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Assessment of Groundwater Quality for Irrigation Use and Evolution of Hydrochemeical Facies in the Yeshwanthapur Sub-Basin, Warangal Dist.

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Abstract: *The Yeshwanthapur is a sub-basin of Aler river basin with an aerial extent of 688 sq. kms with a perimeter of 136 kms. The study area comprises Archaean group of rocks represented by Peninsular Gneiss Complexes occupy major part of with grey and pink granite/gneisses. Assessment of groundwater quality for irrigation use and hydrochemical evolution of groundwater has been studied. Hydrochemical analysis has been carried out based on concentrations of Ca+, Mg+, Na+, K+, Cl+, F, So-, Co- and HCo3, Sodium adsorption ratio (SAR) and Percent Sodium (%Na) have been studied to evaluate suitability of irrigation use most of the area groundwater in the basin*

Keywords: *Groundwater quality, Hydrochemical analysis, Irrigation use, Yeshwanthapur sub-basin, Warangal.*

I. Introduction

The Yeshwanthapur is a sub-basin of Aler river basin and forms part of Warangal district in Telangana with an aerial extent of 688 sq. kms with a perimeter of 136 kms. The sub-basin lies between north latitude 17° 53' 10" to 17° 28' 42" and east longitude 79° 04' 24" to 79° 24' 51" represented in parts of the Survey of India toposheet No's 56 O/1, 56 O/2, 56 O/5, 56 O/6, and 56 O/7 (Fig.1). The north-western part of the study area at Venkiryala village is having maximum elevation of 516 meters above Mean Sea Level (MSL) and minimum at Thatipamula village having 240 meters above MSL with slope in NW to SE direction. The maximum length and width of Yeshwanthpur sub-basin is 49.3 kms and 22.7 kms respectively. Red and black cotton soils which dominated the area with a character of swelling clays integrated drainage networks with high density slope areas and so on causing rapid runoff leaving relatively little water for recharge. The investigated area receives scanty rain fall and has limited surface water resources. The climate of the surface of the sub-basin is semi-arid and receives an average rainfall of 765.80 mm, out of which 90% is received during north western (June-Sep) monsoon period. The average temperature is 28 + 5° C on the basis of climatic classification the area falls under Semi-arid climatic zone (D-type). Geology of the study area comprises Archaean group of rocks represented by Peninsular Gneiss Complexes with grey and pink granite/gneisses occupy major part of the area and in many places leached calcium carbonate precipitates are found which are locally known as Kankar (Fig.2). They form hard layers just below the top soil and have high fluoride content. These deposits are associated with black and alkanlie soils. They are formed by the depositions of CaCo3 as nodular masses.

