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Hydro-Chemical Evaluation of Ground Water of Area Around Raisar, Bikaner District, Rajasthan, India

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Abstract

Hydro-chemical characteristics of ground water of area around Raisar District Bikaner have been studied to evaluate the suitability of water for irrigation and domestic uses. Ground water sample of twenty four key wells of the study area were collected and analyzed for physico-chemical parameters. The ground water sample has been classified on the basis of Sodium Absorption Ratio (SAR) values, Piper Diagram and US Salinity Laboratory Diagram. The hydro-chemical water facies identified by using Piper Trilinear Diagram and of majority of water samples belongs to Sodium Chloride Type. According to US Salinity Laboratory Diagram almost 50% water samples are lying under C_4S_2, C_4S_3, C_4S_4 category which indicates very high salinity and medium to very high SAR values so these water samples are not suitable for irrigation purpose. The major identifiable geochemical processes responsible for the evolution of the various ions are mineral weathering, chemical reactions and anthropogenic activities.

Keywords: Physico-chemical, piper diagram, US salinity diagram, SAR, Hydro-chemical.

Introduction

Water is a prime natural resource, a basic human need and a precious national asset and hence its use needs appropriate planning, development and management[1]. It has unique chemical properties due to its polarity and hydrogen bonds so that it is able to dissolve, absorb and adsorb various compounds[2]. Therefore in nature, water is not pure as it acquires contaminants from its surrounding and those arising from humans and animals as well as other biological activities[3]. Water quality analysis is important aspect in ground water studies. The hydro chemical study reveals quality of water for its suitability for drinking, agriculture and industrial purposes[4].

The Bikaner district lies in arid zone of western Rajasthan and is a part of Thar Desert. It covers an area of about 27,244 sq km and lies between North Latitudes $27^0$11' to $29^0$03' and East Longitudes $71^0$54' to $74^0$12'. The present research work covers an area around Village Raisar and falls between North Latitude $27^0$50' to $28^0$05' and East Latitude $73^0$30' to $73^0$45'[5]. The important villages located in the study area are Raisar, Naurangdesar, Bamblu, Gersar, Pemasar, Udasar, Bhinasar, Himtasar, Shivbari, and Ridmalsar etc. Here ground water is the main source of drinking water for local population because there is no seasonal and no perennial stream in this area. The quality of ground water resources of these villages vary naturally and widely depending on climate, season, geology of bedrock as well as anthropogenic activities[6].

The objective of the present work is to discuss the major ion chemistry of ground water of this area. The chemical parameters of ground water play a significant role in classifying and assessing the water quality. In present study suitability of water is evaluated on the basis of Sodium Absorption Ratio (SAR), Salinity Hazard, Piper Diagram and US Salinity Laboratory Diagram.

Material and Methods

Water samples were collected from tube wells of study area before monsoon in year 2012. Total 24 water samples were collected from different locations like residential area, agricultural area and industrial area in one litre clean plastic container according to the water quality standard guideline[7].

The temperature, pH and conductivity of the water samples were determined on the spot using a thermometer, pH meter and conductivity meter respectively. Various standard methods were used for the determination of other parameters. Total dissolved solid (TDS) of water samples were measured by using gravimetric method; Total alkalinity was determined by visual titration method using methyl orange and phenolphthalein as indicator. Total hardness (TH) of water was estimated by complexometric titration method using EDTA as complexing agent in presence of buffer solution and Eriochrome Black–T as indicator. The chloride ions were generally determined by titrating against a standard solution of $AgNO_3$ using Potassium Chromate as an indicator[8]**.** Sulphate content was determined by gravimetric method using 5% solution of $BaCl_2$ & dilute H_2SO_4 in the pH range 4 -5.5. The sulphate present in the sample was calculated after drying the precipitate. Fluoride and nitrate in the water samples were estimated by UV – visible spectrophotometer[9].

