

1 **Consequence of Ground Water Irrigation on Physico-Chemical Properties of**
2 **Soils of Kanholibara Village in Nagpur District, Maharashtra.**

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4 **ABSTRACT**

5 A field experiment entitled “Effect of Ground water irrigation on various soil properties of
6 Kanholi-Bara in Nagpur District Was conducted during Kharif season of 2015-2016 at Kanholi-
7 Bara of Hingana tahsil in Nagpur District. The soil samples were collected from that area
8 comprises two source of irrigations viz well water and bore well water and soybean crop which
9 were taken in these fields. The mean value of pH 7.79 was recorded with ground water irrigation
10 and EC in ground water irrigated soil 0.81 dS m⁻¹.The organic carbon contain in ground water
11 irrigated soil with high SAR and RSC was lower by 35.19 per cent less than mean value of
12 organic carbon. The lowest available nitrogen, phosphorus and potassium status were 185.44,
13 15.65 and 178.80 kg ha⁻¹ respectively were obtained with the application of ground water of high
14 RSC and SAR. The highest accumulation of heavy metal in soil 1.16 mg kg⁻¹ lead, 1.30 mg kg⁻¹
15 Cobalt, 1.19 mg Kg⁻¹Nikel and 0.037 mg kg⁻¹Cadmium were present in soil with the application
16 of high SAR and RSC irrigation water. Due to continuous and injudicious irrigation with poor
17 quality ground water adversely affect the physical and chemical properties of soil .

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

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21 **INTRODUCTION**

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23 Water is one of the limiting factors for agricultural development in developing countries in
24 order to meet the growing demand of the increasing population. Water is one of the precious
25 sources of nature and required for crop production whereas an invaluable basic natural resource
26 for human being it sustains life on the earth, water is being used for several purposes viz.
27 drinking, Irrigation, hydro-electric production, Industries, transport, sanitation, recreation etc.
28 However, the largest use is for Irrigation which enables to increase the farm production. A part of
29 rain water percolates in the ground through joints and cracks in the rocks and is known as ground

30 water. It is a major source of Irrigation in India. About 60% of the Irrigated land in the country
31 depends on groundwater (Shah *et al.*, 2000). In Maharashtra the total geographical area of 30.77
32 Mha spread over in thirty-one districts out of which about 59.2 % (18.31 M ha) area is under
33 crops and 20.8% under forests. The irrigated area is 11.4% of the gross cropped area in the state.

34 Irrigation is practiced in those parts of the world where rainfall is not sufficient to support
35 crop growth or where the rain does not fall when the plants need water. The objective of irrigation
36 is to supply plants with water, as needed, to increase yields. An irrigation project should take
37 water use efficiency into account as well as the economy involved. When applying irrigation
38 water, excesses as well as shortages should be avoided (Varallyay, 1977).

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

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

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

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

56 The problems of soil salinity/sodicity and water logging in canal, bore well
57 irrigated Vertisols are of severe and deserve an immediate attention for corrective measures,
58 therefore monitoring of salinity/sodicity in such irrigation areas is essential and hence the detail
59 knowledge of properties of dry land soils and their inter-relationship will be useful for managing
60 salt affected soils of similar areas elsewhere in the state for sustainable crop production. It was felt

61 necessary to take up the study on the assessment of soil salinity and sodicity status in the
62 particular area. The location specific information based on detailed characterization of
63 kanholibara villege area soils under irrigation is very much essential for judicious management of
64 such soils. The irrigation induced salinity/sodicity problem in black clay soil has not been
65 extensively studied although some attempts have been made and the information is scattered.

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MATERIALS AND METHODS

68 *Study area*

69 Geographically, Kanholi-Bara is situated at the latitude 20.93 and longitude 78.84
70 at the elevation of 321.26 m above sea level and lies under sub-tropical zone, covering an net
71 cropped area of about 704.71 ha⁻¹ in Hingana Tehsil of Nagpur district, Maharashtra. Kanholi
72 Bara is characterized by hot and dry summer and fairly cold winter. This area shows wide diurnal
73 fluctuation in temperature. The maximum and minimum temperature ranged from 26.9⁰C to
74 43.0⁰C and 13.7⁰C to 26.6⁰C, respectively, whereas the relative humidity varied from 20 to 72 per
75 cent during the crop growth period, mean annual rainfall is about 1,566.3 mm.

