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Original Article

Chemical Quality Evaluation of Ground Water for Human Application in Vicinity of Meghnagar, Jhabua Region, Madhya Pradesh, India

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ABSTRACT

The document presents an account of chemical quality delineation of ground water suitability for human applicators of Meghnagar study area, Jhabua district, Madhya Pradesh in India for the diverse applications. The main objective concerns to assess the ground water quality in vicinity of study area, and to delineate its suitability for domestic and, drinking applications. The representative twenty five ground water samples were collected from the open dug wells, existing in Meghnagar study area. These water samples were subjected to chemical analysis with principal objective to delineate the ground water quality for human applications Piper trilinear diagram indicates the delineation of ground water quality and reveals its suitability for The present work has been carried out with main objectives: to assess the ground water quality in vicinity of study area, and to delineate its suitability for domestic and drinking applications. It clearly shows the similarities and difference among ground water samples because those with similar qualities will tend to plot together as groups. The comparison of analyzed values with the recommended limits by Bureau of Indian Standards and World Health Organization reveal that ground water is suitable for drinking and domestic applications

KEYWORDS: *Chemical Guality Evaluation Ground water Meghnagar, Jhabua district, Madhya Pradesh in India.*

1. INTRODUCTION

In general, the ground water is distributed more than surface water through whole earth and is used by approximately 95 % of rural population for requirements. The rapidly increasing development of population is resulting a number of environmental problems, which are causing quality degradation

of ground water. Commonly, presence of any ion in ground water in excess of prescribed limit can not be admitted by the human body.

The quality of water is governed by the dissolved salts and numerous factors, namely the climate, soil characteristics, rock types, topography of the area, human activities, saline water intrusion in coastal region and others. It depends on the physical and chemical composition of soil or rock through which it moves. The ground water quality is classified mostly into four categories: Physical, Chemical, Biological and Radiological. The quality of ground water is of equal importance as its quantity in ground water management programmer (Todd, 1980). The presence of total dissolved salts in water is determined by chemical analysis. These dissolved salts in the water dissociate into electrically charged particles called ions having positive charge known as cations such as Calcium, Potassium, and ions with the negative charge ions, are known as anions namely, Calcium carbonate *aquifer* system determines the suitability of groundwater for irrigation, domestic water supply, industrial purposes, livestock watering and other uses (Todd, 2001).

The physical, chemical, biological and radiological characteristics of groundwater delineate its application for domestic, industrial and agricultural uses. The groundwater quality data provide important clue to the geological history of rocks and indication of groundwater recharge, discharge, movement and storage. The knowledge of water quality is also essential for the rational management of water and land resources (Karanath, ,1994, 2003).

The physical quality parameters comprise the temperature, pH, specific conductance, total dissolved solid and others. The chemical quality parameters include hardness, calcium, magnesium, sodium, potassium, chloride, carbonate, bicarbonate, nitrate and sulphate. Groundwater samples of the study area, do not have any biological and radiological degradation, hence, the physical and chemical qualities have been evaluated.

The ground water is normally clean and pure than the largest part of surface water. The water percolates through soil and rocks to screen bacteria. On the other hand, a few spring and well water may restrain consequently much dissolved matter, which makes the water unsuitable to drink. The water having high concentration of dissolved salts namely, the sodium, calcium, magnesium, potassium, chloride, sulphate, and bicarbonate, is known as the saline water.

2. COLLECTION OF GROUND WATER SAMPLES

The techniques for sample collection, preservation, analysis and interpretation have been described by Rainwater and Thatcher (1968), Hem (1970), Walton (1970), Brown *et al* (1970), I.C.M.R. (1975), Todd (2001), Karanth (2003) and others.

Ground water samples of study area have been collected from 25 ground water wells. The samples have been collected in pre–clean sterilized polyethylene bottles of 1 liter capacity and properly labeled containing information of Locality, Sample number, Date of collection,. After collection of water samples, the bottles were tightly sealed and kept in a box. The collected samples were brought to the Laboratory for analysis. The ground water samples have been analyzed for pH, and electrical conductivity (EC) using pH meter and EC meter respectively. The ionic concentrations of sodium, calcium, magnesium, potassium, carbonate, bicarbonate, chloride, sulphate have been determined by using the standard laboratory methods.

3. METHOD OF CHEMICAL ANALYSIS

Water quality is entirely distinct and delineated by analyzing its physical as well as chemical characteristics as described in the following text: The methods of chemical analysis have been adopted by several workers namely, Rainwater and Thatcher (1968), Brown *et.al* (1970), and American Public Health Association (1998). The procedure proposed by Richards (1954) for verification of chemical analysis has been employed for checking the determined values. The determined physical and chemical parameters are displayed (Table 3 and 4). The ionic concentrations have been plotted on

the trilinear diagram of Piper (1953), and. Sadashivaiah *et.al,* 2008) diagram. The U. S. Salinity diagram (1954 and Wilcox disgram (1955) have been used for determination of irrigation quality of ground water..

