Available online at **www.joac.info**

ISSN: 2278-1862

Journal of Applicable Chemistry

2023, 12 (4): 318-328

(International Peer Reviewed Journal)

Assessment of Ground Water Quality and Impact on Health of Balod District in Chhattisgarh

Manoj K. Ghosh* and Sheshkumari Sahu

Department of Chemistry, Bharti Viswavidyalaya, Durg, Chhattisgarh, **INDIA**

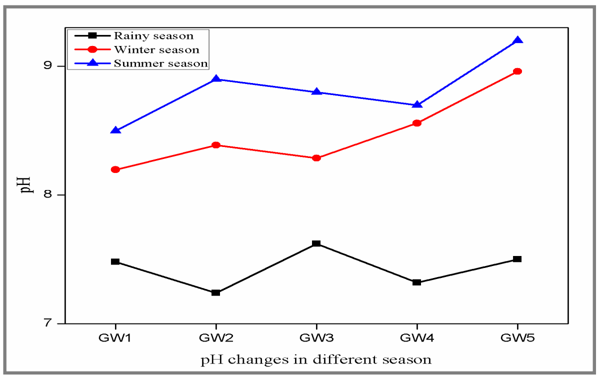
Email: ghoshkuniversity@gmail.com

Accepted on 18th July, 2023

ABSTRACT

Water quality assessment is a crucial part to understand the suitability of groundwater for various purposes, including commercial, irrigation, and drinking uses, across different locations in Balod district of chhattisgarh from september 2021 to Aug 2022 in seasonal variation. The purity of groundwater was evaluated by computing the water quality index(WQI), which combines various water quality criteria under one meter and provides a thorough picture of water suitability. The present study area was conducted in balod distict of chhattisgarh, where lots of borewell and borehole were used to collect groundwater samples. A comprehensive characteristic of physicochemical parameters was measured, including Potential of Hydrogen (pH), Hardness (H), biological oxygen demand (BOD), total dissolved solids (TDS), chemical oxygen demand (COD), electrical conductivity (EC), dissolved oxygen (DO), and concentrations of major ions such as calcium (Ca), magnesium (Mg). Additional, parameters like nitrate, fluoride (F), sulphate (SO_4), and chloride (Cl) were investigated to find out the presence of potential pollutants. In this study, ICMR and BIS standards are frequently used for monitoring. The results shows that while the water is not particularly suitable for drinking, it is nevertheless useful for household tasks, bathing, and agriculture, among other things. The physicochemical properties are changeable in different seasons, according to seasonal changes, though.

Graphical Abstract:



Seasonal variation of PH

Keywords: Water quality Index, Health Impact, Dysentery, Hepatitis, Groundwater.

INTRODUCTION

Several millions of people around the world, groundwater is an essential supply of drinking water, especially in locations where surface water is limited or unreliable. It often provides a consistent and reliable water supply, especially during droughts or periods of low rainfall. Groundwater plays a crucial role in agriculture and irrigation, supporting crop growth and food production [1, 2]. A lot of the farmer depends on groundwater for irrigation purposes, especially in regions where surface water resources are limited [3]. Groundwater sustains wetlands, streams, and other vital ecosystems, acting as a crucial water source for maintaining their ecological balance Water is one of several essential resources and the elixir of life. Life is not possible on this planet without water [4, 5]. Groundwater is a vital resource for commercial, irrigation, and drinking uses in Chhattisgarh, India. Ground water quality is of paramount importance as it directly impacts human health, agriculture, and the overall environment [6]. Contaminated groundwater can harm plants and crops when used for irrigation, leading to reduced agricultural productivity and potential food chain contamination [7, 8]. Groundwater contamination can affect soil quality, inhibiting microbial activity and nutrient cycling, and potentially impacting the overall health of terrestrial ecosystems [11, 12]. Salinity and high concentration of solid in water (TDS) in groundwater can have adverse effects on human health. Drinking water with elevated TDS levels may lead to gastrointestinal issues, dehydration, and increased risk of kidney stone. Groundwater contamination from both anthrop ogenic and natural sources is linked to an increased risk of illnesses like thyroid, dengue, malaria, fluorosis, diarrhoea, dysentery, hepatitis, cancer, gastro-intestinal liver disease, and intestinal infection, among others [13]. A WQI is used to assess and summarize the overall quality of water based on various physicochemical, biological, and sometimes microbiological parameters. It provides a single number or rating that represents the overall water quality, making it easier to interpret and compare different water sources [14]. The calculation of a WQI involves assigning weights to different parameters and combining them to create single value using a mathematical formula [15, 16]. It helps in identifying trends, monitoring changes over time, comparing different water sources, and assessing compliance with water quality standards and guidelines [17-21].

Objective of the study: This article mainly focusing on the quality of groundwater, health impact to human and animal kingdom, types of diseases develop in this area and suitability for drinking purpose.

Location of study Area: Arc-GIS (version 9.0) software has been used for the present study. Balod district in the Indian state of Chhattisgarh is the study area. The town of Balod is located near the Tandula River. It is situated is 44 km from dhamtari and 58 km from durg. The latitude and logitude of Balod district in Chhattisgarh, is 20° 43' 47" N, 81° 12' 16" E which is shown in GPS maps. Due to industrial activity, the quality of the groundwater in Balod is continuously declining.

