INVESTIGATE THE IMPACT OF WATER POLLUTION ON AQUATIC ECOSYSTEMS: A CASE STUDY 0F THE GANGES RIVER

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ABSTRACT

Water is synonymous with life. Water is simply as important as oxygen for breathing. Without water, life as we know it could not have evolved and would die. Rivers have been an integral part of human civilizations from times miserable. Therefore, rivers are considered to be sacred. There are various reasons for water pollution like urbanizations, industrialization, religious activities and many more. Kumbh Mela is considered as one of the greatest religious festivals of Hindus where millions of people gather together for spiritual experiences in godliness. It occurs in four different places. Prayagraj (Allahabad) is the place where the present study was carried out to assess the impact of changes occurring in the properties of water during Kumbh 2006. In the present study, the following ten different sampling sites were selected along river Ganga and Yamuna: Ganga Arti Ghat (S1), Daraganj (S2), Shastri Bridge (S3), Saraswati Ghat (S4), Gaughat (S5), Boatclub (S6), Sangam (S7), Arail Kaccahr (S8), Arail Uparhar (S9), Chhatnag (S10). Kumbh fair was held from January 14, 2006 to March 4, 2006. Water samples were collected during the monthly intervals from December 2005 to May 2006. The observed values of different physicochemical parameters like pH, electrical conductivity, total dissolved solid, total hardness, calcium hardness, magnesium hardness, alkalinity, chloride, dissolved oxygen and biological oxygen demand (BOD) of samples were compared with National Standard (BIS, 1991) and International Standards by World Health Organization (WHO). According to the result obtained most of the parameters were within the permissible limit except BOD and hardness which were found to be beyond the permissible limit. However, as per the present investigation and analysis, it was observed that the quality of water was very poor which was not fit for drinking purpose, irrigating purpose etc.

KEY WORDS: Kumbh Mela, Water, Physicochemical parameters, Ganga, Yamuna, Life, Urbanizations

1. INTRODUCTION

It is all known fact that life on the earth is possible only because of one of the most important natural resource waters (Gupta and Orbán, 2005). Interestingly, in the whole solar system, the earth is the only planet where water covers one-third of the total geographical areas. In contrast, the other planets like Mars are too cold or like Venus too hot (Falkenmark, 2006). Water is one of the most essential of all the natural resources present on the earth (Frappart, 2001). As an important part of the environment, water occurs as solid, liquid and gas forms on the earth. As a liquid, it forms a hydrosphere, which covers approximately three-fourths of the earth's surface. Worldwide, 768 million people do not have access to an adequate water supply and over 80% of this population live in rural areas (WHO and UNICEF, 2001). About 97% of the total available water on earth is mostly saline, and hardly 3% of water containing a reasonable amount of salt. Just 1% of the available water is used for routine purposes (Grey et al., 2001). WHO's studies revealed that about 1.1 billion people live in shortage of drinking water supply (WHO, 2003). Water consumption expanded twice as quickly as the world's population over the last century (FAO, 2007). Water is also required in peri-urban areas to sustain a variety of livelihoods (Gomes et al., 2005; Maryati and Humaira, 2003; Rozzoli and Maheshwari, 2004).

Rivers have been an integral part of human elemental right since the dawn of human civilization. Rivers play a significant role in fulfilling the potable water requirements in the world. Rivers are called a large natural body of water emptying into an ocean, lake or other water bodies and typically fed by converging tributaries along its course (Gupta et al., 2009). A small portion of this freshwater fulfils the freshwater requirements of human beings. The global freshwater shortage due to water

contamination urgently demands to improve water conservation around the world (Dahunsi et al., 2002).

