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Preliminary study in Irrigational quality of Groundwater sources in parts of Soygaon block, District Aurangabad, India

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Abstract

Groundwater quality assessment for irrational use was carried out in Soygaon taluka of Aurangabad district. Twenty one groundwater samples were analyzed for geochemical variations and irrigation quality. The samples were chemically analyzed for physicochemical parameters including; pH, Conductivity, total dissolved solids, Alkalinity (CO_3^{2-}, HCO_3^-), Calcium, Magnesium, total hardness, sulphate, Sodium, and Potassium and to determine irrigational status Sodium adsorption ratio (SAR), Magnesium adsorption ratio (MAR), Percent sodium, Residual sodium carbonate (RSC), Kelley's ratio (KR), Permeability index (PI) and Residual sodium bicarbonate (RSBC) were calculated. The correlation between US Salinity diagrams showed that 11 samples fall under C_2S_1 and 10 samples falls in C_3S_1 category. While in Wilcox's diagram it was found that 9 samples had water quality varying from excellent to good while remaining 12 samples had water quality varying from good to permissible. Quality assessment for irrigation suitability shows that the groundwater of the area belongs well to Moderate category and can be used for irrigation.

Keywords: Groundwater, irrigation water quality, SAR, Wilcox diagram, soygaon area.

Introduction

Groundwater is of major importance in providing the mains water supply, and is intensively exploited for private, domestic and industrial use in many rural and urban centers of the developing world. Groundwater plays a fundamental role in shaping the economic and social health of many rural and urban areas. However, no comprehensive statistics exist on the proportion of rural and urban water supply world-wide derived from groundwater[1]. Groundwater resources play a major role in ensuring livelihood security across the world, especially in economies that depend on agriculture. The socio-economic dependency on groundwater is explained over a range of factors[2,3]. India is a vast country with a highly diversified hydrogeologic set-up. The ground water behavior in the Indian sub-continent is highly complicated due to the occurrence of diversified geological formations with considerable lithological and chronological variations, complex tectonic framework, climatologically dissimilarities and various hydrochemical conditions. Quality of water is assuming great importance with the rising pressure on agriculture and rise in standard of living[4,5]. Access to safe drinking water remains an urgent necessity, as 30% of urban and 90% of rural Indian population still depend completely on untreated surface or groundwater resources[6,7].

From the time when there is an constantly increasing demand for the ground water resources as a result of the change in climatic system, insufficient rainfall as well as arid winters, which have led to be deficient in water. Consequently this study was undertaken to hit upon the suitability of groundwater sources for irrigational purposes, so as to better understand the customary conditions. The study is of wide scope as it will not only help to find out the irrigational quality of the groundwater sources of the area, but will also provide baseline statistics for agricultural planners, as well as for the water resource planning for the area.

Study area: Soygaon is one of the taluka place of Aurangabad district of Maharashtra, It lies northen side of Aurangabad city about 100km and covers a total area of 650.93km^2 (Figure-1). It has eighty four villages and total population of the taluka is 901424 (India Census, 2001). Soygaon is bounded on the north by Jalgaon district, on the south by Kannad and Sillod taluka of Aurangabad district and Jalna district, on the east by Buldhana district, on the west by Chalisgoan of Jalgaon districts. Agriculture is main occupation of the area. The area has a tropical climate, characterized by hot summer and general dryness throughout the year except during the south west monsoon season. December is the coldest month of the year with the mean daily maximum and minimum temperature of 28.9°C and 10.3°C respectively. May is the hottest month with mean daily maximum temperature of 39.8°C and minimum of 24.6°C. The average annual rainfall is around 813.2 mm and about 90% of the rainfall takes place from June to September months. Geologically, intact area constitutes a sequence of Deccan Trap basaltic lava flows while alluvium occupies a small portion. There are two distinct hydreogeological units which is different units of basaltic lava flows and isolated patches of alluvial deposits. Groundwater is the main source of water for irrigation[8,9].