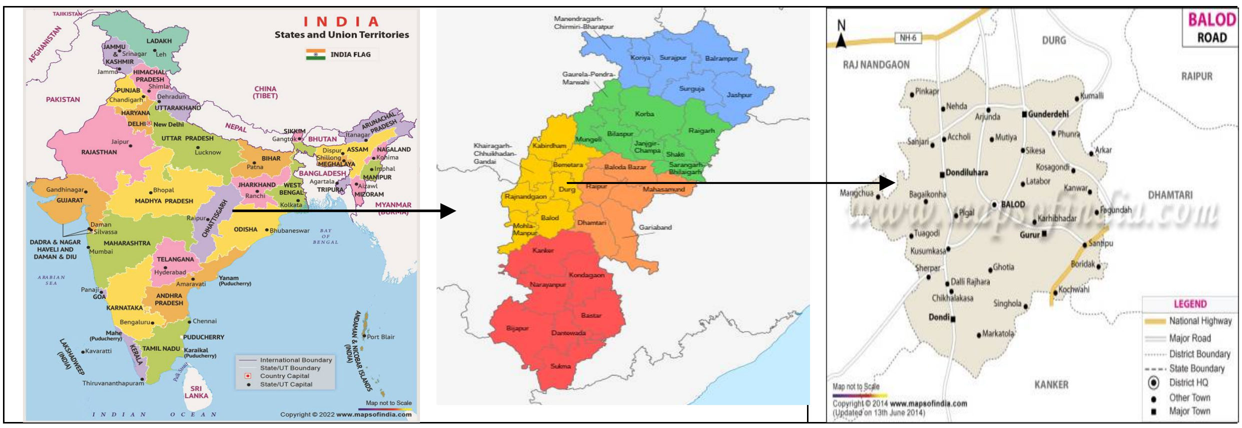


Figure 1a. GPS location of groundwater at Balod district in Chhattisgarh

MATERIALS AND METHODS

The study focused on collecting water samples from various sources, such as wells and boreholes. During September 2021 to Aug 2022, five different water samples were taken from various Balod District villages in pre-cleaned 1-litre polyethylene bottles for the current experiment. Within six hours of sample collection, processing began immediately, putting the material in dark boxes,. Standard techniques were used to analyze the water.

Table 1. Chemical variable and the method used to measure them [1-3]

Parameters	Methods
pH	Systronics pH meter
BOD	BOD Merck BOD meter
Alkalinity	Alkalinity Titration with acid HCl
TH	EDTA Method
TDS	HM digital meter TDS-3
EC	Systronic Conductivity Meter-304
Sodium	Flame photometer
Calcium	Flame photometer
Magnesium	Flame photometer
Chloride	Argentometric titration
Fluoride	Ion Selective Electrode
potassium	Flame photometer
Nitrate	UV Spectroscopy
Sulphate	Turbiditimetric Method
COD	Spectroquanta Merck COD meter
DO	Chemiline DO meter CL-930

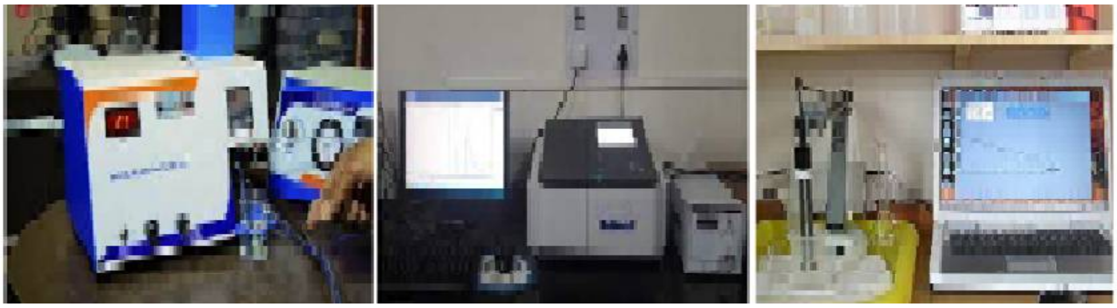


Figure 1b. Some highly sophisticated Instruments used for the detection of parameters.

Water Quality Index: The WQI is a numerical expression that provides an overall rating of the water's quality based on numerous parameters.

Table 2. WOI-based classification water quality

Class	WQI	Water quality status
1	Less than 25	Excellent water quality
2	26-50	Good water quality
3	51-75	Poor water quality
4	76-100	Very poor quality
5	More than 100	Unsuitable for drinking

Calculation of Wqi: With the help of the weighted arithmetic mean method, WQI was calculated.
Calculation of quality rating (qn):

$$qn = 100[(Vn-Vi) / (Sn-Vi)]$$

Table 3. Standard value of drinking water

S.No.	Parameters	Standard value (S_n)	Unit weight (w_n)	Recommended agency
1	pH	8.5	0.083	ICMR/BIS
2	EC	300	0.002	ICMR
3	Turbidity	10	0.010	BIS
4	TDS	500	0.001	ICMR/BIS
5	TH	300	0.471	ICMR/BIS
6	Fluoride	1.5	0.002	BIS
7	Chloride	250	0.003	ICMR
8	Magnesium	30	0.024	ICMR/BIS
9	Calcium	75	0.009	ICMR/BIS
10	Alkalinity	120	0.006	ICMR
11	SO_4	150	0.005	ICMR/BIS
12	Nitrate	45	0.016	ICMR/BIS
13	COD	20	0.025	ICMR
14	BOD	5	0.100	ICMR
15	DO	5	0.141	ICMR/BIS

