The Andhra Agric.J 55 (1):33-37, 2008

Clay Mineralogy of Red and Black soils of Vegetable Growing area of Guntur District, Andhra Pradesh

A Sathish, P Prasuna Rani and M Seshagiri Rao
Dept. of Soil Science & Agricultural Chemistry, Agricultural College, Bapatla 522 101, A.P.

ABSTRACT

Studies on six soil profiels representing black and red soils of vegetable growing area of Guntur District revealed that the black soils were clay to clay loam in texture and exhibited relatively higher cation exchange and base saturation values than red soils having sandjy clay to sandy loam texture. Black soils were dominated by smectite group of minerals with minor quantities of illite and kaolinite. Kaolinite was the major mineral follwed by illite in red soils, which did not contain any smectite minerals.

Keywords: Black soils, Clay mineralogy, Illite, Kaolinite, Red soils, Smectite.

The soil colloids are the sites of important processes in soil, govening chemical properties like ion exchange, nutrient availability, fixation and soil physical properties like soils structure, hydraulic conductivity and infiltration. Identification of the type of colloids present gives an indication of soil behaviour and helps in planning of proper management practices. Vegetable growing area of Guntur district of Andhra pradesh, is comprising of both red and black soils to a considerable extent. The information about clay mineralogy of the soils is lacking. Hence the present study was formulated with an objective of identifying and quantifying different clay minerals present in the study area.

MATERIAL AND METHODS

In the present study an attempt was made to study the clay mineralogy of the representative soils covering red and black soils of vegetable growing area of Guntur district. Four profiles in black soils and two in red soils were opened up to parent material/ hard substratum. Horizon wise soil samples were collected and analysed for different soil properties following standard methods. Clay fraction was separated by sedimentation and then treated with NaCl to prepare Na clay (Jackson, 1979). Suitable quantities of sodium clay suspensions were treated with $CaCl_2$ and KCl to prepare Ca and K clays, respectively. Each sample was subjected to different pretreatments like Ca-saturated clay at room temperature, Ca-saturated ethylene glycol solvated clay, K saturated clay at room temperature and K-clay subjected to 550^{O}C. X-ray diffraction analysis was carried out on Philips X-ray diffractometer with Ni filtered Cu-K radiations. Quantification of the mineral was carried out as per Gjem, (1967).

RESULTS AND DISCUSSION

The results of some of the important soil properties are presented in Table1. Relatively high sand content was observed in red soils represented by profiles III and IV (46-78 %). Black soil profiles consisted of high amounts of silt and clay compared to red soils. The texture of red soils varied from sandy clay to sandy loam, whereas in black soils it varied from clay to clay loam. Black soils recorded relatively higher pH values compared to red soils due to the presence of calcium carbonate. The cation exchange capacity (CEC) and base saturation are high for black soils than red soils due to high clay content.

The d-spacings obtained from X-ray diffractograms of four different treatments given to the clay samples of sub - surface horizons of all the profiles are given in the Table 2 and X-ray diffraction patterns of clay samples of profile II and IV are shown in Fig. 1 and Fig 2.

In profiles I, II, V and VI The Ca-saturated clay samples exhibited a strong first order peak between 12.96 and 14.80 Å, which expanded to 15.93 to 17.27 Å on the ethylene glycol solvation. These peaks were shifted to a range of 12.28 to 14.19 Å in K-saturated samples at 25^{o} C and to around 9.93 Å peak in K-saturated heated to 550^{o}C samples. Small second order reflections were observed at around 8.51 Å (profiles I&II) in Ca-ethylene glycol solvation and 4.95 Å in K- saturated heated to 550^{o}C treatment . Weak sharp third order reflections were identified at 4.72 Å (profiles I&II) in K-saturated sample, which was shifted to 3.33 Å on heating to 550^{o}C. This wide variation in d-spacing values shows the highly expanding nature of the minerals, when saturated with ions and solvated with glycol. This expandability of the

