ASSESSMENT OF GROUNDWATER QUALITY FOR IRRIGATION IN THE TATTEKERE WATERSHED, PERIYAPATNA AND HUNSUR TALUKS IN MYSORE DISTRICT, KARNATAKA, INDIA

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Abstract

Suitability of groundwater for irrigation was assessed in the study area in Mysore District, Karnataka based on various water quality parameters. From the study of suitability of the groundwater from the irrigational point of view, it is seen that Sodium Adsorption ratio (SAR) of all the water samples are of excellent class. On the basis of Residual sodium carbonate (RSC), all the water samples are of Good class. The water from deeper aquifers has better quality in general than that of the shallow aquifers. The groundwater of the study area is suitable for irrigation purposes except some cases where the water is saline in nature and has magnesium hazard. In order to achieve the set objectives various infrastructure like well-designed monitoring network for groundwater levels, installation of digital water level recorders (DWLR'S) upgrading of water quality laboratories, establishment of data centers were implemented over the period of project.

Key words: Water quality, sodium adsorption ratio, Residual Sodium Carbonate, Deeper aquifers.

1. Introduction

Groundwater can play an important role in Indian agriculture and in shaping the country's economy. A good quality of groundwater can help in the better yield of crops. Water used for irrigation purpose should have certain quality specifications. The suitability of water for irrigation mainly depends upon the tolerance of plants to certain chemical constituents, properties of soils and irrigation practices. Groundwater always contains some amount of constituents dissolved in it. The excess quantity of soluble salts may be harmful for many crops because their presence affects the soil structure, permeability and aeration. Hence it is essential to properly evaluate groundwater quality for irrigation purpose.

2. Study Area

The study area comprises of Piriyapatna and Hunsur taluks, Mysore district of Karnataka. It lies between latitude 12º15'00" to 12º25'47"and longitude 75º58'48" to 76º15'36" and falls in the Survey of India Toposheet numbers 57D/2, 57D/3, 57D/4, 57D/7, 57D/8, 57D/11, 48P/14, 48P/15. It covers an area of 320.00sq. kms. It is in the 788 m elevation(altitude). The climate of the area is subtropical monsoon type with hot (Maximum temperature 37^{0}C) summer and a relatively cold winter (minimum temperature 24^{0}C). The rainfall is quite erratic since the average annual rainfall is 718 mm with 45 rainy days. Most of the people of the area depend on agriculture as their livelihood and as the agriculture is mostly rain-fed, people suffer due to erratic rain fall pattern.

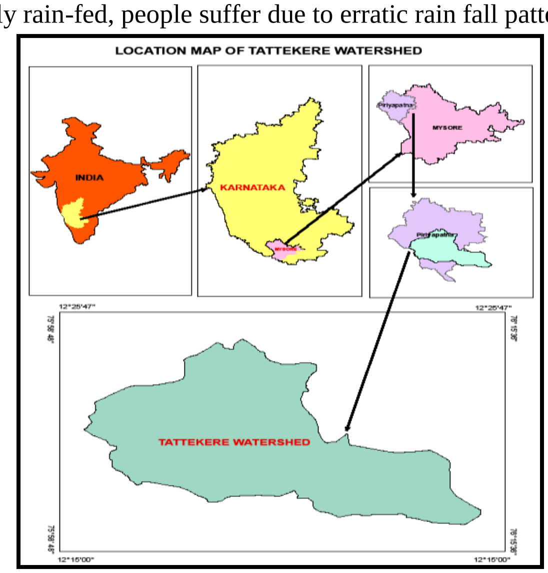

Fig.1 Location of study area

Kharif and Rabi are the two crop seasons in the study area. Paddy is the principal crop of this area. In addition, maize, ragi, black gram, til, ground nut, mustard, sugar cane, potato, and wheat are also cultivated. The river and tank waters are not available in many places and moreover rain water irrigation is not dependable. Hence groundwater is the only source to be developed for irrigation.

