SOIL MINERALOGY AND ITS IMPACT ON THE FERTILITY OF SOILS FOR URBAN AND PERI-URBAN AGRICULTURE IN SOUTH –EASTERN, NIGERIA.

[1]Chris-Emenyonu, C.M, [1]Onweremadu, E.U,[2]Njoku, J.D and [1]Ahukaemere,C.M
1.Department of Soil Science and Technology, Federal University of Technology, PMB 1526 Owerri, Nigeria.
2. Department of Urban and Regional Planning, Federal University of Technology, PMB 1526 Owerri, Nigeria
Email: Pricessm2@yahoo.com, Chinonso.Chris-Emenyonu@futo.edu.ng

ABSTRACT
Fertility of urban and peri-urban soils for agricultural production is largely dependent on soil mineralogy. This is because soil mineral is an index in understanding soil fertility.The study investigated the influence of soil mineralogy on urban Agriculture in south-eastern part. Clay minerals were investigated by means of X-ray diffraction method using clay separates less than two microns in size from selected Bt- horizons of the three profile pits under three parent material Results revealed that quartz and kaolinite dominated for all soils studied, other minerals present were albite, muscovite, anatase and hematite. There were clear variations in clay mineralogy in respect to lithology.In Asu river group, quartz was characterized by strong diffraction peaks at 4.25A^0 ,3.34 A^0, 2.46 A^0 and 2.28 A^0(first, second third and fourth peak) respectively while Albite and muscovite had strong peaks at 6.387 A^0,6.381 A^0 and 20.13 A^0 respectively . Soils of Imo clay shale, quartz was identified at 4.26 A^0, 3.35 A^0, 2.46 A^0, 2.28A0,2.24 A^0,2.13 A^0 and 1.98 A^0 from first order reflection peak to seventh order. Haematite occurred at 3.69 A^0, 2.70 A^0, 2.52 A^0, 2.29 A^0, 2.21 A^0, 2.08 A^0 and 1.84 A^0 from one reflection peak to seventh order reflection peak whilekaolinite was characterized by strong reflection at 7.13 A^0 and Anatase had seven peaks at 3.52 A^0, 2.43 A^0, 2.38 A^0, 2.33 A^0, 1.89 A^0 and 1.76 A^0. However, soils derived from coastal plain sand had mainly two minerals, kaolinite and quartz. Quartz occurred at strong refection peak of 4.26 A^0, 3.35 A^0, 2.6 A^0 and kaolinite occurred at a single reflection peak of 7.13 A^0. Soil properties related to soil fertility such as cation exchange capacity, Organic matter content, percentage Base saturation and effective cation exchange capacity were higher in soils under Imo clay shale and Asu river group except organic matter content and base saturation which had higher values in soils under coastal plain sands.
KEYWORD: Reflection Peak, Mineralogical, Urban, Lithologies, Muscovite.

INTRODUCTION
The knowledge of soil minerals has been reported to be an important index in understanding the soil fertility properties due to the fact that mineral surfaces serve as both the source and sink of plant nutrients (Azu,*et al* 2018). Currently, there is shortage in food production in South eastern Nigeria as a result of climate change, land degradation, and rural-urban migration . Urban and peri-urban agriculture is the cultivation of crops and rearing of animals within the cities including forestry and fishing EPR Sauthor(2014). Urban and peri-urban agriculture is on the increase as a result of population growth and the need to increase land under agricultural cultivation in order to feed the teeming population.FAO (2001) reported urban and peri-urban agriculture contributes greatly to poverty alleviation. Emankhu,*et al (* 2015) reported that there is increasing interest in peri-urban areas and this is evident from the studies and researches that have been carried out in this area in the last twenty years). Soil parent material has been reported to have remarkable influence on soil properties affecting crop yield. According to Unamba- Oparah*et al.,* (1989), knowledge of clay mineralogy is useful for understanding of many important characteristics related to soil nutrient status.

