

Environmental Impact of Indira Gandhi Canal Project in Rawatsar Tehsil of Hanumangarh District, Rajasthan

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Abstract: In Rawatsar tehsil of Hanumangarh district, seepage from the Indira Gandhi canal system, excessive use of water in cultivated fields and accumulation of water in depressions have brought more than perceptible change in the environment through sub-soil water level rise, waterlogging and soil salinity. The field data and spectral characteristics of IRS-IB LISS II FCCs reveal that nearly 165 sq. km (34.25%) of the total command area is under waterlogging and soil salinity. The problems of the affected area have been categorised as slight (67.95 sq. km), moderate (3.37 sq. km), severe (93.67 sq. km) and very severe (36.76 sq. km). The areal extent of waterlogging and soil salinity is increasing every year. However, there is scope to arrest these problems using improved technologies of land and water resources management.

Key words: Irrigation, canal water, waterlogging, salinization, environment.

The Indira Gandhi Canal Project (IGNP) is one of the major irrigation projects of the country, which was planned to transform desert ecosystem in a productive agricultural system. It envisages use of 9.3 billion cubic metres (bcm) of the Ravi and the Beas waters in 1.8 million hectare land for agriculture, drinking water, afforestation, etc. However, since the inception of canal irrigation project in 1961, irrigation in the command area is being practised in a liberal way without adequate attention to long term side effects on natural resources and environment. Due to intensive irrigation, seepage from canals and water courses over the years have created a severe problem of waterlogging and soil salinization in many areas. This has resulted in reduction of land productivity and degradation of other natural resources in the affected areas. The areal extent of waterlogging and soil salinization is constantly increasing. This

paper deals with problems of waterlogging and soil salinization in Rawatsar tehsil of Hanumangarh district, Rajasthan.

Materials and Methods

Rawatsar tehsil of Hanumangarh district covers 1840 sq. km area and lies between latitude 28°46'30" and 29°20'45"N and between longitude 74°2'30" and 74°37'0"E in the north of arid Rajasthan. The average annual rainfall at Hanumangarh is 253.3 mm. In the south, central and south-west the soils are coarse textured with dune and interdune relief. In the north and north-east of the tehsil, the area is mostly under canal irrigation, and the soils are highly variable in texture, ranging from sand to loamy sand, sandy loam, loam, silty loam and silty clay loam. Except in canal command area, the surface water resources of tehsil are limited. The groundwater is

Table 1. Surface and groundwater quality in waterlogged area in IGNP canal command area (Rawatsar)

Water sample*	Site	pH	EC (dS m ⁻¹)	Cation (mg L ⁻¹)					Anion (mg L ⁻¹)			Na (%)	SAR
				Na	K	Ca ⁺	Mg ⁺⁺	Cl	CO ₃	HCO ₃	SO ₄		
SW ₁	Jeevnagar	7.8	8.30	600	52	88	165	665	36	170	34	60.5	45.9
GW ₁	Jeevnagar	7.6	5.10	250	9	160	136	367	0	122	66	36.6	16.5
	Chalk												
GW ₂	Chhaiya	7.8	49.80	460	48	48	681	4409	24	195	749	77.5	233.4
SW ₂	Bherusari	7.4	340	3099	439	120	4439	30806	120	366	4705	79.3	649.3
GW ₃	Sardarpura	8.6	40.1	338	5	16	39	142	36	171	49	78.7	56.7
SW ₃	Gandheli	7.8	114.9	600	70	352	136	891	36	146	85	49.1	69.3
GW ₄	Neharwali	8.0	8.90	825	16	88	112	568	48	146	279	72.7	68.7
	Dhani												

*SW = Surface stagnated water, GW = Ground water.

either brackish, or has excessive salts and fluoride and, therefore, not suitable for any use (Anonymous, 1995).

Based on field traverses and visual interpretation of image characteristics like tone, texture, size and pattern on IRS-IB LISS II FCCs (October 1994 and February 1995) the areas under waterlogging and soil salinity were mapped. On the FCCs, very dark grey tone is for water bodies and waterlogged areas. The soil salinity areas appear in whitish and dull white to dull red tone (in cropped area). The whitish tone of the saline areas is due to high spectral reflectance from surface salt crust and dull red is caused by the chlorophyll content of poor standing crop in fields. The areas associated with heavy textured soils appear in white to dark grey tone. Salinity developed in sandy soils is due to high water table and appears in bright whitish tone (Singh *et al.*, 1992).

