How to Cite:
Tiwari, D., Yadav, M., Kumar, R., & Singh, S. K. (2022). The impact of organized bathing on Ganga basin water quality during KUMBH-2022 by spatial and temporal analysis. *International Journal of Health Sciences*, *6*(S3), 3672–3686. https://doi.org/10.53730/ijhs.v6nS3.6600

The impact of organized bathing on Ganga basin water quality during KUMBH-2022 by spatial and temporal analysis

Dipti Tiwari
Department Applied Sciences and Humanities RAMA University Kanpur-India

Monika Yadav
Department Applied Sciences and Humanities RAMA University Kanpur-India

Rajendra Kumar
Department Applied Sciences and Humanities RAMA University Kanpur-India

Santosh Kumar Singh
Department Mechanical Engineering United Institute of Technology Prayagraj-India

***Abstract*---**This current study explores the effect of mass bathing during the occasion of Kumbh in Prayagraj on Ganga Basin River water quality by Spatial and Temporal Analysis. Due to the nature of pollution entering the river during this event, the following 7 different sampling sites were selected Sobatiyabagh(s-1), Daraganj(s-2), Gaughat(s-3), Sangam(s-4), Arail Kachar(s-5), Arail Uphar(s-6), Chhatnag (s-7). Kumbh Mela was held from 14 Jan-2022 to 1st March-2022. Water samples were collected during the monthly intervals from December 2021-March-2022. The found values of different Physicochemical parameters like Ph, Electrical conductivity, Hardness, Dissolved Oxygen, BOD, etc., of samples were compared with permissible limits (According to WHO, BIS). The result concluded that except for BOD and hardness, all parameters are within permissible limits during Kumbh. But pre- and post-Kumbh samples results stated that chloride contents are also high in some places. However, it is clear in the present investigation that Ganga Basin water is not potable even when it is not used directly for other purposes.

***Keywords*---**water, spatial, temporal, physicochemical, Ganga basin.

Manuscript submitted: 27 Dec 2021, Manuscript revised: 09 March 2022, Accepted for publication: 18 April 2022

Introduction

Water is the basic building block of all living things. It's a one-of-a-kind resource in the world's vast array. The existence of life on Earth would not be possible without water. Many activities, including food production and manufacture, as well as energy generation, manufacturing, and production in the industrial sector, need drinking water (Narain and Narayanamoorthy, 2016) 'Potable water' is defined as water that has a pH of 6.5–8.5 and is devoid of germs, pathogens, and other pollutants. Despite the country's 16% population, India has only 4% of its land area covered by freshwater. The average yearly water supply for India's 1.2 billion residents is 1,170 cubic meters (NIH 2010). Though India has been fortunately endowed with enough freshwater to fulfil its population’s basic needs, increasing water contamination with numerous pollutants due to anthropogenic activities and continuous climate change has severely affected freshwater resources, both resources of quantity and quality (Giao et al., 2021). In addition to a broad variety of diseases and disorders, pollution may have an impact on physical, chemical, and/or biological health. There are several that have been recognized as carcinogenic, which indicates that they affect living organisms when taken through water and may potentially result in cancer (Kim et al., 2015). It has been shown that water pollution is responsible for approximately 80 per cent of the world's ailments, according to a WHO study released in 2013. In addition to harming human health, pollution in water affects the survival of other organisms and the economics of a country. The protection of human life and the preservation of the global economy have been the focus of several initiatives in recent years. The Bureau of Indian Standards (BIS) and WHO (Guidelines for drinking water quality) have created water quality standards that allow for safe water quality. To summarize, BIS and WHO standards go no further than table 1. Numerous water contaminants have been shown to have toxicological effects on people, as seen in table 1.

Water pollution is caused by two basic factors. Those sources that can be located and those that can't are two distinct categories. Pollution points include the release of wastewater effluent (from municipal and industrial sources) and storm sewer overflow. Non-point sources of pollution, such as those that come from a multitude of places but cannot be linked to a single source, may pollute both groundwater and surface water. Stormwater runoff from farms or urban trash cans is an excellent example of this Both Gupta and Singh (2017) Tanneries and chemical plants near river banks are very rare in many industrial areas, where untreated waste is poured into rivers and causes major pollution (Sinha et al, 2011) (Chaudhry and Sharma,2016) Industrial discharge is the primary source of water pollution. Pollutants are found in the reservoir depending on the kind of business.

