Consequence of Groundwater Irrigation on Physico-Chemical Properties of Soils of Kanholibara Village in Nagpur District, Maharashtra, India

Sagar N Ingle[1], V. P. Babhulkar[1] , Shubham B Girdekar[1], and S. K. Sarkate[1]

[1]*Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola- 444104, India*

ABSTRACT

A field experiment entitled "Effect of Groundwater irrigation on various soil properties of Kanholi-Bara in Nagpur District Was conducted during Kharif season of 2015-2016 at Kanholi-Bara of Hingana tahsil in Nagpur District Maharashtra, India. The soil samples were collected from that area comprises two source of irrigations *viz* well water and bore well water and soybean crop which were taken in these fields. The mean value of pH 7.79 was recorded with ground water irrigation and EC in groundwater irrigated soil 0.81 dS m^{-1}.The organic carbon contains in ground water irrigated soil with high Sodium Absorption Ratio (SAR) and Residual Sodium Carbonate (RSC) was lower by 35.19 per cent less than mean value of organic carbon. The lowest available nitrogen, phosphorus and potassium status were 185.44, 15.65 and 178.80 kg ha^{-1} respectively were obtained with the application of ground water of high RSC and SAR. Whereas the highest accumulation of heavy metal in soil 1.16 mg kg^{-1} lead, 1.30 mg kg^{-1} Cobalt, 1.19 mg Kg^{-1}Nikel and 0.037 mg kg^{-1} Cadmium were present in soil with the application of high SAR and RSC irrigation water. Due to continuous and injudicious irrigation with poor quality groundwater adversely affect the physical and chemical properties of soil.

Key words: *SAR. RSC, Groudwater, Physicho-Chemical*

*Corresponding author (sagarsoils26@gmail.com)

INTRODUCTION

Water is one of the limiting factors for agricultural development in developing countries in order to meet the growing demand of the increasing population. Water is one of the valuable sources of nature and required for crop production. Water is being used for several purposes viz. drinking, Irrigation, hydro-electric production, Industries, transport, sanitation, recreation etc.

However, the most abundant use is for Irrigation which enables to increase the farm production. A part of rain water percolates in the ground through joints and cracks in the rocks and is known as ground water. It is a significant source of Irrigation in India. About 60% of the Irrigated land in the country depends on groundwater (Shah *et al.*, 2000). In Maharashtra the total geographical area of 30.77 Mha spread over in thirty-one districts out of which about 59.2 %(18.31 M ha) area is under crops and 20.8% under forests. The irrigated area is 11.4% of the gross cropped area in the state.

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. The objective of irrigation is to supply plants with water, as needed, to increase yields. An irrigation project should take water use efficiency into account as well as the economy involved. When applying irrigation water, excesses, as well as shortages should be avoided (Varallyay, 1977).

The history of irrigated agriculture has shown that irrigation can cause severe deterioration of soil productivity. Many early civilizations, whose rise was supported by the productivity of irrigated agriculture, were thought to fall as a result of problems caused by irrigation (Gulhati and Smith, 1967).

The most common reasons for failure of irrigation projects are associated with waterlogging, salinization, and alkalization. These problems appear gradually and are influenced by the quality and quantity of irrigation water, condition of the irrigated land, and other soil environment factors. As the problems develop, they may be recognized by the failure of the irrigated land to maintain high yields. If allowed to continue, the problems may become so severe that the irrigated land will no longer be productive (Kovda, 1973).

Salt problems and waterlogging are caused by lack of adequate drainage, poor quality water, or improper management practices or any combination of the three. These problems, in addition to damaging plants, cause deterioration of some desirable soil properties

In India groundwater is major threat to irrigated agriculture. The problem has been increasing gradually with the expansion of irrigation facilities associated with the faulty water use management. This problem is appearing at a fast rate in deep black and medium black soils of the central peninsular India.

The problems of soil salinity/sodicity and water logging in canal, bore well irrigated Vertisols are of severe and deserve an immediate attention for corrective measures, therefore monitoring of salinity/sodicity in such irrigation areas is essential and hence the detail knowledge of properties of dry land soils and their inter-relationship will be useful for managing salt affected soils of similar areas elsewhere in the state for sustainable crop production. It was felt necessary to take up the study on the assessment of soil salinity and sodicity status in the particular area. The location-specific information based on detailed characterization of kanholibara village area soils under irrigation is very much essential for judicious management of such soils. The irrigation induced salinity/sodicity problem in black clay soil has not been extensively studied although some attempts have been made and the information is scattered.