The soil and water samples from the tehsil were also analysed. Analysis of physico-chemical characteristics of the soils (Pipar, 1950; Jackson, 1967), salt composition of saturation extract, surface and groundwater quality (Richards, 1954), was

carried out and data were interpreted. Based on the severity classification of salt affected soils, as suggested by Richards (1954), the degraded soils in the IGNP area were classified into four severity classes, viz., slight ($EC_e < 5$ dS m⁻¹), moderate ($EC_e 5-10$ dS m⁻¹), severe ($EC_e 10-40$ dS m⁻¹) and very severe ($EC_e > 40$ dS m⁻¹). The taxonomic classification of the soils was done using the soil taxonomy criteria suggested by Soil Survey Staff (1975, 1994).

Results and Discussion

Rawatsar tehsil has many environmental problems: waterlogging, soil salinity and wind erosion/deposition. Out of the total culturable command area (CCA) of 481.66 sq. km, nearly 165 sq. km (34.25%) is affected by waterlogging and soil salinity. The remaining cultivated area is mainly affected by wind erosion/deposition where various forms of dune exist. Rainfed cultivation is practised in the interdune plains, and on sand dunes at places, resulting in high sand movement during summer period. Moreover, some of the interdune

Table 2. Physico-chemical characteristics of salt affected soils

Category	Depth (cm)	EC 1:2 (dS m ⁻¹)	pH 1:2	CaCO ₃ (%)	Particle size distribution (%)				Texture class*	Taxonomic classification of soils
					CS	FS	Silt	Clay		
Slight	0-20	0.8	8.7	5.6	4.8	82.6	5.5	6.1	LS	Coarse loamy
	20-60	1.0	8.6	4.4	5.2	82.6	6.8	6.4	LS	Typic
	60-120	1.3	8.7	5.8	5.5	80.5	8.4	6.6	LS	Haplocambids
	120-160	1.3	8.7	6.0	6.8	75.0	11.0	7.2	LS	
Moderate	0-25	1.5	8.6	5.4	3.2	83.7	8.6	5.5	LS	Coarse loamy
	25-50	2.1	8.7	4.0	2.5	81.1	10.6	6.8	LS	Typic Calci-salids
	50-80	2.2	8.8	5.2	2.8	76.2	13.2	8.8	SL	
	80-120	3.1	8.9	6.8	2.6	73.6	14.2	10.6	SL	
	120-160	4.2	8.9	9.0	3.4	55.0	24.8	16.8	SIL	
Severe	0-20	11.4	9.5	6.8	3.6	73.8	14.0	10.6	SL	Coarse
	20-65	9.6	9.0	8.7	3.8	69.1	16.1	12.0	L	loamy/fine loamy
	65-105	8.8	8.9	11.2	6.5	61.3	18.0	15.2	L	Typic
	105-130	8.6	8.8	14.8	6.8	51.0	26.0	16.2	SIL	Haplocalcids-salids
	130-160	5.5	8.8	16.7	2.5	46.9	28.0	22.6	SIL	
Very severe	0-25	27.0	9.0	8.3	3.4	43.6	36.4	16.6	SIL	Fine loamy,
	25-55	18.0	8.9	10.4	3.8	47.2	33.2	15.8	SIL	Typic Haplo-
	55-110	17.0	8.8	11.4	6.7	27.7	46.3	29.2	SICL	Aquic-salids
	110-160	14.8	8.8	6.8	6.0	15.3	49.0	30.7	SICL	
	160-185	12.8	8.9	4.0	2.6	8.9	56.7	32.8	SICL	

*LS=Loamy sand, SL=Sandy loam, SIL=Silt loam, L=Loam, SICL=Silty clay loam, CS=Coarse sand, FS=Fine sand.

areas, particularly in southern part of the tehsil, suffer from severe root zone limitation due to accumulation of free earth alkaline carbonate and gypsum.

Surface water irrigation with canals have proved to be a very potential system to improve the crop productivity of the arid tract. However, adoption of this system is never free from environmental hazards, due to terrain characteristics and subsurface conditions (Mann and Chatterji, 1978). Use of irrigation waters is too high. During the period 1988 to 1995, the average rate of water use, measured in terms of water released at the head of feeder canal (IGNP), was 1260 mm against the design value of 560 mm (Kapoor, 1997). The ground

water table in the area is rising at an alarming rate. During the year 1952-72, 1972-82 and 1982-92, the average rise in water table was 0.42, 1.17 and 0.76 m per year, respectively, primarily due to return flow of irrigation water and standing water in depressions (Anonymous, 1995).

