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WATER QUALITY INDEX AND INTER-PARAMETER CORRELATION OF GROUNDWATER IN NEW BARRACKPORE MUNICIPALITY OF WEST BENGAL

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ABSTRACT

This presented work has been carried out to know the impression of some water quality parameters on underground water of the New-Barracpore municipality and for the systematic and comprehensive assessment of overall eminence of water quality, Weighted Arithmetic Water Quality Index (WQI) method has been used by using the experimental values of different physico-chemical parameters. Box and Whisker plot has been drawn to know the distribution of summarised experimental data and Pearson's correlation matrix method was also used to know the corelation coefficients between different water quality parameters. For the attainment of this mission, eighteen water samples have been collected from various location of the municipality using the global positioning system (GPS) network. Using standard methods, experiments were carried out to explore the following water quality indicators: temperature(T), electrical conductivity (EC), pH, dissolved oxygen (D.O.), hardness (H), calcium ion (Ca^{2+}), magnesium ion (Mg^{2+}), and chloride ion (Cl^{-}). A in-depth study were made with experimental values and the standard accepted/permissible limits of different parameters prescribed by the Bureau of Indian Standards (BIS) and/or World Health Organisation (WHO). WQI concluded that the average quality of water under the municipality is fair.

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Keywords: New-Barracpore; WQI, Ground water, GPS, BIS, WHO.

1. INTRODUCTION

In scientific literature, it has been observed that “Water Quality” has been narrated in a large extent, may be due to reason that after air, the second most significant component for life is water[1] .So, such a essential constituent must be obtainable for all at a satisfactory level and attempt should be made to get safe, accessible and adequate amount of water [2]. Not only for human beings, water is also vital for the survival of plants, animals along with other living organisms [3]. On the basis of sources, water are divided in to two groups, ground water and surface water[4]. Water coming from both the sources may be polluted through natural and anthropogenic ways, though most of the ways are anthropogenic activities like domestically, agricultural, industry related activities [5] . Biological(e.g. bacteria, algae), chemical(e.g. pH, alkalinity, chloride, hardness, dissolved oxygen, toxic inorganic substances) and physical(e.g. temperature, electrical conductivity, colour, turbidity) parameters are the three parameters which indicate the quality of water [6].

For a particular area or source, quality of water are assessed through these parameters and if the values cross a particular limits then that water ot water area is consider as unsafe or harmful[7]. Presently, many scientists are continuously doing their research work on

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water quality measurement and a continual deterioration in the water quality is noticeable. Therefore, in order to consider of suitable water source, a single parameter named " Water quality Index (WQI)" has been described that has the capacity to reduce the balk information in to a simplified, logical single value. In the year 1965, initially WQI was developed by Horton based on some common water quality parameters [8] and after few years, based on individual weights of different parameters, Brown and his co-worker, developed a new WQI which was modified and similar to Horton index[9].Later on some modifications have been taken into account by several scientists [10,11].

All over the world, many researchers are using these WQI methods in order to describe water quality for common uses. Sunita Shresta et al. evaluated ground water quality of Kathmandu valley, Nepal for drinking purpose with the use of WQI method[12].Water quality of Noyyal river, a important river of Tamil Nadu, India was assessed with WQI and multivariate statistical technique by Abirami Subramanian and Sushmitha Baskar [13]. The water quality of the industrial area under Bhilai Steel Plant (BSP) was determined with emphasis on different water quality parameters like pH, total alkalinity, D.O., sulphate, chloride, hardness, magnesium, calcium, nitrate, etc. using the Water Quality Index method by Vinod Jena *et al.* [14]. By applying the weighted arithmetic Water Quality Index method, fourteen different physical and chemical water quality parameters were evaluated in the Paradeep area of Odisha, India, by Hementa Meher et al. [15]. The water suitability of Sagar Dighi, Koch Bihar, and different districts in the southern part of West Bengal were examined by water quality researchers with the help of WQI tools [16, 17]. The seasonal effect on water quality of some positions of the Hooghly River and some of its nearby locations was assessed with some common physico-chemical parameters and the Water Quality Index tool by Diptendu Datta and others[18]. Keeping in view the above mentioned precedent, we have decided to measure physico-chemical parameters of underground water in different wards under the New-Barracpore Municipality, a area covered by the Kolkata Metropolitan Development Authority (KMDA) and to assess the suitability of water quality to using arithmetic WQI method and the analysed were also compared with the standard value recommended by BIS and/or WHO [2,7].

2. EXPERIMENTAL METHODOLOGY

Study area:

New Barracpore Municipality area under the district of North 24 paraganas of the state of West Bengal is the study area which is incorporated with the Kolkata Metropolitan Development authority (KMDA). It is true that the number of tubewells is decreasing in order day by day, still a large number of people are using tubewells for multiple purposes. So we have decided to check the present status of tubewell water quality parameters. For this purpose, Water samples have been collected from eighteen (18) different positions of municipality. The sample collection

Table 1: General information about water samples with reference points.