All living organisms and the environment are affected by water pollution, which is a global issue and challenge. Urbanization, pollution caused by climate change, and other social and economic issues all contribute to water contamination via poor agricultural practices and the release of effluents from sewage treatment plants into rivers (Evans et al., 2019; Malki et al., 2017; Ondigo et al., 2018; Zeng et al., 2021). Kumbh Mela-2022's effect on river water quality is one of the themes considered in this research. Mass bathing is one of these traditional events when people get together to wash together in holy waters. In India, it is a long-standing custom to take a dip in one of the holy rivers on certain religious occasions. There has been a change in the environment due to human development toward the scientific age. Religious faith has not been harmed by this shift in focus, though. On certain days of the year, considerable groups still congregate along the banks of holy rivers to take holy baths. There are now dangerous pollution levels in rivers that used to carry clean water. People continue to practice traditional rituals despite a significant increase in visual, biological, and olfactory pollution. There is no way to stop the people, their traditions, or their religious convictions.

The most important Hindu festival is the Kumbh Mela (often called the Kumbh). In terms of religious gatherings, Kumbh is the largest in the world. Indians from all around the country come together to participate in a mass bath. It is possible that taking a bath will purify the soul, provide happiness, and speed up the process of reincarnation's end on certain favourable days. Every 12 years, a festival is organized to honour the four holy cities (Prayagraj, Haridwar, Ujjain and Nasik). Kumbh is held in one of these locations every three years since the event occurs every three years. Prayagraj, the confluence of the Ganga, Yamuna, and legendary Saraswati rivers, Haridwar, the Ganga, Ujjain, the Shipra, and Nasik Godawari rivers are all sites where the Kumbh is celebrated. Bathing in the Kumbh is timed according to the astronomical cycles of the sun and moon. All across the globe, a diverse group of pilgrims and individuals from all walks of life meet on this one day to bathe together as one. The Kumbh at Prayagraj, the world's biggest human gathering, is seen in the cover shot. Prayagraj attracts millions of visitors every year around the 14th of January to spend a month camping and swimming in the Sangam (Makar Sankranti). As far as the Hindu religion and manner of life are concerned, nothing compares to the influence that Holi has. There are a number of reasons why this study is focusing on water quality in Prayagraj's Ganga basin before and during the Kumbh Mela in 2019.

Table 1
BIS and WHO water quality standards and potential effects of various parameters on human health and the environment

Parameters	Permissible Limit		Potential Impact on Health and environment
	BIS (Permissible Limit)	WHO (Permissible Limit)	
pH	6.5–8.5	6.5–8.5	Affects mucous membrane, bitter taste, and corrosion
Turbidity(NTU)	1–5		A high level is associated with disease-causing bacteria
TDS (mg/l)	500–2,000	500–1,000	Undesirable taste, gastrointestinal irritation, corrosion, or incrustation
Total hardness (mg/l)	200–600	200–500	Poor lathering with soaps, deterioration of the quality of clothes, and

			scale forming
Dissolved oxygen (mg/l)	6		Corrode water lines, boiler, and heatexchangers
Chloride(mg/l)	250–1,000	200–300	Eye/nose irritation, stomach discomfort,increase corrosive character of water
Calcium (mg/l)	75/200	100–300	Vascular calcification included blood pressure, lipids, and lipoprotein level
Magnesium(mg/l)	30–100	-	Eczema in children
Biological oxygen Demand(BOD) (mg/l)	-	3.5mg/lt	The larger the carbon or organic content, the more oxygen is consumed. A high organic content means an increase in the growth of microorganisms which contribute to the depletion of oxygen in water bodies.
BOD	-	3.5mg/lit	The larger the carbon or organic content, the more oxygen is consumed. A high organic content means an increase in the growth of microorganisms which contribute to the depletion of oxygen in water bodies.
MPN/100 ml	–	10	Nausea, vomiting, and Diarrhea

Methodology

Prayagraj is an old and unique city in the state of Uttar Pradesh, India where two rivers, the Ganga and the Yamuna with invisible Saraswati have a confluence. In the present investigation, all the water samples would be collected from various regions of the river Ganga and the Yamuna located at Prayagraj, Uttar Pradesh, India. The water samples would be collected from the 7 different sites of Rivers Ganga and Yamuna from December 2021 to March 2022 with variations of monthly intervals. Sampling would be start viz. upstream of Prayagraj at Sobatiya bagh(Pryagraj up-Prj up *25.4457°N & 81.8631° E*), where Ganga enters in the city anddownstream at Chhatnaag (Prayagraj down- Prj dn 25 24 54 N & 81 54’38 leaves the city after the confluence with the river Yamuna) as shown in Figure 1

