International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 04 Issue 10
September 2017

Chemical Quality of Groundwater in Shivna River Basin, North Western Region of Madhya Pradesh, India

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Abstract:

The Groundwater is a essential source for domestic and agriculture use and all over life on the world. The chemical quality investigation of groundwater in Shivna River Basin, North –western region Madhya Pradesh, India main objective of the present study.55 ground water samples collected from the open dug wells of the Shivna River Basin. Physical characters include determination of colour, taste, odour, turbidity, pH, Total Dissolved Solids and Total Hardness. The chemical analysis involves the determinations of ionic concentrations of both cations and anions. The analyzed physico - chemical parameters have been used for the delineation of ground water suitability for various applications such as domestic, drinking and irrigation. The ranges pH = 5.7 -9.8, Specific conductivity= 430 - 671 micro mhos/cm, Total Hardness= 250 -1380, Total dissolved solids= 246 -1250, Calcium =22.00 -515.00 ppm, Magnesium =18 -350, Sodium= 68 -152 ppm, Potassium =1.00 -5.00 ppm, Chlorides = 180.00 -1300 ppm, Sulphate=82 -330 mg/l Carbonate and Bi-Carbonate=15.09 -41.03 ppm, Nitrate, 13- 49 .

Key words: Chemical analysis, Groundwater, Shivna River Basin, Madhya Pradesh, India.

Introduction:

The chemical analysis of water provides considerable insight into the health and workings of lakes, rivers, oceans, and ground water. Water chemistry has helped scientists to define the different currents and circulation of the world's oceans, improved their understanding of water's interactions with earth's geologic materials, and given insight into the impact of human activities on water bodies. Chemical analyses are used in conjunction with biological and physical parameters to characterize the quality and understand the chemical evolution of fresh water. Standardized analytical methods permit the integration of data collected on disparate water bodies regardless of geographic location .Chemical analysis of water involves several steps, which are closely linked: planning, sample collection, analytical chemistry, quality assurance, and data management. If these steps are followed, the data may be used for short-and long-term trending, modeling and predicting, and basic research. If necessary, and if chain-of-custody is employed, the data can also be utilized objectively in litigation (www.google.com).

Study Area:

The study area is located in the Shivna River Basin within the Latitudes 23º 32' to 24º 15' N and Longitudes 74º 47' E to 75º 22' E (Survey of India, Toposheet No 46 I/13 and 14, 46 M/ 1, 2 and 5, 45 L/ 16, 45 P/4, 7 and 8 on the scale of 1: 50,000, Figure -1). Shivna River originates from the Sevna village, (23^0 42'30.6" N: 74^0 48' 91.4" E) at an elevation of about 524 m. in Pratapgarh District of Rajasthan, Shivna River is a main tributary of Chambal River, which extends over 103.4 km covering parts of Madhya Pradesh and Rajasthan, Shivna River Basin covers a total area of 3361.52 sq. km. The present study area constitutes a part of Malwa Plateau of the Deccan Volcanic Province (Upper Cretaceous to Lower Eocene). It is characterized by the development of different basaltic lava flows and alluvium mainly along the river course. The study area is approachable both

by road and rail throughout the year. The temperature ranges from 4.1^{0}c to 45^0 C with an average of 24.3 ^{0} C. The minimum rainfall has been recorded as 227.30 mm and the maximum rainfall has been noted as 1441.80 mm.Annual average rainfall has been computed as 734.00 mm.

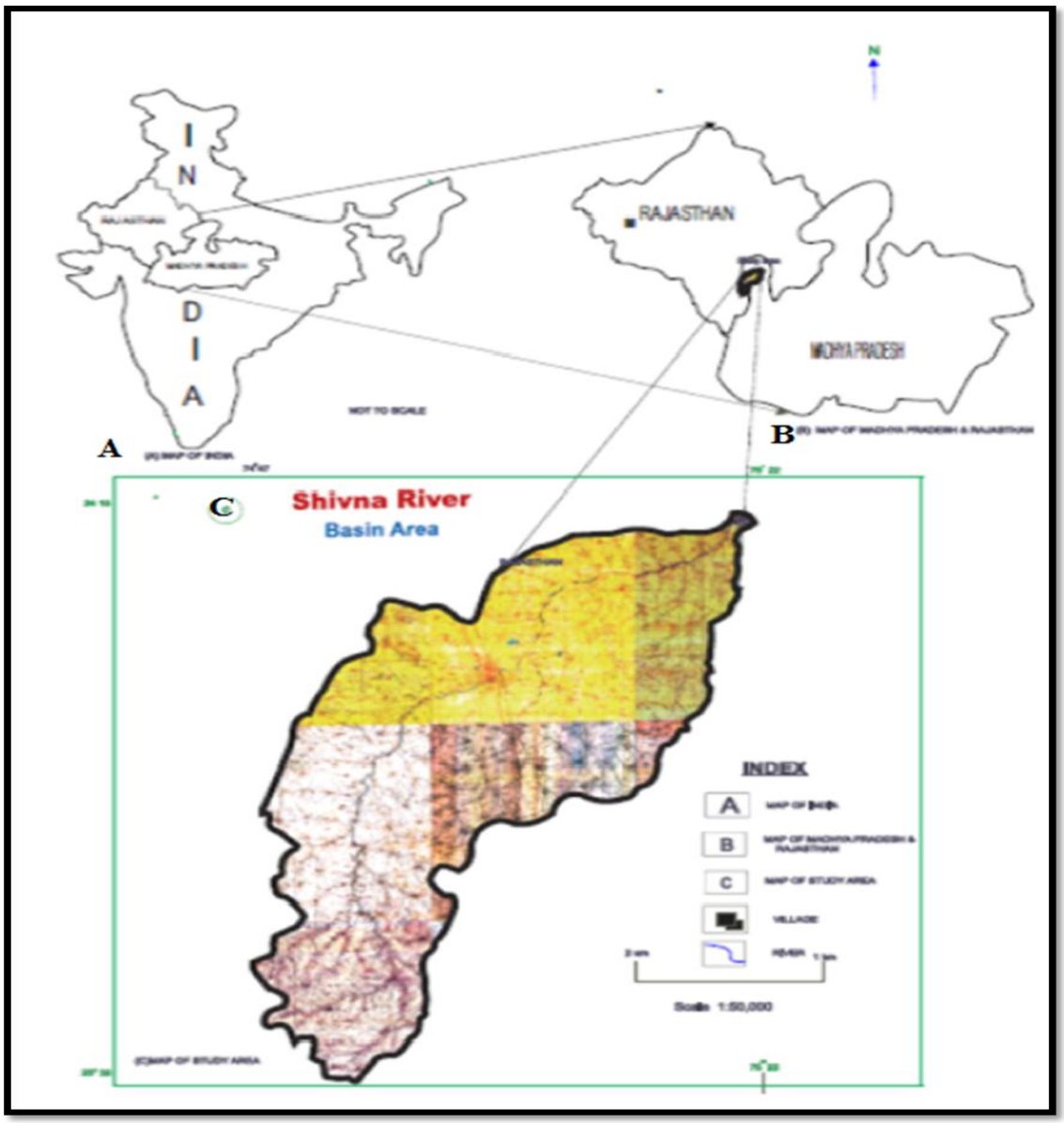

Figure 1. Location Map of Shivna River Basin, North Western Region, Madhya Pradesh, India.

