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Morphology, physico-chemical properties and classification of salt-affected soils of Rudauli Block, Faizabad, Uttar Pradesh

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ABSTRACT

The detailed soil survey of Salt-affected soils of Rudauli Block, Faizabad district (U.P.) was carried out during the year 2014. The studies on morphological characteristics physical and chemical properties of soils were undertaken through profile sampling. Based on the data obtained, the soils were categorized and classified up to soil series level Salt-affected soils, in general, were clay loam to silt loam in texture. The colour of soil samples was hue 10 YR with value varied from 4 to 7 and chroma 2 to 6. The pH of surface horizon varied from 8.69 to 9.23 whereas in the subsurface horizons it ranged from 9.12 - 9.97. Electrical conductivity (EC) indicates that the soils are non-saline and which varied from 0.26 to 1.07 dS m^{-1}. The organic carbon (OC) content is generally low in surface and very low in subsurface horizons in both the soils of ustic and udic moisture regime. The cation exchange capacity (CEC) values of the soils varied from 12.1 to 29.9 cmol (p+) kg^{-1} and the values increased with the depth. The exchange complex of all the pedons was dominated by Na+ followed by Ca++, Mg++, K+ and ESP, the value of exchangeable bases also increased from surface downwards. The exchangeable bases in all the pedons were in order of Na+ > Ca+2 > Mg+2 > K+ on the exchange complex. Based on soils characteristics, the soils are classified as Typic Agriustept, Typic Natrustept.

Keywords: Salt-affected soils, morphology characteristics, physico-chemical properties, Rudauli, Faizabad

INRTRODUCTION

Salt-affected soils are widespread all over the world. In addition to the constraints of scarcity or too much water in these soils, the basic fertility and land use capability of these soils is directly related to a few chemical properties, such as salinity and sodicity. It is the reason why the study of salt affected soils, as a pioneering branch of pedology, soil mapping, remote sensing, soil reclamation, soil utilization, has received so much attention (e.g. Richards, 1954). Soil is the most important natural resource, which is a treasure of any country. But it is finite, non-renewable and is constantly degrading. Proper use of this vital natural resource influences the existence of life system and socio-economic development of any country. To achieve soil resource management in agro-ecological regious needs knowledge on morphological, physical and chemical characteristics and classification is an essential requirement. In India, salt affected soils occur in patches due to variability in rainfall, topography, vegetation and parent material. The present investigation was therefore conducted under Rudauli Block, Faizabad, U.P. with the objective to know the morphology, physico-chemical properties and classification of salt-affected soils.

MATERIALS AND METHODS

The study area lies between $26^0$69.618' to $26^0$78.217'N latitude and $81^0$68.834' to $81^0$73.721'E longitude covering parts of Rudauli Block, Faizabad district. The climate of the study area is semi arid with an average rainfall of 550-900mm. Three pedons encompassing Isroliya (Padon 1), Vanmau (Padon 2) and Saraiyan (Padon 3) representing salt-affected soils were selected and profiles were exposed to study morphological characteristics. Soil colour of the pedons was measured both under dry and moist condition using Munsell soil colour chart. Other morphological characteristics studied were depth of solum, depth of each horizon, texture, structure, consistency at dry, moist and wet conditions, etc. The morphological features of the studied pedons were described in the field as per Soil survey Manual of USDA (Soil Survey Staff (1998). Soil samples from different horizons

were collected, air-dried, crushed and passed through a 2-mm sieve. Soil samples were analyzed for bulk density (Core method), hydraulic conductivity (Constant Head Method), field capacity and permanent wilting point (Pressure membrane apparatus), pH, EC (1:2.5 ratio of soil:water), organic carbon (wet oxidation), K^+, Na^+, Mg^{2+} and Ca^{2+} were determined by adopting standard methods (Richards 1954, Jackson 1973). Cation exchange capacity and ammonium acetate (pH 7.0) extractable bases were determined using method of Richards (1954) and particle size distribution by Bouyoucous hydrometer method. The soils were classified according to Soil taxonomy (Soil Survey Staff 1998).

