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HYDRO-GEOCHEMISTRY AND QUALITY ASSESSMENT OF GROUND WATER OF JAIPUR CITY AND ITS ADJOINING AREA (RAJASTHAN)

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ABSTRACT

The chemical characteristics of ground water of Jaipur city and its adjoining area (Jaipur district), Rajasthan have been studied to evaluate the suitability of water for irrigation and domestic uses. Twenty five water samples representing the deep and shallow ground water of the area were collected and analysed. It is observed that the quality of most of the area is suitable for both the purposes. An attempt has also been made to classify the ground water of the study area on the basis of piper diagram and U. S. Salinity laboratory classification. Majority of water samples belong to the {sodium-potassium, sulphate-chloride}; {sodium-potassium, carbonate-bicarbonate} hydro-chemical group and remaining water samples under the category of {calcium-magnesium, sulphate-chloride};{calcium-magnesium, carbonate-bicarbonate}.According to U. S. Salinity laboratory classification 20% water samples lying are under the C2S1, category and can be used for irrigation purposes and 48 % water samples are lying under C3S1, C3S2, C3S3 (high salinity -low to medium SAR values) and remaining water samples are lying under C4S2, C4S3, C4S4 category, which are not suitable for irrigation.

Key words: Hydro-geochemistry, Ground water, Fluoride, Jaipur city

INTRODUCTION

As a result of rapid urbanization and industrialization in several parts of the country, there has been several fold increase in generation of waste water. For most of the cities and towns, domestic sewage is being discharged without proper treatment into the rivers or land for irrigation. Jaipur city area and its adjoining area between N-latitude 26º 47'-27º 02' and east longitude 75º36' - 75º55' covers the study area. Geo-morphologically, the area is characterized by landscapes of sandy plains, hills and intermountain valley and is mainly drained by southerly flowing Amanishahnalla. The city enjoys semi-arid climatic condition receiving 656 mm of mean rainfall. The land is largely used for domestic

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housing, office complexes, industries, gardening and agricultural activities of adjoining area of the city. Till some time ago, the quality of ground water was considered to be relatively very good in comparison to surface water Handa[1] has carried out ground water contamination studies in various parts of the country. Study on ground water quality with respect to drinking, irrigation and industrial purposes have been carried out in different parts of India (Bhat and Hegde[2], SubbaRao[3], Majumdar and Gupta[4], Khurshid et al[5], Rajshekharan[6] et al., Kulshresta[7] studied about physico-chemical characteristics of ground water and effluents in Sanganer of Jaipur districts in Rajasthan. Some work on this aspects has been so far carried out in the study area by Gita Seth et al.[8, 9] The aim of the present study is to assess the suitability of ground water quality for drinking and irrigation purpose for proper planning and development of the area.

EXPERIMENTAL

Material and methods

Water samples collected from open well and hand pump from the study area were investigated during May 2007. Eleven locations were in the residential area and 14 locations were in the agricultural area and industrial area. The samples were collected in one litre clean plastic container following the water quality standard guideline APHA, WHO[10].

For determination of iron, samples were collected in different bottles treated with dilute HCl (1 : 1). Analysis of water samples were carried out i mmediately after the collection.The samples collected from the wells were analysed for major ion chemistry, employing the standard water quality procedures APHA[11]. pH and electric conductance (EC) were measured using pH and EC-meter. Total dissolved solids were computed by multiplying the EC by conversion factor 0.65 (ranging from 0.55 to 0.75) as suggested by Hem[12]. Total Hardness as $CaCO_3$ was measured by using standard EDTA solution. Mg was calculated taking the difference of TH and Ca. Chloride was determined by volumetric method using standard $AgNO_3$ solution. Sulphate was estimated through turbiditimetric method. Fluoride was estimated by ECR-Method using spectrophotometer. NO_3 was determined by UV-Visible spectrophotometer 108 (Systronic).

RESULTS AND DISCUSSION

Potability of ground water

The hydro-chemical analysis results are shown in Table 1.

