Evaluation of Groundwater Quality for Drinking Purposes of Tribal Society in Meghnagar Study Region, Jhabua District, Madhya Pradesh, India

Vinod Bhuriya[1], Dilip Dixit[2], and Pranava Mishra[3]

Author's Affiliations:
[1]Department of Geology, P.M. COE, S.C.A. Govt. P.G. College Jhabua, Madhya Pradesh- 457661, India.
[2]Madhya Pradesh Jal Nigam Bhopal, District- Bhopal, Madhya Pradesh- 462004, India.
[3]Department of Zoology, Govt. Kamla Nehru Girls College, Damoh, Madhya Pradesh-470661, India.

*Corresponding Author: Dr.Vinod Bhuriya, Department of Geology, P.M. COE, S.C.A. Govt. P.G.
 College Jhabua, Madhya Pradesh- 457661, India.
 E-mail: drvinodbhuriyageo@gmail.com

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Abstract:
A study called "Evaluation of Groundwater Quality for Drinking Purposes of Tribal Society in Meghnagar study Region, Jhabua District, Madhya Pradesh, India" was carried out to assess the shallow groundwater quality of a specific Pat River basin. Twenty samples were taken from an open-pit well in the Meghnagar research area. Turbidity, electrical conductivity, total dissolved solids, and total hardness have all been measured, and the physical parameters show that all samples are colorless, odorless, and tasteless. Calcium, magnesium, sodium, potassium, chloride, sulphate, carbonate, bicarbonate, nitrate, and fluoride were among the chemical characteristics that were determined. Determining the physical and chemical characteristics of groundwater is crucial for defining its suitability for tribal society's drinking needs, and the quality assessment indicates that the groundwater in the research region is suitable for drinking.

Keywords: *Evaluation, Groundwater Quality, Drinking,Tribal Society, Meghnagar study Region, Jhabua District, Madhya Pradesh, India.*

INTRODUCTION

The purpose of the water quality analysis is to determine various physical and chemical characteristics of groundwater samples taken from the Meghnagar research area and to gather information on groundwater quality from various wells. The age range of the groundwater-bearing rock formations, or aquifers, is Archaean to Recent. The type and depth of the soils and subsurface geological formations that groundwater passes through have a major impact on the natural chemical composition of groundwater. Surface water bodies and the atmosphere both have an impact on groundwater quality (CGWB, 2010).

Location of the Study Area:
The Meghnagar research area, which spans 68 km2 on a 1:50,000 scale, is located between latitudes 22° 55' and 23° 0' N and longitudes 74° 25' and 74° 30' E (Survey of India Toposheet no. 46 J/5, Figure 1). The research location has a tropical monsoon environment. The temperature