Results and Discussion

The hydro-chemical analysis results are shown in table – 1. (a), (b) On the basis of data of table – 1 (a) (b) maximum and minimum concentration of major parameters of ground water samples are given in table – 2.

The study area is classified in two categories on the basis of value of TDS. The area -1 has water samples from key well number 1-12 having high TDS value and area -2 has water samples from key well number 13-24 having low TDS value comparatively. On the basis of it Piper Diagrams and US Salinity Diagrams are prepared.

Piper Diagram: The hydro chemical parameters of ground water samples presented by plotting them on a Piper Tri linear Diagram. These plots include two triangles, one for plotting cations and other for plotting anions. The cations and anions fields are combined to show a single point in a diamond shaped field from which inference is drawn on the basis of hydro-geochemical facies concept[10]. Hydro-geochemical facies interpretation is a useful tool for determining the flow pattern and origin of chemical histories of ground water. The Piper Diagram is useful in bringing out chemical relationship among ground water samples in more definite terms[11]. Piper Diagrams are prepared and shown as in figure-2 (for sample 1 – 12) and figure-3 (for sample 13 – 24). These Piper Diagram shows that almost all ground water samples fall in lower right part in the both cation and anion triangles. For cation concentration water is predominately sodium-potassium type and for anion concentration it is predominately Chloride type but in figure-3 Piper Diagram for 13-24, water samples 21, 22, 23 have carbonate – bicarbonate type hydro-chemical group. The result obtained through the interpretation of the diamond shaped cation to anion graph almost all samples have sodium –chloride type water, it means non carbonate alkali exceeds 50% i.e. chemical properties are dominated by alkalies and strong acid. Only sample No. 21, 22, 23 have mixed type water.