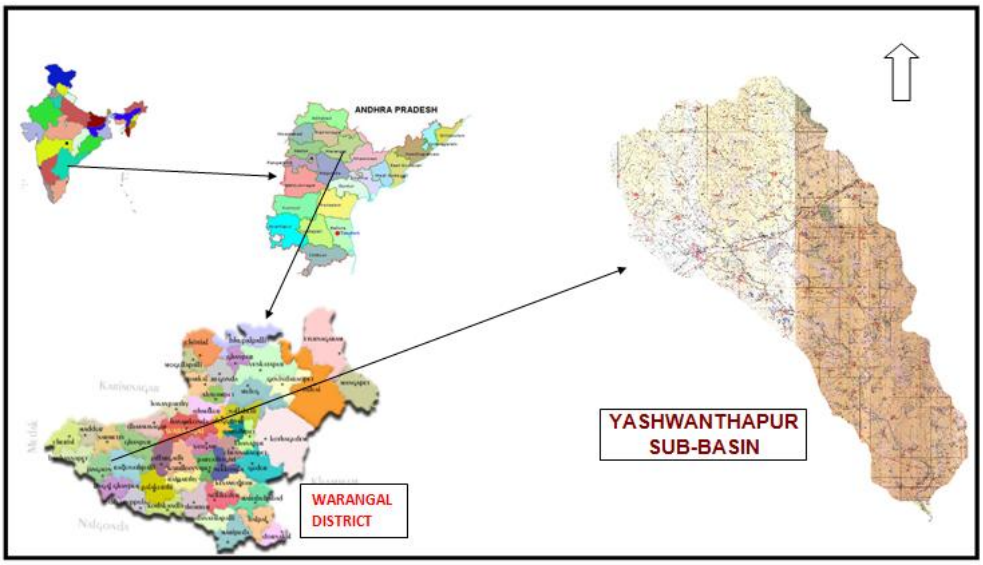

Fig. 1 Showing Location map the Study Area

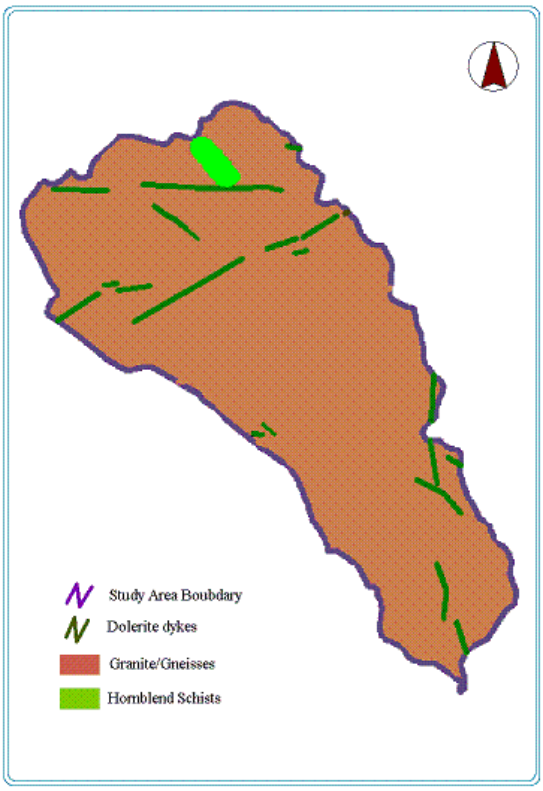

Fig.2 Showing Geology of the Area

II. Experimental Methods

Groundwater samples were collected at selected locations based on hydrogeomorphology all over the area of the sub-basin. Detailed hydrogeological investigations have been carried out to know the geochemical behavior and to assess the quality of groundwater in the area. 34 samples were collected in which 21 is from dug wells 13 from bore wells (Fig.3). Physical and chemical parameters of 34 samples were analysed to know the quality of water as per standards and the data is presented in Table.1 major iron concentrations were determined by using Bureau of Indian standards BIS (1991) and WHO international Standard (2006) methods.

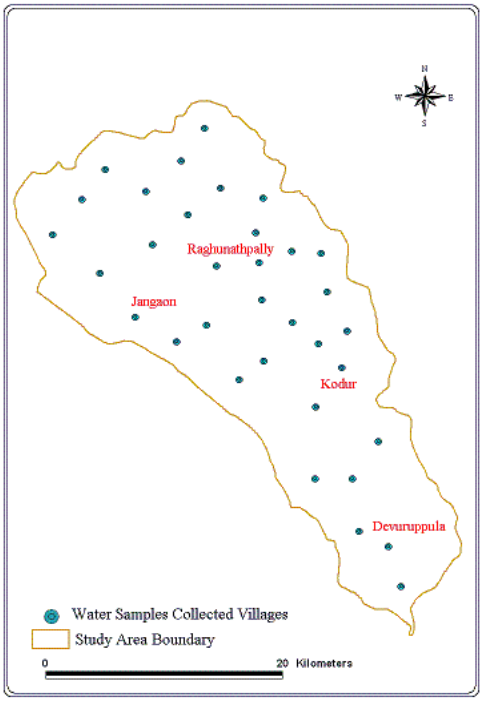

Fig. 3 Water sample locations in the study area

Table 1. Chemical Analysis Data of Groundwater Samples of the Area
(Values are in ppm except TDS and EC)

