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ORIGINAL ARTICLE

ASSESSMENT OF WATER QUALITY OF BHAGIRATHI RIVER AT LOWER GANGETIC PLAIN OF BERHAMPORE, WEST BENGAL, INDIA

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ABSTRACT

Bhagirathi River is one of the major fluvial water sources in Berhampore, Murshidabad, West Bengal, India. Due to increasing population and the untreated discharge released into the water body through different anthropogenic activities makes it polluted day by day. This changes the physico-chemical parameters of the water and makes it unhealthy for human use. Due to growing pollution in the Bhagirathi River of Berhampore, there is a change in the water quality which has been observed by analyzing the various physico-chemical parameters like Dissolved oxygen, Chemical Oxygen Demand, Alkalinity, Chlorinity, Salinity, pH, free carbon dioxide, Total Dissolved Solids and Conductivity. When the water sample of Bhagirathi River was compared with the Municipality water sample of Berhampore, a difference among these parameters were observed. Berhampore Municipality uses the Bhagirathi River water, treats them to reduce the amount of pollution and supply for the domestic and commercial uses. Observing the various aforementioned parameters tested from these two-water samples showed that the Bhagirathi River water is much more polluted and is not potable instead harmful for living organisms. On the contrary, water sample of Berhampore Municipality which is actually treated, purified and then supplied as drinking water have normal potable physico-chemical characters.

Key words: Bhagirathi River, anthropogenic activities, water pollution, physico-chemical parameters, potable.

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INTRODUCTION

Water is the most important abiotic factor which is required for supporting life ranging from microorganisms, plants, animals and humans. Water is also essential for maintaining the ecological balance by the hydrological cycle. Water is most essential element used in variety of purposes like food production, pharmaceutical industry, and for other special purposes (World Health Organization, 2002). Most of the water found on the surface of earth is saline found in the oceans and seas. Much less amount is the freshwater, which is found flowing through the rivers, streams and occur as groundwater. Fresh water is the vital source of water for drinking and sustaining the life of various organisms. Concern over the number of contaminants in drinking water has long been a divisive issue on a global scale (Bashir, Ali & Bashir, 2012). Due to the ever-increasing population, there is a huge discharge of the waste materials in the water bodies and that is causing to water pollution. These pollutants are causing change in the water quality parameters. Numerous issues that lead to nitrogen enrichment in lakes have been examined. Longer growing seasons and changes in land use may result in increased fertiliser use, which could then leach into rivers, lakes, and watercourses, raising the danger of eutrophication and biodiversity loss. Numerous factors, including Biological Oxygen Demand (BOD), temperature, electrical conductivity, Total Dissolved Solids (TDS), Dissolved Oxygen (DO), and others, can be used to evaluate the quality of water (Bhateria & Jain, 2016). The river Ganga and its major tributaries, the Bhagirathi, Jalangi, and Bhairab, make up the majority of the river system in the Murshidabad district. Murshidabad district of West Bengal is in the south of Ganga River. The Ganga River's Bhagirathi branch originates at Nurpur, 25 kilometers below Farakka, and flows southward after leaving the area just to the north of Plassey. The triangle-shaped district has been split in half by the Bhagirathi River, creating two distinct geographic areas that are nearly equal in size, with radically different geologies, habitation patterns, and even religious practices. The district east of the Bhagirathi has drainage lines that are rather irregular because the main rivers do not always flow in this direction, contrary to the district's general inclination, which is from north-west to south-east (Panda & Bandyopadhyay, 2011). Bhagirathi river is the major source of freshwater for the people of Murshidabad district Bhagirathi River system endows many drainages channel flowing over the entire district and it brings much of alluvial soil, silt which makes the district much more fertile and many crops can be produced for this (Mukherjee, 2022). The river water is being polluted every day due to the anthropogenic causes. Due to the rapid growth of population and uncontrol dumping of the sewage into the river Bhagirathi, the pollution is being increased and the water quality degrades which turns out to be harmful for human utilization and for the survival of many aquatic flora and fauna. By the discharge of different waste products into the Bhagirathi River, change in the water quality occur and by analyzing the water quality (WQ) parameters it can be determined the change in the quality of the water (Kumar, Sharma & Taxak, 2017). By analyzing the water quality based on certain parameters like the amount of dissolved CO_2, Alkalinity, Chlorinity and Salinity, pH of the water and color of the water sample and the amount dissolved oxygen and COD in the water helps us to give an insight upon the water quality and the assessment helps in analyzing how pollution have degraded water quality of the river Bhagirathi flowing through the Berhampore block of Murshidabad district. The dynamics of the Bhagirathi River in Murshidabad district have changed over time and the water quality also have changed in due course of time (Mandal *et al*., 2018). There is a need for proper water treatment and some preventative measures to reduce water pollution and manage to offer safe drinking water because of the rise in population, agricultural practices, and industrialization. And there is great expectation in the Murshidabad districts for the PWS/WS plan, which is run by WBPHED, to provide clean drinking water door to door in rural regions (Khatun, 2017). It is viewed that residential, human, and industrial sources are the primary causes of Ganga River water contamination at Bhimgoda Barrage, Haridwar, India. The excessive turbidity and Total Solids (TS) levels in the River Ganga's water were to blame for its unsatisfactory water quality, which had a negative effect on recreation and tourism. This can be harmful to fish and other aquatic species because it decreases food sources, ruins breeding grounds, and interferes with gill function. To establish a strategy to manage the environmental risks caused by these factors and to restore the environmental security of the river Ganga, regular water quality monitoring and stringent law enforcement are desirable (Chakraborty *et al*., 2021). Water Quality Index (WQI) was analyzed from the Bhagirathi River, a tributary of the Ganga in India. It considers eleven parameters, including pH, electric conductivity, total dissolve solids, suspended solids, dissolve oxygen, biological oxygen demand, total alkalinity, total hardness, chloride, nitrate, and sulphate. The ability of water to carry an electric current is measured by its electrical conductivity. Temperature and the presence of dissolved ions or solids, which add to the water's total dissolved solids (TDS), are two of the many variables that affect it (Dewangan *et al*., 2023). TDS and Conductivity parameters are temperature dependent as the movement of ions depend upon temperature. There is a certain permissible limit for TDS and Conductivity which shows the potability of water.