Table 1. Physical and physico-chemical properties of the study area

Profile No	Horizon	Depth (m)	Sand %	Silt %	Clay %	Texture	pH	CEC cmol(p+) kg^{-1} soil	Base Saturation %
I	Ap	0.00-0.21	24.1	32.7	43.2	c	7.9	41.3	97
	A2	0.21-0.45	22.6	31.8	45.6	c	8.0	42.4	99
	A3	0.45-0.71	21.2	31.1	47.7	c	8.1	46.2	97
	Ass1	0.71-0.98	19.6	30.5	49.9	c	8.0	48.4	98
	Ass2	0.98-1.27	16.7	29.9	53.4	c	8.0	50.9	97
	Ass3	1.27-1.54	15.0	28.3	56.7	c	8.1	53.0	96
II	Ap	0.00-0.28	26.5	30.8	42.7	c	8.0	43.5	98
	A2	0.28-0.54	24.7	29.6	45.7	c	8.1	42.4	99
	Ass1	0.54-0.72	23.1	30.4	46.5	c	8.1	44.6	97
	Ass2	0.72-0.99	21.9	29.5	48.6	c	8.2	44.6	99
	Ass3	0.99-1.34	18.8	28.4	52.8	c	8.2	45.6	99
	Ass4	1.34-1.65	18.1	27.8	54.1	c	8.3	47.8	97
III	Ap	0.00-0.21	66.3	14.7	19.0	scl	7.1	7.7	89
	B	0.21-0.49	61.3	15.2	23.5	scl	7.3	9.5	80
	Bt1	0.49-0.72	55.7	17.9	26.4	scl	7.3	10.8	81
	Bt2	0.72-1.04	52.5	18.4	29.1	scl	7.3	12.4	82
	Bt3	1.04-1.33	48.8	15	36.2	sc	7.4	15.1	83
	Bt4	1.33-1.5	46.1	15.5	98.4	sc	7.4	15.8	82
	C	1.5+	Weathered parent material with pockets of soil						
IV	Ap	0.00-0.19	78.2	9.8	12	sl	7.1	4.8	82
	Bt1	0.19-0.39	76.4	7.4	16.2	sl	7.1	5.4	82
	Bt2	0.39-0.69	75.2	8.2	16.6	sl	7.2	7.7	81
	Bt3	0.69-0.92	72.6	10.3	17.1	sl	7.3	8.2	84
	C	0.92+	Weathered parent material with pockets of soil						
V	Ap	0.00-0.19	42.7	20.6	36.7	cl	7.8	35.9	97
	A2	0.19-0.39	43.5	18.6	37.9	cl	8.0	39.1	98
	Ass1	0.39-0.60	34.5	20.6	44.9	c	8.1	38.0	99
	Ass2	0.60-0.99	32.9	19.8	47.3	c	8.1	42.4	98
	Ass3	0.99-1.32	31.4	18.5	50.1	c	8.2	44.6	98
	AC	1.32-1.70	27.4	20.8	51.8	c	8.2	45.7	98
VI.	Ap	0.00-0.21	42.7	21.7	35.6	cl	7.9	38.0	98
	A2	0.21-0.50	41.4	20.4	38.2	cl	7.8	36.9	99
	Ass1	0.50-0.79	38.9	20.8	40.3	cl	7.9	41.3	96
	Ass2	0.79-1.09	32.3	22.4	45.3	c	7.9	44.6	97
	Ass3	1.09-1.39	28.7	23	48.3	c	8.1	45.7	97
	AC	1.39-1.68	24.2	24.3	51.5	c	8.1	47.9	98

Table 2. d-spacing of X-ray diffractograms in clay fraction Å

Profile No.	Calcium saturated		Potassium saturated		Clay mineral
	Glycol solvated	Room temperature	Room temperature	550^{0}C	
I	17.04	14.79	14.19	9.93	
	8.51	-	-	4.95	Smectite
	-	-	4.72	3.33	
	-	9.92	-	9.93	
	5.36	4.96	4.95	4.95	Illite
	3.33	3.33	3.34	3.33	
	7.11	7.12	7.13	-	
	3.57	3.57	3.56	-	Kaolinite
II	17.27	14.8	14.1	9.95	
	8.54	-	-	-	Smectite
	-	-	4.74	-	
	-	-	10.54	9.86	
	4.96	4.99	-	4.99	Illite
	-	3.33	3.33	3.34	
	7.13	7.13	7.11	-	
	3.57	3.57	3.56	3.49	Kaolinite
III	9.93	9.95	9.94	10.00	
	4.97	4.97	4.99	5.02	Illite
	3.34	3.34	3.33	3.34	
	7.13	7.13	7.12	-	
	3.51	3.57	3.57	-	Kaolinite
IV	9.96	9.91	9.93	9.92	
	4.97	4.97	4.97	4.98	Illite
	3.33	3.32	3.32	3.34	
	7.12	7.12	7.14	-	
	3.57	3.57	3.57	-	Kaolinite
V	15.93	12.96	12.28	9.91	
	-	-	-	4.96	Smectite
	-	-	-	3.32	
	-	10.15	10.11	9.91	
	4.87	4.95	4.96	4.96	Illite
	3.34	3.34	3.33	3.32	
	7.13	7.17	7.13	-	
	3.57	3.58	3.57	-	Kaolinite
	-	-	-	-	
	-	3.21	3.21	3.08	Feldspar
VI	16.57	15.54	12.5	9.72	
	-	-	-	5.00	Smectite
	-	-	-	3.34	
	9.95	-	-	9.72	
	5.55	4.97	4.93	5.00	Illite
	3.33	3.33	3.33	3.34	
	7.14	7.12	7.13	-	
	3.57	3.57	3.57	-	Kaolinite
	-	-	-	-	
	3.21	4.73	3.13	-	Feldspar

