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Assessment of ground water quality and its effect on physico-chemical properties of soils under Pench irrigation project in Nagpur district, Maharashtra

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Abstract
In order to assess the groundwater quality and its effect on soils of right bank canal command area of Pench irrigation project in Nagpur district particularly in Parsheoni Tahasil, the present study was undertaken. Soils of this area are clay loam to clayey with more than 35 per cent clay. Bulk density of these soils varied from 1.28 to 1.53 Mg m^{-3}. The saturated hydraulic conductivity (HC) of these soils ranged from 0.81 to 2.71 cm hr^{-1}. Soil reaction was low to moderately alkaline (pH 7.43 to 8.53). These soils are non-saline as indicated by the electrical conductivity, which ranged from 0.119 to 0.552 dS m^{-1} at 25 ^oC, but more accumulation of salts was observed in surface layer of these soils. Organic carbon content (2.7 to 6.2 g kg^{-1}) was low to moderate. The calcium carbonate content of these soils ranged from 1.5 to 6.13 per cent. The high CEC (33.76 to 58.49 cmol (p+) kg^{-1}) and base saturation (90.5 to 95.1 per cent) indicate the potential of these soils in terms of fertility. The exchangeable cations were in order of Ca > Mg > Na > K. The Ca/Mg ratio of soil varied from 1.80 to 2.9 and the exchangeable sodium percentage (ESP) varied from 2.67 to 4.86 whereas the exchangeable magnesium percentage (EMP) ranged from 23.09 to 30.62 and exchangeable calcium percentages ranged from 55.22 to 66.16. These soils of study area were not qualified for alkali soils as the ESP was less than 15 and so soils are very good for cultivation point of view. In the saturation extract, soluble sodium percentages which ranged between 23.49 to 60.64. The SAR ranged between 0.9 to 3.07. The soluble Ca/Mg ratio ranged between 1.2 to 2.93. The water samples of this area had medium salinity and low sodicity hazards (C_2S_1). On the basis of above facts, it is concluded that, in order to optimized the production on sustainable basis, injudicious and over irrigation to crops should be avoided and seepage losses through irrigation canals should be controlled.

Keywords: Ground water, characterization, irrigation water quality, saturation extract, etc.

Introduction
India is called as the country of Agriculture. Irrigation is practiced in those parts of the world where rainfall is not sufficient to support crop growth or where the rain does not fall when the plants need water. Now a days irrigation has become very essential due to irregularity of rain. Agricultural productivity is governed by the good quality land. Salinity of the soil is important factor. Irrigation is the need of today. It is therefore necessary that the quality of water should be checked at regular time of interval (Wankhade, 2015) [16]. The history of irrigated agriculture has shown that irrigation can cause severe deterioration of soil productivity. Irrigation water always contains some soluble salts irrespective of its source. The suitability of waters for a specific purpose depends on the types and amounts of dissolved salts. Some of the dissolved salts or other constituents may be useful for crops. However, the quality or suitability of waters for irrigation purposes is assessed in terms of the presence of undesirable constituents, and only in limited situations is irrigation water assessed as a source of plant nutrients. Some of the dissolved ions, such as NO_3, are useful for crops (Adamu, 2012) [1].

The primary goal of water analysis is to examine the effect of the water on the soil, and ultimately on the plants grown on the soil. As such, much of the interpretation of the water analysis is based on a prediction of the consequences for the soil. Typically, the quality of irrigation water is assessed based on the salt and salt inducing contents, the presence and abundance of micro and macro nutrients, trace elements, alkalinity, acidity, hardness and the amount of suspended solids (U. S. Salinity laboratory Staff, 1954, Ajayi *et al.* 1990) [13, 3]. Another effect of carbonates and bicarbonates is on the alkalinity status of the soil.

High alkalinity indicates that the water will tend to increase the pH of the soil or growing media, possibly to a point that is detrimental to plant growth. Another aspect of alkalinity is its potential effect on sodium. Soil irrigated with alkaline water may upon drying, causes excess of available sodium.

The Pench Irrigation Project is one of such projects situated on Pench River covering its command area in the part of Nagpur district through Its Left Bank and Right Bank Canals. The Pench Right Bank Canal provides irrigation to the areas falling between Kanhan River a North and Nag river in south. The irrigation was started since 1992 from Right Bank Canal. Hence, it was felt pertinent to elucidate the effect of irrigation on physical and chemical properties of soils of study area.