Table 4. The physicochemical Variable of ground water have a seasonal variation

		Sampling Stations					
Parameters	Seasons	GW1	GW2	GW3	GW4	GW5	Average
pH	Rainy	7.48	7.24	7.62	7.32	7.5	7.41
	Winter	8.20	8.39	8.29	8.56	8.96	8.42
	Summer	8.5	8.9	8.8	8.7	9.2	8.82
EC (us cm^{-1})	Rainy	852.4	812.2	727.4	681.2	904.4	795.5
	Winter	892.4	877.4	760	730	940.8	840.2
	Summer	904	890	909	820	979	900
Turbidity (NTU)	Rainy	2.64	1.5	2.3	2.7	2.9	2.40
	Winter	1.94	1.14	1.8	2.3	2.5	1.93
	Summer	2.9	3.2	3.5	3.9	3.6	3.42
TDS (mg L^{-1})	Rainy	335.3	320.6	512.4	381.6	396.5	389.2
	Winter	480	425	525	430	440	460
	Summer	666	610	702	675	655	661.6
TH (mg L^{-1})	Rainy	227.6	201	257.6	212.6	264.6	232.6
	Winter	275.4	240.8	295	280.4	311.2	280.55
	Summer	377.4	394.6	436.8	413.6	520	428.4
Fluoride (mg L^{-1})	Rainy	0.45	0.26	0.32	0.25	0.19	0.29
	Winter	0.82	0.47	0.54	0.35	0.32	0.50
	Summer	1.65	1.34	1.42	0.91	0.81	1.22
Chloride (mg L^{-1})	Rainy	72.2	61.4	56.0	66.5	81.6	67.54
	Winter	87	76	69	79	85	79.2
	Summer	236.4	198.4	175.4	154.6	209	194.7
Magnesium (mg L^{-1})	Rainy	13.5	12.4	18.8	16	14	14.14
	Winter	15	14	20	17	16	16.4
	Summer	17	16	22	19	18	18.4
Calcium (mg L^{-1})	Rainy	47.8	57.4	54	43.6	62.5	53.0
	Winter	51	62	57.4	46	64	56.08
	Summer	56	68	64	54	69	62.5
Alkalinity (mg L^{-1})	Rainy	93.2	104.8	124.8	95	88.4	101.2
	Winter	275	230	187	195	205	218.4
	Summer	298	345	315	285	308	310
SO_4 (mg L^{-1})	Rainy	32.6	44.6	37.2	40.8	38	38.64
	Winter	38	48	42	46	44	43.6
	Summer	58	67	55	64	62	61.2
Nitrate (mg L^{-1})	Rainy	10.5	13	15	11.5	12	12.4
	Winter	13	16	18	15	17	15.8
	Summer	18	22	20	19	21	20
COD (mg L^{-1})	Rainy	4.9	5.86	7.2	6.84	3.98	5.75
	Winter	7	12	10	8	6	8.6
	Summer	14	15	12	13	12	13.2
BOD (mg L^{-1})	Rainy	5.72	7.1	6.8	5.9	4.86	6.07
	Winter	7.72	6.2	5.8	5.2	5.8	6.14
	Summer	6.6	5.9	5.6	6.3	7.0	6.28
DO (mg L^{-1})	Rainy	4.54	4.36	5.26	4.42	4.25	4.56
	Winter	3.54	5.36	4.26	5.38	4.5	4.60
	Summer	4.5	4.7	5.2	4.9	3.9	4.64

Table 5. Water quality index calculation during the rainy season

Rainy season						
S.No.	Parameters	Standard value	Unit weight (w_n)	Observed value	Quality rating (q_n)	Weighted (w_n q_n)
1	pH	8.5	0.083	7.41	27.3	2.265
2	EC	300	0.002	795.5	265.1	0.530
3	Turbidity	10	0.010	2.40	24	0.24
4	TDS	500	0.001	389.2	77.84	0.007
5	TH	300	0.471	232.6	77.5	36.50
6	Fluoride	1.5	0.002	0.29	-142	-0.284
7	Chloride	250	0.003	67.54	27.0	0.081
8	Magnesium	30	0.024	14.14	49.8	1.195
9	Calcium	75	0.009	53	70.6	0.635
10	Alkalinity	120	0.006	101.2	84	0.504
11	SO_4	150	0.005	38.64	25.76	0.128
12	Nitrate	45	0.016	12.4	27.5	0.44
13	COD	20	0.025	5.75	28.75	0.718
14	BOD	5	0.100	6.07	121.4	12.14
15	DO	5	0.141	4.56	104.5	14.7
		$\sum wn$ = 0.898		$\sum wn\ qn$ = 70.364		
		Wqi = $\sum wn\ qn / \sum wn$ = 78.3				

Where qn = Quality rating for the nth parameter, Vn = Observed value of nth parameter, Sn = Standard permissible value of nth parameter, Vi = Ideal value of nth parameter of pure water.

In the most of the time Vi = 0 except in certain parameter like pH =7.0 (natural water) and permissible value pH =8.5 (polluted water) similarly for dissolve oxygen = 14.6 mg L^{-1} etc.