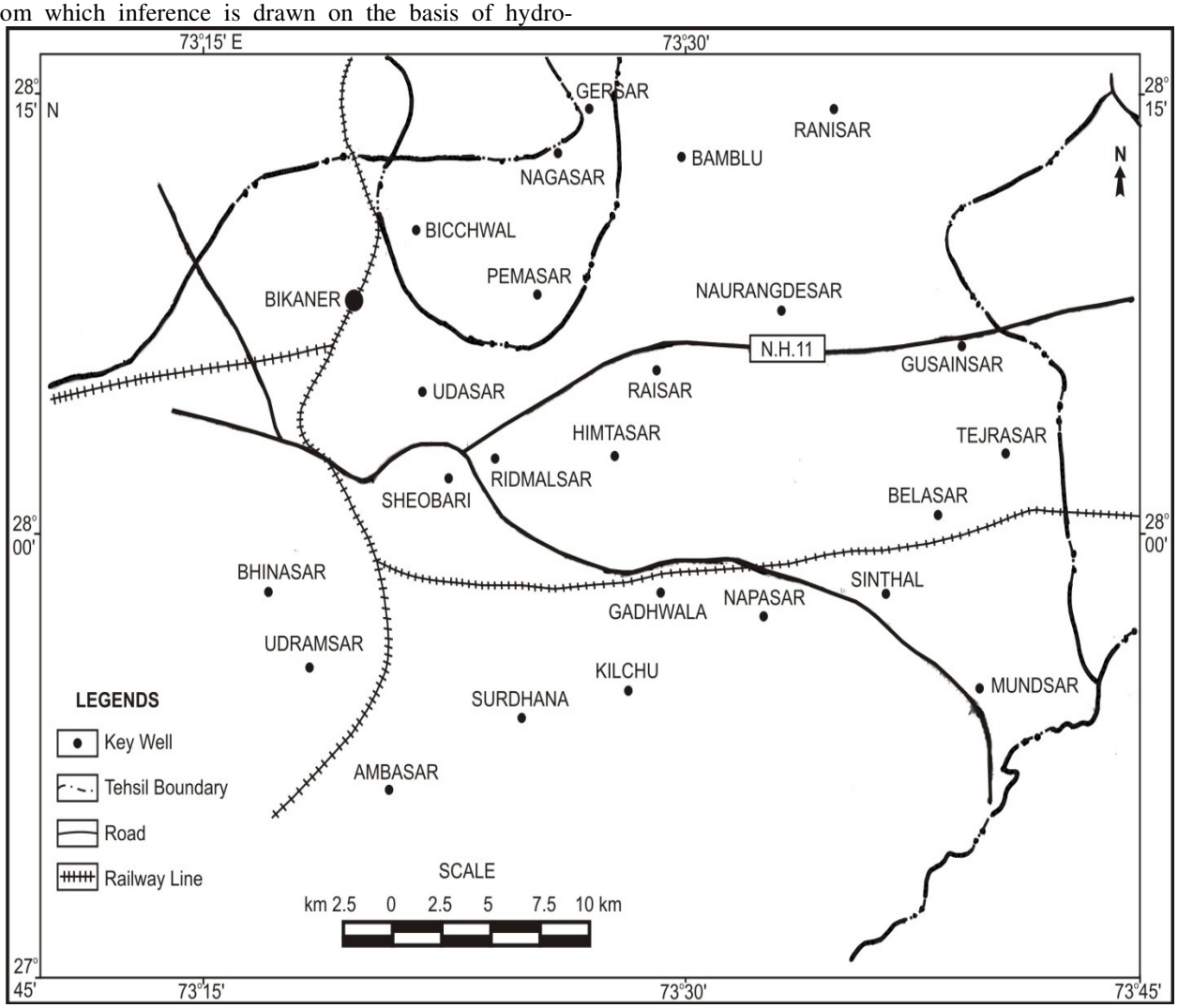

Figure-1
Map Showing Location of Villages in Study Area

Table-1(a)
Physico-chemical parameters of ground water of various villages around Raisar 2012

KeywellNo.	Name of Village	pH	TDS mg/l	EC µ S/ cm	Total Alkalinity mg/l	Total hardness mg/l	Ca^{2+} mg/l	Mg^{+2} mg/l
1	Ranisar	7.4	980	1507.69	370	220	40	29
2	**Naurangdesar**	7.6	3010	4630.77	230	440	84	55
3	Bamblu	7.5	2380	3661.54	330	430	80	55
4	**Gersar**	8.5	2103	3235.38	300	280	52	36
5	**Nagasar**	7.9	3376	5193.85	170	460	52	80
6	Bichwal	8.3	2722	4187.69	370	525	50	97
7	**Pemasar**	8.1	2846	4378.46	320	480	80	68
8	Udasar	7.6	2091	3216.92	290	330	60	37
9	**Raisar**	7.3	3789	5829.23	250	580	104	77
10	**Himtasar**	7.9	2620	4030.77	160	400	68	55
11	**Ridmalsar**	8.1	2450	3769.23	360	300	56	38
12	Sheobari	7.7	1890	2907.69	430	340	64	34
13	Bhinasar	8.2	945	1453.85	160	245	24	44
14	Udramsar	7.6	1910	2938.46	310	250	48	31
15	Ambasar	7.7	632	972.31	270	120	28	12
16	Surdhana	8.1	596	916.92	220	100	18	13
17	Kilchu	7.8	555	853.85	220	250	48	32
18	Gadwala	7.4	1680	2584.62	250	340	60	46
19	Napasar	7.9	1390	2138.46	270	210	40	26
20	Sinthal	7.7	474	729.23	240	270	52	34
21	Mundsar	7.8	587	903.08	250	150	28	19
22	Belasar	7.8	700	1076.92	300	170	32	22
23	Tejrasar	8.1	796	1224.62	260	220	14	45
24	Gusainsar	8	700	1076.92	300	180	32	24

Table-1(b)
Physico-chemical parameters of ground water of various villages around Raisar 2012