Table 1. The results of ground water samples of Jaipur city and its adjoining area, Rajasthan

S.No.	pH	EC (μ siemens /cm)	CO_3^{2-} (mg/L)	HCO_3^- (mg/L)	Cl^- (mg/L)	SO_4^{2-} (mg/L)	NO_3^- (mg/L)	PO_4^{3-} (mg/L)	TH (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^+ (mg/L)
1	7.8	3230	0	650	420	104	490	0.15	250	48	32	632
2	7.8	2100	0	561	312	226	18	0.25	260	48	34	422
3	7.3	580	0	293	43	7	16	0.10	170	52	10	51
4	7.7	3900	0	329	1136	446	25	0.20	1240	176	194	516
5	7.4	1380	0	464	134	178	110	0.11	530	120	56	144
6	7.2	2700	0	769	362	77	295	0.10	360	88	34	496
7	7.6	1500	0	488	241	5	250	0.30	430	52	73	248
8	7.6	3300	0	659	710	156	85	0.50	250	72	17	700
9	8.2	1370	0	610	135	13	22	1.50	470	112	46	100
10	8.2	685	0	171	135	12	14	0.50	200	36	27	70
11	7.6	2670	0	451	497	313	25	0.10	320	52	58	483
12	8.1	700	0	329	32	110	17	0.10	150	16	27	136
13	7.9	1510	0	281	227	103	165	0.10	480	116	46	146
14	7.5	4800	0	549	1022	580	53	0.05	450	68	68	958
15	8.2	860	0	281	50	100	16	0.06	110	30	19	152

Cont…

S.No.	K^+ (mg/L)	F^- (mg/L)	Fe^{3+} (mg/L)	SiO_2 (mg/L)	TDS (mg/L)	Location
1	5.0	1.10	0.40	18.00	2100	Bhaiswa h/p
2	1.8	4.00	0.20	12.30	1365	Junsiya h/p
3	9.6	0.80	0.15	10.00	377	Ghantiyali h/p
4	3.3	2.30	0.12	15.20	2535	Sanodiya h/p
5	2.9	0.80	0.17	12.00	897	Korsina h/p
6	24.0	3.00	0.30	17.00	1755	Morada h/p
7	4.0	3.50	0.10	10.00	982	Dabari h/p
8	0.5	3.90	0.31	22.00	2145	Sawamiki dhani d/w
9	29.0	0.90	1.50	12.00	891	Rasala
10	3.4	0.80	0.20	10.00	445	Babru d/w
11	5.0	1.60	0.10	18.00	1735	Jatwara h/p
12	1.0	0.80	0.10	12.40	455	Risani o/w
13	3.0	0.50	0.15	10.00	982	Secretarate h/p
14	6.0	5.10	0.40	25.00	320	Dudu d/w
15	1.1	2.40	0.10	12.60	559	Hastera d/w

Cont…

S.No.	pH	EC (μ siemens /cm)	CO_3^{2-} (mg/L)	HCO_3^- (mg/L)	Cl^- (mg/L)	SO_4^{2-} (mg/L)	NO_3^- (mg/L)	PO_4^{3-} (mg/L)	TH (mg/L)	Ca^{2+} (mg/L)	Mg^{2+} (mg/L)	Na^+ (mg/L)
16	8.45	1020	48	464	43	28	35	0.15	70	8	12	230
17	7.3	500	0	232	28	30	58	0.10	220	40	29	41
18	6.8	920	0	512	57	38	9	0.10	340	60	41	100
19	7.6	3840	0	464	1278	101	25	0.25	816	92	158	658
20	7.1	1600	0	464	248	212	6	0.10	210	48	22	355
21	7.6	1200	0	159	191	10	240	0.10	440	60	71	76
22	6.88	360	0	116	35	5	36	0.04	135	28	16	20
23	7.69	2460	0	378	702	28	34	0.10	400	60	61	437
24	8.2	1230	0	366	121	92	12	0.08	70	12	10	253
25	8.23	2300	0	683	277	144	27	0.02	150	20	24	495

Cont...

S.No.	K^+ (mg/L)	F^- (mg/L)	Fe^{3+} (mg/L)	SiO_2 (mg/L)	TDS (mg/L)	Location
16	8.2	3.10	0.10	11.20	663	Luniawas dw
17	3.2	0.25	0.05	8.00	325	Raj. college h/p
18	10.0	0.80	0.11	7.00	598	Bhichi d/w
19	4.2	2.40	0.21	19.00	2496	Phulera d/w
20	1.6	3.70	0.14	11.00	1040	Padasoli d/w
21	2.5	0.16	0.04	10.00	780	Sodala
22	2.0	0.14	0.05	6.00	234	Vidyadhar ngr hp
23	11.0	0.60	0.10	14.00	1599	Siwar d/w
24	0.8	5.00	0.12	10.00	800	Patan d/w
25	1.0	3.20	0.04	14.00	1495	Malahara d/w

A pH range of 6.5-8.5 is normally acceptable as per guidelines suggested by WHO and BIS. The pH value of samples in the study area is with in the range 6.88-8.45 of safe limit for drinking purposes. The conductivity value of the samples varied between 360 micro simens to 4800 micro simens. The concentration of total dissolved solids in the present study is observed in the range of 234 to 3120 mg/L. These values lies approximately 68% between desirable and maximum permissible limit. Desirable limit for total dissolved solids is 500 mg/L and maximum permissible limit 1500 mg/L as prescribed for drinking purpose.

