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## RESEARCH ARTICLE

## Groundwater Quality Assessment Studies of Doddhalla Sub-basin, Karnataka, India.

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### Abstract

Major ion chemistry such as Ca, Mg, Na, K, CO<sub>3</sub>, HCO<sub>3</sub>, Cl and SO<sub>4</sub> along with physical parameters such as pH, EC, TDS and H were analysed to study and assess the water quality status of Doddhalla Sub-basin, Karnataka, India. Geologically, it forms part of Kaladgi Basin. Groundwater in the study area is neutral to moderately alkaline in nature. Piper's diagram for hydrochemical facies classification of groundwaters shows water samples to be of class – mixed CaMgCl and NaCl type. EC varies from 620 to 3798 µS/cm. Water samples were compared with Indian and International standards to determine its quality for drinking purpose and almost all of the samples are within permissible and allowable limits. Classification based on SAR for irrigation suitability revealed all samples to be in excellent category. Wilcox diagram suggested 68% of water samples to be in good to permissible category.

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## INTRODUCTION

Groundwater is the only source of fresh water available apart from streams and lakes. It has wide applicability from domestic to agricultural and industrial purposes. With the absence of monsoons and irregular rain pattern surface water resources are depleting at faster rates. Thus groundwater is the only source of water to fulfil the human needs.

Groundwater quantity and quality are equally important factors in the context of modern water management. Quality of water is mainly affected by pollution from different sources. Sectoral approaches divide the total available water, leading to scarcity (Sajil et al. 2012).

Anthropogenic activities can alter the relative contributions of the natural causes of variations and also introduce the effects of pollution (Whittemore et al. 1989). Standard urban ground water problems like inadequately controlled groundwater abstraction, excessive urban infiltration and excessive subsurface contaminant load are initiated by the requirement of water supply, wastewater or solid waste disposal (Pokrajac 1999).

Many researchers have studied, assessed and evaluated water quality for different purposes and in varied kind of basins (John Devdas et al 2007, Subba Rao 2006 & 2008, Arumugam & Elangovan 2009, Goyal et al 2010, Subramani et al 2010, Ravikumar & Somashekar 2011, Vasanthavigar et al 2011)

Also a number of studies were conducted to decipher groundwater potential sites in different geological set ups using remote sensing and GIS techniques (Krishnamurthy and Srinivas 1995; Kamaraju 1997; Sreedevi and others 2002; Srivastava and Battacharya 2000).

Thus in the present study an attempted has been made to study and assess the water quality of Doddhalla Sub-basin, Karnataka, India for its suitability for different purposes such as domestic, agriculture and industrial. Also to suggest and recommend authorities measures for sustainable management of resources.

## Study Area

The present study area, Doddhalla Sub-basin is tributary of Malaprabha River and is spread over an area of 293 km<sup>2</sup>, covering major portion in Bagalkot district and small part of Belgaum district, Karnataka, India. Geographical extent is longitude 75°8'24"E and latitude 16°10'14"N and is covered in Survey of India (SOI) toposheets numbered 47P/3; 47P/4 and 47P/8. The climate is hot and dry with temperature reaching its peak in the month of April and May. The area receives moderate rainfall. Red sandy soil is observed with vegetation mostly of shrubs and thorny grass.