Undoubtedly, contamination and shortage of water is a serious concern throughout the globe (Zubaidi et al., 2005; Hasan et al., 2006). Water pollution is a terrible problem mostly anthropogenic (manmade) as a result of agricultural practices such as insecticides, pesticides, and fertilizers, industrial pollutants such as heavy metals (lead, mercury, chromium, and copper), toxic chemicals, dyes etc. which ultimately results in water scarcity (Boelee et al., 2006; van Vliet et al., 2005). Inadequate storage or discharge of household wastes and chemicals including expired medicines (antibiotics), paints, oils, organic detergents, disinfectants, pesticides, toothpaste, petrol and diesel fuel could result in pollution of groundwater (Anand et al., 2005; Li et al., 2005; Sasakova et al., 2005; Xie et al., 2020). In addition, the presence of pathogenic microorganisms or their genetic material in the water ecosystem is also contributing to water pollution and its nearby environment as well (Anand et al., 2005b; Anand et al., 2005c). All these factors/parameters chiefly influence or determine the quality of river water (Muangthong and Shrestha, 2003; Zhang et al., 2005). Furthermore, several essential pathways such as wastewater load synergies, hydrological properties, sedimentation and metabolism in water bodies are potentially known to control gradients of water quality (Jung et al., 2004). Discharge of untreated municipal and industrial wastewater into the natural water bodies are the major causes of water contamination (Chau et al., 2003). Most importantly, all these anthropogenic activities are adversely deteriorating the physiochemical and microbiological activities/qualities of river water worldwide (Bojarczuk et al., 2005; Edokpayi et al., 2005; Lenart-Boroń et al., 2005; Leong et al., 2005; Sila, 2006). Effective surveillance of physicochemical and microbiological parameters together with novel treatment technologies will potentially reduce water contamination in rivers (Bisi-Johnson et al., 2005; Chatanga et al., 2006; Oliveira et al., 2005; Weng, 2020). Hence, evaluation of water quality in terms of physicochemical and microbiological parameters/factors will also help to take appropriate management decisions to reduce river water pollution. Moreover, this form of action has particular value for the protection of global human health from water contamination. Pollution of rivers not only threatens humans but also more than 140 fish species, 90 amphibian species and the endangered Dolphins of the Ganges river (Jain, 2020). Moreover, the river Ganga is one of the major sources of global ocean plastic pollution (Chowdhury et al., 2020; Nelms et al., 2005). Water pollution is a global issue and challenge, harming all living beings and the environment. There are various reasons for water pollution like climate change, urbanization, discharge of wastewater treatment plants effluents, industrialization, improper agricultural practices, improving quality of lifestyle, religious activities and various social activities (Evans et al., 2006; Malki et al., 2005; Ondigo et al., 2005; Zeng et al., 2005). Among these, this paper focuses on the changes caused in the river water quality due to religious and ritualistic activities during Kumbh Mela-2006. Mass bathing is one of these ritualistic events where people gather together and take a holy dip in sacred rivers. This gathering of millions of people and mass bathing is called “Kumbh”. Say why it is called Kumbh at Prayagraj as it is held at Sangam, the confluence of rivers Ganga, the Yamuna and invisible Saraswati. Continuous mass bathing, precipitation inputs, throwing of ashes, sewage discharge and addition of many organic compounds in water adversely affect the quality of the river water. The discharge of various organic and inorganic materials into river water highly affects the physicochemical and microbiological properties of water. In the present study, an attempt has been made to study the comparative changes occurring in physicochemical properties of river Ganga and Yamuna pre during and post-Kumbh Mela.

2. MATERIALS AND METHODS

2.1. Sites and sampling description 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 were collected from various regions of the river Ganga and the Yamuna located at Prayagraj, Uttar Pradesh, India. The water samples were collected from

the ten different sites of Rivers Ganga and Yamuna from December 2005 to May 2006 at a monthly interval. The selected sampling sites are shown below:

S1- Ganga Arti Ghat
S2- Daraganj
S3-Shastri Bridge
S4-Saraswati Ghat
S5-Gaughat
S6- Boatclub
S7-Sangam
S8-Arail Kchhar
S9-Arail Uparhar
S10-Chhatnag

The area for the present investigation was selected from ten different sites of river Ganga and river Yamuna at Prayagraj, which is in the southeastern part of state Uttar Pradesh 98m above the mean sea level at 25°27'N 81°50'E25.45°N 81.84°E. All study samples were collected in sterile plastic bottles and immediately transported to the laboratory under ice-cold conditions.

