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Characterization of Saline Soils of Uppugunduru Region, Prakasam District, Andhra Pradesh

K Nancy Jasmine, P Prasuna Rani, P R K Prasad and R Lakshmi Pathy

Department of Soil Science and Agricultural Chemistry, Agricultural College, Bapatla-522 101

ABSTRACT

The present study was carried out by collecting 100 representative soil samples from Uppugunduru region of Prakasam district. Texture of the soils varied from clay to sandy clay. WHC ranged from 32.98 to 70.81 per cent with a mean value of 51.94 per cent and relatively high values were observed in clay soils. Higher bulk density values were recorded in sandy clays than clay soils. The soils were found to be neutral to moderately alkaline in reaction. The electrical conductivity of saturation extract (ECe) of soil samples varied from 0.74 (non saline) to 40.02 dS m^{-1} (very strongly saline) with a mean value of 13.61 dS m^{-1}. The soils of the region were low to medium in organic carbon. Cation exchange capacity of the soils ranged from 30.80 to 53.71 cmol (p^+) kg^{-1}. The most dominant exchangeable cation was calcium followed by magnesium, sodium and potassium.

Key words : Exchangeable bases, Physico-chemical properties and Saline soils.

Soil is the most precious natural resource, on which agriculture mainly depends on. All soils contain some soluble salts, which is indeed essential for the healthy growth of plants. However, when quantity of salts in active root zone exceeds a particular limit, the performance of most crops is adversely affected. Soils that contain excess salts, which impair its productivity are called saline soils. In India, out of 6.72 million ha of salt affected soils, 2.95 million ha (44%) are saline in nature (including coastal sands). In undivided Andhra Pradesh out of 2,74,207 ha of salt affected soils, 77,598 ha are saline (Mandal *et al.,* 2010). Uppugunduru region of Prakasam district, Andhra Pradesh is well known for saline soils with low productivity. Detection of salinization, assessment of the extent and the degree of severity, particularly in its early stage is vital for timely management.

In order to sustain productivity of these soils, there is a need to characterize, which helps in identifying the existing or anticipatory problems and suggesting suitable reclamation measures. Keeping this in view the present study was carried out to characterize the soils in terms of physical, physico-chemical and electro-chemical properties.

MATERIAL AND METHODS

Representative soil samples (100) up to 25cm depth were collected during the month of June 2014. The analysis of soils for different textural fractions was carried out by Bouyoucos hydrometer method (Piper, 1966). Water holding capacity was determined by Keen Raczkowski brass cup method as described by Sankaram (1966). Bulk Density was determined by clod method as given by Black and Hartge (1986). Soil reaction was determined in 1:2.5 soil water suspension using glass electrode pH meter and the conductivity of saturation extract was estimated using Wheatstone conductivity bridge (Jackson, 1973). Organic carbon content of the soils was determined by wet digestion method of Walkley and Black as described by Jackson (1973). The cation exchange capacity and exchangeable bases (Ca, Mg, Na and K) of the soils were estimated by the method given by Bower *et al.* (1952). The ESP of soils was computed by using the following equation (Anonymous, 2004).

$$ESP = \frac{\text{Cation exchange capacity (meq 100 g}^{-1}\text{ soil)}}{\text{Exchangeable sodium (meq 100 g}^{-1}\text{ soil)}} \times 100$$

RESULTS AND DISCUSSION

Physical Properties:

The data on particle size distribution and textural classification of the study area are presented in table 1. Based on the per cent distribution of sand, silt and clay, the soils of the study area were classified into two textural classes *viz.,* clay and sandy clay. The per cent sand, silt and clay contents of the soils ranged from 27 to 55, 7 to 18 and 35 to 63 with mean values of 40.39, 12.12 and 47.49, respectively. Out of the total samples studied 83 per cent of the samples were clay while, the remaining 17 per cent were sandy clay in texture (Table 2). Similar particle size distribution was observed in Kukadi Command in Ahmednagar district of Maharashtra (Nagaraju and Gajbhiye, 2014). The lesser variation in soil texture might be due to the formation of the soils on plain topographic position from similar parent material (Reddy *et al.,* 2013).

The water holding capacity of soils presented in table1 ranged from 32.98 to 70.81 per cent with a mean value of 50.62 per cent. Relatively high WHC values were observed in clay textured soils (51.94 %) than sandy clay (44.23%) (Table 3). The dependent nature of water holding capacity on clay content might be due to adsorption of water on clay particles dominated by swell-shrink group of clay minerals (smectite), which have high capacity to retain water. This is confirmed by the significant positive correlation between clay and WHC (r = 0.774**).

The bulk density of the soils varied from 1.23 to 1.59 Mg m^{-3} with a mean value of 1.44 Mg m^{-3} (Table 1). Bulk density values were found to decrease as the texture became finer. The mean bulk density values recorded were 1.52 and 1.43 Mg m^{-3}, respectively for sandy clay and clay textured soils (Table 3). Lower bulk density with increase in finer texture could be due to the higher clay content with more surface area (Pravin *et al.,* 2013). This can be supported by the significant negative correlation (r = -0.692**) between clay and bulk density. The results were in agreement with findings of Ram *et al,* (2010) in soils of eastern plains of Rajasthan.