Sl. No.	Sample ID	Collection Date and time	Co-ordinates			Elevation (meter)	
			Latitude	Longitude	HA	Altitude	EA
1.	G_1	15.05.23;12.03PM	22.685782°	88.446418°	4.76	32	0.12
2.	G_2	15.05.23; 12.32PM	22.685107°	88.444919°	4.16	30	0.10
3.	G_3	15.05.23; 12.53PM	22.683855°	88.446104°	5.23	31	0.13
4.	G_4	15.05.23; 1.25PM	22.682473°	88.451737°	3.90	33	0.10
5.	G_5	15.05.23; 2.22PM	22.682735°	88.441685°	5.14	31	0.13
6.	G_6	24.05.23; 11.52AM	22.678391°	88.435776°	4.53	29	0.11
7.	G_7	24.05.23; 12.12PM	22.686334°	88.440881°	3.90	30	0.10
8.	G_8	24.05.23; 12.26PM	22.6849°	88.442409°	5.03	29	0.13
9.	G_9	24.05.23; 12.48PM	22.684813°	88.442389°	5.07	33	0.13
10.	G_{10}	24.05.23; 1.12PM	22.690385°	88.446587°	4.10	33	0.10
11.	G_{11}	24.05.23; 1.34PM	22.689342°	88.440192°	3.60	33	0.09
12.	G_{12}	24.05.23; 1.50PM	22.692925°	88.439317°	3.90	31	0.10

points are Bhattacharya para , Agapur, Ward-03(G_1); Bhattacharya para , Chandrapally,Ward-13(G_2); Dinabandhu Mitra road,Ward-16(G_3); Sukanta sarani,Ward-15(G_4); School road,Ward-17(G_5); Kodalia,Ward-20(G_6); Satin Sen nagar,Ward-11(G_7); Sarat Chatterjee road,Ward-12(G_8); Surya Sen road,Ward-04(G_9); Ward-05(G_{10}), JC Bose road,Ward-08(G_{11}); Ward-06(G_{12}); South kodalia,Ward-18(G_{13}); Kali bari road,Ward-02(G_{14}); Ward-01(G_{15}); Kazi Nazrul Islam sarani,Ward-07(G_{16}); Ward-9(G_{17}) and Navapalli,Ward-10(G_{18}).General geographical information of reference point i.e water sample collection point are given in Table.1 and Figure.1.

13.	G_{13}	1.06.23; 11.51AM	22.67636°	88.438265°	5.74	29	0.14
14.	G_{14}	1.06.23; 12.24PM	22.686801°	88.4478°	7.13	29	0.20
15.	G_{15}	1.06.23; 12.43PM	22.690265°	88.450758°	3.36	29	0.08
16.	G_{16}	1.06.23; 1.08PM	22.692052°	88.437222°	5.24	30	0.13
17.	G_{17}	1.06.23; 1.18PM	22.689878°	88.434534°	4.60	31	0.11
18.	G_{18}	1.06.23; 1.52PM	22.689212°	88.43945°	3.95	33	0.10