Collection of Groundwater Samples:

The chemical analysis has been carried out of representative 55 ground water samples collected from the open dug wells of the Shivna River Basin area. The locations of ground water sampling sites are shown (Figure 2). The procedure of water sample collection described by Rainwater and Thatcher (1960) has been followed in the present work. The representative water samples were collected in plastic bottles of 1 liter. The bottles were rinsed by a few drops of glacial acetic acid to avoid pollution and labels having details of sample number, location, well number, depth of wells, diameter of wells, water bearing formations and

date of collection were properly pasted. The bottles were properly sealed and stored in a container for laboratory analysis.

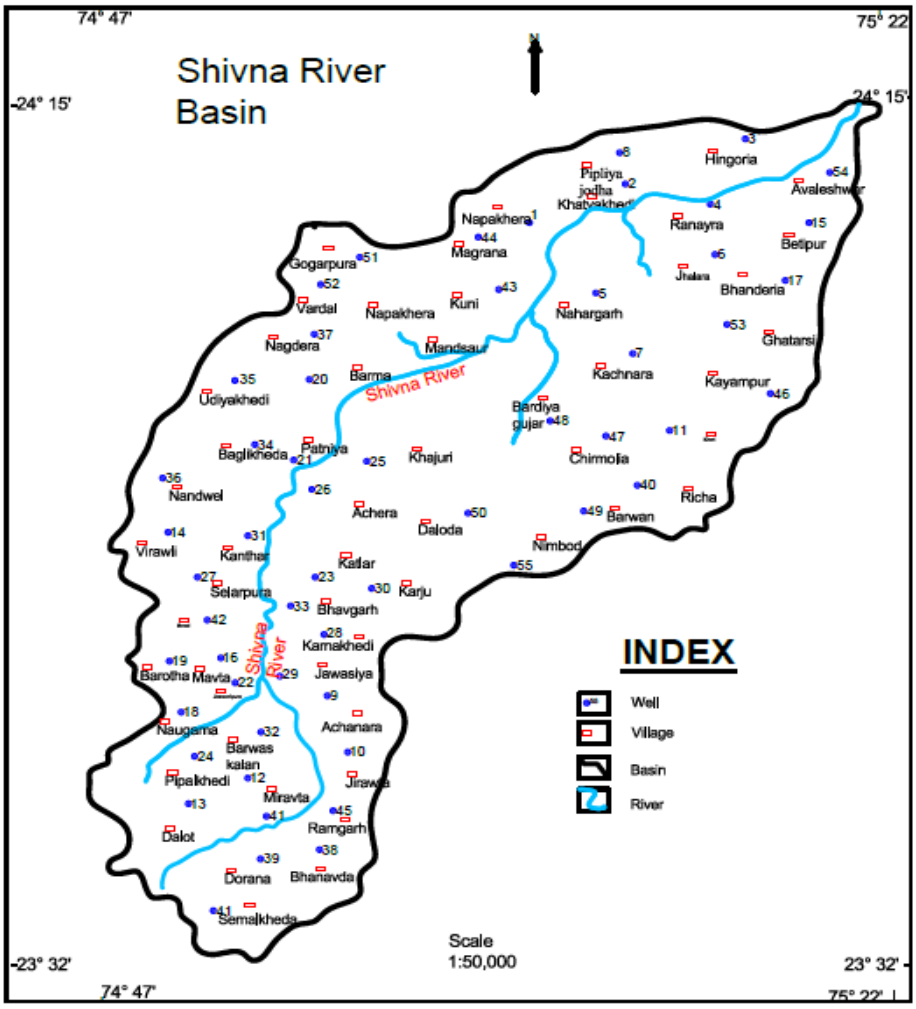

Figure 2. Location map of Ground water Sample Sites of Shivna River Basin.

Physical characters include determination of colour, taste, odour, turbidity, pH, Total Dissolved Solids and Total Hardness The chemical analysis involves the determinations of ionic concentrations of both cations and anions. The analyzed physics - chemical parameters have been used for the delineation of ground water suitability for various applications such as domestic, drinking and irrigation.

Techniques of Chemical Analysis:

The methods of chemical analysis of ground water samples have been described by many workers and are available in books. The first publication containing approved analytical methods for the analysis of water samples was prepared by Rainwater and Thatcher (1960). This publication has been revised several times since 1960 in a series entitled, "Techniques of Water-Resources Investigations of the U.S. Geological Survey" (TWRI), and in a new series of Open-File Reports started in 1992 entitled, "Methods of Analysis by

the U.S. Geological Survey National Water Quality Laboratory." (www.google.com). The procedures of chemical analysis have been suggested by Rainwater and Thatcher (1960), Vogel (1975), APHA, AWWA, and WPCF (1980), Swarup *et al* (1992) and others.

The suitability of ground water for drinking use has been determined by plotting the ionic concentration on Trilinear Piper's diagram and comparison of various parameters and ionic concentrations with the standard prescribed limits by W.H.O. (1993) and B.I.S. (Bureau of Indian Standard, 1983). The appraisal of quality for agriculture/irrigation reason has been made by plotting the investigative data and different parameters on Wilcox diagram and U.S.G.S. Salinity diagram.

Groundwater Chemical Analysis of Study Area:

The chemical analysis of 55 ground water samples collected from observation wells existing in the area of present study has been carried out by employing standard techniques of chemical analysis of water samples. The physical properties determined in respect of ground water have been recorded in tabular form (Table 1).

Physical Properties:

Physical properties of ground water samples of study area include Colour, Odour, Taste, Hydrogen ion concentration (pH), Total hardness, Specific Conductivity and Total Dissolved Solids (TDS). Determined values of these parameters are recorded (Table 1)**.**

Colour in water may be due to the inorganic ions, such as iron and manganese, humus and peat materials, planktons, weeds and industrial wastes. The term colour is used to mean the true colour of water from which turbidity has been removed. The term apparent colour includes not only the colour due to substances in solution but also that due to suspended matter. Apparent colour is determined on the original sample without filtration or centrifugation. All the examined samples of ground water were observed as colourless.

