© 2015 IJSRSET | Volume 1 | Issue 6 | Print ISSN : 2395-1990 | Online ISSN : 2394-4099
Themed Section: Science and Technology

Water Quality Assessment for Drinking and Irrigational Suitability of Galgibagh River Sub-basin (GRSB), Goa

A. Sreenivasa, Ajaykumar N. Asode*

Department of Studies in Geology, Karnatak University, Dharwad, Karnataka, India

ABSTRACT

Water quality studies of Galgibagh River Sub-basin, Goa was carried out to determine its suitability for drinking and irrigational purposes. Analysis were carried out for major cations viz Ca, Mg, Na and K and anions viz CO3, HCO3, Cl and SO4 along with physical parameters such as pH, EC, TDS and H. Analysis were carried out following standard procedures of APHA. Obtained results were compared with BIS and WHO standards to determine its suitability for drinking purpose and it was found all waters to be safe. While it's irrigational suitability was determined from parameters such as SAR, RSC and sodium percent and it was found that almost 84% of the waters of study area are found to fit for irrigation. USSL and Wilcox diagrams were plotted to study the suitability for irrigation.

Keywords: Galgibagh River, Water Quality, Drinking purpose, Irrigation, Goa

I. INTRODUCTION

Quality and quantity of groundwater is very important for the proper growth and development of human kind. Variation of groundwater quality in an area is a function of physical and chemical parameters that are greatly influenced by geological formations and anthropogenic activities (Subramani et al 2010).

The study area Galgibagh River Sub-basin (GRSB), has an aerial extent of 96 km2 and geographically located between 14o56' N latitude and 74o01'E longitude. The sub-basin is located in down south of Cancona taluk, South Goa, Goa (Fig. 1). Geologically, Peninsular gneiss forms the basement rock ans major lithounit include metabasalt, quartzite and sericite schist (Fig. 2).

Physiographically the area is part of Western Ghats. Drainage basin is elongated in shape with dendritic pattern (Fig. 3). The major soil type includes laterite and alluvial soils. The area experiences warm and humid type of climate with minimum and maximum temperature being 21oC and 36oC in winter and summer respectively. Humidity increases during monsoon as compared to other seasons.

Agriculture and related practices is the main occupation of the people in the region. Wide range of crops, vegetables and fruits are grown such as rice, rabi, cashew nuts, brinjal, ladyfinger, banana, mango, jackfruit etc. Thus rainfall plays an important role in determining the groundwater potential of the study area.

Therefore an attempt has been made to study and assess the quality of water of GRSB for suitability of different purpose such as domestic, agriculture and industrial.