The major drainage system in the area is controlled by Cauvery River with tributaries the Shimsha, the Hemavati, the Arkavati, Honnuhole, Lakshmana Tirtha, Kabini, Bhavani River, the Lokapavani, the Noyyal and the Amaravati River. The soil in major part of the area is alfisols, which include red sandy, red loamy, red earth and older alluvium. The lateritic soil is restricted to the high and sloping land and foot hill regions. The location map of the study area is shown in **Fig. 1.**

3. Objectives of the area

Preparing water resource action plan leading up to treatment of drainage lines, checking runoff and soil Erosion, improving the storage capacity of tanks for human and agriculture purposes, recharge of groundwater, overall development of agriculture productivity and employment generation.

4. Geological setting and Methods:

Geologically, the study area is mainly composed of igneous and metamorphic rocks of Pre-Cambrian age either exposed at the surface or covered with a thin mantle of residual and transported soils. The rock types of the area charnockite and granite. A fairly wide area consists of charnockite series of rocks particularly along the southwestern part of the area. The intervening area consists of granitic gneiss with thin beds, lenses and elongated runs of various amphibolite schist, hornblende schist and metabolitic schist. Dolerite dyke patches are more in the northwestern and southeastern part of the area. The spatial distributions of different units are given in Figure 78.

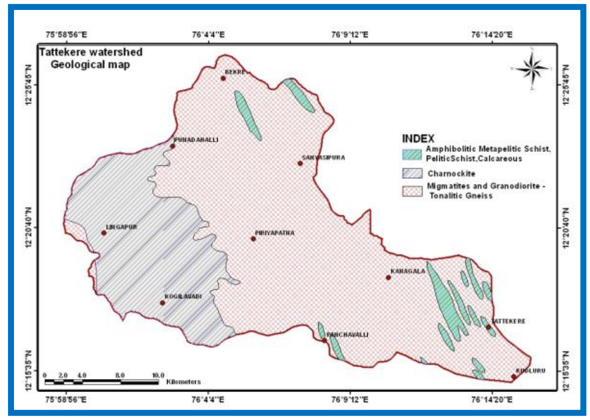

Fig.2 Geology of study area

The different generations of folds(at least three), faults, joints etc. affect the rocks of the area. On the other hand, the structural disturbances are responsible for creating secondary porosities in the hard rocks helping in the storage and movement of groundwater.

5. Methodology:

Fifty **(**50) numbers of ground water samples (41 from tube wells and 9 from dug wells) were collected systematically during the (2012-13) from the study area. The analysis was done by standard methods proposed by APHA (1985) to find out various physico-chemical parameters such as hydrogen ion concentration (pH), electrical conductance (EC), total dissolved solids(TDS), total hardness (TH), total alkalinity (TA), carbonate (CO_3^{2-}), bicarbonate (HCO_3^-), chloride (Cl^-), sulphate (SO_4^{2-}), nitrate (NO_3^-), fluoride (F^-), sodium, potassium, calcium and magnesium. The pH, EC, TDS, temperature etc. were determined in the field. The range of concentrations of various physico-chemical parameters is given in Table 1.

Several factors like total dissolved solids (TDS), percent sodium (%Na), residual sodium carbonate (RSC), sodium adsorption ratio (SAR), permeability index (PI) and potential soil salinity (PS) etc. which are calculated from the above parameters(Table 2) decide the suitability of water for irrigation. In addition to the above, other characteristics such as the nature and composition of the soil, subsoil, depth of water table, drainage conditions, topography, climate, type of wells, crop pattern, cultural practices etc. also decides whether a particular quality of water is detrimental to crop or not.