Odour is recognized as a quality factor affecting acceptability of drinking water and food prepared from it, tainting of fish and other aquatic organisms and aesthetics of recreational waters. Most organic and some inorganic chemicals contribute taste or odour. These chemicals may originate from municipal and industrial waste discharges, natural sources, such as decomposition of vegetable matter or from associated microbial activity. All the examined samples of ground water were observed as odourless/.

Taste of water samples depend on the higher concentration of acidic and alkaline salts and also due to organic materials and toxic elements. All water samples are Tasteless.

Table .1 Physical parameters of open dug well water samples of Shivna River Basin, North Western Region M. P.

S.No.	Well No.	Location	Colour	Odour	Taste	pH	Specific Cond.	TDS	TH
1	1	Napakheda	C.L.	O.L.	T.L.	8.8	640	550	490
2	2	Khatyakhedi	C.L.	O.L.	T.L.	9.4	628	550	780
3	3	Hingoria	C.L.	O.L.	T.L.	9	645	550	840
4	4	Ranayara	C.L.	O.L.	T.L.	9	622	1010	990

5	5	Nahargarh	C.L.	O.L.	T.L.	8.8	632	550	490
6	6	Jhalara	C.L.	O.L.	T.L.	8.7	670	890	490
7	7	Kachnara	C.L.	O.L.	T.L.	9	528	940	490
8	8	Pipliya Jodha	C.L.	O.L.	T.L.	8.9	534	780	850
9	9	Achnara	C.L.	O.L.	T.L.	9	544	950	750
10	10	Jirawta	C.L.	O.L.	T.L.	9.5	532	840	820
11	11	Kheri	C.L.	O.L.	T.L.	9.2	538	980	820
12	12	Mirawata	C.L.	O.L.	T.L.	9	430	850	740
13	13	Dalot	C.L.	O.L.	T.L.	9.5	598	920	870
14	14	Virawali	C.L.	O.L.	T.L.	9.2	478	820	870
15	15	Betipur	C.L.	O.L.	T.L.	9.5	608	1020	750
16	16	Mavta	C.L.	O.L.	T.L.	9.8	635	1120	890
17	17	Bhanderiya	C.L.	O.L.	T.L.	9.5	620	950	820
18	18	Naugama	C.L.	O.L.	T.L.	8.8	613	910	930
19	19	Barotha	C.L.	O.L.	T.L.	9.5	595	980	970
20	20	Berma	C.L.	O.L.	T.L.	8	592	870	445
21	21	Patniya	C.L.	O.L.	T.L.	8.7	645	780	434
22	22	Jasawantpura	C.L.	O.L.	T.L.	5.7	637	322	329
23	23	Katlar	C.L.	O.L.	T.L.	8.9	658	266	459
24	24	Pepalkheri	C.L.	O.L.	T.L.	5.7	638	460	414
25	25	Khajuri	C.L.	O.L.	T.L.	8.6	642	246	345
26	26	Achera	C.L.	O.L.	T.L.	6.8	671	312	277
27	27	Salarpura	C.L.	O.L.	T.L.	5.9	534	326	289
28	28	Karnakhedi	C.L.	O.L.	T.L.	8.8	536	730	550
29	29	Jawasiya	C.L.	O.L.	T.L.	9.6	545	456	385
30	30	Karju	C.L.	O.L.	T.L.	6.7	532	510	250
31	31	Kanthar	C.L.	O.L.	T.L.	8.8	538	380	290
32	32	Barwas kalan	C.L.	O.L.	T.L.	9	430	680	840
33	33	Bhavgarh	C.L.	O.L.	T.L.	8.8	599	780	490
34	34	Baglikheda	C.L.	O.L.	T.L.	8.7	477	720	630
35	35	Udiyakhedi	C.L.	O.L.	T.L.	8.5	602	820	520
36	36	Nandwel	C.L.	O.L.	T.L.	7.9	639	620	680
37	37	Nagdera	C.L.	O.L.	T.L.	8	622	780	580
38	38	Bhanavda	C.L.	O.L.	T.L.	8.2	613	580	280
39	39	Dorana	C.L.	O.L.	T.L.	8.5	590	520	620
40	40	Richa	C.L.	O.L.	T.L.	8.9	594	600	740
41	41	Semalkheda	C.L.	O.L.	T.L.	8.3	544	720	840
42	42	Movai	C.L.	O.L.	T.L.	8.5	532	950	920
43	43	Kuni	C.L.	O.L.	T.L.	8.5	538	780	850
44	44	Magrana	C.L.	O.L.	T.L.	8.8	430	680	880
45	45	Ramgarh	C.L.	O.L.	T.L.	7.9	598	1250	950
46	46	Kyampur	C.L.	O.L.	T.L.	8.5	478	880	880
47	47	Chirmolia	C.L.	O.L.	T.L.	9	608	530	540
48	48	Gujar bardiya	C.L.	O.L.	T.L.	8.2	638	780	540
49	49	Barwan	C.L.	O.L.	T.L.	8.5	620	1080	1000
50	50	Daloda	C.L.	O.L.	T.L.	8	612	1130	1120
51	51	Gogarpura	C.L.	O.L.	T.L.	8.2	595	480	380
52	52	Vardal	C.L.	O.L.	T.L.	8.7	593	1150	1380
53	53	Ghatarsi	C.L.	O.L.	T.L.	7.9	634	580	550
54	54	Avaleshwar	C.L.	O.L.	T.L.	7.8	670	590	530
55	55	Nimbod	C.L.	O.L.	T.L.	8.7	520	680	540

Abbreviation: C.L. – Colouless, O.L. – Odouless, T.L. – Tasteless.

pH Value : In the present work, the pH value ranges from 5.7 (Sample No. 22 at Jaswantpura village) to 9.8 (Sample No.16 at Mavta village) indicating that the water is alkaline in nature. (Table-1)

Electrical Conductivity (Specific conductivity): In the present study area, determined values of specific conductivity reveals a range from 430 (Sample no.44, village-Magrana) to 671 (Sample no. 26, village-Achera) micro mhos/cm.(Table 1). The higher values of Specific conductivity indicate the higher concentration of ionized mineral salts in ground in water.

Total Hardness : In the Shivna River Basin total hardness values range from 250 to 1380 mg/l in ground water samples (Table 1). The minimum total hardness of ground water samples has been recorded as 250 (Sample No.30, Karju village) and maximum total hardness ground water sample has been recorded as 1380 (Sample No.52, Vardal village).

Total Dissolved Solids: In the present study, the calculated values of total dissolved solids in ground water (Table 1) indicate a range from 246 (Sample No. 25, village-Khajuri) to 1250 (Sample No.45, village-Ramgarh).TDS range indicates that the quality is fairly good for drinking use.