The interpretation of FCCs and data from field traverses reveal that the area under waterlogging is 36.76 sq. km in the Rawatsar tehsil. Its maximum spread is 23.76 sq. km (64.65%) along the Indira Gandhi main canal and in interdunal depressions. The same along the Ghaggar diversion canal, located in the north-west, is 9.53 sq. km (25.92%). Along the minor irrigation canal system the spread is 2.77

Table 3. Saturation extract composition of salt affected area

Category	Depth (cm)	ECe dS m ⁻¹	Cation (meL ⁻¹)				Anion (meL ⁻¹)			
			Na ⁺	K ⁺	Ca ⁺	Mg ⁺⁺	Cl	CO ₃ + HCO ₃	SO ₄	SAR
Slight	0-20	3.2	17.2	0.5	7.3	2.5	22.1	3.2	12.2	7.7
	20-60	4.7	22.2	0.2	6.5	4.5	21.6	4.4	12.2	13.0
	60-120	4.8	27.4	0.2	6.3	4.2	22.8	3.8	11.4	11.9
	120-160	5.2	39.0	0.3	3.2	5.7	20.0	9.7	19.2	17.6
Moderate	0-25	6.2	53.2	1.2	10.9	3.1	33.4	10.2	22.0	20.0
	25-50	8.6	58.0	1.2	10.5	4.7	54.0	6.0	25.0	21.0
	50-80	10.4	70.0	1.2	19.2	6.3	49.4	7.6	42.0	20.0
	80-120	12.6	80.0	0.5	24.5	16.2	59.0	9.6	48.7	17.2
	120-160	12.8	88.0	0.5	26.0	15.8	83.5	3.2	48.7	19.2
Severe	0-20	41.2	333.6	11.5	33.5	39.3	325.5	21.0	71.4	51.4
	20-65	38.8	300.0	11.6	93.5	18.3	264.1	9.6	87.0	40.0
	65-105	26.8	220.0	8.8	70.8	18.0	224.4	11.0	82.2	33.5
	105-130	24.8	174.0	6.6	28.5	18.2	162.8	18.0	46.5	36.2
	130-160	16.4	147.0	2.5	13.5	18.5	145.0	4.0	32.3	37.0
Very severe	0-25	98.0	880.0	36.0	72.0	34.0	660.0	24.0	340.0	114.2
	25-55	72.0	580.8	32.0	74.4	41.2	545.2	32.0	151.2	78.3
	55-110	68.0	500.0	24.0	100.0	196.0	610.5	30.0	80.0	56.0
	110-160	56.0	400.0	16.0	80.0	76.0	352.6	24.0	195.2	50.0
	160-185	46.0	360.0	12.0	68.0	56.0	310.0	18.0	168.0	46.1

sq. km (9.43%). Further, it has been observed that the problem of waterlogging is existing, particularly in areas where canal system has been constructed, in the embankment and seeped water is being accumulated in the surrounding depressional areas.

Water in the main Indira Gandhi Canal contains total dissolved solids of 150 mg L^{-1} with specific electrical conductance values less than 0.25 dS m^{-1} (Kapoor, 1997). However, the quality of stagnated water in waterlogged area is highly deteriorated. Water collected at the surface and by capillary action, where ground water table is fairly high, on evaporation leaves behind salts and makes the land unfit for

agriculture. The highest EC value of 340.0 dS m^{-1} and pH value of 7.35 was observed in long standing seepage water collected around Bherusari village in depressional areas (Table 1). Seepage water in depressional area near Gandheli village along the branch canal of the main Indira Gandhi Canal has EC and pH values of 114.7 and 8.27 dS m^{-1} , respectively. At Jeevnagar Chak, the values are 7.84 and 7.82, respectively. In all these samples, sodium is a major constituent (600 to 30999 mg L^{-1}) of cations while chloride (665 to 28806 mg L^{-1}) dominates among anions. Sodium varies from 49.6 to 79.28% and Sodium Adsorption Ratio (SAR) is 29.27 to 649.28. Such water is not suitable for any use.