Table 1. Different methods for analyzing water parameters

S.No.	Parameters	Methods
1	pH	Digital pH meter (Jackson *et al.*, 1973)
2	Electrical Conductivity(dSm^{-1})	Digital conductivity meter (Jackson *et al.*, 1973)
3	TDS	TDS meter
4	Alkalinity (mg/L)	Titration method (Huibregtse and Moser, 1976)
5	Chloride (mg/L)	Argentometric method (Shukla *et al.*, 2018)
6	Dissolve Oxygen (mg/L)	Wrinkler's method (Trivedi and Goel, 1984)
7	BOD (mg/L)	Wrinkler's method (Trivedi and Goel, 1984)
8	Total hardness(mg/L)	EDTA Titrimetric method (Trivedi and Goel, 1984
9	Magnesium hardness (mg/L)	EDTA Titrimetric method (Trivedi and Goel, 1984)
10	Calcium hardness (mg/L)	By difference (Trivedi and Goel, 1984)

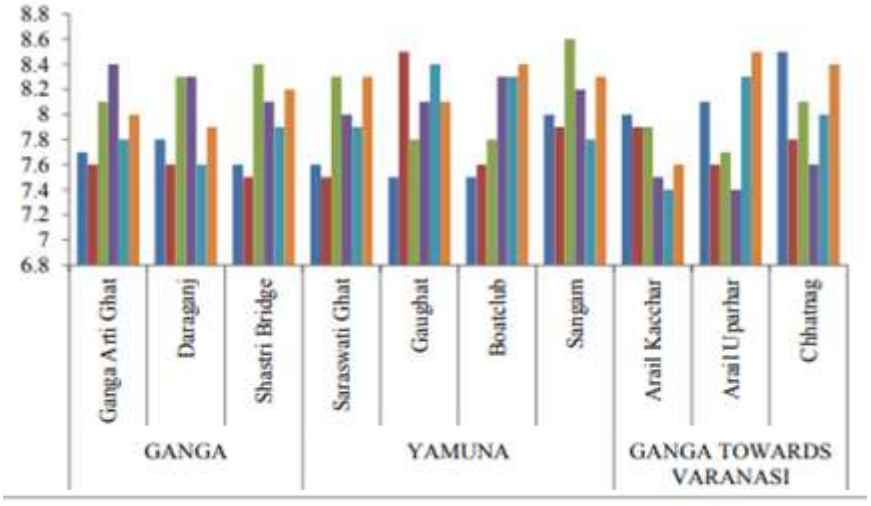
Table 2. BIS and WHO standards of physicochemical parameters of river water

S.NO	Parameters	BIS (ISO: 10500:1991)	WHO
1	pH	6.5-8.5	< 8
2	E.C (dS/m)	100 dS/m – 2000 dS/m	-
3	TDS	200 mg/L – 500 mg/L	500-1000 mg/L
4	Alkalinity (mg/L)	200 mg/L – 600 mg/L	-
5	Chloride (mg/L)	250 mg/L – 1000 mg/L	<250 mg/L
6	Total Hardness (mg/L)	300 mg/L – 600 mg/L	500 mg/L
7	Calcium Hardness (mg/L)	75 mg/L – 200 mg/L	75 mg/L
8	Magnesium Hardness (mg/L)	30 mg/L – 100 mg/L	50-100 mg/L
9	Dissolve Oxygen (mg/L)	> 6.0 mg/L	> 5mg/L
10	BOD (mg/L)	< 2 mg/L	<3 mg/L

