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WQI directed assessment of potable water quality with special reference to fluoride at Barkagaon Block of Hazaribag District, Jharkhand, India

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Abstract- The present study was considered to evaluate the quality of groundwater by using the water quality index (WQI) at Barkagaon Block of Hazaribag district, Jharkhand. WQI is the most effective tool for the measurement of the quality of water. 108 groundwater samples were collected from the hand pump and well for the analysis of physico-chemical parameters such as pH, TDS, Alkalinity, Fluoride, Chloride, Total hardness, Magnesium and Calcium. WQI rating was carried out to evaluate over all ground water quality status of the studied area. The maximum WQI value was 230 while 46.09 was the minimum. The computed WQI values were compared and were categorized as very good water-0.93%, good water-44.44%, poor water-53.70%, very poor water-0.93% and unfit for drinking purpose-0%. The Value of WQI was higher in fluoride-containing sample water than in other samples. The high value of WQI in the studied areas was probably due to the increased value of pH, TDS, alkalinity, Fluoride, Chloride, Total hardness, Magnesium and Calcium in the groundwater.

Key words: WQI, Fluoride, groundwater, Barkagaon block.

INTRODUCTION

Water plays a very vital role in the maintenance of human health and welfare. Clean and safe water is a fundamental right of human beings.[1] About 780 million people do not have access to clean and safe water due to this, about 6-8 million people die each year.[2] The reduction of water-borne diseases is one of the major health goals in developing countries. Water also plays an important role in metabolic activities and serves as a solvent forming solutes in the human body.[3,4] The quality of groundwater depends upon the presence and concentration of various chemical components which are mostly derived from the geological formation of the particular region as reported by WHO, 2004.[5-7] Groundwater contamination is one of the major environmental issues.[8,9] When human beings take polluted water may lead to verities of diseases like cholera, typhoid, dysentery, skin problems, fluorosis, mental disorder etc.[10-13] Therefore, it is important that assess the quality of groundwater sources to ascertain their suitability for drinking.[1,4,14-17] In this regard, the present study was undertaken to assess the Physico-chemical characteristic of groundwater. The water quality index is determined after the assessment of different parameters. Water Quality Index (WQI) provides a single number that expresses the overall water quality at a certain location and time, based on several water quality parameters.[3,18-20]

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MATERIAL & METHOD

Study Area:

Barkagaon block is 447.9 km^2 and the altitude is about 600 meters from the mean sea level. It lies between 23°52'5" North latitude and 85°14'15" East longitudes which consist of 83 revenue villages of 23 panchayats. The total population is 1,10,958 as per the census report 2011.

Collection Sites:

108 groundwater samples were collected from a hand pump and well at different sites in sterilized polythene bottles of one letter capacity. The Physicochemical parameters were analysed for WQI such as pH, TDS, alkalinity, Fluoride, Chloride, Total hardness, Magnesium and Calcium.

Methodology:

The water quality index (WQI) is a technique that provides the composite influence of individual water quality parameters on the overall quality of water. The objective of WQI is to turn complex water quality data into information that is understandable and usable to understand the quality of drinking water. In this regard, the groundwater samples were analysed to assess different Physico-chemical parameters such as pH, TDS, alkalinity, Fluoride, Chloride, Total hardness, Calcium and Magnesium as per the guideline of APHA-2005. The pH was measured by using a portable pH meter (model- pH 009(I) pen type digital meter while TDS was measured by using an HM meter. Measurement of Alkalinity was done by titrimetric method while Chloride test was done by Water testing kit (Nice Chemical Pvt. Ltd.). The amount of total hardness and calcium were measured by the EDTA method (APHA-2005, 21st edition) while the amount of magnesium was measured by subtraction of total hardness and calcium hardness. The fluoride concentration was measured by using the Hand Held colorimeter (fluoride HR code H1739 by HANNA Instruments Inc.). After analysis, the standards for drinking purposes have been considered for the calculation of WQI. WQI is calculated by adopting the following steps,

In the first steps, each of the all parameters has been assigned a weight (wi) according to its relative importance in the overall quality of water for drinking purposes (Table-1) ranging between 1 to 5.