The results indicate good water quality during winter, while poor in summer and rainy seasons. This information is useful for public use, pollution mitigation, and water quality management. (Pathak, Prasad & Pathak, 2015). The Bhagirathi River, a tributary of the Ganges, faces pollution from industrial activities. To assess water quality, samples were analyzed for heavy metals, including nickel, copper, lead, cadmium, chromium, iron, zinc, manganese, magnesium, and arsenic. Remote Sensing System and Geographic Information Systems were used for development planning (Arora *et al*., 2017).

Berhampore Municipality uses this Bhagirathi River water and purifies it for the household supply and also supply to the commercial areas. The study shows an estimation of the water quality of the water supplied by the Berhampore Municipality and water quality assessment in contrast to the Bhagirathi River before the purification process gives a comparative analysis of the degree of the pollution which is removed after the treatment. Thus, the comparative study provides the idea about how the water quality based on certain parameters which differs the untreated Bhagirathi River and the Municipality water supply. Thus, the physiochemical analysis of the water serves as the vital test for analyzing the water quality and the degree of pollution in the water.

Present investigations regarding the analysis of physio-chemical characteristics the water sample collected from the river Bhagirathi of Berhampore block and from the Berhampore municipality water is an exclusive novel work which is not carried out previously in this region.

The comparative analysis of the water sample gives us the idea about the degree of pollution in the river water of Bhagirathi in comparison to the water supplied by Berhampore municipality.