Keywell No.	Name of Village	Cl^- mg/l	SO_4^{2-} mg/l	NO_3^- mg/l	F^- mg/l	Na+ mg/l	K+ mg/l	CO_3^{2-} mg/l	HCO_3^- mg/l	SAR
1	Ranisar	199	30	17	0.3	230	12	40	261	6.72
2	**Naurangdesar**	880	150	44	0.64	609	4	54	170	12.63
3	Bamblu	627	110	59	0.7	402	4	60	61	8.43
4	**Gersar**	765	170	26	0.92	574	4	62	145	14.91
5	**Nagasar**	1212	240	55	1.16	1085	22	53	221	21.92
6	Bichwal	712	170	41	0.84	550	7	24	122	10.4
7	**Pemasar**	780	190	46	0.7	901	4	36	73	17.82
8	Udasar	319	90	35	0.36	454	5	33	128	11.32
9	**Raisar**	1220	180	84	0.5	867	5	46	107	15.64
10	**Himtasar**	847	110	122	0.52	459	4	24	110	9.98
11	**Ridmalsar**	590	150	155	1.7	570	7	52	290	14.35
12	Sheobari	380	80	75	0.7	395	4	40	195	9.88
13	Bhinasar	393	110	51	0.96	298	5	60	240	8.3
14	Udramsar	790	170	36	0.3	153	5	20	107	4.21
15	Ambasar	113	30	25	0.56	164	3	30	122	6.5
16	Surdhana	106	40	32	0.26	49	2	26	141	2.13
17	Kilchu	142	40	25	0.4	143	4	27	122	3.9
18	Gadwala	430	60	31	0.4	177	2	60	134	4.16
19	Napasar	414	30	83	0.56	249	6	32	114	7.5
20	Sinthal	170	60	16	0.3	103	4	38	128	2.71
21	Mundsar	95	20	15	0.3	77	3	42	158	2.74
22	Belasar	140	30	29	1.2	149	3	72	158	4.94
23	Tejrasar	142	30	21	0.62	276	6	95	336	8.04
24	Gusainsar	667	200	31	0.8	142	2	48	152	4.6

Table-2
Maximum and Minimum Concentration of Major Parameters of Ground Water

S. No.	Major parameters	Min. Conc. (mg/l)	Max. Conc. (mg/l)	Average Value
1	TH	100	580	304
2	TDS	474	3789	1717.6
3	Na^+	49	1085	378.2
4	K^+	2	22	5.29
5	Ca^{+2}	14	104	50.58
6	Mg^{+2}	12	97	42.04
7	CO_3^{-2}	20	95	44.75
8	HCO_3^-	61	336	158.13
9	Cl^-	95	1220	505.5
10	SO_4^{-2}	20	240	103.75
11	NO_3^-	15	155	40.08
12	F^-	.26	1.7	.65

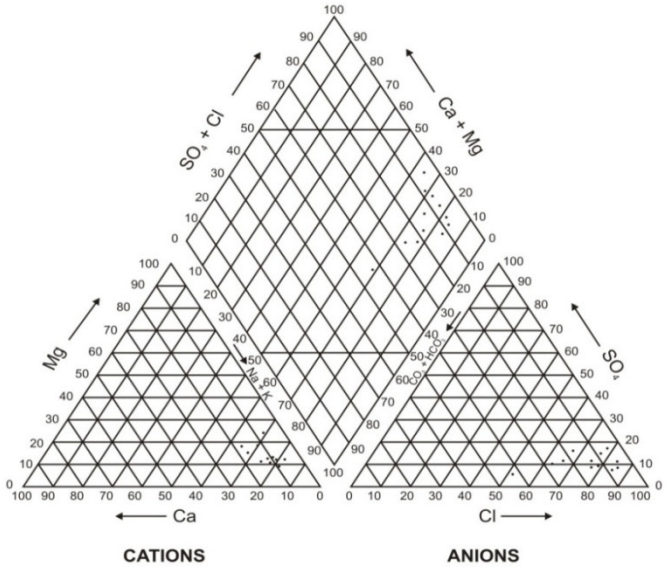

Figure-2
Piper Diagram of year 2012 (Water Samples Number 1-12)