EA- Elevation Accuracy; HA- Horizontal Accuracy

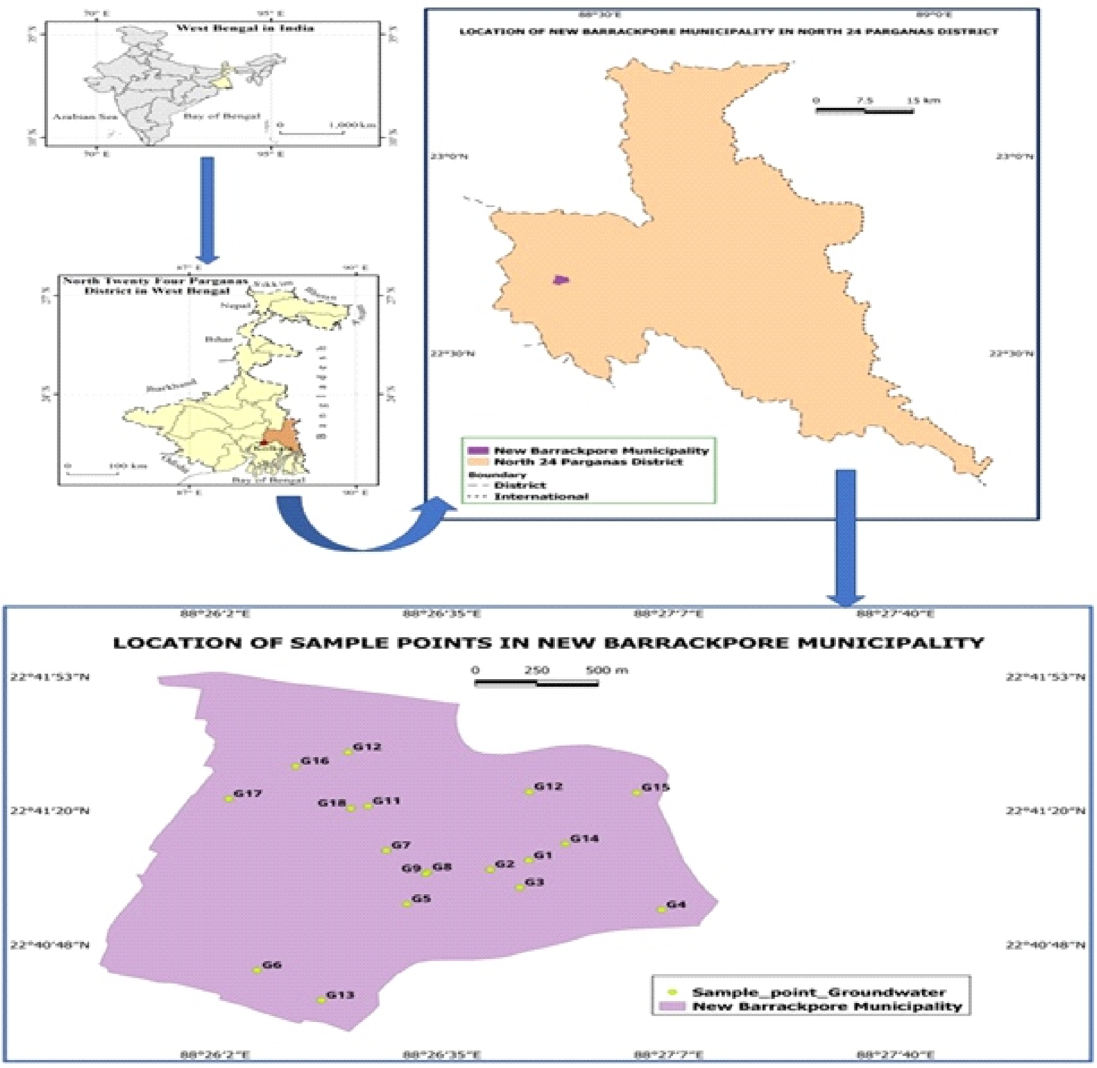

Fig. 1: Reference points for water samples are indicated within the geographical map of the study area, New-Barracpor Municipality.

Collection of water samples

Samples of water were collected from a tube well, used for washing hands and mouths, planting, bathing, or even drinking. GPS was used to identify the exact location of the water collection centre (Figure 2). All the samples were collected in clean polyethylene bottles or in glass bottles with a one-litre capacity. Every container was washed nicely with 5% HNO_3 solution and was rinsed with distilled water. The collected samples were covered with an airtight cap for smooth transport to the laboratory. Proper labelling was made to avoid any misidentification.

Fig. 2a: Sample no. G_{15} collection centre.

Fig. 2b.: Sample no. G_{14} collection centre.

Fig. 2c: Sample no. G_{16} collection centre.

Analytical Methods

An effort was made to check and estimate different physical and chemical parameters, namely temperature, electrical conductivity (EC), pH, dissolved oxygen (D.O.), total hardness, calcium ion (Ca^{2+}), magnesium ion (Mg2+), and chloride ion (Cl^-). The chemical analysis was performed in the chemistry departmental laboratory of Mrinalini Datta Mahavidyapith, Birati, Klokata. The temperature of water and the atmospheric temperature were measured using a glass thermometer with a range from 0 °C to 100 °C. Conductivity and pH were measured by taking 50 ml of water into a biker and placing electrodes for electrical conductivity and pH separately using the digital conductivity metre 611 and the digital pH metre 112 made by Electronics India. The estimation of chloride ions in water samples was carried out following the argentometric titration method using potassium chromate (KCrO4) solution as an indicator [19]. Hardness, calcium ion (Ca2+), and magnesium ion (Mg2+) content in water samples were determined by the EDTA titrimetric method by using Eriochrome-Black-T, methyl red, and Patton-Reeder's indicators [20]. Winkler's method was followed to determine the dissolved oxygen of the samples; starch solution was used as an indicator [19].

Weighted arithmetic Water Quality Index:

The Weighted Arithmetic Water Quality Index (WQI) method is an efficacious and straight-forward method to introduce information about water quality in an excellent way. It is a compilation of a number of different parameters that can be used to describe the overall quality. It is also a measure of the admissibility of water for human consumption that considers the associated effects of different water quality parameters [21]. In this work, the WQI was calculated using the weighted arithmetic water quality index method that was originated by Horton (1965) [8] and modified by Brown et al. (1972) [9] with the following equation:

$$WQI = \sum QnWn / \sum Wn \quad \text{............................ (1)}$$

Where, Qn = Quality rating of n^{th} water quality parameter and Wn = Unit weight of n^{th} water quality parameter.