Methodology

Geographically, Right Bank Cannal of Pench Irrigation Projects is located between 79º 0' to 79º 15' E longitudes and 21º 15' to 21º 30' N latitudes covering an area of about 7485.35 ha in Parsheoni Tahasil of Nagpur district, Maharashtra. The elevation of area ranges from 250 to 350 m. The catchment area of the project consists of different types of landforms such as hills, foot hills, river valleys and plains. However, the command area of the project has gently sloping terrain and facilitates irrigation by gravity. A few minor irrigation tanks and ponds exist in the command area.

Fifty surface soil samples were collected with free survey where there is a differentiation in soils. Physical properties of the soils, such as particle size distribution were determined by the international pipette method (Klute and Dirksen, 1986) [9]. The bulk density was determined by clod coating method (Black and Hartge, 1986) [5]. The hydraulic conductivity was measured by constant head method described by Klute and Dirksen (1986) [9]. Chemical properties like pH and EC of the soil suspension (1:2 ratio) was determined by the methodology of Jackson (1973) [8]. For the determination of soil organic carbon (SOC), the modified Walkley and Black wet oxidation method was used (Walkley and Black, 1934; Jackson, 1973) [15, 8]. The free calcium carbonate was determined by rapid titration method (Piper, 1966) [10]. The exchangeable cations and cation exchange capacity of soils were determined using methods outlined by Richards (1954) [11]. The method described by Richards (1954) [11] was followed for the saturation extract preparation.

Water samples were collected from the different villages namely Bitoli, Amgaon, Babhulwada, Tamaswadi, Bhangemahiri, Pendhari, Parsheoni and Navegaon khairi. The chemical parameters like pH, EC, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, SO_4^{2-}, Cl^{-} were analysed using standard methods given by Richards 1954 [11]. SAR was determined to study suitability of water for irrigation.

Results and Discussion

1. Chemical composition and quality of irrigation water

Quality of irrigation water is one of the main factors that affect the physical and chemical properties of soil and ultimately, the crop growth. The irrigation water must be free from excess soluble salts and from concentration of specific substances that may create soil quality problem such as salinity, sodicity, permeability and specific ion toxicity. Sometime the source of irrigation creates hazards to soil quality. In the semi-arid and arid regions, irrigation is essential for successful crop production, but the main source of irrigation is ground water and canals, which is usually saline with varying degrees of salt concentration, and there continuous application affects crop growth. The analysis of irrigation water from sources of the study area for its chemical composition and to know the quality is necessary to its suitability for irrigates soils. The composition of water sample collected from wells and irrigation canals at different places are presented in table 1.

Table 1: Chemical composition of irrigation water

Sample No.	pH	EC	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	SO_4^{--}	Cl^{-}	SAR	RSC	SSP	Ca/Mg	Na/K	HCO_3/Ca
1	7.08	0.49	2.3	1.1	0.42	0.08	-	2.7	0.27	0.93	0.32	-1.4	19.86	2.09	5.53	1.17
2	6.09	0.52	3.1	0.8	0.9	0.06	-	2.3	0.38	2.18	0.64	-2.9	30.79	3.88	15	0.74
3	7.16	0.47	3.2	0.8	0.7	0.05	-	2.3	0.37	2.08	0.49	-2.7	23.43	4	13.73	0.72
4	7.34	0.44	3	0.7	0.62	0.05	-	2.2	0.82	1.35	0.46	-1.7	22.04	4.29	12.16	0.73
5	7.24	0.48	3.1	0.7	0.82	0.08	-	3.2	0.33	1.17	0.59	-1.1	28.05	4.43	10.79	1.03
6	7.16	0.45	2.5	1.1	0.63	0.05	-	2.2	0.32	1.76	0.47	-2.4	26.98	2.27	12.35	0.88
7	7.44	0.35	3.2	0.7	0.7	0.1	-	3.2	0.46	1.04	0.5	-3.1	23.38	4.57	6.86	1
8	6.95	0.34	2.7	1.1	0.9	0.28	-	2.9	0.4	1.68	0.65	-1.8	35.62	2.45	3.19	1.07

(Table 1 is here.)

