Assessment of Groundwater Quality for Irrigation use and Evolution of Hydrochemical Facies in the Peddavagu Sub-Basin in Part of Warangal & Karimnagar Districts of Telangana State, India

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Abstract

The Peddavagu basin occupying an area of about 1751 km². The area falls under a semi-arid type of climate and consists of pink & gray granites and intrusions of dolerite dykes of Archaean age. Assessment groundwater quality for drinking, irrigation purpose use and hydrochemical evolution of groundwater has been studied. For this study groundwater samples were collected from 75 of the 36 bore wells and 39 open wells representing the entire study area. The water samples were analyzed for physio-chemical parameters like pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), Calcium (Ca^{+2}), Magnesium (Mg^{+2}), Sodium ($Na+$), Potassium ($K+$), Carbonate ($CaCo3$), Bicarbonate ($HCo3$), Chloride ($Cl+$), Sulphate (So^{+2} 4), Nitrate ($No3$), and Fluoride (F) using standards techniques in the laboratory and compared with the standards. The groundwater quality information maps of the entire study area have been prepared using spatial interpolation technique for all the above parameters. The result obtained in this study and the spatial database established in GIS will be helpful for monitoring and managing groundwater pollution in the study area. Mapping was coded for potable zones in the absence of better alternate source and non-potable zones in the study area, in terms of water quality.

Key words: *Groundwater, Quality, Hydrochemical parameters, spatial interpolation, irrigation Peddavagu sub-basin Warangal & Karimnagar Districts, Telangana State.*

I. INTRODUCTION

Groundwater is one of earth's most vital renewable and widely distributed resources as well as an important source of water supply throughout the world. The quality of water is a vital concern for mankind since it is directly linked with human welfare. In India, most of the population is dependent on groundwater as the only source of drinking water supply (NIUA, 2005; Mahamood and Kundu, 2005; Phansalkar et al., 2005). The groundwater is believed to be comparatively much clean and free from pollution than surface water. Groundwater can become contaminated naturally or because of numerous types of human activities; residential, municipal, commercial, industrial, and agricultural activities can all affect groundwater quality (U.S, EPA, 1993; Jalali, 2005a; Rivers et al., 1996; Kim et al., 2004; Srinivasmoorthy et al., 2009; Goulding 2000; Pacheco and Cabrera, 1997). Contamination of groundwater can result in poor drinking water quality, loss of water supply, high clean-up costs, high costs for alternative water supplies, and/or potential health problems. A wide variety of material has been identified as contaminants found in groundwater. These include synthetic organic chemicals, hydrocarbons, inorganic cat ions, inorganic anions, pathogens, and radio nuclides (Fetter, 1999). The importance of water quality in human health has recently attracted a great deal of interest. In developing countries like India around 80%of all diseases are directly related to poor drinking water quality and unhygienic conditions (Olajire and Imeokparia, 2001; Prasad, 1984).

Groundwater is a valuable natural resource that is essential for human health, socio-economic development, and functioning of ecosystems (Zektser, 2000; Humphreys, 2009; Steube et al., 2009). In India severe water scarcity is becoming common in several parts of the country, especially in arid and semi-arid regions. The overdependence on groundwater to meet ever-increasing demands of domestic, agriculture, and industry sectors has resulted in overexploitation of groundwater resources in several states such as Gujarat, Rajasthan, Punjab, Haryana, Uttar Pradesh, Tamil Nadu, among others (CGWB 2006; Garg and Hassan, 2007; Rodell et al., 2009). Geographic information system (GIS) has emerged as a powerful tool for storing analyzing, and displaying spatial data and using these data for decision making in several areas including engineering and environmental fields (Stafford, 1991;

Goodchild, 1993; Burrough and McDonnell, 1998; Lo and Yeung, 2003).

Groundwater can be optimally used and sustained only when the quantity and quality is properly assessed (Kharad et al., 1999). GIS has been used in the map classification of groundwater quality, based on correlating total dissolved solids (TDS) values with some aquifer characteristics (Butler et al., 2002)

Considering the above aspects of groundwater contamination and use of GIS in groundwater quality mapping, the present study was undertaken to map the groundwater quality peddavagu sub-basin in Telangana ,India.. The literature survey indicates that several researchers have mad studies on groundwater quality of both bore wells and open wells in the area. Some have studied only physic-chemical parameters, while some have observed the parameters in a combined state; while a few have studied the bacteriological status of these waters. Further there are reports only on the detection of hydro-chemical factors.. This study aims to visualize the spatial variation of certain physic-chemical parameters through GIS. An appropriate assessment of the suitability of groundwater for domestic water supplies requires the concentrations of some important parameters like pH, electrical conductivity (EC), total dissolved solids (TDS), Ca, Mg, K, Na, Cl, HCO3, and SO4, and comparing with the guideline values set for potable water (WHO, 2004). Irrigation water quality refers to the kinds and amounts of salts present in the water and their effects on crops growth and development. High salt concentrations influence osmotic pressure of the soil solution and affect the ability of plants to absorb water through their roots (Glover, 1996). However, an appropriate evalution of the water quality prior to its use in irrigation will help in arresting any harmful effect on plant productivity and groundwater recharge. The suitability of water for irrigation is determined in several ways including the degree of acidity or alkalinity (pH), EC, sodium adsorption ratio (SAR) and sodium percentage. A detail geochemical study was carried out in order to identify groundwater quality and its suitability for domestic use by comparing the concentrations of selected water quality parameters.

