Physico-Chemical Properties of Some Alluvial Soils Containing High Sodium Carbonate in the Indo-Gangetic Basin

S. V. GOVINDA RAJAN and R. S. MURTHY

All India Soil and Land Use Survey, Soil Correlation Centre, Bangalore, India

Soils containing excessive soluble salts particularly carbonate and bicarbonate and high exchangeable sodium, present serious difficulties in the Indo-Gangetic basin of North India, specially in the State of Uttar Pradesh. The formation of such soils is attributed to one or more factors like the semi-arid climate and lowlying topography on one hand, intensive irrigation practices, high water-table and lack of adequate drainage on the other.

The harmful effects of sodium carbonate on soils are generally known, yet the specific conditions favouring its formation or occurrence have not been clearly defined in many cases. KELLEY [3] has referred to five different ways by which sodium carbonate is formed in the soils. GEDROIZ [2] has proposed that sodium carbonate is formed in soil by reaction between Na-clay and H_2CO_3 as the principal way in which Na_2CO_3 is formed in soils. The importance of biological formation of Na_2CO_3 has been re-emphasised by recent research workers. ANTIPOV-KARATAEV [1] has pointed out that soils often become alkaline under the combined influences of an aerobic environment, an abundance of readily oxidisable organic matter and moderate concentrations of soluble Na_2SO_4. WHITTIG and JANITZKY [4] have studied the chemical transformations and physical translocations responsible for Na_2CO_3 formation.

Experimental

The soils selected for this investigation occur along the drainage ways and distributaries of irrigation canals. A number of irrigation canals and distributaries run through the area, chief among them being the Lower Ganges canal (Bhongnipur branch) flowing north-south and Upper and Lower Ganges canal (Cawnpore and Etawah branches). The water table is met with at a depth of 180 cm or less.

The morphological characteristics of the profiles are given in the following descriptions.

Profile 1. Besundhara in district Etawah; high flood plain of the Yamuna; poorly drained; salt efflorescence on the surface.

Table 1

Data of water extract analyses of soils.

Profile N° and depth (cm)	Elec. cond.* mmhos/cm	Soluble ions (me/l)						
		CO_3^{2-}	HCO_3^-	Cl^-	SO_4^{2-}	Na^+	K^+	$Ca^{2+} + Mg^{2+}$
1								
0— 10	40.0	182.0	118.0	37.2	55.5	371.3	1.7	0.7
10— 40	12.0	62.0	24.0	9.6	16.8	110.9	1.1	0.4
40— 84	2.0	3.0	3.5	2.8	14.1	22.8	0.5	0.1
84—112	1.3	1.1	3.5	2.0	6.9	13.0	0.4	0.1
102—142	1.3	1.1	3.0	3.9	8.0	15.2	0.3	0.5
142—175	1.0	1.0	6.5	1.8	1.0	9.1	0.3	0.9
2								
0— 6	120.0	525.0	200.5	209.5	190.0	121.6	3.9	0.4
6— 12	40.0	1 36.0	106.0	59.5	99.0	399.5	1.7	0.3
12— 45	18.3	100.0	8.0	30.1	46.3	182.2	1.4	0.8
45— 65	10.0	48.0	7.5	17.7	27.4	99.5	0.9	0.3
65— 94	3.8	13.5	7.5	8.7	38.0	38.0	0.7	0.6
94—135	1.8	2.0	6.0	3.5	6.8	17.4	0.2	0.8

* Electrical conductivity of twice saturation extract.

Depth

0— 10 cm Light gray (2.5 Y 7/2 dry) loam with white slat crust; weak granular; loose and friable; strong effervescence with dilute HCl; the top soil is loose, dry and fluffy; deposition of black organic matter in patches.

10— 40 cm Pale yellow (2.5 Y 7/4 moist) slay loam with few fine iron concretions scattered; moderate medium blocky; slight effervescence with dilute HCl.

40 —84 cm Light olive brown (2.5 Y 5/4 Y 5/4 moist) clay loam with common, medium sized distinct iron concretions; slight effervescence with dilute HCl.

84—102 cm Light olive brown (2.5 Y 3/4 moist) clay loam with iron concretions, dark brown in colour, many, coarse, prominent and concentrated; moderate coarse blocky; very sticky and plastic; slight effervescence with dilute HCl.

102—142 cm Same colour and texture as above but with no iron and lime concretions; massive.

