

## Pre-monsoon and post-monsoon groundwater chemical analysis for Burdwan (West Bengal), India

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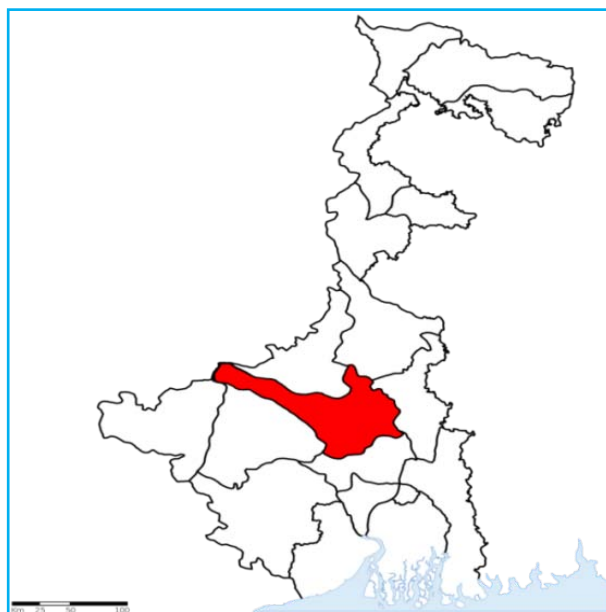
**सार** – यह अध्ययन पश्चिम बंगाल के बर्दवान जिले में प्री-मानसून और पोस्ट-मानसून के दौरान भूजल की गुणवत्ता का पता लगाने के लिए किया गया है। इसके लिए वर्ष 2017 के लिए प्री-मानसून और पोस्ट-मानसून सीजन के लिए केंद्रीय प्रदूषण नियंत्रण बोर्ड (सीपीसीबी) की वेबसाइट से भौतिक-रासायनिक मापदंडों का डेटा एकत्र किया गया है। यह पाया गया है कि मानसून के बाद के मौसम के दौरान पानी की गुणवत्ता सभी स्टेशन उत्कृष्ट की श्रेणी में आते हैं और प्री-मानसून सीजन के दौरान अधिकांश स्टेशनों की पानी की गुणवत्ता अच्छी होती है।

**ABSTRACT.** This study has been carried out to find the groundwater quality of Burdwan district of West Bengal during pre-monsoon and post-monsoon. For this, the data of physicochemical parameters have been collected from Central Pollution Control Board (CPCB) website for the pre-monsoon and post-monsoon season for the year 2017. It is found that during the post-monsoon season, the water quality of all the stations falls in the category of excellent, and during the pre-monsoon season, the water quality of most of the stations is good.

**Key words** – CPCB, Water quality index, Burdwan, Physicochemical analysis.

### 1. Introduction

Groundwater is the water present beneath the Earth's surface in soil pore spaces and fractured rock formations. Water is a prime natural resource and basic human need. Without water, humans, as well as many species, cannot sustain themselves in this world. It is estimated that approximately 1/3<sup>rd</sup> of the world's population use groundwater for drinking purpose (Nickson *et al.*, 2005). Apart from this, it is primarily used in washing, cleaning, agriculture, industries, etc. Freshwater is increasingly becoming a scarce quantity due to over exploitation and pollution. The water stored in the aquifer suffers from pervasive contamination, generally irreversible, unlike rivers (Nag and Suchetana, 2016). The rate of groundwater renewal is prolonged compared to the surface water. About 97.2% of the water on Earth is salty, and only 2.8% is present as freshwater, from which 20% constitute groundwater (Rajankar *et al.*, 2009). As per the central ground water board, in India, the utilizable water is estimated to be 1123 Billion Cubic Meter (BCM) / year. The surface water is 690 BCM/year and groundwater is 433 BCM/year. The stage of groundwater development is 58%. But due to industrialization, urbanization, chemical proliferation, improper waste disposal, etc., groundwater quality is at stake.



**Fig. 1.** The study area

According to WHO, 80% of all diseases in human beings are caused by water (Shivasharanappa *et al.*, 2011). Therefore safe drinking water is a high priority today.