4. PHYSICAL ANALYSIS

The physical parameters of water include examination of Colour, Odour, Taste, Hydrogen ion concentration (pH), Electrical Conductivity (EC), and Total Dissolved Solids (TDS). The physical parameters are described and their determined values are recorded (Table 1.1).

- **Colour**

The colour in water is mainly due to materials in solution. These materials are mostly organic compounds leached from the decaying vegetation and inorganic coloured compounds met within the industrial waste effluents. In study area, total collected ground water samples are colourless (Table 1.1).

- **Odour and Taste**

The presence of decomposed organic material and volatile chemical substances in water impart the odours and tastes of water. The water for drinking purposes must be free from the undesirable odour and taste. The odour and taste in water are measured by diluting the water sample until the odour or taste is barely noticeable by the human tongue. All the samples in study area are odourless and tasteless (Table 1.1).

5. HYDROGEN ION CONCENTRATION

'Hydrogen ion concentration' (pH) has been referred to a scale of intensity of the acidity or alkalinity and it has been calculated as the concentration of H^+ ions in water. The most pure water at 25^0 C is dissociated to 10^{-14} g molecules per litre of water into H^+ and OH^- ions. Garg (1979) described that the pH value of water denotes the reciprocal of hydrogen ion concentration the pure water, impact, is a balanced combination of H^+ ions and OH^- ions, and contains 10^{-7} moles per liter of each. The pH value of neutral water = log $1/10^{-7}$ = 7. The water will be acidic, if its pH is less than 7 and will be alkaline, if its pH is more than 7. Th,e pH value is increased during day largely due to the photosynthesis action (consumption of Co_2), whereas decreases at night because of respiratory activity. The factors namely, exposures to air, temperature, and disposal of industrial wastes and others cause change in the pH.

In the study area, the pH values of the dug well water samples (range from 7.01 to 8.10 (Table 1.1). The minimum pH value of 7.09 has been noted at Jhayara and maximum value of 8.10 has been recorded at Amarpura. The analysis indicates s that ground water samples of study area are within the desirable limits as recommended by WHO and BIS.

- **Electrical Conductivity**

Electrical Conductivity **(E, C),** also known as Specific Conductivity has been the reciprocal of electrical resistance. It is a measure of the ability of a conductor to convey electricity and its unit is μ mho/cm. All water is essentially, capable of conducting an electric current. Conductance depends on the concentration of ionized mineral salts in solution, and, to a limited extent, there is a simple relationships between the two.

The determined values of Electrical Conductivity in study area, indicate a range of variation from 305 to 910 μ moho /cm (Table 1) .The minimum E.C. value of 305 has been recorded at Kesariya, wheras the maximum value if E.C. has been observed at Kalyanpura.

Table 1: Physical Parameters of dug water samples of Meghnagar area, Jhabua, District, M. P.

Well No.	Location	Colour	Ordour	Taste	EC at 25°C	TDS ppm	pH
1.	Dhebar	CL	OL	TL	321	268	7.20
2.	Dhebar	CL	OL	TL	785	257	7.04
3.	Bhagaur	CL	OL	TL	515	325	7.95
4.	Balban	CL	OL	TL	310	395	8.00
5.	jhayara	CL	OL	TL	340	301	7.01
6.	Hirapur	CL	OL	TL	810	460	7.02
7.	Barkhera	CL	OL	TL	550	290	7.92
8.	Junwaniya	CL	OL	TL	320	355	7.00
9.	Junwaniya	CL	OL	TL	901	250	7.20
10.	Amlipathar	CL	OL	TL	360	332	7.80
11.	Dundaka	CL	OL	TL	490	295	7.07
12.	Negariya	CL	OL	TL	416	320	7.80
13.	Ishgarh	CL	OL	TL	365	345	7.95
14.	Kalyanpura	CL	OL	TL	910	403	7.30
15.	Kesariya	CL	OL	TL	305	372	7.45
16.	Amarpura	CL	OL	TL	385	395	8.10
17.	Antarbeliya	CL	OL	TL	745	289	7.33
18.	Meghnagar	CL	OL	TL	485	364	7.32
19.	Partapura	CL	OL	TL	355	358	7.71
20.	Rampura	CL	OL	TL	567	290	7.21
21.	Mauripara	CL	OL	TL	360	385	7.95
22.	Bhendarlya	CL	OL	TL	300	415	7.40
23.	Gundipara	CL	OL	TL	625	365	7.32
24.	Gopalpura	CL	OL	TL	430	310	7.20
25.	Nawapara	CL	OL	TL	625	422	7.09

Abbreviation: CL = Colourless, OL = Odourless, TL = Tasteless

- **Total Dissolved Solids**

Total dissolved solids of the groundwater indicate total concentration of salts present in it, may be considered as indicator of salinity for classification of ground water. Total dissolved solids indicate mainly various kinds of minerals present in the water. In natural water, dissolved solids are composed mainly of Carbonate, Bicarbonate, Chloride, Sulphate, Phosphate and Nitrate of Calcium, Magnesium, Sodium, Potassium, Iron and Manganese.

