Evaluation of Salinity Problem in Swell-Shrink Soils of a Part of the Purna Valley, Maharashtra

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Abstract : *The study on evaluatation of salinity problem in swell-shrink soils (Vertisols) of the Purna valley in Amravati district was undertaken. The non-irrigated soils have mild alkalinity (pH 8.5 to 8.9), very low exchangeable sodium percentage (ESP) and low electrical conductivity of the saturation extract (ECe< 4 ds m^{-1}), and thus they are neither saline nor sodic in the surface. However, mild sodicity (ESP >, 15) has been noticed in the subsoil horizons. Despite uniform clay content and non-sodic nature of the soils, the saturated hydraulic conductivity decreases sharply with depth (5.5 to 0.3 mm hr^{-1}) and thus leads one to know as to how the drainage of the soils could be severely impaired due to incomplete leaching of salts. The well and river waters of the area are not safe for irrigation. Continuous use of such waters would hasten the sodification process that may adversely affect the future agricultural prospects. Alternatively, growing crops under rainfed condition would be a prudent approach as the content of salts are well below the crop rooting zones.*

In Maharashtra, black soils (Vertisols and their intergrades) occupy an area of about 30 million hectares of which about 0.54 million is reported to be salt - affected (Agrarwal *et al.* 1979 ; Abhange *et al.* 1986). These areas are confined to the lower topographical situations of most of the river valleys (Basu & Sirur 1938; Basu & Tagare 1943). One of these areas is the Purna valley covering parts of Amravati, Akola and Buldhana districts. The problem of salt affliction in the soils of these areas has been reported in the recent past (Adyalkar 1963 ; Tanpur 1971 ; Puranik *et al.* 1972 ; Sagare *et al.* 1991). However, during the traverse in these areas the presence of salts as efflorescence is hardly seen. But, the farmers complain about waterlogging problem after heavy rains which delays the sowing of the kharif crops. Moreover, use of well water as a source of supplemental irrigation in rabi season crops adversely affects the crop yields.

The present study was, therefore, undertaken to examine precisely the properties of the swell-shrink soils of the valley from both non-irrigated and irrigated areas and also to evaluate the quality of well and river waters with a hope that the results may be of help in managing these soils for optimal land use.

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TABLE 1. Physical properties of soils

Depth (cm)		Size class and particle diameter (mm)			Hydra. condu.		Water retention		AWC
		Sand (2.0 - 0.05)	Silt (0.05 - 0.002)	Clay (<0.002)			33 kPa	1500 kPa	
		<-----% of <2.0 mm-------->			mm hr^{-1}	<----------% ---------->			
Khartalegaon (KH-1)									
0	-17	11.1	36.3		52.6	5.5	42.0	27.1	14.9
17	-39	4.5	40.1		55.4	4.2	42.9	31.2	11.7
39	-99	6.6	25.2		68.2	3.3	44.5	32.4	12.1
99	-129	6.6	24.9		68.5	3.3	44.7	31.8	12.9
Khartalegaon (KH-2)									
0	-15	3.3	42.5		54.2	6.4	36.3	23.9	12.4
15	-38	4.0	35.8		60.2	5.4	37.4	23.8	13.6
38	-71	3.9	33.6		62.5	4.6	40.3	24.4	15.9
71	-115	6.6	30.9		62.5	3.8	42.0	26.3	15.7
115	-150	9.6	30.4		60.0	2.1	40.2	26.3	13.9
Khartalegaon (KH-3)									
0	-16	5.1	34.1		60.8	5.3	41.7	27.1	14.6
16	-39	1.8	33.6		64.6	3.2	42.5	26.6	15.9
39	-64	6.7	28.7		64.6	2.4	42.5	26.5	16.0
64	-88	2.2	32.1		65.7	0.9	44.4	26.8	17.6
88	-140	2.5	27.0		70.5	0.9	46.6	28.1	16.5
Kokarda (KD)									
0	-15	7.4	28.8		63.8	5.5	41.0	25.1	15.9
15	-38	3.0	31.6		65.4	2.1	42.6	25.5	17.1
38	-68	2.5	26.3		71.2	2.2	46.0	26.2	19.8
68	-98	2.3	27.6		70.1	1.9	45.1	26.0	19.1
98	-127	2.4	29.3		68.3	1.9	44.2	24.4	19.8
127	-138	2.4	29.9		65.7	1.8	44.7	24.7	20.0
Gayvadi (GY)									
0	-15	3.4	26.1		70.5	1.6	44.5	22.9	21.6
15	-33	2.6	25.9		71.5	1.4	45.0	25.0	20.0
33	-55	4.6	23.1		72.3	0.6	45.5	26.0	19.5
55	-83	3.2	24.1		72.7	0.5	45.7	26.7	19.0
83	-125	4.5	23.7		71.8	0.3	44.6	26.5	18.1