Further, according to Brown et al the quality rating scale for any individual parameter is calculated usin the expression as given in equation:

$$Qn = \{(Vn-Vi)/(Sn-Vi)\} x100 \quad \text{............... (2)}$$

Where Vn is the actual estimated or experimental value of a water quality parameter. Sn is the standard recommended permissible value of a water quality parameter that can be obtained from the standard table. Vi is the ideal value of the water quality parameter. All the ideal values (Vi) are taken as zero except pH and dissolved oxygen [22]. For pH, the ideal value is 7.0, and for dissolved oxygen, the ideal value is 14.6 mg/l.

The unit weight for any water quality parameter is calculated based on recommended standard values using the expression given in the equation:

$$Wn = K/Sn \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

where Sn is the standard recommended value and K is the proportionality constant, which depends on the standard values of different water quality parameters and is calculated by using the expression given in the equation:

$$K = [1/(\sum 1/Sn = 12,3 \ldots\ldots n)] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Table 2: WQI and corresponding water quality status [8,23-25].

Sl. No	WQI	Status	Grade	Possible usages
1.	0 -25	Excellent	A	Drinking, Irrigation and Industrialisation
2.	26-50	Good	B	Domestic, Irrigation and Industrialisation
3.	51-75	Fair	C	Irrigation and Industrialisation
4.	76-100	Poor	D	Irrigation
5.	101-150	Very Poor	E	Restricted Irrigation
6.	> 150	Unfit for drinking	F	Need proper treatment before use

Karl Pearson's Coefficient of Correlation

The term "correlation" refers to a conjunction or link. So, through a correlation study, we may analyse the connection or interrelation of different parameters or variables. The widely used Pearson's coefficient of correlation, denoted by "r" is simply a mathematical method is used to calculate the degree of linear relationship among different variables and clearly states the direction and strength of the relationship. The mathematical formula for Karl Pearson's coefficient of correlation is expressed as

$$r = \frac{n\sum XY - \sum X \sum Y}{\sqrt{[n\sum X^2 - (\sum X)^2][n\sum Y^2 - (\sum Y)^2]}} \quad \ldots\ldots\ldots\ldots (1)$$

, where "r" is the correlation coefficient, "n" is the total number of records or data for each variable, and X and Y are different variables. The "r" value is always within the range of +1 to -1, i.e., -1 ≤ r ≥ +1. The positive (+) value signifies the positive linear correlation, and the negative (-) value signifies the negative linear correlation, whereas the zero (0) value signifies no linear correlation among variables. The closer the value to 1, the stronger the relationship. As per the guidance that Evans (1996) suggested, we may use the various terminology for differentiating the range of absolute values of "r" as for '0.00 – 0.19' "very weak", '0.20 – 0.39' "weak", '0.40 – 0.59' "moderate", '0.60- 0.79' "strong" and for '0.80-1.00' "very strong".

Chemicals and glass goods

Groundwater samples were procured from different wards of the municipality. Ammonium hydroxide, ammonium chloride, Eriochrome-Black-T, ethylene diamine tetraacetic acid, manganous sulphate, orthophosphoric acid, potassium dichromate, potassium iodide, potassium nitrate, sodium azide, sodium thiosulphate, sodium hydroxide, sulfuric acid, starch, and zinc acetate were purchased from Loba Chemicals, Bombay, India. The essential glass apparatus like the burrate, pipette,dropper, conical flask, volumetric flask, measuring cylinder, BOD bottle, watch glass, and beaker made with Borosil glassware were used.

3. RESULTS AND DISCUSSION

Scattered data on physico-chemical water quality parameters of several selected groundwater reference points have been documented below in **Table 1,3** and **Table 4**. The results were analysed using BIS/WHO as reference guidelines. The standard data as per the Bureau of Indian Standards (BIS) has been given in the **Table 5**.

Table 3: Some physical parameters of the underground water samples.