The concentration of dissolved solids is an important parameter in drinking water (Table 1) and other water quality standards. They give a particular taste to the water at higher concentration and also reduce its portability. Concentration of total dissolved solids in drinking water occurs as:

Excellent	Less than 300 mg / liter
Good	Between 300 mg to 600 mg / liter
Fair	Between 600 mg and 900 mg / liter
Poor	Between 900 mg and 1200 mg/liter
Unacceptable	Greater than 1200 mg / liter

Dissolved Solids (TDS) vary from 250 mg/l (Junwaniya) to 460 mg/l (Hirapur) mg/l. in the study area, determined values of total dissolved solids are within the prescribed permissible standard limits. (Table 1).

6. CHEMICAL QUALITY ANALYSIS

The determinations of chemical parameters include the following: Total Hardness, and Common cations and anions

- **Total Hardness**

Hardness of water is mainly due to the presence of carbonate and non-carbonate ions. Garg, (1979) has defined hardness as "the calcium carbonate equivalent of calcium and magnesium ions present in water as expressed in ppm or mg/l." Generally, hardness in water is of two types –

(1) ***Temporary hardness*** – when the calium and magnesium are present in water, this hardness can be removed by boiling or by adding lime in the water.
(2) ***Permanent hardness*** when Sulphates, chlorides and nitrate of calcium and magnesium are present in water. It cannot be removed by boiling and, needs special treatment of water.

Hardness, mg / liter	Water class
0 – 75	Soft
75 –150	Moderately hard
150-300	Hard
Over 300	Very hard

The determined values of hardness in ground water samples have been displayed (Table 1.2) .In the study area, total hardness in ground water samples ranges from 160 mg / l (Dhebar) to 315 mg / l (Lshgarh, Amarpura).

Common Cations

- **Calcium**

Calcium is one of the principal cations in groundwater. Being present in high quantity in the rocks, it is leached from there to contaminate the water. The principal source of calcium in groundwater is some member of the silicate minerals group like plagioclase, pyroxene and amphibolites among igneous rock and metamorphic rock and limestone, and dolomite among the sedimentary rocks. Calcium is also present in form of absorbed ions negatively charged minerals surface in soil and rocks. The quantities in natural water generally, vary from 10 - 100 mg/l depending upon the type of rock. The industrial waste and other waste are also good source of calcium. In dissociation of $CaCO_3$ minerals, CO_2 plays an important role. Weathering of silicate rocks in the presence of CO_2 release calcium into the groundwater. Calcium, as such, has no hazardous effects on human health. In fact it is one of the important nutrients required by the organism. Concentration up to 1800 mg / litre has been found not to impair any physiological reaction in man (Lehr *et al* 1980).

The range of calcium content in groundwater is largely dependent on the solubility of calcium carbonate, sulphide and very infrequently chloride. The calcium content of ground water samples of investigated area (Table 1.2) ranges from 64 mg/l (Bhagaur) to 205 mg/l (Lshgarh)..

- **Magnesium**

Magnesium is one of the alkaline earth metals and magnesium also occurs in all kind of natural water with calcium. The concentration of magnesium generally remains lower than calcium. The principal sources of magnesium in groundwater are basic igneous rocks such as dunite, pyroxene and

amphibolites. Volcanic rocks such as Basalt, metamorphic rocks such as talc and tremolite schist and of sedimentary rocks such as dolomite usually limestone also contains some magnesium carbonate. Concentration of magnesium in ground water varies from about nil to a few hundred ppm in water from magnesium rich rock or dolomitic limestone. Low concentration of magnesium is non-toxic. But high concentration of Mg may be cathartic and diuretic. (Lehr *et al,* 1980) Concentration as high as 500 mg / litre impart an unpleasant taste to the water thus rendering it unpalatable. Mg adds to the hardness of the water and with Ca poses the problem of scale formation in the boilers. The magnesium concentration in ground water samples of the study area, ranges from 61. mg/l (Negariya) to 165 mg/l (Gundipara)).

- **Sodium**

It is also one of the important cations occurring naturally. The concentration in natural water is generally lower than the calcium and magnesium. In natural water the major source of sodium is weathering of various rock. Sodium is primarily derived from feldspar in igneous rocks and its weathering products in other material. Shale and clay layer often yield water with relatively high sodium content. Other sources of sodium are leached and deep percolation water from the upper soil layers and contamination oh ground water by salty connate water or water of marine origin. Many industrial waste and domestic sewage are rich in sodium and increase its concentration in natural water after disposal. Sodium does not affect the hardness of water; through it is very important in determining the quality of irrigation and drinking water. At lower concentration there is no adverse effect on the health. The higher concentration of sodium can be related to cardiovascular disease, and in women toxemia associated with pregnancy. Sodium concentration in groundwater ranges from about 1 ppm in humid and snow-fed region to over 100.000 ppm in brines. Groundwater in well-drained area with a good amount of rainfall has usually less than 10 to 15 ppm of sodium. In the study area, the sodium concentration in ground water ranges from 40 mg/ l (Barkhera) to 76 mg/ l (Dhebar).