Parent material is the backbone on which other materials act to form soil (Udoh and Akpan ,2015). Parent material affects the mineralogy, chemistry, and morphology of soils under the same condition in the tropics (Ahukaemere*et al*,2015). Variations in soil clay minerals is a reflection of the lithology from which they the soil is formed and the behaviour of a soil depends partly on the parent rock from which it was formed (Salome Hephzibah Waziri *et al 2013).* Also, Nkwopara*et al* (2016) reported that variations exhibited in soil clay minerals were dependent mainly on soil parent materials. Furthermore, parentmaterial has a remarkable influence on soil cation exchange capacity, soil fertility and productivity and hence contributes greatly in the capacity for soils to produce food for the teeming population.

In Nigeria, prior to now, many agricultural activities are carried out in the rural areas with limited inputs; however, with rapidly growing cities and food insecurities in most cities, there is need to utilize urban soils for agricultural activities. The study of clay minerals in soils will enable one understand many of the physical and chemical differences among soils in various parts of the world (Brady and Weil, 2002). Nkwopara*et al* (2016) recommended that soil mineralogical properties be considered in soil management for the production of crops and trees. In line with this, some urban soils of South-eastern Nigeria were studied to investigate their mineralogy with respect to their parent materials for enhanced urban and peri-urban agriculture and sustainable soil management.

MATERIALS AND METHODS

Description of the Study Areas

The study was conducted in Ebonyi State lying approximately within longitudes 7° 30' and 8° 30' East, Okigwe (latitude 5º46N and longitude 7º15E) and Abia State lies between latitudes 4°45' and 6° 00'North and longitudes 7°00' and 8°09'East (Nnabugwu and Ibeabuchi, 2015).Soils are derived from Asu river group, Imo clay shale (Imo shale group), andcoastal plain sands, respectively (*Figure 1*). The climate is humid and tropical,with an average annual rainfall of 2500 mm, a mean annual temperature varyingbetween 27 and 28oC, and relative humidity of between 75 and 80% (NIMET, 2018) and the soils were of a flat topography (0 – 1 % slope).

Three different parent materials (Asu river group, Imo clay shale and coastal plainsands) were randomly selected for the study. A total of three soil profile pits were dug, one for each parent material and describedaccording to FAO's (2006) guidelines, .Samples were collected according to genetic horizons. A total of 14soil samples were taken to the laboratory for routine analyses. Three samples were collected from the Bt horizons and used for mineralogical analyses, one sample per profile pit.