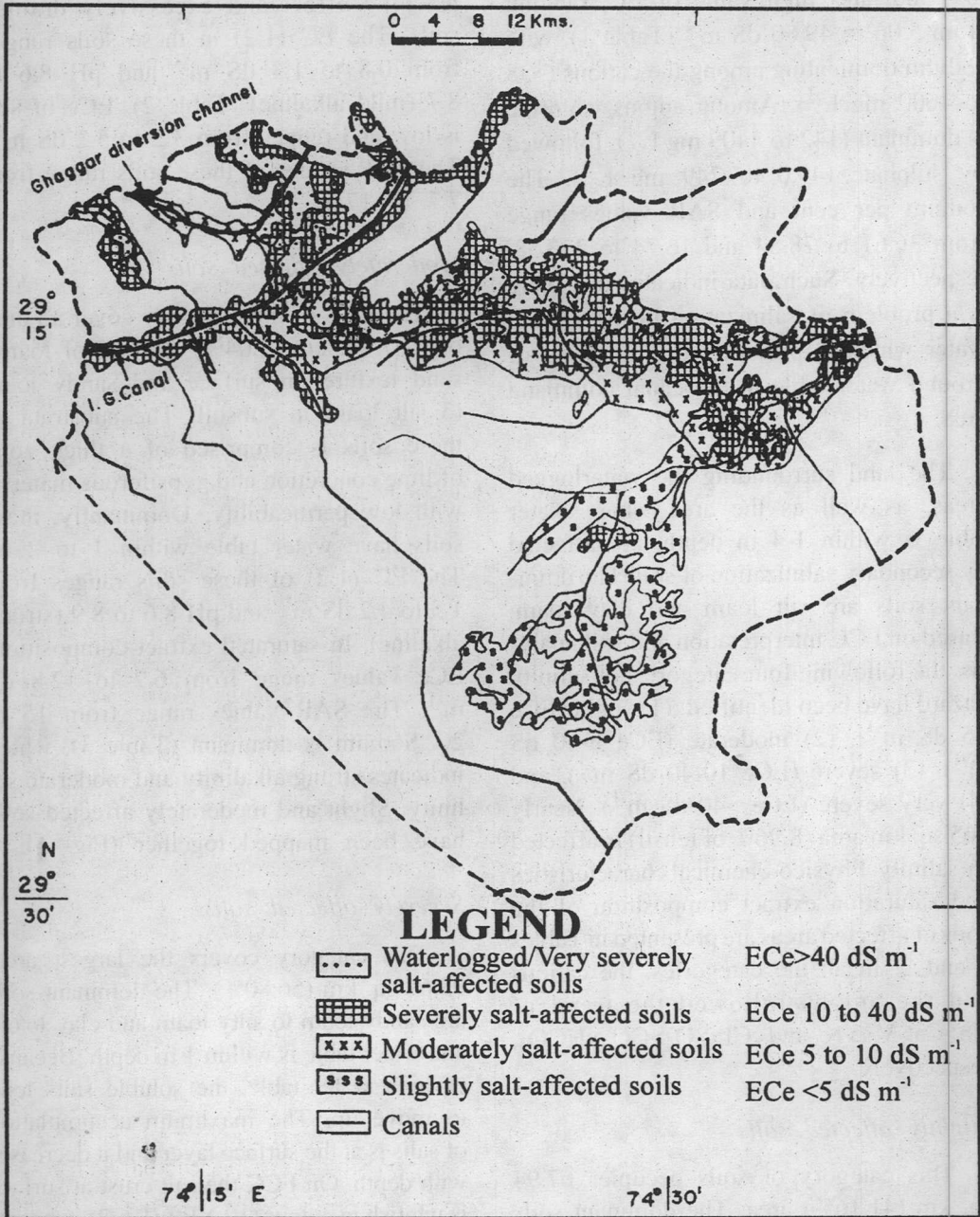


Fig. 1. Development of waterlogging and soil salinity along Indira Gandhi Canal in Rawatsar tehsil.

The analysis of ground water samples also indicates high value of EC, ranging from 5.06 to 49.80 dS m⁻¹ (Table 1), with sodium dominating among the cations (338 to 4600 mg L⁻¹). Among anions, chloride is dominant (142 to 4409 mg L⁻¹), followed by sulphate (49.0 to 749 mg L⁻¹). The sodium per cent and SAR values range from 36.61 to 78.84 and 16.74 to 233.38, respectively. Such data indicates that there is a problem of salinization in the ground water which is primarily due to rising of ground water table in the canal command area.