Physico-chemical Properties

The data pertaining to soil reaction of Uppugunduru soils in terms of pH values are presented in table 1. Soils were neutral to moderately alkaline in reaction with values ranging from 7.2 to 8.5 with a mean value of 7.97.

Critical observation of data revealed that 11.07 and 6.02 per cent of the samples were neutral (6.6 -7.3), 47.17 and 28.91 per cent samples were mildly alkaline (7.4 - 7.8), 47.05 and 59.03 per cent were moderately alkaline (7.9- 8.4) in sandy clay and clay soils, respectively. Similar pH values were earlier reported by Marsonia *et al*. (2008) in saline soils of Porbandar district of Gujarat. More number of mildly alkaline (28.91%) and moderately alkaline (59.03%) in soils clay texture could be due to the presence of high clay with high percent base saturation. This can be supported by a significant positive correlation (r = 0.853**) between clay content and total cations. High pH in some soils might be due to the presence of relatively higher exchangeable sodium. This is confirmed by significant positive correlation between pH and exchangeable sodium content in the soils (r = 0.729**).

The electrical conductivity of soils in saturation extract varied from 0.74 to 40.02 dS m^{-1} with a mean value of 13.67 dS m^{-1} (Table 1). The soils varied from non- saline to very strongly saline. Out of 100 soil samples, 21 samples were found to be non-saline (ECe 0-2 dS m^{-1}), 7 samples were slightly saline (ECe 2-4 dS m^{-1}), 15 samples were moderately saline (ECe 4-8 dS m^{-1}), 16 samples were strongly saline (ECe 8-16 dS m^{-1}) and 41 samples were very strongly saline (ECe >16 dS m^{-1}). Perusal of data in table 5 indicated that in sandy clay texture, 5.88, 5.88, 11.76, 23.52 and 52.94 per cent of samples were in normal, slightly saline, moderately saline, strongly saline and very strongly saline groups. The variation in ECe among different soils could be due to variation of natural conditions in time and space. The uneven distribution of irrigation water and seasonal or yearly changes of agricultural practices, might also contribute. Usually the areas in depressions will be more saline. Similar results (1.0 to 52.7 dS m^{-1}) were reported by Ratnam *et al.* (2010) in the Pilot area at Uppugunduru, Prakasam district.

The organic carbon content of the soils varied from 1.20 to 6.80 g kg^{-1} with mean a value of 2.80 g kg^{-1} (Table 1). As per the ratings given by Ramamurthy and Bajaj, (1969) 96 samples were low in organic carbon content (<5.0 g kg^{-1}) while, the remaining 4 samples were medium (5.0-7.5 g kg^{-1}). The results were in accordance with Samiron and Shanwal (2014) in the soils of Indo-Gangetic plains and Brahmaputhra valley under semi arid

Table 1. Physical and physico-chemical properties of soils of Uppugunduru region.

S.No	Parameter	Range	Mean
1	Mechanical composition		
	i) Sand (%)	27-55	40.39
	ii) Silt (%)	7-18	12.12
	iii) Clay (%)	35-63	47.49
2	WHC (%)	32.98-70.81	50.62
3	BD (Mg m^{-3})	1.23-1.59	1.44
4	pH	7.2-8.5	7.97
5	ECe	0.74-40.02	13.67
6	OC (g kg^{-1})	1.20-6.80	2.80

Table 2. Mechanical composition of soils related to texture.

Textural class	No.of Samples	Sand		Silt		Clay	
		Range	Mean	Range	Mean	Range	Mean
sc	17	46-55	50.71	7-14	10.65	35-42	38.65
c	83	27-54	38.28	7-18	12.42	38-63	49.30

sc = sandy clay and c= clay

Table 3. Physical and physico-chemical properties of soils related to texture.

Textural class	No.of Samples	BD Mg m^{-3}		WHC (%)		OC (g kg^{-1})	
		Range	Mean	Range	Mean	Range	Mean
sc	17	1.44-1.59	1.52	39.21-54.70	44.23	1.4-4.1	2.83
c	83	1.23-1.59	1.43	32.98-70.81	51.94	1.2-6.8	2.85

sc = sandy clay and c= clay

Table 4. Soil reaction related to texture.

Textural class	No.of Samples	pH		Neutral	Mild A	Mod. A	SA	VSA
		Range	Mean					
sc	17	7.2-8.4	7.82	2	7	8	-	-
c	83	7.2-8.5	8.00	5	24	49	5	-

Mild A= mildly alkaline, Mod. A= moderately alkaline, SA= strongly alkaline and VSA= Very strongly alkaline. sc = sandy clay and c= clay

Table 5. Electrical conductivity in relation to soil texture.

