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Characterization and classification of salt affected soils of Samni farm, Bharuch district, Gujarat

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Abstract : The shrink-swell soils of the Samni farm were studied for their morphological, physical and chemical characteristics. These soils are deep to very deep, dark grayish brown to very dark grayish brown in colour and had low to medium organic carbon. The calcium carbonate ranged from 77.5 to 82.8 g kg^{-1} and increased with depth while CEC ranged from 36.4 to 53.9 cmol kg^{-1}. In general, soil salinity (except pedon 1), ESP and SAR increased with depth. These soils are classified as Typic Haplusterts (Pedon 1, 2), Udic Haplusterts (Pedon 3) at sub group level with smetitic meperalogy and fine (P1) and very-fine (P2, P3) textural family class. Three categories of soil salinity/alkalinity were identified for these soils and appropriate managements have been suggested.

Additional key words: *Salt affected soils, Vertisols, characterization, degradation, management*

Introduction

In India, 6.7 million ha is affected by soil salinity, out of which 2.2 M ha (NRSA 1996) area is spread over in Gujarat and mostly confined in coastal and inland canal commands areas. These soils are either barren or under restricted cultivation. These soils are commonly found in areas of Vertisols and associated soils covering 4.9 M ha in Gujarat (NBSS Staff 1988). The salt affected Vertisols covering an area of 0.12 M ha in Gujarat pose constraints like sub-surface salinity/sodicity, low hydraulic conductivity and narrow working moisture range. Due to high spatial variability of soil salinity in Samni farm, Bharuch district, Gujarat warrants for characterization and classification so that an appropriate agro-management can be suggested.

Materials and Methods

The Research farm of Central Soil Salinity Research Institute, Regional Research Station, Bharuch, is located near Samni Village (21°51'70" to 21°52'02" N latitude and 72°54'70" to 72°55'19" E longitude) at an elevation of 9 m above mean sea level and cover an area of 23.5ha.

The climate of the area is semi-arid with maximum and minimum temperatures of 39.6°C and 12.1°C respectively. The area receives an average annual rainfall of 867 mm. The soil moisture and temperature regimes are ustic and hyperthermic, respectively.

At present the farm is used for experimental purposes of salt tolerant grasses, guava, chiku and pomegranate, jatropha and screening trials for salinity tolerance in cotton and wheat varieties.

During detailed soil survey (AIS&LUS 1970), 20 pedons were morphologically characterised (Soil Survey Division Staff 1985). Three typical pedons were included in present study. The horizon-wise soil samples were analysed for particle-size, pH, organic carbon, ECe, $CaCO_3$, exchangeable cations, cation exchange capacity (CEC) and exchangeable sodium percentage (ESP) by following the standard methods (Jackson, 1967).

Table 1. Morphological characteristics of soils

Horizon	Depth (cm)	Colour	Texture	Structure	Gravel (%)	Consistence D	M	W	Nodules S	Q	Root S	Q	Efferves-cence	Other features
						Pedon 1 (Typic Haplustert)								
Ap	0-20	10YR 3/2	c	m2 sbk	fg 5	h	fr	ssps	m	c	vf/f	m	e	-
Bw1	20-43	10YR 2/2	c	m2 sbk	fg 3	-	fr	ssps	f	f	c	f	e	-
Bw2	43-71	10YR 2/2	c	m3 sbk	fg 3	-	fi	sp	f	f	f	f	e	
Bss	71-03	10YR 3/3	c	m2 abk	-	-	fi	sp	f	f	f	f	e	ss
BC	03-35	10YR 3/3	c	m2 sbk	-	-	fr	ssps	-	-	f	f	e	-
C	135+	10YR 4/4	c	m1 sbk	-	-	fr	ssps	-	-	-	-	es	-
						Pedon 2 (Typic Haplustert)								
A	0-30	10YR 3/2	c	m2 sbk	-	h	fr	ssps	vf	f	f-m	m		-
Bw	30-66	10YR 3/2	c	m3 sbk	-	h	fr	sp	vf	f	f	m		pf
Bss1	66-97	10YR 3/1	c	c3 abk	-	vh	fi	sp	vf	f	f	f		ss
Bss2	97-130	10YR 3/1	c	c3 abk	-	vh	vfi	sp	vf	f	vf	f		ss
Bss3	130-156	10YR 3/2	c	c3 abk	-	vh	vfi	sp	vf	f	vf	f		ss
BC	156-170	10YR 3/3	gc	m2 sbk	fg 15	h	fi	ssps	m	c	-	-	e	-
C	170+	10YR 4/3	gc	m2 sbk	cg 15	h	fr	ssps	m	m			es	-
						Pedon 3 (Udic Haplustert)								
A	0-25	10YR 3/2	c	m 2 sbk	fg 2	sh	fr	ssps	vf	f	f	c	e	-
Bw	25-46	10YR 3/2	c	m 2 sbk	fg 2	h	fr	ssps	vf	f	f	c	e	pf
Bss1	46-81	10 YR 2/2	c	m 2 abk	-	h	fi	sp	vf	f	f	f	e	ss
Bss2	81-112	10 YR 2/1	c	m 2 abk	-	h	fi	sp	-		f	f	e	ss
Bss3	112-136	10 YR 3/2	c	m 2 abk	-	h	fi	sp	-		f	f	e	ss
C	136+	10 YR 4/3	c	m 1 sbk	fg 5	sh	fr	ssps	f/m	c	f	f	es	-

Saturation extraction was analysed as per the procedure described by Richard (1954). Based on the values of electrical conductivity, exchangeable sodium percentage, pH and sodium absorption ratio, broad categories of soils were identified and delineated.