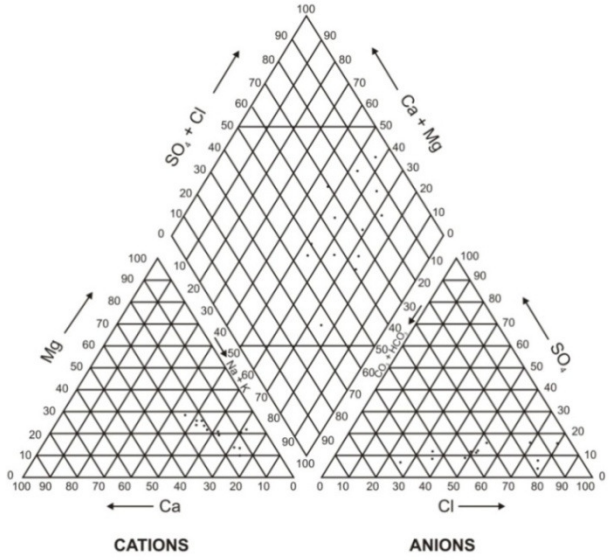

Figure-3
Piper Diagram of Year 2012 (Water Samples Number 13-24)

Salinity Hazard: The importance of electrical conductivity (EC) is its measure of salinity. It talks about the conducting capacity of water which in turn is determined by the presence of dissolved ions and solids[12]. The physico-chemical study of water samples indicates that water has very high electrical conductivity. Electrical conductivity is related to the total concentration of ions present in water. High concentrations of ions in water make the soil saline and also affect the salt intake capacity through roots[13]. In present area values of EC varies from 729.23 µs/cm to 5829.23 µs/cm. The classification of ground water with respect to salinity hazards of the study area given in table-3.

Almost all water samples fall under high and very high category (95.83 %). These water samples can be used for irrigation purpose under some salinity controlled techniques for growing plants having good salt tolerance with no adverse effects on productivity[15].

SAR: Sodium Absorption Ratio (SAR) is an important parameter for determination of suitability of irrigation water because it is responsible for sodium hazard. SAR is defined as –

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

Where all the concentration is expressed in meq/l.

The calculated value of SAR in the study area ranges between 2.13 to 21.92. The classification of ground water with respect to Sodium hazard of the study area is given in table -4.

The result shows that 29.16% samples have medium SAR value and 4.16% samples have high SAR value. There is a significant relationship between SAR values of irrigation water and the extent to which sodium is absorbed by the soil. If the water used for irrigation in high in sodium and low in calcium, the cation

exchange complex may become saturated with sodium. This can destroy soil structure owing to dispersion of clay particles[16].

US Salinity Diagram: On the basis of data, US Salinity Diagram is prepared in which EC is taken as salinity hazard and SAR is taken as sodium hazard.

Table-3
Salinity hazard classification on the basis of EC values (After Richard, 1954)[14]

Salinity hazard class	EC in µs/cm	Water Class	Number of key wells	%
C_1	< 250	Low	0	0
C_2	250-750	Medium	1	4.16
C_3	750-2250	High	11	45.83
C_4	> 2250	Very High	12	50

Table-4
Sodium hazard classification on the basis of SAR values

Sodium hazard class	SAR Range	Water Class	Number of key wells	%
S_1	< 10	Low	16	66.66
S_2	10-18	Medium	7	29.16
S_3	18-26	High	1	4.16
S_4	> 26	Very High	0	0

