

## Mineralogical and Textural Characteristics of Soils from Sangamner Area, Ahmednagar District, Maharashtra, India

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### ABSTRACT

Studies were conducted to know the mineralogical and textural characteristics of soils in relation to soil fertility status of Sangamner area, Ahmednagar district, Maharashtra. For this purpose particle size distribution was determined from 62 surface soil samples collected from the area. Representative ten sample clay fractions were subjected to X-ray diffraction analysis for mineralogical characterization. Clay fractions have been found to be dominated by illite which is generally facilitated due to high  $K_2O$  content in soils. Montmorillonite present in the salt affected soils has the predominance of magnesium. Kaolinite, chlorite, halloysite were also detected. The textural analysis revealed the clay content varies from 9.51 to 53.61%. Clay and clay loam type of soils were found in the downstream part which is possibly attributable to inadequate drainage conditions prevailing in the area. The proportion of silt content was followed by sand and coarse sand. The textural classification of the soils showed 35.48% samples were clay, 22.58% samples were clay loam, 21% sandy clay, 16% sandy and 5 % sandy clay. This indicates that majority of the samples have clay and clay loam category. The present investigation suggested that adequate drainage and leaching, crop rotation, blending of saline water with good quality of water, use of manures and mulching and desiltation of Ojhar weir can be adapted as measures to improve soil fertility of the area. Farmer's participation has been looked as the best means of avoiding further degradation of soils in the area.

**Key words:** Particle size distribution, Montmorillonite, Clay and clay loam, Textural triangular diagram, XRD diffractogram.

### INTRODUCTION

Soil is a dynamic and complex system of air, water, decomposing organic matter, living plants and animals. In addition to this, soil consists of rock fragments, clays, sands and silts organized into definite pattern as dictated by environmental conditions. The major factors involved in the process of soil formation are parent material, climate, time, topography and biota<sup>1</sup>. These factors are influencing the mineralogical, mechanical and chemical properties of soils. The physical properties of the soils greatly influences its uses and behavior towards plant growth. This also influences the chemical and biological properties of the soils and it is of utmost importance in relation to plant growth as well as soil fertility.

The mineral matter is a major component of soil. The mineralogical information of soils is essential for understanding soil genesis and for developing appropriate management practices for the maintenance of soil fertility. The color of the soil is also largely caused by the presence of certain minerals. The interaction of soil clay with nutrient ions, water and organic substances determines the soil fertility, which in turn largely controlled by the quality and nature of minerals<sup>2</sup>. Therefore, to understand the utility of soils, it is very essential to know the mineralogy. The mineralogy influences soil fertility through its control on the type and quality of plant nutrients which may be released by weathering. The shape of the particles affects their packing and thus related to soil structure<sup>3</sup>. The study of minerals is the study of nature of soils. Many

Researchers<sup>4-9</sup> have studied the clay mineralogy of normal and salt affected soils from different parts of the country.

Texture is probably the most important of the soil characteristics. Soil texture has profound effect upon the properties of soils including its water supplying power, rate of water intake, aeration, fertility ease of tillage and susceptibility to erosion. It is a guide to the value of land. Land use capability and soil management practices are determined by the texture<sup>10</sup>. Clays also acts as a major store of plant nutrients and therefore many aspects of soil fertility are ultimately influenced by texture<sup>11</sup>. Voluminous research work has been conducted in the area of textural characterization of soils<sup>12-15</sup>. The soils from the Sangamner area mainly derived from the Deccan basalts. The area is experiencing the problems of salinization, alkalinsation, waterlogging etc due to over irrigation, excess use of chemical fertilizers, intensive cultivation with modern production technology and establishment of sugarcane and allied industries. Therefore attempts have been made to study the mineralogical and textural characteristics of soils in order to know their fertility status from study area.

#### **The study area**

The Sangamner area is located in the Ahmednagar district of Maharashtra. Sangamner is a taluka headquarter which is located at a distance of 150 km from Pune on Pune-Nashik National Highway No. 50 (Fig.1). The area is drained by the Pravara river which is a tributary of Godavari. Pravara river originates in the mountainous region of Western Ghats and flows into low-lying fertile alluvial plain in the downstream part. Several dams and weirs have been constructed across Pravara river. Of these, Bhandardara dam is located in the source region and the Ozar weir is in the downstream direction of Sangamner town. These dams and weirs have been augmenting the irrigational water needs of the area. Over 90% of the study area is practising intensive agriculture. It should be noted that subsequent to the establishment of co-operative sugar-mill at Sangamner in 1967, the agriculture in the area has witnessed rapid changes in the cropping pattern. The industrial units developed in the area generate large volumes of waste water which mixes with

surface and groundwater resources thereby contaminating them. At places, the lagoons used for storage of waste waters have caused degradation of soils as well as water due to infiltration of effluents. Thus, the soil resources are facing severe threat from both irrigation practices as well as from agro-based industry.