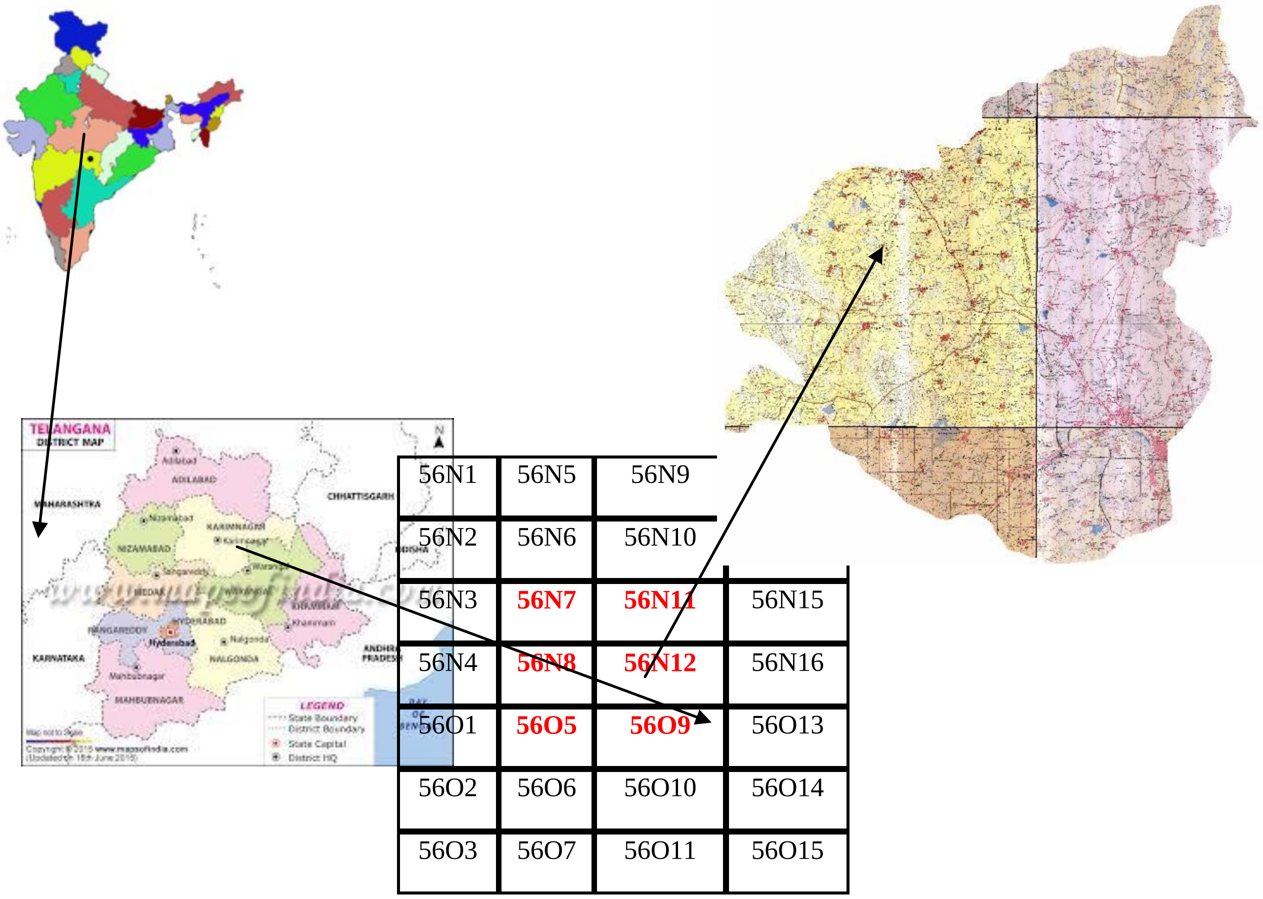

Fig. 1 showing location map of the study area

The main objective of the research work is to make a groundwater quality assessment using GIS, based on the available physic-chemical data from 76 locations in peddavagu sub basin. The purposes of this assessment are (1) to provide and overview of present groundwater quality, (2) to determine spatial distribution of groundwater quality parameters such as Hardness, TDS, NO3, and Cl-, and (3) to generate groundwater quality zone map for the peddavagu sub basin.