Map for Sampling site S-1,S-2,S-3,S-4,S-5,S-6,S-7

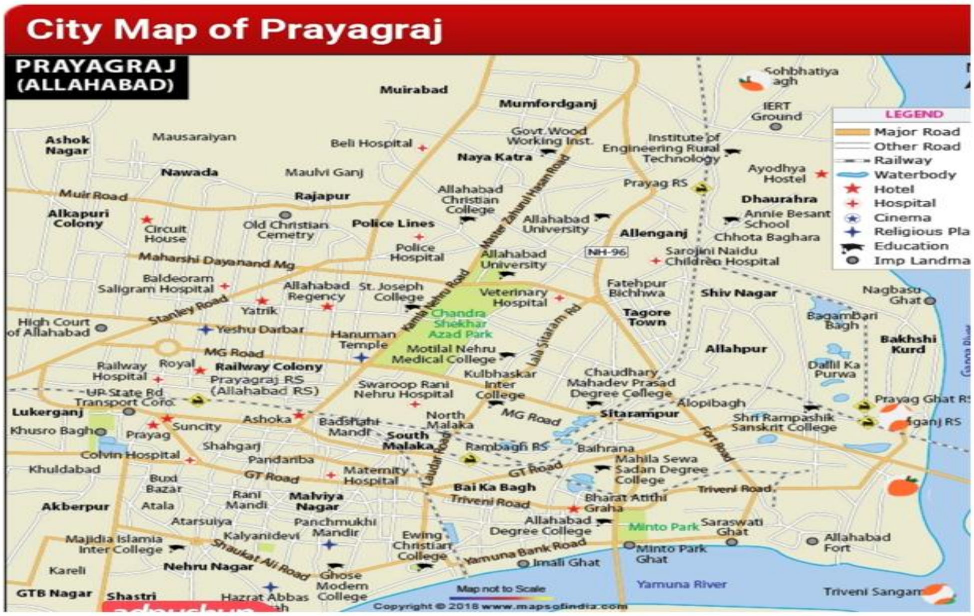

Figure 1. Map of Prayag raj showing Various locations

Sample collection

The water samples were collected from 7 sites viz: Sobatiyabagh, Daraganj, Gaughat Sangam for physicochemical analysis during pre-kumbh and post-Kumbh for the years2021-2022. Parameters like temperature, pH and dissolved oxygen (DO), etc. were estimated on the spot immediately after the collection of the samples whereas water analysis relating to other chemical factors was done in the laboratory. Table-2

Name of Sampling site	Place of Samplingsite	The geographical location sampling site	Timing and date of collection of water sample				
			Pre-Kumbh	During Kumbh Jan)	During Kumbh Jan)	Post - Kumbh	Timing *Morning*
S-1	Sobatiyabagh	*25.4457° N, 81.8631° E*	*24-DEC-2021*	*14-january-2022*	*1st Februrary-2022*	*March-2022*	*7 AM-8 AM*
S-2	Daraganj	*25.4427° N, 81.8812° E*	*24-DEC-2021*	*14-January-2022*	*1st February-2022*	*March-2022*	*7 AM8 AMM*
S-3	Gaughat		*24-DEC-2021*	*14-January-2022*	*1st February-2022*	*March-2022*	*7 AM8 AMM*

S-4	Triveni Sangam	*25.4210° N, 81.8902° E*	*24-DEC-2021*	*14-January-2022*	*1st February-2022*	*March-2022*	*7 AM8 AMM*
S-5	Arail Kachar	25.4214° N 81.8907° E	*24-DEC-2021*	*14-January-2022*	*1st February-2022*	*March-2022*	*7 AM8 AMM*
S-6	Arail uparhar	25.4118° N 81.8961° E	*24-DEC-2021*	*14-January-2022*	*1st February-2022*	*March-2022*	*7 AM-8 AM*
S-7	Chhatnag	*25.4022° N, 81.9116° E*	*24-DEC-2021*	*14-january-2022*	*1st February-2022*	*March-2022*	*7 AM-8 AM*

Physicochemical analysis

The various physicochemical parameters will be assessed using various standards protocols. The temperature of water samples will be recorded at the sampling sites immediately with the help of a Celsius thermometer. DO will fix on sampling sites with Manganese, sulfate, and alkaline Potassium iodide solution. Other parameters will be evaluated following the protocols mentioned in table 2.