Sl. No.	Sample ID	Colour	Odour	Electrical Conductivity		Temperature (oC)	
				(μS/cm)	in ppm unit	Water	Air
1.	G1	Colourless	Odourless	0.471	301	28	33
2.	G2	Colourless	Odourless	0.690	442	31	34
3.	G3	Colourless	Odourless	0.505	323	26	34
4.	G4	Colourless	Odourless	0.642	411	26	35
5.	G5	Colourless	Odourless	0.646	413	28	37
6.	G6	Colourless	Odourless	0.594	380	26	29
7.	G7	Colourless	Odourless	0.663	424	27	30
8.	G8	Colourless	Odourless	0.609	390	27	31
9.	G9	Colourless	Odourless	0.544	348	29	32
10.	G10	Colourless	Odourless	0.570	365	27	32
11.	G11	Colourless	Odourless	0.564	361	26	33
12.	G12	Colourless	Odourless	0.561	359	26	34
13.	G13	Colourless	Odourless	0.635	406	26	37
14.	G14	Colourless	Odourless	0.545	349	27	37
15.	G15	Colourless	Odourless	0.537	344	28	38
16.	G16	Colourless	Odourless	0.758	485	26	38
17.	G17	Colourless	Odourless	1.090	697	29	38
18.	G18	Colourless	Odourless	0.744	476	26	38

Table 4: Chemical parameters of underground water samples of different position.

Sl. No.	Sample ID	pH	DO (mg/L)	Hardness (ppm)	Calcium (ppm)	Magnesium (ppm)	Chloride (mg/L)
1.	G1	7.30	6.98	291.06	81.16	21.41	35.50
2.	G2	7.10	6.04	390.85	93.80	37.99	42.60
3.	G3	7.35	5.93	324.32	87.15	25.86	35.50
4.	G4	7.06	6.82	465.69	121.74	39.20	71.00
5.	G5	7.15	6.91	357.58	96.46	28.29	49.70
6.	G6	7.30	5.06	339.29	103.11	19.80	58.22
7.	G7	7.23	5.97	375.88	98.46	31.52	63.90
8.	G8	7.20	5.87	334.30	93.13	24.65	45.44
9.	G9	7.11	6.98	365.90	97.79	29.50	46.15
10.	G10	7.12	7.01	365.90	101.12	27.48	52.54
11.	G11	7.15	7.80	382.53	98.46	33.14	51.12
12.	G12	7.13	7.07	357.58	93.13	30.31	58.93
13.	G13	7.10	7.20	327.65	93.13	23.03	71.71

14.	G14	7.36	7.95	320.99	87.81	24.65	41.89
15.	G15	7.58	7.99	322.66	86.48	25.86	37.63
16.	G16	7.53	8.41	400.83	103.78	34.35	115.02
17.	G17	7.61	7.63	487.31	129.06	40.01	261.28
18.	G18	7.66	6.98	370.89	101.78	28.29	92.30

The collected water samples are clear and colourless, with no objectionable odour. In this work, the experimental temperatures are range from 26 °C to 31 °C. 15 °C is the acceptable limit as prescribed by the WHO for water temperature for drinking purposes, but it is better to keep water at 25 °C for 30 minutes before drinking. Due to the high temperature of water, the growth of microorganisms may be increased, which may enhance many troubles connected to taste, odour, colour, etc.

Table 5: Water quality parameter table as per BIS 10500:2012.

Parameters	Temp* (^{0}C)	pH	EC** (µS/cm)	DO mg/L	HA (ppm)	Ca^{2+} (ppm)	Mg^{2+} (ppm)	Cl^- mg/L
Acceptable limit	15	6.5-8.5	200	3.0	200	75	30	200
Permissible	-	NR	1000	5.0	600	200	100	1000

*Prescribed by WHO**as per BIS2009, NR- No relaxation, HA-hardness

The electrical conductivity of all the samples except G_{17} (Ward-9:1.09 S/cm) fulfil the minimum and maximum permissible limits (0.2 S/cm to 1.0 S/cm) (Table 3) of drinking water guidelines. The normal range of pH in groundwater systems as per BIS is 6.5 to 8.5, and our experimental results (Table 4,5 and Figure 3) of the study area are within the range of 7.06 (G_4: Sukanta sarani,Ward-15) to 7.58 (G_{18}: Navapalli, Ward 10), i.e., a general trend towards weakly alkaline in nature.

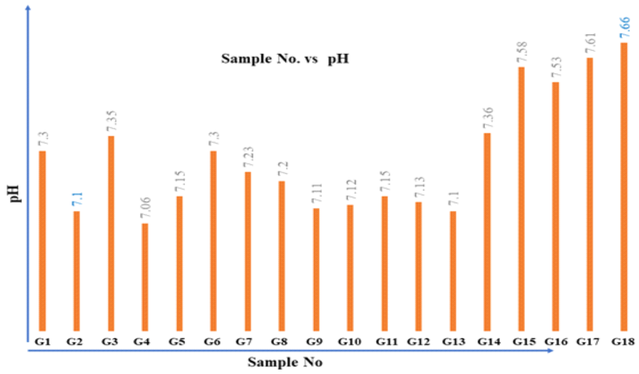

Fig. 3: Comparative study in pH of collected water samples.

