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Estimation of Minerals Oxides Contents Using X-ray Flouresence in Soils of Yorro Local Government Area of Taraba State, Nigeria.

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ABSTRACT

Soil minerals are natural products in solid state and may be formed in a number of ways and they play a vital role in agriculture and industry. The mineral composition of soil samples from Yorro local government area of Taraba state was determined using X-ray fluorescence spectrometer. The results of the analysis showed considerable amount of SiO_2, Al_2O_3, Fe_2O_3, K_2O, TiO_2, CaO, MgO, SO_3 and P_2O_3 which occur as major elemental oxides, while ZrO_2, SrO, ZnO, CeO_2 and Nd_2O_3 as minor elemental oxides. Silicon oxide, SiO_2 recorded the highest total mean value in all the locations, which is due to its hardness and the ability to with stand weathering. In the same vein the results of the statistical analysis showed significant and non-significant difference in various locations on comparison of the study area. The result of this study revealed that the studied area is endowed with various mineral oxides which have great agricultural and industrial importance.

Keywords: X-Ray Fluorescence, Minerals, Elemental Oxide, Yorro.S

Introduction

Soil is a product of several factors: the influence of climate, relief (elevation orientation and slope of terrain, organisms, and the soil's parent materials) original minerals interacting over time. lt continually undergoes development by way of numerous physical, chemical and biological processes, which include weathering with associated erosion. Given its complexity and strong internal connectedness, soil ecologists regard soil as an ecosystem (Ponge, 2015).

Bulk of soil consists of mineral particles that are composed of arrays of silicate ions (SiO_4^{4-}) combined with various positively charged metal ions. It is the number and type of the metal ions present that determine the particular mineral. The most common mineral found in Earth's crust is feldspar, an aluminosilicate that contains sodium, potassium, or calcium (sometimes called bases) in addition to aluminum ions. Weathering breaks up crystals of feldspars and other silicate minerals and releases chemical compounds such as bases, silica, and oxides of iron and aluminum (Fe_2O_3 and alumina, Al_2O_3). The following have been found as mineral formed by edaphic processes: hematite, goethile, magnetite, calcite, gypsum, basanite chalcedony, chloride, compounds of manganese and lencoxene (Pipkin and Trant 2001). Many minerals can also sometimes have an inherited origin, such as the case for examples of carbonate (Youdeowei et al., 1999). Minerals and particularly secondary (clay) minerals have been regarded as an assessed either as indicators of the origin of soils and changes which have occurred in them through their development or else as the most reaching inorganic components of soils (Churchman and Lowe, 2012).

Soil minerals play a significant role in dictating the suitability and behavior of soil for various land uses. They provide physical support for plants, contribute to soil structural formation, are sources of many soil nutrients, and can act as sorbents of several environmental pollutants. Therefore, understanding soil mineralogy is essential to understanding many facets of land use and is often a key to solving specific agricultural and environmental problems. The most common methods used for soil mineral characterization include X-ray diffraction, X- ray fluorescence, thermal elemental and optical analysis.

In addition, the varying chemical, physical and biological soil properties studied, has specified greatly, recommendations for the future of agricultural soil corrections, sustainability and other industrial applications. The X-ray fluorescence is a multi- elemental analytical technique with broad application in science and industry. The technique is based on the principle that individual atoms, when excited by an external energy source emit X-ray photons of characteristics energy wavelength. Which upon counting the number of photons of each energy emitted from a sample, the elements present may be identified and quantified (James and Jeffery, 2012).

Materials and Methods

Study Area

The study area is Yorro Local Government Area which is situated in Northern part of Taraba State, Nigeria. Yorro has an area of 1275 km^2 and latitude of 8.9087 and longitude of 11.48434’. The GPS coordinates are 8°54'31.32" N and 11°29'3.62" E. The sampled locations are Langaviri, Barkin Yorro, Nyaja, Shara and Zampa respectively.