MATERIALS AND METHODS

Study area

Geographically, Kanholi-Bara is situated at the latitude 20.93 and longitude 78.84 at the elevation of 321.26 m above sea level and lies under sub-tropical zone, covering an net cropped area of about 704.71 ha^{-1} in Hingana Tehsil of Nagpur district, Maharashtra. Kanholi Bara is characterized by hot and dry summer and fairly cold winter. This area shows wide diurnal fluctuation in temperature. The maximum and minimum temperature ranged from 26.9^0C to 43.0^0C and 13.7^0C to 26.6^0C, respectively, whereas the relative humidity varied from 20 to 72 per cent during the crop growth period, mean annual rainfall is about 1,566.3 mm.

Surface soil samples were collected with free survey where there is a differentiation in soil. A composite soil sample (0-15 cm) depth, after harvesting of soybean crop was taken from the different spots of the experimental area were taken. These samples were stored in polythene bags then processed and labeled as per the need for laboratory analysis. Physical properties of the soils, such as particle size distribution were determined by the international pipette method (Klute and Dirksen, 1986). The bulk density was determined by core method described by Yaalon (1957). The hydraulic conductivity was measured by constant head method described by Richards (1954). Chemical properties like pH and EC of the soil suspension (1:2 ratio) was determined by the methodology of Jackson (1973). For the determination of soil organic carbon (SOC), the modified Walkley and Black wet oxidation method was used (Walkley and Black, 1934; Jackson, 1973). Nitrogen was determine by alkaline potassium permanganate method described by Subbiah and Asija (1956). Available P was estimated calorimetrically as per Olsen method whereas Available potassium in soil was extracted by Neutral ammonium acetate solution and potassium was determined using flame photometer (Jackson, 1967). Subsequentely available Sulphur by Turbidimetric method given by Chesnin and Yien (1951).

The exchangeable cations like calcium of soils were determined using methods outlined by described by Jackson (1967). Heavy metals (Pb, Co, Cr, Cd) in the di-acid extract was determined by u atomic absorption spectrophotometer (ASS) as described by Page *et al*. (1982).

About 20 groundwater samples from irrigated field of the farmers from study area were collected and on the basis of laboratory analysis of groundwater samples results 15-20 sites of the farmers fields. The chemical parameters like pH, EC, Ca2+, Mg2+, Na+, CO_3^- , HCO_3^- were analysed using standard methods given by Richards 1954. SAR and RSC 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, quality and yield. The irrigation water must be free from excess soluble salts and from the concentration of specific substances that may crate 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 groundwater (well and bore well) which is usually saline and sodic and contain toxic heavy metals when industrial areas are surrounded by them. And contain varying degree of salt concentration and their continuous application affects crop growth, quality and yield. 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 well and bore well at different places are presented in (Table 1).

Table 1. Chemical Composition of Irrigation Water.

Sample No.	pH	Ec dS m^{-1}	Cations			Anions		SAR	RSC	Ca/Mg	No_3-N (mg L^{-1})
			Ca^{++}	Mg^{++}	Na^{+}	Co_3^{-}	HCO_3^{-}				
1.	7.69	0.77	2.42	0.91	8.00	1.63	3.45	3.50	1.75	3.31	5.3
2.	7.75	0.88	2.02	0.81	8.15	1.72	3.76	3.95	2.65	2.50	5.7
3.	7.77	0.89	1.97	0.80	8.24	1.72	3.79	3.87	2.47	2.49	5.8
4.	7.84	1.59	1.96	0.69	8.58	1.76	4.10	4.21	2.92	2.09	7.2
5.	7.73	0.87	2.05	0.82	8.20	1.70	3.64	3.86	2.38	2.78	5.6
6.	7.71	0.79	2.06	0.83	8.18	1.69	3.58	3.84	1.95	1.95	5.4
7.	7.98	1.67	1.70	0.60	9.40	1.76	4.12	4.95	3.21	2.84	8.1
8.	7.55	0.61	2.88	0.97	6.23	1.55	3.11	2.53	0.81	2.97	3.2
9.	7.79	1.38	1.84	0.88	8.42	1.75	3.89	4.06	2.74	2.46	5.8
10.	7.65	0.72	2.42	0.87	7.44	1.68	3.56	3.27	1.45	2.83	4.8
11.	7.59	0.64	2.61	0.92	6.66	1.60	3.29	2.83	1.24	2.79	3.9
12.	7.61	0.66	2.61	0.92	6.66	1.60	3.29	3.08	1.36	2.84	4.0
13.	7.81	1.49	1.84	0.88	8.42	1.75	3.89	4.07	2.87	2.46	7.1
14.	7.63	0.71	2.62	0.94	6.59	1.57	3.23	3.21	1.40	2.80	4.3
15.	7.87	1.62	1.81	0.63	8.48	1.66	3.90	4.33	3.12	2.87	7.3
16.	7.99	1.78	2.95	0.89	7.38	1.77	3.48	5.33	3.59	2.83	8.2
17.	7.67	0.73	2.55	0.90	7.68	1.66	3.45	3.30	1.66	2.66	4.8
18.	8.10	1.83	1.35	0.55	9.49	1.78	4.16	5.49	4.04	2.45	8.5
19.	7.91	1.65	1.86	0.64	8.86	1.68	3.99	4.47	3.17	2.91	7.8
20.	7.57	0.63	2.84	0.95	6.49	1.56	3.21	2.66	0.98	2.99	3.6