range in the research area is 11°C to 43.5°C. The research region is typically somewhat arid. Relative humidity ranges from 20 to 30 percent in April to May and from 34.4 to 50 percent in July, August, and September. The study region's terrain consists of a variety of lava plateaus and dome-shaped hillocks. The Meghnagar study region receives about 889.508 mm of rain on average.
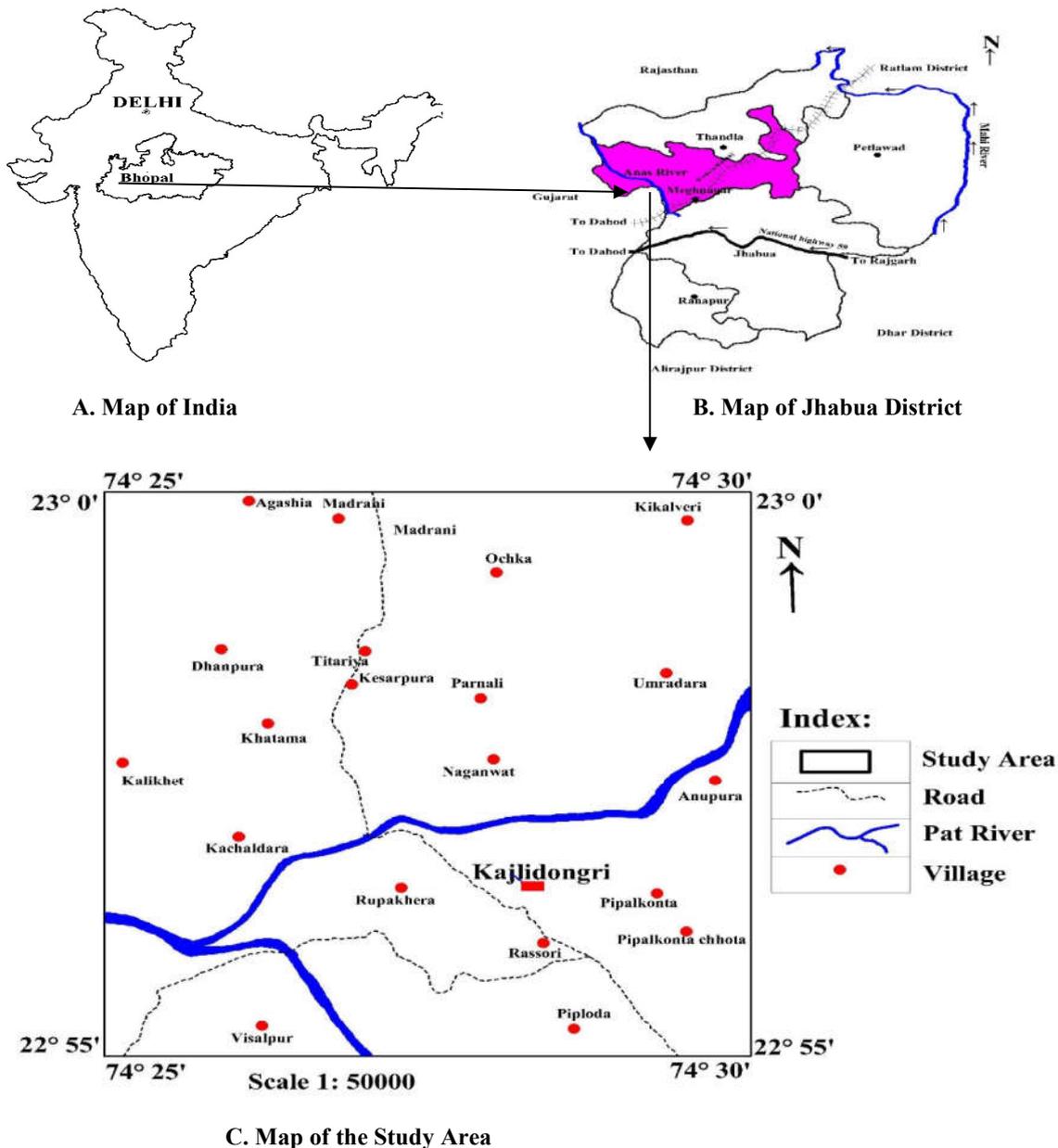

A. Map of India

B. Map of Jhabua District

C. Map of the Study Area

Figure 1: Showing location map of the Study Area, Meghnagar Block, Jhabua District (M. P.).

Hydrogeological conditions of the study area:

The current study area is part of Madhya Pradesh's Jhabua region, which is covered with Deccan Traps lava flows and Aravallis formations. Rocks including phyllite, quartzite, conglomerate, limestone, sandstone, and basalt make up the study area's geology. Structural elements including folds, joints, and foliation define the area. Groundwater exists in the research region under both confined and unconfined conditions, according to hydrogeological investigations.