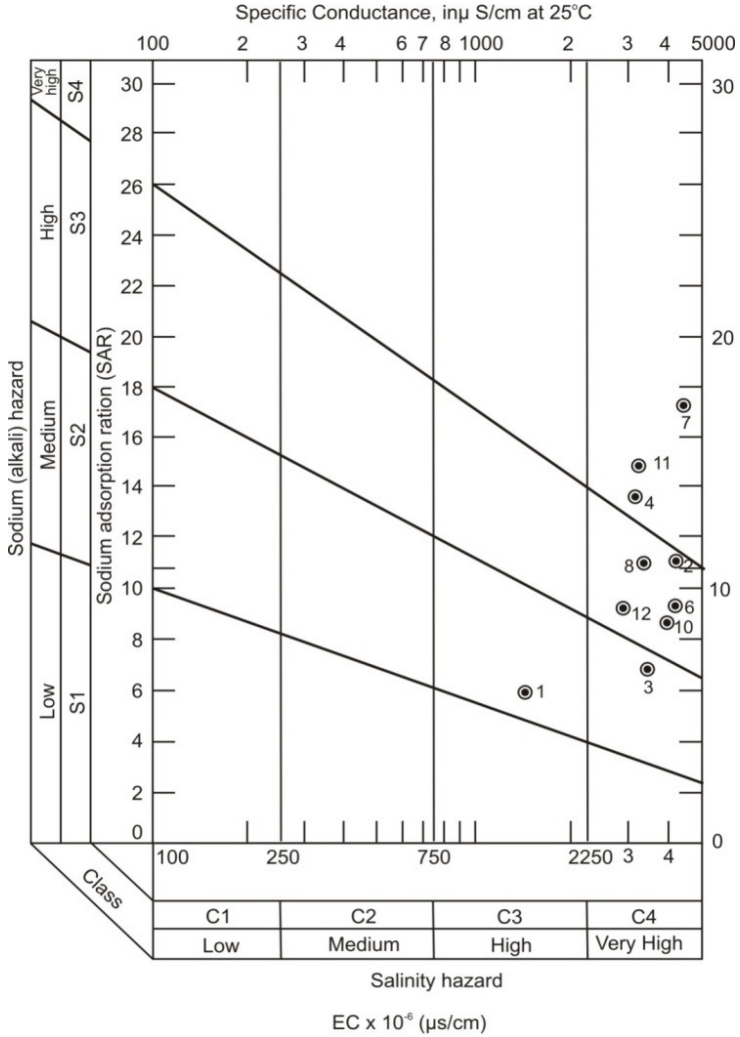

Figure-4
US Salinity Diagram for Classification of Irrigation Water (After Richards Years 1954 (Water Samples Number 1-12)

US Salinity Diagram prepared in figure-4 (sample number 1-12) of area-1 has shown that sample number 1 is lying in C_3S_2 category (high salinity- medium SAR value); sample number 3 in C_4S_2, sample number 2,6,8,10,12 in C_4S_3 and sample number 4,7,11 in C_4S_4 category (very high salinity – medium to very high SAR value). The two water sample number 5, 9 have EC value more than 5000 µS / cm are not taken US Salinity Diagram.