Apparatus/Equipment’s /Instruments

The following apparatus and instrument were used: X – Ray fluorescence spectrophotometer Bruker Model S2 Ranger, Auger, Pestle and Mortar, Sieve, Weighing balance, Polythene bags and Spade.

Soil Sampling

The samples were collected in according to the standard methods as reported by Penuel et al., (2017) and Tazabia et al., (2019). The soil samples were collected with an auger, hoe and shovel. The soil was sampled from four coordinates of the sampling site at an interval distance of 10 meters and 0 to 30 cm below the soil surface in triplicate and homogenized. The samples was kept in a polythene bag to preserve it and taken to the laboratory for further processing as described by Penuel et al., (2017) and Tadzabia et al., (2019).

Soil Sample Preparation

Soil samples were dried by spreading them on clean polythene sheet in the laboratory for seven days. The dried soil samples were ground using mortar and pestle and sieved through a 2mm mesh sieve to obtain fine powder form. Gross samples were reduced to test sample sizes through the process of cone and quartering. The method involved forming cone shape with the sample and dividing it into four equal portions and taking the two opposite sides of the quarter while the other two quarters were discarded. The retained two quarters were recombined and the process was repeated until about 100g of the sample is obtained. Maitera *et al.,* (2015) and Okunola *et al.,* (2008).

Analysis of Soil Samples Using X-Ray Fluorescence Spectrometer (XRF).

X-Ray Fluorescence Spectrometer (XRF) was used for the identification and evaluation of mineralogical contents of the soil samples as described by Tadzabia *et al*, (2019). 2.0g of powdered soil samples was fused with 0.40g of stearic acid in 2oml platinum crucible and it was pressed with hydraulic press to obtain soil pellets. The soil pellets formed were exposed to short wave length x-ray radiation ionization takes place and ejection of inner electron shell takes place. Electron from outer electron shells falls into the lower shells to fill the space left behind and fluorescence radiation (energy) is released. The energy of which is equal to or characteristics of the atom present. The fluorescence radiation (energy) released is the evaluated by a detector.

Statistical Analysis

Analysis of variance (ANOVA) at 95% level of probability ($p<0.05$) was applied on the result generated using SPSS Version 2.5 statistical Package and significant means comparison was also carried out using Duncan Multiple Range Test.

Results and Discussion

Table 1 presents the results of the major mineral component in soils of Yorro Local Government Area. Silicon oxide (SiO_2) was the most abundant oxide found in the soil sample with a total mean value of 57.79%, ranging from 49.67% to 64.07%. From the result obtained Barkin Yorro varies significantly from other locations at $p<0.05$. Aluminium oxide (Al_2O_3) composition was found in the entire sample with an average value of 19.12% ranging between 18.36% to 22.50%. There was significant difference at $p<0.05$ in Zampa location compared to other locations. Iron oxide (Fe_2O_3) measured in the soil samples ranged between 3.30% to 22.50% with an average composition of 7.06% Langariri and Nyaja varies significcantly with Barkin Yorro, Shara and Zampa locations at $p<0.05$. Potassium oxide (K_2O) content was also detected in the soil sample with a range of 7.6% to 0.52% with an overall mean value of 8.33%. At $p<0.05$ Langaviri and Nyaja Locations varies significantly with Barkin Yorro, Shara and Zampa locations. Titanium oxide (TiO_2) detected in the soil sample also recorded a total mean concentration of 1.83% to 3.03% respectively. At $p<0.05$ Barkin Yorro area and

Shara location varies significantly with Langaviri, Nyaja and Zampa with respect to titanium oxide