Calculation of pH and DO as below.

$$q_{pH} = 100\ (V_{pH}-7.0\ /\ 8.5-7.0),\quad q_{DO} = 100(\ v_{DO}\ -14.6)/\ (5.0-14.6)$$

Calculation of unit weight (Wn): Wn = k/Sn

Where Wn = Unit weight for nth parameter, Sn = Standard value for nth parameter, K = Proportionality constant.

$$K = 1/[1/sn + 1/sn \ldots\ldots\ldots\ldots +1/sn\ ]$$

$$WQI = \sum_{n=1}^{n} qnwn/wn$$

Table 6. Water quality index calculation during the winter season

Winter season						
S.No.	Parameters	Standard value	Unit weight (w_n)	Observed value	Quality rating (q_n)	Weighted (w_n q_n)
1	pH	8.5	0.083	8.42	94.6	7.85
2	EC	300	0.002	840	280	0.56
3	Turbidity	10	0.010	1.93	19.3	0.193
4	TDS	500	0.001	460	92	0.092
5	TH	300	0.471	280	93.3	43.94
6	Fluoride	1.5	0.002	0.5	-100	-0.2
7	Chloride	250	0.003	79.2	31.6	0.094
8	Magnesium	30	0.024	16.4	54.6	1.31
9	Calcium	75	0.009	56.0	74	0.66
10	Alkalinity	120	0.006	218.4	182	1.092
11	SO_4	150	0.005	43.6	29	0.145
12	Nitrate	45	0.016	15.8	35	0.512
13	COD	20	0.025	8.6	43	1.075
14	BOD	5	0.100	6.14	122	12.2
15	DO	5	0.141	4.6	104	14.6
		$\sum wn$ = 0.898		$\sum wn\ qn$ = 84.523		
		Wqi = $\sum wn\ qn / \sum wn$ = 94.12				

Table 7. Water quality index calculation during the summer season

Summer season						
S.No.	Parameters	Standard value	Unit weight (w_n)	Observed value	Quality rating (q_n)	Weighted (w_n q_n)
1	pH	8.5	0.083	8.82	121	10.04
2	EC	300	0.002	900	300	0.60
3	Turbidity	10	0.010	3.42	34.2	0.342
4	TDS	500	0.001	661.6	132	0.132
5	TH	300	0.471	428.4	142.8	67.25
6	Fluoride	1.5	0.002	1.22	-1.22	44
7	Chloride	250	0.003	194.7	77.8	0.233
8	Magnesium	30	0.024	18.4	61.3	1.471
9	Calcium	75	0.009	62.5	83.3	0.749
10	Alkalinity	120	0.006	310	258	1.548
11	SO_4	150	0.005	61.2	40.8	0.204
12	Nitrate	45	0.016	20	44.4	0.710
13	COD	20	0.025	13.2	66	1.65
14	BOD	5	0.100	6.28	125.6	12.56
15	DO	5	0.141	4.64	103.7	14.621
		$\sum wn$ = 0.898		$\sum wn\, qn$ = 112.19		
		Wqi = $\sum wn\, qn / \sum wn$ = 124.9				

RESULTS AND DISCUSSION

The analytical results from several sample locations from September 2021 to Aug 2022 are summarized in table 4. Table 3 describes acceptable limits and suggests an agenesis. The results obtained seasonally are given below.

pH: Increased pH in groundwater can affect the taste and aesthetic qualities of water. Alkaline water may have a bitter or metallic taste, which can be undesirable for drinking and cooking purposes. The sample's pH ranged from 7.24 in the winter to 9.2 in the summer, making it alkaline groundwater. The pH range increases from GW $_2$ to GW_5.

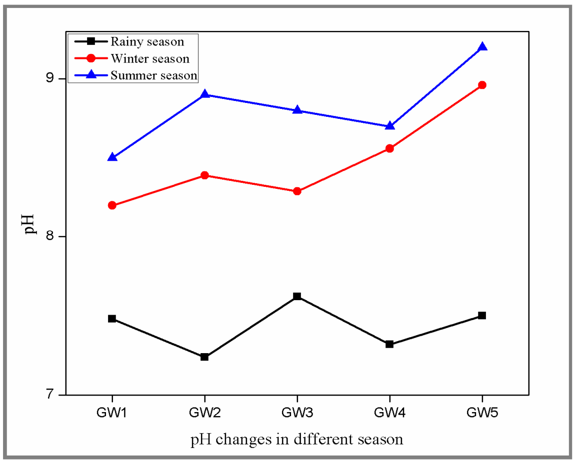


Figure 2. The pH level change as the season change..

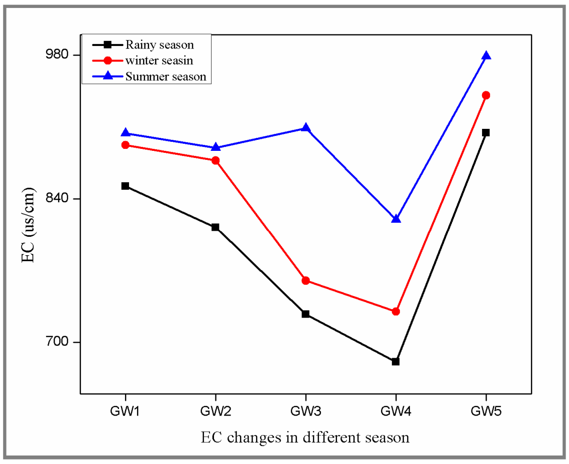


Figure 3. The EC level change as the season change.