#### **MATERIAL AND METHODS**

Selected 62 surface soil samples (0-20cm) were collected (Fig 1) in cloth bags as per the standard procedures<sup>16,17</sup>. 49 samples are from irrigated and 13 from non –irrigated areas. Quartering technique was used for preparation of soil samples. The samples were dried in air and passed through 2 mm sieve and stored in cloth bags. The textural analysis was done by using International Pipette Method<sup>10,18,19</sup>.

Out of 62 soil samples, representative 10 sample clay fractions obtained by International pipette method were subjected to X-ray diffraction analysis for mineralogical characteristics. Six samples (S.No. S6, S 10, S 11, S 13, and S26) were from irrigated / salt affected zone whereas four (S.No. S29, S49, S56 and S59) were from non-irrigated area (Fig 1). For X ray diffraction analysis samples were powdered to 250 – mesh ASTM sieve. The characteristics of clay samples were recorded on PW172. X – Ray diffractometer using CuK $\alpha$  radiation operated at 30 KV and 30 mA (Cu). The CuK $\alpha$  radiation wavelength was 1.542 $\text{Å}$ . The scanning speed was maintained at 0.05 $^\circ$  2 $\theta$  /s and chart speed was 5 mm/2 $\theta$  starting with 2 $\theta$  = 10 degrees. For the identification of different peaks, Hanwalt's method has been used in which peaks are composted with ASTM cards. The typical X-ray diffraction pattern of the clay fractions under investigation is shown in Fig 2.

#### **RESULTS AND DISCUSSION**

##### **Mineralogical characteristics of soils**

It is observed from the fig 2 that the important clay minerals identified in the clay fractions of the soil samples under investigation are illite, montmorillonite, kaolinite, chlorite and halloysite.

**Table 1: Textural Characteristics of the soils from Sangamner area**

S. No.	Particle size distribution (%)				Soil
	Coarse sand	Fine sand	Silt	Clay	Class
S1	6.08	24.92	21.6	46.75	Clay
S2	8.48	29.92	15.35	45.73	Clay
S3	13.28	28.4	12.2	40.53	Clay
S4	19.88	13.22	21.1	39.48	Clay loam
S5	14.32	10.86	25.17	43.93	Clay
S6	9.48	20.88	32.15	31.98	Clay loam
S7	18.21	23.12	15	42.18	Clay
S8	16.52	17.97	22.07	37.43	Clay loam
S9	7.29	16.17	29.08	41.33	Clay
S10	28.08	6.07	20.87	39.83	Clay loam
S11	5.01	14.33	31.15	43.53	Clay
S12	14.62	25.54	30.15	28.06	Clay loam
S13	3.52	12.05	26.82	50.23	Clay
S14	9.51	22.24	26.37	35.68	Clay loam
S15	31.65	9.81	18.22	37.16	Clay loam
S16	11.21	27.93	33.3	29.51	Clay loam
S17	6.57	14.11	21.17	51.03	Clay
S18	5.48	15.52	26.6	44.93	Clay
S19	12.45	33.62	15.72	43.18	Clay
S20	2.15	15.75	23.42	52.33	Clay
S21	32.68	36.81	13.73	13.51	Sandy loam
S22	27.67	16.6	19.35	31.71	Sandy clay loam
S23	15.52	42.76	16.65	20.58	Sandy clay loam
S24	22.02	42.79	12.42	18.11	Sandy loam
S25	7.31	16.35	20.12	49.71	Clay
S26	5.30	15.55	23.35	51.03	Clay
S27	33.31	27.67	13.35	21.04	Sandy clay loam
S28	18.25	28.51	19	29.09	Sandy clay loam
S29	21.26	40.13	14.55	19.38	Sandy loam
S30	32.78	20.06	12.65	29.26	Sandy clay loam
S31	17.08	22.62	14.52	39.31	Sandy clay
S32	6.292	19.91	23.4	42.61	Clay
S33	7.127	11.35	20.65	53.16	Clay
S34	3.22	22.71	28.15	37.56	Clay loam
S35	10.17	19.6	10.67	51.57	Clay
S36	13.28	33.29	24.4	32.73	Clay loam
S37	6.647	23.56	15.57	48.06	clay
S38	11.67	34.88	21.97	27.03	Clay loam
S39	25.104	41.25	12.12	17.78	Sandy loam
S40	19.086	33.56	18.35	22.91	Sandy clay loam
S41	19.094	31.54	14.27	26.81	Sandy clay loam
S42	9.935	37.28	23.426	24.61	Sandy clay loam
S43	7.317	41.96	11.87	33.11	Sandy clay loam
S44	11.983	32.76	14.87	34.93	Sandy clay loam
S45	4.143	34.75	11.22	41.56	Sandy clay