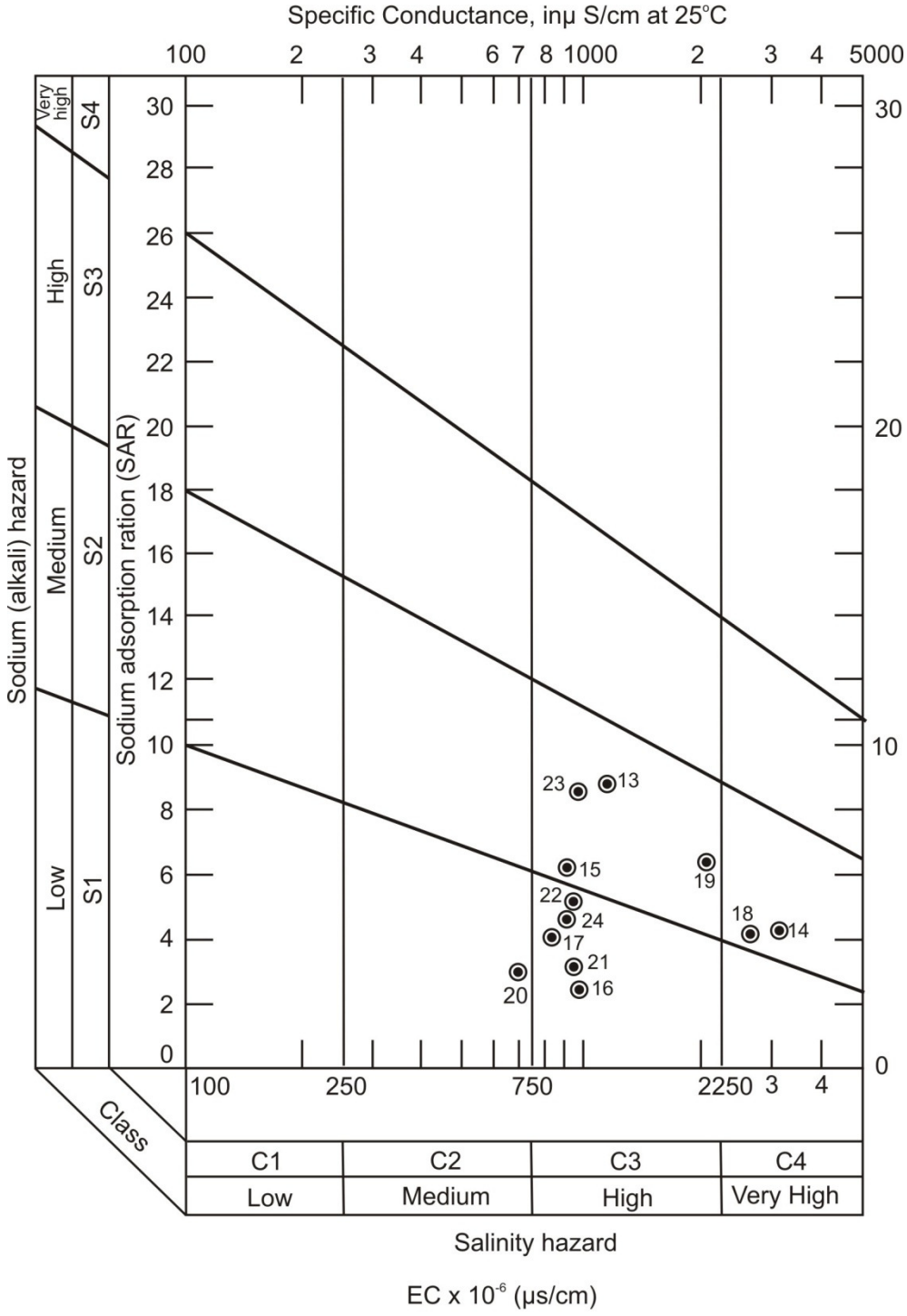

Figure-5
US Salinity Diagram for Classification of Irrigation Water (After Richards Years 1954 (Water Samples Number 13-24)

US Salinity Diagram prepared in figure-5 (sample number 13 - 24) of area-2 has shown that sample number 20 is lying in C_2S_1 category (medium Salinity – low SAR value), sample number 14, 18 in C_4S_2category (high salinity – medium SAR value) while sample number 13,15,16,17,21,22,23 in C_3S_1 and C_3S_2 category (high salinity – low to medium SAR value).

The study of US Salinity Diagram of figure-4 (sample number 1-12) of area-1 and figure-5 (sample number 13-24) of area-2 shows that in area-1 most of the water samples are lying in C_3S_3 and C_4S_4 category it means very high salinity zone and high to very high sodium hazard value while in area-2 most of the water samples are lying in $C_3S_1$and C_3S_2 category it means high salinity and low to medium sodium hazard value. It indicates that ground water of area-2 (sample number 13-24) has good quality in compare to ground water of area-1 (sample number 1-12).