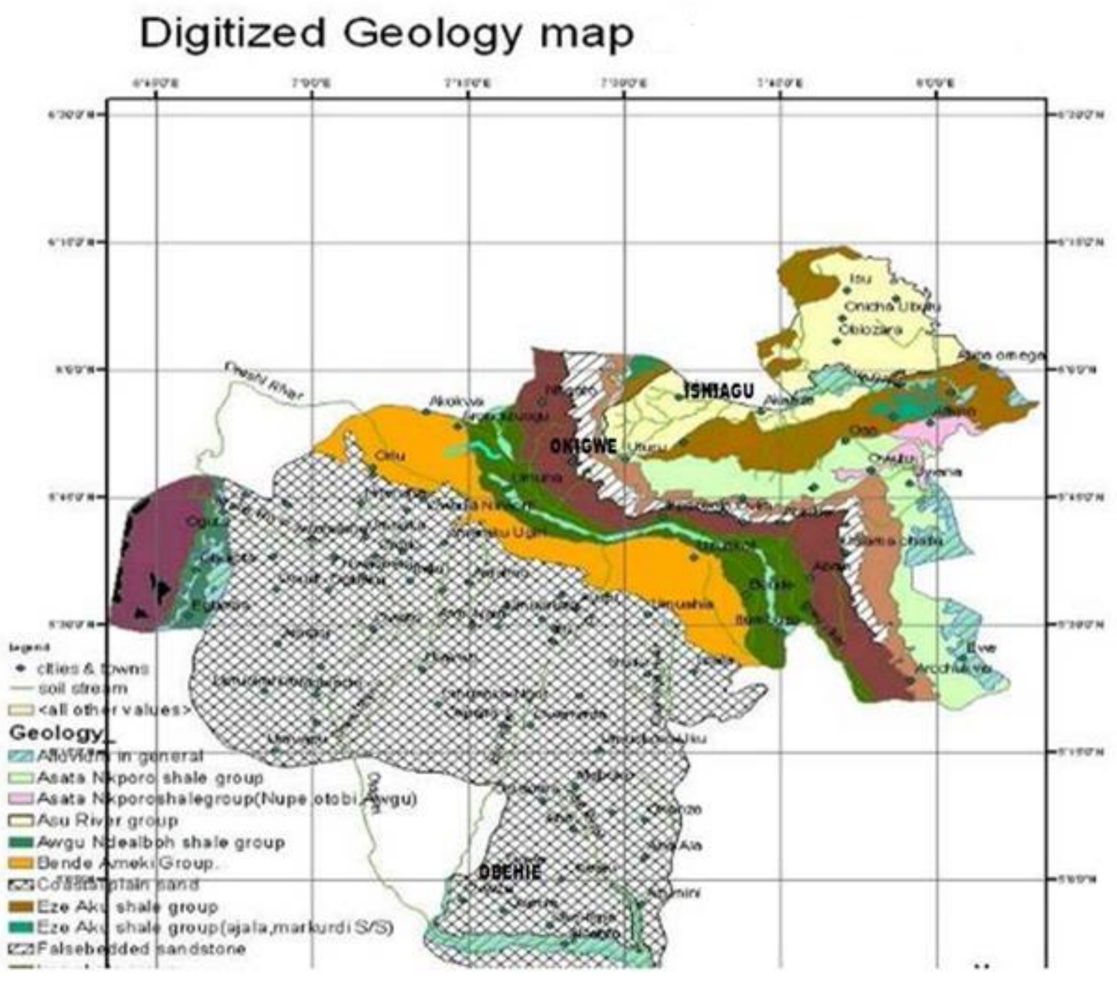

Fig 1. GEOLOGY MAP OF STUDY AREA

Soil Analyses

Bulked soil samples collected were air-dried, gently crushed and passed througha 2-mm sieve to obtain fine earth separates. The processed soil samples wereanalyzed for some physico-chemical properties following standard procedures. Particle size analysis was done using the hydrometermethod.Soil pH in 1:2.5 water suspension was measured with a pH meter. Organiccarbon was measured by the Walkley and Black method. Available phosphorous(P) was determined according to Bray No. 2 method.Bulk density was determinedby the core method, CEC was determined by using the neutral ammonium acetatemethod, and base saturation was calculated.

Soil mineralogy was conducted at the Geochemistry Laboratory of the Nigerian Geological Survey Agency, Kaduna. The analytical equipments used for this analysis were the Energy Dispersive X-Ray Fluorescence (EDXRF) and Atomic Absorption Spectrometer (AAS). The clay fraction was isolated from other components (pre –treated) according to the procedure of Omueti (1980) to remove organic matter prior to mineralogical analyses. Sample preparation for the analysis started with the samples being finely ground, homogenized and average bulk composition determined. 0.5g soilsample was put into 5 ml tube and DCB (3 ml sodium citrate-sodium bicarbonate and 0.1 g sodium dithionite) was added. This was heated at 80^0C for 15 min and occasionally stirred, then allowed to cool and centrifuged. The supernatant was discarded inorder to remove free iron. Also, 3ml of 0.5 mol/ L $MgCl_2$ was added and stirred and centrifuged. This procedure was done 3 times. It was saturated with 5 % glycerol and 1 ml of water was added and centrifuged and the supernatant was discarded. The suspension was then taken and placed on a glass slide and air dried. Powdered sample was then further prepared using the preparation block and compressed in a sample holder to create a flat and smooth surface which was later mounted on the sample stage in the XRD cabinet to determine the clay mineral present (Onyekuru*et al*,2018).