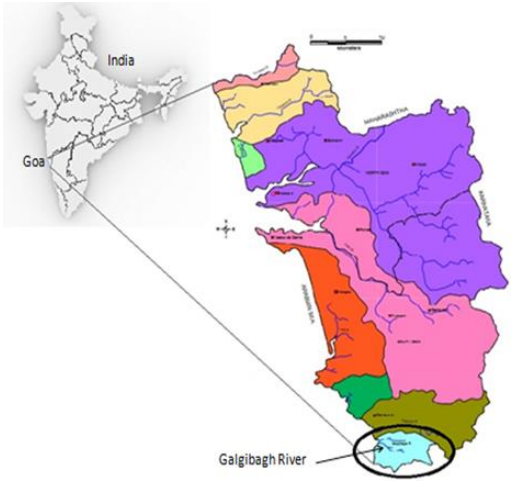

Figure 1 : Location of GRSB

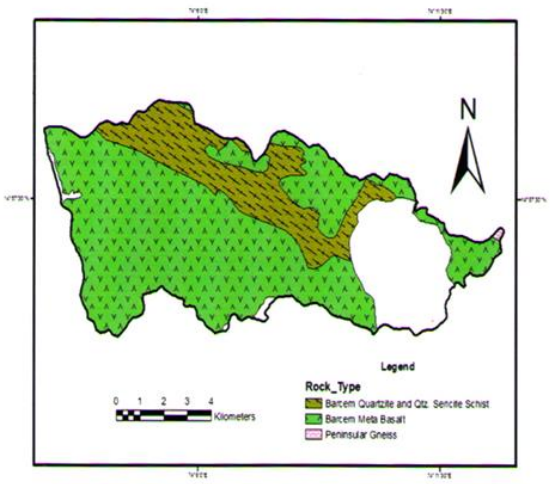

Figure 2: Geology of GRSB

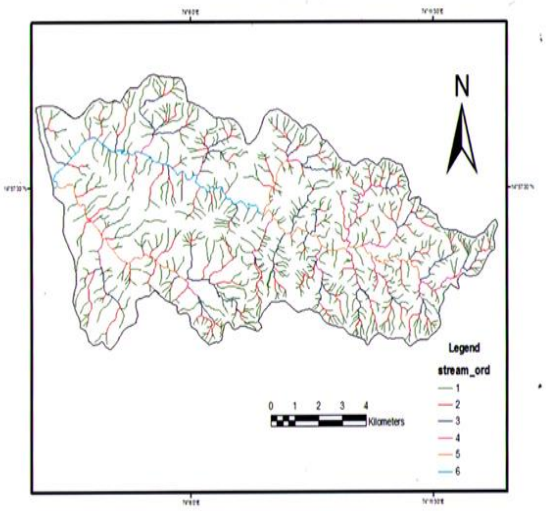

Figure 3: Drainage of GRSB

II. METHODS AND MATERIAL

25 units of water samples were collected from different sources in one litre pre-rinsed and washed cans. Physico-chemical analyses were carried out following standard procedures of APHA (1992). pH and electrical conductivity (EC) were tested directly in the field. Total dissolved solids (TDS) was calculated manually from EC*0.645 (Todd 1980). Sodium (Na) and potassium (K) were subjected to atomic absorption spectrophotometer (AAS). Calcium (Ca), hardness (H), carbonates (CO_3) and bicarbonates (HCO_3), chloride (Cl) and sulphate (SO_4) were analysed volumetrically. Different thematic maps were generated in GIS environment using ArcGIS v10. Table 1 representing physico-chemical analyses results of GRSB.

Table 1: Physico-chemical analyses results

Sl No	pH	TDS	EC	TH	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4
1	6.92	529	341	16	9.61	1.94	16.46	0.39	0	100	71	46
2	7.11	505	326	14	8.01	1.46	12.83	0.29	0	110	44.02	15
3	5.62	961	620	20	11.22	1.94	3.94	0.03	0	20	19.88	10
4	5.48	714	461	10	6.41	1.46	6.98	0.04	0	15	31.24	18
5	5.6	961	620	8	8.01	2.92	5.67	0.02	0	20	36.92	15
6	5.9	714	461	12	9.61	2.92	5.58	0.02	0	30	19.88	10
7	5.98	714	461	14	8.01	1.46	4.7	0.02	0	20	19.88	15
8	5.93	1195	771	14	6.41	0.48	4.98	0.03	0	30	24.14	10
9	5.99	961	620	16	10.42	2.92	4.5	0.05	0	25	19.88	10
10	5.47	481	310	10	8.01	2.43	4.86	0.01	0	25	25.56	10
11	6.3	1195	771	18	12.82	3.41	5.31	0.02	0	20	39.76	5
12	5.81	1442	930	22	16.03	4.38	6.34	0.04	0	25	34.08	15
13	5.72	714	461	28	12.02	0.48	4.97	0.03	0	25	29.82	10
14	6.23	1195	771	28	20.04	5.36	7.46	0.37	0	20	35.5	5
15	5.69	714	461	10	12.82	5.36	6.99	0.04	0	15	39.76	10
16	6.49	714	461	18	31.26	14.61	8.04	0.05	0	20	28.4	15
17	5.92	961	620	32	46.49	20.46	7.06	0.01	0	25	24.14	10
18	5.84	714	461	40	20.04	2.43	8.65	0.007	0	25	21.3	10
19	5.74	481	310	46	28.05	5.84	9.22	0.06	0	15	26.98	15
20	5.51	1442	930	20	33.66	15.59	11.03	0.03	0	30	22.72	34
21	5.85	1195	771	14	3.2	1.46	13.1	0.04	0	35	21.3	18
22	5.72	481	310	12	2.4	1.46	12.33	0.005	0	20	24.14	10
23	6.48	1195	771	30	8.01	2.43	19.02	0.01	0	25	28.4	15
24	6.01	1442	930	28	6.41	2.92	22.82	0.03	0	20	45.44	10
25	7.27	1442	930	20	4.8	1.94	26.97	0.02	0	25	42.6	15

III. RESULTS AND DISCUSSION

Total Dissolved Solids (TDS)

The suitability of groundwater for any purpose based on TDS is affected with the duration of water beneath regardless of its stay or flow. Accordingly groundwaters of GRSB has been classified based on Freeze and Cherry (1979) (Table 2) and which revealed that, 64% of the water samples fall in fresh water category while 36% fall in brackish.

