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Water Quality Index for Ground Water (GWQI) of Dhar town, MP, India

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Abstract

This paper deals with the quality of ground water for public consumption to determine the ground water quality index (GWQI) of Dhar town. Physico-chemical parameters of ground water from 10 bore wells from different localities of the town were monitored seasonally during the study period. The parameters investigated were turbidity, pH, total alkalinity, total dissolved solids, hardness, sulphate, chloride, fluoride and nitrates. Seasonal GWQI were determined using mean value of the parameters. Results obtained from the study revealed that GWQI during each season is well within the permissible limit and the ground water is safe for drinking or fit for human consumption.

Keywords: Ground water quality index, GWQI, ground water, physico-chemical parameters, bore wells, Drinking water.

Introduction

Water in its pure form occurs rarely in nature. Comprising over 70 % of the Earth's surface, water is the most precious natural resource on our planet[1]. Very small amount of water i.e. less than 1% is fit for human consumption which signifies the importance of this essential commodity on the earth. The most widely spread danger associated with drinking water is the direct or indirect contamination by human and animal feacal matter, chemical, municipal, domestic and industrial liquid discharge etc. Availability of clean water is going to be the greatest constraint for human health. Keeping this into consideration an attempt was made to evaluate the Physico-chemical Characteristics of ground water of the town to determine whether the water is fit for human consumption or not. In this study water quality parameters are represented in a single form called water quality index (WQI) that facilitate to get composite influence of all the quality parameters on that system also helps to compare the overall quality of water with a unit value[2,3]. The objective of water quality index is to make number of complex water quality parameters into information that is understandable for the public[4].

Material and Methods

The study was conducted seasonally for a period of one year from Jan 2010 to Feb 2011. Water samples from 10 bore wells of different localities of Dhar town were collected seasonally in clear pre-sterilized polythene bottles. Physico-chemical Characteristics were determined as per the standard methods[5]. Consideration of too many parameters in calculating water quality index is not recommended. Hydrogen ion concentration, chlorides, color, total dissolved solids, fluorides, hardness, nitrites, alkalinity, turbidity, sulfates, dissolved Oxygen and phenols are recognized as preliminary indication of quality and are used in calculating quality index for public water supply[2] (figure 1 and figure 2).

Calculation of GWQI: The Ground Water Quality Index (GWQI) is calculated using Weighted Arithmetic Index method as suggested by Brown et al [2]. The quality rating / sub index (Q_i) corresponding to the i^{th} parameter is calculated by using following expression.

$$Q_i = \sum_{i=1}^{n} [\{ M_i (-) I_i / (S_i - I_i) \}] \times 100$$

Where M_i = estimated values / of the i^{th} parameter in the laboratory, I_i,= ideal values of the i^{th} parameter and S_i = standard values of the i^{th} parameter. The sign (-) indicates the numerical difference of the two values, ignoring the algebraic sign. All the ideal values (I_i) are taken as zero except for pH=7, DO=14.6 and fluorides=1.5. In the present study unit weight (W_i) was calculated by a value inversely proportional to the recommended standard (S_i) of the corresponding parameter.

$$W_i = 1 / S_i$$

The overall Ground water quality index (GWQI) is calculated by aggregating the quality rating (Q_i) with unit weight (W_i) linearly.

$$WQI = \{ (\sum_{i-1}^{n} Q_i W_i) / (\sum_{i-1}^{n} W_i) \}$$

Generally, water quality index (WQI) is discussed for a specific and intended use of water. In this study, the WQI of ground water for drinking purpose is considered and the permissible GWQI for the drinking water is taken as 100. Status of water quality based on WQI is as follows:

From - 00 to 25 = Excellent, 26 to 50 = Good, 51 to 75 = Poor, 76 to 100 = Very poor 100 and above = Unsuitable for drinking[2, 6].