Total hardness (TH)

It represents the concentration of calcium and magnesium salts or both.This classification suggest, that most of the samples lies between desirable and maximum permissible limits as prescribed by BIS[10]. Higher concentrations of TH > 600 mg/L develops scales on the water heater, boiler and cooking utensils and also increase soap consumption for washing. Most of the samples showed TH in safe limit, suggested for drinking purpose.

Nitrate

Nitrate enters the human body through drinking water, causing a number of health disorders such as methemoglobinemia, hypertension etc.[4] In most of samples in study area, the concentration of nitrate is in safe limit as prescribed by BIS.

Fluoride

Fluoride has considerable physiological significance on human life for maintaining the normal growth of bone structure. Maximum permissible limit for fluoride is 1.5 mg/L as prescribed by BIS. 50% Water samples were found to have more fluoride values than the maximum permissible limit

Purpose for irrigation

Salinity

High concentration of salts in irrigation renders the soil saline. This also affects the salt intake capacity of plants through roots. The classification of well's water from the study area with respect to the salinity hazards is as follows –

Salinity category	EC (micromhos/cm at 25°C)	No. of well in each category	% Wells
Low	< 250	0	0
Medium	250-750	5	20
High	750-2250	12	48
Very high	> 2250	8	32

Most of the water samples fall under medium to high salinity category (68%). These can be used for irrigation purposes under some salinity controlled techniques for growing plants having good salt tolerance with no ill effects on productivity.The salt tolerance crops as wheat, sun-flower, rye, and vegetables such as cabbage, carrot, cucumber, onion, tomato etc. can be safely grown in the study area and remaining water samples were under very high salinity category (32%).

SAR (Sodium adsorption ratio): The values of SAR are given in the table,

Sample No.	SAR	Sample No.	SAR
1	17.30	14	19.60
2	11.30	15	6.20
3	1.60	16	11.90
4	6.30	17	1.20
5	2.70	18	2.30
6	11.30	19	10.00
7	5.20	20	10.60
8	19.20	21	1.60
9	1.90	22	0.74
10	2.10	23	9.50
11	10.90	24	13.40
12	4.80	25	17.55
13	2.90		

Sodium adsorption ration (SAR) is an important parameter for determination of suitability of irrigation water because it is responsible for the sodium hazards. SAR is defined as –

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

where the concentration are expressed in meq./L

The SAR value in ground water of the study area ranges from 0.74-19.65. The classification of well water from the investigation area with respect to SAR is as follows –

SAR range	Class	No. of wells	%
< 10	Excellent	14	56
10-18	Good	9	36
18-26	fair	2	8
> 26	poor	0	0

Piper[12] classification

Piper classification is shown in Piper diagram in Fig. No.1 and 2

Sodium-potassium, sulphate-chloride hydro-chemical group is found in water sample S. No. 1, 2, 8, 11, 14, 19, 20, 23 and 25 and sodium-potassium, carbonate-bicarbonate hydro-chemical group is found in water sample S. No. 6, 12, 15, 16 and 24 and remaining water samples were under the category of hydro-chemical group calcium-magnesium, sulphate-chloride; calcium-magnesium and carbonate-bicarbonate. The results obtained through Piper diagram have shown that the majority of wells 36% under sodium-potassium, sulphate-chloride hydro-chemical group and potassium, carbonate-bicarbonate hydrochemical group and remaining water samples having calcium-magnesium, sulphate-chloride; calcium-magnesium, carbonate-bicarbonate hydro-chemical group.

Hydrochemical data plot of the well waters in the USSL Diagram[14] in Fig. 3, 4, 5. The classification is as under –

C1S1, C1S2, C1S3, C1S4 - There is no sample in this group.