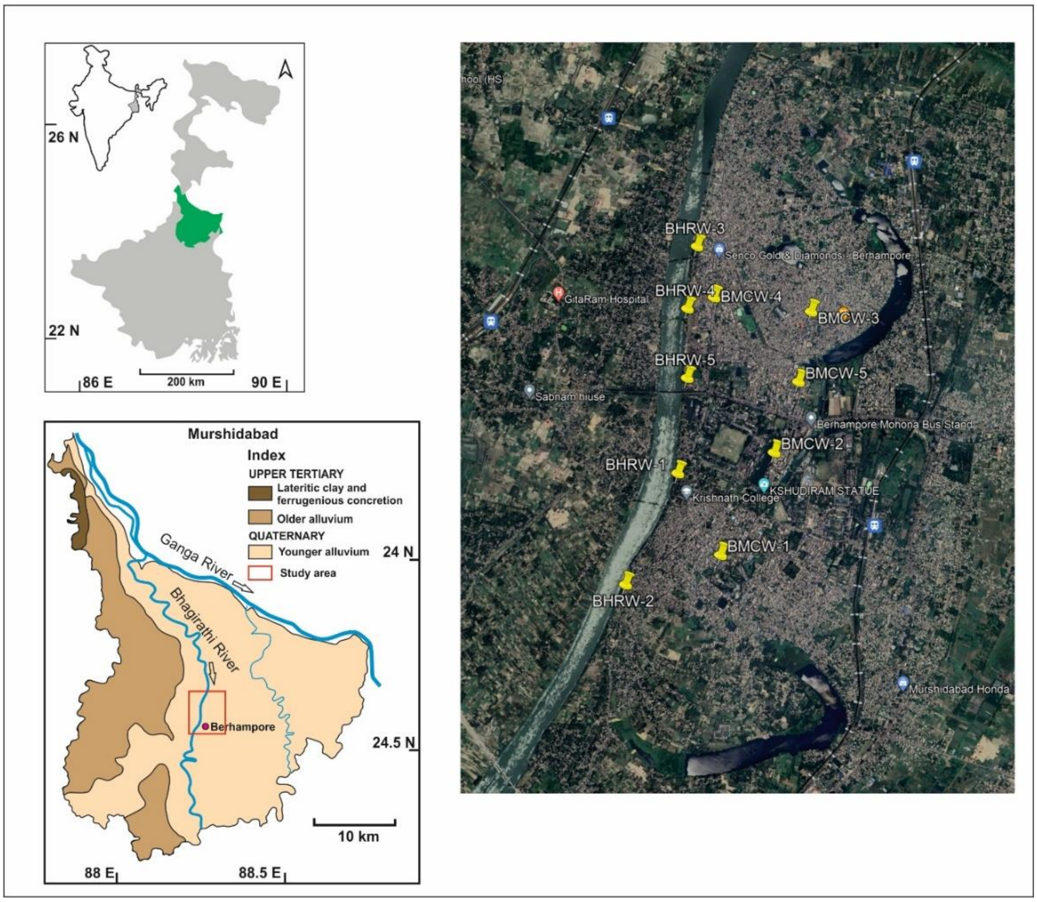

Figure 1. Map showing the water sampling locations from Bhagirathi River and Berhampore Municipal Corporation Outlets:

Bhagirathi River Water (BHRW): Region 1: Krishnath College Ghat (BHRW-1): 24° 05′ 32.19″ N; 88° 14′ 42.38″ E, Region 2: Binapani Ghat (BHRW-2): 24° 04′ 56.89″ N; 88° 14′ 26.04″ E, Region 3: Bhoirob Tola Ghat (BHRW-3): 24° 06′ 45.92″ N; 88° 14′ 45.85″ E, Region 4: Radhar Ghat (BHRW-4): 24° 06′ 25.35″ N; 88° 14′ 43.37″ E, Region 5: Kandi Bus Stand Market Ghat (BHRW-5): 24° 06′ 02.75″ N; 88° 14′ 44.26″ E.
Berhampore Municipal Corporation Water (BMCW): Region 1: Gorabazar Water Outlet (BMCW-1): 24° 05′ 06.74″ N; 88° 14′ 58.22″ E, Region 2: Laldighi Water Outlet (BMCW-2) - 24° 05′ 39.44″ N; 88° 15′ 15.52″ E, Region 3: Indrapastha Water Outlet (BMCW-3) - 24° 06′ 25.18″ N; 88° 15′ 26.88″ E, Region 4: Khagra Water Outlet (BMCW-4) - 24° 06′ 29.15″ N; 88° 14′ 52.55″ E, Region 5: Ranibagan Water Outlet (BMCW-5) - 24° 06′ 02.28″ N; 88° 15′ 23.21″ E.

MATERIALS AND METHODS

The water samples were collected from five different regions alongside the Bhagirathi River and five different regions of local Berhampore Municipal Corporation water outlets (Figure 1).

1. Test for Dissolve CO_2: 50 ml of each water sample is taken in a conical flask. 2-3 drops phenolphthalein indicator is added. If the samples turn Pink, there is no free CO_2 in the water. If the solutions remain colourless, it is treated against 0.02 (N) NaOH till the pink color appears (Singh, 2014).

2. Test for Dissolve O_2: Fill the water samples in a BOD bottle of known volume carefully, avoiding any kind of bubbling in the bottle after placing the stopper. Then pour 2 ml of $MnSO_4$ and alkali well below the surface from the walls of the bottle: a precipitate will appear. Then place the stopper and shake well by inverting the bottle repeatedly, allow the precipitate to settle. After that 1-2 ml of conc. H_2SO_4 is added and shake well to dissolve the precipitate. Then the whole content or a part is taken from the samples for titration. Titration is done with Sodium thiosulphate ($Na_2S_2O_3$) using starch as indicator. End point is initial dark blue color became colorless (Gorde & Jadav, 2013).

3. Test for Chlorinity & Salinity: It involves 3 stages viz- (i) Standardization of NaCl solution (0.025 N): 1.648 gm of dry weight of analytical grade of NaCl in 1000 ml of distilled water; Here 1 ml of the solution contains 1 mg of cl, (ii) Standardization of $AgNO_3$ solution: 10 ml of NaCl standard solution is taken in a conical flask. 0.5 ml of $KCrO_4$ is added to the solution and titrated with $AgNO_3$ until the appearance of a permanent red colored

solution. With this strength of $AgNO_3$ can be calculated. (iii) Cl^- estimation: 50 ml of water sample is taken in a conical flask and 0.5 ml of potassium chromate is added and titrated against $AgNO_3$ (Berenguen *et al.*, 2018).