**TABLE 1**  
**Physicochemical parameters for pre-monsoon season**

Measured chemical substances	Pre monsoon physicochemical analysis				
	Stations				
	Mine pit water	IISCO	Durgapur Town	Burdwan University	Burdwan Station
BOD (mg/l)	0.38	0.69	0.71	2.17	1.39
COD (mg/l)	5.62	7.34	3.90	7.34	3.90
pH	8.45	7.24	7.31	7.53	7.09
Chloride (mg/l)	47.64	42.68	119.11	12.90	169.73
Fluride (mg/l)	0.49	0.44	0.43	0.33	0.19
Cadmium ( $\mu$ g/l)	NT	NT	NT	NT	NT
Calcium (mg/l)	52.80	93.60	84.80	48.00	68.00
Copper ( $\mu$ g/l)	BDL	NT	NT	NT	NT
Iron (mg/l)	BDL	0.78	NT	NT	1.83
Lead (mg/l)	NT	7.95	NT	NT	NT
Mercury ( $\mu$ g/l)	NT	NT	NT	NT	NT
Nitrate (mg/l)	0.19	0.78	0.99	0.87	0.42
Phosphate (mg/l)	0.05	BDL	0.04	0.02	0.03
Sulphate (mg/l)	75.37	68.66	137.18	5.73	40.43
Total alkalinity (mg/l)	308.00	348.00	184.00	70.00	244.00
Fecal coliform (MPN/100 ml)	NIL	NIL	17.00	7.00	NIL
Total hardness as CaCO <sub>3</sub> (mg/l)	226.00	310.00	292.00	176.00	342.00
Total dissolved solids (mg/l)	416.00	646.00	598.00	226.00	746.00
Arsenic ( $\mu$ g/l)	NT	NT	NT		NT
Conductivity ( $\mu$ s/cm)	804.10	1108.00	864.00	419.00	1072.00
Temperature ( $^{\circ}$ C)	34	26	24	28	28

Therefore monitoring and conserving water is essential. Various physicochemical parameters play a vital role in groundwater quality for consumption, irrigation and other purposes. When these parameters are above the prescribed limits (WHO Guidelines for drinking water quality 2011; Bureau of Indian Standards for Drinking Water, 1991 and CPCB, 2008), severe health issues can be. In the past several researchers have studied the groundwater quality and its suitability for drinking and other purposes (Nag and Das, 2017; Chatterjee, *et al.*, 2010; Arumugam and Elangovan 2009; Sukumar *et al.*, 2015; Srinivasamoorthy *et al.*, 2011; Raju 2007; Kavita and Vineeta, 2010; and Prakash and Somashekhar, 2006). The present study focuses on groundwater quality at Burdwan district in

West Bengal and hence determining its suitability for drinking and other purposes.

## 2. Data and methodology

The study area shown in Fig. 1 lies between 22°56' N to 23°53' N and 86°48' E to 88°25' E. It has an area of 7024 sq km and a population of 7723663 (bardhaman.nic.in/distataglance.html). It is one of the largest districts of West Bengal. It is one of the premier districts in India in terms of mineral value. The average rainfall in this district is 150 mm. The study is conducted by taking the data of five representing sites of this district. The data for the physicochemical parameters are collected

**TABLE 2**  
**Physicochemical parameters for post-monsoon season**

Measured chemical substances	Post monsoon physicochemical analysis				
	Stations				
	Mine pit water	IISCO	Durgapur town	Burdwan University	Burdwan Station
BOD (mg/l)	0.62	0.97	1.21	1.32	0.91
COD (mg/l)	3.22	3.75	7.50	5.91	5.66
pH	8.39	7.99	7.84	7.40	7.12
Chloride (mg/l)	38.99	40.55	37.44	42.11	124.78
Fluride (mg/l)	0.21	0.24	0.21	0.14	0.13
Cadmium (µg/l)	NA	NA	NA	NA	NA
Calcium (mg/l)	40.00	12.00	20.00	16.00	39.20
Copper (µg/l)	NA	NA	NA	NA	NA
Iron (mg/l)	NA	NA	NA	NA	NA
Lead (µg/l)	NA	NA	NA	NA	NA
Mercury (µg/l)	NA	NA	NA	NA	NA
Nitrate (mg/l)	0.86	0.71	0.91	0.65	0.26
Phosphate (mg/l)	BDL	0.01	0.01	0.02	0.02
Sulphate (mg/l)	80.68	33.70	104.42	14.76	34.98
Total alkalinity (mg/l)	224.00	88.00	156.00	160.00	200.00
Fecal coliform	NIL	NIL	NIL	NIL	4
Total hardness as caco3 (mg/l)	190.00	54.00	114.00	84.00	164.00
Total dissolved solids (mg/l)	476.00	250.00	500.00	284.00	592.00
Arsenic (µg/l)	NA	NA	NA	NA	NA
Conductivity (µs/cm)	728.50	327.00	665.20	464.80	907.70
Temperature (°C)	34	26	26	29.5	28.5