Table 2 : TDS classification based on Freeze & Cherry

TDS (mg/lit)	Nature of Water	No. of Samples	%
<1000	Fresh	16	64
1000-10000	Brackish	09	36
10000-100000	Saline	-	-
>100000	Brine	-	-

Hardness (H)

Hardness of waters is generally expressed as the total concentration of Ca and Mg (mg/lit) equivalent to CaCO3. This is determined by substituting the concentration of Ca and Mg in the equation as mentioned under.

Hardness = 2.497 (Ca) + 4.115 (Mg)

Based on this the hardness of the GRSB range from 08 to 46 mg/lit.

Hardness of the waters of GRSB has been classified based on Sawyer and Mccarthy (1967) (Table 3) which revealed that all the waters fall in water class Soft.

Table 3 : Hardness classification based on Sawyer & McCarthy

Hardness (mg/lit)	Water Class	No. of Samples	%
0-75	Soft	25	100
75-150	Moderate	-	-
150-300	Hard	-	-
>300	Very hard	-	-

Electrical Conductivity (EC)

EC of the waters of GRSB has been classified based on Sarma et al (1982) (Table 4) and is presented in Table and based on that it was found that, 68% of the water samples fall in water class Good while rest 32% fall in Permissible.

Table 4 : EC classification based on Sarma et al

EC µs/cm	Water Class	No. of Sample	%
<250	Excellent	-	-
250-750	Good	17	68
750-2000	Permissible	08	32
2000-3000	Doubtful	-	-
>3000	Unsuitable	-	-

Domestic Purpose

Waters samples of GRSB were compared with national (Bureau of Indian Standard, 2003) and international (World Health Organisation, 2005) standards and it was found that all waters are safe and fit for domestic purpose (Table 5).

Table 5 : Comparison of BIS and WHO standards

Parameter	BIS (2003)		WHO (2005)		No. of Samples exceeding permissible
	Desirable	Permissible	Desirable	Permissible	
pH	6.5-8.5	-	7.0-8.5	9.2	-
TDS	500	2000	500	1500	-
TH	300	600	100	500	-
Ca	75	200	75	200	-
Mg	30	100	50	150	-
Cl	250	1000	200	600	-
SO_4	200	400	200	400	-

Irrigation Purpose

Sodium Absorption Ratio (SAR)

SAR is considered a better measure of sodium hazard in irrigation as it is directly related to the adsorption of sodium by soil and inhibits the supply of water needed for the crops by reducing soil permeability. It measures the proportion of sodium ions in water than that of calcium and magnesium. It is calculated using formula as under.

$SAR = Na/\sqrt{(Ca+Mg)}^{1/2}$ all values are in epm.

Based on this the waters of GRSB is classified as shown in Table 6 and it was found that all the water samples fall in water class Excellent.

Table 6 : Classification based on SAR hazard

SAR epm	Alkalinity Hazard	Water Class	No. of Samples	%
<10	S1	Excellent	25	100
10-18	S2	Good	-	-
18-26	S3	Doubtful	-	-
>26	S4	Unsuitable	-	-

Also the SAR (alkali hazard) and specific conductance (salinity hazard) data are plotted in US Salinity Laboratory (USSL 1954) diagram to determine the suitability of water for irrigation (Fig. 4). The diagram shows that, 84% of water samples in GRSB fall in field C2S1 indicating medium salinity and low alkalinity while 16% of water samples fall in field C3S1 indicating high salinity and low alkalinity.