4. Test for Alkalinity: Take 50 ml water samples in 250 ml conical flask and add 3 drops of phenolphthalein indicator. If the water turns Pink, titrate with 0.02 (N) H_2S0_4 solution until the pink colour disappears. Note the volume of acid used. Then add 2-3 drops of methyl orange indicator in the same conical flask. If the water turns yellow, then titrate it with same acid until faint-orange color (end point) is obtained. Note the total volume of acid used [15].

5. Test for COD: Water samples in triplicate along with distilled water are taken. 5ml each of $K_2Cr_2O_7$ is added to all the six flasks and keep them in boiling water bath (100°c) for one hour and then allow samples to cool. After that 5ml of KI in all 6 flasks are added followed by 10 ml of 2 (M) conc H_2SO_4. Then, titrate contents of each flask with 0.1 (M) Na_2SO_4 until yellow colour appears. Now I ml of starch solution to all six flasks the solution is added, and they turn blue in colour. Then Titrate with 0.1 (M) Sodium thiosulphate NaS_20_4; end Point blue colour disappear. Note down the burette reading, before and after titration and find out the volume of thiosulphate for each solution sample. 3 readings are taken and their mean for each sample are calculated. The volume of sodium thiosulphate used for each blank is also found out (Parambudy, Supriyatim & Setiawan, 2018).

6. Test for pH: pH meter is used for measurement of pH of the samples (Singh, 2014).

7. Test for TDS and Electrical conductivity: Conductivity meter is used for the measurement of conductivity of the water samples and TDS.

Table 1. Results of Different Parameter for Bhagirathi River Water and Berhampore Municipality Water supply

Parameters	Bhagirathi River Water			Municipality Water		
	Location	Values	Mean	Location	Values	Mean
Free CO_2 in water (in ppm)	BHRW-1	N.D	N.D (not detected)	BMCW-1	12.90	
	BHRW-2	N.D		BMCW-2	13.50	
	BHRW-3	N.D		BMCW-3	12.00	12.64
	BHRW-4	N.D		BMCW-4	11.50	
	BHRW-5	N.D		BMCW-5	13.30	
Dissolve Oxygen (in mg/l)	BHRW-1	9.5		BMCW-1	14	
	BHRW-2	8.3		BMCW-2	16	
	BHRW-3	9.73	8.3672	BMCW-3	15.5	15.40
	BHRW-4	7.306		BMCW-4	16.25	
	BHRW-5	7		BMCW-5	15.25	
Chlorinity (in ppm)	BHRW-1	79		BMCW-1	27.3	
	BHRW-2	77		BMCW-2	26	
	BHRW-3	76.5	78.81	BMCW-3	25.90	26.67
	BHRW-4	80.5		BMCW-4	28.15	
	BHRW-5	81.05		BMCW-5	26.00	
Salinity (in ppt)	BHRW-1	0.190		BMCW-1	0.0775	
	BHRW-2	0.180		BMCW-2	0.0785	
	BHRW-3	0.169	0.171	BMCW-3	0.07705	0.07741
	BHRW-4	0.158		BMCW-4	0.078	
	BHRW-5	0.158		BMCW-5	0.076	
Alkalinity (Carbonate Ions) (in ppm)	BHRW-1	23		BMCW-1	70	
	BHRW-2	20		BMCW-2	68	
	BHRW-3	19	21.6	BMCW-3	69.5	69.2
	BHRW-4	24		BMCW-4	69.25	
	BHRW-5	22		BMCW-5	69.25	
Alkalinity (Bicarbonate Ions) (in ppm)	BHRW-1	55		BMCW-1	140	
	BHRW-2	54.5		BMCW-2	142	
	BHRW-3	52.5	53.6	BMCW-3	138.5	139.4
	BHRW-4	50.55		BMCW-4	137.25	
	BHRW-5	55.45		BMCW-5	139.25	
Chemical Oxygen Demand (in mg/l)	BHRW-1	1200.60		BMCW-1	620.20	
	BHRW-2	1250.25		BMCW-2	615.50	
	BHRW-3	1220.75	1221.92	BMCW-3	619.25	618.25
	BHRW-4	1218		BMCW-4	620	
	BHRW-5	1220		BMCW-5	618.25	
pH	BHRW-1	7.80		BMCW-1	7.9	
	BHRW-2	7.90		BMCW-2	7.9	
	BHRW-3	7.80	7.83	BMCW-3	7.8	7.90
	BHRW-4	7.82		BMCW-4	8.0	
	BHRW-5	7.83		BMCW-5	7.9	