from Central Pollution Control Board (CPCB) website for pre-monsoon and post-monsoon season for the year 2017. The representing sites are namely Mine-pit (station code 1766), IISCO (station code 1767), Durgapur Town (station code 1768), Burdwan University (station code 2528), and Burdwan Station (station code 2529).

Different physicochemical parameters are determined according to the procedure described in the APHA, AWWA and WPCF 1998 (APHA *et al.*, 1998). The results obtained are compared with the drinking water standards specified by the World Health Organization (WHO, Guidelines of drinking water quality recommendation, 2006), Bureau of Indian Standards (Bureau of Indian Standards, 2012) and CPCB guidelines for drinking and usable water (CPCB, 2008). The values of physicochemical parameters for pre-monsoon and post-

monsoon season obtained from the CPCB website are listed in Table 1 and Table 2. The abbreviations, NT=No trace, BDL=Below Detection Level, NA = Not Available.

Water Quality Index (WQI) is calculated by following three steps. In the first step, every eight fully available parameters and considered important has been assigned a weight ( $w_i$ ) each according to its relative importance in the overall quality of water for drinking purposes. The maximum weight of 5 is given to Nitrate due to its significant importance in water quality assessment (Ramakrishniah *et al.*, 2009). In the second step, relative weight is calculated by using equation

$W_i = w_i \div \sum_{i=1}^n w_i$ . Here  $W_i$  is the relative weight,  $w_i$  is the weight of each parameter and 'n' is the number of parameters. The calculated WQI for drinking water based

**TABLE 3**  
**Water quality index for pre-monsoon season**

Chemical Parameters	Weightage (wi)	Relative weightage (Wi)	Standard concentration (mg/l) (Si)	Mine pit			IISCO			Durgapur town			Burdwan university			Burdwan station		
				Concentration of parameters (mg/l) (Ci)	Quality rating (qi)	Sub Index (Sli)	Concentration of parameters (mg/l) (Ci)	Quality rating (qi)	Sub Index (Sli)	Concentration of parameters (mg/l) (Ci)	Quality rating (qi)	Sub Index (Sli)	Concentration of parameters (mg/l) (Ci)	Quality rating (qi)	Sub Index (Sli)	Concentration of parameters (mg/l) (Ci)	Quality rating (qi)	Sub Index (Sli)
Chloride	3	0.107	250	47.64	19.06	2.04	42.68	17.07	1.83	119.11	14.98	1.60	12.90	5.16	0.55	169.73	67.89	7.26
Fluride	4	0.143	1	0.49	49.00	7.00	0.44	44.00	6.29	0.43	21.00	3.00	0.33	33.00	4.72	0.19	19.00	2.72
Calcium	2	0.071	75	52.8	70.40	5.00	93.60	124.80	8.86	84.80	26.67	1.89	48.00	64.00	4.54	68.00	90.67	6.44
Nitrate (NO <sub>3</sub> -N)	5	0.179	45	0.19	0.42	0.08	0.78	1.73	0.31	0.99	2.02	0.36	0.87	1.93	0.35	0.42	0.93	0.17
Sulphate	4	0.143	200	75.37	37.69	5.39	68.66	34.33	4.91	137.18	52.21	7.47	5.73	2.87	0.41	40.43	20.22	2.89
Total alkalinity	3	0.107	200	308	154.00	16.48	348.00	174.00	18.62	184.00	78.00	8.35	70.00	35.00	3.75	244.00	122.00	13.05
Total hardness as CaCO <sub>3</sub>	3	0.107	300	226	75.33	8.06	310.00	103.33	11.06	292.00	38.00	4.07	176.00	58.67	6.28	342.00	114.00	12.20
Total dissolved solids	4	0.143	500	416	83.20	11.90	646.00	129.20	18.48	598.00	100.00	14.30	226.00	45.20	6.46	746.00	149.20	21.34
				WQI=55.95			WQI=70.36			WQI=66.83			WQI=27.06			WQI=66.07		