MATERIALS AND METHODS

The study area is located in between 20^0 45' to 21^0 15' N latitudes and 75^0 15' to $77^0$45' E longitudes. Seven Vertisol pedons (KH-1, KH-2, KH-3, KD, GY, CH-1 and Ch-2) were exposed (Fig.1) and morphologically described. The KH-1, KH-2 and KH-3 pedons were from Khartalegaon village where PKV, Akola intends to carry out intensive soil management studies in the near future. The CH-1 and CH-2 pedons were from the Chendkapur village and were selected to comprehend the extent of adversity being caused due to the use of well water for irrigation. CH-1 pedom was from a field where dry land farming is practised, and the CH-2 pedon was from a field of a similar landscape as CH-1 but where irrigation from well water was practised from 1977 to 1985. Water samples from wells and rivers of the study area were also collected for analysis.

The horizonwise soil samples collected in the field were subjected to different laboratory analyses. Particle size distribution was done by the international pipette method using sodium hexametaphosphate as the dispersing agent (Kilmer & Alexander 1949). Water retention and saturated hydraulic conductivity (HC) estimations of the fine earth fractions (2 mm) of soils were carried out as per procedures outlined by Black *et al.* (1965). All other determinations were made according to methods of Richards (1954).

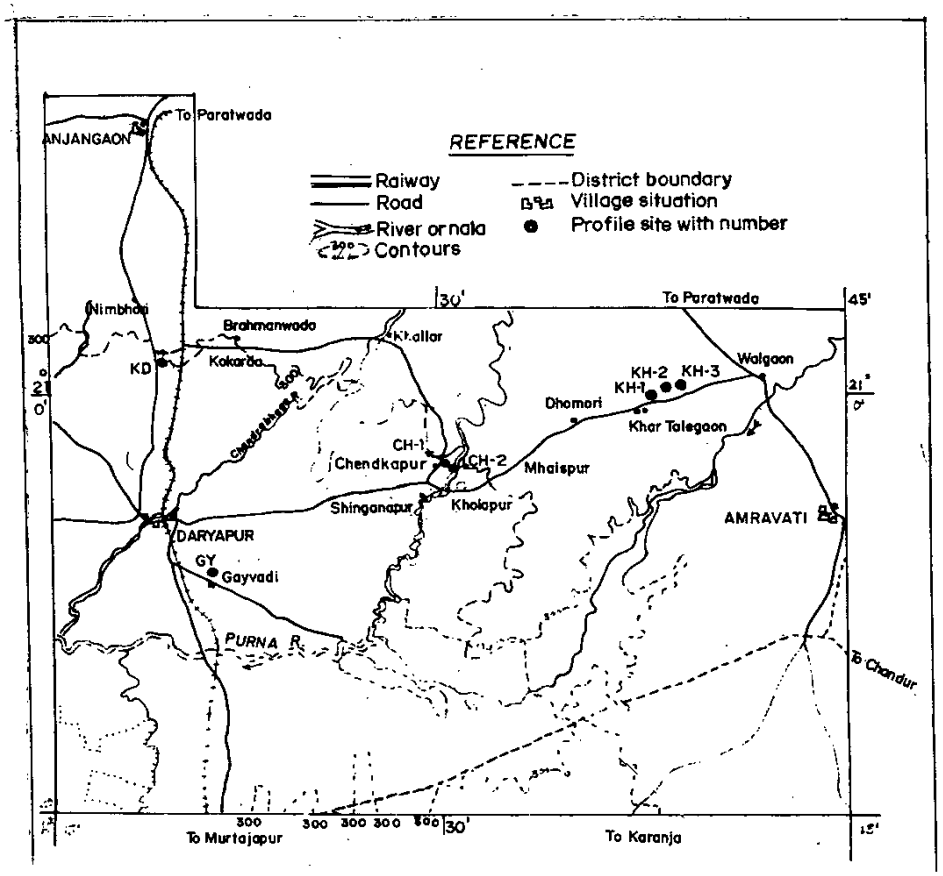

Figure 1. Locations of soil sampling sites.