Sl. No.	Village	Bore type	pH	EC	TDS	Alkanity	TH	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	F	NO_3	Fe	%Na	SAR
1	Manchupahad	DW	7.2	2600	1495	180	648	364	52	141	23	0.0	468	272	64	0.8	10.0	0.3	28.3	9.77
2	Venkiryala	BW	7.4	1750	1137	108	480	128	32	112	12	0.0	397	104	78	0.4	0.0	0.0	43.7	9.33
3	Adavikeshavapur	BW	7.5	1780	1157	100	520	100	26	68	0.0	20.0	280	92	42	0.4	0.0	0.0	30.1	0.06
4	Yerragollaphad	BW	7.5	1250	812	140	568	292	47	79	39	12.0	218	80	51	1.6	0.0	0.0	25.8	6.06
5	Wadlakonda	DW	7.8	1130	735	124	264	211	52	85	0.0	0.0	438	68	36	2.6	0.0	0.0	24.4	7.41
6	Jangon	DW	7.5	870	565	168	344	108	29	77	0.0	0.0	317	40	72	0.8	0.0	0.0	35.6	9.30
7	Yeshwanthapuram	BW	8.0	530	344	120	296	40	36	67	27	18.0	369	32	43	2.0	0.0	0.0	55.2	10.9
8	Marigudi	DW	7.6	1670	1080	156	408	156	43	108	40	0.0	445	108	48	2.2	0.0	0.0	42.7	10.8
9	Nellutla	DW	7.7	490	318	96	228	56	28	47	38	0.0	235	104	56	0.4	0.0	0.0	50.2	7.25
10	Nidigonda	DW	7.3	1900	1235	164	684	166	43	93	34	0.0	409	292	92	1.6	0.0	0.0	37.8	9.09
11	Patelgudem	DW	7.9	470	305	96	220	64	30	80	0.0	3.0	439	80	28	0.6	0.0	0.0	45.6	11.6
12	Kundaram	DW	7.5	750	487	80	328	148	66	124	0.0	0.0	369	132	38	0.6	5.0	0.0	36.7	11.9
13	Mekalagutta	BW	7.4	750	487	72	220	56	19	51	0.0	0.0	347	68	44	2.4	0.0	0.1	40.4	8.32
14	Madalagudem	BW	7.6	970	630	96	256	52	26	48	0.0	8.0	360	28	26	1.6	0.0	0.0	38.1	7.68
15	Kottagudem	DW	7.3	1800	1170	116	380	98	23	44	42	0.0	204	240	52	0.8	5.0	0.0	41.5	5.65
16	Aswaraopalli	DW	7.3	2200	1430	128	424	104	42	119	28	0.0	277	100	80	1.2	0.0	0.0	50.2	13.9
17	Ibrahimpur	DW	7.9	770	500	92	272	100	38	86	36	0.0	475	68	49	1.6	0.0	0.0	46.9	10.3
18	Dasannagudem	DW	7.6	1060	689	116	908	196	52	124	0.0	0.0	280	480	82	2.4	0.0	0.0	33.3	11.1

Table 1. Chemical Analysis Data of Groundwater Samples of the Area
(Values are in ppm except TDS and EC)

Sl. No.	Village	Bore type	pH	EC	TDS	Alkanity	TH	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	F	NO_3	Fe	%Na	SAR
19	Vildhi	DW	7.1	1850	1202	88	400	68	64	61	22	12.0	390	136	43	0.4	0.0	0.0	38.6	7.50
20	Raghunathpally	BW	7.5	2800	1820	132	416	328	44	72	56	0.0	185	300	62	1.2	0.0	0.0	25.6	3.22
21	Venkatapally	BW	7.9	1240	806	176	224	28	24	52	29	0.0	292	96	71	2.0	5.0	0.0	60.9	10.2
22	Govardhanagiri	BW	7.5	1230	799	120	500	100	81	112	05	0.0	334	76	28	1.4	0.0	0.0	39.3	11.7
23	Kommala	DW	7.5	3100	2015	196	804	32	31	27	13	12.0	372	292	32	1.8	0.0	0.0	38.8	4.81
24	Yella Reddy Gudem	BW	7.4	920	598	140	372	192	78	96	39	0.0	488	48	47	1.8	0.0	0.0	33.3	8.26
25	Kanchanpally	DW	7.6	1720	1118	188	612	136	67	82	18	19.0	302	88	26	0.8	0.0	0.0	33.0	8.13
26	Bhanjipet	DW	7.0	1600	1040	160	936	128	49	65	06	0.0	289	436	26	0.4	0.0	0.0	28.6	6.90
27	Gobbeta	DW	7.5	1580	1027	100	364	60	43	34	09	0.0	427	128	61	2.4	5.0	0.0	29.5	4.73
28	Kodur	BW	7.3	1840	1196	112	544	196	58	26	40	0.0	341	204	70	1.2	0.0	0.0	20.6	2.30
29	Padamati Thanda	DW	6.8	2200	1430	80	608	320	34	49	26	0.0	488	168	83	1.8	0.0	0.0	17.5	3.68
30	Pedda Madur	BW	7.2	2150	1400	164	228	64	40	80	11	0.0	390	90	45	0.4	5.0	0.0	46.7	11.0
31	Karavendi	DW	7.4	1350	877	116	346	98	38	66	0.0	5.0	359	130	33	1.4	5.0	0.1	32.7	8.00
32	Devuruppula	DW	7.3	2064	1342	220	820	208	27	102	42	0.0	218	200	47	2.4	15.0	0.2	38.0	9.40
33	Sitharampuram	BW	7.4	2490	1618	104	1268	296	52	48	38	11.0	374	160	29	2.2	10.0	0.0	19.8	3.63
34	Gollapalli	DW	7.3	2320	1508	210	980	208	59	53	23	16.0	231	160	57	2.2	10.0	0.0	22.1	4.58
	Average		**7.46**	**1564**	**1010**	**131**	**496**	**144**	**43.3**	**75.8**	**20.4**	**4**	**347.2**	**150**	**51.2**	**1.40**	**2.20**	**0.02**	**36.2**	**7.89**
	Maximum		**8.0**	**3100**	**2015**	**220**	**1268**	**364**	**81**	**141**	**56**	**20**	**488**	**480**	**92**	**2.6**	**15**	**0.3**	**60.9**	**13.9**
	Minimum		**6.8**	**470**	**305**	**72**	**220**	**28**	**19**	**26**	**0**	**0**	**185**	**28**	**26**	**0.4**	**0**	**0**	**17.5**	**0.06**