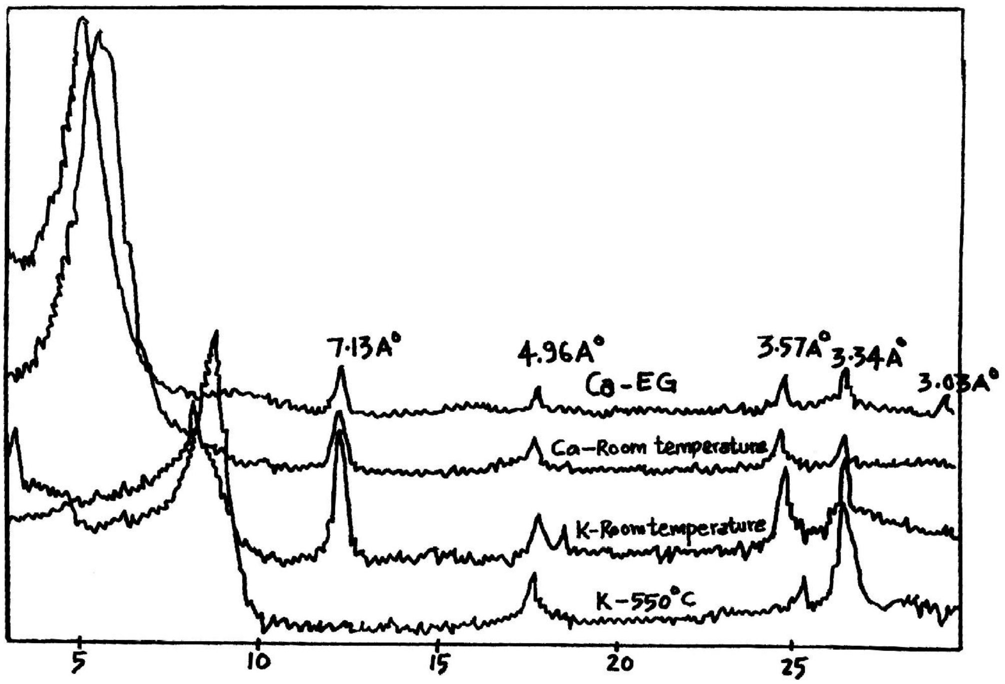

Fig. 1 X - ray Diffractogram of Profile II

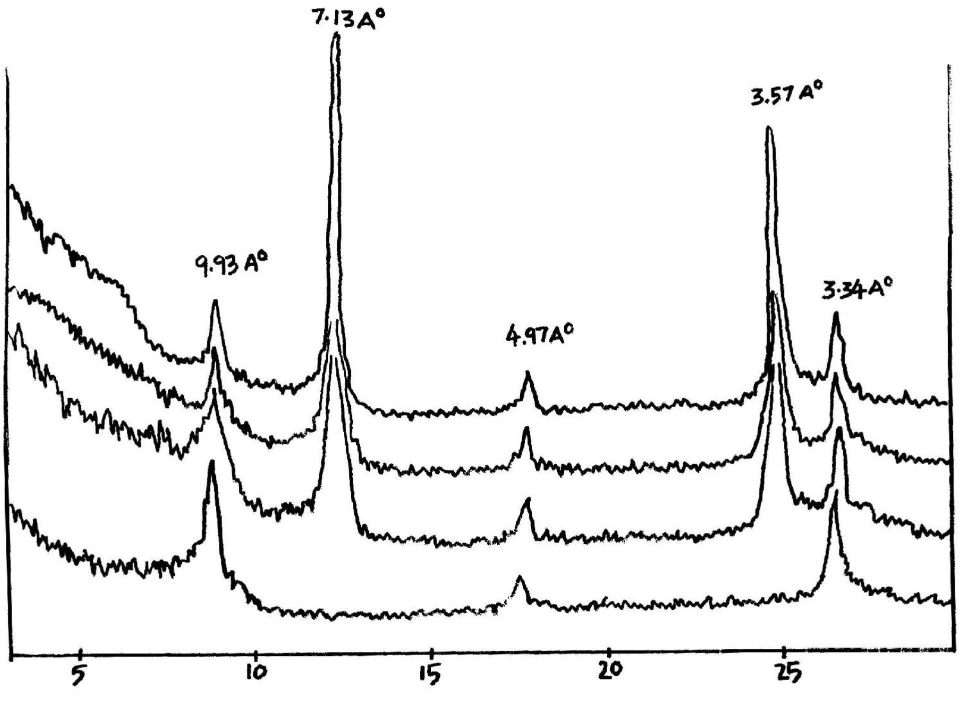

Fig.2. X-ray Diffractogram of Profile IV

Table 3. Relative proportion of the clay minerals in the soil (%)