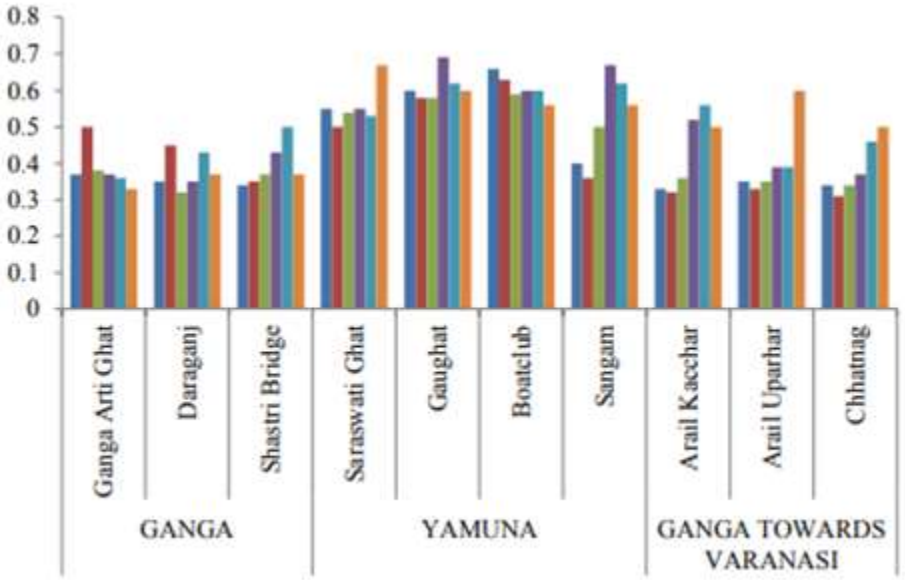
3. RESULTS AND DISCUSSION

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

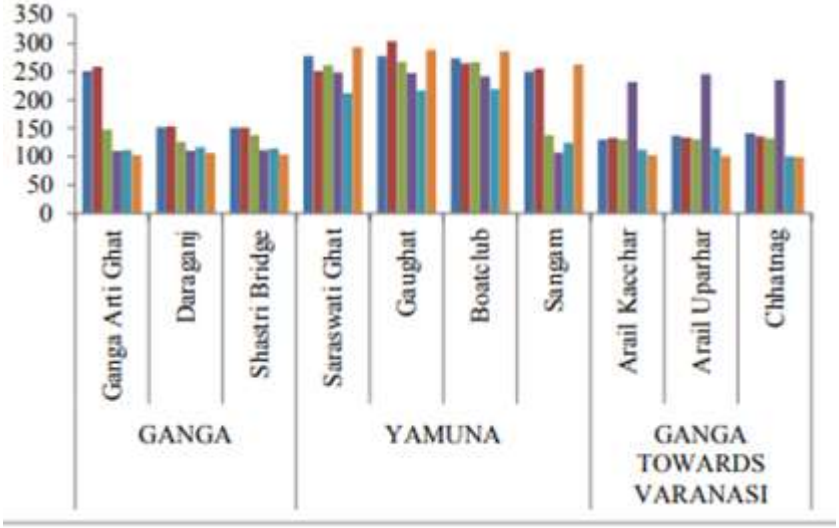
pH: pH is the strength scale of water acidity and alkalinity. It is an essential chemical parameter for testing water quality. The pH of study water samples was measured with an automated (digital) pH meter. Fig. 1 shows that the maximum pH (8.6) was recorded at site 7 in February 2006 whereas site 8 and site 9 have shown minimum pH (7.4) in April and March respectively. 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).



EC (dSm-1): Electrical Conductivity represents the total concentration of soluble salts or minerals salts in water, thereby making the water unsuitable for drinking. The maximum EC (0.69 dSm-1) was recorded as at Site 5 (Gaughat) in March (during Kumbh) whereas site 10 (Chhatnag) has the minimum EC (0.31 dSm-1) recorded in January (pre-Kumbh). The increase in EC values indicates that there is a source of dissolved ions in the vicinity. Higher the value of dissolved solids, the greater the number of ions in water. An increase in the level of conductivity and cations are the product of the decomposition of organic material (Singh et al., 2008). Discharge of domestic sewage directly in river water and leaching of chemical fertilisers from agricultural land by rainwater also cause high water conductivity



TDS (mgl-1): Total Dissolved solids (TDS) is a measure of the combined content of all organic and inorganic substances suspended in water. The result of turbidity reveals that the monthly variation ranging from maximum (304 (mg/L) at Site 5 (Gaughat) in January (pre-Kumbh) to a minimum (99.5 mg/L) at site 10 (Chhatnag) in May (post-Kumbh). According to most of the studies, TDS value increases after post-winter and decrease in monsoon seasons. Higher the amount of TDS results in a higher value of turbidity and EC (Khatoon et al., 2001). Interestingly, it was seen that the TDS was increasing with increasing EC.



