



Short Communication

Mapping and Characterization of Waterlogged and Salt-affected Soils in Loonkaransar area of Indira Gandhi Nahar Pariyojona for Reclamation and Management

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Loonkaransar lift canal was introduced in Stage II of Indira Gandhi Nahar Pariyojona (IGNP) to improve soil productivity and livelihood security in the Thar Desert covering Loonkaransar Tehsil of Bikaner district, Rajasthan (FAO/UNDP 1971). Arid climate, severe wind erosion and undulating topography are major constraints for low productivity potential (Shankarnarayana and Gupta 1991). Emergence of soil salinity and waterlogging problems at the post-irrigation have been reported by several authors (Mathur *et al.* 1996; Mandal and Sharma 1997; Khan *et al.* 1999; Dwivedi and Sreenivas 2002). Uncontrolled irrigation, coarse texture, and poor to imperfect drainage have caused development of perched water table and soil salinization in irrigated areas (Hooja *et al.* 1995). Assessment of nature, extent and distribution of salt-affected soils is necessary for reclamation and management and hence the present study was carried out.

The study area lies between 28°25'N and 28°45' N latitude and 73°35'E and 74°00'E longitude (Fig. 1) with an altitude of 194-200 m above mean sea level (amsl). The average annual rainfall (255 mm), evaporation (open pan) (3-13 mm day⁻¹) and mean annual temperatures (5-42 °C) justified the soil moisture and temperature regimes as torric and hyperthermic, respectively. The area falls under the sandy plains, dunes and *tal* (alluvial plain) with overburden aeolian sand (Singh and Kar 1991). The selenite (transparent, colourless gypsum) deposit is a common occurrence in this area. The introduction of canal irrigation altered soil moisture content, pH and soluble salt composition and perched water table formation in absence of natural surface drainage (Hooja *et al.* 1995; Shankarnarayana and Gupta 1991).

The geo-coded false colour composites (FCC) for pre- (February), post-monsoon (October) and sum-

mer (June) seasons were visually interpreted to delineate waterlogged and salt-affected soils. The interpreted units were transferred on the georeferenced basemap on 1:50,000 scale that showed spatial distribution of waterlogged salt affected soils.

Ground truth was conducted for locating salt-affected soils during March 2002 and waterlogged areas in November 2004. A total of 11 soil profiles (90-120 cm) were studied for morphology and horizon-wise soil samples were collected for chemical characterization and classification. These were analyzed for soluble ions (Na^+ , K^+ , Ca^{2+} , Mg^{2+} , Cl^- , SO_4^{2-} , CO_3^{2-} , HCO_3^-), pHs, ECe, CaCO_3 , organic matter and soil separates (sand, silt and clay) using standard methods (Richards 1954; Jackson 1973). Water samples were collected from various sources such as a drainage *sump* (effluent collector), auger bore and accumulated seepage water (*tal*) for quality appraisal (Richards 1954). The reclamation, management and use potentials of soils were suggested.

Mapping Salt-affected and Waterlogged Soils

The interpretation of IRS data (Fig.1) showed prominent image features for irrigated crop (red to dark red), pasture and scrub lands (dark green), waterlogged (irregular dark blue or blue-black tones) and salt-affected soils (white salt crust). The waterlogged areas (*surface ponding*, 7281 ha) showed prominent energy absorption in IRS Band 4 (NIR) data and were primarily located in low-lying sandy flats and depressions. The cropped areas showed moderate vigour during February and scattered in November and June due to less water availability. The mixed spectral signatures ranging from grayish to dark grey tones with red mottles showed poor vegetative growth in mustard (*rabi*) crop and dying *sisham* (*Dalberjia sissoo*) trees associated with high water table. Such areas were