Table 3
Water quality parameters to be analyzed using standard protocols

Parameters	Method	Reference
1. pH	pH Meter	APHA, (1985)
2. Temperature	Thermometer	APHA,(1985)
3 EC (μS/cm)	Conductivity Meter	APHA,(1985)
4. Turbidity	(Ntu) Nephelometer	APHA,(1985)
5. Total Hardness (mg/L)	Titration Method (The total hardness of water is estimated by titrating the water sample against EDTA using the Eriochrome Black-T (EBT) indicator).	APHA,(1985)
6. Chloride (mg/L), Magnesium (mg/l)	Volumetric Titrimetric (The Argentometric method employs a solution of silver nitrate for titration. In the titration the chloride ion is precipitated as white silverchloride.)	APHA,(1985)
7. Total Dissolved Solids (mg/L)	Gravimetric method (Gravimetric methods are the most accurate and involve evaporating the liquid solvent and measuring the mass of residues left.)	APHA,(1985)
8. Total Alkalinity (mg/L)	Titration Method(The alkalinity of water can be determined by titrating the water sample with Sulphuric acid of known values of pH, volume and concentrations. Based on the stoichiometry of the reaction and the number of moles of Sulphuric acid needed to reach	APHA,(1985)

Results and Discussion

The results were based on the data collected during the experimental investigation of the study and were presented through subjective analysis. The physicochemical parameters selected in the present research might be acted as an important indicator for potential water pollution levels in Rivers Ganga and the Yamuna at Prayagraj, Uttar Pradesh, India.

Alkalinity (pH)

pH is the measuring scale of water acidity and alkalinity. It is a measurement of an electrically charged particle in a substance and the equipment used for the measurement of pH is a pH meter for the analysis of water samples. Figure 2 shows that the maximum pH (8.4) was recorded at S-3 in February 2022 whereas site5 and site 6 have shown minimum pH (7.2) in March. Excessive mass bathing and the addition of various anthropogenic compounds in water may increase the photosynthesis of algal bloom. Discharge of sewage from the drains also affects the pH and due to cations and anions, water may become alkaline (Singh and Bhargava, 2009).

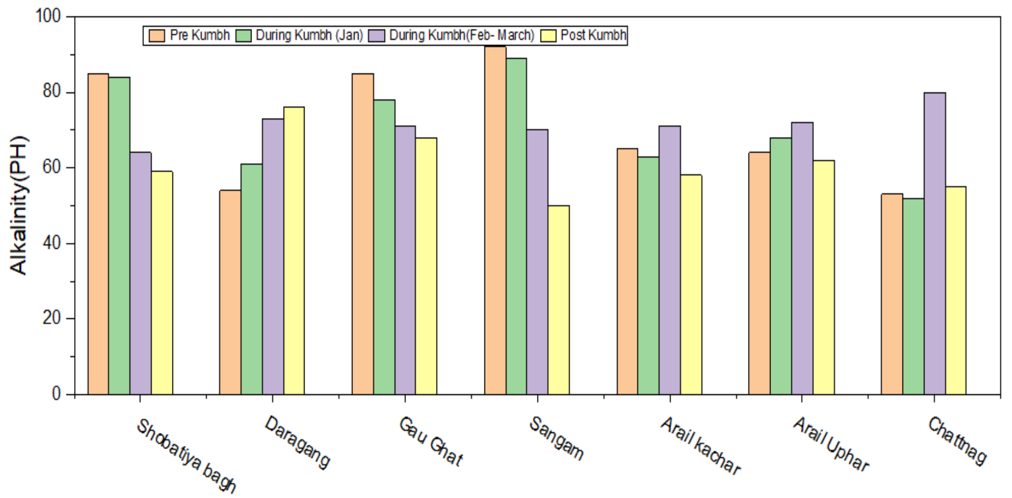

Figure 2. Alkalinity variations at various locations

Electrical Conductivity (EC)

Electrical Conductivity of water is the ability to conduct an electrical current due to the presence of salts, minerals, ss, or other chemicals dissolved in water. The analysis of water samples revealed that there is maximum EC recorded in S-2,i.e. 0.65dSm^{1} during the peak of Kumbh, whereas in S-6 recorded a minimum pre-Kumbh, i.e. 0.33 Sm^{-1}. As shown in Figure 3, an increased level of organic material due to discharge of domestic waste without treatment and accumulation of synthetic fertiliser from agricultural land during runoff are the main responsible factors for the higher level of the EC in the Ganga basin.