- **Potassium**

Like sodium, potassium is also a naturally occurring element, however, the concentration remains quite lower than the sodium, calcium and magnesium .The major source in natural fresh water is weathering of the rocks but the quantities increase in the polluted waste due to disposal of water waste. In igneous rocks potassium is less common but more abundant in sedimentary rock as potassium feldspar. In ground water its concentration is ordinarily 10 mg/l and sodium exceed 15 mg/l (ppm.).

In the study area, the potassium concentration in ground water samples ranges from 0.40 mg/l (Bhagaur) to 2.60 mg/l (Bhendarlya).

Common Anions

- **Carbonate and Bicarbonate**

Bicarbonate occurs in low salinity waters and its concentration usually decreases with the increase in Electrical Conductivity. Bicarbonate and Carbonate are mostly present in groundwater, except the strongly acidic water. The primary source of carbonate and bicarbonate ions in groundwater is the dissolved carbon dioxide in rain, which, as it enters the soil dissolves more carbon dioxide. Bicarbonate concentration of more than 200 mg/liter is not uncommon in ground eater, and higher concentration can occur where Co_2 is produced within the aquifer. The pH of the water indicates the form in which the carbon dioxide is present in water. The presence of carbonic acid is indicating when the pH is less than 4.5 bicarbonate if the pH is between 4.5 and 8.2 and carbonate if the value of pH is over 8.2.

In the study area, the concentration of carbonate in ground water samples is nil. The bicarbonate concentration ranges from 85 mg/ l (Dhebar)).to 260 mg/ l (Bhendarlya).

- **Sulphate**

Sulphate is naturally occurring in all kinds of natural waters. It is an important constituent of hardness with calcium and magnesium. Discharge of industrial waste and domestic sewage in waters tend to increase its concentration. Sulphate is formed by oxidation of pyrite and other sulphides widely distributed in igneous and sedimentary rocks. Sulphate is naturally occurring anion in the all kinds of waters. It is an important constituent of hardness with calcium and magnesium sulphate produces an objectionable taste at 300-400 mg/l., above 500 mg/l a bitter taste. At concentration around 1000 mg/l it reveals laxative effects. The concentration of sulphate in ground water samples of the study area ranges from 60 mg/ l (Bhendarlya) to 155 mg/ l (Meghnagar).

- **Chloride**

Chloride occurs naturally in all kinds of water. In natural fresh water, however, chloride concentration is commonly less than sulphate and bicarbonates. The most important source of chloride in the water is discharge of domestic sewage. The chloride content in the rainwater is usually less than 10 ppm. In the present stud area, samples, chloride concentration varies from 74 mg/l (Bakhera) to 220 mg / l (Gundipara).

- **Nitrate**

Nitrogen is a very minor constituent of the rocks, but it is a major constituent of the atmosphere. Nitrogen and Oxygen dissolve in rainwater. The average content in rainwater is reported to be 0.2 ppm (Riffenburg, 1926). The greatest contribution of nitrate in groundwater is from decaying organic matter, sewage water and nitrate fertilizers. Groundwater when not polluted, contain less than 5 ppm of nitrates but polluted water contain up to 100 pm, as even more In the present study area, the nitrate ranges from 12 mg/ l (Kesariya) to 45 mg/l (Lshgarh).

- **Fluoride**

Fluoride is a essential microelement for the human health. The smaller quantities of 1.0 mg/L in ingested water are usual considered good to have a beneficial effect on the rate of occurrence of dental carries, particularly among children .The major sources of fluoride in ground water are fluoride- bearing rock such as fluorspar, cryolite, fluorapatite and hydroxyl apatite. The permissible limit of fluoride is 1.5 mg/l, which is the upper permissible limit for drinking water in Indian context (WH.O, 1983; BIS, 1991). The Fluoride is strongly having electro-negativity; it attracts positively charged calcium ions in teeth and bones. In the study area, the fluoride concentration ranges from 0.20 mg/ l (Kalyanpura) to 1.05 mg / l (Jhayara).

Table 2: Determination of Concentration of Ions of Ground Water Sample of Meghnagar study area, Jhabua, District M.P. (Values expressed in ppm)

S. No.	Location	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	NO_3	F	TH
1.	Dhebar	82	90	60	1.20	-	85	130	150	30	0.65	172
2.	Dhebar	75	85	76	0.45	-	100	145	120	29	0.47	160
3.	Bhagaur	64	110	62	0.40	-	150	205	90	25	0.32	174
4.	Balban	120	95	55	0.75	-	135	201	110	21	0.30	215
5.	jhayara	66	135	65	2.00	-	140	200	69	23	1.05	201
6.	Hirapur	110	108	64	1.75	-	185	140	100	35	0.40	218
7.	Barkhera	102	110	40	1.20	-	165	74	128	27	0.25	212
8.	Junwaniya	127	119	61	1.65	-	150	105	109	40	0.53	246
9.	Junwaniya	120	130	60	1.50	-	135	125	133	34	0.33	250