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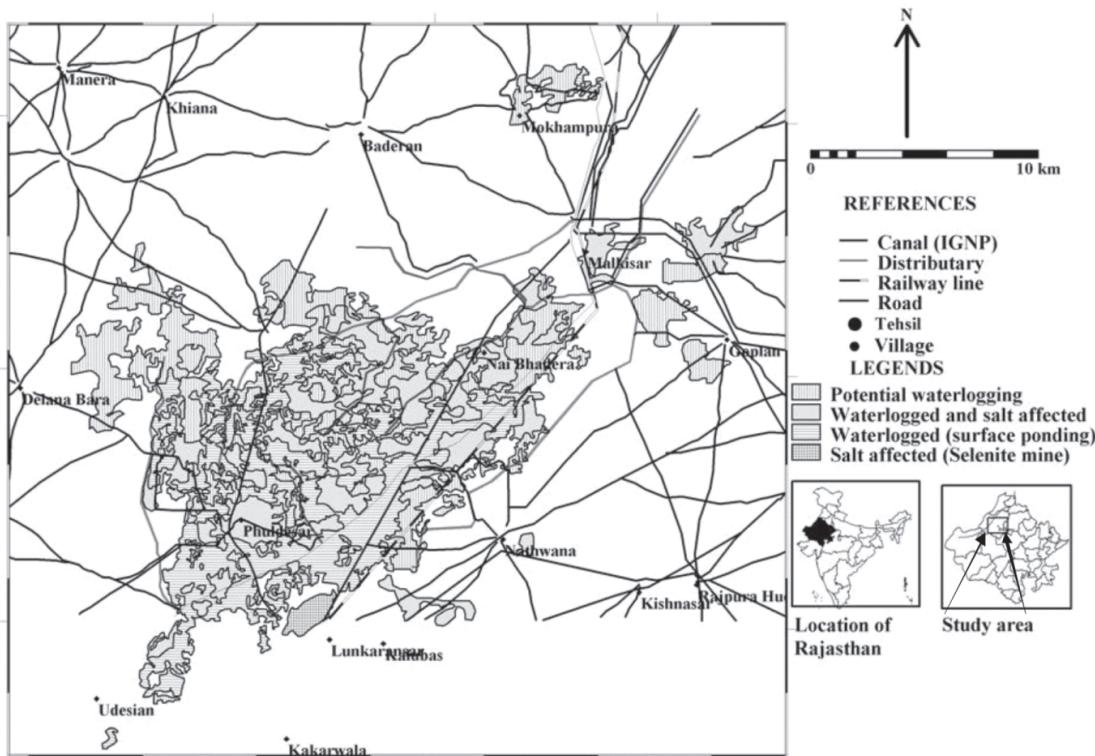


Fig. 1. Distribution of waterlogged and salt-affected soils in Loonkaransar area of IGNP, Rajasthan

classified as Potential Waterlogging Zone (7559 ha). Surface salt efflorescence was identified by prominent signature from barren salt crusts (2655 ha) and stressed vegetations (3450 ha) in irrigated areas. Strong reflections of localized selenite deposit (239 ha) were also identified in sandy plains close to the Loonkaransar town (Singh and Kar 1991).

Characteristics of Salt-affected Soils and Water

During the ground truth survey, soil and water samples were collected from the waterlogged and salt-affected areas for physicochemical characterization and quality appraisal. The salt-affected soils were characterized as high, moderate and slightly saline based on field study and physico-chemical characteristics. Salient characteristics of five pedons were presented to show salt content, composition of soluble salts and pedogenic nature of soils (Table 1). Morphological characteristics of all pedons showed pale brown to dark yellowish brown colour, loamy sand to sand texture, single grained to weak, coarse subangular blocky structure, loose (dry) to moist friable consistence and presence of few to abundant CaCO_3 nodules/concretions. A few iron and manganese mottlings were found in subsurface (50 cm) layers of P1 (sandy plain) and P2 (sand dune), due to prolonged waterlogging. The CaCO_3 concretions (2-5

cm, 10-30%) were noted at a depth of 1m in P1, P2 and P3. The restricted drainage, moist soil profile, high water table (0.5 to 2.0 m) and secondary salinization were common features in the command area (Mathur *et al.* 1991; Hooja *et al.* 1995; Mandal and Sharma 1997). Poor horizon development and strong aeolian activity are prominent features in soil profiles.