METHODOLOGY

In order to ascertain the physical and chemical quality characteristics for various purposes, twenty groundwater samples were taken from the observation wells situated in the Meghnagar research region. The samples were gathered in one-liter plastic bottles and labeled with information on the well's location, the date of collection, the sample number, and the observation well number. The samples of ground water were transported to the lab for chemical analysis after being wrapped in plastic containers (Figure 2).
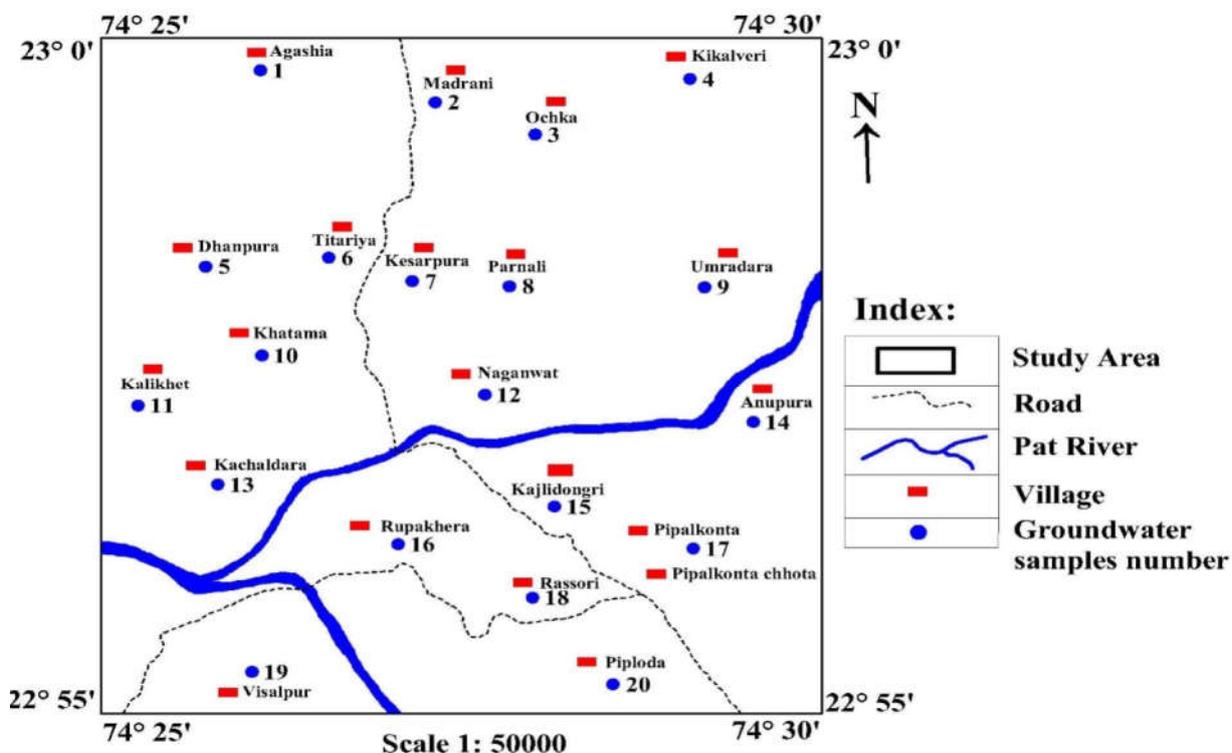

Figure 2. Displaying locations map of the collected groundwater samples in the study area.

RESULTS

Physical Parameters of Groundwater:

The Meghnagar research area's physical groundwater parameters, which include color, odor, taste, turbidity, pH, electrical conductivity, total dissolved solids, and total hardness of shallow groundwater, are shown in tabular form (Table 1).

Table 1: Physical parameter of the open dug well samples of Meghnagar study region,Jhabua District, Madhya Pradesh.