10.	Amlipathar	124	105	54	1.25	-	165	130	80	18	0.45	229
11.	Dundaka	165	45	67	1.40	-	140	150	115	30	0.54	210
12.	Negariya	154	61	58	1.60	-	205	110	90	37	0.40	215
13.	Ishgarh	205	110	50	1.25	-	150	205	125	45	0.35	315
14.	Kalyanpura	192	80	63	2.45	-	170	135	150	20	0.20	272
15.	Kesariya	134	103	48	1.40	-	225	160	80	12	0.65	327
16.	Amarpura	170	145	60	1.65	-	130	145	105	31	0.40	315
17.	Antarbeliya	135	82	55	1.25	-	180	125	75	35	0.25	217
18.	Meghnagar	131	102	70	1.50	-	250	85	155	40	0.60	233
19.	Partapura	107	145	59	2.05	-	135	78	95	29	0.45	252
20.	Rampura	119	105	61	1.75	-	120	110	130	20	1.00	224
21.	Mauripara	128	75	70	1.05	-	195	135	105	25	0.50	203
22.	Bhendarlya	110	95	71	2.60	-	260	90	60	15	0.25	205
23.	Gundipara	116	165	68	1.50	-	220	220	120	21	0.47	281
24.	Gopalpura	135	62	65	1.65	-	90	190	115	35	0.75	197
25.	Nawapara	92	130	67	2.25	-	135	140	100	29	0.60	222

Abbreviation

Ca = Calcium Na = Sodium CO_3 = Carbonate Cl = Chloride
NO_3 = Nitrate Mg = Magnesium K = Potassium
HCO_3 = Biocarbonate SO_4 = Sulphate F = Fluoride

7. GRAPHIC REPRESENTATION OF ANALYTICAL DATA

There are many analysis of ground water from a particular area. These analyses came in study and compared with the help of certain graphic representation. These graphs indicate the total amount of cations and anions present in the groundwater of a particular area. Various diagrams are useful for this purpose. The determination of ionic concentration of ground waters is recorded in different units such as milligram per liter (mg/liter) or ppm (parts per million). The commonly followed methods graphic representation of chemical data includes are -
Pie diagram, Piper's trilinear diagram, U. S. salinity diagram, and Wilcox diagram.

Table 3: Determination of Chemical Parameters of Ground Water Sample of Dug Well of Meghnagar area, Jhabua, District M.P. (Values expressed in epm)

S.No.	Location	Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4	NO_3	F
1.	Dhebar	1.09	7.40	2.61	0.03	-	1.39	3.66	3.12	0.48	0.03
2.	Dhebar	3.74	6.99	3.08	0.01	-	1.63	4.09	2.49	0.46	0.02
3.	Bhagaur	3.19	9.04	2.69	0.01	-	2.45	5.78	1.87	0.40	0.01
4.	Balban	5.98	7.81	2.39	0.01	-	2.21	5.67	2.29	0.33	0.01
5.	jhayara	3.29	11.10	2.82	0.05	-	2.29	5.64	1.43	0.37	0.06
6.	Hirapur	5.48	8.88	2.78	0.04	-	3.03	3.94	2.08	0.56	0.02
7.	Barkhera	5.08	9.04	1.74	0.03	-	2.70	1.97	2.66	0.43	0.01
8.	Junwaniya	6.33	9.78	2.65	0.04	-	2.45	2.96	2.26	0.64	0.03
9.	Junwaniya	5.98	10.69	2.61	0.03	-	2.21	3.52	2.76	0.54	0.01
10.	Amlipathar	6.18	8.63	2.34	0.03	-	2.70	3.66	1.66	0.29	0.02
11.	Dundaka	8.23	3.70	2.91	0.03	-	2.29	4.23	2.39	0.48	0.03
12.	Negariya	7.68	5.01	2.52	0.04	-	3.35	3.10	1.87	0.59	0.02
13.	Ishgarh	10.22	9.04	2.17	0.03	-	2.45	5.78	2.60	0.72	0.02
14.	Kalyanpura	9.58	6.58	2.74	0.06	-	2.78	3.80	3.12	0.32	0.01
15.	Kesariya	6.68	8.47	1.74	0.03	-	3.68	4.51	1.66	0.16	0.03
16.	Amarpura	8.48	11.92	2.61	0.04	-	2.13	4.09	2.18	0.50	0.02
17.	Antarbeliya	6.73	6.74	2.39	0.03	-	2.95	3.52	1.56	0.56	0.01

18.	Meghnagar	6.53	8.39	3.04	0.06	-	4.09	2.39	3.22	0.64	0.03
19.	Partapura	5.33	11.92	2.56	0.02	-	2.21	1.97	1.97	0.46	0.02
20.	Rampura	5.93	8.63	2.65	0.04	-	1.96	3.10	2.70	0.32	0.05
21.	Mauripara	6.38	6.16	3.04	0.02	-	3.19	3.80	2.18	0.40	0.02
22.	Bhendarlya	5.48	7.81	3.08	0.06	-	4.26	2.53	1.24	0.24	0.01
23.	Gundipara	5.78	13.57	2.95	0.03	-	3.60	6.20	2.49	0.33	0.02
24.	Gopalpura	6.73	5.10	2.82	0.04	-	1.47	5.35	2.39	0.56	0.04
25.	Nawapara	4.59	10.69	2.91	0.05	-	2.21	3.94	2.08	0.46	0.03