The pH values ranged between neutral to alkaline (7.4 to 9.3) (Table 1). The ECe values were low in P1 (0.9 to 3.9 dS m⁻¹) and P2 (0.4 to 2.3 dS m⁻¹); moderate in P4 (3.6 to 11.5 dS m⁻¹) and P5 (1.4 to 6.1 dS m⁻¹) and high in P3 (18.7 to 142.0 dSm⁻¹). The ECe values decreased with increasing depth in P1 (3.9 to 0.9 dS m⁻¹), P5 (6.1 to 1.4 dS m⁻¹) and P3 (142.0 to 18.7 dS m⁻¹), while there increased in P2 (0.4 to 10.2 dS m⁻¹) and P4 (3.6 to 11.5 dS m⁻¹). The high salt content at surface layer of P3 may be ascribed to the lower topographic position that receives salts periodically through runoff (Mandal and Sharma 1997). High water table (1.2 m) and secondary salinization were responsible for increasing sub-surface salinity in P2 and P4 (Mandal and Sharma 1997). High base saturation (85 to 100%) of soil prior to irrigation also supports salinity development with rising water table (Shankarnarayana and Gupta 1991).

Ionic composition of soils showed the dominance of anions for Cl^- and SO_4^{2-} , Na^+ , Ca^{2+} and Mg^{2+}

Table 1. Selected properties of soil profiles in Loonkarsansar area of IGNP command

Depth (cm)	Hori- zon zon	pHs	Soil properties				CEC [cmol(p ⁺) kg ⁻¹]	ECe (dS m ⁻¹)	Composition of saturation extract (me L ⁻¹)				Texture
			CaCO ₃ (%)	OM (%)	ESP	Silt (%)			Na ⁺	Ca ²⁺ + Mg ²⁺	Cl ⁻	SO ₄ ²⁻	
P1: Slightly saline soils (28°31'05"N, 73°45'22"E) sandy plain, leveled, currently under <i>Sisham</i> and grasses, WT* 1.2 m, Torripsammants													
0-19	A1	8.0	2.18	0.18	1.9	85.4	8.3	6.2	5.61	3.9	21.8	20.0	5.6
19-66	C1	8.1	3.03	0.12	2.1	86.2	5.9	7.9	4.89	1.4	7.4	9.0	1.0
66-96	C2	8.0	5.06	0.12	1.7	91.1	4.4	4.4	8.51	1.1	3.3	11.0	0.2
96-125+	C3	8.3	6.05	0.12	1.7	91.2	4.3	4.3	4.20	0.9	4.4	8.0	0.4
P2: Slightly saline soil (28°31'49"N, 73°45'26"E) uncultivated, sandy dune, leveled, currently under plantations, WT* 1.5 m, Torripsammants													
0-22	A1	8.5	1.00	0.16	1.1	95.9	2.1	4.0	3.60	0.4	1.0	4.0	1.5
22-76	C1	8.2	0.55	0.19	1.2	94.0	2.0	4.3	7.80	0.6	0.9	8.0	2.5
76-105	C2	8.8	4.00	0.19	10	91.5	2.2	4.9	8.90	6.2	38	8.0	12.0
105-147	C3	8.4	8.00	0.12	1.5	93.0	4.3	4.5	6.40	10.2	62.4	10.0	65.0
147-160+	C4	9.3	11.30	0.18	1.4	90.9	4.5	4.6	4.20	1.6	10.5	4.0	5.0
P3: Strongly saline soil (28°36'10"N, 73°49'14"E), sandy dune, <i>Ganthia</i> and <i>Frans</i> grasses, Khejri, WT* 0.75 m, Torripsammants													
0-7	A1	7.4	1.8	0.18	1.7	93.1	2.3	4.7	4.20	142.0	1150.9	400	1919.0
7-43	C1	7.8	3.4	0.15	21	91.5	2.1	6.3	6.70	24.5	109.9	139	255.0
43-65	C2	7.9	4.7	0.15	17	93.5	2.2	4.3	4.70	23.0	120.2	128	223.5
65-115+	C3	7.9	5.1	0.15	15	91.5	4.2	4.3	4.60	18.7	89.5	100	187.0
P4: Moderately saline soil (28°31'03"N, 73°45'20"E), sandy dune, under scattered mustard cropping, unproductive, WT* 1.0 m, Torripsammants													
0-15	Ap	7.9	1.4	0.14	19	91.4	2.13	5.53	4.23	7.5	24.4	43	46.5
15-30	C1	8.3	0.5	0.18	21	89.4	4.38	6.14	6.98	3.6	19.0	12	17.5
30-60	C2	8.2	6.6	0.18	15	91.3	4.32	4.32	4.62	8.7	47.2	48	20.5
60-90	C3	8.2	7.6	0.16	16	91.2	4.35	4.35	4.34	11.5	77.5	21	86.0
P5: Moderately saline soil (28°36'09"N, 73°49'11"E), sandy plain, fallow, unproductive, used for mustard crop, WT 0.75 m, Torripsammants													
0-30	A1	9.3	2.6	0.12	8	95.6	2.17	2.17	3.33	6.13	35.4	10.0	36.0
30-60	C1	8.4	7.1	0.12	5	95.3	2.32	2.32	3.91	2.29	14.4	8.0	15.0
60-90	C2	8.6	8.6	0.12	6	95.6	2.17	2.17	3.33	1.38	5.1	16.0	7.0

