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Original Research Paper

Hydro-Chemical Analysis and Classification of Groundwater in Tiptur Town and its Surrounding Areas, Tumkur District, Karnataka

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ABSTRACT

Tiptur Taluk is located in the southeastern corner of Karnataka state at north latitude 13°16ôand east longitude of 76°29ô The Taluk spreads over an area of 785.5 sq.km and frequently face water scarcity as well as quality problems. The major sources of employment are coconut business and agriculture, horticulture and animal husbandry covering almost 70 to 80% of the workforce. Water samples were collected from 50 locations during the period of summer and winter season, 2009-11. The class of groundwater belonged to C2S1, C3S1 and suitability of water for irrigation was evaluated based on the sodium adsorption ratio, Na%, salinity hazard and USSL diagram.

INTRODUCTION

Groundwater is an invisible natural resource. It is beneath ground surface in the dark pores and fissures of sands and rocks of the upper portion of the earth's crust. The general public is less familiar with groundwater than with the more visible components of the water cycle, such as rain and surface water. Groundwater is used to meet 23% of all irrigation demands, to feed 53% of all public water supplies and to cover 97% of all rural domestic water demands (Jayavel Raja et al. 2010).

Water quality analysis is one of the important aspects in groundwater studies. The hydro-chemical study reveals that the quality of water is suitable for drinking, agriculture, and industrial purpose. Further, it is possible to understand the change in the quality due to rock water interaction or any type of anthropogenic activities. Groundwater often contains seven major chemical ions Ca^{+2}, Mg^{+2}, Cl^{-}, $HCO3^{-}$, Na^{+}, K^{+} and SO_4^{-2}. The chemical parameters play significant role in classifying and assessing water quality. Chemical classification also throws light on concentration of various predominant cations, anions and their interrelationship. A number of techniques and methods have been developed to interpret the chemical data.

Presentation of chemical analysis in graphical form makes the understanding of complex groundwater system simpler and quicker. Methods of representing the chemistry of water and class have been used by plotting USSL diagram in many parts of world.

The objective of the present work is to discuss the major ion chemistry of groundwater of Tiptur Taluk. In this case the methods proposed by USSL classification have been used to study the hydro-chemical characteristic of groundwater and its suitability for irrigation based on SAR (Sadashivaiah et al. 2008).

STUDY AREA

Tiptur is a taluk and sub-divisional headquarters of Tumkur district, Karnataka. The town is famous for its coconut cultivation and marketing and is also called Kalpataru Nadu. The town with a population of 2,17,124 (2011 census) and municipal area of 11.6 sq. km is governed by City Municipal Council (CMC).

Being the headquarters of the revenue sub-division (named after Tiptur) comprising the taluks of Tiptur, Turuvekere and Chikkanayakanahalli, the town is an administrative center also. Tiptur lies at north latitude of 13°16' and east longitude of 76°29' at an altitude of 850.30 meters above sea level.

MATERIALS AND METHODS

Groundwater samples were collected from 50 locations in Tiptur Taluk (Fig. 1) during summer and winter seasons

Fig. 1: Sampling locations of in Tiptur Taluka.

2009-11. The collected samples were transferred into cleaned polythene containers for analysis of chemical characteristics. Chemical analysis was carried out for the major ion concentration of the water samples using standard procedures recommended by APHA (1998). The analytical data were used for classification of water for utilization purpose and for ascertaining various factors on which the chemical characteristics of water depend.

RESULTS AND DISCUSSION

Chemical classification throws light on the concentration of various predominant cations, anions and their interrelationship, and a number of techniques and methods have been developed to interpret the chemical data. Zaporozee (1972) has summarized various modes of data representation and discussed their possible uses.

Classification based on total dissolved solids (TDS): There is a great geological variability in chemical composition of groundwater. Such variability is a function of geological substrate in which groundwater is found, the residence time of water in the subsurface and groundwater interactions (Loaiciga 2000). Groundwater chemistry alters when the water flows through the surface geological environment which increases the dissolved solids and major ions (Suresha et al .2009).

Groundwater can be classified on the basis of total dissolved solids (Freez & Cherry 1979) as given in Table 1. It is an important governing factor that determines suitability of water for various uses (Nanjundasamy et al. 2007).