RESULTS AND DISCUSSIONS

Physical, Chemical and Mineralogical properties of Soils

The results of the physical and chemical properties are shown on Table1. Results revealed that soils of coastal plain sands had higher sand fraction (854.04gkg), least clay and silt (68.80gkg and 75.60gkg) respectively, Imo clay shale had values of 579.6gkg (sand), 313.6gkg (clay) and 146.8gkg (silt) while Asu river group had sand fraction of 338.6gkg, 348.6gkg (clay) and 312.8(silt). The higher values of sand fraction obtained at the coastal plain sand is as a result of the parent material (Chris-Emenyonu, *et al* 2017; Chris-Emenyonu and Onweremadu, 2011; Chris-Emenyonu, 2015). Asu river group had higher bulk density (1.48 gcm^3) while coastal plain sand had the least(1.24 gcm^3), lower bulk density in the coastal plain sand is as a result of the porous nature of these soils (% 55.20) while Asu river group had the highest bulk density and least percentage porosity(%44.21), this can be attributed to the higher clay content of the soils. All soil studied were highly acidic irrespective of parent material with values ranging from 3.43 to 4.37 and increased down the profile pits. Some researchers also reported a sharp increase in soil pH with increasing soil depth (Webb and Dowling (1990; Khan *et al* (2004)] due to higher accumulation of Ca^{2+} in the sub-surface soil(Kaihura*et al* ,1999). Organic matter content ranged from 5.59gkg to 18.59gkg with the highest value obtained soils formed from Imo clay shale and least value obtained at Asu River group, this also resulted to low values of available phosphorus obtained on soil formed from Asu River group (8.89). organic matter and available phosphorus distribution generally decreased with depth except in Bt_3 horizon of coastal plain sand where there was organic matter bulge , this contradicts the reports of Idoga and Azagaku (2005) that Organic matter is known to decrease with depth in pedon and it could be as a results of decomposition of buried organic matter rich materials.Cation exchange capacity and effective cation exchange capacity was irregularly distributed down the profile pits. Urban Soils formed from Asu river group had the highest values (12.90Cmolkg, 6.93Cmolkg), while Imo clay shale and coastal plain sand had values of (10.12 Cmolkg. 4.12cmolkg), (11.12Cmolkg, 6.21Cmolkg) respectively. Percentage base saturation was high in all soil studied with higher value of 93.43% obtained in urban soils under coastal plain sands. Fertility parameters measured in study areas were low and is in agreement with the findings of Asher *et al.(* 2002), who reported that nutrient supply by a soil, and the type of problems one is likely to encounter, often differ greatly, depending on the parent material from which the soil originates.

Table 1. Some Physico-Chemical Properties of the Study area

HOR	Depth	Sand gkg⁻¹	Silt	Clay	BD gcm³	TP %	pH(KCl)	OM gkg⁻¹	Avail.P mgkg⁻¹	CEC Cmol kg	ECEC	BS %
ASU RIVER GROUP												
A	0-30	389.6	292.8	389.6	1.37	48.3	3.86	8.03	15.14	10.22	4.27	74.71
AB	30-53	689.6	232.8	77.6	1.41	46.8	4.08	7.10	7.33	12.15	6.37	91.37
BC	53-77	509.6	272.8	217.6	1.45	45.3	4.77	3.50	7.07	15.26	9.82	91.04
C	77	338.6	312.8	348.6	1.48	44.21	4.80	1.72	5.16	13.98	7.26	90.63
R												
MEAN		**481.85**	**277.8**	**258.35**	**1.43**	**46.15**	**4.37**	**4.59**	**8.86**	**12.90**	**6.93**	**86.94**
IMO CLAY SHALE												
A	0-22	589.6	192.8	217.6	1.16	56	3.70	22.93	17.20	10.26	4.72	73.00
AB	22-65	589.6	72.8	337.6	1.16	56	3.68	22.93	15.60	10.82	4.12	77.44
Bt1	65-102	549.6	132.8	317.6	1.18	55	3.72	18.79	12.10	11.16	5.18	83.40
Bt2	102-130	589.6	72.8	337.6	1.39	48	3.42	17.10	8.66	9.25	3.38	84.02
Bt3	130-185	579.6	262.8	357.6	1.41	46.8	3.60	11.24	5.28	9.10	3.16	89.24
MEAN		**579.6**	**146.8**	**313.6**	**1.26**	**53.60**	**3.62**	**18.59**	**11.77**	**10.12**	**4.12**	**81.42**
COASTAL PLAIN SAND												
A	0-18	889.60	77.60	32.80	1.04	61.00	3 .20	6.89	21.60	14.22	8.60	93.72
AB	18-50	849.60	97.60	52.80	1.20	55.00	3.12	5.52	16.60	11.26	6.19	91.80
Bt1	50-100	831.80	87.60	72.80	1.30	51.00	3.60	18.27	16.26	13.18	7.06	94.10
Bt2	100-130	849.60	57.60	92.80	1.30	51.00	3.52	6.21	12.60	8.83	4.86	92.59
Bt3	130-196	849.60	57.60	92.80	1.37	58.00	3.70	3.62	8.20	8.10	4.33	94.92
MEAN		**854.04**	**75.60**	**68.80**	**1.24**	**55.20**	**3.43**	**8.10**	**15.05**	**11.12**	**6.21**	**93.43**