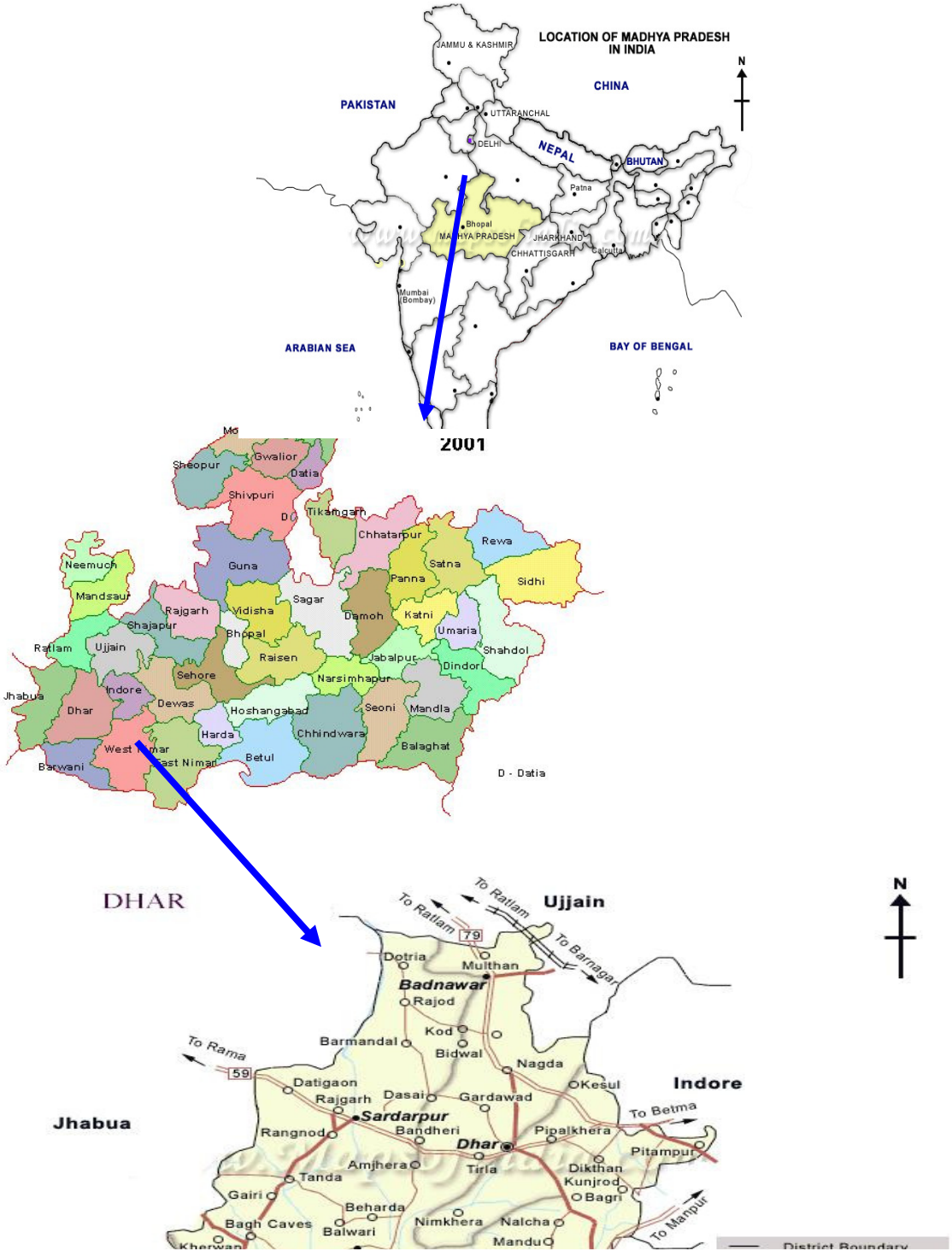

Figure-1
Map showing location of Dhar District in M.P., India

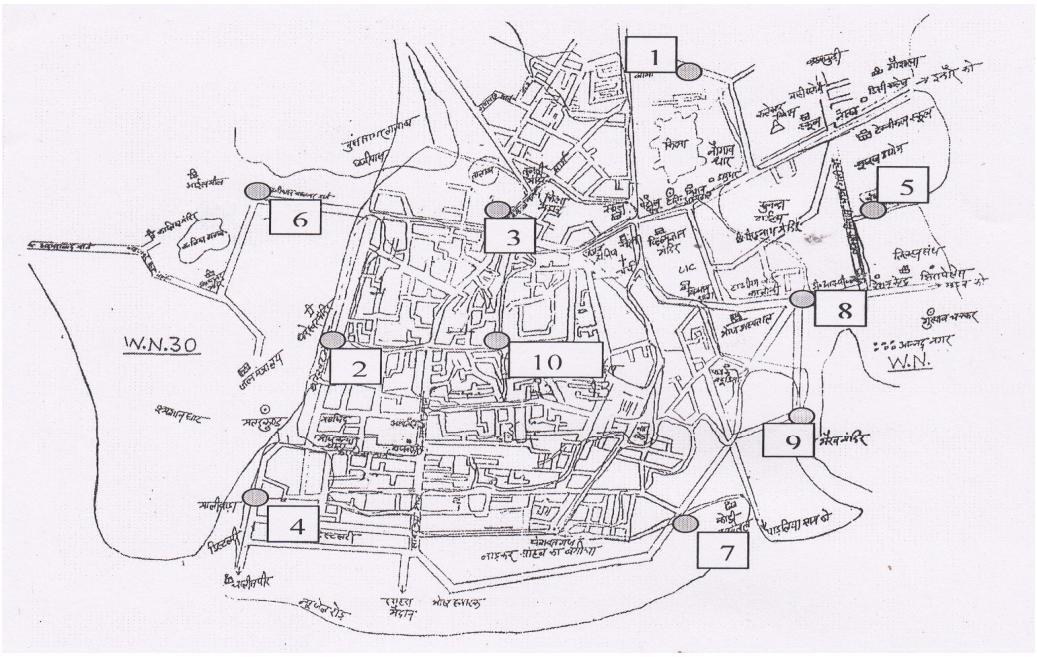

Figure-2
Location Map of Dhar town showing sampling stations

Results and Discussion

Hydrogen ion concentration (pH): The pH value of natural water changes due to biological activity and industrial contamination. pH has no adverse effects on health. The average pH values of this investigation are too low and well within the standard permissible limits[7].

Total dissolved solids: According to WHO the maximum allowable limit of total dissolved solids in groundwater for domestic purpose is 1500 mg/l[8]. Source water may also contain various types of ions of high concentrations causing acute pollution. The most annoying solutes are calcium and magnesium bicarbonates (Ca^{2+}, $2HCO3^-$) and (Mg^{2+}, $2HCO3^-$)[9]. TDS values are mainly due to carbonates, bicarbonates, chlorides, sulphates, phosphates, nitrates etc. Usually TDS in water does not harm human beings, but high concentration can cause heart and kidney diseases. Usually ground water has high level of dissolved salts. The drinking water containing more than 5000 mg/l of TDS is not considered desirable and it can also cause excessive scaling in water[10]. During present study the minimum average TDS value recorded was 831.9 mg/l during rainy and the maximum recorded was 1092 mg/l during summer season. Both these values are much higher than that of the permissible limit[7].

Alkalinity: The main source for alkalinity is due to weathering of rocks. Higher alkalinity value contributes sour and saline taste to water. Although, alkalinity is not harmful to human beings yet the water supplied with less than 100 mg/l is desirable. It is important in calculating the dose of alum and bicides in water[11]. During present study the minimum average total alkalinity value recorded was 149 mg/l during rainy season and the maximum recorded was 388 mg/l during summer. Both these values are much higher than that of the standard permissible limit[7].