Conclusion

From the result of the study area, it is observed that the quality of ground water varies from place to place. On the basis of salinity hazard classification most of the water sample fall under high to very high salinity category (95.83%) and SAR values shows that 66.66% water samples are of low class , 29.16% are of medium class and 4.16% sample fall in high class for sodium hazard . Interpretation of Piper Diagram reveals that ground water in the study area is mainly Sodium – Chloride type it means alkalinity exceeds weak acids. The US Salinity Diagram of both area has shown that only one sample (4.5%) lying in C_2S_1 category, that is good for irrigation purpose and 45.4% samples lying in C_3S_1, C_3S_2 category (high salinity – low to medium SAR) can also be used for irrigation purposes but after proper management and strategies. Remaining 50% samples lying under C_4S_2, C_4S_3, C_4S_4 categories that are not suitable for irrigation and domestic purposes.

References

1. Yadav Janeshwar, Pathak R.K. and Khan Eliyas, Analysis of Water Quality using Physico-Chemical Parameters, Satak Reservoir in Khargone District, MP, India, *Int. Res. J. Environment Sci.,* **2(1),** 9-11 **(2013)**

2. WHO, Water for pharmaceutical use in – Quality Assurance of Pharmaceuticals; A Compendium of Guidelines and Related Materials, 2nd updated edn. World Health Organization, Geneva, **2,** 170–187 **(2007)**

3. Mendie U., The Nature of Water, In the Theory and Practice of Clean Water Production for Domestic and Industrial use, Lagos: Lacto – Medals Publishers, 1-21 **(2005)**

4. Kelley W.P., Permissible Composition and Concentration of Irrigation Water. Proc. ASCE, **66,** 607 **(1940)**

5. Survey of India-Catalog.'.

6. Shandilya A.K. and Sharma S., Hydro- Meterological Analysis of Bikaner for Climatic Classification, Oikoassay, **17(1&2)**, 41–44 **(2004)**

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

8. APHA, Standard Methods for Analysis of Water and Waste Water, 18th Edition*, American Public Health Association, Ine.*, Washington DC **(1992)**

9. Raman N. and Murugensan A., Evalyation of Borewell Water of Various Places Located in and Around Virudhunagar, *Asian Journal of Chemistry,* **13(3),** 995 **(2001)**

10. Piper A.M., A Graphical Procedure in the Geochemical Interpretation in Ground Water Analysis, *Trans. AM. Geophysics Union,* **25**, 914–928 **(1944)**

11. Kumar Manjesh and Kumar Ramesh Assessment of Physico-Chemical Properties of Ground Water in Granite Mining Areas in Goramachia, Jhansi, UP, India, *Int. Res. J. Environment Sci.,*. **2(1),** 19-24, **(2013)**

12. Walton W.C., Ground Water Resources Evalution, MC Graw Hill Book, New York **(1970)**

13. Dandwate R. Sunita, Study of Physico-chemical Parameters of Groundwater Quality of Kopargaon Area, Maharastra State, India during Pre-monsoon and Post-monsoon Seasons*, E-Journal of Chemistry*, **9(1),** 15-20 **(2012)**

14. Richard L.A. Diagnosis and Improvement of Saline and Alkali Soil, US Department of Agricultural Hand Book, No. 60, 160 **(1954)**

15. Garg Jaipal, Joshi Anita and Seth Gita, Hydro Geochemistry and Quality Assessment of Ground Water of Jaipur City and its Adjoining Area (Rajasthan), *Int . j. chem. Sci.,* **6(1),** , 422-436 **(2008)**

16. Tatawat R.K., Chandel Singh C.P., Quality of Ground Water of Jaipur City, Rajasthan (India) and its Suitability for Domestic and Irrigation Purpose, *Applied Ecology and Environment Research,* **6(2),** 79-88 **(2008)**