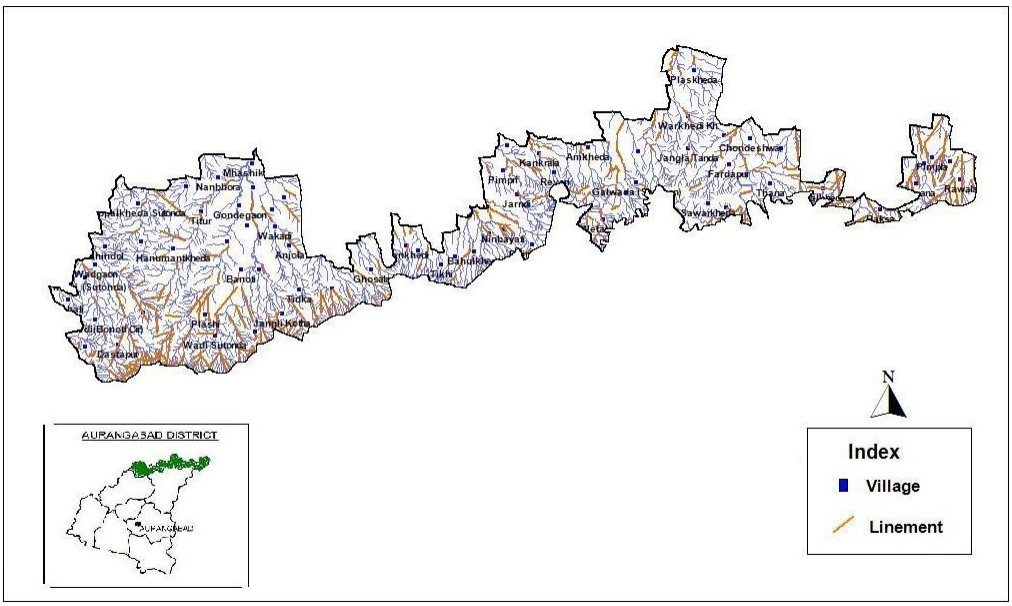

Figure-1
Location map of Soygaon block, district Aurangabad

Material and Methods

Twenty one groundwater samples were collected from dug wells at different locations, during pre-monsoon season. After proper collection, the samples were sealed and brought to the laboratory for analysis. The analysis of the samples was done, using standard procedures recommended by APHA[10] and Trivedy and Goel[11]. The pH, electrical conductivity (EC), total dissolved solids (TDS) were measured at the sample site using handheld analyzing kits. Carbonate (CO_3^{2-}) and bicarbonate (HCO_3^-) were determined using acid titration method; chloride (Cl^-) concentration was measured by $AgNO_3$ titration method; sulfate measured by $BaCl_3$ method using spectrophotometer. Sodium (Na^+) and potassium (K^+) was analyzed using flame photometer. Calcium (Ca^{2+}) and magnesium (Mg^{2+}) were determined using the titration method. In categorize to ascertain irrigational quality, Sodium Adsorption Ratio (SAR), Magnesium Adsorption Ratio (MAR), Permeability Index (PI), Percent Sodium (%Na), Residual sodium bicarbonate (RSBC), Residual sodium carbonate (RSC) and Kelley's ratio (KR) were calculated using standard equation. Overall data reproducibility for anions was within ±10%. Cationic and anionic charge balance (<10%) is an added proof for the precision of the data.

Results and Discussion

Hydro-chemical analysis of groundwater samples is presented in (table-1), pH range from 7.03 to 8.49 indicating alkaline nature of pH, EC values varies from 311 to 1690 µs/cm, the total solids ranged from 202 mg/L to 1099 mg/L and Total hardness values varied from 128 to 456 mg/L. Calcium, magnesium, sulphate, sodium and potassium concentrations represented appreciable quantities.

Table-1
Physicochemical analysis summary of groundwater samples in the study area

Sr. No.	Parameter	Unit	Maximum (N=21)	Minimum	Average
1	pH		7.03	8.49	7.56
2	EC	µs/cm	311	1690	856
3	TDS	mg/L	202	1099	556
4	Ca++	mg/L	19	98	62
5	Mg++	mg/L	14	60	35
6	Na+	mg/L	25.3	85.9	55
7	K^+	mg/L	0.1	5	0.7
8	CO_3^-	mg/L	0	32	3.4
9	HCO_3^-	mg/L	44	364	215
10	SO_4^-	mg/L	16	98.44	48
11	Cl^-	mg/L	48	164	105
12	TH	mg/L	128	456	298

Irrigational quality of water: Groundwater utilized for irrigation is an essential aspect in productivity of crop, its yield and quality of irrigated crops. The quality of irrigation groundwater depends mostly on the occurrence of dissolved salts and their concentrations. Sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) are the mainly significant quality decisive factor, which persuade the groundwater quality moreover its fittingness for irrigation. The total salt concentration, sodium percentage (%Na), residual sodium

carbonate (RSC), sodium adsorption ratio (SAR) and Kelley index (KI) are the important parameters used for assessing the suitability of water for irrigation uses[12]. The computed values of these parameters calculated by the following equations are furnished in table 2.