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RESULTS AND DISCUSSION

Different physio-chemical tests were carried out using the water samples collected from the Bhagirathi River situated at the lower Gangetic plane Berhampore town, Murshidabad district, West Bengal and Berhampore Municipal corporation outlet. The water quality assessment was done using different parameters for the assessment of water quality. The different parameters observed from these different water sample were free CO_2 in the water, dissolved O_2, COD in the water sample, Chlorinity, Salinity, Alkalinity (Carbonates and Bicarbonates) ion and pH of these water sample were analyzed from the respective zones and then the mean value were taken from each zone and are tabulated (Table 1).

Parameters	Bhagirathi River Water			Municipality Water		
	Location	Values	Mean	Location	Values	Mean
Total Dissolved Solids (TDS) (in ppt)	BHRW-1	0.489	0.4878	BMCW-1	0.363	0.3626
	BHRW-2	0.488		BMCW-2	0.364	
	BHRW-3	0.487		BMCW-3	0.360	
	BHRW-4	0.485		BMCW-4	0.361	
	BHRW-5	0.490		BMCW-5	0.365	
Conductivity (mS/cm)	BHRW-1	0.981	0.9816	BMCW-1	0.726	0.7232
	BHRW-2	0.980		BMCW-2	0.722	
	BHRW-3	0.983		BMCW-3	0.724	
	BHRW-4	0.979		BMCW-4	0.723	
	BHRW-5	0.985		BMCW-5	0.721	

Bhagirathi river water is slightly muddy in appearance; on the other hand, Berhampore municipality water looks dirt free (Figure 2).

Figure 2. Photograph showing the difference of color between the water samples collected from Bhagirathi River and Berhampore Municipal Corporation Outlet.

Free carbon dioxide interacts with pH and bicarbonate-carbonate equilibrium in addition to its involvement in photosynthesis. Additionally, it causes some vital nutrients to become soluble due to the production of carbonic acid. Higher concentrations of free CO_2 will have a negative impact on respiration and other physiological processes. While some subsurface fluids may have a concentration of free carbon dioxide higher than 10 ppm, surface water typically has a lower concentration. 12.64 ppm of free carbon dioxide is present in the municipality water sample used in our investigation. Testing was done to see if there was any free CO_2 in the river Bhagirathi water sample as well. When the phenolphthalein indicator was added, the sample immediately turned pink, indicating that it has a pH of greater than 8.3 because the indicator has an end point for this value. As a result, the water sample does not have a significant amount of free CO_2.

Fish, invertebrates, and all other aquatic organisms have access to a certain amount of oxygen in aquatic habitats. The majority of aquatic plants and animals need oxygen to survive; fish, for example, cannot persist in water with dissolved oxygen levels below 5 mg/L for very long. Low levels of dissolved oxygen in water are indicators of contamination and play a crucial role in defining the technique used to reduce pollution and improve water quality. According to our experiment, the Dissolved Oxygen (D. O.) for the Bhagirathi River is 8.37 mg/L, which is significantly lower than the D. O. for municipal water, which is 15.40 mg/L. (Figure 3). This suggests that the water in Bhagirathi is more contaminated.