In the second step, the relative weight (Wi) is calculated from the following formula i.e.

$$Wi = wi/\sum_{ni=1} wi$$

Where,

Wi = relative weight,

wi = weight of each parameter

n = number of parameters.

Calculated relative weight values of each parameter are given in table- 2.

In the third step, a quality rating scale (qi) for each parameter is calculated by dividing its concentration in each water sample by its respective standard i.e. BIS standard and the result is multiplied by 100.

$$Qi=(Ci/Si)*100$$

Where,

Qi = quality rating based on concentration

Ci = concentration of each chemical parameter in each water sample in mg/L

Si = BIS standard for each chemical parameter in mg/L.

WQI calculation was done by the following formula:-

$$SIi= Wi*Qi$$

$$WQI= SIi$$

Where,

SIi= sub-index of each parameter

The computed WQI values are classified into five categories i.e. very good water, Good water, Poor water, Very Poor Water, and Unfit for drinking purposes.

RESULT & DISCUSSION

The result of 108 groundwater samples such as pH, TDS, Alkalinity, Fluoride, Chloride, Total hardness, Magnesium and Calcium are shown in the table-2. The pH was observed between 6.7 to 8.6. The value of TDS varied between 67 to 618 mg/L, the minimum value was seen at Sukulkhapia while the maximum value was seen at Mahugaikalan. The result of alkalinity showed between 50 to 170mg/L. The amount of fluoride concentration was observed between 0.4 to 6.5mg/L in five sites of nine sample minimum was observed at Napokhurd (0.4mg/L) in GW64* while maximum vale was seen at Gali (6.5mg/L) in GW26** at Gali site. The Chloride value was also varied between 50-420, the minimum value of chloride was seen at Babupara (GW21) while the maximum was seen at Mahugaikalan (GW1*). The Total hardness was seen between 140 - 480mg/L i.e. Sukulkhapiya (GW9) and Dambadih (GW10*). The value of magnesium was observed between 36-322 mg/L. The highest vale was

observed at Gail (GW27) and the lowest was seen at Sukulkhapiya (9). The amount of Calcium was seen between 32 to 316 mg/L at Mardosoti (GW6) and Pakariyatola (GW22*).

The result of the water quality index (WQI) was shown in table-2 which was commonly used to evaluate the overall groundwater quality status of the study area. The maximum WQI value was observed in sample number GW49* at Kairy (230) while the minimum value of WQI was observed in sample number GW9 at Sukulkhapiya (46.09). The higher value of WQI was seen in fluoride-containing water samples compared to non-fluoridated water samples. The computed WQI values were compared with standard values,[20,21] and were categorized as very good water-0.93%, good water-44.44%, poor water-53.70%, very poor water-0.93% and unfit for drinking purpose-0% (Table-3 and Fig-1). The high value of WQI in the study area is due to the higher value of pH, TDS, alkalinity, Fluoride, Chloride, Total hardness, Magnesium and Calcium in the groundwater. So, these results showed that the category of poor water is more than 50% indicating unsafe for drinking purposes, and it is ultimately causing health problems for people who reside in the areas.