TABLE 2. Chemical properties of soils

Depth (cm)	pH (1:2) water	ECe at 25°C	Cationic composition of saturation extract .				SAR	CEC	Exch Na	Exch Na
			Ca	Mg	Na	K				
			d m^{-1}	<---------- me L^{-1} --- -------->				c mol (p+) kg^{-1}		%
Khartalegaon (KH-1)										
0-17	8.6	1.3	5.8	1.2	6.4	0.2	3.4	43.9	1.6	3.6
17-39	8.6	1.3	4.5	1.3	6.8	0.2	4.0	42.2	1.8	4.3
39-99	8.8	2.2	7.8	2.9	9.8	0.2	4.2	46.1	2.2	4.8
99-129	8.9	2.4	7.7	5.0	12.5	0.2	5.0	46.7	2.8	6.0
Khartalegaon (KH-2)										
0-15	8.5	1.0	2.8	1.1	6.0	0.2	4.3	51.3	2.4	4.7
15-38	8.5	0.8	2.1	0.5	3.9	0.1	3.4	54.5	2.3	4.2
38-71	8.5	0.8	1.8	0.7	7.7	0.1	4.3	57.6	3.1	5.4
71-115	8.6	1.1	2.0	0.8	7.0	0.2	5.9	61.3	4.0	6.5
115-150	8.8	1.2	1.4	1.7	8.6	0.1	6.9	63.5	5.1	8.0
Khartalegaon (KH-3)										
0-16	8.5	0.8	2.1	1.0	4.3	0.1	3.4	53.2	1.8	3.4
16-39	8.7	1.4	3.8	1.0	5.3	0.2	3.4	54.0	2.2	4.1
39-64	8.8	1.7	4.5	2.0	10.6	0.2	5.9	51.3	3.6	7.0
64-88	8.8	1.7	2.3	1.5	13.1	0.2	9.4	54.3	6.1	11.2
88-140	8.9	2.3	3.6	1.4	18.6	0.2	11.8	55.5	7.2	13.0
Kokarda (KD)										
0-15	8.4	0.7	1.6	1.3	3.8	0.1	3.1	56.5	2.1	3.7
15-38	8.6	0.8	1.4	1.5	5.5	0.3	4.6	62.9	3.3	5.2
38-66	8.6	1.1	1.7	0.9	7.8	0.1	6.9	60.3	4.9	8.1
66-98	8.8	1.6	2.3	1.5	12.3	0.1	8.9	59.1	6.3	10.7
98-127	8.9	2.1	2.6	1.9	15.8	0.2	10.6	61.3	7.8	12.7
127-138	8.9	2.3	2.3	1.7	20.3	0.2	14.4	56.5	8.7	15.4
Gayvadi (GY)										
0-15	8.6	1.2	1.6	0.8	8.5	0.2	7.7	48.7	4.5	9.2
15-33	8.9	1.3	2.5	0.6	11.2	0.2	8.8	50.6	5.3	10.5
33-55	9.0	1.9	2.4	2.0	15.8	0.3	10.6	49.6	6.2	12.5
55-83	9.2	2.2	2.7	1.1	16.6	0.3	12.1	48.3	7.1	14.7
83-125	9.3	5.2	5.5	4.5	39.3	0.8	22.1	51.8	9.2	17.8

TABLE 3. Water sample analysis

Characte ristics	Location			
	Chendkapur	Kokarda	Khartalegaon	Gandhigram
Source	Well	Well	Well	Purna river
pH	8.3	7.5	7.6	7.9
EC (dS M^{-1}) at 25^0C	2.7	15.0	18.0	1.4
Anions (me L^{-1})				
$CO3^{--}$	0.5	0.2	0.3	0.2
$HCO3^{-}$	2.8	13.8	11.2	2.8
Cl^{-}	9.6	125.8	135.6	7.7
$SO4^{--}$	15.3	10.3	29.0	3.8
Cations (me L^{-1})				
Ca^{++}	5.2	27.7	13.1	3.0
Mg^{++}	2.1	13.8	19.1	1.6
Na^{+}	20.7	110.0	142.8	9.9
K^{+}	0.1	0.6	1.0	0.1
SAR	10.8	73.2	80.6	67.3
Class rating (Richards 1954)	C4-S2	C4-S3	C4-S4	C3-Sl