Table 2 Classification of ground water based on TDS (Davis and De Wiest 1966)

TDS (mg/l)	Water type	No. of sample	Percentage of sample
<500	Desirable for drinking	9	16.36
500–1,000	Permissible for drinking	39	70.91
<3000,	Useful for irrigation	7	12.73
>3,000	for drinking and irrigation	-	-

Chemical Properties:

The chemical characteristics include determinations of cations and anions and parameters such as the Calcium, Magnesium, Sodium, Potassium, Chloride,, Sulphate, Bicarbonate, Carbonate, and Nitrate, (Table 3).

Table 3 Chemical parameter of open dug well water samples of Shivna River Basin, North Western Region, M. P. (in ppm).

S.No.	Well No.	Location	Ca	Mg	Na	K	Cl	So_4	Co_3	HCo_3	No_3
1	1	Napakheda	220	250	107	3.5	950	150	-	39.47	28
2	2	Khatyakhedi	245	250	142	4	950	330	-	40.09	28
3	3	Hingoria	380	340	82	2	950	150	-	23.04	28
4	4	Ranayara	240	250	68	4	950	150	-	23.07	28

5	5	Nahargarh	220	250	80	3.5	950	150	-	29.38	28
6	6	Jhalara	220	250	152	2.1	950	150	-	21.58	28
7	7	Kachnara	220	350	73	2	1210	150	-	17.18	28
8	8	Pipliya Jodha	220	250	78	1.95	1300	150	-	27.35	28
9	9	Achnara	220	150	87	1.5	650	150	-	20.12	28
10	10	Jirawta	220	150	85	3	550	150	-	19.91	28
11	11	Kheri	235	150	90	2.75	720	150	-	16.09	28
12	12	Mirawata	235	150	94	3.5	720	150	-	22.5	28
13	13	Dalot	235	150	92	3.61	750	130	-	28.2	28
14	14	Virawali	235	150	100	2.71	850	130	-	28.75	28
15	15	Betipur	235	150	130	2.15	990	130	-	24.08	28
16	16	Mavta	350	150	128	1.35	980	130	-	18.09	28
17	17	Bhanderiya	260	150	148	1.85	980	130	-	25.34	28
18	18	Naugama	160	150	118	2.5	910	130	-	17.84	28
19	19	Barotha	180	150	80	2.1	910	130	-	24.68	28
20	20	Berma	140	150	152	2.3	820	130	-	19.85	28
21	21	Patniya	122	32	73	3.5	290	200	-	38.05	26
22	22	Jasawantpura	70	126	78	3	198	156	-	41.03	43
23	23	Katlar	68	32	87	2	267	239	-	23.07	31
24	24	Pepalkheri	52	23	85	5	540	210	-	22.5	49
25	25	Khajuri	68	40	152	3.5	232	135	-	29.22	31
26	26	Achera	69	125	73	2.1	259	180	-	21.45	48
27	27	Salarpura	58	112	78	2	248	170	-	16.89	39
28	28	Karnakhedi	80	62	87	1.95	350	175	-	26.52	21
29	29	Jawasiya	76	56	85	2.5	234	167	-	20.12	32
30	30	Karju	60	90	90	3	232	198	-	18.95	40
31	31	Kanthar	90	118	94	2.75	240	210	-	16.09	30
32	32	Barwas kalan	150	80	92	3.5	280	150	-	22.3	28
33	33	Bhavgarh	250	85	100	3.61	210	200	-	27.6	30
34	34	Baglikheda	250	30	130	2.71	480	290	-	27.25	25

35	35	Udiyakhedi	150	18	128	2.15	430	300	-	23.54	22
36	36	Nandwel	150	22	148	1.37	410	210	-	17.03	15
37	37	Nagdera	230	28	118	1.85	250	120	-	25.35	14
38	38	Bhanavda	95	18	80	2.5	390	150	-	16.87	18
39	39	Dorana	28	30	152	2.1	180	120	-	24.68	15
40	40	Richa	30	24	73	2.3	450	180	-	18.97	22
41	41	Semalkheda	25	18	100	2.75	410	190	-	20.12	25
42	42	Movai	22	21	130	3.5	1300	110	-	19.91	41
43	43	Kuni	155	211	128	3.61	240	220	-	16.09	40
44	44	Magrana	220	150	148	28	650	150	-	22.5	28
45	45	Ramgarh	210	130	118	2.2	1100	130	-	28.2	26
46	46	Kyampur	118	75	80	1.35	750	115	-	28.75	13
47	47	Chirmolia	110	82	152	1.85	480	100	-	24.18	23
48	48	Gujar bardiya	115	130	73	2.5	420	87	-	17.09	26
49	49	Barwan	215	170	78	2.1	980	90	-	25.34	24
50	50	Daloda	515	160	87	2.3	1050	110	-	17.84	27
51	51	Gogarpura	215	90	85	3.4	250	85	-	24.68	21
52	52	Vardal	514	190	90	3	1150	155	-	18.75	27
53	53	Ghatarsi	119	193	94	1	690	85	-	20.12	21
54	54	Avaleshwar	95	193	90	2	600	82	-	19.95	20
55	55	Nimbod	120	113	102	3.7	720	110	-	15.09	22

Characteristics of Cations:

Calcium: The concentration of calcium in ground water of Shivna River Basin varies from 22.00 ppm (Sample No-42, at Movai) to 515.00 ppm (Sample No-50, at Daloda). The range of calcium concentration in ground water sample in the study area has been displayed (Table 3, 4).

Table .4 Concentration of Calcium in Shivna River Basin.

Range of Calcium [ppm(Mg/l)]	Number of water sample	% of sample
<75	11	20
75-200	18	32.72
>200	26	47.27

Magnesium: In the present study area, Magnesium concentration indicates a range from 18 (Sample No.41, village-Semalkheda) to 350 (Sample No.7, village Kachnara). 20 samples of ground water have Magnesium values more than 159 mg/l and should be used after treatment of Magnesium content.

Table .5 Concentration Range of Magnesium

Mg Range Mg/l	No of water sample	% of sample	Remarks
<30 (If there are 240 Mg/l SO4)	8	14	Maximum acceptable concentration as per international standard
>30	20	36.36	Maximum allowable concentration up to 150.
>150	27	49.0	---

Sodium: The sodium concentration in the present ground water samples indicates a variation range from 68 ppm (Sample No. 4, village-Ranayra) to 152 ppm (Sample No. 47, village-Chiramolia) . The concentration of sodium content in ground water has been assigned as a result of the release of soluble product, during the weathering of plagioclase feldspar (Devis and DeWiest, 1966).