76 Surface soil samples were collected with free survey where there is a differentiation in
77 soil. A composite soil sample (0-15 cm) depth, after harvesting of soybean crop was taken from
78 the different spots of the experimental area were taken. These samples were stored in polythene
79 bags then processed and labeled as per the need for laboratory analysis. Physical properties of the
80 soils, such as particle size distribution were determined by the international pipette method (Klute
81 and Dirksen, 1986). The bulk density was determined by core method described by Yaalon
82 (1957). The hydraulic conductivity was measured by constant head method described by Richards
83 (1954). Chemical properties like pH and EC of the soil suspension (1:2 ratio) was determined by
84 the methodology of Jackson (1973). For the determination of soil organic carbon (SOC), the
85 modified Walkley and Black wet oxidation method was used (Walkley and Black, 1934; Jackson,
86 1973). Nitrogen was determine by alkaline potassium permanganate method described by Subbiah
87 and Asija (1956). Available P was estimated calorimetrically as per Olsen method whereas
88 Available potassium in soil was extracted by Neutral ammonium acetate solution and potassium

89 was determined using flame photometer (Jackson, 1967). Subsequently available Sulphur by
90 Turbidimetric method given by Chesnin and Yien (1951).

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

94 About 20 ground water samples from irrigated field of the farmers from study area were
95 collected and on the basis of laboratory analysis of ground water samples results 15-20 sites of the
96 farmers fields. The chemical parameters like pH, EC, Ca²⁺, Mg²⁺, Na⁺, CO₃⁻, HCO₃⁻ were
97 analysed using standard methods given by Richards 1954. SAR and RSC was determined to study
98 suitability of water for irrigation.

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RESULTS AND DISCUSSION

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1. Chemical composition and quality of irrigation water

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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 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 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).

115 **Table 1. Chemical Composition of Irrigation Water.**

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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

117 The pH of these water samples ranged from 7.55 to 8.1 while electrical conductivity from 0.61 to
118 1.83 dS m⁻¹. The sodium adsorption ratio (SAR) varied between 2.53 and 5.49; the maximum value
119 was observed in sample no. 18 and minimum value observed in sample no. 8. The carbonate was
120 found ranges from 1.55 to 1.78 while bicarbonate ranged from 3.11 to 4.16. The residual sodium
121 carbonate (RSC) was above the normal range in water samples of the study area. The irrigation
122 water containing RSC more than 2.5 me L⁻¹ is not suitable for irrigation purposes (Richards,
123 1954) The soluble Ca/Mg ratio of this water sample ranged from 1.95 to 3.31. The maximum value
124 was observed in sample no 1 and minimum value was observed in sample no. 6. Similar result was
125 observed in Kadu (1997).

126 Whereas the Nitrate nitrogen content in water is varies from 3.2 to 8.5 the highest value
127 was observed in sample No. 18(8.5) followed by 8.2 and 8.1 in sample No.16 and sample No.7
128 respectively and lowest value was observed in sample No.08 (3.5).this water samples are under
129 second class (Intensity of problem is moderate)..Very frequently ground water contain high
130 amount of nitrate. When such type of irrigation water is applied on soils continuously, various
131 properties of soils are affected, Similar result was closely paint by Almasri and Kaluarachchi
132 (2004).

133 As per the quality criteria of irrigation water given by U. S. Salinity Laboratory (Richards, 1954),
134 the studied water samples were medium in salinity and low in sodium, hence classified as C2S1
135 and can be used for irrigation.