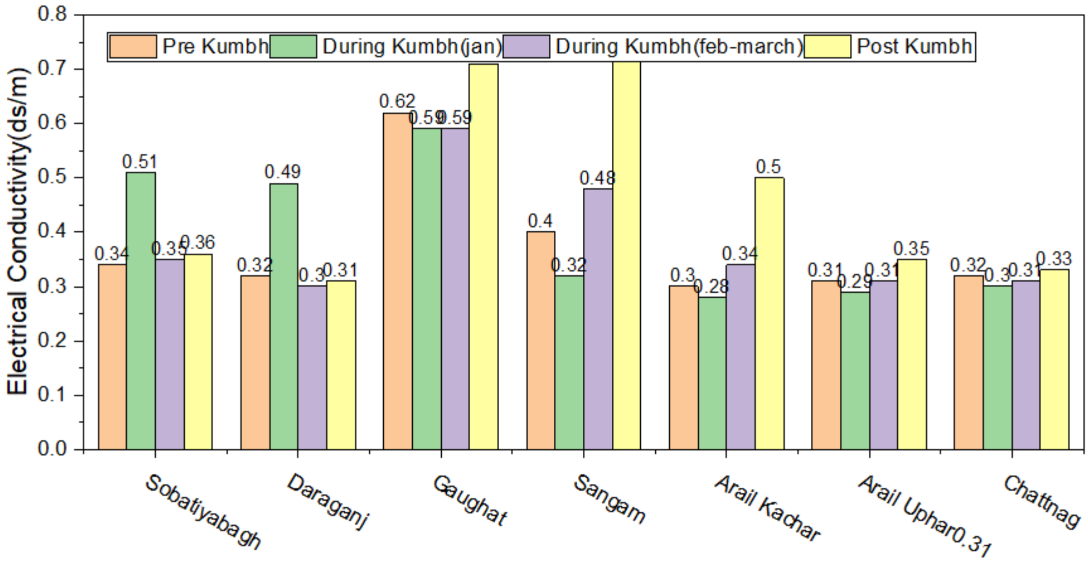

Figure 3. Electrical Conductivity of various Samples

Total dissolved solids (TDS)

Is the term used to describe the inorganic salts and small amounts of organic matter present in solution in water. The result of The DS analysis reveals that the maximum turbidity recorded in S-3 is 300 mg^{-1} during Kumbh, whereas 98.5 mg^{-1} is the minimum value recorded during post-Kumbh in S-5. As shown in Figure 4, the literature review has observed that the TDS value is always higher during post-winter seasons. And at the same time, if the TDS level is high, the EC value would also be on the higher side.

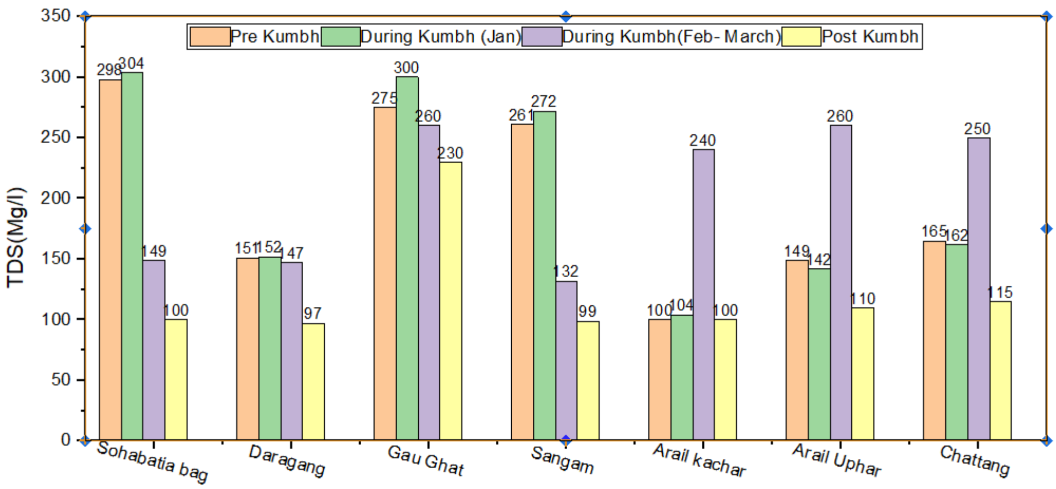

Figure 4. Total dissolved solids of various samples

Total hardness(mg/L)

The hardness of water is due to the presence of soluble bicarbonates, chlorides, and sulfates of calcium and magnesium. The total hardness of water consists of magnesium hardness and calcium hardness. Water hardness is an integral part of the water balance calculation, along with pH, alkalinity, and sometimes TDS and temperature. The result stated that S-3 contains a higher value of 425 mg/L during post-Kumbh at the same time by spatial variation in S-6 minimum value observed i.e. 143mg/L during Kumbh. As shown in Figure 5, If the level of dissolved minerals is high, it will accelerate the hardness of the water. Therefore, the area where people depend on water reservoirs for domestic purposes has more hardness.