The pH of these water samples ranged from 7.55 to 8.1 while electrical conductivity from 0.61 to 1.83 dS m-1. The sodium adsorption ratio (SAR) varied between 2.53 and 5.49; the maximum value was observed in sample no. 18 and the minimum value observed in sample no. 8. The carbonate was found ranges from 1.55 to 1.78 while bicarbonate ranged from 3.11 to 4.16. The residual sodium carbonate (RSC) was above 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) The soluble Ca/Mg ratio of this water sample ranged from 1.95 to 3.31. The maximum value was observed in sample no 1 and minimum value was observed in sample no. 6. A similar result was observed in Kadu (1997).

Whereas the Nitrate nitrogen content in water is varies from 3.2 to 8.5 the highest value was observed in sample No. 18(8.5) followed by 8.2 and 8.1 in sample No.16 and sample No.7 respectively and lowest value was observed in sample No.08 (3.5).this water samples are under second class (Intensity of problem is moderate)..Very frequently groundwater contain high amount of nitrate. When such type of irrigation water is applied on soils continuously, various properties of soils are affected, Similar result was closely paint by Almasri and Kaluarachchi (2004).

As per the quality criteria of irrigation water given by U. S. Salinity Laboratory (Richards, 1954), the studied water samples were medium in salinity and low in sodium, hence classified as C2S1 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 1.32 to 1.51 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 1.07 to 2.26 cm hr-1. Low Hydraulic conductivity indicates poor structure and drainage of soil.

Ahmed and Wester (1988) reported that high clay content and exchangeable sodium responsible for low hydraulic conductivity (Table 2).

Soil reaction was low to moderately alkaline (pH 7.55 to 8.1). These soils are non-saline as indicated by the electrical conductivity, which ranged from 0.61 to 1.83 dS m-1 at 25o C, but more accumulation of salts was observed in surface layer of these soils. Organic carbon content (0.70 to 1.46 g kg-1) was moderate to high; Organic matter has been found to be more or less uniformly distributed in the first meter of the profile in some Indian Vertisols. For example, organic C and total N in the profile of a deep Vertisols at the ICRISAT Similar result were closely paint by Dulal (1965); Singh *et al*. (1991), presented in (Table 3.)

The available Nitrogen content of soils varied from 185.44 to 300.01kg ha^{1}. (Table 3.) The available Phosphorus content of soils varied from 15.65 to 19.45 kg ha^{1} The available Potassium content of soils varied from 178.80 to 330.8kg ha^{-1} Similar results was also noted by Singh (1988). While the available Sulphur content of soils varied from 11.56 to 12.51kg ha^{1} respectively were obtained with the application of groundwater of high RSC and SAR. similar result were closely confirmative by Patangray et al (2018)

Table No. 2. Physical properties of soils influence by groundwater irrigation

Sample No.	Bulk density	Particle size analysis %			Texture	Hydraulic conductivity ($cm\ hr^{-1}$)
		Sand	**Silt**	**Clay**		
1.	1.39	14.57	32.13	53.30	Clay	1.77
2.	1.43	12.81	31.81	55.38	Clay	1.49
3.	1.42	14.81	29.34	55.85	Clay	1.56
4.	1.46	13.12	28.25	58.63	Clay	1.28
5.	1.41	12.23	34.12	53.65	Clay	1.63
6.	1.40	16.21	28.33	50.02	Clay	1.70
7.	1.49	12.81	18.13	59.06	Clay	1.07
8.	1.32	25.75	31.34	42.91	Clay	2.26
9.	1.44	11.85	31.12	57.03	Clay	1.42
10.	1.37	21.65	28.33	50.02	Clay	1.91
11.	1.34	10.58	27.72	61.70	Clay	2.12
12.	1.35	15.21	34.17	50.62	Clay	2.05
13.	1.45	25.28	39.75	34.97	Clay	1.35
14.	1.36	13.12	28.25	58.63	Clay	1.98
15.	1.47	16.12	27.11	56.77	Clay	1.21
16.	1.50	10.12	31.45	58.43	Clay	1.00
17.	1.38	14.57	32.13	53.30	Clay	1.84
18.	1.51	11.82	30.17	58.01	Clay	0.93
19.	1.48	11.85	31.12	57.03	Clay	1.14
20.	1.33	18.23	27.38	54.39	Clay	2.19