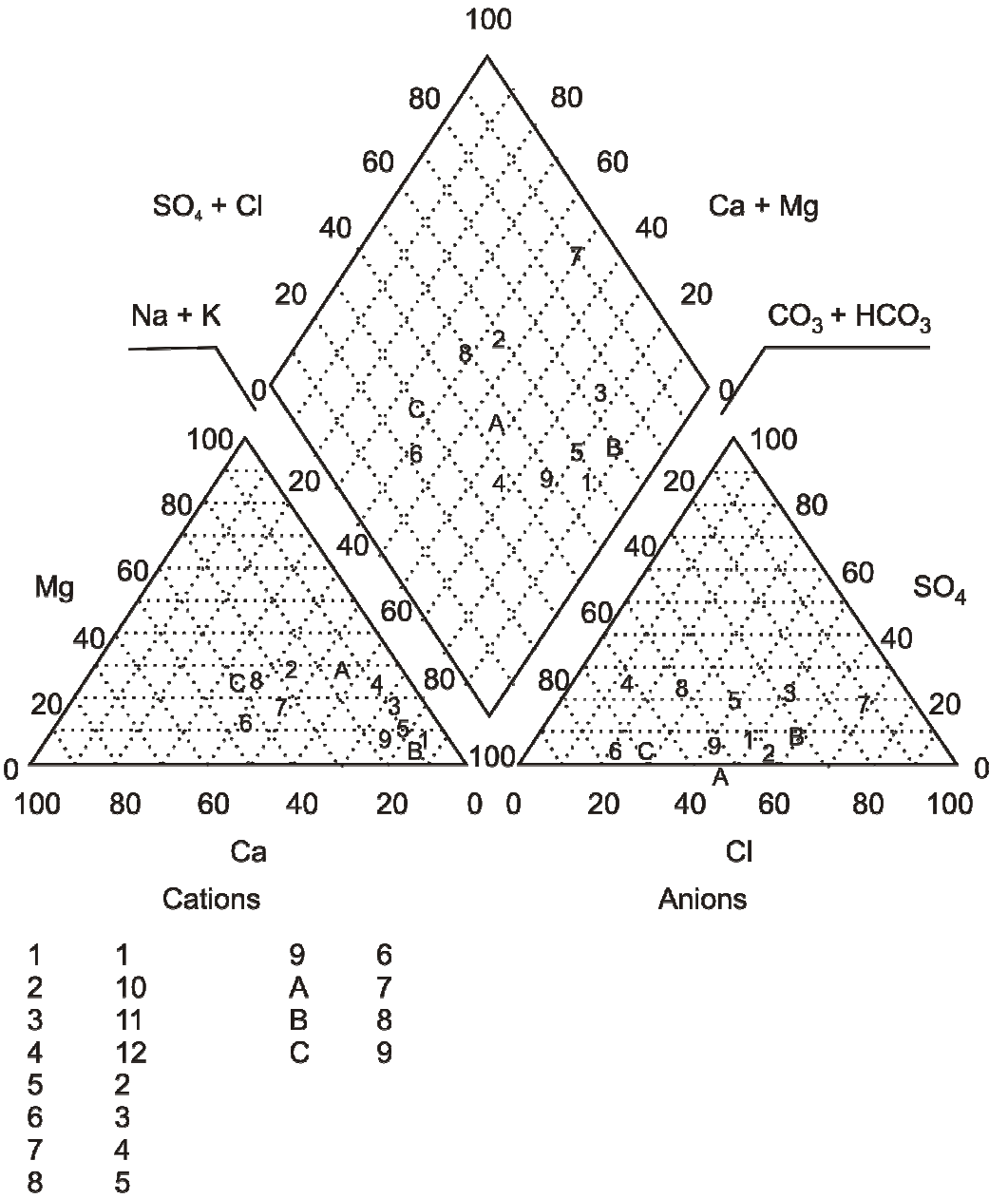

Fig. 1: Piper diagram

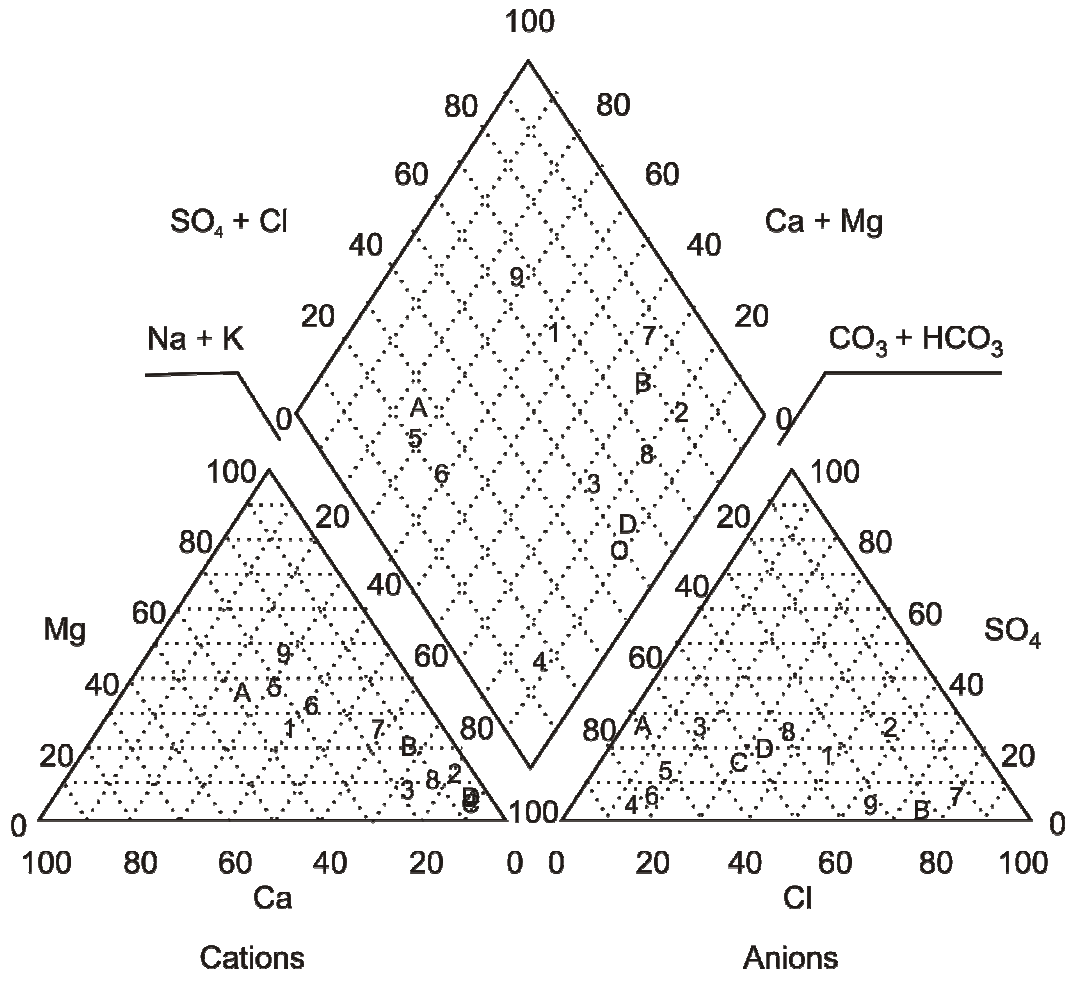

Fig. 2 : Piper diagram

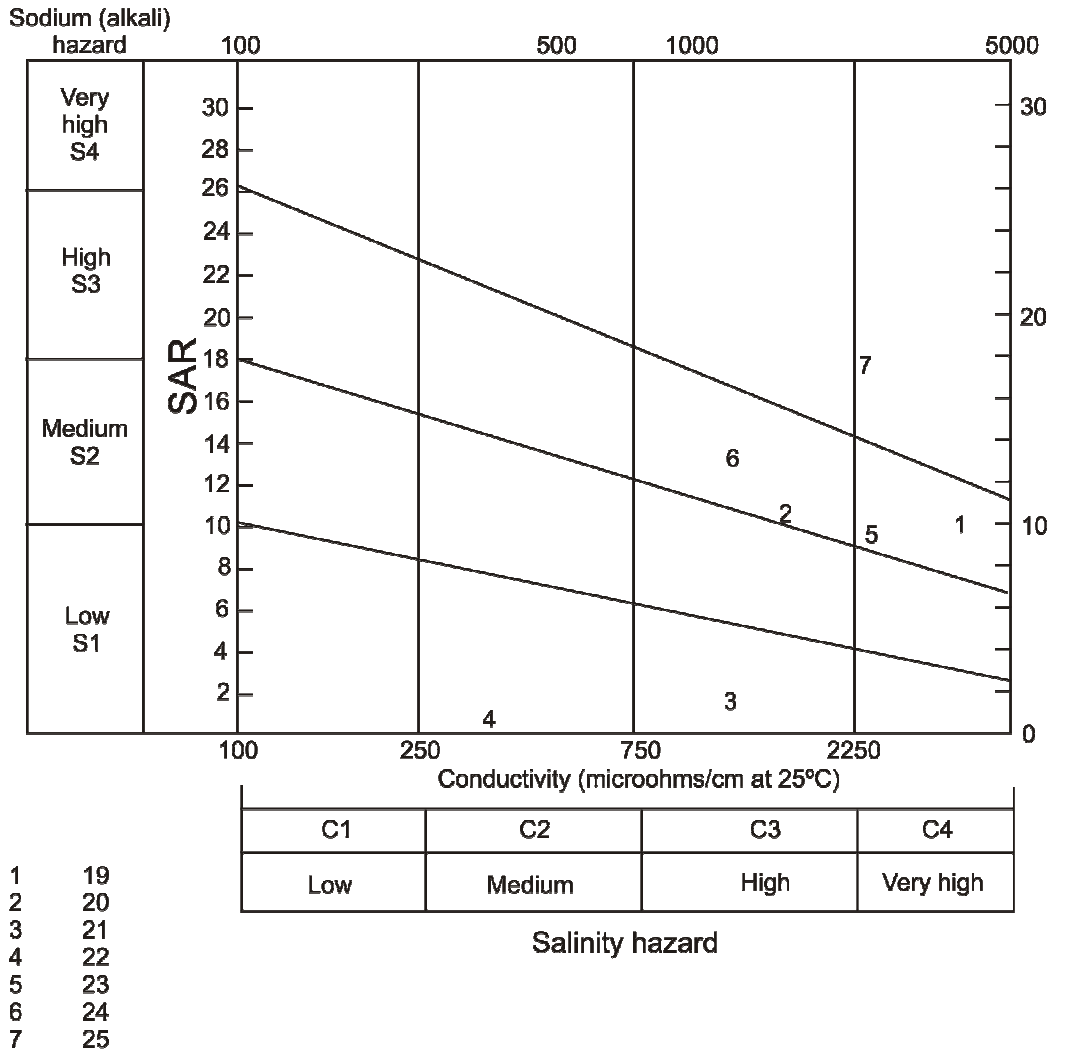

Fig. 3: Wilcox diagram

C2S1 class having in water sample No. 3, 10, 12, 17 and 22 and C2S2, C2S3, C3S4 class, no sample is found. C3S1 class having in water sample No. 5, 9, 13, 18 and C3S2 class having water sample No.7, 15 and C3S3 class having in sample No. 2, 6, 16, 20, 24 remaining water samples having C4S2, C4S3, C4S4 class.

The U. S. salinity diagram has shown that water samples No.3, 10, 12, 17 and 22 lying under the C2S1,category and can be used for irrigation purposes and water sample

no.5, 9, 13, 18; 7, 15; 2, 6, 16, 20 and 24 lying under C3S1,C3S2,C3S3 (high salinity - low to medium SAR values) are also used for irrigation purpose after proper management. Strategies need to be adopted. Remaining water samples lying under C4S2, C4S3 and C4S4 category, which are not suitable for irrigation.