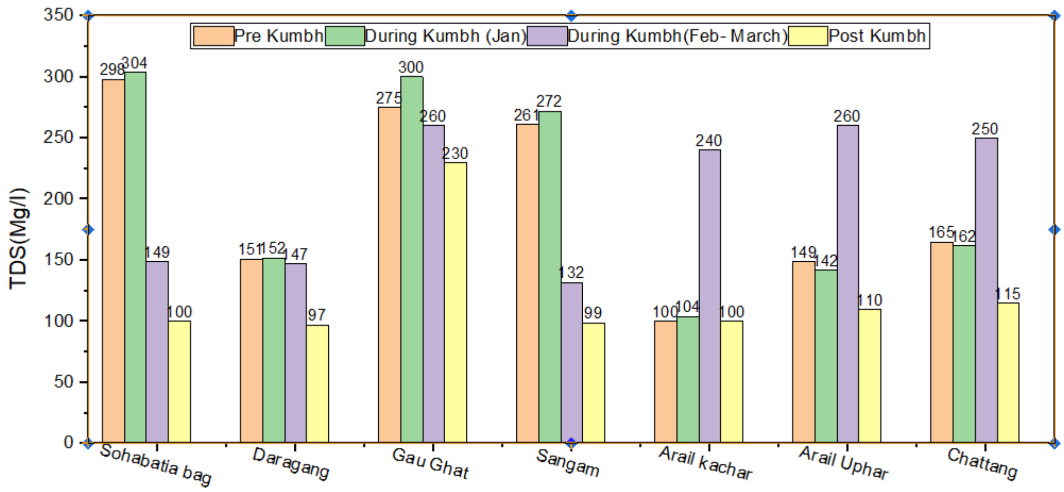

Figure 5. Total hardness of various samples

Calcium hardness(mg/L)

Calcium hardness is a measurement of calcium ions in the water. The meaning of “hard” means that it has high mineral content. Analysis of water samples shows that there is variation in calcium hardness at monthly intervals in which the maximum value is recorded at S-3,280mg/L after Kumbh. In contrast, the minimum level is recorded in S-1 during Kumbh. Discharge of domestic and industrial wastewater sewage water without treatment is the reason for the increased value of calcium hardness. As shown in Figure 6

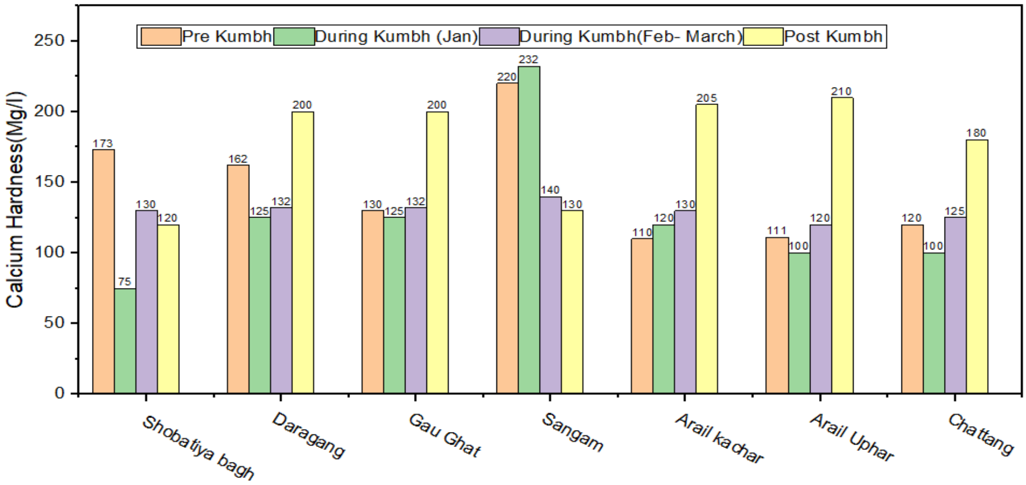

Figure 6. Calcium hardness of various samples

Magnesium hardness (mg/L)

Magnesium hardness is a measurement of magnesium ions in the water; Magnesium is mainly responsible for water hardness. Observation reveals that monthly variation recorded maximum in S-4 220mg/L during Kumbh in January whereas minimum at S-2 in February. A higher level of magnesium hardness is not favourable for aquatic life as a well human being also. As shown in Figure 7