EC: An increase in electrical conductivity (EC) in water or soil indicates a higher concentration of dissolved salts and minerals. Here, the EC of every sample varies depending on the season and is between 681.2 to 987 µs cm^{-1} from various locations of balod district.

.

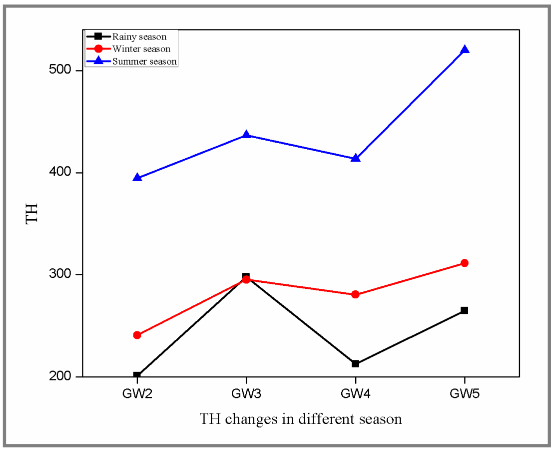


Figure 4. The TH level change as the season change.

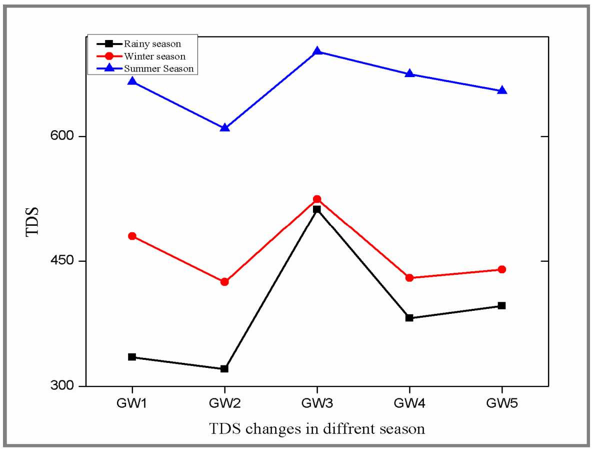


Figure 5. The TDS level change as the season change.

The sample's turbidity varied between 1.5 and 3.9 NTU, with a mean value of 2.4 to 3.5 NTU. The mean value of turbidity is within permissible limit.

TDS: TDS in the sample ranged from 320 to 702 mg L^{-1}, with a mean value of 389 to 661. During summer, the value is above the permissible limit, while average value of winter and rainy season the value is in the permissible limit.

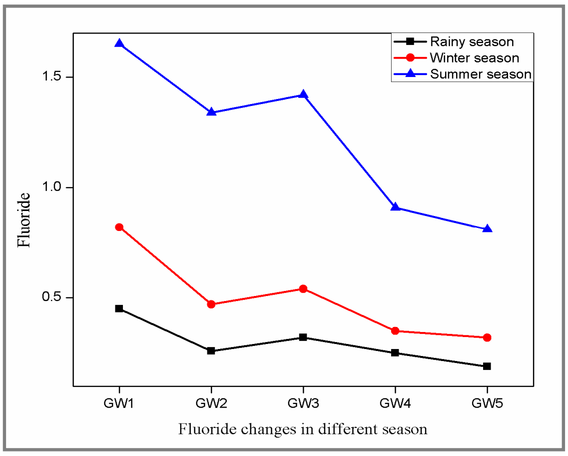


Figure 7. The Fluoride level change as the season change.

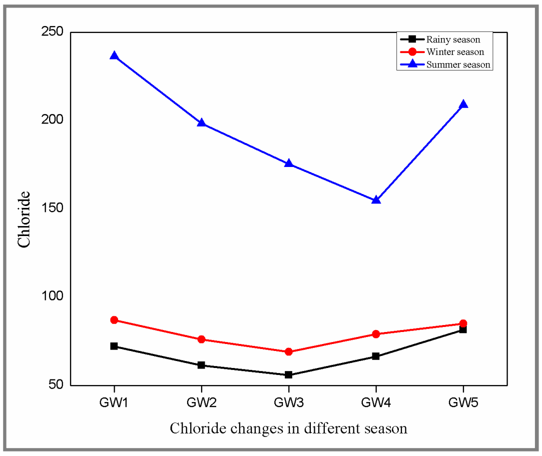


Figure 8. The chloride level change as the season change.

TH: The sample's TH varied between 201 to 520 mg L^{-1}, with average value 232 to 428. In summer season TH of GW5 value is above the permissible limit.

Fluoride: The sample's Fluoride varied between 0.19 to 1.65 mg L^{-1}, with average value 0.29 to 1.22. The concentration of fluoride is below the permissible limit.

Chloride: The sample's Chloride varied between 56 to 236 mg L^{-1} with average value 67 to 194. The concentration of Chloride is below the permissible limit.

Magnesium: The sample's Magnesium varied between 12.5 to 22 mg L^{-1}, with average value 14.14 to 18.4. The concentration of Magnesium is below the permissible limit.