Table 1- Showing Relative weightage of different parameters

Parameters	BIS	Weight(wt)	Relative weight (Wt)
pH	8.5	4	0.13
TDS	500	5	0.16
Alkalinity	200	3	0.09
F^-	1	5	0.16
Cl^-	250	5	0.16
Total hardness	300	2	0.06
Mg^{++}	30	3	0.09
Ca^{++}	75	3	0.09

Table 2- Showing Value of WQI and Quality of Water

Zone	Panchayat	Site	Sample No.	Physico-chemical parameter								Value of WQI	Quality of water
				pH	TDS	Alkalinity	F^-	Cl^-	Total hardness	Mg^{++}	Ca^{++}		
I	Mahugaikalan	Mahugaikalan	GW1*	13	19.77	7.2	0	26.88	9.2	70.8	26.88	173.73	Poor water
			GW2**	13	17.92	4.95	0	25.6	6.6	35.4	25.44	128.91	Poor water
			GW3	12.85	8.16	3.15	0	8.32	5.6	49.2	13.92	101.2	Poor water
		Mardosoti	GW4*	13	8.26	4.05	0	6.4	7	60	18	116.71	Poor water
			GW5**	12.39	12.93	4.5	0	12.8	8.2	75	19.2	145.02	Poor water
			GW6	13	2.4	3.15	0	7.68	3	35.4	3.84	68.47	Good water
		Sukul Khapiya	GW7*	12.08	11.52	4.5	0	12.8	7.2	52.8	22.08	122.98	Poor water
			GW8**	11.93	13.34	1.8	0	14.08	8	46.8	29.28	125.23	Poor water
			GW9	10.24	2.14	3.15	0	4.48	2.8	10.8	12.48	46.09	Very Good water
	Badam	Dambadih	GW10*	11.32	11.87	5.85	0	9.6	9.6	75.6	27.36	151.2	Poor water
			GW11**	11.62	12.51	4.5	0	7.68	7.2	24	33.6	101.11	Poor water
			GW12	11.47	10.59	3.6	0	6.4	6	12	31.2	81.26	Good water
		Babupara	GW13*	11.77	3.49	4.05	0	3.2	3.2	20.4	11.04	57.15	Good water
			GW14**	11.93	5.06	2.7	0	4.48	6.2	64.2	11.52	106.09	Poor water
			GW15	12.23	2.24	3.6	0	4.48	3.4	33	7.2	66.15	Good water
		Koritala	GW16*	11.93	15.62	3.6	0	14.08	8.2	42.6	32.16	128.19	Poor water
			GW17**	12.08	3.33	1.8	0	3.2	4.6	24.6	17.76	67.37	Good water
			GW18	12.39	4.29	2.7	0	6.4	3.8	33	9.6	72.18	Good water
	Godalpura	Godalpura	GW19*	12.08	4.09	3.15	0	4.48	3.6	37.2	6.72	71.32	Good water
			GW20**	11.93	8.8	4.95	0	9.6	6.6	52.8	18.72	113.4	Poor water
			GW21	12.23	3.42	3.15	0	3.2	3.2	20.4	11.04	56.64	Good water
		Pkariya Tola	GW22*	11.93	13.95	5.85	0	12.8	8	33.6	34.56	120.69	Poor water
			GW23**	11.62	19	6.75	0	20.48	11.2	73.2	37.92	180.17	Poor water
			GW24	11.93	3.9	2.7	0	4.48	3.6	28.8	10.08	65.49	Good water
		Gali	GW25*	13.15	8.5	7.65	24	6.4	5.6	33.6	20.16	119.06	Poor water
			GW26**	12.85	7.81	3.15	104	7.68	5.8	24	13.2	178.49	Poor water
			GW27	13.85	8.19	2.25	0	6.4	8.6	96.6	12.96	148.85	Poor water
II	Ango	Ango	GW28*	12.69	10.72	3.15	0	6.4	7.8	66.6	20.16	127.52	Poor water
			GW29**	12.85	10.46	5.85	0	6.4	3.6	9	18	66.16	Good water
			GW30	12.69	14.24	3.6	0	9.6	3.4	12	15.6	71.13	Good water
		Ambatola	GW31*	12.85	6.24	4.05	0	6.4	4.6	48	14.88	97.02	Good water
			GW32**	12.85	13.38	2.7	0	9.6	7	83.4	8.64	137.57	Poor water
			GW33	12.54	11.55	2.25	0	11.52	4	6	21.6	69.46	Good water
		Srigarsari	GW34*	11.62	10.69	13.95	0	4.48	9.2	67.2	28.32	145.46	Poor water
			GW35**	11.93	19.9	7.2	0	19.2	9.6	60	33.6	161.43	Poor water
			GW36	12.69	4.86	2.7	0	4.48	5.8	43.8	17.28	91.61	Good water