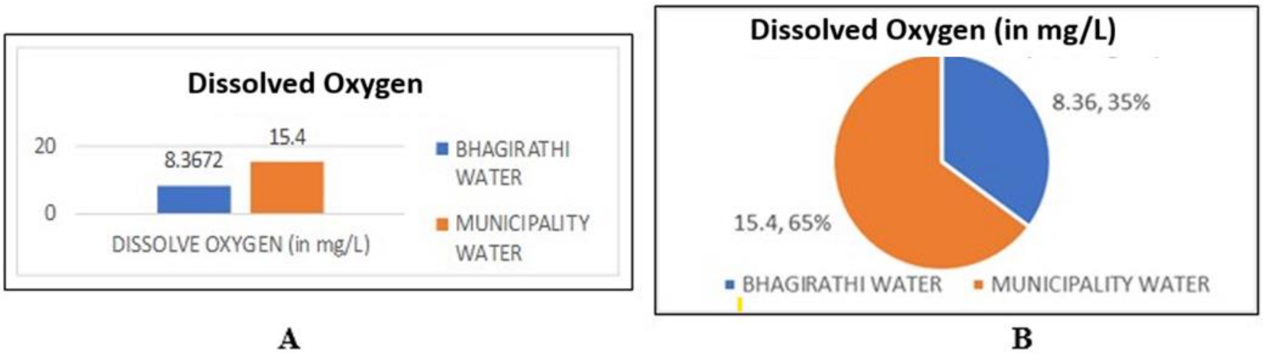
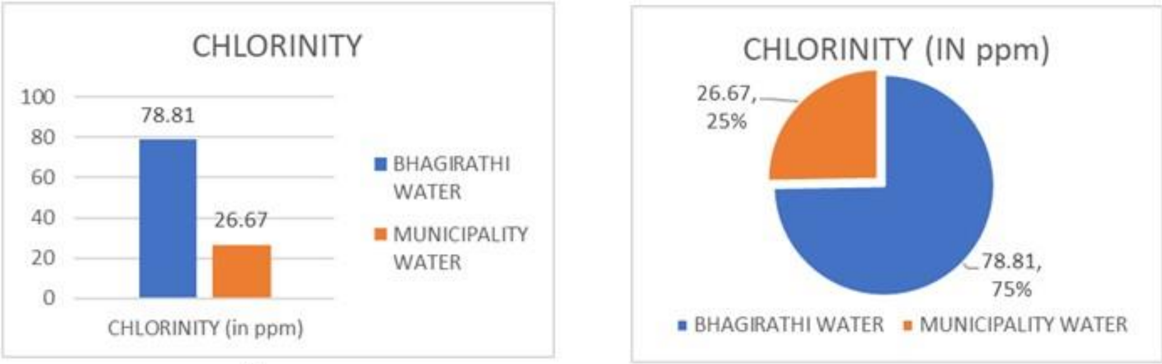


Figure 3. (A & B). Comparison of dissolved Oxygen between two water samples.

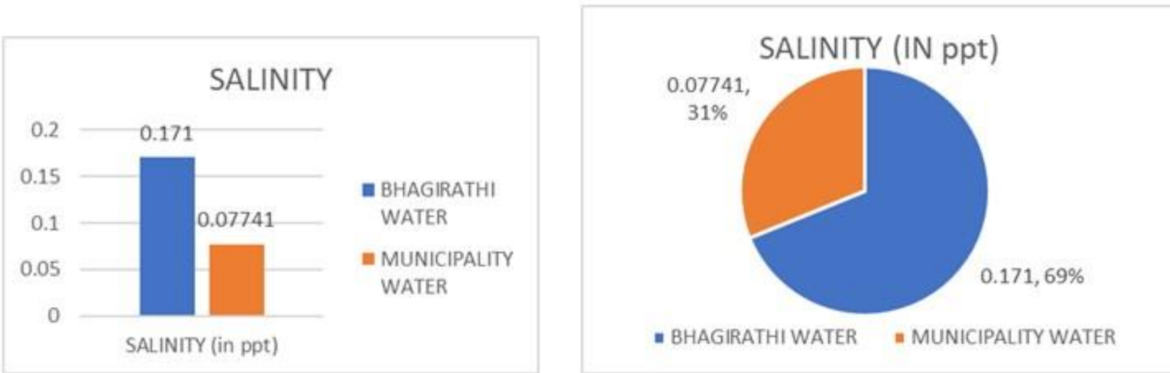
A naturally occurring element called chloride is present in most natural waterways. It is most frequently found as a component of salt (sodium chloride), though it can also occur alone or in conjunction with other elements like potassium or calcium. It fluctuates in fresh water between 1 and 100 ppm. High chloride levels can corrode metal fixtures and pipelines, give water a "salty" taste, and harm home appliances. So, water with less chlorine in it is safe to consume. Our research demonstrates that the water is both freshwater and that municipal water's chlorination level (26.67 ppm) is lower than that of the Bhagirathi River (78.81 ppm), making it safer to use for drinking and household tasks. (Figure 4).



A B

Figure 4 (A & B). Comparison of Chlorinity between two water samples.

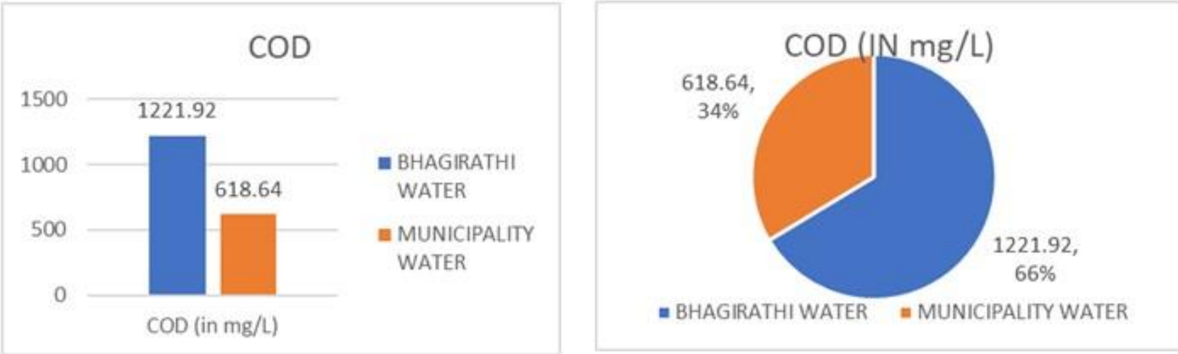
The amount of dissolved salt in a body of water is known as salinity. It makes a significant contribution to conductivity and influences many aspects of the chemistry of natural waters as well as the biological activities that take place there. It is often expressed in ppt. Salinity in fresh water is 0.5 ppt or less. Our test demonstrates that both waters are freshwater. Bhagirathi water is more salinized than municipal water. That demonstrates that municipal water is purer than water from the Bhagirathi River. (Figure 5).