The land surrounding the waterlogged areas, as well as the area where water table is within 1-4 m depth, are affected by secondary salinization of soil. The dominant soils are silt loam and clay loam. Based on FCC interpretation and soil analysis, the following four categories of salinity hazard have been identified: (1) slight (ECe <5 dS m⁻¹), (2) moderate (ECe 5-10 dS m⁻¹), (3) severe (ECe 10-40 dS m⁻¹), and (4) very severe (ECe >40 dS m⁻¹). Nearly 165 sq. km area (8.96% of tehsil) is affected by salinity. Physico-chemical characteristics and saturation extract composition of the soils of affected areas are presented in Tables 1 and 2. In all the categories, the cations and the anions followed the trend of Na>Ca>Mg>K and Cl>SO₄>CO₃>HCO₃, respectively.

Slightly affected soils

This category of soils occupies 67.94 sq. km (41.16%) area. The dominant soils are sand to loamy sand in texture, underlain by a thick zone of lime concretion at >1.5 m depth. The deep sandy areas do not

show much salt accumulation due to quick leaching effect and excessively drained soils. The EC (1:2) in these soils ranges from 0.8 to 1.3 dS m⁻¹ and pH 8.6 to 8.7 (mild alkaline) (Table 2). ECe of soil is low and ranges from 3.2 to 5.2 dS m⁻¹. The SAR values of these soils range from 7.7 to 17.6.

Moderately affected soils

The soils of this category cover an area of 3.37 sq. km (2.04%) and are of loamy sand texture on surface and sandy loam to silt loam in subsoil. The substrata of these soils is comprised of a thick zone of lime concretion and gypsiferous material with low permeability. Dominantly, these soils have water table within 1 to 2 m. The EC (1:2) of these soils ranges from 1.5 to 4.2 dS m⁻¹ and pH 8.6 to 8.9 (strong alkaline). In saturated extract composition, ECe values range from 6.2 to 12.8 dS m⁻¹. The SAR values range from 15 to 20. Sodium is dominant (Table 3), which indicates strong alkalinity and moderate salinity. Slight and moderately affected soils have been mapped together (Fig. 1).

Severely affected soils

This category covers the largest area, 93.69 sq. km (56.80%). The dominant soils are sandy loam to silty loam and clay loam, and water table is within 1 m depth. Because of high water table, the soluble salts tend to move up. The maximum accumulation of salts is at the surface layer and it decreases with depth. On FCC the salt crust at surface is whitish in colour (10 YR 6/1-6/2), whereas the salts in patches are dark grey and brownish due to strong alkalinity. EC (1:2) of these soils ranges from 5.5 to 11.4 dS m⁻¹ and

pH 8.8 to 9.5. Soils have comparatively high percentage of silt (14 to 28%) and clay (10.6 to 22.6%), which reduces the permeability of water and leaching of salts. SAR values are quite high, ranging from 33.5 to 51.4. Besides high salinity, these soils contain high exchangeable sodium over calcium and magnesium and are in strong alkaline condition with salinity.

Very severely affected soils

This category of soils has severe problem of waterlogging and occupies 36.76 sq. km (7.63%) area. The soils are silt loam to clay loam and silty clay loam, underlain by heavy clay and a thick lime concretion zone. These soils belong to old Ghaggar flood plain, showing alluvium characteristics (Kar, 1997; Ahmed *et al.*, 1998). Soils are under waterlogging along the Indira Gandhi canal, Ghaggar diversion channel and a few minor irrigation canals, and suffer from lack of internal and external drainage.

The soil samples collected from this unit were in saturated condition and their EC (1:2) ranged from 12.8 to 27 dS m⁻¹ and pH 8.8 to 9.0. These soils have high silt (33.2 to 56.7%) and clay (16.6 to 32.8%). Due to fine texture, soils have a tendency of salt accumulation. EC_e values range from 46 to 98 dS m⁻¹. SAR values are very high, ranging from 46.1 to 114.2 and contain high exchangeable sodium which affects the vegetation and disturbs the physical condition of soils. These results are quite comparable with results of study conducted by FAO (1971a,b) in IGNP phase I area.

Conclusions

Intensive irrigation and seepage from canal and water courses have caused major

environmental problem in the form of waterlogging, soil salinity and degradation of natural resources in command area. To counter these ill effects, a series of technological activities involving water management, changes in cropping pattern, relining of water courses and introduction of vertical, horizontal and bio-drainage systems are required to be adopted.

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