The pH of these water samples ranged from 6.09 to 7.44 while electrical conductivity from 0.34 to 0.52 dS m^{-1}. The sodium adsorption ratio (SAR) varied between 0.32 and 0.65; the maximum value was observed in sample no. 8 and minimum value observed in sample no. 1. The carbonate was not found in any of the sample while bicarbonate ranged from 2.2 to 3.2. The residual sodium carbonate (RSC) was below the normal range in water samples of the study area. The irrigation water containing RSC more than 2.5 me L^{-1} is not suitable for irrigation purposes (Richards, 1954) [11]. It means this water is suitable for irrigation. The soluble sodium percentage (SSP) in range of 19.86 to 35.62. The maximum value of SSP was seen in sample no. 8 and minimum value was seen in sample no 1. The soluble Ca/Mg ratio of this water sample ranged from 2.09 to 4.43. The maximum value was observed in sample no 5 and minimum value was observed in sample no. 1. As per the quality criteria of irrigation water given by U. S. Salinity Laboratory (Richards, 1954) [11], the studied water samples were medium in salinity and low in sodium, hence classified as C_2S_1 and can be used for irrigation.

2. Physico-chemical properties of soils of study area

The Particle size Distribution data showed that all the soils have high amount of clay compared to sand and silt fractions since the soil developed by basaltic parent material produce high amount clay (Eswaran *et al*. 1988). Bulk density of these soils varied from 1.28 to 1.53 Mg m^{-3}. Comparative low values of bulk density in the study area soils can be ascribed to high clay content and dominated by smectitic clay mineral, which is expanding type of clay mineral (Bharambe *et al*. 1999). The saturated hydraulic conductivity (HC) of these soils ranged from 0.81 to 2.71 cm hr^{-1} (Table 2 a & b). Soil reaction was low to moderately alkaline (pH 7.43 to 8.53).

These soils are non-saline as indicated by the electrical conductivity, which ranged from 0.119 to 0.552 dS m^{-1} at 25° C, but more accumulation of salts was observed in surface layer of these soils. Organic carbon content (2.7 to 6.2 g kg^{-1}) was low to moderate; Sarkar *et al*. (2002) [12] observed similar result. The calcium carbonate content of these soils ranged from 1.5 to 6.13 per cent.

The high CEC (33.76 to 58.49 cmol (p+) kg^{-1}) and base saturation (90.5 to 95.1 per cent) indicate the potential of these soils in terms of fertility, similar result were obtained by Gabhane *et al*. (2006) (Table 2 a & b). The exchangeable cations were in order of Ca > Mg > Na > K similar result were observed by Balpande *et al*. (2007). The Ca/Mg ratio of soil varied from 1.80 to 2.9 and the exchangeable sodium percentage (ESP) varied from 2.67 to 4.86 whereas the exchangeable magnesium percentage (EMP) ranged from 23.09 to 30.62 and exchangeable calcium percentages ranged from 55.22 to 66.16. These soils of study area were not qualified for alkali soils as the ESP was less than 15 and so soils are very good for cultivation point of view.