Study area: The peddavagu sub-basin that forms part of the Manair River which is tributary to river Godavari is situated about 70 km west of Warangal city the area under investigation is geographically located in 10 mandals Warangal and Karimnagar Districts of Telengana. The sub-basin lies between the North latitudes 18˚ 20' 30" to 17˚ 53' 20" and East longitudes 79˚14' 58" to 79˚ 40' 44" which forms parts of the Survey of India (SOI) toposheet No.s 56N/7, 56N/8, 56N/11, 56N/12, 56O/5, 56O/9 on 1:50,000 scale with an area extent of 1309 km² (Fig.1) investigation is intended to study the morph metric characteristics of the drainage basin with a special stress on groundwater conditions of the area with the help of strahlar's (1952) classification.

II. TOPOGRAPHY AND CLIMATE

The area has hilly topography on the north – western part of the sub-basin. The area slopes form south – west to northern part of the basin with the altitude from a maximum of 662 mts which is located on the north –western part of the sub-basin and minimum altitude of 400 mts lies on the western part of the basin is observed of most part of the hilly terrain in the north is covered by Dharmasagar reserve forest and the main cultivation is confined to the plains. The annual average rainfall of the area as 880.00mm, and most of the rainfall received from southwest monsoon, from of June to September. Around 78 percent of rainfall received from southwest monsoon and around 13 persent from north east monsoon and around a percent of rainfall received from winter of summer. September is the rainiest month in the peddavagu sub-basin. The climate of the study area is generally and dries with the temperature varying between 13˚C to 46˚C and occasionally touches 49˚C. The soil cover of the basin consists of Block cotton soils, Red soils, Loamy soils. Paddy, jowar, bajra, maiza, sunflower, groundnut are the principal crops grown in the study area. The study area is located in semi and tropic zone have been recorded at several places on some days in May.

Geology of the Area: The peddavagu basin area comprises Archaean group of rocks represented by peninsular granites

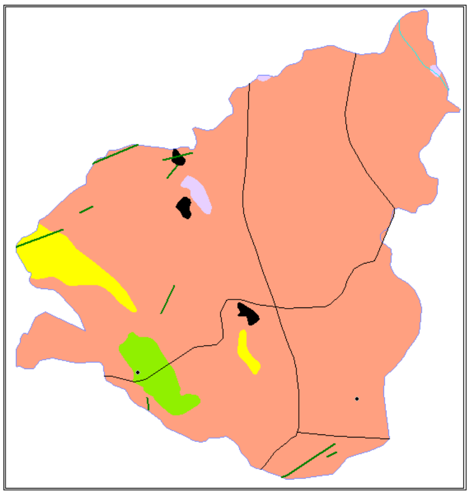

Fig 4.1 Geology of the Study Area

III. METHODOLOGY

As part of the study, groundwater samples are collected from 75 bore and dug wells. The samples taken during March 2009 were analyzed for various physical & chemical parameters (Fig.2) (Table1).

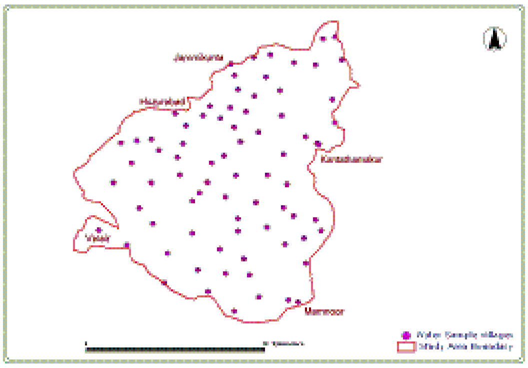

Fig 2 Water samples location in the study area

Table 1. Chemical Analysis Data of Groundwater Samples Peddavagu sub-basin

(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	Class
1	Valair	BW	7.9	1310	700	80	668	172	41	61	10	20	120	180	44	0.8	0	Nil	25.0	5.91	C3S1
2	Valair	DW	7.8	1240	660	68	348	128	38	42	13	0	180	200	82	0.8	5	0	17.1	4.50	C3S1
3	Mupparam	BW	8.1	1013	580	52	252	80	29	54	8	0	110	108	54	2..0	0	0	36.2	7.31	C3S2
4	Gundlasagar	DW	8.1	1010	626	56	408	52	44	46	6	40	85	80	62	0.8	5	0	30.1	6.64	C3S2
5	Ramapuram	BW	8.2	2000	1300	84	740	368	36	120	14	30	90	350	74	0.4	0	0.3	24.9	8.44	C3S2
6	Elkurthi	BW	8.0	950	589	30	328	100	54	68	12	25	125	140	66	1.6	0	0	34.1	7.75	C3S2
7	Khatampally	BW	7.6	1800	1170	60	880	176	70	118	10	10	150	308	60	1.2	20	0	14.6	6.21	C3S2
8	Madikonda	DW	7.6	630	390	52	280	120	84	49	9	0	180	52	52	1.2	5	0	22.1	4.90	C2S1
9	Hasanparthy	BW	6.0	1600	992	120	332	80	80	34	21	40	80	160	48	0.8	15	0.3	25.6	3.81	C3S1
10	Devanpeta	BW	7.3	1460	950	300	500	125	64	59	4	20	60	160	54	1.5	10	0.6	24.8	6.06	C3S1
11	Pegadapally	BW	6.8	1650	1023	100	480	188	38	48	0	20	112	220	46	0.4	15	0.5	23.6	4.52	C3S1
12	Nagaram	DW	6.9	1870	1171	92	404	132	64	92	10	0	108	236	44	1.4	0	0.3	19.4	4.85	C3S1
13	Vanagapahad	BW	7.1	1940	1202	188	1108	200	39	87	0	20	100	304	39	0.8	10	0.3	28.4	7.95	C3S2
14	Munipalli	DW	6.6	1290	799	128	548	108	44	42	7	30	110	148	41	1.2	0	0	24.3	4.83	C3S1
15	Bheemaram	BW	7.4	400	248	64	176	100	35	50	11	35	120	60	35	0.4	6	1.0	31.1	6.09	C2S1
16	Mucharla	DW	7.3	1690	1047	124	492	64	40	46	6	40	136	188	38	2.0	5	0	29.5	5.85	C3S1
17	Somidi	BW	7.5	1000	620	84	1680	380	117	82	6	20	100	104	88	0.8	10	0	15.4	5.16	C3S1
18	Hanamkonda	DW	7.2	1510	936	116	464	336	29	117	6	0	100	188	36	0.4	15	0.1	46.7	8.16	C3S2
19	Kadipikonda	DW	7.5	710	440	80	324	104	25	68	8	40	60	144	61	1.0	0	0	33.7	8.46	C2S2