Based on the above classification, the data generated during the period of study show that 86% of water belongs to freshwater type and 14% belongs to brackish water category.

Classification based on total hardness (TH): Sawyer & McCarty (1967) classified waters into four categories based on hardness (Table 2). Total hardness is due to the dissolution of more minerals present in the geological strata consisting of hard granite rocks, gneissic formation, chlorite schist and mica schist belt. The observation made in the present study reveals that 98% of water belongs to very hard category and 2% belongs to hard type.

Electrical conductivity (EC): Groundwater can also be classified into five categories on the basis of electrical conductivity (Table 3).

In the present study, the data reveal that 8% of the samples belong to good type, 40% belong to permissible category, 36% belong to brackish type and 16% belong to saline category.

Handa's classification: Handa (1965) executed a new scheme of classification mainly used by hydrogeologists. It is a modified Hill-Piper diagram. It includes groundwater hardness, salinity and sodium hazard simultaneously. He merged both the trilinear plot of Piper and US Salinity Research Laboratory diagram (USSL diagram).

Sodium hazard is considered for salinity classification. This diagram helps in classifying groundwater into the following classes.

A. Hardness	:	Permanent (A_1, A_2, A_3)
	:	Temporary (B_1, B_2, B_3)
B. Salinity	:	C_1, C_2, C_3, C_4, C_5
C. Sodium hazard	:	S_1, S_2, S_3

Groundwater hardness: Hardness in water is caused by divalent cations. Hardness is classified as temporary and permanent hardness. Temporary hardness is mainly due to carbonates and bicarbonates of calcium and magnesium. Permanent hardness is due to sulphates and chlorides of calcium and magnesium. Hardness is used as an equivalent concentration of calcium carbonate. It is also used as an indicator of the rate of scale formation in hot water heaters and low pressure boilers.

Based on Handa's (1965) classification, majority of the water samples of the study area belong to carbonate hardness which attributed to the geology of the study area.

Table 1: Classification of water based on total dissolved solids (TDS).

Category	Total dissolved solids (mg/L)
Freshwater	<500
Brackish water	500-30000
Saline water	30000-50000
Brine water	>50000

Table 2: Classification based on total hardness.

Category	Total Hardness (mg/L)
Soft	0-75
Moderately Hard	75- 150
Hard	150-300
Very Hard	>300

Table 3: Classification based on electrical conductivity.

Category	Electrical conductivity (μmohs/cm)
Excellent	0-333
Good	333-500
Permissible	500-1000
Brackish	1,000-1,500
Saline	1,500-10,000

Table 4: The Handa's classification of waters.

Class	Salinity	Sodium Absorption ratio (SAR)
C_1	Low	2.5
C_2	Low-Medium	2.5-7.5
C_3	Medium-High	7.5-22.5
C_4	High-Very high	22.5-37.5
C_5	Extremely high	>37.5
Class	Salinity	Sodium hazard (Na%)
S_1	Low-Sodium water	0-30
S_2	Low-Medium sodium water	30-57.5
S_3	Medium-High sodium water	>57.5-100

Table 5: Classification based on chloride concentration.

Main type	Code	Cl^- (mg/L)
Oligohaline	G	< 5
Fresh	F	30-150
Fresh-Brackish	f	150-300
Brakish	B	>300

Groundwater salinity and sodium hazard: Water having low salinity and low sodium belongs to (C_1S_1), low medium salinity and low medium sodium water (C_2S_2), medium high salinity and medium high sodium (C_3S_3) and high to very high salinity (C_4S_3) category (Table 4).