Table 2(a): Physico-chemical properties of soils of study area

S. No	Bulk Density (Mg Kg^{-1})	Particle size distribution (%)			Texture	HC (cm hr^{-1})	pH	EC (dS m^{-1})	OC (g kg^{-1})	$CaCO_3$ (%)	Exchangeable cations (cmol (p+) kg^{-1})				CEC	ESP	EMP	ECP	% BS	Ca/Mg	Na/K
		Sand	Silt	Clay							Ca^{2+}	Mg^{2+}	Na^+	K^+							
1	1.41	12.23	34.12	53.65	C	1.35	8.36	0.151	3.9	4.65	28.6	13.2	1.8	1.1	49.12	3.66	26.87	58.22	91	2.17	1.64
2	1.46	10.12	31.45	58.43	c	0.98	8.39	0.197	3.5	4.75	30.2	12.2	2.1	0.9	48.82	4.3	24.99	61.86	93	2.48	2.33
3	1.51	12.81	28.13	59.06	c	0.93	8.53	0.178	2.7	5.34	32.3	13.2	1.7	0.8	52.4	3.24	25.19	61.64	91.6	2.45	2.13
4	1.52	14.2	26.57	59.23	c	0.98	8.41	0.16	3.8	4.13	34.2	14.1	2.2	0.8	56.81	3.87	24.82	60.2	90.3	2.43	2.75
5	1.46	13.25	29.11	57.64	c	1.11	8.46	0.125	4.6	4.58	35.2	13.2	2.1	0.9	54.56	3.85	24.19	64.51	94.2	2.67	2.33
6	1.42	14.81	29.34	55.85	c	1.13	7.85	0.214	5.6	2.62	31.12	15.2	2.1	1.1	53.13	3.95	28.61	58.57	93.2	2.05	1.91
7	1.4	13.27	36.38	50.35	c	1.56	7.78	0.177	4.1	2.87	28.82	12.1	1.6	1.1	47.78	3.35	25.33	60.32	91.3	2.38	1.45
8	1.48	11.85	31.12	57.03	c	1.12	8.5	0.201	4.8	5.42	32.6	12.3	2.2	0.9	52.06	4.23	23.63	62.62	92.2	2.65	2.44
9	1.41	13.12	36.82	50.06	c	1.27	7.96	0.119	4.1	2.75	31.56	14.2	1.8	0.7	52.29	3.44	27.16	60.36	92.3	2.22	2.57
10	1.38	17.12	37.51	45.37	c	2.17	7.9	0.147	5.1	2.88	24.9	12.3	1	0.8	41.45	2.41	29.68	60.08	94.1	2.02	1.25
11	1.38	17.34	35.78	46.88	c	1.96	7.78	0.196	4.8	2.65	28.3	11.2	1.4	1.2	45.66	3.07	24.53	61.98	92.2	2.53	1.17
12	1.35	16.21	38.42	45.37	c	2.13	7.82	0.22	4.3	2.32	28.6	13.2	1.8	0.8	47.08	3.82	28.04	60.74	94.3	2.17	2.25
13	1.41	11.27	36.72	52.01	c	1.2	8.45	0.23	4.1	4.25	32.5	11.2	2.1	0.7	49.36	4.25	22.69	65.84	94.2	2.9	3
14	1.39	15.21	34.17	50.62	c	1.21	8.23	0.16	4.1	4.11	27.95	12.3	2.1	0.8	45.33	4.63	27.14	61.66	95.2	2.27	2.63
15	1.46	14.17	29.34	56.49	c	1.15	7.85	0.16	4.5	2.13	32.2	12.3	1.8	1.1	51.35	3.51	23.95	62.7	92.3	2.62	1.64
16	1.43	10.81	34.58	54.61	c	0.98	7.43	0.196	4.1	2.5	32.25	11.4	2.4	1.4	49.38	4.86	23.09	65.32	96.1	2.83	1.71
17	1.51	13.12	28.25	58.63	c	0.98	7.71	0.168	6.2	1.63	36.7	14.2	1.8	0.7	58.49	3.08	24.28	62.75	91.3	2.58	2.57
18	1.43	17.21	32.07	50.72	c	1.35	7.78	0.185	4.3	2.62	30.1	12.1	2.2	0.8	48.86	4.5	24.76	61.6	92.5	2.49	2.75
19	1.37	18.27	31.81	49.92	c	1.42	8.2	0.165	3.8	4.23	27.65	11.2	1.8	0.9	44.39	4.05	25.23	62.29	93.6	2.47	2
20	1.45	14.71	31.12	54.17	c	1.18	8.47	0.261	3.7	4.36	30.2	12.3	2.1	0.7	49.45	4.25	24.87	61.07	91.6	2.46	3
21	1.48	16.12	27.11	56.77	c	1.11	8.02	0.219	4.3	4.11	30.5	12.3	1.7	1.1	49.67	3.42	24.76	61.4	91.8	2.48	1.55
22	1.5	11.34	30.12	58.54	c	0.98	8.01	0.552	3.6	4.13	33.5	14.3	2.3	0.9	55.25	4.16	25.88	60.63	92.3	2.34	2.56
23	1.47	12.81	31.81	55.38	c	1.1	7.99	0.142	5.8	3.63	35.2	12.5	2.1	0.8	53.21	3.95	23.49	66.16	95.1	2.82	2.63
24	1.44	17.14	26.11	56.75	c	0.91	8.25	0.312	4.8	4.13	32.7	13.4	2.2	0.8	53.78	4.09	24.92	60.8	91.3	2.44	2.75
25	1.53	10.58	27.72	61.7	c	0.85	8.27	0.227	4.6	4.28	32.4	12.6	2.3	0.9	52.05	4.42	24.21	62.25	92.6	2.57	2.56