S46	7.559	53.32	22.07	12.28	Sandy loam
S47	9.139	51.83	16.15	18.01	Sandy loam
S48	6.592	35.87	20.15	32.11	Sandy clay loam
S49	12.846	36.87	16.05	28.36	Sandy clay loam
S50	18.03	45.97	12.95	19.73	Sandy loam
S51	4.33	19.39	22.52	48.58	Clay
S52	11.28	50.03	16.93	17.91	Sandy loam
S53	21.12	41.34	16.1	17.86	Sandy loam
S54	10.372	26.884	18.12	40.36	Clay loam
S55	3.696	29.51	23.87	38.68	Clay loam
S56	6.117	33.33	20.27	33.68	Clay loam
S57	4.23	31.55	12.37	45.26	Clay
S58	2.199	28.66	13.75	46.93	Clay
S59	4.777	28.35	10.87	46.56	Clay
S60	19.932	49.24	7.875	19.51	Sandy loam
S61	11.266	34.59	10.8	35.51	Sandy clay
S62	6.595	29.1515	12.2	44.56	Clay

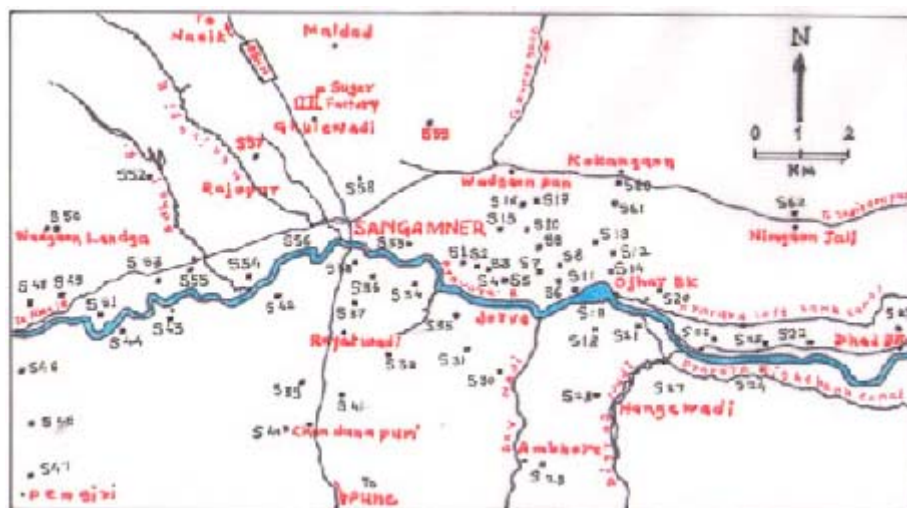


Fig. 1: Location map showing soil sampling stations in the study area

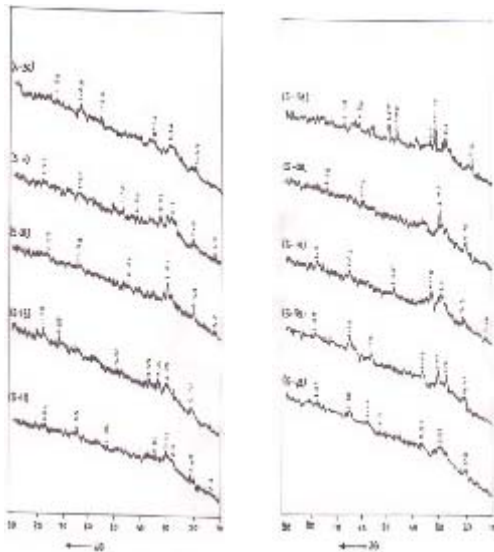
### Illite

The dominance of illite in all samples reflected the alkaline nature of the soils along with high concentration of aluminum and potassium. This is further evidenced by the chemical analysis of soils<sup>20</sup>. Illite is identified by series of basal reflections at  $1.99^{\circ}A$ ,  $3.32^{\circ}A$ ,  $2.57^{\circ}A$  and  $2.07^{\circ}A$ , besides the weaker reflections at  $1.52^{\circ}A$ ,  $4.81^{\circ}A$  and  $3.1^{\circ}A$ . The presence of illite in the samples is indicative of the influence of olivine / enstatite pyroxene dominated parent material. However, the formation of illite is more favoured due to high  $K_2O$

content of these soils<sup>20</sup>. This is possibly due to excessive use of potash fertilizers.

### Montmorillonite

The XRD pattern of salt affected soils in the area revealed the formation of montmorillonite (smectites). This can be attributed to alkaline condition and availability of sodium and magnesium. Such hyper alkaline condition can be developed due to impeded drainage in the area<sup>1,21</sup>. Montmorillonite presence is seen as 100% reflection at  $4.41^{\circ}A$  and weaker reflections at  $1.53^{\circ}A$



**Fig. 2: XRD diffractogram for some clay fractions of representative soil samples**



**Fig. 3: Triangular diagram showing textural classification of soils from study area**

to 3.48°A. Similarly, weaker reflections were also identified in the range of 1.29° A to 7.73°A. Under alkaline conditions, the pyroxenes from basalt are believed to weather to clay of this type and fine sand. The smectite type of minerals once formed, remain stable under alkaline conditions that can develop impeded drainage. In the low lying area, it appears that slightly weathered parent materials under alkaline conditions, low Mg and poor

drainage condition have accelerated the formation of smectite<sup>22</sup>. However, the normal soil showed less proportion of montmorillonite indicating adequate drainage and leaching of magnesium from the host rock basalt.