The required limit of hardness in drinking water is 200 ppm, whereas in the absence of an alternative source, the permissible limit is 600 ppm. Results show (Table.4 and Figure.4) that the hardness ranges from 291.06 ppm (G_1: Bhattacharya Para, Agapur, Ward-03) to 487.31 ppm (G_{17}: Ward-9), which are much lower than those at which poisonous properties may occur. No health-based guiding principle is anticipated by WHO, but it occurs with the formation of soap scum, cloud-like stains, clogged pipes, faded and brittle laundry, corrosion, and deteriorated appliances.

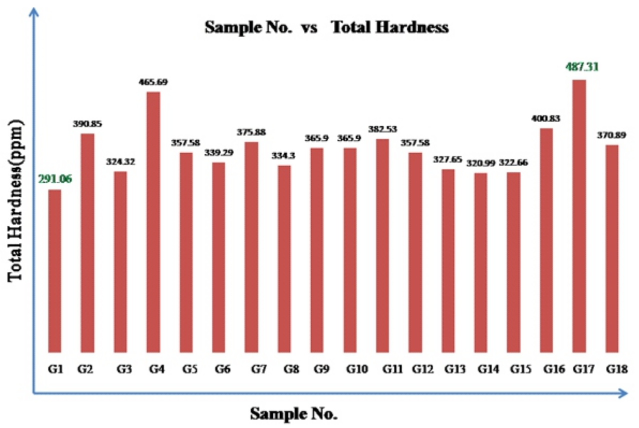

Fig. 4: Comparative study in Hardness of collected samples.

Experimental results with a lowest value of 81.16 ppm (G_1: Bhattacharya Para, Agapur, Ward-03) to a height value of 129.06 ppm (G_{17}: Ward-9) of calcium ion (Table 4, Figure 5) are within the range (75 ppm–200 ppm) of limits framed by BIS. The results of magnesium ion is not similar to hardness and calcium ion. Where the normal accepted range of calcium ion is from 30 ppm to 100 ppm, but the experimental results are in the range of 19.80 ppm to 40.01 ppm, which is in general the lower range of the normal limit. Even more than 61% of samples show magnesium levels lower than 30 ppm (Table 4, Figure 5). It may also be observed that in each sample, the concentration of magnesium ion is much lower than that of calcium ion. The BIS guideline prescribes the acceptable and permissible limits of chloride ion in drinking water to be 200 mg/L to 1000 mg/L (Table 5), and as per the WHO guideline, no health-based guideline value is proposed for chloride in drinking water. However, chloride concentrations in excess of about 250 mg/litre can give rise to a detectable taste in water. The ranges of our experimental results are from 35.50 mg/L to 261.28 mg/L (Table 4, Figure 6), i.e., in most cases chloride occurs well below that of those at threshold values.

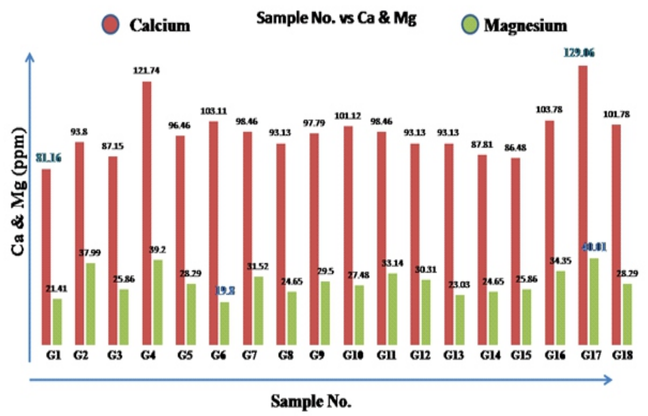

Fig. 5: Comparative study in Calcium and Magnesium collected Samples.

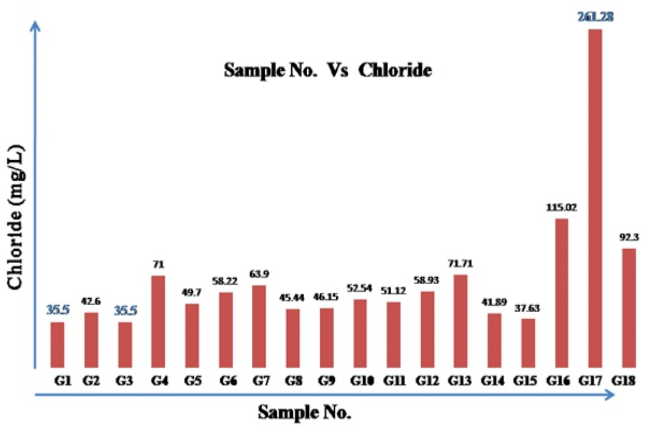

Fig. 6: Comparative study in Chloride ion in the collected samples.