Table 2(b): Physico-chemical properties of soils of study area

Sample No.	Bulk Density (Mg Kg^{-1})	Particle size distribution (%)			Texture	HC (cm hr^{-1})	pH	EC (dS m^{-1})	OC (g kg^{-1})	$CaCO_3$ (%)	Exchangeable cations (cmol (p+) kg^{-1})				CEC	ESP	EMP	ECP	% BS	Ca/Mg	Na/K
		Sand	Silt	Clay							Ca^{2+}	Mg^{2+}	Na^+	K^+							
26	1.51	11.82	30.17	58.01	c	0.97	8.21	0.151	4.2	4.26	30.2	14.3	1.8	1.1	51.3	3.51	27.88	58.87	92.4	2.11	1.64
27	1.35	25.75	31.34	42.91	c	1.52	8.58	0.179	2.8	6.13	22.3	12.3	1.8	1.4	40.38	4.46	30.46	55.22	93.6	1.81	1.29
28	1.29	28.25	33.72	38.03	cl	2.31	8.31	0.161	3.9	4.13	24.5	11.3	1.2	0.7	39.85	3.01	28.35	61.48	94.6	2.17	1.71
29	1.42	27.21	25.17	47.62	c	1.13	8.4	0.144	3.1	5.73	28	12.2	1.9	0.8	45.11	4.21	27.04	62.07	95.1	2.3	2.38
30	1.38	25.28	39.75	34.97	cl	2.71	8.34	0.319	3.7	4.58	22	8.3	0.9	0.7	33.76	2.67	24.59	65.17	94.5	2.65	1.29
31	1.41	25.97	27.81	46.22	c	1.54	8	0.229	5.8	3.9	24	9.3	1.4	0.9	37.83	3.7	24.58	63.44	94.1	2.58	1.56
32	1.4	25.62	31.17	43.21	c	1.42	7.83	0.286	5.1	3.5	25.1	11.2	1.6	1.4	41.68	3.84	26.87	60.23	94.3	2.24	1.14
33	1.42	27.36	26.75	45.89	c	1.29	7.83	0.228	4.6	2.88	26.7	12.8	1.6	1.4	44.74	3.58	28.61	59.68	95	2.09	1.14
34	1.39	27.14	31.25	41.61	c	1.68	7.87	0.375	3.1	5.8	22.8	11.3	1.1	0.9	39.76	2.77	28.42	57.35	90.8	2.02	1.22
35	1.28	31.56	32.71	35.73	cl	2.57	7.76	0.181	5.3	1.5	22.2	12.3	1.2	1.1	40.17	2.99	30.62	55.26	91.6	1.8	1.09
36	1.41	30.12	28.12	41.76	c	1.65	8.16	0.185	3.5	3.65	24.2	12.2	1.5	1.4	42.9	3.5	28.44	56.41	91.6	1.98	1.07
37	1.43	24.27	26.13	49.6	c	1.22	8.2	0.192	3.3	4.48	27	12.3	2.1	1.4	46.27	4.54	26.58	58.35	92.5	2.2	1.5
38	1.46	21.12	27.37	51.51	c	0.95	8.34	0.162	3.8	6.13	29.2	12.3	2.1	0.8	46.93	4.47	26.21	62.21	94.6	2.37	2.63
39	1.42	21.65	28.33	50.02	c	1.14	8.24	0.154	3.8	4.38	30.12	15.2	2.2	0.8	52.92	4.16	28.72	56.91	91.3	1.98	2.75
40	1.42	18.21	32.48	49.31	c	1.21	8.2	0.294	3.5	4.63	29.27	13.6	1.8	0.4	48.25	3.73	28.18	60.66	93.4	2.15	4.5
41	1.41	28.96	25.71	45.33	c	1.26	7.39	0.223	4.2	4.98	26	11.2	1.9	1.1	44.27	4.29	25.3	58.73	90.8	2.32	1.73
42	1.43	18.23	27.38	54.39	c	0.81	8.48	0.373	3.8	6.12	28.6	12.3	2.3	1.2	49.01	4.69	25.1	58.36	90.6	2.33	1.92
43	1.43	14.31	31.12	54.57	c	0.85	8.12	0.186	3.9	4.82	31.46	15.3	2.4	1.5	55.37	4.33	27.63	56.82	91.5	2.06	1.6
44	1.4	14.71	34.51	50.78	c	1.12	8.2	0.158	3.1	5.1	31	14.3	2.2	1.8	52.73	4.17	27.12	58.79	93.5	2.17	1.22
45	1.4	20.93	27.91	51.16	c	0.98	7.9	0.16	3.2	3.95	30.97	16.3	2.3	1.2	54.01	4.26	30.18	57.34	94	1.9	1.92
46	1.45	15.83	28.24	55.93	c	0.83	8.35	0.281	3.6	4.56	29.2	15.2	1.6	1.4	51.63	3.1	29.44	56.55	91.8	1.92	1.14
47	1.37	16.47	35.42	48.11	c	1.23	8.12	0.162	3.3	4.71	28.88	12.3	1.7	0.9	47.79	3.56	25.74	60.43	91.6	2.35	1.89
48	1.4	14.3	27.54	58.16	c	0.81	8.3	0.377	3.5	4.13	33.12	14.3	2.1	0.9	55.29	3.8	25.87	59.91	91.2	2.32	2.33
49	1.33	14.57	32.13	53.3	c	0.91	7.65	0.281	3.8	3.56	31.61	15.2	2.1	1.1	54.6	3.85	27.84	57.9	91.6	2.08	1.91
50	1.41	16.41	28.17	55.42	c	0.87	8.16	0.226	4.9	4.78	28.3	12.3	2.1	1.4	48.73	4.31	25.24	58.08	90.5	2.3	1.5