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(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	Class
20	Malakpeta	DW	7.0	910	564	60	320	168	40	47	7	8	80	148	82	0.4	0	0	23.7	6.29	C3S1
21	Timmapur	BW	6.9	1970	1221	140	728	120	39	38	6	46	86	432	44	1.4	0	0.1	28.6	6.50	C3S2
22	Arepally	BW	8.5	561	359	94	220	24	39	28	6	40	97	70	36	1.8	2	0	23.7	3.10	C2S1
23	Mamnoor	BW	8.0	1340	858	102	540	56	97	63	7	0	310	220	24	1.2	15	0.1	21.2	7.2	C3S2
24	Warangal	BW	8.2	708	453	114	120	24	15	46	8	0	160	90	3	2.3	10	0	66.5	10.4	C3S2
25	Dharmaram	BW	8.8	1320	845	120	440	88	54	64	8	60	190	220	77	1.8	10	0.1	33.6	7.56	C3S2
26	Nadikuda	DW	7.8	900	560	77	317	112	38	48	11	20	66	120	81	0.4	10	0	33.7	5.54	C3S1
27	Kanthamakur	BW	8.6	1200	768	80	440	88	55	17	10	40	100	216	76	1.2	3	0.2	26.7	0.51	C3S1
28	Ramakrishnapur	DW	8.6	920	589	90	700	120	97	55	12	40	100	130	67	1.1	10	0	27.3	0.35	C3S1
29	Mogullapelly	BW	8.2	990	634	116	420	64	43	63	6	0	140	120	154	1.0	7	0	19.4	0.30	C3S1
30	Mulkalpally	DW	8.2	1070	685	132	500	80	73	23	8	0	80	120	107	0.8	0	0.1	10.0	0.20	C3S1
31	Vemulapelly	DW	8.2	1785	1142	109	540	64	92	170	7	0	180	270	164	1.8	0	0.4	41.2	1.10	C3S1
32	Pulligilla	BW	7.9	515	330	76	200	32	29	34	6	0	60	300	73	1.3	0	0.1	29.1	0.4	C3S1
33	Mettupally	DW	8.6	840	538	120	220	46	44	90	6	60	90	120	35	3.5	15	0.3	48.1	0.9	C3S1
34	Jupaka	BW	7.3	658	427	64	289	105	39	35	7	0	100	65	62	0.9	0	0	13.2	3.04	C2S1
35	Kandugula	OW	7.8	217	142	92	224	116	49	49	8	0	200	52	59	1.6	0	0	25.2	5.39	C1S1
36	Huzurabad	BW	7.2	443	652	126	200	122	29	35	11	20	180	74	40	2.0	0	0	23.3	4.34	C2S1
37	Bornapally	Bw	7.7	401	249	56	336	69	74	42	13	0	30	80	61	2.8	0	0	27.7	5.0	C3S2
38	Katrapally	BW	7.7	495	307	48	304	56	73	46	15	10	50	65	120	2.4	0.3	0	32.1	5.75	C2S1
39	Chinnapapaiahpally	BW	7.5	1382	587	74	560	88	29	42	6	40	60	85	46	1.0	0	0	29.1	5.49	C3S1
40	Bhimpally	DW	8.2	732	454	65	348	74	39	44	8	20	70	90	121	1.0	0	0	31.5	5.85	C2S1