Potassium: The concentration of potassium in ground water samples of area indicates a variation range from 1.00 ppm (Sample No.53 Ghatarsi) to 5.00 ppm (Sample No 24, Pipalkhedi). The occurrence of higher concentration of potassium in ground water can be assigned to the presence of igneous (basalt) rocks in the area.

Chlorides: The concentration of Chloride in ground water samples of area indicates a variation range from 180.00 ppm (Sample No.39 Dorana) to 1300 ppm (Sample No 42, village - Movai). The classification of ground water, on the basis of chloride concentration is given in Table 6.

Table 6. Classification of Ground water of Shivna River Basin Based on Chloride Contents

Chloride Range Mg/liter	Quality	Number of sample	% of samples
<100	Safe	-	-
100 to 150	Tolerable	-	-
150 to 200	Tolerable to some extent	2	3.63
200 to 250	Intolerable health hazard	53	96.36

The classification on the basis of concentration of chloride content in the Basin area suggests that

three samples (3.63 %) are tolerable to some extent, whereas 53sample (96.36 %) belongs to intolerable limit and cause health hazard.

Sulphate: In the Basin area Sulphate range determined minimum 82 mg/l, village Avaleshwar Sample no.54 and maximum range 330 mg/l village Khatyakhedi Sample no. 2.

Carbonate and Bi-Carbonate: Carbonate and bi-Carbonate ions in ground water are the dissolved carbon dioxide in rain, which as it enters the soil, dissolves more carbon dioxide. The pH of the water indicates the form in which carbon dioxide is present. Presence of carbonic acid is indicated when pH is less than 4.5, of bi-carbonate in pH between 4.5 to 8.2 and carbonate in pH 8.2 (Karanth, 2003). In the Shivna River Basin, bi-carbonate in ground water ranges from 15.09 to 41.03 ppm. The minimum bi-carbonate has been recorded as 15.09 ppm and maximum bi-carbonate has been observed as 41.03 ppm Sample No. 22 at Jasawantpura village.

Nitrate: In the present study area, Nitrate concentration indicates a range from 13(Sample No.46 village Kayampur) to 49 (Sample No. 24 village Pipalkhedi).

Data Representation of Analysis:

The data of chemical analysis have been displayed both in the tabular and graphic forms of data representation. The data measurements are recorded in different units such as milligrams per liter (mg/liter) or ppm and milliequvialents per liter (emg/liter) or epm. Thes data have been used for assessment chemical quality of ground water suitability for domestic, drinking, irrigation and industrial application.

Delineation of Groundwater quality:

The delineation of chemical quality of ground water is one of the most importance aspects in the formulation of a development and management of ground water resource planning, which requires top priority implementation of a plan for catering the sustained water supply to the every country facing water supply problem. The chemical quality of ground water suitability of Shivna River Basin has been discussed for different applications.

Table .7 Chemical Parameters of open dug well water samples of Shivna River Basin (values expressed in percentage of epm.).

Well No.	Location	Ca	Mg	Na	K	Cl	So4	Co3	HCo3
1	Napakheda	30.253	56.673	12.827	0.247	87.668	10.216	-	2.116
2	Khatyakhedi	31.291	52.637	15.810	0.262	78.071	20.015	-	1.914
3	Hingoria	37.512	55.330	7.057	0.101	88.447	10.307	-	1.246
4	Ranayara	33.639	57.765	8.309	0.287	88.445	10.307	-	1.248
5	Nahargarh	31.265	58.569	9.911	0.255	88.145	10.272	-	1.584
6	Jhalara	28.732	53.823	17.305	0.141	88.517	10.315	-	1.168

7	Kachnara	25.533	66.963	7.386	0.119	90.930	8.319	-	0.750
8	Pipliya Jodha	31.378	58.781	9.698	0.143	91.126	7.760	-	1.114
9	Achnara	40.450	45.465	13.944	0.141	84.154	14.333	-	1.513
10	Jirawta	40.522	45.546	13.648	0.283	81.812	16.467	-	1.721
11	Kheri	41.804	43.988	13.957	0.251	85.709	13.178	-	1.113
12	Mirawata	41.519	43.687	14.477	0.317	85.331	13.120	-	1.549
13	Dalot	41.643	43.818	14.212	0.328	86.974	11.126	-	1.900
14	Virawali	41.168	43.318	15.271	0.243	88.298	9.967	-	1.735
15	Betipur	39.383	41.440	18.992	0.185	90.005	8.723	-	1.272
16	Mavta	49.327	34.850	15.726	0.097	90.202	8.831	-	0.967
17	Bhanderiya	40.801	38.804	20.246	0.149	89.853	8.797	-	1.350
18	Naugama	31.285	48.350	20.114	0.250	89.540	9.440	-	1.020
19	Barotha	36.138	49.645	14.001	0.216	89.191	9.404	-	1.405
20	Berma	26.874	47.465	25.435	0.226	88.412	10.345	-	1.243
21	Patniya	50.795	21.963	26.495	0.747	63.083	32.108	-	4.809
22	Jasawantpura	20.159	59.817	19.582	0.443	58.759	34.167	-	7.074
23	Katlar	34.410	26.694	38.378	0.519	58.451	38.615	-	2.934
24	Pepalkheri	31.217	22.762	44.483	1.538	76.265	21.889	-	1.846
25	Khajuri	25.351	24.583	49.398	0.669	66.550	28.580	-	4.870
26	Achera	20.308	60.647	18.729	0.317	64.060	32.858	-	3.082
27	Salarpura	18.610	59.243	21.818	0.329	64.705	32.735	-	2.560
28	Karnakhedi	30.882	39.455	29.277	0.386	70.769	26.115	-	3.115
29	Jawasiya	31.187	37.882	30.406	0.526	63.425	33.407	-	3.168
30	Karju	20.807	51.451	27.208	0.533	59.618	37.552	-	2.829
31	Kanthar	24.465	52.877	22.275	0.383	59.357	38.331	-	2.312
32	Barwas kalan	41.223	36.243	22.041	0.493	69.365	27.425	-	3.210
33	Bhavgarh	52.176	29.244	18.194	0.386	56.203	39.505	-	4.292
34	Baglikheda	60.362	11.941	27.362	0.335	67.619	30.151	-	2.230