Profile No.	Smectite	Illite	Kaolinite	Feldspar
1	93.46	3.37	3.17	-
2	94.33	0.82	4.13	0.72
3	-	41.56	58.44	-
4	-	23.65	76.35	-
5	78.17	11.62	10.21	-
6	91.31	1.73	4.82	2.14

mineral on saturation confirmed the presence of smectite (Sanyal, 2000), which has poor interlayer attraction. High CEC values of black soils can also be attributed to the high amounts of smectitie minerals.

In Ca-saturated samples, another first order reflection was observed at 9.92 to 10.15 Å d-sapcing in different profiles and second order peaks were noticed at around 4.96 Å. A first order reflection was seen at 9.95 Å spacing in profile V I in ethylene glycol solvated samples. Second and third order reflections were found at around 5.36 A° and 3.33 Å d-spacing in both the calcium treated samples of all the four profiles. In K-saturated heated to 550°C sample, sharp well defined reflections between 9.72 and 9.93 Å d-spacing were observed. Higher order peaks at around 4.95 Å and 3.34 Å were observed in K-saturated samples of all the profiles. Almost a constant d-spacing value in all the treaments confirmed the presence of a non-expanding mineral, illite with a basal sapcing of around 10Å (Sanyal, 2000). The interlayer K ions, which fit snuggly in the interlayer space restricts the expansion of illite along c-axis in the presence of water and polar liquids.

Small, conspicuous first order peaks were observed at around 7.12 Å d-sapcing, whereas higher order peaks were noticed at 3.57 Å in all the treatments of profiles I, II, V and VI except the heat treatment, where the peak disappeared. This nonexpan-ding nature of the mineral with d-spacing of around 7.2 Å confirmed the presence of kaolinite (Sanyal, 2000), a non expanding mineral having hydrogen bonds that hold the layers together.

In profiles V and VI small reflections were observed in Ca-saturated and K-saturated samples at around 3.21 Å d-sapacing. This peak shifted to 3.08 Å in K-saturated 550°C heated treatment indicating the feldspars.

Sharp well defined first order reflections were observed between 7.12 Å and 7.14 Å d-spacing in all the treatments except K saturated heated to 550°C of both the profiles showing its non expanding nature indicating the presence of kaolinite. Sharp and conspicuous second order reflection was noticed at 3.57 Å d-spacing in both Ca saturated and K-saturated samples, which shifted to 3.51 Å d-spacing in Ca-saturated ethylene glycol solvation treatment in profile III. These second and third order peaks further confirmed the presence of kaolinite.

Other first order peaks were observed at 9.95 Å and 9.91 Å d-spacing in Ca-saturated sample, which shifted to 9.93 Å and 9.96 Å d-spacing on Ca-saturation and ethylene glycol solvation in profiles III and IV, respectively. In K-saturated sample of profile III, first order peaks were observed at 9.94 Å and 10.0 Å at 25°C and 550°C, respectively, whereas in profile IV they were noticed at 9.93 Å and 9.92 Å for 25°C and 550°C treatments, respectively . In both the profiles small second order reflections were noticed at around 4.97 Å d-sapcing in all the treatments. Presence of such peaks confirmed the presence of illite as explained above.

The soils of the study area showed smectite, kaolinite, illite and feldspar type of minerals in the clay fraction. Relative proportions of different clay minerals are given in table 3.

Black soils showed higher proportions of smectite and lesser amounts of illite and kaolinite. Relatively high base saturation with Ca++ and Mg++ as dominant cations, alkaline pH, precipitation, $CaCO_3$ and poor drainage might have resulted in the synthesis and dominance of smectite minerals.

Red soil profiles showed dominance of kaolinite followed by illite. In semi-arid climatic conditions kaolintie was dominant in red soils (Osher and Buol, 1998). High amount of kaolinite indicates the advanced stage of weathering with low CEC and base saturation values.

LITERATURE CITED

Gjem O 1967 Meddr. Norsak Skogfros Res. 21:81

Osher L J and Buol S W 1998 Relationship of soil properties to parent material and landscape position in Eastern Madre de Dios peru.

Jackson M L 1979 Soil chemical analysis advanced course. 2nd edition, published by Anthod. Dept. of Soil Science, University of Wisconsin, Madison, Wisconsin.

Sanyal S K 2000 Soil colloids pp 229-260 Fundamentals of Soil Science Published by Indian Society of Soil Science.

(Received on 25.01.2007and revised on 18.03.2007)