**Kaolinite**

It is a major component in almost all the soil samples from study area. It is represented by basal reflection at 7.13 to 7.24° A and 3.55° A. However, in the presence of chlorite as in the case of present samples, the above reflection interfere and coincide with the chlorite at 7.14 and 3.54°A respectively. The other reflections were identified with the lesser intensity at 2.43°A, 2.86, 2.57 and 2.2°A. In the upland soils the dominance of kaolinite might be attributed to the good internal drainage. The plagioclase feldspar has undergone weathering to kaolinite at low pH. However, it is observed that kaolinite reflection does not show any systematic variation in intensity.

**Chlorite**

It is represented by basal reflections at 7.14°A and weak reflection at 1.55°A. However, because of interference and coincidence of reflections of chlorite with reflection of kaolinite, it was rather difficult to distinguish between the peaks of kaolinite and chlorite in the soil samples under study.

**Halloysite**

It is the mineral, which belongs to kandite group<sup>21</sup>. It is known to occur in two forms with basal spacing 10° A and 7° A as halloysite and methalloysite respectively. In the present study, 100% intensity has been detected at 4.43° A and 4.52° A, which indicated the presence of hydrated halloysite in all the samples under study.

By and large, it can be inferred that the formation of illite in the area is generally facilitated by the presence of cations like potassium and sodium in sufficiently large quantities. The montmorillonite present in salt affected soils is due to the predominance of magnesium or other alkaline earth cations. Kaolinite, chlorite and halloysite were also detected in the soils samples. However, no remarkable difference was seen in the clay mineral composition in the soils from the area.

### **Textural characteristics of soils from the Sangamner area**

The textural characteristics of the soils are the most important laboratory determinations made in the soil studies. It deals with the process of determining the amount of individual soil separates below 2 mm in diameter i.e. sand, silt and clay. The relative proportions of these soil separates are referred to as soil texture. The various relationships that exist between plant and soil are controlled to a great extent by soil texture<sup>1</sup>.

It is observed from the table 1, that majority of the soils are in the clay and clay loam category. The clay content varies from 9.51 to 53.61 %. However, the clay and clay loam type of soils were reported predominantly from the downstream part and in the catchment of Ojhar weir (S. No. S1, S2, S3, S4, S5, S8, S9, S10, S12, S14, S15, S16 and S33). This is possibly due to inadequate drainage due to unfavorable topography and siltation at Ojhar weir. In addition to this, presence of alluvial deposits showing low permeability has lead to higher clay content.