Table 1

Serial No	Location	Ec	pH	Ca	Mg	Na+K	HCO_3	CO_3	Cl	NO_3	SO_4	TDS
1	KUDLURU	1220	7.09	165	73	98	530	10	230	62.0	89	795
2	HONNENAHALLI	1200	7.06	162	75	92	526	10	224	61.8	78	786
3	HAIRIGE	733	8.10	33.6	47.04	66.5	310	10	88	0.21	28.3	480
4	TATTEKERE	730	7.65	18.2	34.48	52.3	300	10	40	0.50	13.8	478
5	HUNASEGALA	736	7.68	19.0	35.00	51.8	320	10	52	0.42	14.0	485
6	NAGAMANGALA	740	7.72	18.8	34.88	52.0	294	10	63	0.80	22.8	500
7	KANAGALA	746	7.75	19.2	34.56	53.2	264	10	55	10	15.6	490
8	HARINAHALLI	860	7.60	62.0	38.0	78.0	450	35.0	58	7.0	20,0	680
9	KARANAKUPPE	1020	6.85	160	75	62	486	10	198	18.8	75.4	700
10	HAMMIGE	1185	6.28	175	80	70	505.7	10	210	14.5	81.8	810
11	PANCHAVALLI	650	8.60	56.0	33.0	90.0	436.4	24.0	42.0	2.60	12.0	495
12	SATYAGALA	2320	7.25	16	68	465	646	42	322	12	225	838
13	KAMPALAPURA	1100	7.02	47	55	380	520	36	204	22.0	28	760
14	BASALAPURA	2050	7.36	50	36	186	486	10	143	14.2	16.8	554
15	TATANAHALLI	642	7.80	62	28	126	455	50	34	18	26	618
16	HUNASEKUPPE	1516	7.78	50	69	160	484	40	138	25	94	834
17	MUMMADI COLONY	86	8.32	60	28	126	340	38	66	16	54	615
18	MALANGI	380	8.70	34	15	40	152	43	17	10	10	250
19	HOSURU	826	8.60	40	22	64	280	45	22	13	22.6	400
20	HABATURU	596	8.56	46	28	92	316	50	30	10	0.5	447
21	TIMKAPURA	978	7.82	86	38	80	295	44	96	16	42	614
22	ANKANAHALLI	1016	7.76	54	58	186	712	10	86	14	52	1136
23	ABBURU	628	7.82	66	28	92	378	48	14	15	16	580
24	PIRIYAPATNA	610	7.80	48	30	112	318	35	54	16	48	725
25	MALLARAJAPATNA	884	7.40	28	35.6	138	398.6	54.4	38.2	3.42	24	552
26	DODDAVADDARAKERE	980	8.00	58	44	190	480	68	88	12.8	58	612
27	SANYSSIPURA	860	8.20	48	52	148	390	72	50	16	78	518
28	HITNAHALLI	820	7.60	46	76	120	420	40	62	8.2	62	442
29	AYICHANAHALLI	830	8.30	45.0	43.0	260	573.0	72	76.0	12.0	120	600
30	BARSE	1020	8.40	128	60	182	442	0	54	15.2	82	1082
31	BEKRE	984	8.00	86	42	140	360	28	37	13.2	86	858
32	KOMALAPURA	480	8.20	50	48	125	432	36	49	10	38	718
33	BASAVANAHALLI	782	7.72	44	28	132	434	58	46	10	32	624
34	PUNADAHALLI	548	8.48	58	34	90	435	26	44	3.8	14	496
35	TELAGANAKUPPE	992	7.80	54	72	88	588	46	70	14.2	45	510
36	VADDARAPALYA	834	7.62	48	58	72	410	34	58	6.4	36	420
37	HUNASAVADI	712	8.08	56	34	80	395	46	16	18	16	518
38	ALANAHALLI	768	7.52	26	28	98	320	29	26	6.4	17.8	458
39	NAVALURU	860	8.70	46	48	100	355	43	40	14	80	560
40	BEMMATTI	1200	7.97	61.0	48.0	145	196.0	24.0	216	14.0	100	775
41	LINGAPURA	566	7.60	58	16	45	214	26	22	14	20	324
42	KIRANGURU	1040	7.92	140	16	124	438	50	110	16	52	808
43	BELATURU	2080	7.80	46	68	546	905	93	205	14	342	1926
44	CHAUDANAHALLI	840	8.43	69.0	28.0	78.0	328.0	48.0	59.0	13.0	20.0	520
45	NARALAPURA	995	9.40	30	48.6	72	328.4	33.8	47.8	10	30	528
46	MUTTURU COLONY	1000	7.66	126	37	50	421	29	78	15	50	560
47	BEGURU	998	8.80	60	48	108	310	50	96	16	45	642
48	CHEPPAPURA	782	8.5	62	36	112	408	54	28	34	30	600
49	SULAGODU	1018	8.00	48	79	50	437	43.6	60	12	24.6	618
50	KOGILAVADI	812	7.62	75	40	105	478	40	50	18	10	676