Total hardness (mg/L): Hardness in water indicates the quality of water mainly in terms of Ca2+ and Mg2+ bicarbonates, chlorides, sulphates and nitrates. The result of total hardness reveals that the monthly variation ranging from a maximum of 420 mg/L at site 5 (Gaughat) in April (post-Kumbh) to the minimum (145 mg/L) at site 10 (Chhatnag) in February (during Kumbh). The higher the amounts of dissolved minerals in water higher will be the hardness. According to the analysis, hardness was found more in those areas where domestic people live on the bank of the rivers. A favourable amount of hardness is useful to protect fishes against harmful effect caused by low range pH (Ehiagbonare and Ogunrinde, 2010; Svobodova et al., 1993)

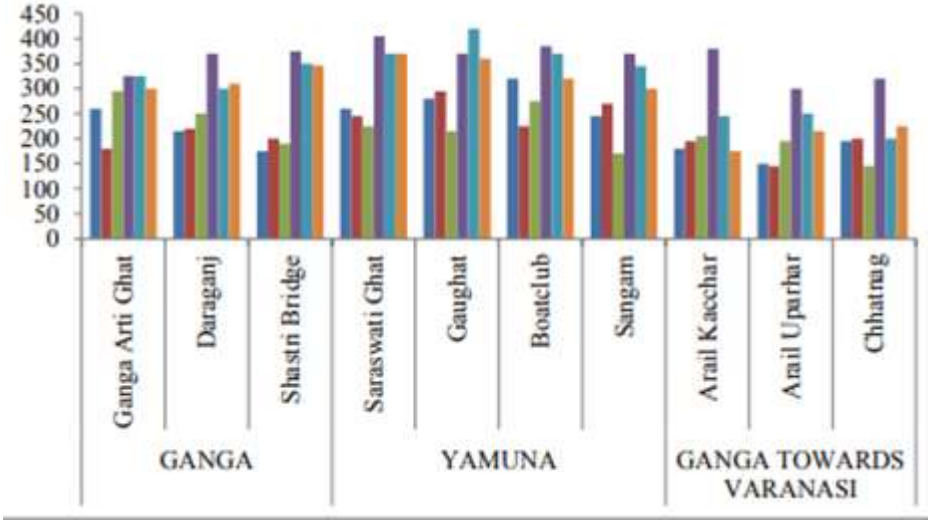
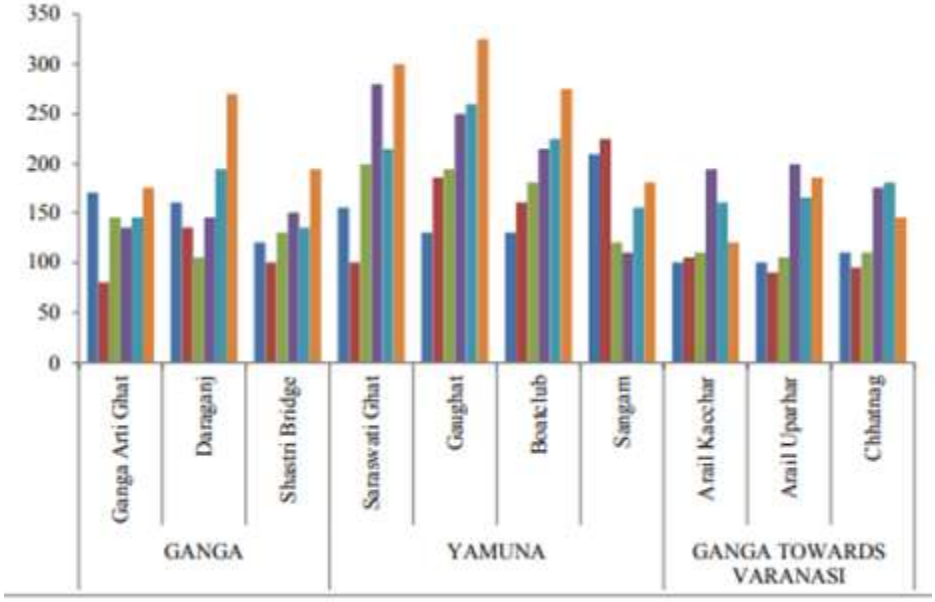
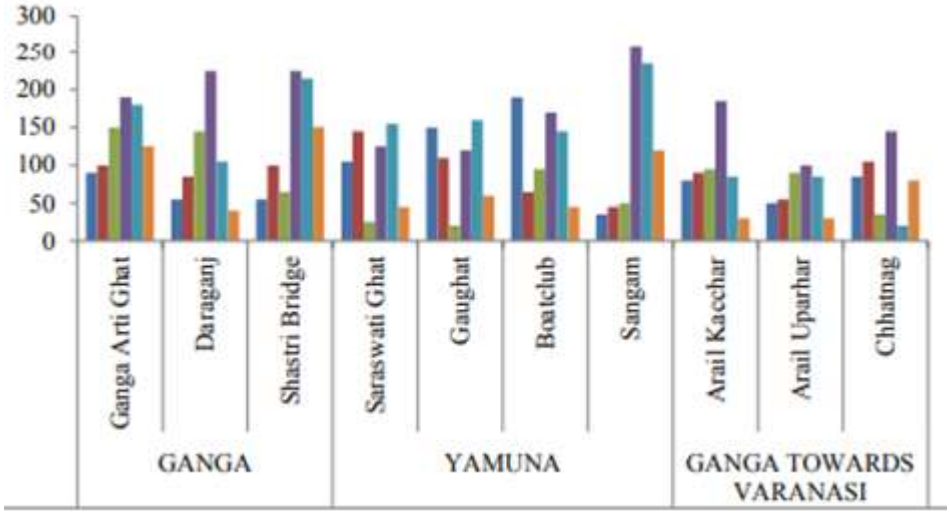