The evaluation of groundwater for the irrigation purposes, depends upon the dissolved salts, relative proportion of bicarbonate to calcium and magnesium, relative proportion of sodium to calcium on the plant and soil, dominant climatic conditions, irrigation techniques, and drainage system (Todd, 2001). The suitability of water for irrigation is dependent upon such factors as soil texture and composition, crop grown and irrigation practices in addition to chemical characteristics of the water. For determination of suitability for irrigation use SAR%, Na% were calculated and plotted on Wilcox diagram (1955) and US Salinity Laboratory diagram (1954). The Wilcox's diagrams are prepared by plotting the sodium percentage (Na%) against electrical conductivity (EC) (Fig.4). The US Salinity Laboratory diagram sodium adsorption ratio (SAR) is plotted on vertical axis and Electrical Conductivity (EC) on horizontal axis (Fig.5). The total dissolved solids content,

measured in terms of specific electrical conductance, excessive sodium content in water renders it unsuitable of soils containing exchangeable Ca++ + Mg++ + Na++ is considerably above 50 in irrigation waters, soils containing exchangeable calcium and magnesium causing deflocculation and impairment of the filth and permeability of soils. The US salinity diagram is divided into four distinct fields both vertical axis sodium (alkali) hazard divided into low sodium water (S1), medium (S2), high (S3), and very high sodium water (S4) (Table.2). Generally low sodium water can be used for irrigation purposes on the horizontal axis salinity hazard is divided into four groups low (C1), medium (C2), high (C3), and very high salinity (C4) water (Table.3). Low salinity water can be used for irrigation purpose for most crops, high and very high salinity water is unfavorable for irrigation purpose.

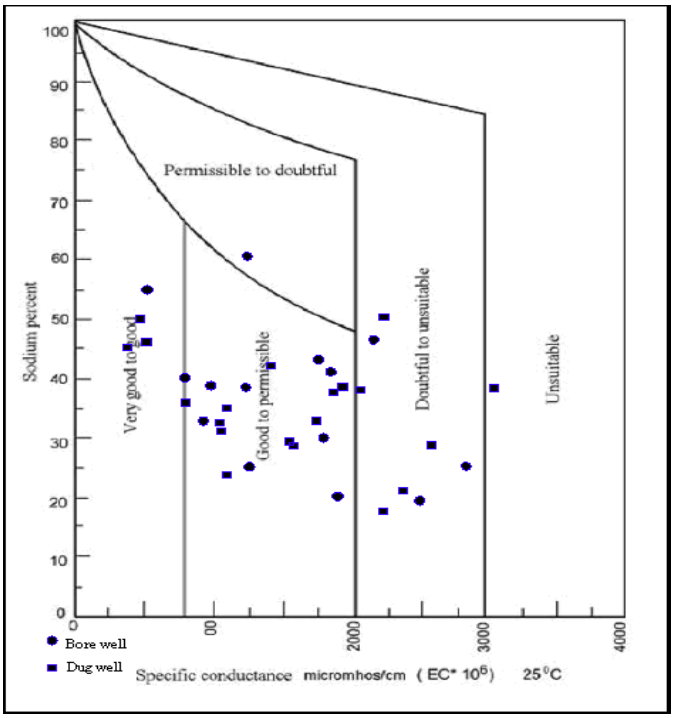

Fig. 4 Plotting of EC Vs Na% on Wilcox's diagram (1955)