**TABLE 4**  
**Water quality index for post-monsoon season**

Chemical Parameters	Weightage (wi)	Relative weightage (Wi)	Standard concentration (mg/l) (Si)	Mine pit			IISCO			Durgapur town			Burdwan university			Burdwan station		
				Concentration of parameters (mg/l) (Ci)	Quality rating (qi)	Sub Index (Sli)	Concentration of parameters (mg/l) (Ci)	Quality rating (qi)	Sub Index (Sli)	Concentration of parameters (mg/l) (Ci)	Quality rating (qi)	Sub Index (Sli)	Concentration of parameters (mg/l) (Ci)	Quality rating (qi)	Sub Index (Sli)	Concentration of parameters (mg/l) (Ci)	Quality rating (qi)	Sub Index (Sli)
Chloride	3	0.107	250	38.99	15.60	1.67	40.55	16.22	1.74	37.44	14.98	1.60	42.11	16.84	1.80	124.78	49.91	5.34
Fluride	4	0.143	1	0.21	21.00	3.00	0.24	24.00	3.43	0.21	21.00	3.00	0.14	14.00	2.00	0.13	13.00	1.86
Calcium	2	0.071	75	40.00	53.33	3.79	12.00	16.00	1.14	20.00	26.67	1.89	16.00	21.33	1.51	39.20	52.27	3.71
Nitrate (NO <sub>3</sub> -N)	5	0.179	45	0.86	1.91	0.34	0.71	1.58	0.28	0.91	2.02	0.36	0.65	1.44	0.26	0.26	0.58	0.10
Sulphate	4	0.143	200	80.68	40.34	5.77	33.70	16.85	2.41	104.42	52.21	7.47	14.76	7.38	1.06	34.98	17.49	2.50
Total alkalinity	3	0.107	200	224.00	112.00	11.98	88.00	44.00	4.71	156.00	78.00	8.35	160.00	80.00	8.56	200.00	100.00	10.70
Total hardness as CaCO <sub>3</sub>	3	0.107	300	190.00	63.33	6.78	54.00	18.00	1.93	114.00	38.00	4.07	84.00	28.00	3.00	164.00	54.67	5.85
Total dissolved solids	4	0.143	500	476.00	95.20	13.61	250.00	50.00	7.15	500.00	100.00	14.30	284.00	56.80	8.12	592.00	118.40	16.93
				WQI=46.94			WQI=22.79			WQI=41.04			WQI=26.31			WQI=46.99		

on eight parameters for pre-monsoon and post-monsoon season are given in Table 3 and Table 4, respectively. In the third step, a quality rating scale ( $qi$ ) is assigned for each parameter. The quality rating scale is determined by dividing its concentration in each water sample by its respective standard according to BIS guidelines. The result is multiplied by 100 :  $qi = (Ci/Si) \times 100$ .

where  $qi$  is the quality rating based on the concentration of  $i^{\text{th}}$  parameter,  $Ci$  is the concentration of each parameter in each water sample in mg/l, and  $Si$  is the BIS water standard for each chemical parameter in mg/l.