Fig. 4. Effect of Kumbh Mela on Total Hardness (mgl-1) of water quality of river Ganga and Yamuna at Prayagraj 2006

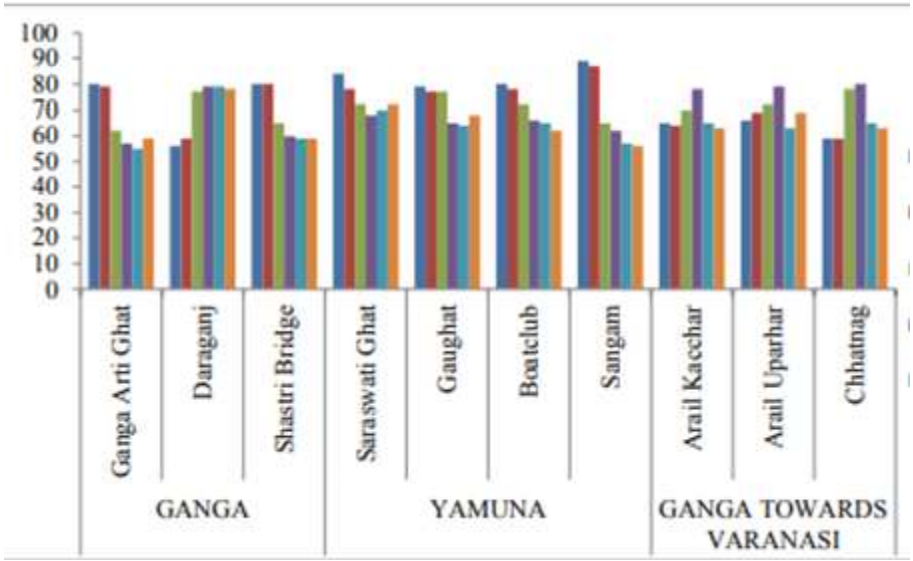
Calcium hardness (mg/L): The observation of calcium hardness reveals that the monthly variation ranging from maximum (325 mg/L) at site 5 (Gaughat) in May (post-Kumbh) to the minimum (80 mg/L) at site 1 (Ganga Arti Ghat) in January. Hardness is caused mainly due to the presence of calcium and magnesium ions. The main source of calcium in natural water is various types of rocks, industrial wastes, domestic waste and sewage.



Magnesium hardness (mg/L): The result of magnesium hardness reveals that the monthly variation ranging from maximum (260 mg/L) at site 7 (Sangam) in March (during Kumbh) to the minimum (25 mg/L) at site 4 (Saraswati Ghat) in February 2006 (during Kumbh). A higher concentration of magnesium makes water unsuitable for humans as well as for aquatic habitat (Singh et al., 2007). The human settlement around river banks is the reason for the high concentration of magnesium hardness. The higher concentration of magnesium makes water unsuitable for humans as well as for aquatic habitat.