S. No.	Location	Co.	Od.	Tas.	Turbidity	pH	E.C.	TDS	TH
1	Agashia	-	-	-	2.95	7.02	490	365	282
2	Madrani	-	-	-	0.90	7.85	405	350	270
3	Ochka	-	-	-	1.50	7.40	305	290	290
4	Kikalveri	-	-	-	1.05	7.20	350	320	298
5	Dhanpura	-	-	-	1.90	7.25	390	300	285
6	Titaria	-	-	-	2.05	7.1	310	360	301
7	Kesarpura	-	-	-	1.10	7.60	410	340	280
8	Parnali	-	-	-	1.75	7.07	450	375	300
9	Umradara	-	-	-	1.05	7.01	302	360	298
10	Khatama	-	-	-	1.25	7.15	380	400	302
11	Kalikhet				1.85	7.57	410	395	296
12	Naganwat	-	-	-	3.40	8.0	610	305	300
13	Kachaldara	-	-	-	1.85	7.75	395	310	295
14	Anupura	-	-	-	1.30	7.71	332	380	297
15	Kajlidongri	-	-	-	1.0	7.07	490	298	302
16	Rupakhera	-	-	-	1.35	7.71	510	308	298
17	Pipalkonta	-	-	-	3.05	7.95	550	470	303
18	Rassori	-	-	-	2.05	7.04	350	395	300
19	Visalpur	-	-	-	2.75	7.05	375	405	295
20	Piploda	-	-	-	2.30	7.56	310	370	280

Colour, odor and taste:
The Meghnagar study region's groundwater samples have all been found to be colorless, odorless, and tasteless (Table 1).

Turbidity:
Water will appear muddy or turbid if it contains significant concentrations of clay or suspended organic debris. The concentration and fineness of the particles in groundwater determine the turbidity (Garg, 1979). The groundwater in the Meghnagar research region shows a turbidity range of 0.90 to 3.40 (Table 1).

Hydrogen ion concentration (pH):
Natural groundwater has a pH of 7. Water with a pH of less than 7 is acidic, whereas water with a pH of more than 7 is alkaline. Groundwater samples in the Meghnagar study area have pH values between 7.01 and 8.0 (Table 1).

Electrical conductivity:
The groundwater sample's E.C. has a minimum value of 302 and a maximum value of 610.

Total dissolved solid:
Groundwater samples in the Meghnagar study region have a minimum TDS of 290 and a maximum TDS of 470. The calculated ranges of the study region samples' total dissolved solids fall within the specified range and show that the water's palatability is beneficial for human consumption.

Total hardness:
Groundwater samples have been found to have a minimum total hardness of 270 and a maximum total hardness of 303. Because groundwater has more opportunities to come into contact with minerals, it is harder than surface water.

Chemical Parameters of Groundwater:
Anions (Chloride, Sulphate, Carbonate, Bicarbonate, Nitrate, and Fluoride) and cations (Calcium, Magnesium, Sodium, and Potassium) of groundwater samples have been identified by chemical analysis (Table 2, 3, 4, & 5).

Table 2: Chemical parameter of open dug wells sample the values expressed in ppm(parts per million) of the study area.

S. No.	Location	Ca	Mg	Na	K	Cl$^-$	SO$_4^-$	CO$_3^-$	HCO$_3^-$	NO$_3^-$	F$^-$
1	Agashia	107	92	57	1.70	110	74	-	170	30	0.70
2	Madrani	95	95	60	2.50	80	69	-	220	21	1.05
3	Ochka	113	90	61	1.30	70	65	-	150	27	0.80
4	Kikalveri	105	85	69	1.80	105	112	-	170	27	0.80
5	Dhanpura	120	107	67	1.70	170	130	-	190	30	0.95
6	Titaria	90	92	70	1.50	210	80	-	90	35	0.85
7	Kesarpura	109	97	60	1.40	155	75	-	205	28	0.90
8	Parnali	120	90	65	1.75	205	220	-	205	35	0.64
9	Umaradara	102	98	71	0.50	250	205	-	190	27	0.58
10	Khatama	125	110	61	1.40	201	107	-	170	31	0.95
11	Kalikhet	130	99	64	1.10	190	180	-	150	30	1.00
12	Naganwat	124	100	62	2.65	67	67	-	240	22	0.78
13	Kachaldara	110	115	68	1.75	190	70	-	165	28	0.75
14	Anupura	110	91	62	1.70	180	90	-	130	27	0.90
15	Kajlidongri	122	109	60	2.05	110	62	-	265	18	0.82
16	Rupakhera	102	90	58	2.30	105	59	-	210	28	0.80
17	Pipalkonta	135	104	62	1.50	205	190	-	180	21	0.72
18	Rassori	128	102	68	1.50	210	74	-	200	42	0.68
19	Visalpur	130	95	62	2.10	200	90	-	180	40	0.95
20	Piploda	115	90	60	2.05	180	80	-	190	39	0.90

Table 3. Chemical parameter of open dug wells sample the values expressed in epm (equivalents per million) of the study area.