Total Hardness (TH): Hardness in water is primarily caused by the presence of calcium and magnesium salts and entry of industrial and other domestic effluents into the water source. Hardness has no adverse effect on human health however; some evidence has been given to indicate its role in heart disease[12]. The minimum average total hardness value, recorded 135 mg/l during rainy season, is well within the standard permissible limit but the maximum value i.e. 876 mg/l during winter is much higher than that of the permissible limit[7].

Nitrate: Nitrate values are used to assess the self purification property of the water source. The main source of nitrate in water body is decaying plant and animal materials. The nitrate values of this investigation are well within the standard permissible limit[7].

Sulphate: Gypsum and other common minerals are the main source of sulphates in water. High concentration of sulphate around 1000mg/L causes gastro intestinal irritation. The sulphate values of this investigation are well within the standard permissible limit[7].

Fluoride: Fluoride is an essential element for human body[13]. Fluoride is an essential element for human body. Most of fluoride enters into human body only during water consumption.

The fluoride values of this investigation are too low and well within the standard permissible limits[7].

Turbidity: Turbid waters are unfit for human consumption and causes adverse health hazards on human beings due to the presence of pathogenic micro organisms. The turbidity values of ground water of Dhar town are within the standard permissible limit [7].

Chloride: The main sources of chloride in water are discharge of domestic sewage, industrial effluents, and agricultural fertilizers. It is an indicator of organic pollution. The minimum average total chloride value 103 mg/l, recorded during rainy season, is within the permissible limit but the maximum value i.e. 417 mg/l recorded during summer is much higher than that of the permissible limit[7].