Alkalinity (mg/L): Alkalinity is the ability of water to neutralise H+ ions. Alkalinity is the measurement of carbonates, bicarbonates and OH ions in water. The observation of alkalinity reveals that the monthly variation ranging from maximum (89 mg/L) at site 7 (Sangam) in December (preKumbh) to a minimum (56 mg/L) at site 2 (Daraganj) in December 2005 and site 7 (Sangam) in May 2006 (post-Kumbh) respectively. A high alkalinity level is good for aquatic life. High alkalinity shows that the liquid can neutralize a high amount of acids, as a result, the pH level remains safely between 7 to 8. Low Alkalinity cause harm to aquatic life. The high alkalinity value suggests a week and strong base in the water body, such as carbonates, bic arbonates and hydroxides (Abassi et al., 1999; Jain et al., 1997).



Chloride (mg/L): Chloride ion is one of the major ions found in water and are generally combined with calcium, magnesium or sodium. Chlorides are leached from various rocks, soil and groundwater by weathering. The chloride ions are highly mobile and are transported to the closed basin. The result of Chloride reveals that the monthly variation ranging from a maximum of (200.5 mg/L) at site 5 (Gaughat) in May (post-Kumbh) to a minimum of (22 mg/L) at site 2 (Daraganj) in December 2006 (pre-Kumbh). A high concentration of chloride in water harms fishes and plant life. An increase in chloride concentration nationwide is due to anthropogenic or human cause factors such as road salts, sewage contamination and water softeners (David et al., 2007).

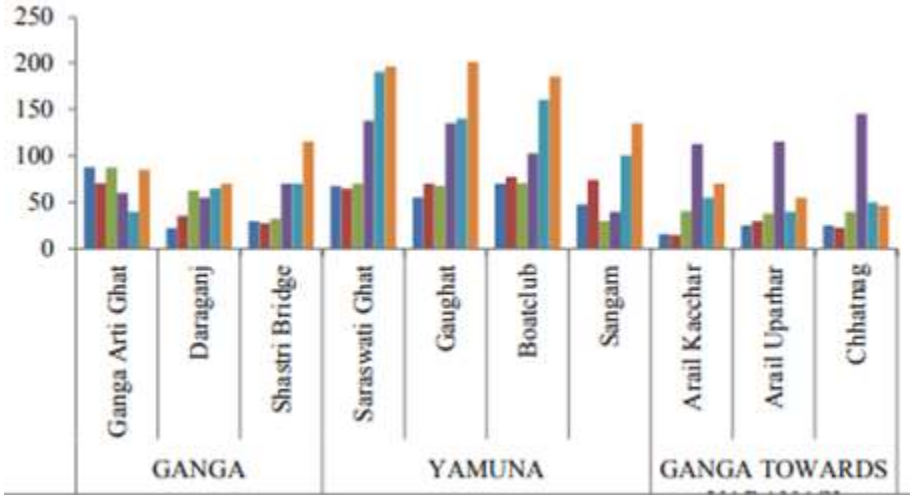


Fig. 8. Effect of Kumbh Mela on chloride (mg/L) of water quality of river Ganga and Yamuna at Prayagraj 2006

Dissolve oxygen (mg/L): The concentration of DO reveals that the monthly variation ranging from a maximum (8.3 mg/L) at site 1 (Ganga Arti Ghat) in December and January (pre-Kumbh) to a minimum of (3.6 mg/L) at site 2 (Daraganj) and site10 (Chhatnag) in December and January 2006 respectively. A decrease in DO is due to an increment in biological and photosynthetic activities. DO test is one of the most important indicators of pollution in river water. The decrease in DO is due to an increase in biological and photosynthetic activities (Bhardwaj, 2005). In the system where the rate of respiration and organic decomposition is high, the value for dissolved oxygen remains lower than those of a system where the rate of photosynthesis is high. High pollution loads may also decrease dissolved oxygen value.