Abbreviation:
Ca = Calcium Na = Sodium CO_3 = Carbonate Cl = Chloride
NO_3 = Nitrate Mg = Magnessium K = Potassium
HCO_3 = Biocarbonate SO_4 = Sulphate F = Fluoride

Table 4: Determination of percentage epm of Ground water samples of Meghnagar Area, Jhabua District, M.P.

S.No.	**Location**	**Ca**	**Mg**	**Na**	**K**	**CO_3**	**HCO_3**	**SO_4**	**Cl**	**NO_3**
1.	Dhebar	28.94	52.37	18.47	0.21	-	16.06	36.06	42.31	5.54
2.	Dhebar	27.06	50.57	22.28	0.07	-	18.80	28.71	47.17	5.30
3.	Bhagaur	21.36	60.54	18.01	0.06	-	23.33	17.80	55.04	3.80
4.	Balban	36.93	48.23	14.76	0.06	-	21.04	21.80	54.00	3.14
5.	hayara	19.06	64.31	16.33	0.28	-	23.53	14.69	57.96	3.80
6.	Hirapur	31.89	51.16	16.18	0.23	-	31.52	21.64	40.99	5.82
7.	Barkhera	31.96	56.89	10.95	0.18	-	34.79	34.27	25.38	5.54
8.	Junwaniya	33.67	52.02	14.09	0.21	-	29.48	27.19	35.61	7.70
9.	Junwaniya	30.96	55.35	13.51	0.15	-	24.47	30.56	38.98	5.98
10.	Amlipathar	35.97	50.23	13.62	0.17	-	32.49	19.97	44.04	3.48
11.	Dundaka	55.34	24.88	19.56	0.20	-	24.38	25.45	45.04	5.11
12.	Negariya	50.36	32.85	16.52	0.26	-	37.59	20.98	34.79	6.62
13.	Ishgarh	47.62	42.12	10.11	0.13	-	21.21	22.51	50.04	6.23
14.	Kalyanpura	50.52	34.70	14.45	0.31	-	27.74	31.13	37.92	3.19
15.	Kesariya	39.47	50.05	10.28	0.17	-	36.76	16.58	45.05	15.98
16.	Amarpura	36.78	51.71	11.32	0.17	-	23.93	24.49	45.95	5.6
17.	Antarbeliya	42.35	42.41	15.04	0.18	-	34.34	18.16	40.97	6.51
18.	Meghnagar	36.23	46.55	16.87	0.33	-	39.55	31.14	23.11	6.18
19.	Partapura	26.87	60.11	12.90	0.10	-	33.43	29.80	29.80	6.95
20.	Rampura	34.37	50.02	15.36	0.23	-	24.25	33.41	28.36	3.96
21.	Mauripara	40.89	39.48	19.48	0.12	-	33.33	22.77	39.70	4.17
22.	Bhendarlya	33.35	47.53	18.74	0.36	-	51.51	14.99	30.59	2.90
23.	Gundipara	25.88	60.77	13.21	0.13	-	28.52	19.73	49.12	2.61
24.	Gopalpura	45.81	34.71	19.19	0.27	-	15.04	24.46	54.75	5.73
25.	Nawapara	25.16	58.60	15.95	0.27	-	25.43	23.93	45.33	5.29

Abbreviation: Ca = Calcium, Na = Sodium, CO_3 = Carbonate, Cl = Chloride, NO_3 = Nitrate, Mg = Magnesium, K = Potassium, HCO3 = Bicarbonate, SO_4 = Sulphate.

The water quality assessment has been carried out by trilinear method. Diagram has been used to understand geochemical evolution of ground water .it shows the relation between the concentrations of various constituents or a group of constituent's .thus on a two coordinate field the relation between the concentrations of calcium, magnesium, sodium, bicarbonate, sulphate, chloride and athers.