Water samples collected from the study area have different salinity groups. The overall seasonal values revealed

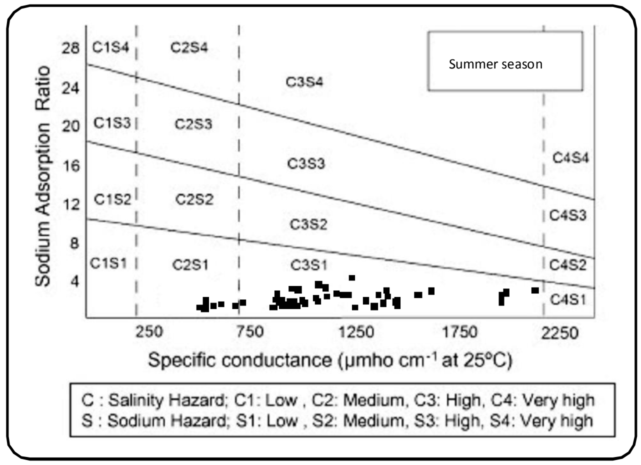

Fig. 2: USSL classsification for summer season during the period of study.

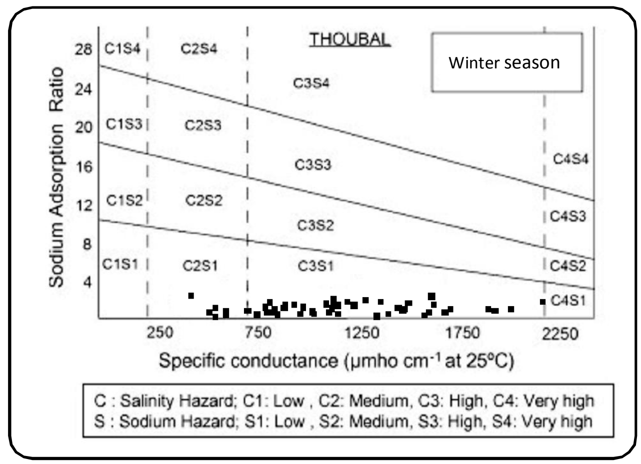

Fig. 3: USSL classsification for winter season during the period of study.

that 28% of the samples belong to low salinity and low sodium category, 58% belong to low salinity and low medium sodium and 14% belong to low medium salinity-low medium sodium category.

Based on this classification, the chemical scatter of the groundwater of the study area is represented in USSL classification diagrams (Figs. 2, 3). The method of calculating sodium adsorption ratio (SAR) is:

$$SAR = \frac{Na^+}{\frac{\sqrt{Ca^{+2} + Mg^{+2}}}{2}}$$

$$Na\ \% = \frac{Na^+ + K^+ \times 100}{Ca^{+2} + Mg^{+2} + Na^+ + K^+}$$

The classification of groundwater samples from the study area with respect to SAR is presented in (Figs. 2, 3). During summer and winter seasons, the SAR value of samples were

Table 6: Classification of water samples during summer season for the year 2009-10.