BD-Bulk Density, Tp-Total Porosity, CEC-Cation exchange capacity,OM-Organic matter, ECEC-Effective cation exchange capacity , BS-Base Saturation

Mineralogical Properties of Soils Studied

Figures 1,2 and 3 show the mineralogical distributions of urban soils under the three different parent materials studied. Mineralogical composition revealed that soils derived from Imo Clay Shale had quartz (SiO_2) at4.26 A^0, 3.35 A^0, 2.46 A^0, 2.28A^0, 2.24 A^0,2.13 A^0 and 1.98 A^0 from first order reflection peak to seventh order. Haematite occurred at 3.69 A^0, 2.70 A^0, 2.52 A^0, 2.29 A^0, 2.21 A^0, 2.08 A^0 and 1.84 A^0 from one reflection peak to seventh order reflection peak while kaolinite was characterized by strong reflection at 7.13 A^0 and Anatase had seven peaks at 3.52 A^0, 2.43 A^0, 2.38 A^0, 2.33 A^0, 1.89 A^0 and 1.76 A^0 respectively (Fig. 1). In Asu river group, quartz was characterized by strong diffraction peaks at 4.25A^0 ,3.34 A^0, 2.46 A^0 and 2.28 A^0(first, second third and fourth peak) respectively while Albite (Na0.98Ca0.02Al1.02Si2.98O18) and muscovite had strong peaks at 6.387 A^0, 6.381 A^0 and 20.13 A^0 (Fig. 3), while soils derived from coastal plain sand had mainly two minerals, kaolinite and quartz. Quartz (SiO_2) occurred at strong refection peak of 4.26 A^0, 3.35 A^0, 2.6 A^0 and kaolinite occurred at a single reflection peak of 7.13 A^0 (Fig 2).Quartz dominance in the three parent materials studied reveals that it is the prominent clay mineral present in soils of South-eastern Nigeria. According to Nkwopara*et al* (2016) dominance of quartz has the tendency of bringing about low pH, low ECEC and generally low fertility status of the soils as observed in soils studied. These results reveal a clear relationship between the soil mineralogical composition and parent materials and the properties of the soils.This is in line with the findings of Radoslovich (2006) and Atkinson & Waugh (2007) that parent material influenced mineralogy of the weathering products in soils.