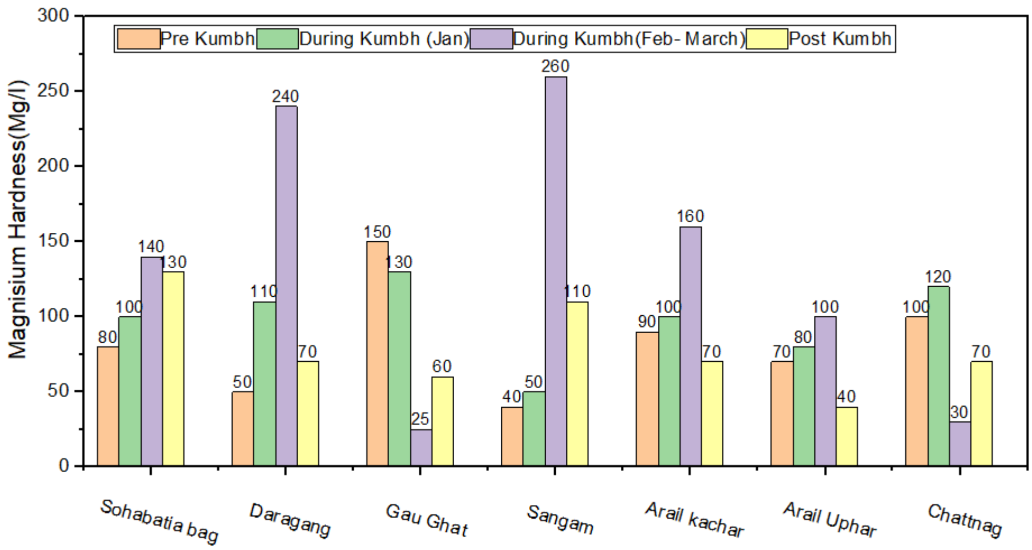

Figure 7. Magnesium hardness of various sample

Chloride(mg/L)

The chloride ion is the anion **Cl^-**. It is formed when the element chlorine (a halogen) gains an electron or when a compound such as a hydrogen chloride is dissolved in water or other polar solvents generally combined with calcium, magnesium or sodium. It is an essential electrolyte located in all body liquids responsible for maintaining acid/base balance, transmitting nerve impulses, and regulating liquid flow in and out of cells (1). Test analysis reveals that monthly interval variation ranges from a maximum at S-3,205 mg/L post-Kumbh whereas a minimum at S-5 in Kumbh. Its increased levels of harm to aquatic life are increased due to excessive use of water softeners in sewage contamination. As shown in Figure 8

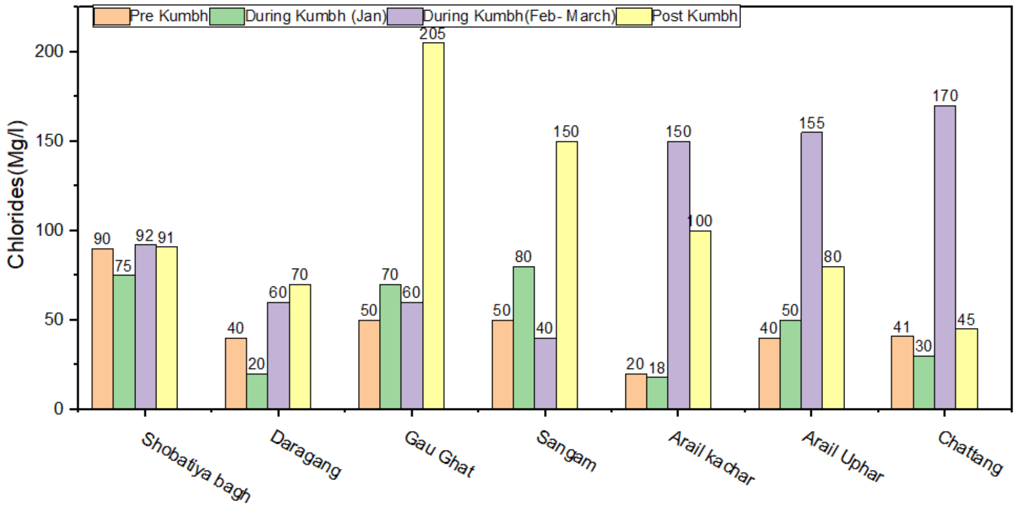

Figure 8. Chlorides in various samples

Dissolved Oxygen(mg/L)

Dissolved oxygen – oxygen molecules dissolved in water – is a significant indicator of water quality. The level of DO shows that monthly interval variation ranges from a maximum at S-1 during pre-Kumbh to a minimum at S-2 and S-7 during pre-Kumbh. Low dissolved oxygen (DO) primarily results from excessive algae growth caused by phosphorus and Nitrogen. Sources of phosphorus include discharges from municipal and private wastewater treatment, cropland and urban stormwater runoff, and natural decay of vegetation. As shown in Figure 9