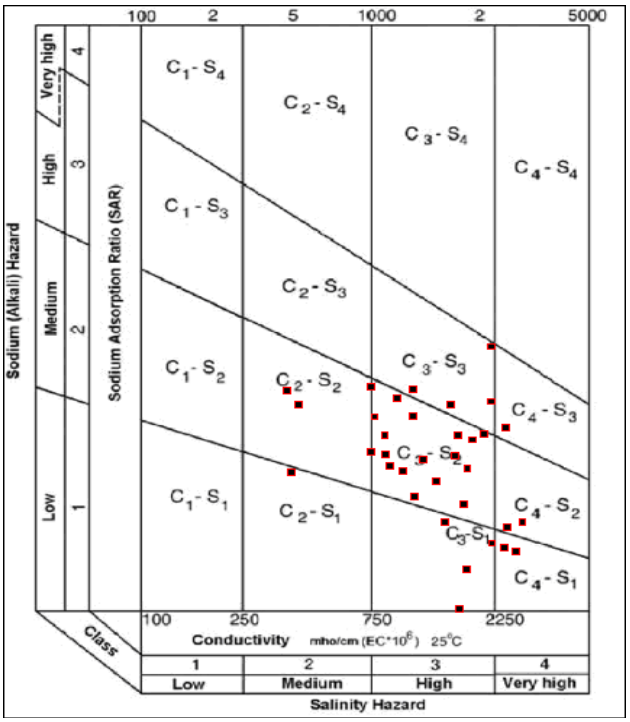

Fig.5. Plotting of sample data on US Salinity laboratory diagram

Table 2. Irrigation water classification based on sodium content

Classification	Comment
S1	Low sodium water can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. However, sodium-sensitive crops such as stone fruit trees and avocado may accumulate injurious concentration of sodium.
S2	Medium sodium water will present an appreciable sodium hazard in fine textured soils having high cation exchange capacity, especially under low leaching conditions, unless gypsum is present in the soil. This water can be used on coarse-textured or organic soils with good permeability.
S3	High sodium water may produce harmful levels of exchangeable sodium in most soils and will require special soil management good drainage, high leaching, and organic matter additions. Gypsiferous soils may not develop harmful levels of exchangeable sodium except that amendments may be required for replacement of exchangeable sodium except that amendments may not be feasible with waters of very high salinity.
S4	Very high sodium water is generally unsatisfactory for irrigation purposes except at low and perhaps medium salinity, where the dissolving of calcium from the soil or the use of gypsum or other additives may make the use of these waters feasible.

Table 3. Groups of irrigation waters based on electrical conductivity

TDS (mg/l)	ECx10^6 at 25^0 C	Class	Remarks
< 200	<250	C1	Low salinity water-can be used for irrigation with most crops on most soils with little likelihood that a salinity problem will develop. Some leaching is required, but this occurs under normal irrigation practices except in soils of extremely low permeability.
200-500	250-750	C2	Medium salinity water can be used if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most instances without special practices for salinity control.
500-1500	750-2250	C3	High salinity water-cannot be used on soils with restricted drainage, special management for salinity control may be required and plants with good salts tolerance should be selected.
1500-3000	2250-5000	C4	Very high salinity water-is not suitable for irrigation under ordinary conditions but may be used occasionally under very special circumstances. The soil must be permeable, drainage must be adequate, and irrigation water must be applied in excess to provide considerable leaching, and very salt-tolerant crops should be selected.

After U.S. Salinity laboratory, 1954.

The overall samples with regard to sodium and salinity hazard are represented in the Table 4.

Table 4 Showing sodium and salinity hazards

S.No	No. of Samples	Field
1	1	C2-S1
2	4	C2-S2
3	4	C3-S1
4	16	C3-S2
5	4	C3-S3
6	2	C4-S1
7	2	C4-S2
8	1	C4-S3

Thus from the above classification most of the water samples indicate the ground water of Yeshwanthapur sub-basin is moderate water.