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137 **2. Physico-chemical properties of soils of study area**

138 The Particle size Distribution data showed that all the soils have high amount of clay
139 compared to sand and silt fractions since the soil developed by basaltic parent material produce
140 high amount clay (Eswaran *et al.* 1988). Bulk density of these soils varied from 1.32 to 1.51 Mg
141 m⁻³. Comparative low values of bulk density in the study area soils can be ascribed to high clay
142 content and dominated by smectitic clay mineral, which is expanding type of clay mineral
143 (Bharambe *et al.* 1999). The saturated hydraulic conductivity (HC) of these soils ranged from 1.07
144 to 2.26 cm hr⁻¹. Low Hydraulic conductivity indicates poor structure and drainage of soil.

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

147 Soil reaction was low to moderately alkaline (pH 7.55 to 8.1). These soils are non-saline as
148 indicated by the electrical conductivity, which ranged from 0.61 to 1.83 dS m⁻¹ at 25o C, but
149 more accumulation of salts was observed in surface layer of these soils. Organic carbon content
150 (0.70 to 1.46 g kg⁻¹) was moderate to high; Organic matter has been found to be more or less
151 uniformly distributed in the first meter of the profile in some Indian Vertisols. For example,
152 organic C and total N in the profile of a deep Vertisols at the ICRISAT Similar result were closely
153 paint by Dulal (1965); Singh *et al.* (1991), presented in (Table 3.)

154 The available Nitrogen content of soils varied from 185.44 to 300.01kg ha¹. (Table 3.) The
155 available Phosphorus content of soils varied from 15.65 to 19.45 kg ha¹ The available Potassium
156 content of soils varied from 178.80 to 330.8kg ha⁻¹ Similar results were also noted by Singh
157 (1988). While the available Sulphur content of soils varied from 11.56 to 12.51kg ha¹ respectively
158 were obtained with the application of ground water of high RSC and SAR. similar result were
159 closely confirmative by Patangray et al (2018)

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Table No. 2. Physical properties of soils influence by ground water 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 ground water 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

181 **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

182 **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

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

UNDER PEER REVIEW

185 **3. Heavy metal content of Soil Influenced by ground water Irrigation:**

186 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
187 no. 8) presented in (Table 4). and high amount of Pb 1.16 mg kg⁻¹ (sample No.18) followed by
188 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,
189 Ni and Zn were associated with parent rocks and corresponded to the first principal component
190 called the lithogenic component. A significant correlation was found between lithogenic metals
191 and some soil properties such as soil organic matter similar result were reported by Mico *et al.*
192 (2006)

193 Cd content in soil sample varies from 0.023 to 0.037 mg kg⁻¹ whereas Co content in soil sample
194 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
195 these heavy metal like Cd, Co and Ni was found to be low amount in (sample no. 8) and high
196 amount in (sample No.18) followed by in sample No. 16 and sample No.7 respectively is due to
197 farmers around industrial areas are using effluents or contaminated river/well water for irrigation
198 purpose. Since these effluents contain high amount of trace elements and other pollutant heavy
199 metals, which hazardous to the soil and crop. Similar result was observed in Patel *et al.* (2004).

200 **4. Relationship of Ground Water Irrigation on Physico-Chemical Properties of Soils.**

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

203 The relationship between Hydraulic conductivity and SAR showed Negative significant
204 correlation ($r = 0.97$). presented in (Table 5) indicate that Hydraulic conductivity of soil decrease
205 with increase in SAR of irrigation water. Similar result was observed in Vaidya *et al.* (2007). The
206 relationship between RSC and Bulk Density showed significant positive relationship ($r = 0.99$)
207 which means that RSC of ground water impact on soil Bulk density. Bulk density of soil increased
208 with increasing RSC of Irrigation water. Similar result was observed in Malewar and More
209 (1988), also Porosity of the soil decreased with the increasing sodicity level (RSC) of the
210 irrigation water. The dispersion ratio and soil strength, however, showed an increasing trend with
211 increasing RSC of the irrigation water. Addition of gypsum had significantly improved infiltration
212 rate and porosity of the soil. Yadav and Kumar (2004)

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

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

229 **Conclusion**

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

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