A B

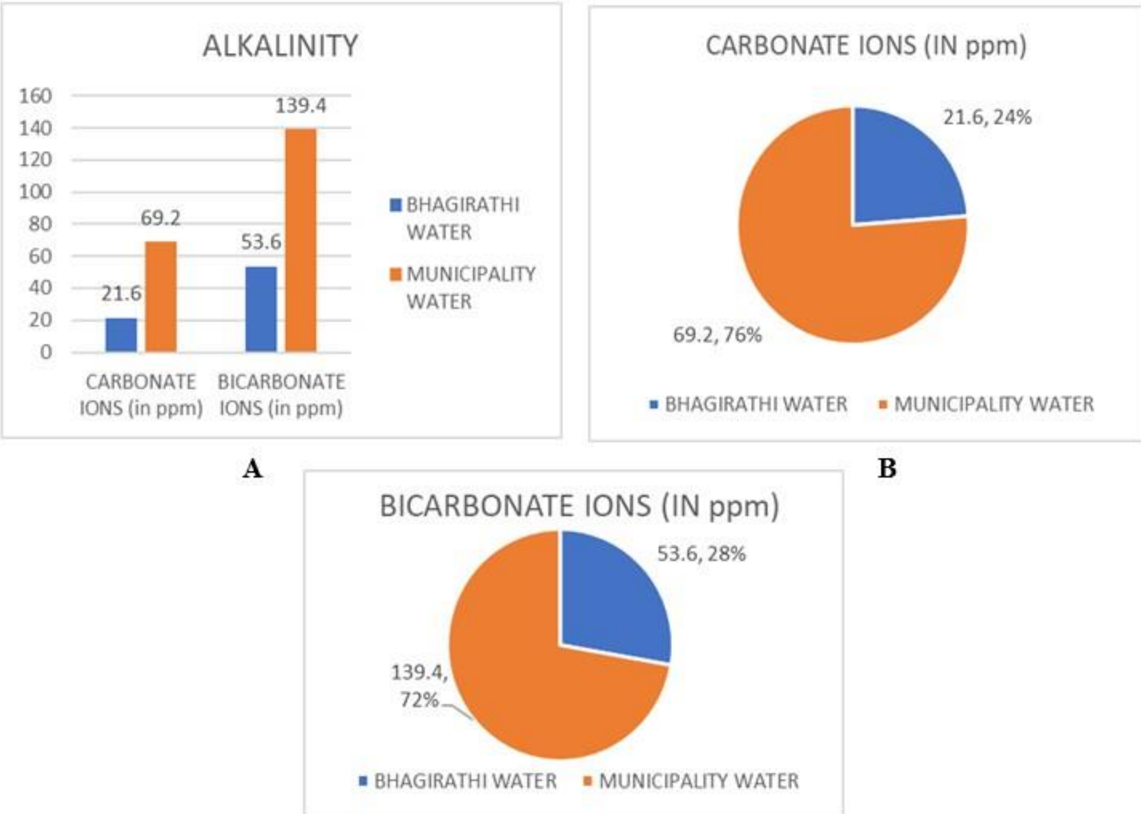
Figure 5 (A & B). Comparison of Salinity between two water samples.

A test called Chemical Oxygen Demand (COD) calculates how much oxygen is needed to chemically oxidize the organic matter and inorganic nutrients, like ammonia or nitrate, that are present in water. Higher COD values indicate that there is more oxidizable organic material present in the sample, which lowers the concentration of dissolved oxygen (DO). Less COD means more filtered water that may be used safely for drinking and household tasks. According to our research, municipal water is just about less than half as safe to use as water from the Bhagirathi River (Figure 6).



A B

Figure 6 (A & B). Comparison of COD between two water samples.