Results and Discussion

Morphological characteristics

Morphological characteristics of the pedons are presented in table 1. Pedon 1 located on the upland plain, is deep, dark brown to very dark grayish brown in colour, moderately well drained and associated with moderate medium sub-angular to angular blocky structure. These soils exhibit 1-2 cm wide crack upto 100 cm thickness.

Pedon 2 is very deep, very dark grayish brown to very dark gray in colour and imperfectly drained. The surface and sub-surface horizons had moderate medium sub angular blocky structure however, strong coarse angular blocky structure was observed in horizons associated with slickenside. Cracks (4 to 5 cm wide) were found upto 156 cm. A layer of $CaCO_3$ nodules was observed in C horizon. The soils representing pedon 3, located on lowland, are deep, very dark grayish brown to black in colour and imperfectly drained. The structure ranges from moderate medium sub-angular blocky in A and Bw horizons and moderate medium angular blocky thereafter. These soils crack 2 to 5 cm wide upto 130 cm depth.

Physical and chemical characteristics

The physical and chemical characteristics and ionic composition of the pedons are presented in tables 2 and 3

Table 2. Physical and chemical characteristics of soils

Horizon	pH	ECe (dSm^{-1})	Particle Size			O.C. ($g\ kg^{-1}$)	$CaCO_3$ ($g\ kg^{-1}$) (< 2 mm)	Exchangeable Cations [cmol(+) kg^{-1}]				CEC [cmol (p^+) kg^{-1}]	ESP
			Sand	Silt (%)	Clay			Ca	Mg	Na	K		
							Pedon 1						
Ap	7.9	1.4	25.4	24.3	50.3	4.3	77.5	27.06	11.47	1.07	1.10	42.56	2.52
Bw1	8.0	1.2	27.6	20.6	51.8	ND	83.0	29.39	8.58	0.97	0.91	40.79	2.39
Bw2	7.8	5.4	26.1	18.3	55.6	ND	83.2	26.78	9.46	0.98	0.92	39.12	2.49
Bss	7.9	8.2	24.6	19.3	56.1	ND	79.9	24.37	12.26	2.30	0.81	40.23	5.72
BC	8.1	10.5	26.5	24.6	48.9	ND	84.6	23.54	9.73	2.34	0.54	36.50	6.42
C	8.0	11.4	26.5	28.3	45.2	ND	120.2	20.63	12.61	2.91	0.30	36.00	8.09
							Pedon 2						
A	7.9	1.2	15.5	28.2	56.3	4.5	78.7	19.83	25.36	1.13	0.96	48.56	2.34
Bw	8.1	1.4	22.8	20.4	56.8	ND	86.0	28.32	24.34	1.69	0.87	56.35	3.01
Bss1	8.4	1.8	14.0	24.5	61.5	ND	82.1	28.83	15.35	2.60	0.70	49.01	5.30
Bss2	8.3	2.3	14.3	21.0	64.7	ND	88.4	30.80	13.86	2.51	0.57	48.25	5.19
Bss3	8.2	2.4	19.4	16.0	64.6	ND	90.8	31.66	9.20	2.03	0.42	44.35	4.58
BC	8.4	2.7	24.7	27.2	48.1	ND	138.8	21.55	17.20	1.75	0.40	41.90	4.17
C	8.3	3.4	25.5	29.9	44.6	ND	182.5	20.96	16.14	0.33	0.38	37.02	0.88
							Pedon 3						
A11	7.6	1.7	20.1	16.6	63.3	5.8	82.8	34.86	12.83	0.52	0.86	51.22	1.02
Bw	7.9	1.5	16.7	22.3	61.0	ND	81.8	32.39	15.33	0.67	0.68	52.01	1.29
Bss1	7.5	1.6	11.5	26.7	61.8	ND	103.2	32.88	14.27	0.63	0.71	50.23	1.25
Bss2	7.5	1.7	12.9	26.3	60.8	ND	92.5	39.86	15.31	0.94	0.61	58.02	1.62
Bss3	7.6	1.2	11.7	23.3	65.0	ND	94.9	32.36	17.61	1.08	0.55	53.06	2.03
C	7.8	1.9	21.3	33.4	45.3	ND	109.5	29.57	23.07	0.87	0.42	55.04	1.57

* ND = Not determined

Table 3. Ionic composition of saturation extract of soils (meq l^{-1})