	Tlaswar	Lamkitand	GW37*	11.93	19.97	6.75	0	17.92	10.2	55.8	38.88	161.45	Poor water
			GW38**	12.39	8	5.85	0	6.4	6.6	61.8	14.88	115.92	Poor water
			GW39	12.23	19.42	6.75	0	9.6	8	61.2	23.52	140.72	Poor water
		Talaswar	GW40*	13.15	5.8	3.15	0	4.48	5	36.6	15.36	83.54	Good water
			GW41**	12.69	9.12	2.25	0	6.4	6.2	60.6	12.96	110.22	Poor water
			GW42	12.08	10.43	9.45	0	4.48	4.2	7.8	22.08	70.52	Good water
		Palandu	GW43*	12.23	11.9	9	0	6.4	2.8	25.2	6.72	74.25	Good water
			GW44**	10.86	3.36	3.15	54.4	3.2	3.6	14.2	15.84	108.61	Poor water
			GW45	13	6.75	0.9	0	6.4	4.4	34.8	12.48	78.73	Good water
	Sikari	Sikari	GW46*	12.54	6.43	4.05	0	4.48	3	24	8.4	62.9	Good water
			GW47**	12.08	19.45	5.85	0	16	10.2	30	49.2	142.78	Poor water
			GW48	12.39	7.62	5.4	0	4.48	5.4	58.2	9.12	102.61	Poor water
		Kairy	GW49*	11.77	25.37	6.75	0	25.6	13.2	114	33.6	230.29	Very Poor water
			GW50**	11.93	12.45	4.95	0	7.68	9.6	62.4	32.64	141.65	Poor water
			GW51	12.08	11.68	3.15	0	10.88	9	83.4	20.64	150.83	Poor water
		Parpen	GW52*	11.77	12.06	4.95	0	6.4	6.6	37.8	24.48	104.06	Poor water
			GW53**	12.08	20.13	6.75	0	19.2	9.6	54	36	157.76	Poor water
			GW54	12.85	8.32	3.6	0	7.68	5	43.8	12.48	93.73	Good water
III	Garsulla	Garsulla Basti	GW55*	12.08	19.84	6.3	0	17.28	10.4	30	50.4	146.3	Poor water
			GW56**	12.08	12.29	5.4	0	6.4	9.6	27	46.8	119.57	Poor water
			GW57	11.77	5.12	4.5	0	3.2	3.8	43.8	5.48	77.67	Good water
		Lurunga	GW58*	10.71	16.99	3.15	46.4	6.4	4.8	20.4	20.64	129.49	Poor water
			GW59**	10.71	8.42	2.7	64	3.2	4.2	12.6	20.16	125.99	Poor water
			GW60	12.85	12.57	2.7	0	10.88	5.4	29.4	20.64	94.44	Good water
		Chano	GW61*	11.77	11.8	6.75	72	5.12	3.6	21.6	12.96	145.6	Poor water
			GW62**	11.77	11.49	9	76.8	6.4	3.8	37.8	7.687	164.747	Poor water
			GW63	11.93	16.99	5.85	0	3.2	4.8	48	9.6	100.37	Poor water
	Napokhurd	Napokhurd	GW64*	13.15	5.63	4.5	6.4	4.48	4	12	19.2	69.36	Good water
			GW65**	12.39	12.32	10.35	33.6	6.4	5.6	18	26.4	125.06	Poor water
			GW66	13.15	10.88	8.55	0	5.12	3.8	33	9.6	84.1	Good water
		Napokalan	GW67*	10.86	11.9	8.1	0	6.4	7.2	45	25.2	114.66	Poor water
			GW68**	11.77	21.18	12.6	0	10.88	10.8	30	52.8	150.03	Poor water
			GW69	13.15	11.07	9	0	5.12	3.6	36	7.2	85.14	Good water
		Barwaniya	GW70*	12.54	11.1	9.9	0	4.48	4	30	12	84.02	Good water
			GW71**	11.77	12.49	5.4	0	9.6	9.4	27	45.6	121.26	Poor water
			GW72	12.38	11.23	4.5	0	7.68	6	36	21.6	99.39	Good water