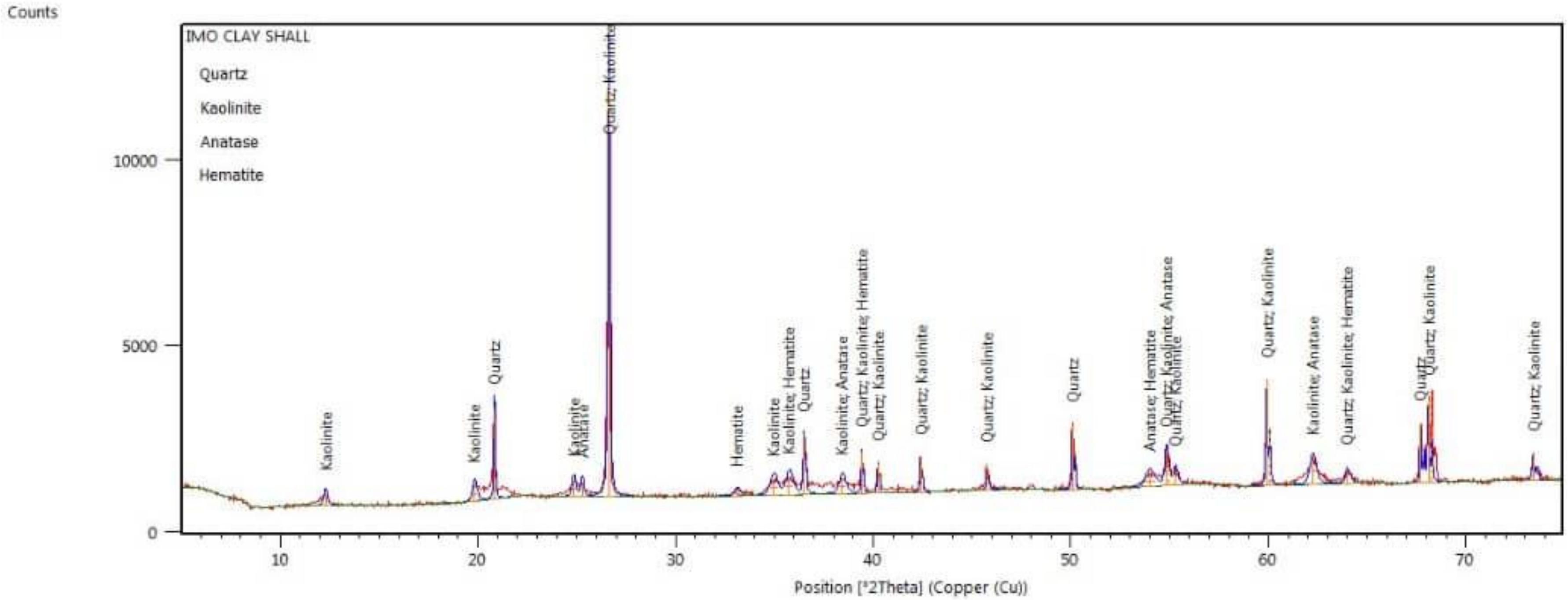

Fig.1. X-ray diffraction patterns of Urban Soils formed from Imo Clay Shale

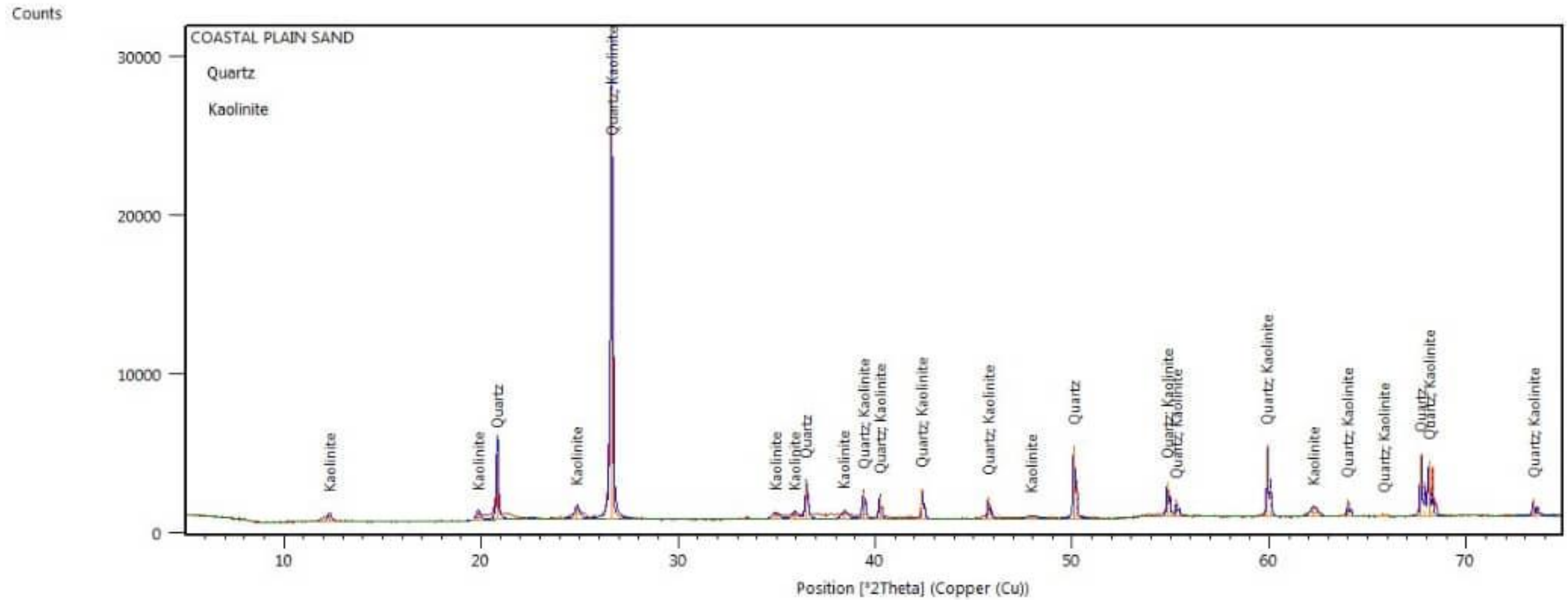

Fig.2. X-ray diffraction patterns of Urban Soils formed from Coastal Plain Sands

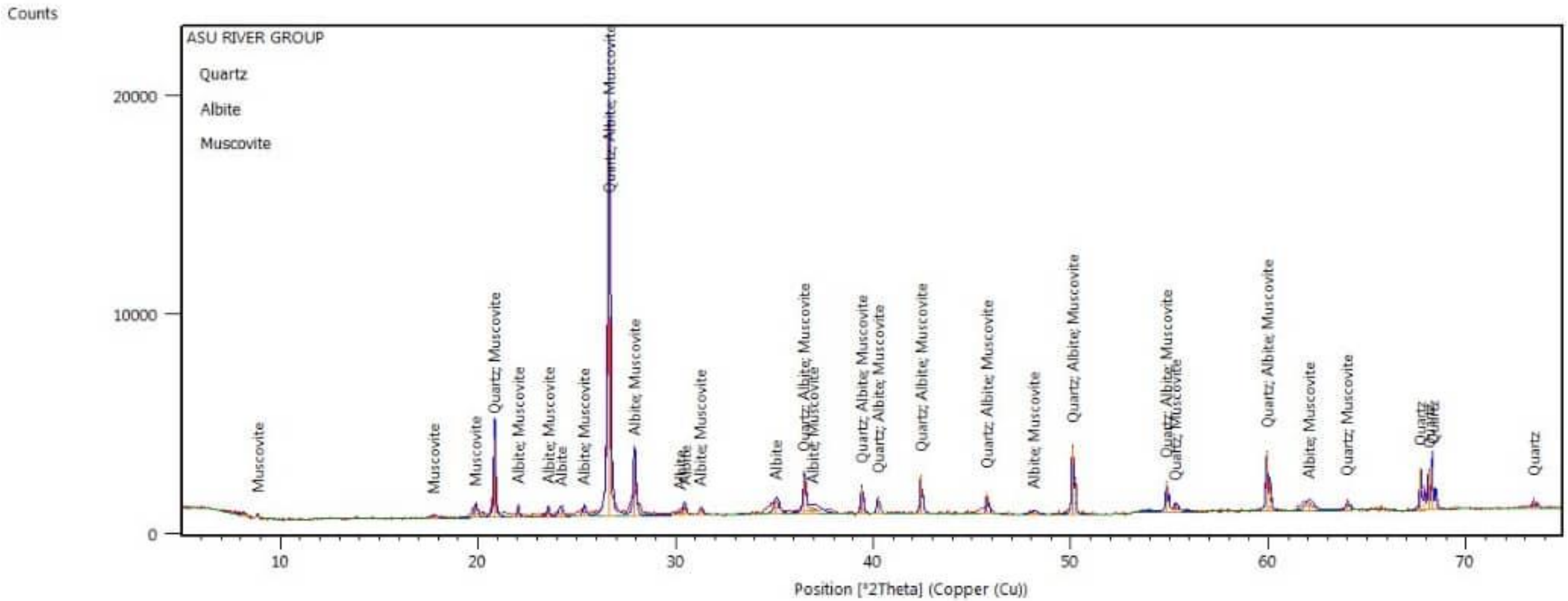

Fig. 3. X-ray diffraction patterns of Urban Soils of Imo Clay Shale

CONCLUSION

Soil parent materials and mineralogy are important in soil fertility and food security. Variations in soil properties and clay mineralogy of studied soils appear to be dependent majorly on the parent materials from which the soils are formed. Those soils developed on coastal plain sands and Imo clay shale had predominately kaolinite and quartz which implies low fertility status of those soils, hence requiring a lot of inputs to improve their fertility status. It is therefore important to considerthe mineralogical properties of these soils before utilizing them for urban and per urban agriculture and before assigning a management plan.

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