For calculating the WQI, the  $Sli$  is first determined for each chemical parameter. Now  $WQI = \sum Sli$ , where

**TABLE 5**  
**Pre-monsoon and post-monsoon WQI**

Station	Pre-monsoon WQI	Post-monsoon WQI
Mine pit water	55.95	46.94
IISCO	70.36	22.79
Durgapur town	66.83	41.04
Burdwan University	27.06	26.31
Burdwan station	66.07	46.99

$Si = Wi \times qi$ , is the sub-index of an  $i^{\text{th}}$  parameter.  $WQI$  for all the stations in pre-monsoon and post-monsoon are shown in Tables 3 and 4. The calculated  $WQI$  values are classified into five categories- excellent water ( $WQI < 50$ ), good water ( $WQI : 50-100$ ), poor water ( $WQI : 100-200$ ), very poor water ( $WQI : 200-300$ ), and water unsuitable for drinking ( $WQI > 300$ ) (Kavita and Vineeta, 2010). Pre-monsoon and post-monsoon  $WQI$  for the stations are shown in Table 5.

### 3. Results and discussion

Physicochemical parameters of the stations obtained in the pre-monsoon and post-monsoon are BOD, COD, pH, Chloride, Fluoride, Cadmium, Calcium, Copper, Iron, Lead, Mercury, Nitrate ( $\text{NO}_3\text{-N}$ ), Phosphate, Sulphate, Total alkalinity, Fecal coliform, Total hardness as  $\text{CaCO}_3$ , Total dissolved solids, Arsenic, Conductivity, and temperature. It is found that in the pre-monsoon season above parameters are in the range 0.38-2.17, 3.90-7.34, 7.09-8.45, 12.90-169.73, 0.19-0.49, NT, 48.00-93.60, NT-BDL, NT-1.83, NT-7.95, NT, 0.19-0.99, BDL-0.05, 5.73-137.18, 70.00-348.00, NIL-17.00, 176.00-342.00, 226.00-746.00, NT, 419-1108, 24-34 respectively and for the post-monsoon season 0.62-1.32, 3.22-7.50, 7.12-8.39, 37.44-124.78, 0.13-0.24, NA, 12.00-40.00, NA, NA, NA, NA, 0.26-0.91, BDL-0.02, 14.76-104.42, 88.00-224.00, NIL-4, 54.00-190.00, 250.00-592.00, NA, 327.00-907.70, 26-34 respectively. The units of these parameters as specified in Tables 2 and 3. It is found that there are no abrupt changes in the concentration of the parameters in the pre-monsoon and post-monsoon seasons. Copper has been found below its detection level in Mine pit water in the pre-monsoon season. 7.95  $\mu\text{g/l}$  Lead has been found at IISCO during the pre-monsoon season. Fecal coliform 17 MPN/100 ml, 7 MPN/100 ml have been observed in the pre-monsoon season at Durgapur town and Burdwan University, respectively. During post-monsoon season fecal coliform 4 MPN/100 ml has been observed at Burdwan station. There are no traces of Arsenic and Mercury found during the pre-monsoon season from the

stations. The water conductivity varies 419.00-1108.00  $\mu\text{s/cm}$  and 327.00-907.70  $\mu\text{s/cm}$  in the pre-monsoon and post-monsoon season, respectively. Water temperature ranges 24-34  $^\circ\text{C}$  in the pre-monsoon season and 26-34  $^\circ\text{C}$  in the post-monsoon season. The calculated  $WQI$  values of each station are  $<50$  during the post-monsoon season, and during the post-monsoon season  $WQI$  value for Burdwan station is 27.06 and for other stations, it is 50-100.

### 4. Conclusions

The result obtained from the analysis shows that most of the parameters are within limits prescribed by BIS, WHO, and CPCB for water used in drinking and other purposes. Considering eight parameters shown in Tables 3 and 4,  $WQI$  is calculated. It is found that during the post-monsoon season, the water quality of all the stations falls in the category of excellent, and during the pre-monsoon season, the water quality of most of the stations is good. The reason for improved water quality during the post-monsoon season compared to the pre-monsoon season may be due to the recharge of groundwater during monsoon rainfall. It can be concluded that the water is suitable for drinking. But if we consider Lead and fecal coliform, then during the pre-monsoon season, water at Durgapur town, IISCO, and Burdwan University are not suitable for drinking, and during post-monsoon season water at Burdwan station is not suitable for drinking. The water can be used for washing, bathing, irrigation, and propagation of wildlife and fisheries purpose.

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**Disclaimer :** The contents and views expressed in this research work are the authors' views and do not necessarily reflect the views of the organization they belong to.

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