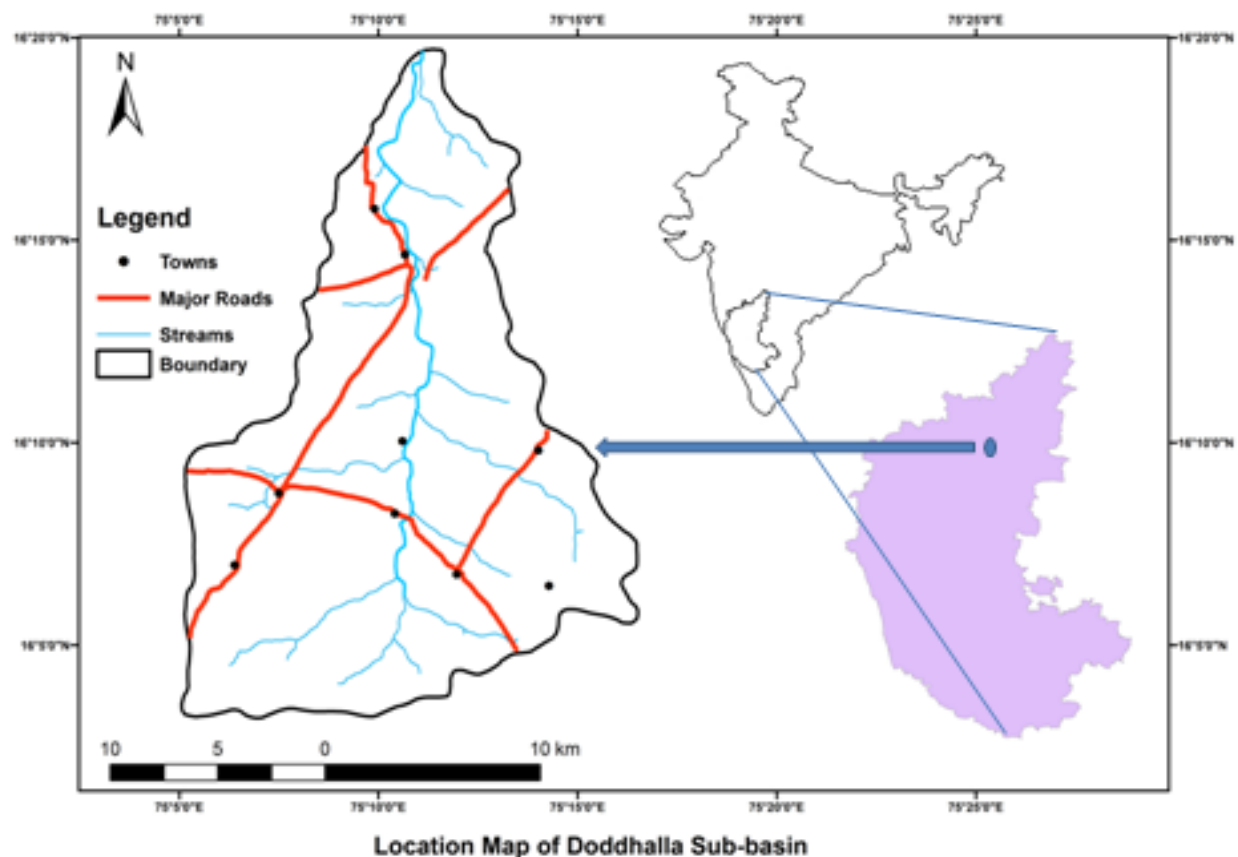


Fig. 1 Location Map of Doddhalla Sub-basin

## Geology of Study Area

The Doddhalla Sub-basin forms part of Kaladgi Basin. The different lithounits exposed in the study area includes limestone, sandstone, clays and shales, quartzites and conglomerates. While numerous quartz veins and few basic dykes are also observed in some parts.

## Materials and Methods

Water samples were collected in one litre polyethylene cans which were prewashed in laboratory and also washed in field with collected samples. A total of 25 representative samples were collected and subjected to analysis. pH and electrical conductivity (EC) were tested in the field using digital meters. Total dissolved solids (TDS) were manually calculated using EC value (Todd, 1980). Calcium (Ca), hardness (H), carbonates (CO<sub>3</sub>) and bicarbonate (HCO<sub>3</sub>), chloride (Cl) and sulphate (SO<sub>4</sub>) were determined volumetrically by titration method. Sodium (Na) and potassium (K) were analysed using flamephotometer. The computational results of physico-chemical analysis of Doddhalla sub-basin is presented in Table 1. Different thematic maps were prepared in GIS environment.