	Potanga	Potanga	GW73*	11.74	14.46	12.15	0	6.4	6.6	46.2	21.12	118.67	Poor water
			GW74**	11.32	24.06	4.5	0	19.2	11.8	88.2	35.52	194.6	Poor water
			GW75	11.93	5.06	2.25	0	4.48	3	21	9.6	57.32	Good water
		Bartola	GW76*	11.77	10.56	6.75	0	3.2	5.4	50.4	12.24	100.32	Poor water
			GW77**	11.47	12.32	4.05	0	10.88	6.8	49.2	21.12	115.84	Poor water
			GW78	11.93	6.14	7.2	0	5.12	4.2	36.6	10.56	81.75	Good water
		Gandhoniya	GW79*	11.77	7.04	2.7	0	7.68	4.8	10.2	12.72	56.91	Good water
			GW80**	12.08	12.09	3.6	0	11.52	7.8	73.8	17.28	138.17	Poor water
			GW81	10.86	4.99	4.05	0	3.2	4.6	13.8	22.08	63.58	Good water
IV	Sandh	Shivadih	GW82*	12.69	11.07	2.7	0	7.68	5.8	39	19.2	98.14	Good water
			GW83**	13.46	13.69	9.9	0	6.4	2.8	27	6	79.25	Good water
			GW84	13	15.55	3.15	0	10.88	6.8	72	12	133.38	Poor water
		Sonpura	GW85*	12.54	9.05	4.5	0	6.4	5.2	36	16.8	90.49	Good water
			GW86**	12.54	12.25	5.85	0	7.68	6.8	54	19.2	118.32	Poor water
			GW87	12.39	14.3	2.7	0	7.68	7.8	42	30	116.87	Poor water
		Mahudi	GW88*	13.15	7.68	7.65	0	3.2	2.8	33.6	3.36	71.44	Good water
			GW89**	13	6.01	5.4	0	3.2	5.2	67.2	4.32	104.33	Poor water
			GW90	12.69	9.95	3.6	0	6.4	4.8	40.8	12.48	90.72	Good water
		Jugara	GW91*	12.85	7.87	5.85	0	4.48	4.2	16.2	18.72	70.17	Good water
			GW92**	12.39	12.29	4.05	0	9.6	7	34.2	28.32	107.85	Poor water
			GW93	12.39	8.5	4.05	0	6.4	5	18.6	22.56	77.5	Good water
	Chepakalan	Arahara	GW94*	12.85	5.89	3.6	0	6.4	5.6	42	16.8	93.14	Good water
			GW95**	10.55	7.33	5.4	0	4.48	5.4	15	14.4	62.56	Good water
			GW96	12.08	3.77	3.15	0	5.12	4.4	33	13.2	74.72	Good water
		Chepa Kalan	GW97*	12.08	14.37	12.6	0	9.6	3.2	9	15.6	76.45	Good water
			GW98**	12.23	19.97	5.4	0	14.72	10.2	54	39.6	156.12	Poor water
			GW99	12.69	9.38	2.7	0	6.4	5	45	12	93.17	Good water
	Darikalan	Dadikalan	GW100*	13	15.1	4.95	0	11.52	5.4	39	16.8	105.77	Poor water
			GW101**	12.69	7.9	2.7	0	6.4	7.6	42	28.8	108.09	Poor water
			GW102	12.08	4.1	2.25	0	3.2	4.2	39	9.6	74.43	Good water
		Chepa Khurd	GW103*	12.84	7.87	3.6	0	4.48	3.8	25.8	12.48	70.87	Good water
			GW104**	12.84	7.2	3.15	0	6.4	4.6	48	8.4	90.59	Good water
			GW105	13.3	10.21	8.1	0	5.12	3.2	33	6	78.93	Good water
		Manjhlidadi	GW106*	13	7.26	9.9	0	4.48	3.8	33	9.6	81.04	Good water
			GW107**	12.38	19.6	6.3	0	12.8	10.2	54	39.6	154.88	Poor water
			GW108	12.23	12.22	10.35	0	6.4	8.6	57	28.8	135.6	Poor water