Textural class	No.of Samples	ECs		Ns	SS	MS	SS	VSS
		Range	Mean					
sc	17	0.96-41.21	17.37	1	1	2	4	9
c	83	0.74-40.21	12.92	20	6	13	12	32

Ns= non saline, SS =slightly saline, MS= moderately saline, SS= strongly saline and VSS= very strongly saline. sc = sandy clay and c= clay

6. Electro-chemical properties of soils of Uppugundur region.

S.No	Parameter	Range	Mean
1	CEC	30.80-53.71	41.53
2	Exchangeable bases (cmol (p^+) kg^{-1})		
	i) Ca^{2+}	16.4-34.4	24.34
	ii) Mg^{2+}	5.2-17.4	10.50
	iii) Na^+	2.24-6.83	4.67
	iv) K^+	0.51-2.35	1.00
3	PBS	92.51-99.95	97.57
4	ESP	4.92-13.86	11.90

Table 7. Summary of cation exchange capacity and ESP of soils related to texture.

Textural class	No.of Samples	CEC cmol (p^+) kg^{-1}		ESP	
		Range	Mean	Range	Mean
sc	17	30.80-41.94	35.18	6.41-13.44	10.05
c	83	33.06-53.71	42.83	4.92-13.86	11.43

sc = sandy clay and c= clay

Table 8. Summary of exchangeable cations related to texture.

Textural class	No.of Samples	Exchangeable bases cmol (p^+) kg^{-1}							
		Ca^{2+}		Mg^{2+}		Na^+		K^+	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean
sc	17	16.4-26.60	21.10	6.8- 10.9	9.02	2.24-5.22	3.53	0.51-2.13	0.86
c	83	17.2-34.40	25.01	5.2-17.4	10.81	2.35-6.83	4.88	0.51-2.34	1.04

sc = sandy clay and c= clay

region. Low organic carbon content in saline soils was due to poor vegetation and high rates of decomposition of organic matter under the prevailing semiarid climate (Singaravel *et al.,* 1996). Similar results were also reported by Chaudhary *et al.* (2006).

Electrochemical Properties

The perusal of data presented in table 6 revealed that cation exchange capacity (CEC) of soils of Uppugunduru region varied from 30.80 to 53.71 cmol (p^+) kg $^{-1}$ with a mean value of 41.53 cmol (p^+) kg^{-1}.

Relatively higher CEC values were observed in clay texture than sandy clays. The mean CEC of clay soils was 42.83 cmol (p^+) kg^{-1} while, it was 35.18 cmol (p^+) kg^{-1} in sandy clays (Table 7). This can be attributed to the presence of more colloidal clay with large surface area and is evident by a significant positive correlation (r = 0.848**) between clay and CEC. Similar results were obtained Vijiyakumar (2009) in soils of Ongole division of Prakasam district.

The data pertaining to exchangeable cations of (Table 6) revealed that their contents were found to be in the order of $Ca^{2+} > Mg^{2+} > Na^+ > K^+$. The exchangeable calcium ranged from 16.4 to 34.4 cmol (p^+) kg^{-1} with a mean value of 24.34 cmol (p^+) kg^{-1}. Exchangeable magnesium varied from 5.2 to 17.4 with a mean value of 10.50 cmol (p^+) kg^{-1}. Exchangeable sodium and potassium contents ranged from 2.24 to 6.83 and 0.51 to 2.34 cmol (p^+) kg^{-1}, respectively with mean values of 4.67 and 1.00 cmol (p^+) kg^{-1}. Perusal of data pertaining to exchangeable cations in relation to soil texture are presented in table 8 indicated that all the exchangeable bases studied were more in clay soils than in sandy clays. Hence it can be attributed to the presence of high clay as well as high CEC in clay textured soils. It was proved by a significant positive correlation of exchangeable Ca, Mg and Na with clay content (r= 0.602**, 0.501** and 0.557**, respectively).

Similar dominance of calcium on exchangeable complex was observed by Sharma *et al.* (1996) in semiarid region of Amritsar district, Punjab. The divalent cations, like Ca^{2+} and Mg^{2+} are relatively less mobile yet among the two, Mg^{2+} ions are more mobile than Ca^{2+} ions. As such, Mg^{2+}, Na and K ions are leached out earlier than the Ca^{2+} ions leading to the dominance of Ca^{2+} on exchange complex.

The data regarding exchangeable sodium per cent of the soil samples presented in table 6 ranged from 4.92 to 13.86 with a mean value of 11.90. Relatively higher ESP values were recorded in clay texture (mean value11.43%) than sandy clay (mean value 10.05%) (Table 7).

The per cent base saturation of Uppugunduru region soils presented in table 6 ranged from 92.51to 99.95 with a mean of 97.57. The per cent base saturation was high in clay soils than sandy soils and it increased with increase in clay content. The relatively high base saturation in soils could be attributed to the recycling of basic cations through vegetation (Shalimadevi and Anilkumar, 2010). High base saturation in the soils could be due to the presence of base contributing minerals such as smectite in black soils (Pal *et al.,* 2006).

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