Table 1. Chemical Analysis Data of Groundwater Samples Peddavagu sub-basin

(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	Class
41	Kannur	DW	8.1	732	454	58	248	92	38	58	14	0	80	110	96	1.4	0	0	30.7	7.20	C2S1
42	Gunded	BW	8.0	1985	1290	57	424	59	64	44	11	0	66	105	85	3.0	0.1	0	30.9	5.62	C3S2
43	MarripalliGudem	DW	7.9	1227	761	68	240	63	76	46	9	40	78	50	141	0.8	0	0	28.8	5.62	C3S1
44	Vangapalli	DW	8.1	732	454	71	280	77	58	66	6	0	86	70	174	0.2	0.3	0	34.7	8.03	C2S1
45	Kamalpur	BW	8.0	866	537	59	360	69	63	59	6	20	90	30	101	0.6	0	0	32.3	7.18	C3S2
46	Uppal	DW	8.4	783	486	75	196	86	79	34	8	20	110	80	86	1.4	0	0	20.2	4.78	C3S1
47	Ambala	BW	8.0	598	371	116	264	120	62	44	8	20	80	116	34	1.0	0.1	0	22.2	4.67	C2S1

48	Maddanapet	DW	8.6	990	614	48	292	116	58	64	6	0	60	82	24	0.6	0.3	0	29.5	6.83	C3S1
49	Vavila	DW	8.3	567	352	84	184	186	44	36	8	20	100	34	59	1.0	0	0	15.3	3.36	C2S1
50	Saidabad	DW	8.1	690	428	57	252	160	25	40	7	20	140	50	44	0.4	0	0	20.2	4.16	C2S1
51	Illanthakunta	DW	8.2	525	326	49	276	44	58	55	5	0	120	70	84	0.4	0	0	37.1	7.70	C2S1
52	Jammikunta	DW	8.5	298	185	59	152	86	24	38	10	10	86	65	196	0.6	0	0	30.4	5.12	C2S1
53	Mallial	BW	7.8	990	614	65	448	92	21	46	6	20	98	85	124	2.2	0.1	0	31.5	6.14	C3S1
54	Madipalli	BW	8.0	762	473	55	320	103	13	28	4	0	44	76	58	0.2	0	0	21.6	3.67	C3S1
55	Gopalpur	DW	8.0	1382	857	58	380	79	42	39	6	20	100	96	74	1.6	0.1	0.3	27.1	5.01	C3S1
56	Deaharajpally	DW	7.9	629	390	58	284	91	31	29	6	20	120	110	86	2.0	0	0.1	22.3	3.71	C2S1
57	Penchilapeta	BW	7.8	732	454	56	304	124	61	41	10	5	66	55	55	1.8	0	0	21.6	4.50	C2S1
58	Jeelugula	BW	7.5	598	371	68	248	143	55	40	8	0	78	85	63	2.2	0.2	0	19.5	4.02	C2S1
59	Gopalpur	DW	8.0	1382	857	42	380	79	42	39	6	20	100	96	74	1.6	0.1	0.3	27.1	5.01	C3S1

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60	Elakathurthi	BW	7.4	443	275	85	200	121	41	44	7	10	130	108	34	0.6	0	0	23.9	4.89	C2S1
61	Chithalpally	BW	7.9	866	537	56	380	167	61	51	9	40	120	186	15	1.2	0	0	20.8	5.01	C2S1
62	Suraram	DW	7.7	670	416	78	280	146	23	38	8	0	80	58	86	2.2	0	0	20.0	4.81	C2S1
63	Desharajupally	BW	7.4	896	656	57	200	73	33	37	5	20	90	64	28	0.6	0.1	0.2	28.4	6.08	C3S1
64	Dandepally	DW	7.6	577	358	66	240	104	24	43	6	40	100	114	26	0.6	0	0	27.6	5.41	C2S1
65	Baopet	DW	7.6	929	476	77	312	92	26	38	11	20	100	121	44	2.2	0.2	0.1	23.6	5.15	C3S1
66	Keshapor	DW	7.8	1008	625	65	260	122	33	41	13	0	80	200	48	2.6	0.3	0.1	24.7	6.31	C3S1
67	Railkal	BW	8.2	906	563	48	388	105	42	50	12	10	60	220	54	1.4	0	0	29.6	5.84	C3S1
68	Bommakal	DW	8.3	474	294	57	240	88	46	38	8	20	120	38	64	1.8	0	0.1	25.5	4.65	C2S1
69	Ammanagirthy	BW	8.5	464	288	47	256	70	28	51	10	0	80	46	74	2.4	0	0.2	38.3	7.28	C2S1
70	Mallarm	DW	7.7	1011	627	56	340	64	44	28	12	10	60	58	86	1.2	0.1	0.1	26.6	3.90	C2S1
71	Vangara	DW	7.6	513	627	72	296	68	54	38	7	20	86	64	28	2.2	0	0	26.9	4.86	C2S1
72	Manikyapur	BW	7.8	453	281	54	224	78	66	49	8	0	50	62	38	1.2	0.1	0	28.4	5.77	C2S1
73	Bheemadevarapally	DW	7.5	711	441	62	300	48	58	44	9	10	76	88	44	1.0	0.1	0	33.3	5.78	C2S1
74	Mutharm	BW	7.8	567	364	47	232	120	29	58	11	10	88	74	54	1.87	0.1	0	31.6	6.73	C2S1
75	Damera	DW	7.9	629	390	51	284	91	31	29	6	20	120	110	86	2.0	0	0.1	22.3	3.71	C3S1
Average			**7.8**	**960**	**603**	**80.1**	**377**	**108**	**48.1**	**51.8**	**8.30**	**16.7**	**102.6**	**126**	**66.9**	**1.31**	**2.74**	**0.08**	**27.4**	**5.21**	
Maximum			**8.8**	**2000**	**1300**	**300**	**1680**	**380**	**117**	**170**	**21**	**60**	**310**	**432**	**196**	**3.5**	**20**	**1**	**66.5**	**10.4**	
Minimum			**6**	**217**	**142**	**30**	**120**	**24**	**13**	**17**	**4**	**10**	**30**	**30**	**3**	**0.2**	**0.1**	**0.1**	**10**	**0.2**	