S. No.	Location	Cation				Anion				Total of Cation	Total of Anion
		Ca	Mg	Na	K	Cl$^-$	SO$_4^-$	CO$_3^-$	HCO$_3^-$		
1	Agashia	5.339	7.567	2.479	0.043	3.103	1.540	-	2.786	15.428	7.429
2	Madrani	4.740	7.814	2.61	0.063	2.256	1.436	-	3.605	15.227	7.297
3	Ochka	5.638	7.403	2.653	0.033	1.974	1.353	-	2.458	15.727	5.785
4	Kikalveri	5.239	6.992	3.001	0.046	2.962	2.331	-	2.786	15.278	8.079
5	Dhanpura	5.988	8.801	2.914	0.043	4.795	2.706	-	3.114	17.746	10.615
6	Titaria	4.491	7.567	3.045	0.038	5.924	1.665	-	1.475	15.141	9.064
7	Kesarpura	5.439	7.979	2.61	0.035	4.372	1.561	-	3.359	16.063	9.292
8	Parnali	5.988	7.403	2.827	0.044	5.783	4.580	-	3.359	16.262	13.722
9	Umaradara	5.089	8.061	3.088	0.012	7.052	4.268	-	3.114	16.25	14.434
10	Khatama	6.237	9.048	2.653	0.035	5.670	2.227	-	2.786	17.973	10.683
11	Kalikhet	6.487	8.143	2.784	0.028	5.359	3.747	-	2.458	17.442	11.564
12	Naganwat	6.187	8.226	2.697	0.067	1.890	1.394	-	3.933	17.177	7.217
13	Kachaldara	5.489	9.459	2.958	0.044	5.359	1.457	-	2.704	17.95	9.52
14	Anupura	5.489	7.485	2.697	0.043	5.077	1.873	-	2.130	15.714	9.08
15	Kajlidongri	6.087	8.966	2.61	0.052	3.103	1.290	-	4.343	17.715	8.736
16	Rupakhera	5.089	7.403	2.523	0.058	2.962	1.228	-	3.441	15.073	7.631
17	Pipalkonta	6.736	8.555	2.697	0.038	5.783	3.955	-	2.950	18.026	12.688
18	Rassori	6.387	8.390	2.958	0.038	5.924	1.540	-	3.278	17.773	10.742
19	Visalpur	6.487	7.814	2.697	0.053	5.642	1.873	-	2.950	17.051	10.465
20	Piploda	5.738	7.403	2.61	0.052	5.077	1.665	-	3.114	15.803	9.856

Table 4. Chemical parameters of open dug well water samplesof the Meghnagar study area, Jhabua District, Madhya Pradesh (Values expressed in percentage of epm).