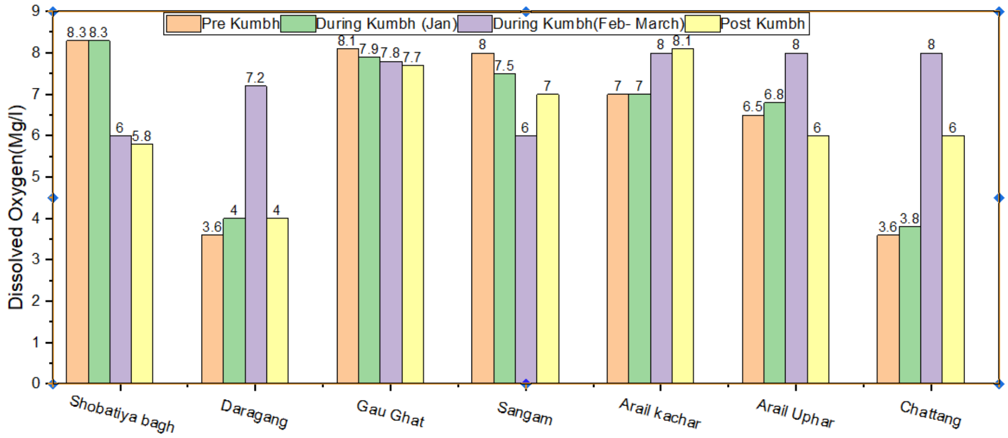

Figure 9. Dissolved Oxygen of various Samples

Biological Oxygen Demand(BOD)(mg/l)

Biochemical oxygen demand (BOD) is the amount aerobic biological organisms demand to degrade organic material present in a given water sample at an optimum temperature over a specific period. The concentration of BOD reveals that monthly interval variation in ranges maximum at S-4 6.3 mg/L during Kumbh howe but minimum at S-3 1.5mg/L after Kumbh. The increased value of BOD denotes the higher level of organic content as a pollutant in water (Bhargava and Tirath,1982). As shown in Figure 10

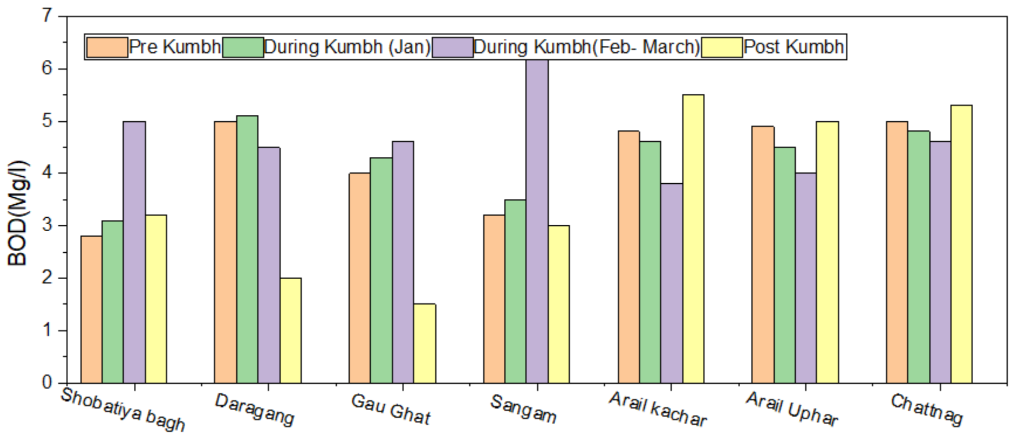

Figure 10. BOD of Various samples

Conclusion

Currently, the planet has ca compromised future for water, both qualitative and quantitative. Hence, its demand of the earth to provide sustainable water resources. In the present scenario, due to overpopulate, on, the need for hygienic water is increasing day by day, so we have to spread awareness among the public about 'Save Water' and, therefore, the local public community to meet the of freshwater and s potable water for everyone. Present research on “THE IMPACT OF MASS BATHING IN WATER QUALITY OF GANGA BASIN DURING KUMBH-2022 BY SPATIAL AND TEMPORAL ANALYSIS” in Prayagraj, U. P expressed variation of water physicochemical characteristics in river water at different Ghats of Prayagraj. In Hindu mythology, Ganga and Yamuna are among the holy rivers and it becoming polluted day by day with an increase in pollution level, discharge of domestic sewage, and municipal waste. As per studies, more than 10-15 million devotees had taken a holy dip, especially during Shahi snan in Sangam. Continuous mass bathing, throwing of ashes, sewage discharge, and addition of many, and the addition of many organic and inorganic compounds in water adversely affect the river's water quality various organic materials in river water highly affects the physicochemical properties of water. According to the present study, the overall pollution rates were high during Kumbh compared to pre-and post-Kumbh analysis. With regards to the overall water quality of river Ganga and Yamuna, some parameters fall under the permissible limit BIS, 1991 except Hardness, Ph and chloride contents were maximum during Kumbh in S-3, Electrical conductivity was maximum in S-2 and BOD was maximum S-4 which were found beyond the permissible limit. It may be due to the presence of an organic pollutant in water. Mass bathing and discharge of various organic components in river water were some of the main reasons for water pollution during this holy period.

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