Horizon	Cations				Anions			
	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	CO_3^{--}	HCO_3^{-}	SO_4^{--}
				Pedon 1				
Ap	3.0	4.5	10.3	0.19	8.5	1.4	1.0	3.4
Bw1	1.8	2.8	9.6	0.12	7.3	2.0	0.5	4.2
Bw2	7.3	4.5	31.6	0.24	30.0	2.0	1.0	9.6
Bss	11.5	7.5	48.1	0.53	46.4	2.6	2.4	16.5
BC	15.0	12.0	84.1	0.14	77.5	2.8	5.5	25.4
C	17.0	12.5	103.3	0.15	81.5	2.6	3.3	44.9
				Pedon 2				
A	2.8	2.3	2.7	0.1	4.0	1.7	2.6	3.2
Bw	2.8	2.5	6.3	0.1	4.5	1.8	2.1	3.5
Bss1	2.5	2.3	9.4	0.0	5.0	2.0	3.4	4.1
Bss2	2.5	1.8	20.8	0.1	8.3	4.4	3.1	5.2
Bss3	4.3	3.8	21.3	0.1	14.8	4.0	3.2	5.6
BC	6.0	4.0	22.9	0.1	18.2	2.6	1.1	5.6
C	7.8	5.2	25.3	0.2	26.4	3.0	1.3	5.9
				Pedon 3				
A1	2.5	3.0	6.6	0.1	5.0	1.2	2.8	3.2
Bw	2.0	3.0	5.1	0.1	4.8	2.0	1.2	3.1
Bss1	2.1	4.0	5.8	0.1	5.3	3.0	0.7	2.9
Bss2	2.5	3.5	5.5	0.1	5.8	3.6	1.6	2.9
Bss3	2.5	2.5	6.3	0.1	5.5	3.0	1.3	3.1
C	3.0	3.0	7.2	0.1	6.0	3.8	1.3	3.4

Table 4. Soil *vs* management of the farm

Soil category	Characteristic features	Area (ha)	Management
Category I (Saline sodic soils)	Presently no surface salinity, sub-surface salinity (ECe) > 4.0 dSm^{-1}, pH 8.4 to 8.7, ESP 6.0 to 16.0 and high SAR	8.75	Best suited for rainfed crops as these soils are at relatively higher elevation, no waterlogging as they are moderately well drained. Careful irrigation strategies to be adopted to avoid upward movement of sub-surface salt.
Category II (Sodic soils)	Soil salinity < 4.0 dSm^{-1}, pH 8.0 to 8.7 and ESP 5-10	9.99	These are potentially sodic if irrigation water of low salt concentration (< 3 mel^{-1}) is applied because the susceptibility to clay dispersion and resultant decrease in hydraulic conductivity increased. Hence at given ESP, the decrease in electrolyte concentration increases the soil dispersion, but at the highest level of electrolyte concentration, the soil disperses slightly regardless of the magnitude of ESP. The soils under this category have to be managed properly.
Category III (Non-saline non-sodic soils)	Salinity 1-2 dSm^{-1}, ESP 2-3 and pH 7.6-7.8	4.76	Due to high clay and calcium carbonate content, waterlogging occurs during monsoon season, so *kharif* crops are not possible and hence it is best suited for *rabi* crops.

respectively. The clay content in these pedons ranged from 44.6 to 65.0 per cent. (Table 2). These soils are slight to moderately alkaline in nature and their pH increased with depth. The calcium carbonate ($CaCO_3$) content ranged from 77.5 to 182.8 g kg^{-1} in different horizon with a tendency to increase with depth. The water stagnation and poor drainage of these soils might be due to higher clay and $CaCO_3$. The ECe of these pedons 1 is less than 4 dSm^{-1}. The organic carbon content varied from 4.3 to 5.8 g kg^{-1}.

These soils have relatively high cation exchange capacity (36.5 to 56.3, cmol kg^{-1}) and dominance of Ca++ on exchange complex followed by Mg++, Na+ and K+. The exchangeable sodium percentage (ESP) ranged from 2.6 to 8.0 in different pedons. The saturation extract (Table 3) showed dominance of sodium ions followed by calcium and magnesium, while preponderance of chloride and sulphate ions with low concentration of CO_3^- and HCO_3^- ions were also found. The SAR of the pedons 1 ranged from 1.7 to 14.3.

Soil Management

By understanding the problems and potentials of these soils, occurrence on different physiographic position and typical characteristics with respect to salinity, sodicity and waterlogging, three groups of soils are to be managed differently for the sustainable production. Category I soils are the best suited for rainfed crops as these are at relatively higher elevation. Appropriate irrigation strategies to be adopted to restrict the upward movement of sub-surface salt. Category II soils are potentially more sodic if irrigation water of low salt concentration (<3 mel^{-1}) is applied owing to their susceptibility to clay dispersion and resultant decrease in hydraulic conductivity (Oster and Schroer 1979; Shainberg *et al.* 1981). The soils under this category have to be managed properly to avoid further degradation. The soils of the category III remain waterlogged during the period of rainy season which may be due to high clay and calcium carbonate content so *kharif* crops are not possible. Hence soils are the best suited for *rabi* crops (Table 4).

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