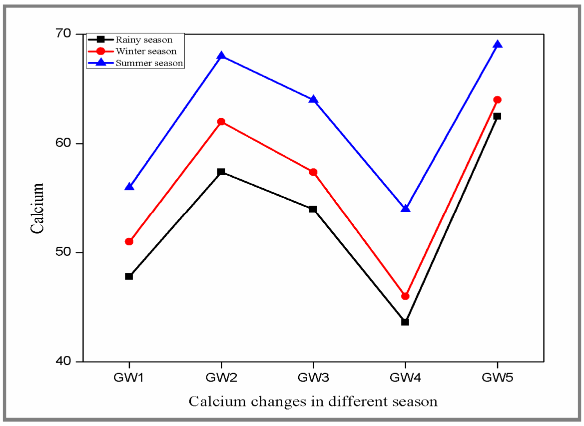


Figure 8. The calcium level change as the season change.

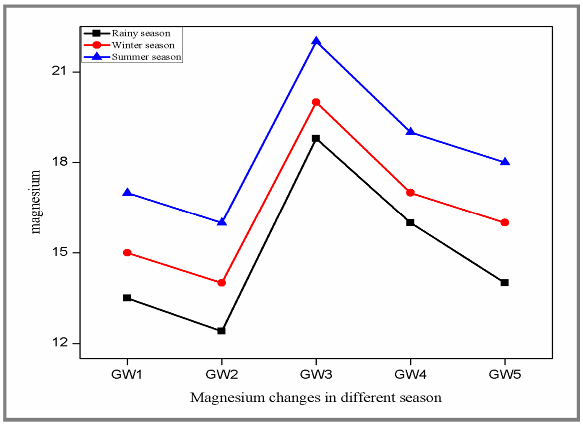


Figure 9. The magnesium level change as the season change.

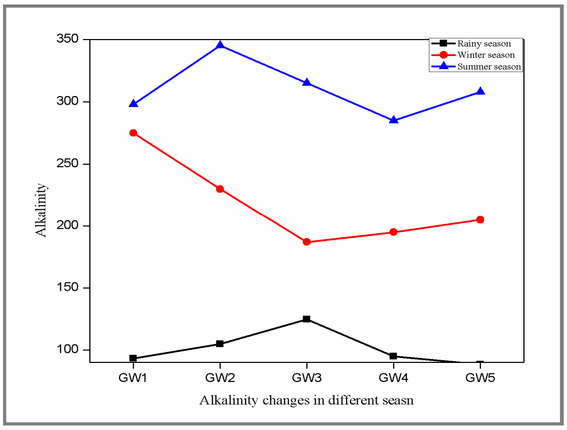


Figure 11. The alkalinity level change as the season change.

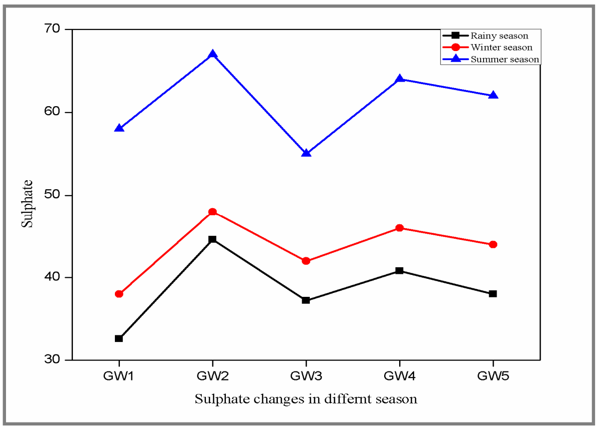


Figure 12. The sulphate level change as the season change.

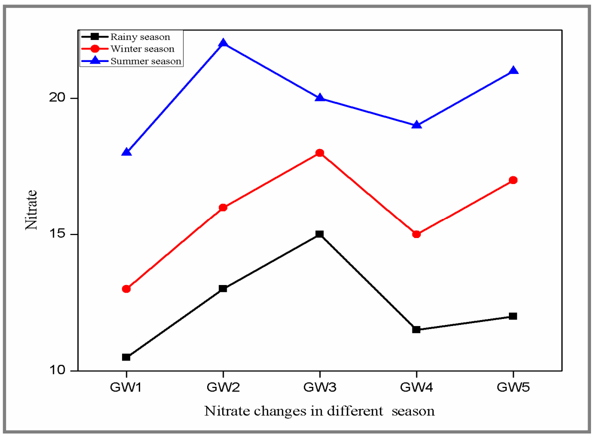


Figure 13. The nitrate level change as the season change

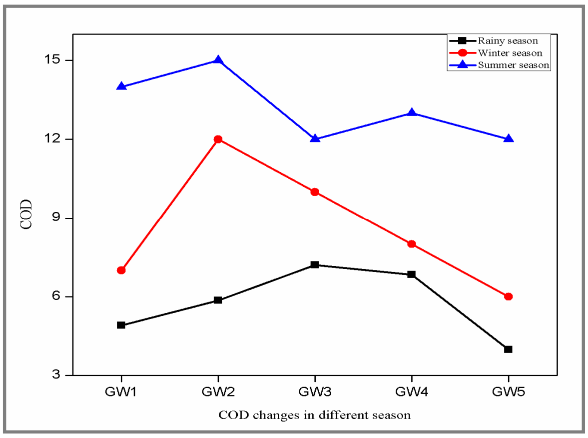


Figure 14. The COD level change as the season change.