3. Saturation Extract Analysis

The Saturation Extract Analysis data are present in table 3 (a) & 3 (b). The pH_s of saturation extract ranged from 7.1 to 8.4. The electrical conductivity (EC_e) of the saturation extract ranged from 0.347 to 0.648 dS m^{-1}. The values of electrical conductivity suggest the absence of toxic salinity in these soils. Ghawade, *et al*. (2009) [7], gave the similar result. The ionic composition of saturation extract indicates that among the soluble cations, sodium was dominant followed by calcium or magnesium. The sodium cations varied from 1.21 to 3.05 me L^{-1}. Calcium, magnesium and potassium cations ranged between 0.97 to 2.81, 0.48 to 1.94 and 0.18 to 0.78 me L^{-1}, respectively. The calcium magnesium ratio (Ca/Mg) ranged from 1.2 to 2.93. The soluble sodium percentage (SSP) ranged from 23.49 to 60.64. The sodium absorption ratio (SAR) ranged from 0.9 to 3.07. Maximum values of SSP were observed in sample no. 2; whereas minimum values were observed in sample no. 21. Maximum values of SAR were observed in sample no. 1; whereas minimum values were observed in sample no. 21. The similar result was given by Ghawade *et al.* (2009) [7].

Table 3(a). Saturation extract analysis

Sample No.	pHs	ECe (dS m^{-1})	Soluble cations (cmol (p+) kg^{-1})				SAR	SSP	Ca/Mg	Na/K
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}				
1	8.05	0.5	1.01	0.84	2.15	0.18	2.24	53.75	1.2	11.94
2	7.85	0.54	1.11	0.87	3.05	0.2	3.07	60.64	1.28	15.25
3	7.94	0.66	2.8	1.1	2.05	0.33	1.47	34.45	2.55	6.21
4	7.83	0.62	2.78	1.21	1.4	0.61	0.99	25.97	2.3	2.3
5	7.75	0.39	1.24	0.95	1.32	0.24	1.26	37.61	1.31	5.5
6	7.8	0.35	0.97	0.62	1.47	0.2	1.65	48.04	1.56	7.35
7	7.87	0.44	1.27	0.78	2	0.23	1.98	49.38	1.63	8.7
8	8.4	0.65	2.81	1.02	2.05	0.4	1.48	34.86	2.75	5.13
9	7.86	0.59	2.83	1.23	1.3	0.45	0.91	24.25	2.3	2.89
10	7.77	0.58	2.78	0.95	1.43	0.46	1.05	27.71	2.93	3.11
11	7.87	0.41	1.1	0.67	1.97	0.18	2.09	52.67	1.64	10.94
12	7.78	0.42	1.28	0.73	1.8	0.2	1.8	47.24	1.75	9
13	7.82	0.43	1.47	0.75	1.66	0.21	1.58	42.78	1.96	7.9
14	8	0.42	1.21	0.79	1.95	0.23	1.95	49.37	1.53	8.48
15	7.84	0.41	1.95	0.49	1.21	0.34	1.43	33.15	1.94	3.56
16	7.97	0.59	2.1	1.31	1.64	0.61	1.26	32.48	1.6	2.69
17	7.75	0.51	1.87	0.95	1.62	0.57	1.36	36.49	1.97	2.84
18	7.75	0.39	0.97	0.63	1.72	0.4	1.92	51.81	1.54	4.3
19	7.7	0.58	2.17	1.17	1.94	0.47	1.5	36.74	1.85	4.13
20	7.63	0.42	1.73	0.87	1.24	0.45	1.09	32.29	1.99	2.76
21	7.87	0.58	2.36	1.94	1.32	0.33	0.9	23.49	1.22	4
22	7.97	0.6	2.03	1.1	2.64	0.61	2.11	45.75	1.85	4.33
23	7.9	0.49	1.86	0.95	1.94	0.34	1.64	40.84	1.96	5.71
24	8.17	0.48	0.98	0.84	1.87	0.37	1.96	50.68	1.17	5.05
25	7.91	0.5	1.32	0.82	2.05	0.57	1.98	48.93	1.61	3.6