In this study Ground Water Quality Index GWQI is calculated as per the procedure explained above for different sampling periods and stations using mean values of selected physico-chemical parameters during the study period. The results obtained are represented in table-4 to 6.

Table-4
Determination of GWQI of Dhar town during rainy season

S. No.	Parameters	Mean value	Standard permissible value (Si)	Ideal value(I)	Unit weight(Wi)	Quality rating (QI)	QI*WI
1	TDS	831.9	500	0	0.00	166.38	0.33
2	Sulphates	93.5	150	0	0.01	62.33	0.42
3	pH	7.63	8.5	7	0.12	42.00	4.94
4	Total alkalinity	212.1	120	0	0.01	176.75	1.47
5	Total hardness	367.5	300	0	0.00	122.50	0.41
6	Chloride	181.7	250	0	0.00	72.68	0.29
7	Fluoride	0.8	1.5	1	0.67	40.00	26.67
8	Turbidity	3.57	10	0	0.10	35.70	3.57
9	Nitrated	2.8	45	0	0.02	6.22	0.14
				∑Wi= 0.93		**∑QiWi = 38.24**	
GWQI = ∑QiWi / ∑Wi = 38.24 / 0.93= 41.08							

All parameters are in mg/l except pH and turbidity. Turbidity is in NTU

Table-5
Determination of GWQI of Dhar town during winter season

S. No.	Parameters	Mean value	Standard permissible value (Si)	Ideal value(I)	Unit weight(Wi)	Quality rating (QI)	QI*WI
1	TDS	1006	500	0	0.00	201.28	0.40
2	Sulphates	110.8	150	0	0.01	73.87	0.49
3	pH	7.91	8.5	7	0.12	60.67	7.14
4	Total alkalinity	311.7	120	0	0.01	259.75	2.16
5	Total hardness	483.4	300	0	0.00	161.13	0.54
6	Chloride	248.4	250	0	0.00	99.36	0.40
7	Fluoride	0.9	1.5	1	0.67	20.00	13.33
8	Turbidity	1.03	10	0	0.10	10.30	1.03
9	Nitrated	31.13	45	0	0.02	69.17	1.54
				∑Wi= 0.93		**∑ Qi Wi=27.23**	
GWQI = ∑QiWi / ∑Wi = 27.23 / 0.93 = 29.04							

All parameters are in mg/l except pH and turbidity. Turbidity is in NTU

Table-6
Determination of GWQI of Dhar town during summer season

S. No.	Parameters	Mean value	Standard permissible value (Si)	Ideal value(I)	Unit weight(Wi)	Quality rating (QI)	QI*WI
1	TDS	1092	500	0	0.00	218.40	0.44
2	Sulphates	137.6	150	0	0.01	91.73	0.61
3	pH	8.26	8.5	7	0.12	84.20	9.91
4	Total alkalinity	274	120	0	0.01	228.33	1.90
5	Total hardness	433	300	0	0.00	144.33	0.48
6	Chloride	312.5	250	0	0.00	125.00	0.50
7	Fluoride	0.80	1.5	1	0.67	40.00	26.67
8	Turbidity	1.51	10	0	0.10	15.10	1.51
9	Nitrated	33.44	45	0	0.02	74.32	1.65
				∑Wi = 0.93		**∑QiWi =43.67**	
GWQI = ∑QiWi / ∑Wi = 43.67 / 0.93 = 46.91							

All parameters are in mg/l except pH and turbidity. Turbidity is in NTU

The results obtained from the study (table-4 to 6) revealed that the GWQI of Dhar town is well within the permissible limit (100) of Water Quality Index and the status of ground water from bore wells of the town is 'good' during all the sampling periods. During the study period the minimum GWQI (29.40) was recorded in winter was while the maximum GWQI (46.91) was recorded during summer. Intermediate condition was observed during rainy season during which GWQI calculated was 41.80. The higher value in summer season may be due to the increased concentration of the minerals owing to lower water levels in bore wells. The minimum value in winter season is due to settlement of anions and cations. Higher values of physico-chemical parameters in summer and lower in winter have already been reported by some authors which supports our findings[14,15]. Detailed study and important contributions on WQI were made some scientists[16-19].

Conclusion

The results obtained from this study clearly indicate usability of ground water for drinking and other domestic purposes. The study also indicates the usefulness of WQI in estimating the drinking water quality of the ground water. It is also helpful for a common man to understand the drinking water quality.

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