Without star= Well, *= HAND PUMP, **= HAND PUMP

Table 3- Showing percentage Contribution of Quality of water
As per Rupal *et al.* (2012)[20] and Kumari & Rani (2014)[21]

WQI		in % Contribution	Number of category of water
Less than 50	Very good water	0.93%	1
50-100	Good water	44.44%	48
100-200	Poor Water	53.70%	58
200-300	Very Poor water	0.93%	1
more than 300	Unfit for drinking purpose	0%	0

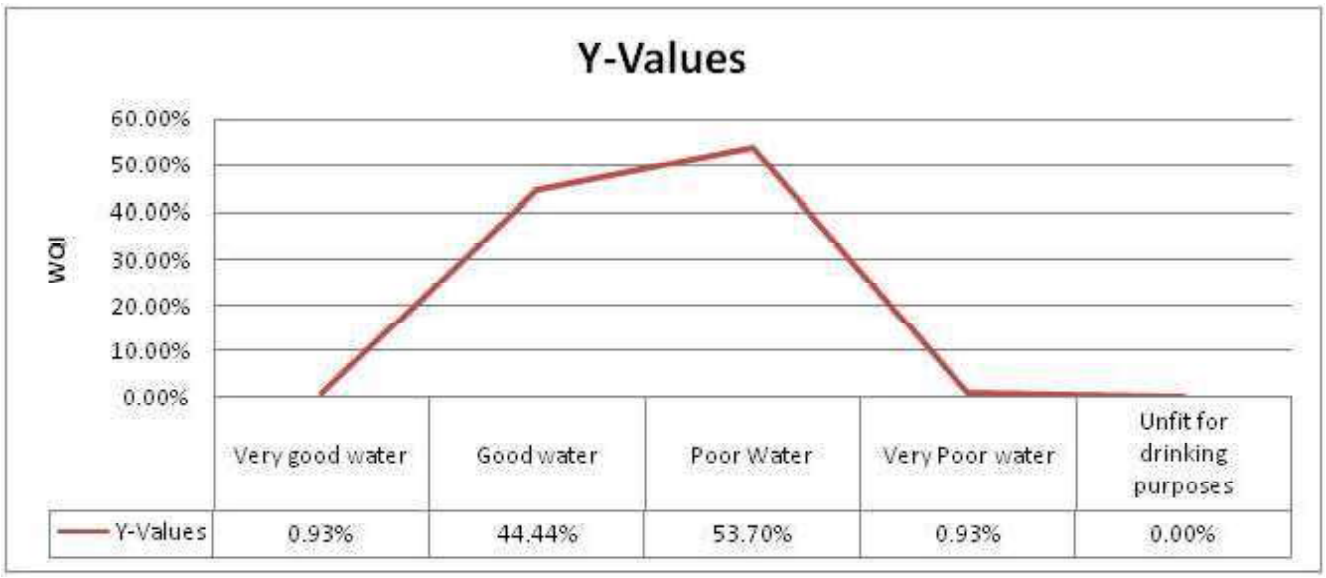

Fig. 1- Showing distribution of WQI

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