RESULT AND DISCUSSION

Morphological properties

Majority of the soils (P1, P2 and P3) were characterized by 10YR as the common hue of the soil matrix with some variation in values and chromas. High colour values ranging from 4 to 7 suggest well drained nature of these salt-affected soils. The presence of mottles in lower horizons of Isroliya pedon may be attributed to the parent material and impendent internal drainage. The colour of the surface horizon was light gray (10 YR 7/2, dry) and pale brown (10 YR 6/3, moist) all pedons. The sub-surface horizon of Pedon 1 has light brownish gray (10 YR 6/2, dry) and dark gray brown colour (10 YR 4/2, moist), whereas sub-surface horizons of Pedon 2 and 3 had brownish yellow (10 YR 6/6, dry) and yellowish brown colour (10 YR 5/6, moist). The texture varied from clay loam to silt loam in all pedons (Table 1). This variation in texture is mainly due to differences in physiography. These results are in conformity with the findings of Nayak *et. al*. (2002). The surface soil structure of the pedon 1 was strong, medium, sub-angular blocky, whereas in sub-surface horizons moderate, medium, sub-angular blocky. The soil structure in surface horizon of padon 2 was strong, fine, prismatic, whereas in sub-surface horizons moderate, medium, prismatic. In pedon 3, soil structure in surface horizon was strong, medium, granular, whereas in sub-surface horizons moderate, medium, sub-angular blocky. The C horizon of all the pedons had predominately massive structure (Mandal and Sharma 2013).

Table 1: Morphological properties of the studied pedons

Horizon	Depth (cm)	Colour		Texture	Structure	Consistency			Other features
		Dry	Moist			Dry	Moist	Wet	
Padon- 1: Isroliya (Rudauli)									
A_p	0 – 18	10 YR 7/2	10 YR 6/3	cl	3 m sbk	sh	vfi	so po	Thin roots are present at a depth of 0-25 cm and Clay films around sand are observed at a depth of 45-75 cm and motteles are present at a depth of 45-100 cm.
B_1	18 – 45	10 YR 7/1	10 YR 6/3	cl	2 m sbk	sh	vfi	ss p	
B_2	45 – 75	10 YR 6/3	10 YR 4/3	cl	2 m sbk	h	fi	ss po	
B_3	75 – 100	10 YR 6/3	10 YR 4/3	cl	2 m sbk	h	fi	ss po	
C	100 – 150	10 YR 6/2	10 YR 4/2	cl	Massive	vh	fi	ss po	
Padon- 2: Vanmau (Rudauli)									
A_p	0 – 20	10 YR 7/1	10 YR 6/3	sil	3 f pr	sh	sfi	s p	Thin roots are present in depth of 0-22 cm.
B_1	20 – 45	10 YR 7/1	10 YR 6/3	sil	3 m pr	h	sfi	s p	
B_2	45 – 90	10 YR 6/6	10 YR 5/6	sil	2 m pr	h	fi	s po	
C	90 – 150	10 YR 6/6	10 YR 5/6	sil	Massive	vh	fi	ss sp	
Padon- 3: Saraiyan (Rudauli)									
A_p	0 – 15	10 YR 7/1	10 YR 6/3	cl	3 m gr	sh	sfi	vs p	Thin roots are present in depth of 0-25 cm.
B_1	15 – 25	10 YR 7/1	10 YR 6/3	cl	3 m sbk	h	fi	s sp	
B_2	25 – 55	10 YR 6/6	10 YR 5/6	cl	2 m sbk	h	fi	ss po	
B_3	55 – 90	10 YR 6/6	10 YR 5/6	cl	2 m sbk	h	fi	ss po	
C	90 – 150	10 YR 6/6	10 YR 5/6	cl	Massive	vh	fi	ss sp	

Texture: *CL- clay loam; SiL- silt loam****; Structure:*** *Size (S) f-fine; m-medium; Grade (G) 2-moderate; 3-strong; Type (T) gr – granular; pr- prismatic;sbk-sub angular blocky;* ***Consistency:*** *Dry (D), sh-slightly hard; h-hard; vh-very hard; Moist (M), fi-firm; vfi-very firm; sfi-slightly firm; Wet (W), so-non sticky;ss-slightly sticky; s-sticky; vs-very sticky; po-non plastic; sp-slightly plastic; p-plastic; vp-very plastic.*