S.No.	Location	Ca	Mg	Na	K	Cl⁻	SO₄⁻	CO₃⁻	HCO₃⁻
1	Agashia	34.60	49.05	16.07	0.28	41.77	20.73	-	37.50
2	Madrani	31.13	51.32	17.14	0.41	30.92	19.68	-	49.40
3	Ochka	35.85	47.07	16.87	0.21	34.12	23.39	-	42.49
4	Kikalveri	34.29	45.77	19.64	0.30	36.67	28.85	-	34.48
5	Dhanpura	33.74	49.60	16.42	0.24	45.17	25.49	-	29.34
6	Titaria	29.66	49.98	20.11	0.25	65.36	18.37	-	16.27
7	Kesarpura	33.86	49.67	16.25	0.22	47.05	16.80	-	36.15
8	Parnali	36.82	45.52	17.39	0.27	42.14	33.38	-	24.48
9	Umaradara	31.32	49.61	19.00	0.07	48.86	29.57	-	21.57
10	Khatama	34.70	50.34	14.76	0.20	53.07	20.85	-	26.08
11	Kalikhet	37.19	46.69	15.96	0.16	46.34	32.40	-	21.26
12	Naganwat	36.02	47.89	15.70	0.39	26.19	19.32	-	54.49
13	Kachaldara	30.58	52.70	16.48	0.24	56.30	15.30	-	28.40
14	Anupura	34.93	47.63	17.17	0.27	55.91	20.63	-	23.46
15	Kajlidongri	34.36	50.61	14.73	0.30	35.52	14.77	-	49.71
16	Rupakhera	33.76	49.11	16.74	0.39	38.82	16.09	-	45.09
17	Pipalkonta	37.37	47.46	14.96	0.21	45.58	31.17	-	23.25
18	Rassori	35.94	47.21	16.64	0.21	55.15	14.34	-	30.51
19	Visalpur	38.04	45.83	15.82	0.31	53.91	17.90	-	28.19
20	Piploda	36.31	46.85	16.51	0.33	51.51	16.89	-	31.60

Calcium

In the Meghnagar study region, the minimum calcium has been recorded as 90 ppm and maximum 135 ppm (Table 2).

Magnesium

An essential component of natural water is magnesium (Mg). Magnesium aids in the removal of fluoride from the water. Magnesium concentrations in the Meghnagar research region have been found to be between 85 and 115 ppm (Table 2). Before water is supplied to the study region, the concentration of magnesium in groundwater must be lowered.

Sodium

One significant component of groundwater is sodium (Na). Feldspars found in igneous rocks are typically the source of sodium. The sodium concentration in the Meghnagar study region has been found to be between 57 and 71 parts per million. The research area's groundwater has a sodium concentration that falls within the suggested range.

Potassium

The silicate minerals found in igneous and metamorphic rocks, such as orthoclase, microcline, nepheline, and biotite, are the main source of potassium (K). Potassium concentrations in the Meghnagar research region have been found to be between 0.50 and 2.65 ppm. The research area's groundwater has a potassium concentration that falls within the suggested range.

Chloride

All kinds of fluids naturally include chloride. A desired maximum of 250 mg/l of chloride in drinking water has been proposed by the Bureau of Indian Standards (BIS); this concentration limit may be increased to 1000 mg/l. The lowest recorded chloride level in the Meghnagar study area was 67 ppm at Naganwat village, while the highest recorded chloride level was 250 ppm at Umaradara village (Table 2). The research area's groundwater has a chlorite concentration that is within the acceptable range.

Sulphate

In all types of natural waters, sulphate is a naturally occurring anion. The groundwater sulphate concentration in the Meghnagar study area varies from 59 to 220 parts per million. The Meghnagar study area's groundwater sulphate concentration is within the suggested range.

Bi-carbonate

The lowest bi-carbonate level in the Meghnagar study area was 90 ppm at Titaria village, while the highest level was 265 ppm at Kajlidongri village (Table 2).

Nitrate

Groundwater nitrate concentrations in the Meghnagar research area range from 18 to 42 parts per million. The Meghnagar study area's groundwater nitrate concentration falls within the recommended range.

Fluoride

The lowest and greatest fluoride levels in the Meghnagar study region are 0.58 and 1.05 parts per million, respectively (Table 2). The study region's groundwater fluoride levels fall within the acceptable limit.

Groundwater Quality for Domestic Purpose:

Plotting the ionic content of groundwater samples that were tested on Piper's trilinear diagrams allowed for the determination of groundwater suitability for residential use in the Meghnagar study region. Parts per million (ppm), equivalents per million (epm), and milligrams per liter (mg/l) have been used to convey the data (Table 2).