35	Udiyakhedi	51.307	10.150	38.167	0.377	64.653	33.290	-	2.056
36	Nandwel	47.470	11.477	40.830	0.222	71.319	26.960	-	1.721
37	Nagdera	60.531	12.148	27.072	0.249	70.763	25.068	-	4.169
38	Bhanavda	48.545	15.163	35.637	0.655	76.395	21.685	-	1.920
39	Dorana	13.268	23.434	62.788	0.510	63.626	31.306	-	5.069
40	Richa	22.325	29.442	47.356	0.877	75.774	22.370	-	1.856
41	Semalkheda	17.451	20.713	60.852	0.984	72.965	24.955	-	2.080
42	Movai	12.810	20.158	65.988	1.044	93.340	5.829	-	0.831
43	Kuni	25.151	56.442	18.106	0.300	58.293	39.437	-	2.271
44	Magrana	36.028	40.494	21.128	2.350	84.003	14.307	-	1.689
45	Ramgarh	39.750	40.565	19.471	0.213	90.734	7.914	-	1.351
46	Kyampur	37.812	39.619	22.347	0.222	88.072	9.967	-	1.962
47	Chirmolia	29.052	35.702	34.996	0.250	84.529	12.997	-	2.474
48	Gujar bardiya	29.171	54.361	16.142	0.325	84.996	12.994	-	2.009
49	Barwan	38.099	49.661	12.049	0.191	92.353	6.260	-	1.387
50	Daloda	60.179	30.821	8.862	0.138	91.980	7.112	-	0.908
51	Gogarpura	48.952	33.780	16.871	0.397	76.436	19.180	-	4.384
52	Vardal	56.657	34.525	8.648	0.169	90.176	8.970	-	0.854
53	Ghatarsi	22.902	61.230	15.770	0.099	90.264	8.207	-	1.529
54	Avaleshwar	19.284	64.582	15.926	0.208	89.271	9.004	-	1.725
55	Nimbod	30.220	46.911	22.392	0.477	88.894	10.023	-	1.082

Ground water quality for domestic application: Ground water quality assessment for domestic application has been determined by plotting ionic concentration on Piper's trilinear diagram.

Trilinear Piper's Diagram: The chemical composition of water is represented by Trilinear plotting in two separate triangles one for anions and the other for cations and finally projected in a central diamond shaped diagram by one single point (Palmer 1911, Hill 1940, Piper 1944, 1953, Handa 1965).

The trilinear diagram has been suggested by Piper (1944, 1953) and commonly knows as Trilinear Piper's Diagram. This diagram represents the provision of comparing different samples together. Piper's (1944, 1953) diagram of plotting was

suggested and represents a Trilinear plotting system. The relative concentration of constitutes is expressed as a percentage of total reacting value and the essential chemical character of water indicated graphically by a single point plotting of cations and anions on Trilinear coordinates. For convenience the sum total of all cation reacting values and anions variable is taken as the 100 percent base for computing percentage reacting values of the several cation and anion variables.

Piper's diagram consists of three distinct fields, two triangular fields at lower left and lower right and intervening diamond shaped field. All the entire three fields have scaled reading in 100 parts. The Plots of ionic concentration on the Trilinear Piper's diagram have been marked with the help of Software GW Chart (Figure 3) plots of diagram indicate that on the diamond shaped field , all the chemically analysized samples of ground water belong to Ca+Mg rich. A few samples reveal less then 50 % Ca+Mg facies having less then 50% SO_4 .The ground water samples of Shivna River Basin represent Ca,Mg , HCO_3 facies.

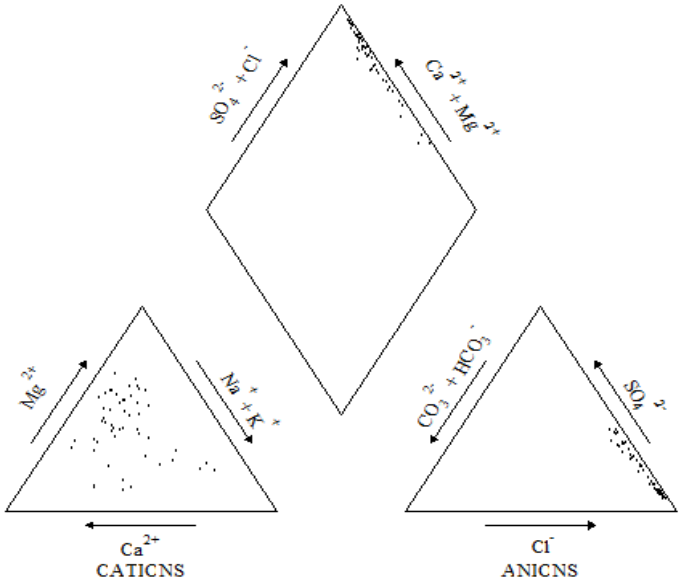

Figure 3 Piper's diagram exhibiting ionic plots of Shivna River Basin ground water samples.

Drinking Quality for Groundwater:

Ground water samples of the Shivna River Basin exceeding the permissible limits prescribed by WHO (2004) and ISI (1993) for drinking purpose. The comparison of determined values of ground water with the standard prescribed limits.The parameter such as pH, EC and TDS are within the maximum permissible limit for drinking.The TH values are also within the maximum permissible limits except a few samples which may be used after proper treatment for reducing hardness of water. The presence of Na, K, HCO3 and SO_4 values within the maximum permissible limits.

Table 8.Comparison of physical and chemical Parameters of ground water samples, in drinking water, Shivna River Basin, North western Region, M.P.

Sr. NO.	Water quality Parameters	WHO International Standards 2004		Indian Standard (ISI 10500,1993)		Range in the Basin area
		Most desirable limit	Max. allowable limit	Highest desirable	Max. permissible	
1	pH	6.5	8.5	6.5-8.5	6.5-9.5	5.7-9.8
2	EC	1400	-	-	-	430-671
3	TDS	500	1500	500	2000	246-1250
4	TH (as $CaCO_3$	100	500	300	600	250-1380
5	Ca^{2+}	75	200	75	200	22-515
6	Mg^{2+}	50	150	30	100	18-350
7	Na^{2+}	-	200	-	200	68-152
8	K^{+}	-	12	-	-	01-May
9	CO_3^{2-}	-	-	-	-	-
10	HCO_3^{-}	-	-	-	-	15.09-41.03
11	SO_4^{2-}	200	400	200	400	82-330
12	Cl^{-}	200	600	250	1000	180-1300
13	NO_3	-	-	-	45	13-49

The values of Ca ,Mg and Cl are more than the maximum permissible limits and making the water unsuitable to drinking purpose hence the ground water sample need the treatment for reduction this ions in the water before the supply. In general the ground water after treatment for quality purification, should be allowed for drinking purpose.

Criteria for Irrigation Quality: The delineation of suitability of ground water quality for irrigation is dependent on the effects of the mineral constituents of the water of both the plant and soil. Soil hazardous to crop development or human and livestock. The following parameter have been determined to assess the ground water suitability for irrigation purpose.