Table 1 Physico-chemical analysis results

Sl. No	Location	Physical parameters				Chemical parameters							
						Cations				Anions			
		TDS	EC	TH	pH	Ca	Mg	Na	K	C O <sub>3</sub>	HCO <sub>3</sub>	Cl	SO <sub>4</sub>
1	Hirekopp	566	930	280	7.25	35	33	27	0.386	0	113	65	22
2	Chikkop	1030	915	390	6.92	48	66	38	0.733	0	260	161	66
3	Bhagojikopp	1680	1441	544	6.73	100	74	48	1.304	0	370	393	150
4	Hulkundh	1948	2604	570	7.01	21	126	310	1.383	0	270	250	400
5	Hulkundh	1152	1535	318	6.90	43	51	118	1.431	0	250	200	170
6	Yadawad	1992	1080	330	7.21	69	236	340	1.722	0	335	300	380
7	Yadawad	699	620	200	6.94	17	24	64	0.207	0	190	112	92
8	Yadawad	1963	3798	500	6.93	111	112	392	2.832	0	345	200	300
9	Gulkonjikopp	1754	1643	450	7.12	36	39	187	1.116	0	400	316	325
10	Gulkonjikopp	1513	1643	440	6.93	60	71	145	3.217	0	280	220	294
11	Vantigod	1589	1674	482	7.42	120	44	101	1.793	0	260	200	380
12	Chennai old	996	853	258	7.64	60	26	61	1.310	0	165	150	275
13	Chennai old	1974	2822	700	7.36	189	107	181	1.263	0	295	200	300
14	Chennai new	1412	1953	452	7.41	8	105	164	3.521	0	180	100	400
15	Kopadhkatti	1122	930	304	7.39	75	29	69	0.774	0	285	142	218
16	Kamankatti	1684	2031	464	7.34	94	56	150	4.620	0	315	220	380
17	Tondikatti	1125	1039	374	6.96	92	35	42	2.181	0	265	200	115
18	Kullur	612	480	218	7.21	46	25	20	0.632	0	175	69	58
19	Bhijaguppi	1821	3488	500	7.59	107	49	258	3.228	0	285	218	400
20	Chipalkatti	1359	1767	490	7.65	80	71	129	3.826	0	145	100	340
21	Hosur	1950	6372	390	7.65	214	134	320	1.752	0	310	200	380
22	Hosur	892	620	326	7.69	48	50	21	0.509	0	205	126	115
23	Hoshalli	862	620	326	7.50	36	57	20	0.376	0	220	105	98
24	Murkatanal	1469	2046	500	7.00	177	113	59	0.373	0	270	250	100
25	Murkatanal	1840	1969	510	7.07	224	86	60	0.639	0	300	280	380

## Results and Discussion

### Drinking Quality

Results of physico-chemical analyses of the study area were compared with different standards viz- Bureau of Indian Standards (BIS 2003) and World Health Organisation (WHO 2005). Table 2 shows the comparison study of water samples of the study area with BIS and WHO standards for drinking purpose. From the comparison study it was found that, all the samples are within permissible and allowable limits except 19 samples of TDS and one each of Ca and Mg having values beyond allowable limit.

Table 2 Drinking water standards of BIS (2003) and WHO (2005)

Parameter	Drinking Water Standards				Samples exceeding allowable limit
	BIS (2003)		WHO (2005)		
	Permissible	Allowable	Permissible	Allowable	
<b>pH</b>	7.0-8.5	6.5-9.2	7-8.5	6.5-9.2	-
<b>TDS</b>	NS	NS	500	1000	19
<b>TH</b>	300	600	-	1000	-
<b>Ca</b>	75	200	75	200	01
<b>Mg</b>	50	150	50	150	01
<b>Cl</b>	250	1000	200	600	-
<b>SO<sub>4</sub></b>	200	400	200	400	-