Calcium: The sample's Calcium varied between 43.6 to 69 mg L^{-1}, with average value 53 to 62. The concentration of Calcium is below the permissible limit.

Alkalinity: The sample's Alkalinity varied between 88.4 to 345 mg L^{-1}, with average value 101 to 310. The mean value indicate that the value was above the permissible limit SO_4 . The sample's SO_4 varied between 32.6 to 67 mg L^{-1} ,with average value 38.64 to 61.2. The mean value indicate that the value was below the permissible limit.

Nitrate: The sample's Nitrate varied between 10.5 to 22 mg L^{-1}, with average value 12.4 to 20. The mean value indicate that the value was below the permissible limit.

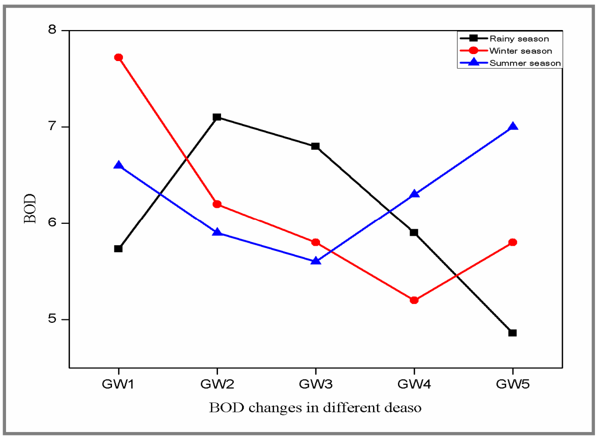


Figure 15. The BOD level change as the season change.

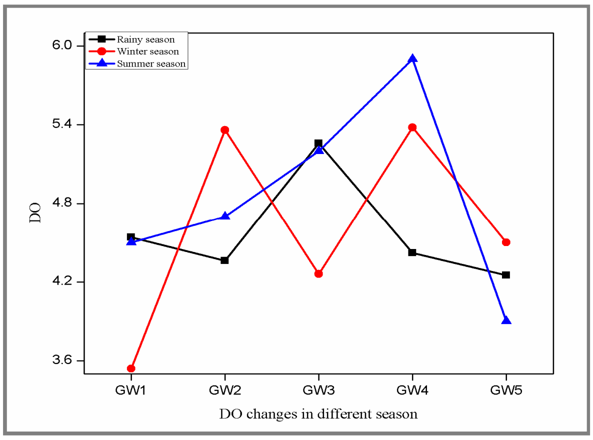


Figure 16. The DO level change as the season change.

COD: The sample's COD varied between 3.98 to 15 mg L^{-1}, with average value 5.75 to 13.2. The mean value indicate that the value was below the permissible limit.

BOD: The mean value of BOD in rainy season 6.07, 6.14 in winter season and 6.28 in summer season. The mean value indicate that the value was below the permissible limit.

DO: The mean value of DO in rainy season 4.56, 4.60 in winter season and 4.64 in summer season. The mean value indicate that the value was below the permissible limit.

Water quality index: WQI out of five sample was computed in the study area of balod district in variable season like summer, winter and rainy as presented by table 7, 6 and 5 respectively. The computed WQI for rainy season indicate that the overall WQI was 78.4 as compared to winter season 94.12 and summer season 124.9 respectively. The value of WQI is high in the summer season, while the rainy season has the lowest value. Due to the high concentrations of TDS, calcium, magnesium, alkalinity, hardness, and EC, the WQI summer season has a high value in groundwater. Some samples' water quality tends to be low during the winter and summer.

Health Impact: Most of the villagers and animal kindoms are suffering from different fatal diseases like dental fluorosis, skeletal fluorosis, arthritis, bone damage, osteoporosis, muscular damage, fatigue, joint-related problems, thyroid renal disease, Carcinogenesis, neurological effects on children's , headaches, muscle tremor, abdominal cramps, kidney damage, hallucinations, loss of memory etc. Some photographs are shown in figure 17 as shown below

Figure 17. Animals and human beings are suffering from different fatal diseases.

APPLICATION

Water quality index integrate the data from different dimensions of a mathematical equation and statistical tools that measures water quality and health issues using a variety of parameters [**22**]. The water quality index was calculated using the weighted arithmetic index system. Further, through this paper villagers of balod district become alert about the presence of toxic elements present in the ground water in balod district. Based on this study, we also organized awareness program for the local residents [**9, 10**].

CONCLUSION

This study was conducted in Balod district of chhattisagrh for measuring quality of groundwater drinking purpose and health impact in this area suffering from different hazardous diseases. The sample shown that the pH of the groundwater is above the permissible limits as prescribed by Indian Council for Medical Research and Bureau of Indian Standard. Some parameters like EC, TDS, and alkalinity values are above the permissible level. The result showed that some variables had elevated readings in both the winter and summer, exceeding both the acceptable standards limits and water quality index. So most important things to focus monitoring water quality and utilizing local method to treat water to make it safe for domestics use, bathing and drinking. Water sample consistency continues to be poor during the study season.

ACKNOWLEDGMENT

Authors are thankful to management of Bharti Viswavidyalaya, Durg and some consultants raipur for providing the lab facilities. Writers are also thankful to chief editor and reviewers of Journal of Applicable Chemistry for their valuable comments and suggestions.