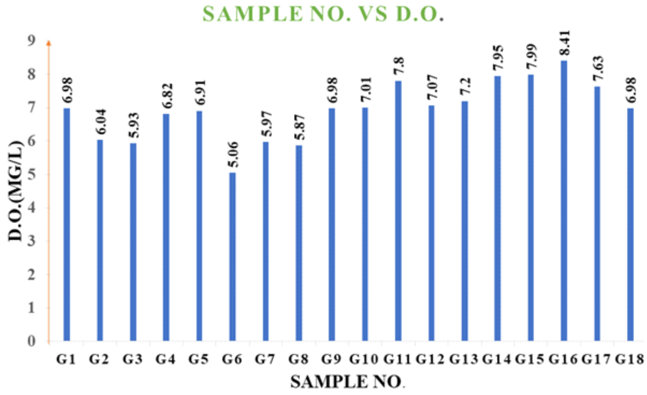

Fig. 7: Comparative study in dissolved oxygen (D.O.) ion in the collected samples.

The exceptionally high value of chloride ion concentration is in sample no. S17, i.e., the water sample of Ward No. 9. In this study, the dissolved oxygen (D.O.) values ranged from 5.06 mg/L to 8.41 mg/L (Table 4 and Figure 7), whereas the BIS standard values are from 3.0 mg/L to 5 mg/L. So it may be revailed that the D.O. of water samples is much higher than the standard value prescribed by the Bureau of Indian Standards (BIS).

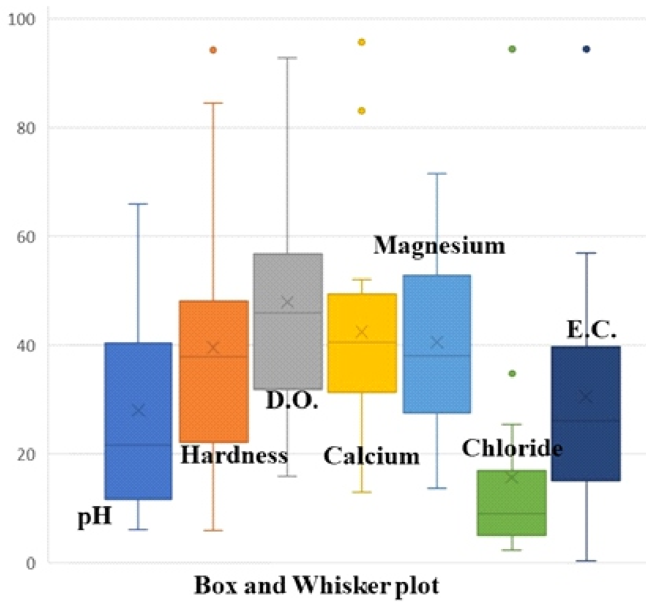

Fig. 8: Ox and Whisker plot of different water quality parameters.

The graphical representation of Box and Whisker plot for different datasets of experimental parameters is shown in figure (Figure 8) after standardization of resulting data in percentile and based on five number summery i.e. minimum, maximum, median, first and third quartiles.

We have calculated the water quality index (WQI) based on the experimental results of some selective physical and chemical water quality parameters. For this study, the WQI of different samples are ranges from 49.72577 to 65.10191(Table 6 and 7), which means the quantitative water qualities of different samples are ranges from good (grade B) to fair (Grade C) quality (Table 7). The average reading of WQI for the overall study area is 61.668, i.e., under the classification of fair quality water, which is suitable for irrigation and industrial purposes but needs proper purification treatment for drinking and domestic purposes to avoid water-related diseases. A stacked line with markers figure for comparative of all samples has been also given in Figure 9. Comparative studies rvealed that sample no. G_{14} shows good quality water and all the others samples are under fair quality category for human uses and and must therefore be treated before use. The relative descending order of WQI of several sample sites follows $G_{17} > G_{18} > G_6 > G_7 > G_2 > G_3 > G_8 > G_4 > G_9 > G_1 > G_5 > G_{15} > G_{10} > G_{11} > G_{16} > G_{12} > G_{13} > G_{14}$.

Table 6: Table for Water Quality Index (WQI) assessment.

Sl. No.	Parameters	Average Experimental values (Va)	Standard Values (Vs)	Recomm-ended by	Unit weight (Wi)	Quality rating (Qi)	(WiQi)
1.	Conductivity	399.11±71.78	200	BIS:2009	0.0132	199.56	2.6342
2.	pH	7.28±0.20	6.5-8.5	BIS:2012	0.3106	18.67	5.7987
3.	Dissolved oxygen	6.92±0.88	5	BIS:2009	0.5280	70.10	37.013
4.	Hardness	329.06±44.44	200	BIS:2012	0.0132	164.53	2.1718
5.	Calcium	93.33±11.16	75	BIS:2012	0.0352	124.44	4.3803
6.	Magnesium	29.19±5.93	30	BIS:2012	0.0880	97.30	8.5624
7.	Chloride	68.36±52.35	250	BIS:2012	0.0106	27.34	1.0275
					ΣWi=0.9987	ΣQiWi =61.588	
		K=2.6433;		WQI= ΣQiWi /ΣWi=61.668			

Table 7: Water Quality Index (WQI) for all samples.