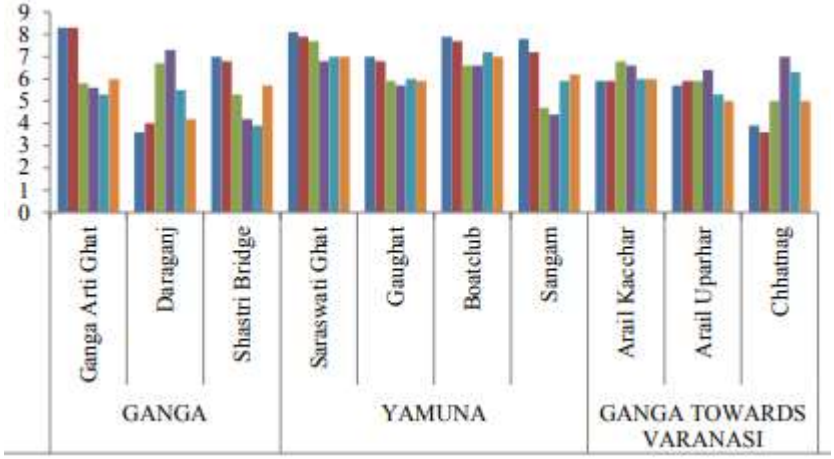


Fig. 9. Effect of Kumbh Mela on DO (mg/L) of water quality of river Ganga and Yamuna at Prayagraj

BOD (mg/L): BOD is the amount of oxygen required by bacteria and other micro-organisms during the biochemical degradation of organic matter present in water under aerobic condition. The concentration of BOD reveals that the monthly variation ranging from a maximum (5.9 mg/L) at site 7 (Sangam) in March (during Kumbh) to minimum (1.5 mg/L) at site 2 (Daraganj) in April (postKumbh). Higher values of BOD were observed due to the presence of an organic pollutant in water (Bhargava and Tirath, 1982).

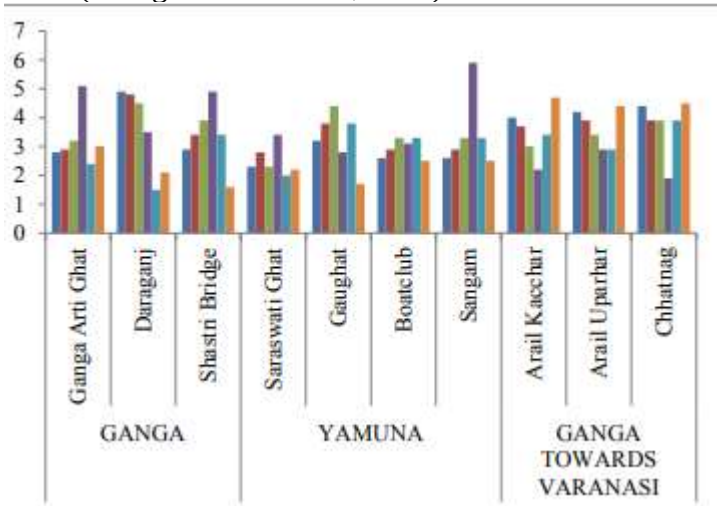


Fig. 10. Effect of Kumbh Mela on BOD (mg/L) of water samples of river Ganga and Yamuna at Prayagraj 2006

4. Conclusions

Currently, the planet faces an uncertain future for water both in terms of quantity and quality. Hence, equal priority should be applied to the quantity and quality of water. The trend of all nations with the growing population and increasing economy is 'Save Water'. Most importantly, sound knowledge and awareness with slogans ‘safe drinking water’ and ‘water conservation’ must be given to the local public community to meet the desire need for ‘fresh water for everyone’. The present research work on “Monitoring of Water Quality of River Ganga and Yamuna during Kumbh-2006 at Prayagraj, U.P” was the concern expressed variation of water characteristics in river water at different Ghats of Prayagraj. According to Hindu mythology, Ganga and Yamuna are among the holy rivers and it is 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 participated and had taken holy dip especially during Shahi snans in Sangam. Continuous mass bathing, throwing of ashes, sewage discharge and addition of many organic and inorganic compounds in water adversely affect the water quality of the river. The discharge of various organic materials in river water highly affects the physicochemical properties of water. According to the present study it was observed that the

overall pollution rates were high during Kumbh as compared to pre-and post-Kumbh analysis. With regards to the overall water quality of river Ganga and Yamuna, most of the parameters fall under the permissible limit of BIS, 1991 except Hardness and BOD which was 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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