**Total Dissolved Solids (TDS)**

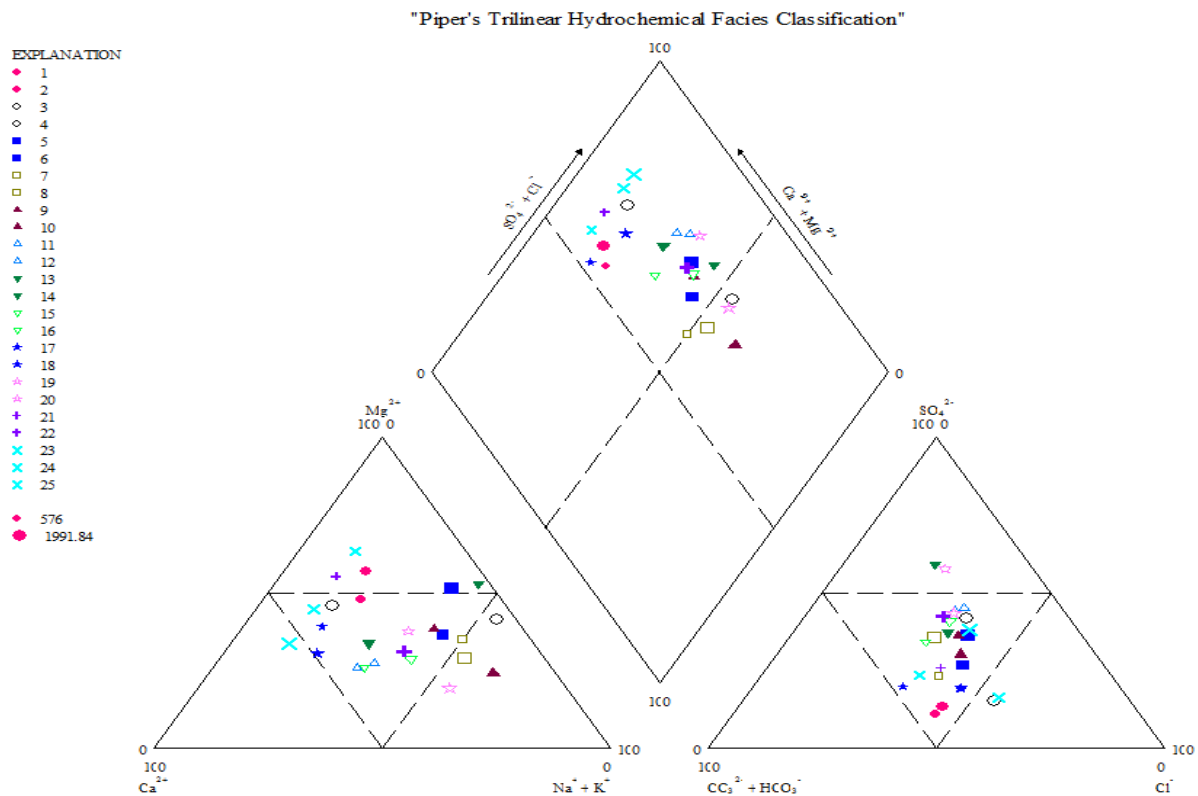
TDS value in the study area range from and water samples was classified based on Freeze and Cherry (1979) and it indicated that 76% of water samples fall in category brackish water and 24% of water samples fall in category fresh water (Table 3).

Table 3 TDS classification based on Freeze and Cherry (1979)

Classification	TDS range	No. of samples	Percentage
Fresh Water	<1000	06	24
Brackish Water	1000-10000	19	76
Saline	10000-100000	-	-
Brine	>100000	-	-

**Piper’s Diagram**

Piper’s trilinear diagram (1944) is widely used to depict chemical data. It enables to know th hydrochemical facies of groundwater and its relationships. Thus plotting cations and anions in Piper plot revealed that the groundwaters of Doddhalla sub-basin to be of class- mixed CaMgCl and NaCl type, indicating weak acids ( $\text{HCO}_3$ ,  $\text{CO}_3$ ) exceeding strong acids ( $\text{SO}_4$ , Cl) and alkalis (Na and K) exceeding the alkaline earths (Ca and Mg).



**Fig. 2 Piper’s Diagram for the waters of Doddhalla Sub-basin**

**Irrigational Quality**

**Sodium Absorption Ratio (SAR)**

SAR is good criterion for determining the suitability of water for irrigation as it measures the sodium hazard in irrigation. SAR measures the relative proportion of sodium ions in water sample to that of calcium and magnesium. The classified SAR is represented in Table 4 and is calculated using:

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

all values are in epm.

Accordingly (Table 4), all the water samples from the study area fall in excellent category. Also plotting the EC vs SAR plot on USSL diagram (Richard 1954) revealed that majority of (13) samples fall in field C3S1, indicating high salinity and low sodium and 4 samples falling in field of C4S1, indicating very high salinity and low sodium (Fig. 3).