Sodium adsorption ratio (SAR) $= Na^{+}/(\sqrt{Ca^{2+}+Mg^{2+}})/2)$ (SAR)
Sodium percentage (%Na) $= Na^{++}K^{+} / (Ca^{2+}+Mg^{2+}+ Na^{+}+K^{+})$ X100
Residual sodium carbonate (RSC) $= (CO_3^{-} + HCO_3^{-}) - (Ca^{2+} + Mg^{2+})$
Kelley index (KI) $= Na^{+}/(Ca^{2+}+Mg^{2+})$
Permeability index (PI) $= (Na^{+} + \sqrt{HCO_3^{-}})$ x 100/ $Ca^{2+}+Mg^{2+}+ Na^{+}$
Magnesium adsorption ratio (MAR) $= Mg^{2+}$X 100/ $Ca^{2+}+Mg^{2+}$
Residual sodium bi-carbonate (RSBC) $= HCO_3^{-} - Ca^{2+}$
(All ionic concentrations used for calculation are expressed in epm)

Table-2
Computed values of irrigation water quality* parameters

Well ID	SAR	% Na	RSC	KR	RSBC	PI	MAR
DW1	1.32	1.89	-1.85	0.46	0.53	56.68	58.30
DW2	1.10	1.23	-0.72	0.49	-0.23	55.59	62.11
DW3	0.78	1.10	-1.16	0.28	0.97	54.70	53.53
DW4	1.64	3.31	-2.82	0.40	1.28	48.92	49.99
DW5	1.53	2.83	-2.81	0.41	0.30	50.06	45.71
DW6	1.76	3.33	-2.64	0.46	0.22	51.98	40.02
DW7	1.84	3.70	-3.38	0.46	1.21	49.88	57.09
DW8	1.86	3.33	-2.58	0.52	-0.45	54.37	33.40
DW9	1.14	1.55	-1.73	0.42	-0.58	56.25	31.04
DW10	1.37	2.17	-1.74	0.43	0.88	55.37	52.22
DW11	1.20	1.78	-1.67	0.40	0.19	54.09	48.09
DW12	1.46	2.33	-2.12	0.46	-0.40	54.69	33.94
DW13	1.24	2.04	-1.56	0.38	0.82	53.66	43.80
DW14	1.13	2.08	-2.37	0.30	1.16	47.06	51.65
DW15	1.49	1.99	-1.26	0.56	0.55	63.24	50.75
DW16	1.51	3.12	-2.82	0.36	0.87	47.17	42.95
DW17	1.40	2.43	-2.90	0.40	1.45	49.59	71.87
DW18	1.67	3.01	-2.63	0.46	-1.48	49.26	33.98
DW19	1.87	3.73	-3.35	0.47	0.26	50.19	45.05
DW20	0.89	1.44	-2.88	0.28	-0.25	44.68	50.71
DW21	0.97	2.07	-3.10	0.23	1.82	40.54	54.23
min	***0.78***	***1.10***	***-3.38***	***0.23***	***-1.48***	***40.54***	***31.04***
max	***1.87***	***3.73***	***-0.72***	***0.56***	***1.82***	***63.24***	***71.87***
avg	***1.39***	***2.40***	***-2.29***	***0.41***	***0.43***	***51.81***	***48.12***

*All ionic concentrations are expressed in epm

Table-3
Classification of groundwater for irrigation quality

Parameter	Range	Water Class	No. of Samples	Samples in (%)
SAR	<10	Excellent (S1)	100	100
	10-18	Good (S2)	-	-
	18-26	Doubtful (S3)	-	-
	>26	Unsuitable (S4)	-	-
% Na	<60	Excellent	100	100
	>60	Unsuitable	-	-
RSC	<1.25	Good	100	100
	1.25-2.50	Doubtful	-	-
	>2.5	Unsuitable	-	-
KR	<1	Suitable	100	100
	>1	Unsuitable	-	-

Sodium adsorption ratio (SAR): The sodium or alkali hazard in the irrigation water are expressed in terms of sodium adsorption ratio (SAR) and classified into four categories as S_1 (SAR<10), S_2 (10-18), S_3 (18-26) and S_4 (>26). The sodium adsorption ratio values for each water sample were calculated by using equation[13], and all the samples fall in excellent (S_1) category (table 2 and 3), indicating that these groundwater sources are suitable for irrigation purpose with no danger of exchangeable sodium.