The consistence of soils varied from slightly hard to very hard, firm to very firm and non-sticky and non-plastic to sticky and plastic in dry, moist and wet conditions respectively. This physical behavior of soils influenced by dry, moist and wet conditions was not only due to the textural make up by also due to type of clay minerals present in these soils. The C horizon of all the pedons had shown non-sticky and non-plastic or slightly sticky and slightly plastic consistence, which might be due to less amount of clay. Similar findings were also reported by Thangasamy *et al.* (2005) in the soils of Sivagiri microwatershed and Chandra Sekhar *et al.* (2017) for Prakasham district of Andhara Pradesh.

Table 2: Physical properties of the studied pedons

Horizon	Depth (cm)	Textural composition (%)			B.D. (Mg m^{-3})	H.C. (mm hr^{-1})	F.C. (%)	P.W.P. (%)
		Sand	Silt	Clay				
Padon- 1: Isroliya (Rudauli)								
A_p	0 – 18	40.32	32.44	27.24	1.37	1.3	27.20	11.80
B_1	18 – 45	39.73	30.76	29.51	1.41	1.0	27.00	11.70
B_2	45 – 75	39.25	29.20	31.55	1.48	0.8	26.90	11.50
B_3	75 – 100	37.77	27.70	34.53	1.52	0.5	26.70	11.30
C	100 – 150	35.55	26.85	37.60	1.57	0.3	26.60	11.20
Padon- 2: Vanmau (Rudauli)								
A_p	0 – 20	34.12	51.77	14.11	1.40	1.1	25.10	10.50
B_1	20 – 45	29.87	53.51	16.62	1.43	1.0	24.90	10.30
B_2	45 – 90	26.10	55.65	18.25	1.49	0.8	24.80	10.20
C	90 – 150	21.44	57.24	21.32	1.53	0.5	24.60	10.10
Padon- 3: Saraiyan (Rudauli)								
A_p	0 – 15	38.20	32.10	29.70	1.37	1.1	28.10	11.30
B_1	15 – 25	38.09	30.20	31.71	1.41	0.8	27.90	11.10
B_2	25 – 55	36.42	29.24	34.34	1.45	0.8	27.70	11.00
B_3	55 – 90	34.87	27.67	37.46	1.48	0.5	27.60	10.80
C	90 – 150	34.55	27.00	38.45	1.52	0.2	27.40	10.70

Physico-chemical properties

Sand content in all the pedons decreased from the surface downwards 40.32 to 21.44 per cent. Silt content ranged from 57.24 to 26.85 per cent. In pedons 1and 3 decreased from surface downwards and pedon 2 increased with depth (Table 2). This might be due to variation in weathering of parent material. The clay content in all pedons increased with depth 14.11 to 38.45 per cent. The physical properties indicated that the soils are silt loam to clay loam in texture, with bulk density 1.37 to 1.57 Mg m^{-3}, hydraulic conductivity 0.20 to 1.30 $mmhr^{-1}$, field capacity 24.60 to 28.10 per cent, permanent wilting point 10.10 to 11.80 per cent, respectively (Raghuwanshi *et al.* 2077). The pH of surface horizon varied from medium alkaline (pH 8.69) to strong alkaline (pH 9.23) whereas in the subsurface horizons it is strong alkaline (pH 9.12 - 9.97) (Table 3). Electrical conductivity indicates that the soils are non-saline and which varied from 0.26 to 1.07 dS m^{-1}. The organic carbon content is generally low in surface and very low in subsurface horizons in both the soils of ustic and udic moisture regime. The cation exchange capacity (CEC) values of the soils (Table 3) varied from 12.1 to 29.9 cmol (p^+) kg^{-1} and the values increased down the depth (Verma *et al.* 2014). The exchange complex of all the pedons was dominated by Na^+ followed by Ca^{++}, Mg^{++}, K^+ and ESP the value of exchangeable bases also increased from surface downwards.