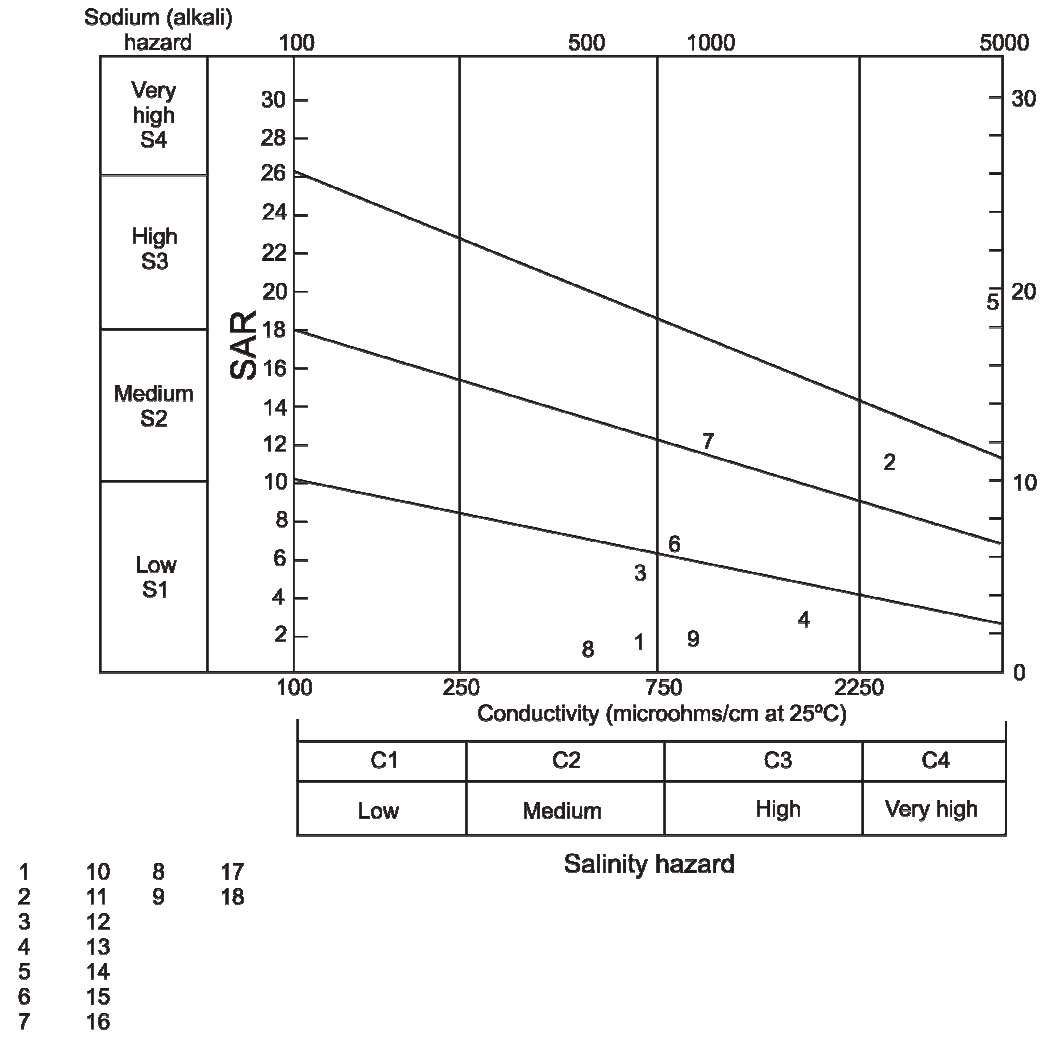

Fig. 4: Wilcox diagram

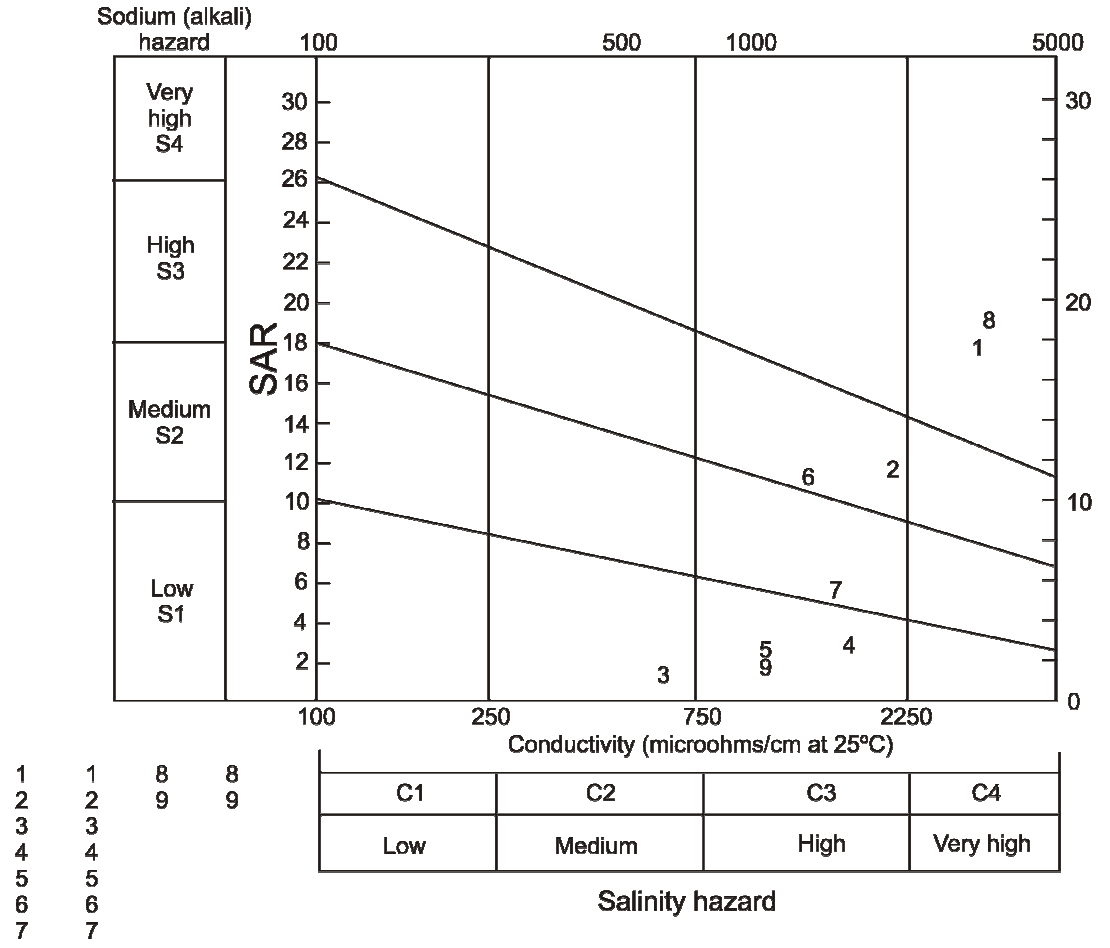

Fig. 5: Wilcox diagram

CONCLUSION

From the results of the study area, it is observed that the quality of ground water varies from place to place. Higher values of certain parameter at certain locations indicate that the water is not suitable for domestic application. Hence, it is recommended that any water source must be thoroughly analysed before being used for domestic application. Most of the water samples fall under medium to high salinity category (68%) and water can be used for irrigation purpose. On the basis of SAR values, it can be concluded that the ground water quality of the study area can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium. 56% water

samples were of excellent class for irrigation and 36 % were of good class for irrigation purposes. According to the Piper classification, the majority of the water samples fall under sodium-potassium, sulphate-chloride hydro-chemical group and sodium-potassium, carbonate-bicarbonate hydro-chemical group. The U. S. salinity diagram has shown that 20% water samples, samples lying under the C2S1, category can be used for irrigation purposes and 48 % water samples lying under C3S1, C3S2, C3S3 (high salinity -low to medium SAR values) can also be used for irrigation purpose but after proper but management, strategies need to be adopted. Remaining water samples lying under C4S2, C4S3 and C4S4 category are not suitable for irrigation.

REFERENCES

1. B. K Handa, Ground Water Contamination in India Key Paper Regional Workshop on Environmental Aspects of Ground Water Development Kurrukshetra Oct. 17-19 (1994).
2. D. M. Bhat and Ganesh R. Hegde, Ground Water Quality in Uttar Kannada District of Karnataka, 1 JEH 39, 61 (1997).
3. Subba Rao, Ground Water Quality in Crystalline Terrain of Guntur District in Andhra Pradesh, Andhra Pradesh Academy Science, **V(2)**, 51 (1998).