IV. SODIUM ADSORPTION RATIO (SAR)

The salinity laboratory of the US department of Agriculture has recommended the use of SAR for studying the suitability of ground water for Agriculture.

The SAR is defined and obtained by

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

Where all the ionic concentrations are exposed mg/l

A soil high in exchangeable sodium is very undesirable for agriculture because it can become - deflocculated and tend to have a relatively important crust. This condition is promoted by water of high SAR and is reserved by water containing a high proportion of Ca and Mg (Hem, 1959).The unfavourable condition created by SAR can be turned favourable adding proper proportion of Gypsum on lime to the soil. Water with low SAR is desirable for agriculture; studies on the suitability of ground water of the investigated area have been carried out. The diagram for evaluation of irrigation waters on the basis of their specific conductance and SAR ratio Fig 2 is used for this purpose. Table 2 gives the standard classification of water for irrigation.

The SAR values in the study areas ranging between 0.2 to 10.4.

Table. 2. Irrigation Classification of ground water according to SAR values

SAR	**Water Class**	**Sample %**
<10	Excellent (S1)	74
10-18	Good (S2)	1
18-26	Doubtful (S3)	0
>26	Unsuitable (S4)	0

V. U S SALINITY LABORATORY DIAGRAM (1954)

U S Salinity laboratory diagram (1954) is useful to study the water for irrigation purpose. In this diagram Sodium Adsorption Ratio (SAR) is plotted on vertical axis and Electrical Conductivity (EC) on horizontal axis.

The US Salinity diagram is divided into four distinct fields both vertical and horizontally. One vertical axis sodium (alkali) hazard divided into low sodium water (S1), medium (S2), high (S3), and very high sodium water (S4). Generally low sodium water can be used for irrigation purpose. High and very high sodium water is generally unfavorable for irrigation purpose. On the horizontal axis salinity hazard is divided into four groups. Low salinity (C1), medium (C2), high salinity (C3), very high salinity (C4) water. Low salinity water can be used for irrigation purpose for most crops. High and very high salinity water is unfavorable for irrigation purpose.

VI. CONDUCTIVITY

Low salinity water: (C-1) can be used for irrigation with many 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.

Medium salinity water: (C-2) 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.

High salinity waters: (C-3) cannot be used on soil with restricted drainage. Even with adequate drainage special management for salinity control may be required and plants with good salt tolerance should be selected.

Very high salinity waters: (C-4) is not suitable for irrigation under ordinary conditions but may be used occasionally under special circumstances. The soil must be permeable, drainage must be adequate, irrigation water must be applied in excess to provide considerable leaching and very salt tolerant crops should be selected.

VII. SODIUM

The classification of irrigation waters with respect of SAR is based primarily on the condition of soil.

Low sodium water (S-1) 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 may accumulate injurious concentrations of Sodium.

Medium sodium water (S-2) will present appreciable sodium hazard in fine textured soils of high cation exchange capacity especially under low leaching conditions unless gypsum is present in the soil. This water may be used in coarse textured or organic soils that have good permeability.

High sodium water (S-3) may produce harmful levels of exchangeable sodium in most soils and requires special soil management, good drainage, high leaching and additions of organic matter. Gypsiferrous soils may not develop harmful levels of exchangeable sodium form such waters. Chemical change may be required for replacement of exchangeable sodium except that with water of very high salinity.

Very high sodium water (S-4) is generally unsatisfactory for irrigation purposes except of low and perhaps medium salinity when the solution of Calcium from the soil or use of gypsum or other change may make the use of this water feasible.

Water samples from the study area are plotted in Fig 3 and it reveals one sample fall in the low salinity hazard (C1) class, 30 samples fall in the medium salinity hazard (C2) class, 44 samples fall in the high salinity hazard (C3) class, and not a single sample fall in the very high salinity hazard (C4) class.