*WT= Water table depth

Table 2. Quality of water in Loonkaransar canal command area

EC (dS m ⁻¹)	pH	Na ⁺	K ⁺	Ca ²⁺ +Mg ²⁺ (me L ⁻¹)	CO ₃ ²⁻ +HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻	SAR
Drainage water: Highly saline, Village and Tehsil Loonkaransar, District Bikaner (28°31'05"N, 73°45'22"E)								
30.66	8.5	285.2	0.52	20.0	11.0	286.0	35.0	90.2
Auger bore (150 cm): Non-saline Village Badhera, Tehsil Loonkaransar, District Bikaner (28°36'09"N, 73°49'11"E)								
3.06	7.33	16.4	0.06	12.0	4.0	18.0	8.0	6.78
Ponded water: Slightly saline, Village Badhera, Tehsil Loonkaransar, District Bikaner (28°36'10"N, 73°49'14"E)								
3.96	8.8	29.3	0.39	10.0	12.0	17.5	10.0	13.1

were the dominant cations. The presence of bicarbonate along with higher contents of Ca²⁺+Mg²⁺ indicated the existence of calcareous parent materials. The presence of Cl⁻ and SO₄²⁻ showed neutral and gypsum parent materials (FAO/UNDP 1971; Shankarnarayana and Gupta 1991). Significant content of CaCO₃ at a depth of 147 cm in P2 indicated initiation of secondary salinization. The organic matter content was generally low. The dominance of sand (85 to 96%) is shown throughout. The CEC values were low due to coarse texture and presence of non-expanding minerals or mixed mineralogy. The ESP values were low (5 to 21).

The chemical composition of water samples showed high EC (30.66 dS m⁻¹) and dominance of Na⁺ (285.2 me L⁻¹), Cl⁻ (286.0 me L⁻¹) and SO₄²⁻ (35.0 me L⁻¹) in drainage water (Table 2). The ponded water (seepage *tal*) showed moderate EC (3.96 dS m⁻¹) and SAR (13.1) and may be used for mixing with good quality water. The auger bore water also showed moderate EC (3.06 dS m⁻¹) and SAR (6.78) with low to moderate salt content. It may be used for irrigation by blending with good quality canal water.

Reclamation and Use Potential of Salt-affected Soils

The soils of the Loonkaransar area are rich in soluble calcium and magnesium chlorides and sulphates. Prior to irrigation, these soils were used for fodder production due to limited water availability. Introduction of irrigation altered the land uses for high water requiring crops *viz.*, wheat and mustard (Hooja *et al* 1995; Mathur *et al*. 1996). The use of surface flood irrigation practice and restricted internal drainage due to the presence of subsurface hard pan caused rising water table and soil salinization in low-lying interdunal areas. Being rich in sulphates, the soils representing pedons P4 and P5 with moderate salinity could be used for growing salt tolerant crops following salt leaching. The soils for pedons (P1 and P2) with low to moderate salinity and loamy sand texture can be suitably used for raising arable crops supported by proper soil/water management

practices. Soils (P3) with high soil salinity can be reclaimed by installation of subsurface drainage followed by salt-leaching.

In conclusion, the visual interpretation of IRS data on 1:50,000 scale facilitated delineation of waterlogged salt-affected soils in Loonkaransar area of IGNPs command, Rajasthan. Lack of natural drainage and coarse soil texture facilitated waterlogging and soil salinization which ultimately affected the soil productivity. The high water table in the irrigated cropped and adjoining areas needs suitable soil and water management to avoid further deterioration. Highly salinized areas may be reclaimed by drainage installation followed by salt-leaching with good quality water.

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