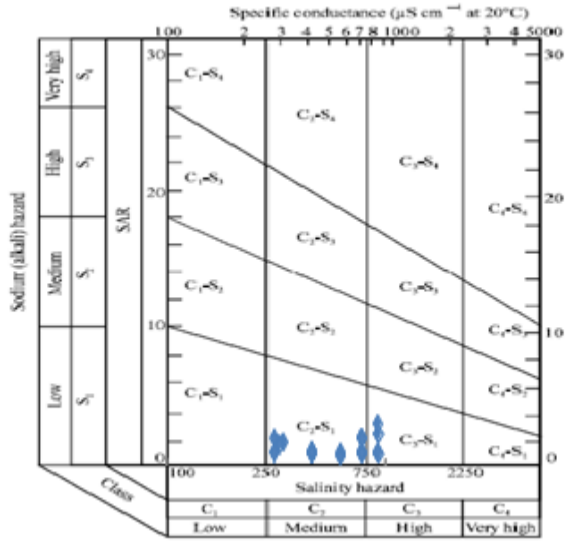

Figure 4 : USSL Diagram (Richards 1954)

Sodium Percent (Na %)

Sodium concentration and electrical conductivity are important parameters for classifying irrigation waters (Raghunath 1987). Sodium percent is determined using the formula:

Na% = Na + K/(Ca+Mg+Na+K) *100
all values are epm.

Based on this the groundwaters of GRSB are classified as presented in Table 7, which reveals 28%, 40% and 16% of water samples fall in the water class of Excellent, Good and Permissible respectively for suitability for irrigation while 16% of water samples are in Doubtful category.

Table 7 : Classification based on Sodium percent

Na% (epm)	Class	No. of Samples	%
<20	Excellent	07	28
20-40	Good	10	40
40-60	Permissible	04	16
60-80	Doubtful	04	16
>80	Unsuitable	-	-

Further Wilcox (1955) classified groundwaters in graphical way based on sodium percent and EC as shown in Fig. 5. And it was found that, 84% of water samples from the study area fall in category Excellent to Good followed by 2% each falling in Good to Permissible and Permissible to Doubtful.

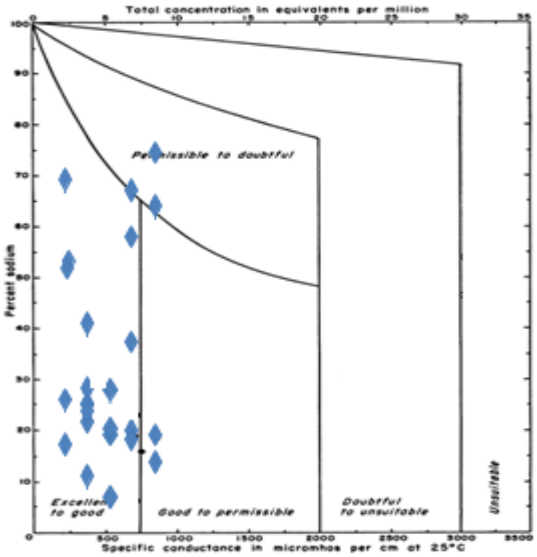

Figure 5: Wilcox Diagram (Wilcox 1955)

Residual Sodium Carbonate (RSC)

In waters having high concentration of bicarbonate, there is tendency for calcium and magnesium to precipitate as the water in the soil becomes more concentrated. Thus results in increase on concentration of sodium in water in the form of sodium carbonate. RSC is calculated by following equation (Eaton 1954).

RSC = HCO3 – (Ca + Mg) all values are in epm

Table 8 : RSC classification for irrigated waters

RSC (epm)	Water Class	No. of Samples	%
<1.25	Good	21	84
1.25-2.5	Doubtful	3	12
>2.5	Unsuitable	1	04

Based on this classification (Table 8), it was observed that in the waters of GRSB, 84% of water samples are in category Good while 12% and 4% of water samples are in category Doubtful and Unsuitable respectively.

IV. CONCLUSION

Water quality studies were carried out for Galgibagh River Sub-basin (GRSB), South Goa, Goa which is part of Western Ghats. Geologically, it is underlain by peninsular gneiss as basement. Comparison of water samples with BIS and WHO standards revealed all waters are safe for domestic use. Irrigation parameters like SAR revealed all samples are free from sodium hazard. Sodium percent revealed that all waters range from excellent-good-permissible category. While USSL diagram to determine the suitability for irrigation revealed 84% of waters to be having medium salinity and low alkalinity. Wilcox diagram also revealed 84% of the water samples falling in excellent to good category.

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