Table No. 3. Chemical properties of soil Influenced by groundwater irrigation

Sample No.	Soil reaction (pH)	EC (dS m^{-1})	Organic carbon (g kg ha^{-1})	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})	Available S (kg ha^{-1})	Exchangeable(Ca^{++}) (coml. (p+) kg^{-1})
1.	7.70	0.712	1.18	257.80	18.05	274.30	12.17	29.05
2.	7.83	0.825	1.02	233.68	17.26	242.60	11.97	28.25
3.	7.83	0.795	1.06	239.71	17.45	250.90	12.01	28.45
4.	7.91	0.933	0.90	215.59	16.64	218.40	11.81	27.29
5.	7.75	0.766	1.10	245.74	17.67	258.70	12.06	28.65
6.	7.72	0.739	1.15	251.77	17.86	266.50	12.11	28.85
7.	8.08	1.070	0.78	197.50	16.04	194.60	11.67	27.05
8.	7.49	0.543	1.46	300.01	19.45	330.8	12.51	30.45
9.	7.86	0.858	0.99	227.65	17.05	234	11.92	28.05
10.	7.65	0.660	1.27	269.86	18.46	290.60	12.26	29.46
11.	7.59	0.585	1.38	287.95	19.05	314.7	12.41	30.06
12.	7.62	0.609	1.34	281.92	18.87	306.3	12.36	29.85
13.	7.89	0.895	0.94	221.62	16.85	226.30	11.87	27.85
14.	7.63	0.634	1.30	275.89	18.65	298.50	12.31	29.65
15.	7.96	0.977	0.86	209.56	16.45	210.70	11.76	27.45
16.	8.10	1.118	0.73	191.47	15.86	186.90	11.61	26.84
17.	7.68	0.686	1.22	263.83	18.27	282.40	12.21	29.25
18.	8.13	1.167	0.70	185.44	15.65	178.80	11.56	26.65
19.	7.98	1.025	0.82	203.53	16.26	202.50	11.71	27.26
20.	7.52	0.566	1.42	293.98	19.27	322.5	12.46	30.25

Table No. 4 Heavy metal content of Soil:

Sample No.	Heavy Metal Content (mg kg^{-1})			
	Pb	**Co**	**Ni**	**Cd**
1.	0.90	1.03	1.01	0.026
2.	0.98	1.11	1.09	0.028
3.	0.96	1.09	1.07	0.028
4.	1.04	1.17	1.15	0.030
5.	0.94	1.07	1.05	0.027
6.	0.92	1.05	1.03	0.027
7.	1.10	1.24	1.23	0.033
8.	0.76	0.89	0.87	0.023
9.	1.00	1.13	1.11	0.029
10.	0.86	0.99	0.97	0.025
11.	0.80	0.93	0.91	0.024
12.	0.82	0.95	0.93	0.024
13.	1.02	1.15	1.13	0.029
14.	0.84	0.97	0.95	0.025
15.	1.06	1.19	1.17	0.030
16.	1.13	1.27	1.26	0.035
17.	0.88	1.01	0.99	0.026
18.	1.16	1.30	1.29	0.037
19.	1.08	1.21	1.19	0.031
20.	0.78	0.91	0.89	0.023

Table No. 5. Correlation coefficient and simple regression equation between properties of soil with quality of irrigation water.

Sr.No.	Parameters	X	R	Regression Equation
1	Hydraulic conductivity	SAR	-0.9761	Y = -0.490x + 3.479 R^2 = 0.9528
2	Hydraulic conductivity	RSC	-0.9907*	Y = -2.218x + 5.827 R^2 = 0.9816
3	SAR	RSC	0.9734	Y = 1.095x – 1.920 R^2 = 0.9476
4	SAR	Bulk Density	0.9761	Y = 0.070x + 1.145 R^2 = 0.9528
5	RSC	Bulk Density	0.9907*	Y = 0.063x + 1.270 R^2 = 0.9816
6	SAR	Soil Reaction (pH)	0.9833*	Y = 0.288x + 6.918 R^2 = 0.9669
7	SAR	EC	0.9825*	Y = 0.228x + 0.068 R^2 = 0.9654
8	SAR	Sulphur per cent	0.9858*	Y = -0.075x + 1.097 R^2 = 0.9718
9	SAR	Exchangeable calcium	0.9696	Y = -0.154x + 29.12 R^2 = 0.011

Note- All “r” values are significant at 1 per cent level. *Showing “r” values are significant at 5 per cent level.