Piper's trilinear diagram:

By highlighting the chemical relationships in large sample groups in more precise terms than with other plotting techniques, the Piper trilinear diagram (1953) is one of the most helpful graphical representations in groundwater quality studies and aids in understanding the geochemistry of shallow groundwater (Walton, 1970). This diagram is composed of two lower triangles that display the percentage distribution of the major anions (SO_4-, $Cl-$, $CO_3–$, and HCO_3-) and cations ($Ca++$, $Mg++$, $Na+$, and $K+$) on an equivalents per million basis. The diamond-shaped portion above summarizes the dominant cations and anions to show the final water type. The anion and cation facies are displayed in this classification system according to major-ion proportion. $Ca+$, $Mg+$, $Na+$, $K+$, $Cl-$, SO_4-, CO_3-, HCO_3-, and NO_3- are the main ionic concentrations found in the majority of natural water. The majority of groundwater samples fall in the field of mixed Ca^{2+}-Mg^{2+}-Cl-type water, according to Piper's diagram (Fitter, 1988; Udayalaxmi et al., 2010).

Plots of ionic concentration data on Piper's diagram of 20 groundwater samples in the Meghnagar study area show that 16 samples belong to the Ca + Mg - Co3 + HCo3 facies and 4 groundwater samples are referable to the Ca + Mg - SO4 + Clfacies, indicating that groundwater is suitable for domestic use and other applications (Figure 3).
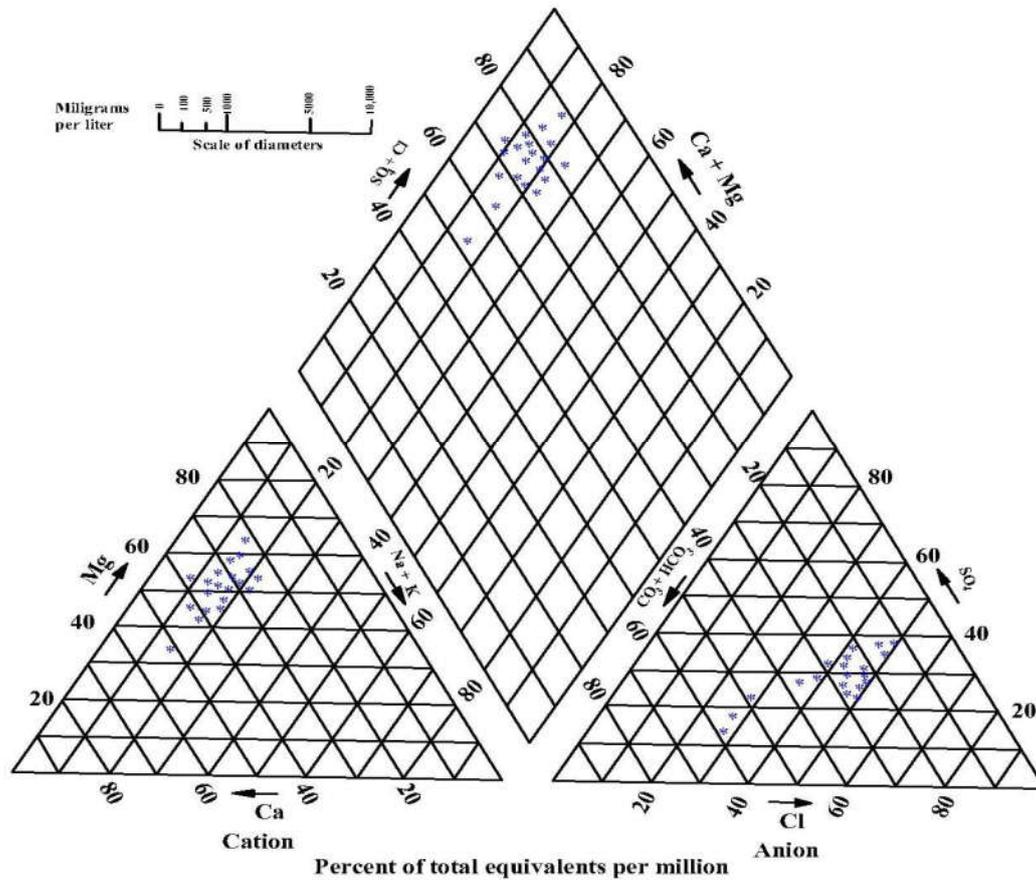
Figure 3. Displaying Piper's trilinear diagram for groundwater samples of Meghnagar study Region, Jhabua District, Madhya Pradesh.

