Rocks and Minerals Oregon Department of Geological and Mineral Industries. 2008: Pp 12-13.
10. Stephen AN. Mineralogy, Phyllosilicates (Micas, Chlorite, talc and Serpentine, Tulane university. 2015: Pp 6-8.
11. Hobart MK. Biotite Mineral, Uses and Properties. Published by Geology.com. 2021: 1-4.

12. Areola O, Ahmed K, Iruueghe OI, Adeleke, BO, & Leong, GC. Certificate Physical and Human Geography for Senior Secondary Schools. University press PLC. 2010.
13. Pidwiny M. Composition of Rocks; Fundamentals of physics Geography 2' Edition. 2006.
14. Pipkin WB, & Trent DD. Geology and the environment (3rd Ed., pp. 27-45). Brooks/Cole USA. 2005.
15. Churchman GJ. Is the geological concept of clay minerals appropriate for soil science?" *Journal of Physics and Chemistry of the Earth*. 2010: 35, Pp 922-940.
16. Kearey P, Klepeis KA, & Vine JF. Global tectonics.John Wiley and sons Ltd West Sussex P0198SQ, United Kingdom. 2009.
17. Alexander P, Maina HM, Barminas JT, & Zira SP. Quality of solid minerals in rocks of michika local government area of Adamawa State, Nigeria, *Journal of Sciences and Multidisciplinary Research.* 2011; 3.23.
18. Swanson and Huffman, 1976
19. Osemeahon S.A, Maitera O.N and Benson A. (2015)."Survey of Solid Minerals in Rocks of Ditera and Waitaldi, Song, Nigeria". *Enviromental and Natural Resources Research*. 5, **4** Pp. 30 - 40.
20. Tadzabia K, Maina HM, Maitera ON and Ndahi JA (2019). "X-ray diffraction analysis of solid mineral contents in rocks of Song Local Government Area of Adamawa State, Nigeria.". *Ew J Anal & Environ Chem* 5(1):Pp 210 – 218.
21. Ako Thomas Agbor, Onoduku Usman Shehu. (2013), "Geology and economic evaluation of Odobola, Ogodo feldspar mineral deposit, Ajaokuta Local Government Area, Kogi State", Nigeria. *Earth Science Research*.; 2 **1**: Pp 52-65.
22. Penuel B.L. Maitera O N, Khan M.E and Ezekiel Y .(2017). X-ray Diffraction Characterization of Sedimentary Rocks in Demsa Local Government Area of Adamawa State, Nigeria, *Current Journal of Applied Science and Technology*. 24 **2**; Pp 2-9.
23. Angus, (2012)
24. Georgieva, M., Cherneva, Z., Hekimova, S., & Petrova, A. (2009). Petrology of marbles from the Arda tectonic unit, Central Rhodope, Bulgaria. *Abstracts of National conference, Geosciences 2009*

25. Rubio, B., Nombela, M. A., & Vilas, F. (2000). "Geochemistry of Major and Trace Elements in Sediments of the Ria de Vigo (NW Spain): an Assessment of Metal Pollution". *Marine Pollution Bulletin, 40*(11), 968-980.