Table 3 (b): Saturation extract analysis

Sample No.	pHs	ECe (dS m^{-1})	Soluble cations (cmol (p+) kg^{-1})				SAR	SSP	Ca/Mg	Na/K
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}				
26	7.8	0.48	1.95	0.48	2.55	0.47	2.31	51.2	4.06	5.43
27	7.84	0.42	1.21	0.92	1.22	0.45	1.18	36.42	1.32	2.71
28	7.76	0.46	0.95	0.49	1.32	0.35	1.56	47.83	1.94	3.77
29	7.92	0.48	1.21	0.87	1.94	0.65	1.9	48.26	1.39	2.98
30	8.34	0.45	1.37	0.97	2.64	0.61	2.44	53.01	1.41	4.33
31	7.98	0.49	1.29	0.83	2.21	0.33	2.15	51.04	1.55	6.7
32	8.09	0.57	1.31	0.81	2.67	0.47	2.59	55.74	1.62	5.68
33	7.93	0.51	1.87	0.94	2.32	0.37	1.96	45.22	1.99	6.27
34	7.72	0.48	1.42	0.61	1.67	0.61	1.66	45.14	2.33	2.74
35	7.16	0.51	2.1	1.03	1.97	0.65	1.57	38.63	2.04	3.03
36	8.11	0.5	1.49	0.97	1.76	0.65	1.59	41.71	1.54	2.71
37	7.1	0.69	1.38	0.78	1.41	0.37	1.36	39.5	1.77	3.81
38	7.95	0.4	1.57	0.91	1.69	0.35	1.52	40.53	1.73	4.83
39	8.07	0.49	1.33	0.76	1.66	0.57	1.62	44.27	1.75	2.91
40	8.05	0.47	1.27	0.72	1.47	0.51	1.47	42.49	1.76	2.88
41	8.01	0.41	1.38	0.76	1.32	0.55	1.28	38.15	1.82	2.4
42	7.3	0.48	1.56	0.84	1.37	0.47	1.25	36.34	1.86	2.91
43	7.98	0.42	1.47	0.92	1.82	0.35	1.66	43.23	1.6	5.2
44	7.67	0.46	1.41	0.97	1.64	0.33	1.5	40.8	1.45	4.97
45	8.03	0.42	1.36	0.91	1.78	0.65	1.67	43.95	1.49	2.74
46	7.75	0.55	1.67	0.96	1.83	0.78	1.6	41.03	1.74	2.35
47	7.87	0.42	1.32	0.84	1.87	0.51	1.8	46.4	1.57	3.67
48	7.69	0.53	1.72	0.87	1.86	0.61	1.63	41.8	1.98	3.05

49	8.1	0.53	1.53	0.83	1.82	0.63	1.68	43.54	1.84	2.89
50	8.26	0.57	1.67	0.89	1.9	0.78	1.68	42.6	1.88	2.44

4. Effect of irrigation on physical and chemical properties of soils

The water quality of all samples is C_2S_1 and can be used for irrigation. Some serious effect occurs on physical and chemical properties of the soils of study area due to improper and over irrigation by farmers. The situation further aggravated by too much of seepage losses from irrigation canals and use of poor quality water from well (Varade *et al*. 1985) [14]. The relationship between bulk density and SAR showed positive significant correlation (r = 0.31) and with soluble Ca/Mg and Na/K (r = 0.33) and (r = 0.37), respectively (Table 4). It means as the bulk density of soil increases in soil the SAR of the water was also increased. The relationship between bulk density and soluble HCO_3/Ca shows negative significant correlation (r = -0.62). The relationship between clay with SAR and SSP shows significant positive correlation (r = 0.37) and (r = 0.30), respectively. It means as the clay increases in soils, the SAR and SSP also increases.