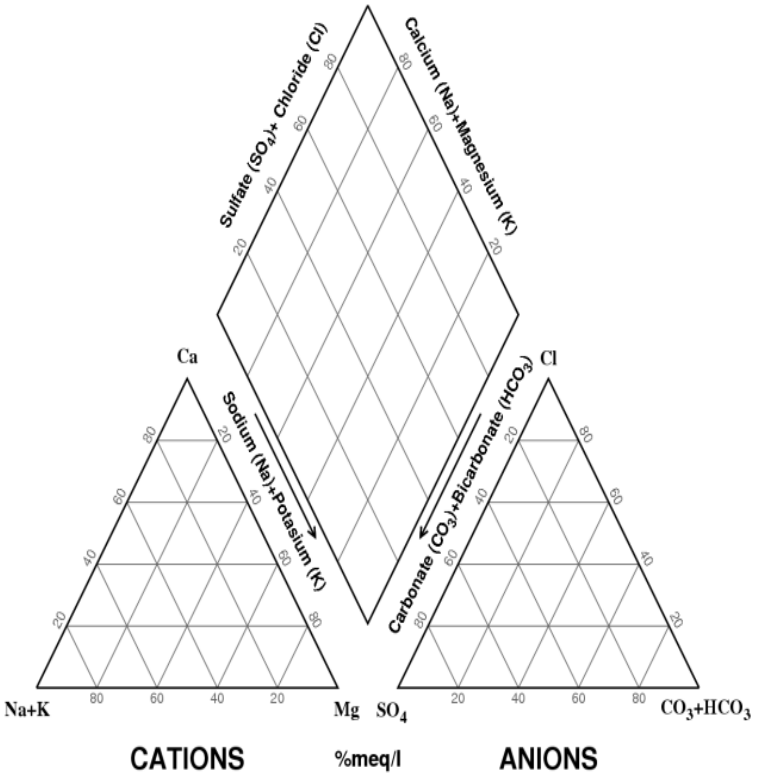

Figure 1: Exhibiting a Piper's Trilimear Diagram of Ground water of study area, Jhanua district Madhya Pradesh.

The trilinear diagram has been adopted by Palmer (1911), Hill (1940) and Piper (1944, 1953), Handa (1965) modified the trilinear diagram proposed by Piper (1953). The Piper diagram consists of two triangular fields and a diamond shaped fields. Here cations Ca and Mg (alkaline earth) and Na (alkali) expressed as % of total cations in milli equivalents per liter, a plot on a single point on the left triangle while anions the HCO_3 (weak acid), SO_4 (strong acid), similarly expressed as % of total anions, appear as a point in the right triangle. These two points are then projected into the central diamond shaped are parallel to the upper edges of the central area showing the overall characteristics of water in diamond shaped block. Minor alkalies like potassium and strong acids like iodide, fluoride and nitrate are clubbed with the major ones.

The types of ground water are recognized on the basis of the position of the plotting in the diamond shaped field as described below –

Area-1	Alkaline earths exceed alkalies
Area-2	Alkaline earths exceed alkalies
Area-3	Weak acids exceed strong acids.
Area-4	Strong acids exceed weak acids.
Area-5	Carbonate hardness exceeds 50%, i.e. chemical properties of the water are dominated by alkaline earths and weak acids.
Area-6	Non-carbonate hardness exceeds 50%.
Area-7	Non-carbonate alkali exceeds 50 % i.e. chemical properties are dominated by alkalis and strong acids-ocean water and many brines plot near the right hand vortex of the sub area.
Area-8	Carbonate alkali exceeds 50% here plot the waters which are inordinately soft in proportion to their content of dissolved solids.
Area-9	No one cation-anion pair exceeds 50%.

The hydro chemical faces are distinctive zones, which have concentration of cation and anion categories. To categorize a composition class, suggested subdivisions of the tri-linear diagram. The interpretation of distinct faces from the 0 to 10 % and 90 to 100 % domain on diamond shaped cation to anion graph is more constructive than using equal 25 % increments. The ionic concentrations are distinctly represented in the diagram Piper trielinear diagram indicates the delineation of ground water quality and reveals its suitability for domestic and drinking uses. It clearly shows the similarities and difference among ground water samples because those with similar qualities will tend to plot together as groups.