Sample No.	SAR	Na%	Handa's Classification	Stuyfzand's Classification	USSL Classification	
					Salinity	Sodium hazard
S1	3.25	55.2	C2 S2	F-Fresh	C2	S2
S2	1.5	45.3	C1 S2	f-Fresh Brackish	C1	S2
S3	0.86	23.4	C1 S1	F-Fresh	C1	S1
S4	2.16	43.4	C1 S2	f-Fresh brackish	C1	S2
S5	1.67	42	C1 S2	F-Fresh	C1	S2
S6	2.31	51.1	C1S2	f-Fresh Brackish	C1	S2
S7	2.93	52.2	C2S2	f-Fresh Brackish	C2	S2
S8	2.65	46.3	C2S2	B-Brackish	C2	S2
S9	2.71	48.2	C2S2	f-Fresh Brackish	C2	S2
S10	1.97	40.7	C1S2	f-Fresh Brackish	C1	S2
S11	1.44	30	C1S1	f-Fresh Brackish	C1	S1
S12	0.95	30	C1S1	F-Fresh	C1	S1
S13	0.97	27.3	C1S1	F-Fresh	C1	S1
S14	4.03	68.8	C2S3	F-Fresh	C2	S3
S15	1.66	34	C1S2	F-Fresh	C1	S2
S16	2.39	48.3	C1S2	f-Fresh Brackish	C1	S2
S17	1.48	36.5	C1S2	f-Fresh Brackish	C1	S2
S18	1.13	27.9	C1S1	F-Fresh	C1	S1
S19	1.64	37.3	C1S2	f-Fresh Brackish	C1	S2
S20	2.75	54.2	C2S2	F-Fresh	C2	S2
S21	2.29	45.3	C1S2	F-Fresh	C1	S2
S22	1.27	25.8	C1S1	F-Fresh	C1	S1
S23	1.37	27.3	C1S1	f-Fresh Brackish	C1	S1
S24	0.78	16.96	C1S1	f-Fresh Brackish	C1	S1
S25	2.56	49.6	C2S2	f-Fresh Brackish	C2	S2
S26	2.22	59.7	C1S3	f-Fresh Brackish	C1	S3
S27	1.58	34	C1S2	F-Fresh	C1	S2
S28	1.24	32.8	C1S2	F-Fresh	C1	S2
S29	2.13	43	C1S2	f-Fresh Brackish	C1	S2
S30	0.94	25.7	C1S1	F-Fresh	C1	S1
S31	1.13	28.7	C1S1	F-Fresh	C1	S1
S32	1.61	37.6	C1S2	F-Fresh	C1	S2
S33	0.81	22.1	C1S1	f-Fresh Brackish	C1	S1
S34	1.26	31.5	C1S2	F-Fresh	C1	S2
S35	1.98	42	C1S2	F-Fresh	C1	S2
S36	1.82	41.1	C1S2	f-Fresh Brackish	C1	S2
S37	1.37	33.6	C1S2	F-Fresh	C1	S2
S38	0.98	22.6	C1S1	F-Fresh	C1	S1
S39	2.86	52.4	C2S2	F-Fresh	C2	S2
S40	1.03	26.6	C1S1	F-Fresh	C1	S1
S41	2.17	46.6	C1S2	F-Fresh	C1	S2
S42	1.58	33.09	C1S2	f-Fresh Brackish	C1	S2
S43	0.79	20.4	C1S1	f-Fresh Brackish	C1	S1
S44	1.26	29.4	C1S1	f-Fresh Brackish	C1	S1
S45	0.96	22.8	C1S1	f-Fresh Brackish	C1	S1
S46	2.05	35.6	C1S2	f-Fresh Brackish	C1	S2
S47	1	21.5	C1S1	f-Fresh Brackish	C1	S1
S48	1.39	36	C1S2	f-Fresh Brackish	C1	S2
S49	1.4	27.3	C1S1	f-Fresh Brackish	C1	S1
S50	0.91	26.7	C1S1	f-Fresh Brackish	C1	S1

less than 10 and are classified as excellent for irrigation water which can be determined graphically by plotting these values as the US salinity (USSL) diagram (Figs. 2, 3). Samples are grouped with C_2S_1 and C_3S_1 classes in summer as well as in winter season.

Stuyfzand's classification: The hydro-chemistry of groundwaters of different environments could be assessed using the scheme proposed by Stuyfzand (1989). This scheme combines special features of other existing classifications with a new type of assessing criteria for sub-divi-

Table 7: Classification of water samples during winter season for the year 2009-11.