Sample No	WQI	Grade	Status	Sample No	WQI	Grade	Status
G1	54.73446	C	Fair Quality	G10	53.58398	C	Fair Quality
G2	61.88294	C	Fair Quality	G11	53.54885	C	Fair Quality
G3	60.75232	C	Fair Quality	G12	53.17017	C	Fair Quality
G4	59.9228	C	Fair Quality	G13	50.44232	C	Fair Quality
G5	54.28133	C	Fair Quality	G14	49.72577	B	Good Quality
G6	65.10191	C	Fair Quality	G15	53.97513	C	Fair Quality
G7	62.76763	C	Fair Quality	G16	53.31535	C	Fair Quality
G8	60.00187	C	Fair Quality	G17	73.84657	C	Fair Quality
G9	55.08813	C	Fair Quality	G18	67.91969	C	Fair Quality

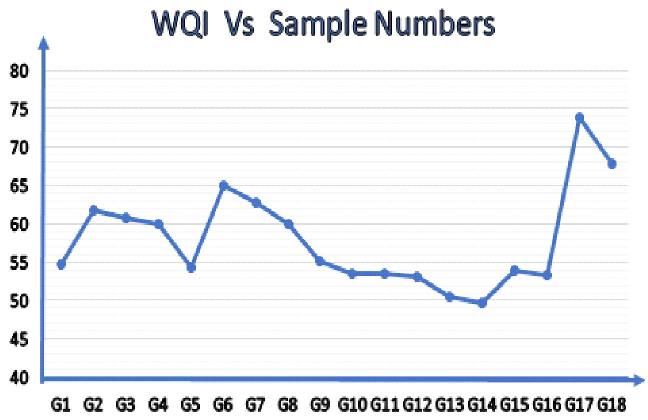

Fig. 9: Stacked lines with markers of all WQI.

The table (Table 8) for the correlation matrix shows a very strong positive correlation of calcium and magnesium with hardness, and hardness also shows a strong correlation with chloride. Electrical conductivity (E.C.) shows a very strong positive correlation with chloride and also shows a strong correlation with calcium, magnesium, and hardness. The inorganic ion calcium shows a strong positive correlation with magnesium and chloride. In this study, dissolved oxygen (D.O) has a strong positive correlation with calcium ion. No significant negative correlation is found among the parameters except for a very weak correlation of pH with magnesium ions (Table 8).

Table 8: Pearson's correlation matrix of water quality parameters

Parameters	E.C	pH	D.O.	Hardness	Calcium	Magnesium	Chloride
E.C.	1						
pH	0.4492	1					
D.O.	0.1834	0.3530	1				
Hardness	0.7731*	0.0720	0.1723	1			
Calcium	0.7793*	0.1293	0.0737	0.9332**	1		
Magnesium	0.6277*	-.0090	0.2600	0.9019**	0.6869*	1	
Chloride	0.9382**	0.5044	0.2946	0.7259*	0.7777*	0.5342	1

** very strong; * strong

Pearson's corelation matrix calculations (Table 8) reveal that electrical conductance has a positive as well as very strong corelation with chloride and also a strong relationship with calcium and magnesium ions. Similarly, the hardness parameter shows a very strong positive correlation with calcium and magnesium ions and also shows a strong correlation with the chloride ion. The correlation matrix also suggests that a strong positive correlation has also been presented between chloride ions, magnesium ions, with calcium ions. No significant negative corelation is presented by matrix calculations except for a very weak corelation among pH and magnesium ions.

4. CONCLUSION

The aim of this project was to measure the physico-chemical parameters of the water quality in the New Barracpore municipality area. All the parameters are not within the range of standard values approved by BIS and WHO. The average values of pH, electrical conductivity, total hardness, calcium, magnesium, and chloride are 7.28, 0.631×10-3 S/cm, 329.06 ppm, 93.33 ppm, 29.19 ppm, and 68.36 mg/L, which are all within the normal range of the standard, while the average value of dissolved oxygen (D.O.) is 7.87 mg/L, which is higher than the normal value of the standard value. The sample no. G17 is remarkable because it shows higher values for most of the parameters. WQI suggests that the water quality of sample no. G_{14} is comparatively good to use for domestic purposes, and other samples need proper treatment before being used for domestic or drinking purposes. Pearson's correlation matrix expresses that a very strong positive correlation is observed for E.C. and chloride, as well as for hardness towards calcium and magnesium ions.

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7. CONFLICT OF INTEREST

The authors announce there is no conflict.

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