Groundwater Quality for Driking Purpose:

The chemical quality of groundwater for drinking purposes in the Meghnagar study area was estimated by comparing the determined ionic values of groundwater samples with the standard limits recommended by various organizations, including the World Health Organization (1983, 1984, 2004) and the Bureau of Indian Standards (1983, 1991). The results are shown here (Table 5).

Table 5: Comparison of Physical and Chemical parameters of shallow groundwater samples in the Meghnagar study region with BSI and WHO for drinking purpose.

S. No.	Water Quality parameters	Bureau of Indian Standards (1983, 1991)		World Health Organization (1983, 1984, 2004)		Investigative samples of the Meghnagar study region	
		Maximum Desirable	Maximum Permissible	Maximum Desirable	Maximum Permissible	Concentration Range in study area (mg/l)	Exceeding Limit in groundwater Sample
Physical parameters							
1	colour	-	-	-	-	Colourless	-
2	Odor	-	-	-	-	Odorless	-

3	Taste	-	-	-	-	Tasteless	-
4	pH	6.5 - 8.5	No relaxation	7.0 - 8.5	6.5 - 9.2	7.01 to 8.0	-
5	TDS	500	1000	500	1500	290 to 470	-
6	TH mg/l	300	600	100	500	270 to 303	-
Chemical parameters							
1	Ca (mg/l)	75	200	75	200	90 to 135	-
2	Mg (mg/l)	30	100	30	150	85 to 115	>100 5, 10, 13, 15, 17, 18
3	Na (mg/l)	-	200	-	200	57 to 71	-
3	Cl (mg/l)	250	1000	200	600	67 to 250	-
4	SO_4 (mg/l)	150	400	200	400	59 to 220	-
5	NO_3 (mg/l)	45	45	-	-	18 to 42	-
6	HCO_3 (mg/l)	-	-	-	-	90 to 265	-
7	Fluoride (mg/l)	0.5	1.5	1	1.5	0.58 to 1.05	-

CONCLUSION

In the Meghnagar study Region, the all groundwater samples indicate suitability for drinking has been determined on the basis of Physical parameters such as turbidity (0.90 to 3.40), pH value (7.01 to 8.02) electrical conductivity (302 to 610 mhos/cm), total dissolved solids (290 to 470), total hardness (270 to 303) and Chemical parameters included Calcium (90 to 135 ppm), Magnesium (85 to 115 ppm), Sodium (57 to 71 ppm), Potassium (0.50 to 2.65 ppm), Chloride (67 to 250 ppm), Sulphate (59 to 220 ppm), Carbonate, Bi-carbonate (90 to 265 ppm), Nitrate (18 to 42 ppm) and Fluoride (0.58 to 1.05).

With the exception of the total hardness parameter, which is below the accepted permissible value indicating the suitability of water for drinking and domestic applications, the chemical parameters show that the groundwater samples of the Meghnagar study area are generally within the range of recommended standard values. The groundwater samples are suitable for drinking and other uses since the pH and TDS values of the examined samples are within the recommended standard limits. Sample numbers 5, 10, 13, 15, 17, and 18 from the Meghnagar research region indicate the presence of magnesium beyond the recommended maximum levels (Table 2). Before providing water to the tribal community, these samples must be processed to lower the amount of magnesium in the groundwater. The Meghnagar study region's groundwater is generally suitable for drinking and other uses, according to the quality evaluation.

ACKNOWLEDGMENT

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