6. Results and discussions:

6.1 Sodium Hazard

The specific electrical conductance indicates the salinity hazard for irrigation. Excess sodium content in water makes it unsuitable for soil. Water with high bicarbonates and relatively low calcium is also known to be hazardous for irrigation (Richards, 1954). The total concentration of soluble salts is important to identify salinity hazard because salt tolerance capabilities of plant species are different. Groundwater of the study area can described to be having low salinity to high salinity on the basis of TDS content (Table 1). The salinity hazard can also be expressed in terms of potential soil salinity (PS) of the water samples.

6.2 Potential Soil Salinity (PS)

Potential soil Salinity (PS) is an important criterion for classification of irrigation waters. The PS as determined by the formula (Doneen, 1962) is given as follows:

$$P.S = Cl^{-} + ½\, SO_4^{2-}$$

where the ionic concentrations are expressed in meq/l.

With respect to Potential soil Salinity (P.S) for irrigation, 50 samples of both [pre-post] the seasons and 47 samples can be classified as of "Excellent to Good" category in the year 2012-13 and only 3 samples are of "Injurious to unsatisfactory" category.

6.3 Sodium Adsorption Ratio

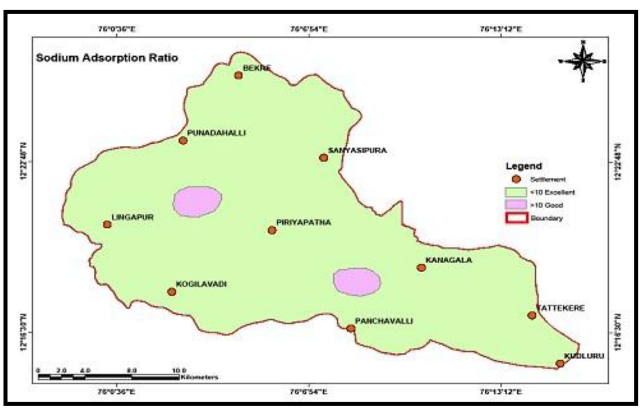

Fig.3 Sodium adsorption of study area

Sodium has a tendency to react with soil reducing its permeability. Water with high sodium content may produce harmful levels of sodium in most soils and requires special water and soil management practices like application of gypsum (Karanth, 1989). If the proportion of sodium is high, the alkali hazard is high and vice versa. But if calcium and magnesium are predominant, the hazard is less. The sodium percent of water samples can be expressed by % Na (Percent Sodium) and SAR (Sodium Adsorption Ratio).

$$\%Na = (Na^{+}+K^{+}) \times 100 / (Ca^{+2} + Mg^{+2} + Na^{+} + K^{+})$$

$$SAR = Na^{+}/\sqrt{(Ca^{+2} + Mg^{+2})/2}$$

where the ionic concentrations are expressed in meq/L

The percent sodium of the study area samples varies from 0.07 to 71.94. According to ISI standards, maximum percent sodium of 60 is recommended for irrigation. Five samples have values beyond the desirable limit. Wilcox (1955) proposed a classification for irrigation water based on electrical conductance (EC) and percent sodium (%Na) which are shown in Fig.2(a)and Fig.2(b). It is seen that majority of groundwater samples of the study area in both the seasons fall under "excellent to good" class but a few fall under "good to permissible" class and "permissible to doubtful" class. Only two samples fall under "doubtful to unsuitable" class".

The SAR values of the samples vary from 0.01 to 6.48 and that of samples vary from 0.04 to 6.08. Since all the values are less than 10, the water samples can be classified as "excellent" for irrigation. There is a direct correlation between the SAR value of water and extent to which sodium is adsorbed by the soil. When SAR values are plotted against EC values (Fig. 3.a and Fig. 3.b) in U.S. Salinity Diagram (Richards, 1954) all the samples fall in the field of "Good Waters" for irrigation but distributed in C_1S_1, C_2S_1 and C_3S_1 fields.