Analysis of the soil sample by XRF instrument also detected the presence of calcium oxide (CaO) with a range of 0.94% to 3.15% and an average mean value of 1.93%. Langaviri location varies significantly from the other locations at $p<0.05$. Magnesium oxide (MgO) detected also recorded an average mean value of 1.95% with range of 0.80% to 3.10%. There was a significant difference between Barkin Yorro locations with Langaviri, Nyaja, Shara and Zampa at $p<0.05$. Manganese oxide also showed a total mean concentration value of 0.25% and a range of 0.10% to 0.27%. There was no significant variation between Langaviri, Nyaja and Zampa location at $p<005$ with respect to manganese oxide. A total mean value of 0.43% and range of 0.33% to 0.48% was recorded for sulfur oxide (SO_3). Nyaja area varies significantly from the other four locations at $p<0.05$. Phosphorus oxide (P_2O_3) was also present in all the samples with an average mean value of 0.60% and range of 0.54% to 0.72% No variation occurred in Langaviri, Nyaja and Shara locations respectively at $p<0.05$. The result is comparable to the work reported by Zanna *et al* (2017) and Tadzabia *et al* (2019)

Table 1: Mean Concentration of Some Major Elemental Oxide in Soil of Yorro Local Government Area (%)

Location	SiO_2	AI_2O_3	Fe_2O_3	K_2O	TiO_2	CaO	MgO	MnO	SO_3	P_2O_5
Barkin Yorro	49.67±2.13^{a}	19.19±1.23^{a}	13.52±1.11^{d}	5.63±0.34^{a}	3.03±0.23^{c}	3.15±0.43^{c}	3.10±0.41^{c}	0.27±0.03^{c}	0.48±0.05^{b}	0.72±0.06^{b}
Langaviri	62.47±2.56^{c}	18.67±1.10^{a}	3.76±0.32^{a}	10.03±1.22^{c}	1.18±0.03^{a}	0.94±0.05^{a}	0.80±0.05^{a}	0.12±0.01^{a}	0.44±0.04^{b}	0.57±0.06^{a}
Nyaja	64.07±3.01^{c}	16.90±1.26^{a}	3.30±0.32^{a}	9.97±1.33^{c}	1.22±0.04^{a}	1.66±0.07^{b}	0.90±0.07^{a}	0.08±0.02^{a}	0.33±0.02^{a}	0.54±0.04^{a}
Shara	56.49±2.41^{b}	18.36±1.43^{a}	8.12±1.11^{c}	8.48±1.23^{bc}	2.38±0.32^{b}	1.94±0.07^{b}	1.90±0.06^{b}	0.20±0.03^{b}	0.47±0.05^{b}	0.55±0.08^{a}
Zampa	56.28±2.08^{b}	22.50±1.12^{b}	6.58±0.61^{b}	7.56±0.52^{b}	1.32±0.05^{a}	1.95±0.04^{b}	1.60±0.06^{b}	0.10±0.01^{a}	0.41±0.05^{b}	0.64±0.08^{ab}
Range	49.67-64.07	18.36-22.50	3.30-13.52	5.63-10.03	1.18-3.03	0.94-3.15	0.80-3.10	0.10-0.27	0.33-0.48	0.54-0.72
Grand Mean	57.79	19.12	7.06	8.33	1.83	1.93	1.95	0.15	0.43	0.60
Standard Deviation	5.69	2.18	3.87	1.90	0.79	0.76	0.13	0.07	0.07	0.08
C.V. (%)	9.85	11.40	54.82	22.81	43.17	39.38	6.67	46.67	16.28	13.33

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

ND = Not Detected

Table 2 presents the results of the minor mineral component in soils of Yorro Local Government Area. Zirconium oxide (ZrO_2) was present in all the entire samples investigated with an average value of 0.19% ranged between 0.13% to 0.23%. The amount of ZrO_2 obtained in Yorro area varies significantly at $p<0.05$. Barium oxide composition in soil sample also revealed a range of 0.13% to 0.32% where Nyaja recorded the highest value of 0.32% and Barkin Yorro recorded the lowest value of 0.13%. Barkin Yorro sample varies significantly from Nyaja, Zampa Langariri and Shara locations at $p<0.05$. Analysis of the soil sample also detected the presence of Rubidium oxide which was found in all the samples with an overall mean value of 0.08% ranging from 0.06% to 0.09% respectively. No significant difference occurred in all the locations at $p<0.05$.