TABLE 4. Comparative soil properties of non-irrigated and irrigated soils

Depth (cm)	Sand (2.0 - 0.05)	Silt (0.05 - 0.002)	Clay (<0. 002)	pH (1:2) water	ECe at 25^0	Ionic composition of satuaration extract							SAR	Exch. HC Nammha^{-1}	
						CO_3^{--}	HCO_3^{-}	Cl^{-}	SO_4^{--}	Ca^{++}	Mg^{++}	Na^{+}	K^{+}		
	<---% of < 2mm) --->				ds m^{-1}	<----------(me L^{-1}) -------->									
Non-irrigated (CH-1) Profile															
0-17	2.0	34.2	63.8	8.3	2.3	-	7.4	8.1	6.5	7.2	5.9	8.9	0.1	3.5	3.8	3.2
17-44	2.0	29.1	68.9	8.4	1.5	-	7.1	6.6	0.8	4.5	3.9	6.0	0.1	2.9	3.4	2.7
44-67	1.4	28.0	70.6	8.5	1.9	-	7.8	6.1	4.3	6.5	4.2	7.2	0.2	3.1	3.6	2.3
67-100	2.0	26.4	71.6	8.6	2.4	-	8.7	7.9	4.9	8.2	4.5	8.7	0.1	3.4	3.9	2.0
100-130	2.0	28.8	69.2	8.6	1.9	-	8.2	6.4	3.9	6.8	3.2	8.0	0.1	3.6	4.2	1.3
Irrigated (CH-2) Profile															
0-15	2.9	33.3	63.8	8.9	5.7	1.0	20.8	21.9	12.7	6.8	5.0	44.2	0.3	18.2	17.8	3.1
15-43	2.3	28.8	68.9	8.9	6.5	1.2	20.1	22.4	15.3	8.0	5.0	52.8	0.3	20.7	18.2	3.2
43-59	1.4	29.4	69.2	8.8	5.2	Tr	20.3	15.9	14.6	6.0	3.6	41.0	0.2	18.7	15.3	3.2
59-93	2.0	26.5	71.5	8.6	3.4	Tr	17.1	11.3	5.2	6.6	2.3	24.4	0.3	11.6	11.6	0.9
9-129	1.2	28.2	70.6	8.6	3.2	Tr	14.1	12.7	4.8	6.4	5.5	19.4	0.3	7.9	7.0	0.9

RESULTS AND DISCUSSION

The soils of KH-1, KH-2, KH-3, KD, GY and CH-1 pedons are fine textured with very high amounts of clay (Table 1). Due to this and smectitic mineralogy the soils have good water retentivity of around 40 per cent at 33 kPa. The available water holding capacity ranges from 12 to 20 per cent (Table 1).

The soils are mostly alkaline (pH 8.5 to 9.3) and the pH increases with depth. The electrical conductivity of the saturation extract (ECe) increases with depth and is, in general, well below 4 dS m^{-1} (Table 2). Sodium adsorption ratio (SAR) and exchangeable sodium percentage (ESP) values, except for the bottom most horizon of KD and GY pedons, indicate that these soils qualify neither for saline soils nor sodic or saline-sodic (Richards 1954). However, it is noteworthy that the saturated hydraulic conductivity of these soils is low and it sharply decreases with depth and reaches almost a negligible value (Tables 1 and 2). There has been an initiation of sodification in the subsurface horizons, however low may be its degree, which has been enough to impair the drainage condition of the soils causing severe water stagnation after the rains.

The data on the quality of water collected from wells and river (Table 3) indicate that, in general, Cl ion dominates among the anions and Na ion in the cations. The water ratings as per Richards (1954) for well waters are C4-S2, C4-S3, and C4-S4 (Table 3) indicating their high salinity and sodium hazards. The ratings for river water is C3-Sl indicating high salinity with low sodium hazards. Continuous use of such waters should hasten the sodification process. The extent of deleterious effect due to the use of such waters can be well comprehended from the development of adverse physical and chemical properties of pedon CH-2 of the irrigated field with reference to pedon CH-1 of the non-irrigated field (Table 4). In just 7 years of irrigation ESP and SAR show a four fold increase in CH-2 compared to CH-1. Likewise ionic composition and electrical conductivity of the saturation extract show 2 to 3 fold increase. In addition, soils have become highly alkaline, and the hydraulic conductivity has further been impaired. The severe consequence of this fact is relfected in waterlogging and also in the apparance of salt efflorescence on the soil surface in the irrigated field. Both these situations have forced the farmer to abandon the agriculature in these fields.

In view of above it, would be prudent to grow crops that are possible under rainfed condition because of the fact that the salts are at present well below the rooting zone of most of the crops.

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