6.4 Residual Sodium Carbonate (RSC)

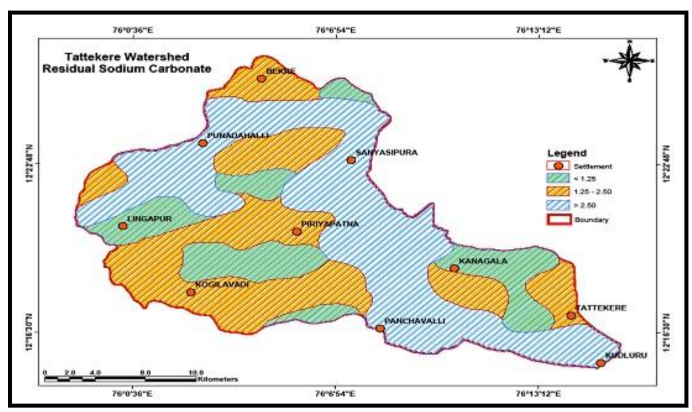

Fig.4 Residual Sodium Carbonate of study area

The concentration of bicarbonate and carbonate also play a vital role for classification of irrigation waters. The relative abundance of sodium with respect to excess of carbonate and bicarbonate over alkaline earth affects the suitability of water for irrigation purpose and this excess is denoted by Residual

Sodium Carbonate (RSC) and is determined by the formula (Richards, 1954) as given below.

$RSC = (CO_3^{2-} + HCO_3^{-}) – (Ca^{+2} + Mg^{+2})$

where the concentration of ions is expressed in meq/l. The RSC of pre-monsoon samples varies from -9.39 to 0.61 and that of the post-monsoon samples varies from -9.39 to -0.10. With respect to RSC values, all the groundwater samples of the study area can be classified as “Good” for irrigation since all the values are less than 1.25.

6.5 Permeability Index (PI)

The permeability of soil is affected to a considerable extent by the composition of water used for irrigation. It is influenced by the relative concentration of sodium, calcium, magnesium, and bicarbonate. Doneen (1964) developed a criterion to assess the suitability of water for irrigation based on permeability index (PI) which can be determined by the formula given below.

P.I. = $\{(Na^{+}+\sqrt{HCO_3^{-}})/(Na^{+}+Ca^{+2}+Mg^{+2})\}$ **X100**

where all the concentrations are expressed in meq/l

Permeability index values of 40-60 fall on 48 samples in class II and 02 samples fall on Class III(unfit) value of 60 -80, Therefore, in the study area Class II(moderate) of 96.0% and Class III of 4%.

PI=Permeability of Index = PI=Na+1/2[HCO3] / (Ca +Mg+Na) x100

Where the all concentration is expressed in epm,

In the study area, the majority of the water samples 96% fall in Class I and 4% in Class II based on permeability index.

6.6 Magnesium hazard

A ratio of $(Mg^{+2}$ x100)/ $(Ca^{+2} + Mg^{+2})$ is used as an index of magnesium hazard of irrigation water. If this ratio is less than 50, no magnesium hazard is found. In the study area, the Mg – ratio of pre-monsoon samples varies from 2.61 to 91.09% and that of the post-monsoon varies from 1.32 to 98.91%. It is found that 34 samples in pre-monsoon and 16 samples in post-monsoon have Mg – ratio of more than 50 and hence can create Mg-hazard to a considerable extent by the water used for irrigation.

Table 2: Physico-chemical quality of groundwater samples of the study area

Sl No	Parameters	Groundwater samples			
		Min	Max	Mean	Sd
1	Temp.	20.00	35.98	29.4	1.11
2	pH	5.69	7.48	6.62	0.35
3	EC	50	2640	488.8	434.4
4	TDS	32	1690	312.8	278
5	TH	30	580	188.97	115.49
6	TA	1.22	450	126	104
7	HCO_3^{-}	12.2	350	94.36	62.84
8	Cl^{-}	6.72	560	64.7	87.9
9	SO_4^{2-}	1.66	187	39	43.5
10	NO_3^{-}	2	55	13.34	9.83
11	F^{-}	0.43	0.84	0.64	0.10
12	Na^{+}	0.05	286	23.9	36.4
13	K^{+}	0.1	41.7	1.93	3.94
14	Ca^{2+}	2.5	187.5	48.62	41.29
15	Mg^{2+}	0	52.4	16.43	10.71