Strontium oxide (SrO) detected in the soil sample was absent in Langaviri locations. This may be due to the fact that it is below the detectable limit of the XRF instrument used. An average mean value of 0.09% was obtained and range of 0.07% to 0.16% was also recorded with respect to strontium oxide (SrO) Barkin Yorro results varies significantly at $p<0.05$ from other locations with regards to strontium oxide contents. Analysis of zinc oxide (ZnO) revealed its absence in Nyaja, Shara and Zampa areas, but it was present in Barkin Yorro, and Langaviri locations with an to total mean concentration of 0.06% and range of 0.05% to 0.07%. The results obtained from Barkin Yorro and Langaviri does not vary significantly at $p<0.05$ with respect to Zinc oxide (ZnO) contents in the soil sample. Cerium oxide (CeO_2) detected by XRF instrument was present in only two locations namely Barkin Yorro and Shara and it was absent in Langaviri Nyaja and Zampa locations. An average mean value of 0.08% to 0.09% was recorded with a range of 0.06 % to 0.09%. There was no significant difference between the two locations with respect to cerium oxide (CeO_2). Neodymium oxide (Nd_2O_3) detected by XRF instrument was absent in Langaviri Nyaja and Shara areas but present in Barkin Yorro and Zampa areas only with a total mean concentration value of 0.08% ranging from 0.06% to 0.01%. No significant difference occurred between the two locations where Neodymium oxide (Nd_2O_3) was detected at $p<0.05$.The minor elemental oxide results obtained from the work is compareable to workmreported by Isaac *et al* (2019) and Osemeahon et al (2015).

Table 2: Mean Concentration of Some Minor Elemental Oxide in Soil of Yorro Local Government Area (%)

Location	ZrO_2	BaO	Rb_2O	SrO	ZnO	CeO_2	Nd_2O_3
Barkin Yorro	$0.20±0.02^{bc}$	$0.13±0.02^{a}$	$0.07±0.01^{a}$	$0.16±0.02^{b}$	$0.07±0.01^{a}$	$0.09±0.03^{a}$	$0.09±0.01^{a}$
Langaviri	$0.15±0.01^{ab}$	$0.22±0.03^{b}$	$0.09±0.02^{a}$	ND.	$0.05±0.01^{a}$	ND.	ND
Nyaja	$0.13±0.05^{a}$	$0.32±0.02^{c}$	$0.09±0.02^{a}$	$0.07±0.01^{a}$	ND.	ND.	ND
Shara	$0.23±0.02^{c}$	$0.22±0.02^{b}$	$0.06±0.01^{a}$	$0.08±0.03^{a}$	ND.	$0.06±0.01^{a}$	ND
Zampa	$0.16±0.03^{ab}$	$0.28±0.02^{c}$	$0.08±0.03^{a}$	$0.08±0.02^{a}$	ND.	ND.	$0.06±0.01^{a}$
Range	0.13-0.23	0.13-0.32	0.06-0.09	0.07-0.16	0.05-0.07	0.06-0.09	0.06-0.09
Grand Mean	0.19	0.23	0.08	0.09	0.06	0.08	0.08
Standard Deviation	0.04	0.06	0.03	0.04	0.01	0.01	0.02
C.V. (%)	21.05	26.09	37.50	44.44	16.67	12.50	25.00

Mean ± Standard Deviation within a column with different superscript letters are significantly different at $P < 0.05$ according to Duncan Multiple Range Test. CV = Co-efficient of Variation
ND = Not Detected

Conclusion

Minerals are important because the play a vital role in human and industrial development. The result generated from this work revealed the presence of both major and minor elemental oxides using analytical technique. Significant variation non-significant variation of the mineral oxides was observed between five different locations of the study area. It can be concluded that the study has helped in providing a data base for the study area and a base line for further study of other locations. In the same vein this will help to trigger profitable mining, mineral exploration and agricultural activities for developmental purposes.

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