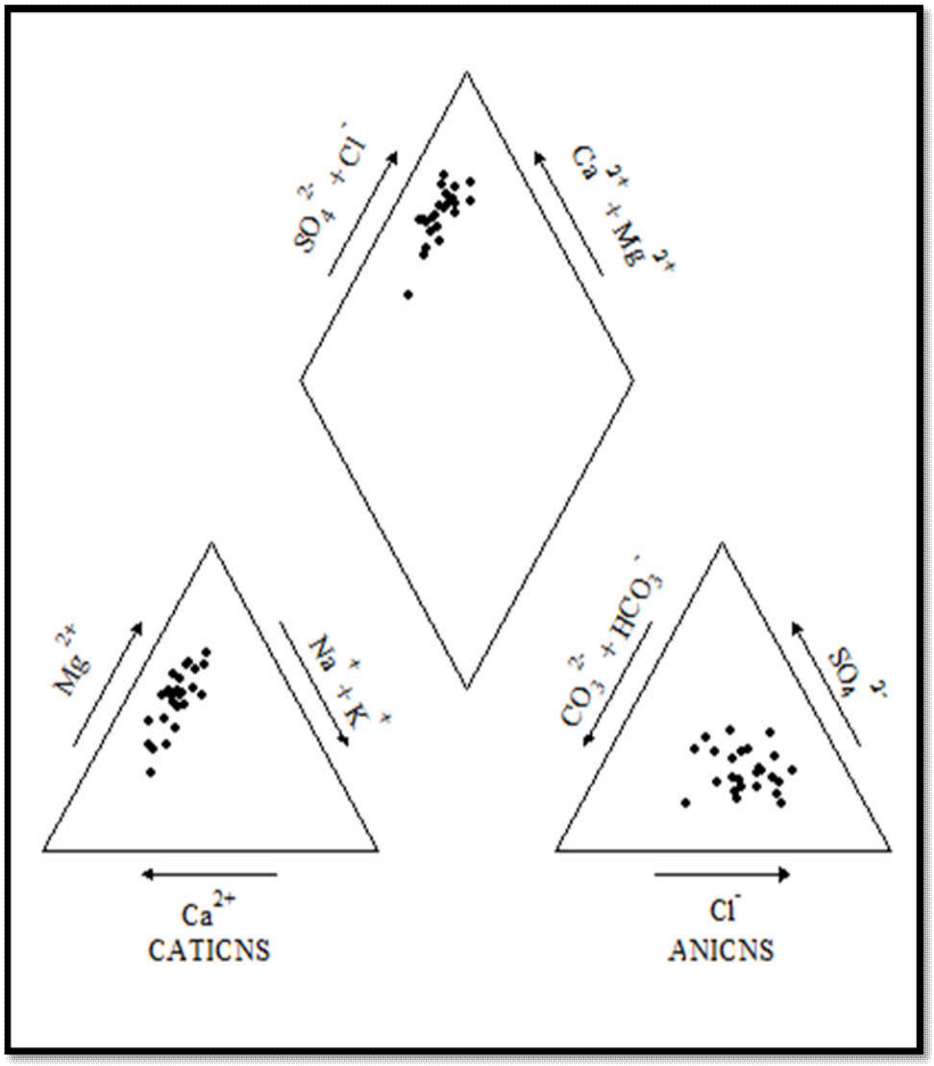

Figure 2: Piper Diagram of ground water samples of study area.
(The plots of ionic concentration on the Pipier diagram have been marked with the help of Software GW Chart.)

8. GROUND WATER QUALITY FOR DOMESTIC PURPOSE

The water is required for drinking use must be colourless, tasteless and odorless. It should be free from turbidity or chemical compounds. The presence of harmful micro organisms and radioactivity should be avoided. The W.H.O. and B.I.S has laid down its international standards. The analyzed values of ground water samples of Meghnagar study area are represented in Piper's trilinear diagram (Figure 2).

Table 5: Comparison of the quality parameters of ground water of the study area with W.H.O and I.S.I standard for drinking purpose

S. No.	Water Quality Parameters (Unit)	WHO (1984, 2004, 2011)		BIS (1983)		Concent-ration in study area	Undesirable effect produced beyond Maximum allow limit
		Max. accep t limit	Max. allow limit	Max. accept limit	Max. allow limit		
1	pH	7.0	8.5	6.5	8.5	7.0 – 8.1	All samples are within the recommended limit.
2	TDS (Mg T.D.S.)	500	1500	500	1500	250- 460	Within minimum limit.
3	Calcium (Mg/l)	75	200	75	200	64 - 205	Sample 13 required reduction of Ca.
4	Magnesium (Mg/l)	50	150	30	100	61 - 165	Sample 23 to be treated.
5	Potassium (Mg/l)					0.40 - 2.60	-
6	Sodium (Mg/l)		200		200	40 - 76	-
7	Bicarbonate (Mg/l)					85 - 260	-
8	Chloride (Mg/l)	200	600	250	1000	74 - 220	Salty taste indicates pollution
9	Sulphate (Mg/l)	200	400	150	400	60 - 155	-
10	Nitrate (Mg/l)	45		45	100	12 - 45	-
11	Total Hardness as $CaCO_3$	100	500	300	600	160 - 315	-

The samples of study are having total hardness within the maximum permissible limits recommended by W.H.O. and B.I.S. The pH ranges from 7.0 to 8.1 in Meghnagar area indicating alkaline water. The water is suitable for drinking purpose. Total Dissolved Solids ranging from 250 to 460 ppm are within minimum permissible limit of water.

The comparison of ground water characteristics of Meghnagar area with standard limits recommended by WHO (1984, 2004, 2011 and BIS 1983) for drinking water quality has been displayed (Table 1.5). Calcium ranges from 64 to 205, which is within the prescribed limit except one sample that requires treatment. The Magnesium indicates a range from 61 t0 165 indicating that one samples has a higher value and that can be used by reducing the Mg content. Chloride is having a range from 74 to 220 ppm indicates a salty taste of water. The rest of the ions such as Potassium, Sodium, Bicarbonate, Soleplate and Nitrate are within the recommended standard values and suitable for domestic and drinking purpose.

9. CONCLUSION

This paper embodies results of chemical quality delineation of ground water resource based on 25 dug well samples collected from the Meghnagar study area located in Jhabua Region of Madhya Pradesh., India. Physico-chemical parameters enable to evaluate the nature of chemical characteristics. Chemical ground water samples analysis delineate its suitability for drinking and domestic essentialities

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