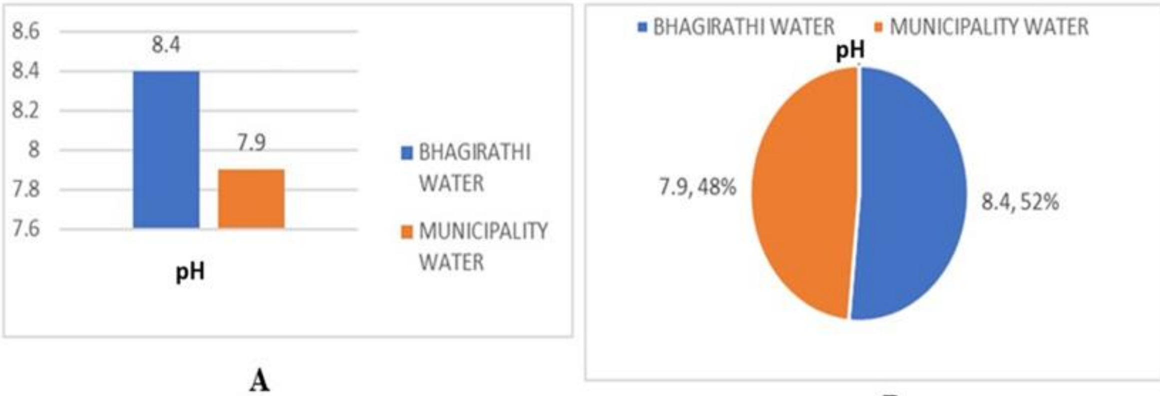
A B

C

Figure 7 (A, B & C). Comparison of alkalinity between two water samples.

A steady pH is maintained by water's alkalinity, which is a measure of its capacity to neutralize acids or fend off changes that make it acidic. Titration is used for assessing a water sample's alkalinity. Our research mainly performs carbonate and bicarbonate test to determine the alkalinity. In both the test municipality water found more alkaline than the water of Bhagirathi River. Municipality water was discovered to be purer than water from the Bhagirathi River. (Figure 7).

The amount of free hydrogen and hydroxyl ions in water is gauged by the pH scale. The pH can affect readily available nutrients, biological processes work, bacteria behavior, and chemicals behavior. In general, water with a pH more than 7 is thought to be acidic. The Environmental Protection Agency mandates that the pH of drinking water be frequently monitored and maintained between the ranges of 6.5 and 8.5, and 6 to 8.5 for groundwater systems. A pH of less than 7 indicates the possibility of the presence of iron, copper, lead, or zinc from plumbing and other metal fittings. The flavor will be abrasive and metallic. High alkaline water doesn't pose a health risk, but it does have aesthetic drawbacks. It becomes harmful when the pH levels reach or surpass 12.5 pH. It can be extremely dangerous when it concerns with human or environmental health, as in the case with all hazardous wastes. Our analysis indicates that the pH of municipal water is 7.90 and that of the Bhagirathi River is 8.4. (Figure 8).



A

B

Figure 8 (A & B). Comparison of pH between two water samples.

The conductivity of the water samples was determined by conductivity meter and Total Dissolved solids were also analyzed in the water sample. The TDS was measured in parts per thousand (ppt) and the conductivity was measured in mS/cm. The temperature at which the following observations were done is at 25°C. The cell constant of the equipment for measuring TDS and conductivity was 0.98. TDS ranged in the Bhagirathi River water sample in the range of 0.485 ppt to 0.489 ppt. TDS range in the Berhampore Municipal Water supply is in the range of 0.360 ppt to 0.365 ppt. TDS level below 0.300 ppt or 300 mg/l is considered safe for drinking. So, the TDS of Bhagirathi River water is not safe for drinking purpose because it is more than 0.485 ppt or 485 mg/l. TDS of Berhampore Municipality Water supply is within 0.365 ppt or 360 mg/l which is near the safe range for drinking purposes. The conductivity should lie within 0.800 mS/cm or 800 uS/cm for the proper drinking purposes. Bhagirathi River Water has a conductivity of 0.979 mS/cm to 0.985 mS/cm which is not most suitable for human drinking purposes. Municipality Water supply has a conductivity of 0.720 mS/cm to 0.726 mS/cm which lies within the limit of 0.800 mS/cm, making it potable for drinking purposes.

Therefore, while municipal water is acceptable for drinking purpose, Bhagirathi water is not potable for use due to high levels of pollutants that are present in them which enters the river system from the agricultural and domestic waste disposal.

CONCLUSION

It can be concluded that Bhagirathi River water is not potable for human consumption and indicates high pollution level in it. The Berhampore Municipality water i.e., the treated water of the Bhagirathi River has the physico-chemical values within the permissible limits and is safe for human consumption and household use.

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CONFLICTS OF INTEREST

Authors have no conflicts of interest.

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