Table 4: Correlation coefficient between properties of soil with quality of irrigation water.

	BD	*SAND*	*SILT*	*CLAY*	*HC*	*pH*	*CEC*	*OC*	*CaCO3*	*ESP*	*EMP*	*ECP*	*SAR*	*RSC*	*SSP*	*Ca/Mg*	*Na/K*	*HCO3/Ca*
BD	1																	
SAND	-0.54*	1																
SILT	-0.48	-0.20	1															
CLAY	0.78*	-0.82*	-0.39	1														
HC	-0.66*	0.54*	0.59*	-0.85*	1													
pH	0.23	-0.14	-0.15	0.21	-0.19	1												
CEC	0.59*	-0.73	-0.30	0.86	-0.76*	0.06	1											
OC	0.09	-0.08	0.01	0.07	0.13	-0.42	0.04	1										
CaCO3	0.16	0.09	-0.29	0.08	-0.31	0.68	-0.08	-0.60*	1									
ESP	0.22	-0.21	-0.32	0.38	-0.59*	0.16	0.31	-0.18	0.33	1								
EMP	-0.50	0.48	0.02	-0.46	0.29	-0.06	-0.24	-0.25	-0.01	-0.25	1							
ECP	0.31	-0.37	0.23	0.21	0.00	0.04	0.03	0.31	-0.13	0.05	-0.78*	1						
SAR	0.31	-0.44	-0.15	0.37	-0.35	0.24	0.04	0.12	0.30	0.56*	-0.64*	0.80*	1					
RSC	0.16	0.19	-0.30	0.23	-0.10	0.49	0.54*	0.29	0.32	0.23	-0.17	0.19	-0.18	1				
SSP	0.16	-0.43	-0.09	0.29	-0.29	0.21	0.01	0.39	0.30	0.73*	-0.43	0.59*	0.89	-0.03	1			
Ca/Mg	0.33	0.03	-0.14	0.13	-0.09	0.04	0.14	-0.47	-0.04	-0.33	-0.52*	0.51	0.29	-0.25	-0.16	1		
Na/K	0.37	0.05	-0.58*	0.58*	-0.65*	0.07	0.29	-0.34	-0.09	0.01	0.17	0.09	0.11	-0.33	-0.13	0.43	1	
HCO3/Ca	-0.62*	-0.04	0.61*	-0.63*	0.70*	-0.12	-0.33	0.46	-0.01	0.00	0.03	-0.06	-0.20	0.50	0.05	-0.46	-0.86	1

Note: All 'r' values are significant at 1 per cent level.
* Showing 'r' values are significant at 5 percent level.

The relationship between hydraulic conductivity with SAR and SSP shows significant negative correlation (r = -0.35) and (r = -0.30), respectively. It indicates that as the hydraulic conductivity increases the SAR and SSP is decreases. The relationship between hydraulic conductivity with soluble HCO_3/Ca shows significant positive correlation (r = 0.70).

The relationship between ESP with SAR and SSP shows significant positive correlation (r = 0.56) and (r = 0.72), respectively. It showed that as the ESP of soil increases the SAR and SSP of water also increases and the relationship between EMP with SAR and SSP shows significant negative correlation (r = -0.63) and (r = -0.42), respectively. The relationship between exchangeable Ca/Mg with SAR shows significant positive correlation (r = 0.74) and the relationship between exchangeable Na/K with SAR and SSP shows significant positive correlation (r = 0.49) and (r = 0.41), respectively. The increases in ESP and EMP of these soils affects hydraulic conductivity (table 4) due to dispersion of clay and their by poor internal drainage. The relationship between clay and hydraulic conductivity indicate the significant negative correlation (r = -0.84). This data suggested that hydraulic conductivity of these soils were impaired by both swelling and dispersion of smectitic clay. Adejumobi *et al*. (2014) [2] revealed similar result.

Conclusion

The soils of Right Bank Canal command area of Pench irrigation project particularly soils of Parsheoni Tahasil in Nagpur district of Maharashtra are clay loam to clayey, calcareous, moderately alkaline with high base saturation and CEC and having high potential for crop production on sustainable basis, over irrigation to the crops should be avoided and seepage losses through irrigation canals should be controlled. The water samples of this area had medium salinity and low sodicity hazards (C_2S_1). The use of bad quality water should be discouraged, keeping in view the probable deterioration of these soils.

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