Table 4 Classification based on SAR

SAR	Water Class	No. of Samples	Percentage
<10	Excellent	25	100
10-18	Good	-	-
18-26	Fair	-	-
>26	Poor	-	-

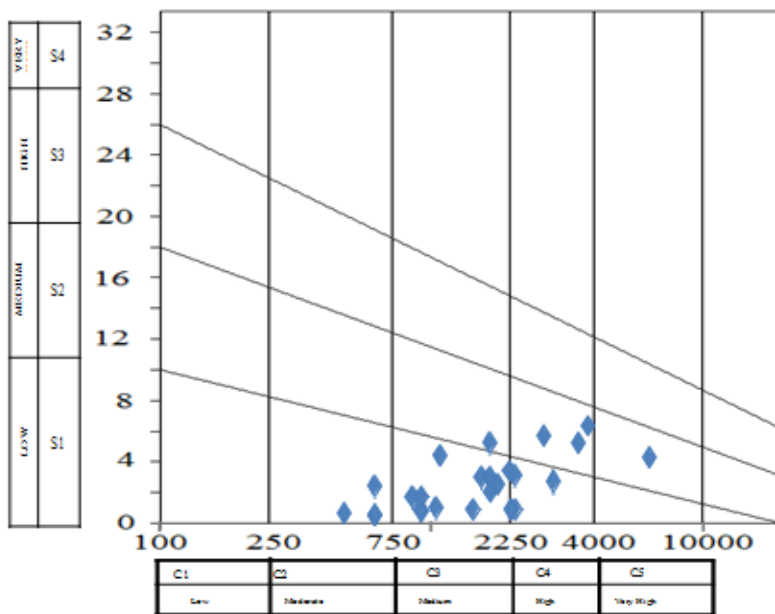


Fig. 3 USSL classification of irrigation waters based on Richard 1954

**Sodium percent (Na %)**

The suitability of the groundwater for irrigation depends on the minerals and its interaction present in water and its effect on plants and soil. When the concentration of sodium is high in irrigation water, sodium ions tend to be absorbed by clay particles which reduce soil permeability (Saleh 1999). This can be computed using:

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

all values are in epm.

Table 5 depicts the classification for irrigation suitability based on sodium percent, indicating 24% of water samples fall in excellent, 32% water samples fall in both good and permissible category. The plot of sodium percent vs EC i.e., Wilcox diagram (1954) indicate 68% of the water samples falling in range good to permissible, 12% of water samples falling in excellent to good and also in unsuitable category (Fig. 4).

Table 5 Sodium percent classification for irrigation water

Class	Na%	No. of samples	Percentage
Excellent	< 20%	06	24
Good	20-40	08	32
Permissible	40-60	08	32
Doubtful	60-80	03	12
Unsuitable	>80	Nil	-

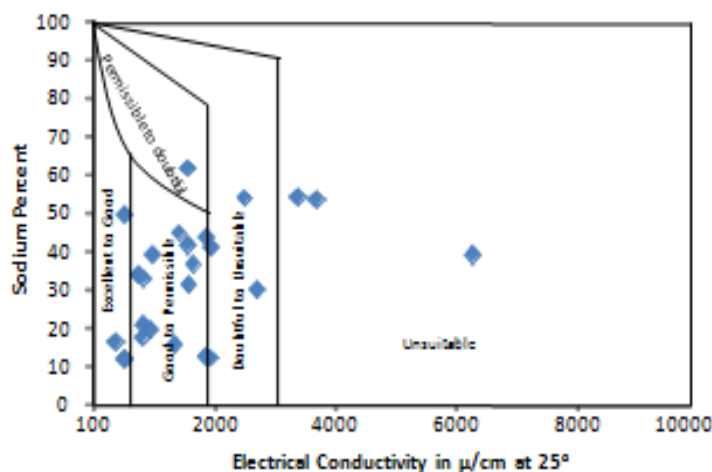


Fig. 4 Classification of irrigated waters based on Wilcox, 1955

## Conclusion

The present study area, Doddhalla Sub-basin, Karnataka, India was undertaken to study and assess its water quality suitability for different purposes. Geologically, it forms part of Kaladgi basin with major lithounits exposed includes- limestone, sandstone, clays and shales, quartzites and conglomerates.

Based on TDS values (Freeze and Cherry 1979) most of the water samples are found to be brackish. Comparison of water samples with different standards such as Bureau of Indian Standards (BIS 2003) and World Health Organisation (WHO 2005) for suitability for drinking revealed, almost all of the water samples fall in permissible and allowable limits.

Classification based on SAR for irrigational suitability indicated all samples to be in excellent category. While USSL diagram (Richard 1954) suggested, majority of samples having high salinity and low sodium. Wilcox diagram (Wilcox 1955) indicated, 68% of the water samples fall in good to permissible range of suitability for irrigation.

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