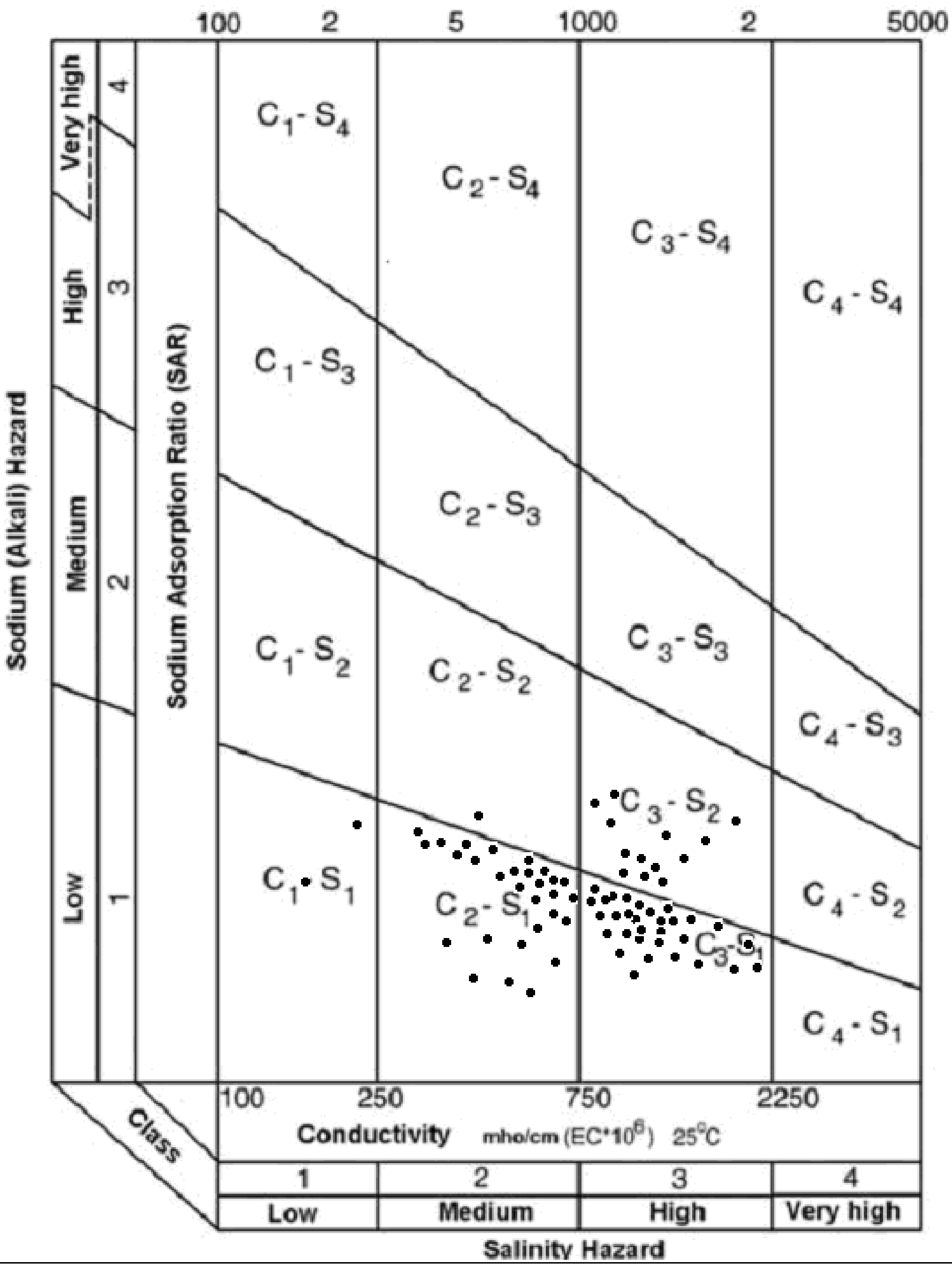

Fig.3. Plotting of sample data on US Salinity laboratory diagram

In sodium alkali hazard which is represented on the vertical axis in Fig 3 In the area 60 samples fall in low sodium water (S1), 15 samples fall in medium sodium water (S2) (Fig 3.).

The overall samples with regard to sodium and salinity hazard are represented in the Table 3

Table 3 Showing sodium and salinity hazards

S.No	No. of Samples	Field
1	1	C1-S1
2	29	C2-S1
3	1	C2-S2
4	30	C3-S1
5	14	C3-S2

Observed from the above classification most of the water samples indicate that the ground water is suitable for irrigation.

VIII. SODIUM PERCENTAGE (NA %)

The concentration of sodium is important in classifying the ground water for irrigation, because it reacts with soil to reduce its permeability and lead to clogging of soil particles, there by reducing the permeability (Nagaraju et al; 2006). Sodium percentage is calculated by the equation and the computed values are given in Table 4.

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

Where, the concentration of all elements is in mg/l

In the study area the percentge of sodium ranges between 10.00 to 66.5 mg/l

Table 4 Irrigation water classification according to Na%

Na%	Water Class	Samples	Minimum & Maximum values of Na%	
			Min	Max
<20	Excellent	09	10.00	66.5
20-40	Good	63		
40-60	Permissible	02		
60-80	Doubtful	01		
>80	Unsuitable	-		

IX. WILCOX'S DIAGRAM (1955)

For irrigation water classification Wilcox's diagram is in common use (Shankar Narayana and Sudhakar Reddy, 1980) Wilcox's diagrams are prepared by plotting the sodium percentage (Na %) against Electrical conductivity (EC).