1. Sodium Percent, 2 Kelley's Ratio, 3. Sodium Adsorption ratio, 4. Residual Sodium Carbonate, 5. Mg-Hazards. The determined values of above mentioned parameters have been displayed (Table 7.10).

Table 9. Indicates derived from the geochemical Parameters.

S. No.	Well no	Sodium Percent	Kelley's Ratio	Sodium Adsorption ratio	Residual Sodium Carbonate	Mg-Hazards
1	1	13.074	0.148	1.172	-30.896	65.197
2	2	16.072	0.188	1.526	-32.133	62.716
3	3	7.158	0.076	0.736	-46.553	59.595
4	4	8.596	0.091	0.733	-32.163	63.197
5	5	10.166	0.11	0.876	-31.061	65.197
6	6	17.445	0.21	1.665	-31.189	65.197
7	7	7.505	0.08	0.712	-39.487	72.396
8	8	9.841	0.108	0.854	-31.095	65.197
9	9	14.086	0.162	1.108	-22.987	52.918
10	10	13.931	0.159	1.083	-22.991	52.918
11	11	14.207	0.163	1.129	-23.802	51.273
12	12	14.794	0.17	1.179	-23.697	51.273
13	13	14.54	0.166	1.154	-23.603	51.273
14	14	15.515	0.181	1.254	-23.594	51.273
15	15	19.177	0.235	1.63	-23.671	51.273
16	16	15.823	0.187	1.442	-29.508	41.4
17	17	20.395	0.254	1.81	-24.898	48.746
18	18	20.364	0.253	1.61	-20.031	60.714
19	19	14.217	0.163	1.066	-20.916	57.873
20	20	25.661	0.342	2.127	-19	63.85
21	21	27.242	0.364	1.521	-8.096	30.187
22	22	20.024	0.245	1.289	-13.185	74.794
23	23	38.896	0.628	2.18	-5.647	43.686
24	24	46.021	0.824	2.469	-4.118	42.168
25	25	50.067	0.989	3.617	-6.205	49.231
26	26	19.046	0.231	1.212	-13.374	74.915
27	27	22.147	0.28	1.379	-11.83	76.095
28	28	29.663	0.416	1.775	-8.657	56.094
29	29	30.932	0.44	1.804	-8.069	54.847
30	30	27.741	0.377	1.717	-10.087	71.204
31	31	22.658	0.288	1.535	-13.934	68.368
32	32	22.534	0.285	1.509	-13.7	46.786
33	33	18.58	0.223	1.394	-19.015	35.918
34	34	27.698	0.378	2.069	-14.496	16.515
35	35	38.543	0.621	2.63	-8.58	16.515
36	36	41.052	0.693	2.986	-9.016	19.47
37	37	27.321	0.372	1.955	-13.365	16.714
38	38	36.292	0.559	1.973	-5.945	23.801
39	39	63.298	1.711	4.756	-3.46	63.85
40	40	48.233	0.915	2.41	-3.16	56.874
41	41	61.836	1.594	3.724	-2.398	54.274
42	42	67.032	2.002	4.758	-2.499	61.143
43	43	18.407	0.222	1.572	-24.828	69.175
44	44	23.478	0.276	1.886	-22.948	52.918
45	45	19.685	0.242	1.578	-20.711	50.507
46	46	22.569	0.289	1.417	-11.586	51.166
47	47	35.246	0.54	2.673	-11.838	55.134

48	48	16.467	0.193	1.108	-16.152	65.078
49	49	12.24	0.137	0.965	-24.297	56.587
50	50	9	0.097	0.859	-38.568	33.869
51	51	17.268	0.204	1.228	-17.727	40.831
52	52	8.818	0.095	0.862	-40.971	37.864
53	53	15.869	0.187	1.238	-21.485	72.779
54	54	16.134	0.19	1.219	-20.29	77.006
55	55	22.87	0.29	1.605	-15.036	60.82

❖ **Sodium Percent:**

Sodium concentration is important in classifying criteria for irrigation water because sodium reacts with soil to reduce its permeability. Soil containing a large proporagation of sodium with carbonate as the predominant anion is termed alkali soils, those with chloride as sulfates the predominant anions are saline soils. The type of sodium saturated soil will support little or growth of crops (Todd 1959, 1980). Sodium percentage is usually expressed as:

$$Sodium\ percent\ (Na\ \%) = \frac{(Na + K)x\ 100}{Na + Ca + Mg + K}$$

The ionic concentration is expressed in equivalent per million (epm). Sodium percentage in Shivna River Basin are water various from 7.158 to 67.032(Table 9).

❖ **Kelley's Ratio**

Kelly's (1946) suggested calculation for the ratio of Na and Ca + Mg this ratio is known as the Kelly's ratio. This ratio is a reflection of alkali hazard of the water. It can be expressed as: Kelly's ration = Na / Ca +Mg

Where, the Na, Ca and Mg ionic concentration are expressed in equivalent per million (epm). Kelly's ratio of Basin area water various form 0.076 to 2.002 (Table 9).

❖ **Sodium Adsorption Ratio**

U. S. Salinity laboratory (Richard 1954) has established a standard on the basis of the sodium adsorption ratio (SAR) of water. The sodium adsorption ratio is defined by the following equation:

$$Sodium\ Adsorption\ Ratio\ (SAR) = \frac{Na}{\frac{\sqrt{Ca + Mg}}{2}}$$

Where, Na, Ca and Mg represents the concentration in equivalent per million (epm). Sodium adsorption ratio in study area are water various from 0.712 to 4.758 (Table 9).

❖ **Residual Sodium Carbonate**

Residual sodium carbonate is used to express carbonate and bicarbonate hazards on water quality by symbol 'RSC'. It is expressed by formula :

RSC= (Co_3 + HCo_3) – (Ca + Mg)

The representation of ionic concentration is expressed in equivalent per million (epm). Eaton (1950) affirmed that the water having excess ions of carbonate and bicarbonate than calcium and magnesium usually contain much greater alkali formation as compared to its sodium adsorption ratio and as a result permeability of soil is decreased. The study area residual sodium carbonate indicate a water varies from -2.398 to -46.53 (Table 9).

❖ **Mg- Hazards**

Paliwal (1972) examined the impact of magnesium hazards on irrigation water by using the following expression:

Mg – Hazard = Mg X 100 / Ca + Mg

The magnesium ratio is the excess amount of magnesium over calcium and magnesium amount,

where otherwise normally the level of calcium and magnesium will be in a state of equilibrium the excess concentration of magnesium affects the quality of soil resulting in poor development of crop. Magnesium Hazard in study area are within the limit from 16.515 to 77.006. (Table 9).