Conflict of Interest: Conflict of interest declared none.

REFERENCES

[1]. M. K. Ghosh, R. Tiwari, A study of water quality index assessment of groundwater and pond water in sirsakala village bhilai-3 chhattishgarh india, *Journal of civil structural environmental and engineering research and development*, **2013**, 65-75.

[2]. K.K Kashyap, M K Ghosh, Water Quality Index (WQI) for Assessment of Groundwater Quality, Around Gevra Coalfields Area, Chhattisgarh, *J. Applicable Chem.*, **2021**, 10(2), 199-211.

[3]. M. K. Ghosh, Removal of Toxic Metal Lead from the Surface Water of Naya Raipur and Its Impact on Human Health, *J. Applicable Chem.*, **2021**, 10(2), 212-219.

[4]. A. Bukhzam, A. Elgornagi, N. Alshelmani, N. Bader, Study of some Physical and Chemical Properties of Ground Water in Sug al Juma'a area in Tripoli, Libia, *J. App. Chem.*, **2021**,10(1), 42-48.

[5]. B. V. Rao, P. V. S. Machiraju, Ch. V. V. Satyavani, Physicochemical and Biochemical Characterization of Ground waters near point Sources for assessing their Quality for user End Application, *J. App.Chem.*, **2014**, 3(1), 290-301.

[6]. S. D. Jadhav, M. S. Jadhav, R.W. Jawle, Study of Heavy Metals in Neera River at Sarola Bridge and Untreated Urban, Sewage Water, *J. App. Chem.*, **2014**, 3(2), 994-967.

[7]. S. K.Halnor, M. Ubale, Adsorption of Heavy Metals: A review, *J. App.Chem.*, **2013**, 2(3), 475-485.

[8]. M. D. Sharma, A. Hemalatha, Spectrophotometer-Based Analysis of Hexavalent Chromium in Various Water Bodies of Hyderabad City Reveals Large Anthropogenic Input, *J App.Chem.*, **2019**, 8(3), 984-991.

[9]. J. S. Jangwan, Bharti, V. Kumar, A. Kumar, Drinking Water Monitoring in Catchment Area of River Krishni, Baghpat, Uttar Pradesh, India, *J. Applicable Chem.*, **2019**, 8(2), 873-883.
[10]. D. Kibami, C. Pongener , Bendangsenla, K. Somasekhara Rao, Dipak Sinha, Physico-Chemical Analysis Of Water Samples of Mokokchung Town-A Preliminary Report, *J. App.Chem.*,**2013**, 2(6), 1634-1640.
[11]. N.Tiwari, R. K.Yadav, Hydrochemical assessment of groundwater resources of korba industrial area in chhattisgarh, *Bull. Env. Pharmacol. Life Sci*., **2022**, 12 (1), 78-90.
[12]. C.P. Devatha, M. K. Verma, S. Singha, Assessing groundwater quality using GIS, *International journal engineering research and technology*, **2015**, 4(11), 689-694**.**
[13]. A.Yadav, A.Nanda, B.L.Sahu, Y.K.Sahu, K.S.Patel, S.Pervez, M.S.Gulgundi, Groundwater hydrochemistry of Rajnandgaon district chhattisgarh central India, *Elsevier*, **2020**, 11, 100352.
[14]. ICMR, ICMR Manual of standard of quality for drinking water supplies, New Delhi, **1962**.
[15]. S.Choudhary, S.Ramteke, K.P.Rajhans, P.K.Sahu, K.S.Patel, S.Chakradhari, Assessment of ground water quality in central india, *Journal of water resources and protection*, **2016**, 8(1), 12-19.
[16]. M. K.Ghosh, K.Yadav, U. Jnghel, P. Gupta, An analysis of quality of groundwater of Patan tehsil of Durg district, Chhattisgarh , India, *Int. Journal Science and Research*., **2016**, 432-436,
[17]. A.Agrawal, N.Dasgupta, V.Pendese, D.Mukhopadadhyay, GIS based analysis of underground water parameters of aarang area, *International journal of modernization in engineering technology and science*, **2023**, 5(4), 5976-5980.
[18]. L. Meshram, Hydrobiological studies on freshwater reservoir of tandula dam of district Balod (C.G.) India, *International journal of science and research*, **2013**, 1886-1869.
[19]. M. K. Ghosh, S. Ghosh, Physicochemical parameter with their remedies of groundwater sample of berla tehsil of durg district chhattisgarh india, *International journal of green and herbal chemistry*, **2013**, 2(2), 332-345.
[20]. A. Biswas, N. K. Jaiswal, S, K. Biswas, A study explore the ground water quality of Dalli-Rajhara area balod district, chhattisgarh. with special reference to pollution due to mining activities, *Journal of civil engineering and environment technolog*y, **2015**, 13-17.
[21]. M. K. Ghosh, Study of water quality index to assess physicochemical parameter of ground water of durg city chhattisgarh india, *The journal of energy and environmental science*, **2013**, 2, 1824-1832
[22]. R. M. Brown, N. I. McClelland, R. A. Deininger, M. F. OConnor, A Water Quality Index - Crashing the Psychological Barrier, *Environmental Science Research*, **1972**, 1, 173-182.