Table 3: Range of concentration of parameters used for irrigation purpose

Sl No	Parameters	Groundwater samples			
		Min	Max	Mean	Std. Dev.
1	EC in µmho/cm	50	2640	488.8	434.4
2	TDS in mg/l	32	1690	312.8	278
3	%Na	0.07	62.95	18.92	14.98
4	SAR	0.00	6.48	0.71	0.86
5	RSC in meq/l	-9.39	0.61	-2.27	2.02
6	Mg Hazard	0.00	91.09	40.86	21.04
7	PS in meq/l	0.13	17.16	2.23	2.68
8	PI	8.20	93.99	51.64	17.5

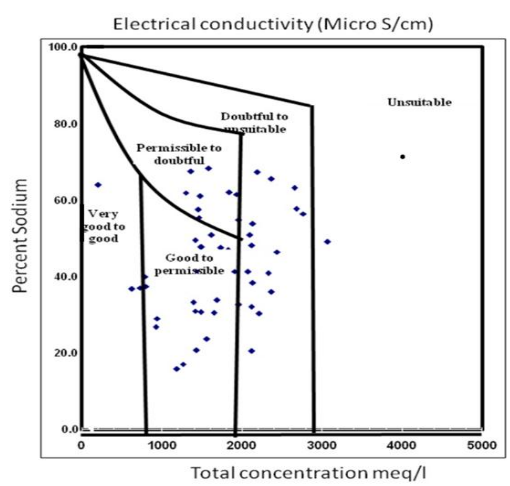

Fig.5 Wilcox diagram

7. Conclusion:

The average values of Groundwater quality parameters in the study area are given in Table - 2.

Some of the factors which decide the suitability of the water for irrigation are described below.

From the study of suitability of the ground water from the irrigational point of view, it is seen that Sodium Adsorption ratio (SAR) of all the water samples in both the seasons are of "excellent" class. On the basis of Residual sodium carbonate (RSC), all the water samples in both the seasons are of "good" class. The water from deeper aquifers has better quality in general than that of the shallow aquifers. The groundwater of the study area is suitable for irrigation purpose except some cases where the water is saline in nature. The U.S. Salinity Diagram (Richards 1854) for classification of irrigation water of both the seasons indicates that all the waters can be classified as "Good Waters" for irrigation. According to Wilcox (1955) diagram, it is seen that majority of groundwater samples of the study area in both the seasons fall under "excellent to good" class but a few fall under "good to permissible" class and "permissible to doubtful" class. Only two samples in the pre-monsoon season fall under "Doubtful to unsuitable" class". The major concern is the magnesium hazard in a number of areas and hence appropriate measures need to be undertaken to combat the hazard.

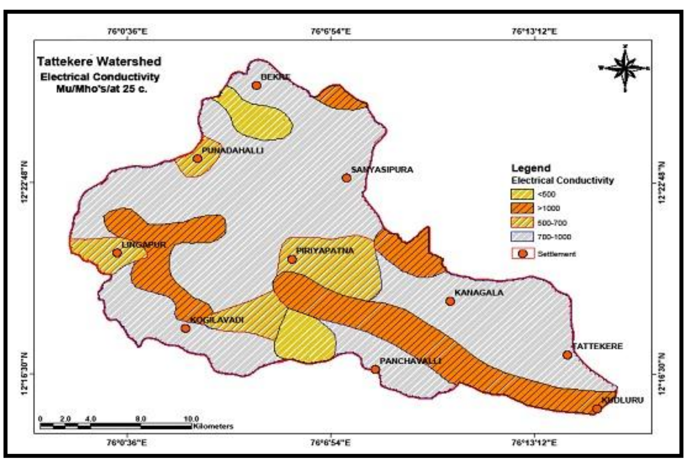

Fig 6.Electric conductivity of study area

All the values are in mg/l except EC, pH and temperature; EC is in μmho/cm,Temp. is in ^{0}C, Sd is the standard deviation.

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