From Wilcox's diagrams (Fig 4) it is found that all the ground water samples of bore and dug wells collected and analysed are 9 samples in excellent to good, 62 samples in good to permissible, two samples permissible to doubtful and one sample in doubtful to suitable (Table 5).

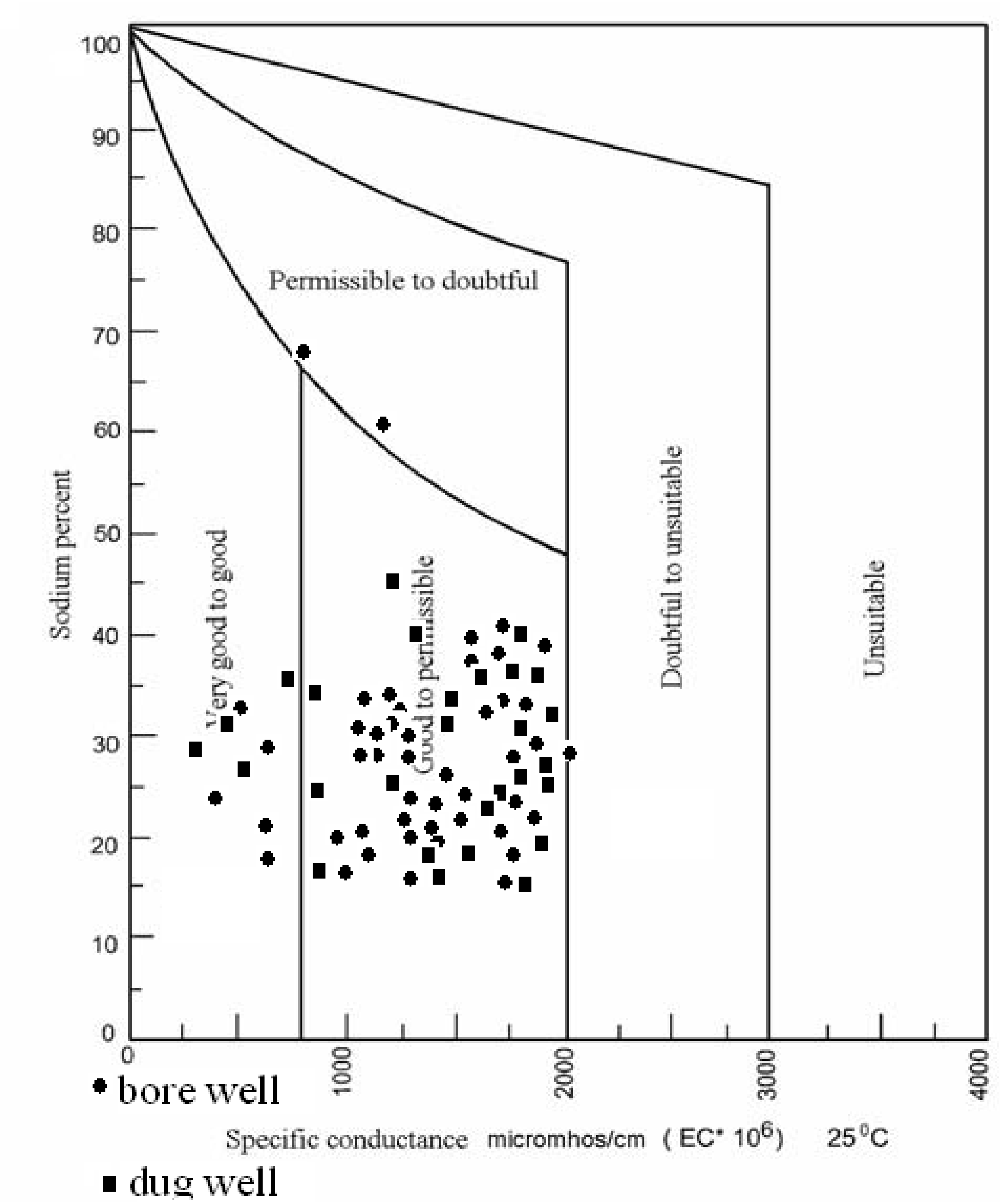

Fig 4. Plotting of EC Vs Na% on Wilcox's diagram (1955)

Table 5. Irrigation water classification of ground water based on Wilcox's diagram (1954)

S.No	No of Samples		Water Class
	Bore Well	Dug Well	
1	4	5	Very good to Good
2	24	39	Good to Permissible
3	0	2	Permissible to Doubtful
4	0	1	Doubtful to Unsuitable
5	0	0	Unsuitable

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. 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.

X. CONCLUSIONS

An Interpretation of hydrochemical analysis for groundwater quality and evolution of hydrochemical facies in the peddavagu sub-basin reveals that concentrations of the major ions and important physical parameters are within the permissible limits for irrigation SAR values in the study areas ranging between 0.2 to 10.4 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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