(a) Application of Wilcox Diagram for Irrigation Quality

Wilcox (1955) has proposed a classification of favourable quality assessment of irrigation water, based on the electrical conductivity and sodium percentage. Ground- water has been classified into (i) excellent to good, (ii) good to permissible, (iii) permissible to doubtful, (iv) doubtful to unsuitable and (v) unsuitable.

In the Shivna River Basin, the plots of the sodium percentage and electrical conductivity values on the Wilcox diagram (Figure .4), indicate that 7 samples are referable to the category of excellent to good quality for irrigation and 47 samples are represents the category of good to permissible for irrigation purposes. In general, ground water is suitable for irrigation use.

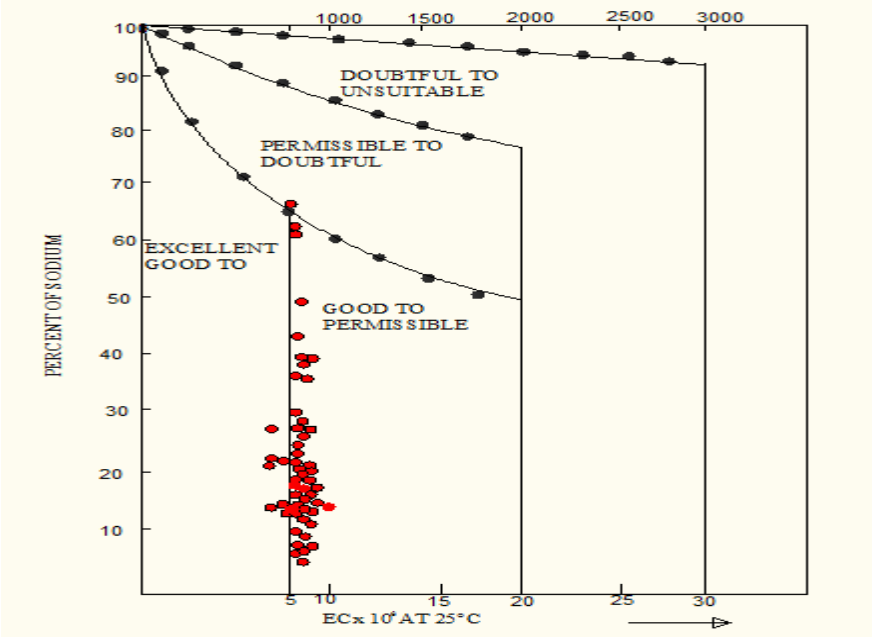

Figure .4 Wilcox diagram representing ground water parameter for irrigation.

(b) Application of U. S. Salinity Diagram

The U. S. Salinity laboratory (1954) suggested a classification of water for irrigation quality, based on the electrical conductivity and sodium adsorption ratio (SAR), which provides direct indication of the salinity and alkalinity hazards by locating the point for particular irrigation water describing 16 classes with electrical conductivity and SAR as coordinates. The figure is binomial and C_1, C_2, C_3 and C_4 represent water classes with increasing hazards from total salt concentration and S_1, S_2, S_3 and S_4 represent water classes for increasing hazards of exchangeable and accessible sodium accumulation in irrigated soils. The U. S. Salinity diagram has been adopted for delineation of ground water quality for irrigation.

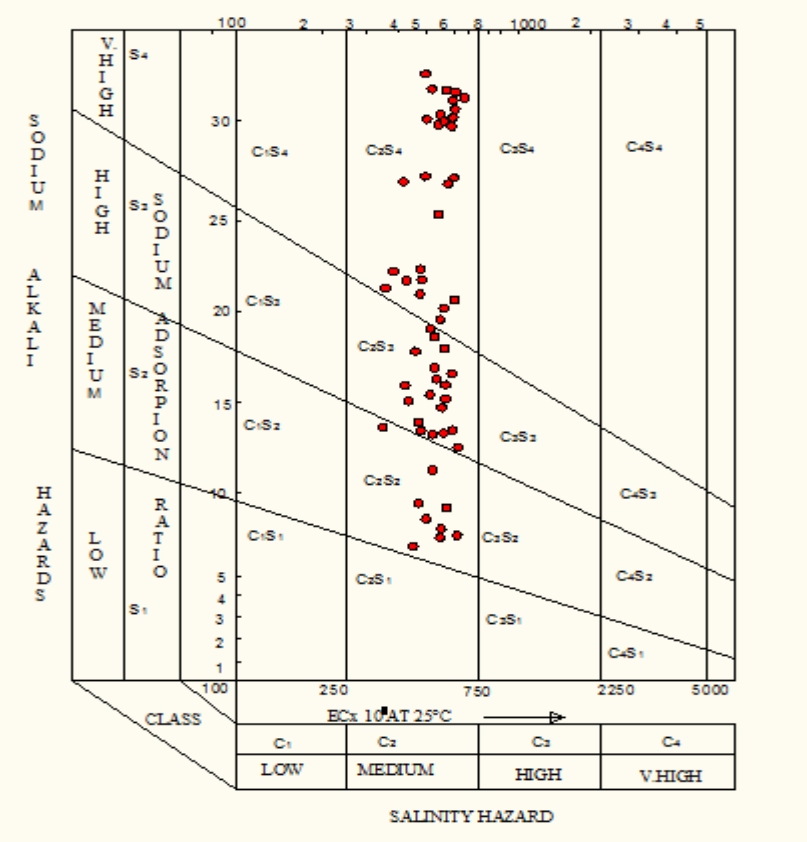

Figure .5 U. S. Salinity diagram exhibiting classification for ground water for irrigation use.

In the Basin are has been plots of the value electrical conductivity and sodium adsorption ratio on U. S. Salinity diagram (Figure .5) reveals that samples belong class C_2S_2 ,C_2S_3 and C_2S_4 representing a medium salinity to very high Sodium.

Conclusion:. The Shivna River Basin groundwater is normally alkaline nature.The area depends economically only on agriculture by using dug wells and bore wells for groundwater. The Basin area is underline by Shale, Sandstone and major area of Basalt. The parameter such as pH, EC and TDS are within the maximum permissible limit for drinking. The TH values are also within the maximum permissible limits except a few samples which may be used after proper treatment for reducing hardness of water. The presence of Na, K, HCO3 and SO_4 values within the maximum permissible limits. The values of Ca, Mg and Cl are more than the maximum permissible limits and making the water unsuitable to drinking purpose hence the ground water sample need the treatment for reduction this ions in the water before the supply. In general the ground water after treatment for quality purification, should be allowed for drinking purpose. Ground water is suitable for irrigation use.

Acknowledgements: Sincere appreciation is recorded to Prof K. N. Singh, Professor and Head, School of Studies in Earth Science, Vikram University, Ujjain for encouragement.

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