142—175 cm Same colour and texture as above but with carbonate concretions, 12 to 35 mm size; violent effervescence with dilute HCl.

Profile 2. Bartha in district Etah; high flood plain of the Ganga; poorly drained (water stands in depressions); salt efflorescence on the surface with black alkali patches.

Depth

0— 6 cm Light gray (2.5 Y 7/2 dry) sandy loam; structureless (single grain); loose; violent effervescence with dilute HCl; top soil is fluffy and loose.

6— 12 cm Light olive brown (2.5 Y 5/4 moist) sandy loam; same structure as above but friable; few grass roots; strong effervescence with dilute HCl.

12— 45 cm Light olive brown (2.5 Y 5/4 moist) loam; columnar; firm and slightly sticky; slight effervescence with dilute HCl.

45— 65 cm Olive brown (2.5 Y 4/4 moist) loam with few, fine and faint iron concretions; columnar: slightly sticky and plastic; slight effervescence with dilute HCl.

65— 94 cm Same colour and texture as above but mixed with small carbonate concretions and few brownish iron concretions, soft and crumbling to powder; slight effervescence with dilute HCl.

94—135 cm Olive brown (2.5 Y 4/4 moist) clay loam with few iron concretions, scattered; more sticky; slight effervescence with dilute HCl.

135+ Water table. Plentiful crabonate concretions which violently effervesce with dilute HCl.

Table 2

Composition of exchangeable cations in the soil.

Profile N° and depth cm	pH	Exchangeable cations			Cation exch. capacity me/100 g	Exch. Na Percentage
		Na^+	K^+	$Ca^{2+} + Mg^{2+}$		
1						
0— 10	9.9	1.6	0.82	9.38	11.8	13.56
10— 40	10.3	17.39	0.71	1.90	20.0	87.00
40— 84	9.4	14.73	0.60	1.97	17.3	85.14
84—102	9.1	13.93	0.60	2.97	17.5	79.60
102—142	8.8	11.19	0.53	1.88	13.6	82.28
142—175	8.8	8.99	0.77	3.54	13.3	67.60
2						
0— 6	9.4	1.45	1.18	5.47	8.1	17.90
6— 12	9.8	8.35	0.90	3.45	12.7	65.74
12— 45	10.1	9.09	0.66	7.55	17.3	52.51
45—65	10.2	13.16	0.73	5.11	19.0	69.29
65— 94	9.9	16.19	0.58	1.33	18.1	89.42
94—135	9.0	9.00	0.42	4.18	13.6	66.19

It is evident from the data that no leaching of salts has taken place in the soil profiles. In profile 1, the electrical conductivity is very high, 40 mmhos/cm in the surface decreasing rapidly with depth, showing thereby, that the upward movement of salts is more dominating. The predominant anions are carbonate and bicarbonate and cation, sodium. Concentrations of carbonate and bicarbonate are much higher as compared to calcium and magnesium. Soluble sodium is 391 m.e/litre in the surface. pH is high in the surface horizon and decreases with depth. This is due to the presence of high Na_2CO_3 in the surface.

In profile 2, excessive accumulation of carbonate and bicarbonate relative to sulphate and chloride accounts for the high pH, up to 10.2, of the soil. Such high concentrations of carbonate and the resultant high alkalinity depress the concentration of soluble calcium and magnesium. Water-table is high and the sub-soil water is saline in addition to its being alkaline, pH of water being 9.5. It contains carbonate as well as bicarbonate of sodium. The accumulation of salts in the surface is due to deposition during evaporation of soil water rising by capillary movement during the hot, dry, summer months. Every litre of sub-soil water evaporating from the surface will leave behind 22.4 me/litre of carbonate + bicarbonate. The rate of capillary rise and evaporation from the surface is so high during dry periods that large amounts of salts are deposited again and again and this seems to be a continuous process.

References

[1] ANTIPOV-KARATAEV, I. N.: Reclamation of solonetz soils in U.S.S.R. Acad. Sci. U.S.S.R. Moscow. 1953.

[2] GEDROITZ, K. K.: Colloidal Chemistry as related to Soil Science. Zhur. Opyt. Agron. **13.** 363—412. 1912.

[3] KELLEY, W. P.: Alkali soils, their formation, properties, and reclamation. Reinhold. New York. 1951.

[4] WHITTIG, L. D. & JANITZKY, P.: Mechanisms of formation of sodium carbonate in soils. J. Soil Sci. **14.** 322—333. 1963.