Sodium percentage (%Na): The % Na is far and wide used for appraised the suitability of groundwater quality for irrigation. High % Na in irrigation groundwater causes barter of sodium in groundwater, and exchange of calcium and magnesium contents in soil having meager internal drainage. The % Na varies from 1.10 to 3.73 meq/L. The % Na < 60 represents safe water while it is unsafe if > 60. As per these criteria the groundwater is safe for irrigation purpose (table 2 and 3).

Residual sodium carbonate (RSC): A high salt concentration in water leads to formation of saline soil and alkaline earth metal cations, expressed as residual sodium carbonate (RSC) are also influencing the water quality for irrigation purposes[14]. The HCO_3^- and CO_3^{--} in the irrigation water tend to precipitate calcium and magnesium ions in the soil resulting in an increase in the proportion of the sodium ions. For this reason, RSC was considered as an indicative of the sodicity hazard of water. A high value of RSC in water leads to an increase in the adsorption of sodium on soil[15]. Table 2 and 3 shows that the calculated RSC indicating that in general groundwater is suitable for irrigation purposes.

Kelley Ratio (KR): Kelley's ratio is also used for the classification of water for irrigation. Water with >1.0 Kelley's ratio indicate an excess level of sodium and unsuitable for irrigation. Water with Kelley's ratio of <1.0 are only considered suitable for irrigation[16,17]. KR values in the groundwater of Soygaon block varied from 0.23 to 0.56 with an average of 0.41. The low KR value (KR<1.0) in analyzed sample suggest that groundwater of the area is suitable for irrigation (table 2 and 3).

Residual sodium bicarbonate (RSBC): Gupta and Gupta have proposed the equation for analyzing the Residual sodium bicarbonate[18] (RSBC). The RSBC values of groundwater samples varies from −1.48 meq/l to 1.82 meq/l with a mean value 0.43meq/l and according to the norm all groundwater samples are found to be suitable (<5 mg/L) (table-2) for irrigation use.

Permeability index (PI): The soil permeability is persuading by long term put into practice of groundwater for irrigation and supplementary reason. Calcium, magnesium bicarbonate and sodium, material of the groundwater are noteworthy donor which have an effect the soil permeability[19-21] to be had water appropriateness classification for irrigation reason base on the permeability index (PI). The PI value of the groundwater ranges from 40.54 to 63.24 with an average values 51.81 (class II) imply that the groundwater samples are suitable for irrigational use (Table 2).