The silt content of the soils ranged from 10.8 to 33% However, higher values of silt were noticed for the soils from irrigated tract and in the areas of lower elevation (S. No. S6, S9, S12, S13, S14 and S16).

The fine sand and coarse sand ranged from 6.076 to 59.24% and 3.696 to 33.31% respectively. The higher content of these sands was recorded in the vicinity and downstream part of Ojhar weir (S.No. S21, S23, S24, S29, S39, S43 and S60). However, low values were found in the areas with flat topography (S, No.S5, S10, and S15) and characterized by alluvial lithology. Similar observations were made by the researchers<sup>7,14,23,24</sup> for the soils from the area which is in proximity to the present study area. This inference is also supported by cation exchange capacity values<sup>20</sup>.

The distribution of particle size influences the moisture retention and transmission properties of soils. This is to say that, coarse textured soils have low moisture retention and high permeability whereas fine textured soils have high moisture retention and low permeability<sup>25</sup>. Considering this,

it can be said that the soils having high clay content (S. No. S2, S3, S4, S5, S7, S8, S9, S10, S16 and S20) will have low infiltration rate. The chemical properties of soils are expected to be influenced by clays than silt and sand particles. This is because clay fraction contains larger alumino – silicates and has higher content of humus. Therefore, they are characterized by a higher charge density per unit surface<sup>26</sup>. In the study area, high proportion of clay in some parts of study area can be considered as one of the important factors influencing the chemical properties of soils<sup>20</sup>.

### **Textural classification of the soil**

Natural field soils are always mixtures of soil separates. The relative percentages of the various soil separates in a field are almost infinite in possible combinations. It is, therefore, necessary to establish limits of variations among the soil separates so as to group them into textural classes. The determination of the textural class of a soil is based on particle size analysis. The soil samples from study area are separated into three size fractions viz. sand, silt and clay. The quantity of each fraction was measured and expressed as a percentage (by weight) of the soil. The distribution of the different sized particles was used for determining textural class of the soil with the help of textural triangular diagram (Fig 3)<sup>10,16</sup>. On the basis of this, five textural groups were obtained viz clay, clay loam, sandy loam, sandy clay loam and sandy clay from the study area (Fig 3).

Out of 62 soil samples, 22 soil samples (35.48%) were clay, 14 samples (22.58%) were clay loam, 10 samples (16.12%) were sandy loam, 12 samples (20.96%) were sandy clay loam and 3 (4.84%) were sandy clay. Thus, majority of the samples in the area represent clay and clay loam type of textural class. The distribution of various textural classes is depicted in Fig 3.

From the Fig, it is observed that the clay and clay loams were located in the central and downstream part in the back-waters of Ojhar weir. (S.No. S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S12, S14, S15, S16, S17, S18, S34, S35, S36, S37, S38, S51, S57, S58, S59 and S62). This particular area is waterlogged due to flat topography and impeded drainage. Similar observations were also

reported<sup>7,23,24</sup> from adjoining areas in the same basin. In nutshell, textural classification of soil provides a basis for making judgement about various other properties important to overall soil behavior in the area.

### CONCLUSION

The studies carried out to know mineralogical characteristics of the soils from Sangamner area have demonstrated the importance of clay minerals in relation to soil fertility. The clay minerals identified by the XRD studies of the representative soil samples indicated presence of illite followed by montmorillonite, kaolinite and halloysite in the area. The formation of illite in the soil is generally facilitated by the presence of cations like potassium and sodium in sufficiently large quantities. The montmorillonite present in salt affected soils has the predominance of magnesium. However, no remarkable difference was seen in the clay mineral composition in the soils from the area.

The textural analysis revealed the predominance of clay to clay loam textural type of soils which are located in the downstream part i.e. in the catchment of Ojhar weir. This is possibly attributable to inadequate drainage conditions prevailing in the area. The five textural groups of

soils viz. clay, clay loam, sandy loam, sandy clay loam and sandy clay were identified in the area. Out of these, majority of the samples represent clay and clay loam type, which are located in the downstream part of the river. The percentage distribution of these textural classes is clay (35.48%), clay loam (22.58%), sandy clay loam (21%), sandy loam (16%) and sandy clay (5%). The present investigation suggested that adequate drainage and leaching, crop rotation, blending of saline water with good quality of water, use of manures and mulching and desiltation of Ojhar weir can be adapted as measures to improve soil fertility of the area. Farmer's participation has been looked as the best means of avoiding further degradation of soils in the area.

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