Sample No.	SAR	Na%	Handa's Classification	Stuyfzand's Classification	USSL Classification	
					Salinity	Sodium hazard
S1	2.29	44.38	C1S2	F-Fresh	C1	S2
S2	2.07	44.10	C1S2	F-Fresh	C1	S2
S3	0.89	29.76	C1S1	F-Fresh	C1	S1
S4	2.51	46.05	C1S2	F-Fresh	C1	S2
S5	1.61	42.03	C1S2	F-Fresh	C1	S2
S6	3.00	53.45	C2S2	F-Fresh	C2	S2
S7	2.38	46.82	C1S2	f-Fresh Brackish	C1	S2
S8	2.28	41.11	C1S2	f-Fresh Brackish	C1	2
S9	2.95	52.59	C2S2	f-Fresh Brackish	C2	S2
S10	1.94	38.63	C1S2	F-Fresh	C1	S2
S11	0.67	19.72	C1S1	F-Fresh	C1	S1
S12	1.17	37.96	C1S2	F-Fresh	C1	S2
S13	1.77	36.71	C1S2	F-Fresh	C1	S2
S14	1.91	40.00	C1S2	F-Fresh	C1	S2
S15	1.28	32.55	C1S2	F-Fresh	C1	S2
S16	1.78	37.02	C1S2	f-Fresh Brackish	C1	S2
S17	1.05	25.30	C1S1	f-Fresh Brackish	C1	S1
S18	1.14	32.09	C1S2	F-Fresh	C1	S2
S19	1.47	36.50	C1S2	f-Fresh Brackish	C1	S2
S20	2.58	48.21	C2S2	F-Fresh	C2	S2
S21	1.89	37.66	C1S2	F-Fresh	C1	S2
S22	2.12	40.15	C1S2	f-Fresh Brackish	C1	S2
S23	1.54	31.80	C1S2	f-Fresh Brackish	C1	S2
S24	0.92	21.09	C1S1	F-Fresh	C1	S1
S25	1.21	36.36	C1S2	F-Fresh	C1	S1
S26	1.97	45.98	C1S2	F-Fresh	C1	S2
S27	1.42	31.25	C1S2	F-Fresh	C1	S2
S28	1.92	40.01	C1S2	F-Fresh	C1	S2
S29	1.68	33.66	C1S2	F-Fresh	C1	S2
S30	1.24	27.98	C1S1	f-Fresh Brackish	C1	S1
S31	1.62	34.82	C1S2	F-Fresh	C1	S2
S32	1.60	37.70	C1S2	F-Fresh	C1	S2
S33	1.11	25.52	C1S1	F-Fresh	C1	S1
S34	1.16	26.57	C1S1	F-Fresh	C1	S1
S35	1.86	39.43	C1S2	F- fresh	C1	S2
S36	1.56	35.52	C1S2	F-Fresh	C1	S2
S37	1.74	35.66	C1S2	F-Fresh	C1	S2
S38	0.72	19.32	C1S1	F-Fresh	C1	S1
S39	2.25	41.52	C1S2	F-Fresh	C1	S2
S40	1.16	25.56	C1S1	F-Fresh	C1	S1
S41	1.28	27.10	C1S1	f-Fresh Brackish	C1	S1
S42	1.44	30.01	C1S1	f-Fresh Brackish	C1	S1
S43	1.05	25.05	C1S1	F-Fresh	C1	S1
S44	0.98	23.93	C1S1	F-Fresh	C1	S1
S45	1.34	32.03	C1S2	F-Fresh	C1	S2
S46	1.48	29.45	C1S1	f-Fresh Brackish	C1	S1
S47	0.79	19.17	C1S1	f-Fresh Brackish	C1	S1
S48	0.91	21.90	C1S1	F-Fresh	C1	S1
S49	1.41	28.66	C1S1	f-Fresh Brackish	C1	S1
S50	1.02	28.51	C1S1	f-Fresh Brackish	C1	S1

sions. This has been successfully used to interpret hydrogeological groundwater of an aquifer (Subramanian 1994, Sathisha & Puttaiah 2006). The main type of Stuyfzand's classification is determined by chloride concentration (Table 5).

As per Stuyfzand's classification, 60.66% of total groundwater samples with respect to all the three seasons belong to fresh category, 38.66% fresh brackish and 0.68%

of total number of water samples belong to brackish category (Tables 6, 7).

CONCLUSIONS

1. Based on total dissolved solids classification, the data generated during the period of the study show that 86% of water belongs to freshwater type, and 14% to brackish water category.
2. About 98% of water samples fall under very hard category, and 2% to hard type.
3. The data generated reveal that 8% of the samples belong to good type, 40% to permissible category, 36% to brackish type, and 16% to saline category.
4. As per Stuyfzand's classification, 60.66% of total groundwater samples with respect to all the three seasons belong to fresh category, 38.66% to fresh brackish, and 0.68% to brackish category.
5. Water is suitable for irrigation based on SAR and Na% and salinity hazard. In addition to water quality, other factors like soil type, crop type, crop pattern, frequency and recharge (rain fall), climate etc. have an important role to play in determining the suitability of water.
6. All the samples are grouped within C2S1 and C3S1 classes in both summer and winter season.
7. Most of the samples in Tiptur Taluk fall in the suitable range for irrigation purpose from USSL diagram.

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