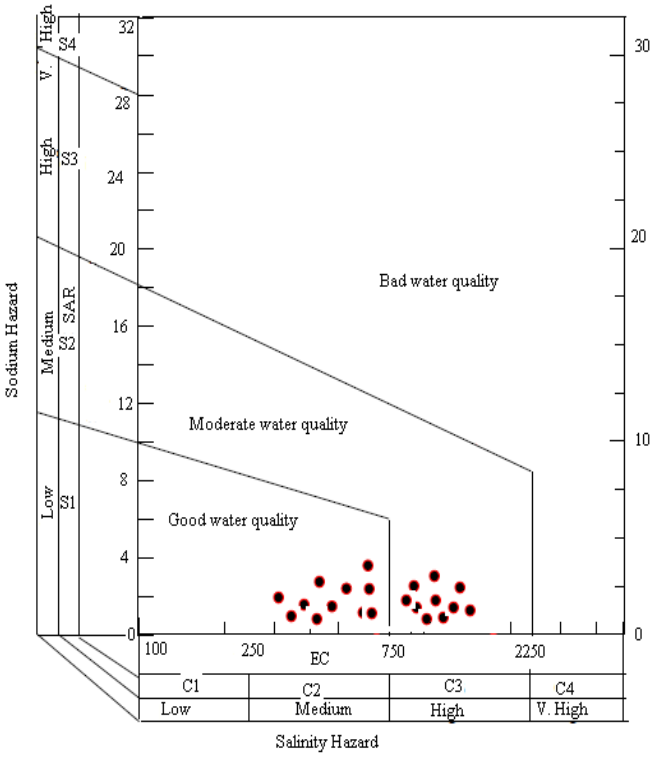

Figure-2
US salinity diagram (USSL) for classification of irrigation

Magnesium adsorption ratio (MAR): Szobolces and Darab[22], had given the equation to calculate Magnesium adsorption ratio (MAR). MAR ratio of the groundwater varied from 31.04 to 71.87 (table-2). High MAR affects the soil unfavorably, a harmful effect on soils[23] appear when MAR exceeds 50. In the present study, out of 21 samples, only 11 samples had MAR less than 50 which would cause no harm to soil and the rest were above 50 which might cause harm to soil.

USSL and Wilcox diagram: The plots of groundwater chemistry of study area in USSL[24] diagram are shown (figure-1). In which the EC is taken as salinity hazard and SAR as alkalinity hazard, shows that most of the water samples belongs to category of C_2S_1 and C_3S_1 indicating good to moderate quality. These groundwater sources can be used to irrigate all types of soils (figure-2). The good water (C_2S_1) can be used for irrigation with little danger of harmful levels of exchangeable sodium and salinity. The moderate water (C_3S_1) may be used to irrigate salt tolerant and semi-tolerant crops under favorable drainage conditions[14].

Plot of analytical data on the Wilcox[25] diagram give you an idea about that groundwater of the area is excellent to good and good to permissible quality for irrigation utilizes. Out of 21

groundwater samples, nine samples plunge in the zone of excellent to good category and twelve samples go downs in good to permissible category (figure-3).

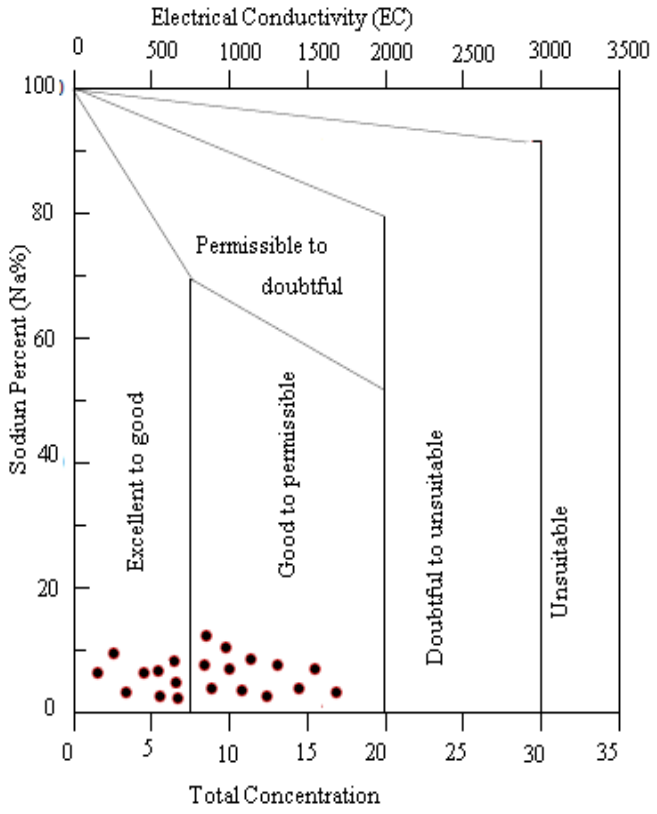

Figure-3
Wilcox diagram for classification based on EC and %Na

Conclusion

Quality assessment for irrigation suitability shows that the groundwater of the area belongs well to Moderate category and can be used for irrigation. According to SAR, all samples are excellent for irrigation use. The RSBC values advise that all the water samples are fit for irrigation use. PI make known that all the samples are superior for irrigation reasons. The USSL diagram of the study area shows that most of the water samples belong to category of C_2S_1 and C_3S_1 indicating good to moderate quality. Wilcox diagram also shows that groundwater is excellent to good and good to permissible quality for irrigation utilizes. Therefore use of these groundwater sources in irrigation will be very beneficial except high values of Magnesium adsorption ratio (MAR) at some sites restricts the suitability of groundwater for agricultural purposes and demands special management plan for the area.

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