III. Results And Discussion

The analytical results and statistical parameters derived from hydrochemical parameters in the groundwater of the Yeshwanthapur sub-basin are presented in the Table.1. pH values in the basin range from 6.8 to 8.0 indicating groundwater of the basin is normal to slightly alkaline in nature. The specific Electrical Conductance (EC) values range from 470 to 3100 µ mhos/cm and higher values indicate that ionic concentration

is more. Total Dissolved Solids (TDS) vary from 305 mg/l to 2015 mg/l are slightly saline. Fluoride concentration in the sub-basin is ranging from 0.4 to 2.6 mg/l and average is 1.4 mg/l some of the samples are identified with above permissible limit in the sub-basin due to the disintegration of biotite, apatite and fluoride minerals present in the acid rocks like granites these are not useful for drinking purpose. In few samples concentration of Calcium, Magnesium, Potassium Sodium Carbonates and Bicarbonates are within permissible limits where as Chlorides Sulphates and Nitrates are above the permissible limits.

Groundwater quality for determination of Irrigation use

Percent Sodium:

To determine the suitability for irrigation use in groundwater is by calculating Na+ percentage (Wilcox, 1955), because Na+ concentration reacts with soil to reduce its permeability (Todd, 1980).

Percent Sodium is calculated as:

$$\text{Percent Sodium} = \frac{(Na+ + K) \times 100}{(Ca2+ + Mg2+ + Na+ + K+)}$$

Where, the concentration is expressed in meq/l.

According to Wilcox classification 6 samples falling under very good to good, 18 samples are under good to permissible, 1 sample under permissible too doubtful, 8 samples are under doubtful to unsuitable, and 1 sample falling unsuitable category (Table.5). Percent Sodium plotted on Wilcox diagram indicates that out of 34 samples, 24 samples belong to very good to permissible category, 08 samples belong to doughtful and 1 sample belong to unsuitable category.

Table 5 Irrigation water classification according to Na%
(Wilcox, 1955)

Na%	Water Class	Sample %
< 201	Very good	6
20-40	Good	18
40-60	Permissible	1
60-80	Doubtful	8
>80	Unsuitable	1

Sodium Adsorption Ratio (SAR):

Another method for determination of suitability for agricultural use in groundwater is by calculating SAR values. Sodium Adsorption Ratio (SAR) is the value of adsorption of Na by soil constituents during water percolation. This ratio has certain advantages for use as an index of the sodium or alkali hazard of the water (Todd, 2001). A higher value of SAR leads to damage of soil structure (Suresh, 1994; Todd, 2001). Alkali hazard in soils is promoted by high SAR and is reversed by water containing high calcium and magnesium.

The SAR is defined and obtained by

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

Where, all the ions are expressed in Meq/l.

The SAR values in the area ranges between 0.06 and 13.9. According to the standards given in the Table No. 6, all the samples are falling in the class of excellent to good category.

Table 6 Irrigation classification of groundwater according to SAR values

SAR	Water Class	Sample %
<10	Excellent (S1)	24
10-18	Good (S2)	10
18-26	Doubtful (S3)	0
>26	Unsuitable (S4)	0

Based on the above analysis the groundwater of the area contains higher concentration of K, Ca, Na, Mg and chloride. The K, Ca, and Na might have been released by the chemical weathering of both the k-feldspars and plagioclases present in the country rocks i.e., granites and granitic gneisses. The high concentration of Mg and Chlorides may be due to the alteration of ferro-magnesium minerals present in the gneisses. The groundwater is mostly neutral to slightly alkaline character. The excess fluoride may be due to the presence of fluorite, mica, and apatite minerals present in the granites.

Further, they are mostly suitable for agriculture. However, they are less suitable for drinking purpose since they have high concentration of fluoride and total hardness.

IV. **Conclusions**

An Interpretation of hydrochemical analysis for groundwater quality and evolution of hydrochemical facies in the yeshwanthapur sub-basin reveals that concentrations of the major ions and important physical parameters are within the permissible limits for irrigation SAR values range from 0.06 mg/l to 13.9 mg/l and water falls in the class excellent to good category. Percent Sodium values indicate the most of groundwater samples belongs to very good to permissible category for irrigation on Wilcox diagram. Thus, the overall groundwater quality in the sub-basin is fresh and suitable for irrigation use.

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