Soil Classification

Based on morphological, physical and chemical properties (Table 1, 2 & 3) the soils under study have been classified according to Soil Taxonomy (Soil Survey Staff 1998). All pedons were classified into order Inceptisols and suborder Ustepts. All pedons have been classified into soil order Inceptisols having Ochric epipedon (less than 1.00 per cent organic matter, high colour value Croma 4 or more moist 6 or more dry) and argillic as well as nitric sub-surface diagnostic

Table 3: Chemical properties of the studied pedons

Horizon	Depth (cm)	pH	EC (dS m^{-1})	O.C. (g kg^{-1})	CEC	Exchangeable cations				ESP (%)
						Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	
						[cmol (p^{+})kg^{-1}]				
Padon- 1: Isroliya (Rudauli)										
A_p	0 – 18	8.69	0.34	2.70	12.1	4.3	3.8	3.0	0.5	24.79
B_1	18 – 45	8.77	0.29	2.50	12.6	4.4	3.8	3.6	0.6	28.57
B_2	45 – 75	8.87	0.26	2.10	13.0	4.3	3.7	4.2	0.6	32.30
B_3	75 – 100	9.06	0.32	1.50	16.2	4.3	3.8	6.8	0.7	41.97
C	100 – 150	9.12	0.28	1.30	16.8	4.4	3.9	7.4	0.7	44.04
Padon- 2: Vanmau (Rudauli)										
A_p	0 – 20	9.23	1.02	4.60	18.2	4.5	4.0	8.6	0.5	47.25
B_1	20 – 45	9.47	1.07	3.80	21.1	4.6	4.1	11.4	0.6	54.02
B_2	45 – 90	9.56	1.02	3.40	23.5	4.8	4.2	13.3	0.7	56.59
C	90 – 150	9.97	1.04	2.80	29.9	5.1	4.4	19.3	0.8	64.54
Padon- 3: Saraiyan (Rudauli)										
A_p	0 – 15	8.92	0.28	4.70	16.5	4.7	4.2	6.0	0.5	36.36
B_1	15 – 25	9.05	0.32	3.40	16.0	4.5	4.0	6.6	0.6	41.25
B_2	25 – 55	9.58	0.43	2.80	19.4	4.2	3.6	10.7	0.7	55.15
B_3	55 – 90	9.63	0.60	2.40	22.0	4.2	3.8	12.6	0.8	57.27
C	90 – 150	9.59	0.52	1.60	19.4	4.1	3.7	10.6	0.7	54.63

horizon.The argillic horizon has developed due to clay illuvation and was identified by the presence of clay cutans and the thickness of the horizon as more than 7.5 cm and also more than one-tenth as thick as the sum of the thickness of all the overlying horizons. As per criteria listed the moisture regime has been identified as Ustic. Hence all pedon at sub-ordered has been classified as Ustepts. It may be concluded that soils of Rudauli were saline to alkaline in nature with low in organic carbon content, medium to high in cation exchange capacity and high in ESP, SAR and exchangeable sodium. The trends of exchangeable cations is in order; Na+ > Ca^{2+}, > Mg^{2+} > K+. The soils of all the pedons were classified as Inseptisols in order and Ustepts in sub order. However, the great group of Pedon 1and 3 was Argiustepts while of pedon 2 Natrustepts.

Table 4: Soil taxonomic classification of the studied pedons

Name of place	Pedon number	Order	Sub order	Great group	Sub group	Family	Series	Phase
Isroliya (Rudauli)	Pedon 1	Inceptisols	Ustepts	Agriustept	Typic Agriustept	Fine mixed hyperthermic	Isroliya	cl
Vanmau (Rudauli)	Pedon 2	Inceptisols	Ustepts	Natrustept	Typic Natrustept	Fine mixed hyperthermic	Vanmau	sil
Saraiyan (Rudauli)	Pedon 3	Inceptisols	Ustepts	Agriustept	Typic Agriustept	Fine mixed hyperthermic	Saraiyan	cl

It is recommended that farmers should avoid over irrigation, stop using chemical fertilizer, use drip irrigation system and apply biological fertilizer.

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