3. Heavy metal content of Soil Influenced by groundwater Irrigation:

Pb content in soil sample varies from 0.76 to 1.16 mg kg^{-1} low amount of Pb 0.76 mg kg^{-1}(sample no. 8) presented in (Table 4). and high amount of Pb 1.16 mg kg^{-1} (sample No.18) followed by 1.13 and 1.10 mg kg^{-1} in sample No. 16 and sample No.7 was due to content of Co, Cr, Fe, Mn, Ni and Zn were associated with parent rocks and corresponded to the first principal component called the lithogenic component. A significant correlation was found between lithogenic metals and some soil properties such as soil organic matter similar result were reported by Mico *et al.* (2006)

Cd content in soil sample varies from 0.023 to 0.037 mg kg^{-1} whereas Co content in soil sample varies from 0.89 to 1.30 mg kg^{-1} While Ni content in soil sample varies from 0.87 to 1.29 mg kg^{-1} these heavy metal like Cd, Co and Ni was found to be low amount in (sample no. 8) and high amount in (sample No.18) followed by in sample No. 16 and sample No.7 respectively is due to farmers around industrial areas are using effluents or contaminated river/well water for irrigation purpose. Since these effluents contain high amount of trace elements and other pollutant heavy metals, which hazardous to the soil and crop. Similar result was observed in Patel *et al.* (2004).

4. Relationship of Groundwater Irrigation on Physico-Chemical Properties of Soils.

Some Serious effects occur on physical and chemical properties of the soils of study area due to improper and over irrigation by farmers.

The relationship between Hydraulic conductivity and SAR showed Negative significant correlation (r =0.97). presented in (Table 5) indicate that Hydraulic conductivity of soil decrease with increase in SAR of irrigation water. Similar result was observed in Vaidya *et al.* (2007). The relationship between RSC and Bulk Density showed significant positive relationship (r=0.99) which means that RSC of groundwater impact on soil Bulk density. Bulk density of soil increased with increasing RSC of Irrigation water. Similar result was observed in Malewar and More (1988), also Porosity of the soil decreased with the increasing sodicity level (RSC) of the irrigation water. The dispersion ratio and soil strength, however, showed an increasing trend with increasing RSC of the irrigation water. Addition of gypsum had significantly improved infiltration rate and porosity of the soil. Yadav and Kumar (2004)

The relationship between clay with SAR and RSC shows positive correlation (r=0.97) It means as the SAR increases in soils, the RSC also increases. SAR is positively correlated with RSC and EC Singh and Marok (1980). the problem of RSC was associated with low salinity (EC below 3 dS m^{-1}). They further noted multiple correlations between water quality parameters and soil characteristics and showed salinity built in soil was positively correlated with salinity of water while pH was influenced by EC, RSC, and SAR. Chauhan *et al.* (1990), whereas the relationship between SAR with Soil reaction (pH) shows Signiant positive correlation (r = 0.98). It indicates that as the SAR increases the soil reaction (pH) increases. pH increases with increase in SAR of irrigation water Chauhan *et al.* (1990)

The relationship between SAR with Electrical Conductivity shows a significant positive correlation (r = 0.98) there is positive correlation of SAR with Electrical conductivity. Singh and Marok (1980). While the relationship between SAR with Sulphur per cent and Exchangeable calcium shows significant positive correlation (r = 0.98) respectively. It showed that as the SAR of irrigation water increases the Sulphur and Exchangeable calcium of soil also increases, and the relationship between SAR and Bulk density showed positive correlation(r=0.97) indicate that Bulk density increases with increase in SAR of Irrigation water.

Conclusion

The Kanholi Bara village of Hingna Tahsil in Nagpur district situated 44 km away from Nagpur, Surrounded by industries from some side, in Kharif farmers of the region taking soybean as a main crop and giving imbalanced fertilizers. In rabbi farmers are taking Gram and providing irrigation and again use imbalanced fertilizer without doing soil and groundwater testing. The Impact of Imbalanced fertilizer use contaminated groundwater was also noticed by other government agencies to carry out the research study in the area. In view of above facts and analytical data of soil, ground water from 20 different farms. Now it can be concluded that, erratic use of groundwater with contamination adversely affects the soil physical properties. Further, the availability of nutrients also affected. Continuous use of such medium RSC water further deteriorates physical condition of soil which directly influences the soil fertility status.

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