4. D. Majumdar and N. Gupta, Nitrate Pollution of Ground Water and Associated Human Health Disorder, IJEH **V(42)**, 28 (2000).
5. S. H. Kurshid, H. Hussain and Zabeerudein, Water Quality Status and Environmental Hazards in Parts of Yamuna-Karwan Sub Basin of Aligarh-Mathura Dists., UP, Indian J. Appl. Hydrology, **V(XV)**, 30 (2002).
6. R. Rajshekharan and N. Kannan, A Correlation Study on Physico-chemical Characteristics of Ground Water Along River Vaigai on Madurai City, Indian J. Environ., Protection, **24(1)**, 41 (2004).
7. S. Kulshrasth, Physico-chemical Characteristics of Ground Water and Effluents in Sanganer Town of Jaipur City, National Envi. Poll. Tech., 1453 (2002). .
8. Gupta Sanjay, A. Kumar and Gita Seth, Study of Some Physico-chemical Characteristics of Various Type of Water in VKI Area in Jaipur (Rajasthan) Chemistry; An Indian Journal, **2**, 612 (2004).
9. Jaipal Garg, Akhalesh Kumar, Kavita Batheja and Gita Seth, Physico-chemical Characteristics of Ground Water of Adjoining Area of NH-8 in Jaipur District, Rajasthan, Chemistry, An Indian Journal, **3**, 8 (2006).

10. Guidelines for Drinking Water Quality, Volume-1, Recommendations, WHO Geneva **172-181**, (1993) pp. 53-79

11. Standard Method for Examination of Water and Waste Water American Public Health Association, Washington DC, 18th Edition (1992) pp. 1134

12. J. D. Hem, Study and Interpretation of the Chemical Characteristics of Natural Waters 2254, Scientific Publisher, Jodhpur (1991)

13. A. M. Piper, A Graphical Procedure in the Geo-chemical Interpretation of Ground Water Analysis, Trans. Am. Geophysics Union, **25**, 914 (1944).

14. W. Willcox, Classification and Uses of Irrigation Water U. S. Department of Agriculture, Circular, Washigton (1955) p. 969.

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