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Limnological features of post-bathing water samples of Sangam during Kumbh-2019 at Prayagraj

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Abstract
Limnological features of post-bath water samples of Sangam during Kumbh-2019 at Prayagraj were studied by conducting various physio-chemical and biological tests. Total of five post-Shahi bath water samples were used in order to examine the limnological features and the sampling was done from the confluence point of three rivers, Ganga, Yamuna and Saraswati, known as Triveni Sangam, at Prayagraj. The experiment was conducted during the Kumbh Mela from January, 2019 to March, 2019 and several parameters were assessed. The physiochemical parameters including Temperature, electrical conductance, total dissolved solids, total suspended solids, hardness, alkalinity, acidity, dissolved oxygen, biological oxygen demand, chemical oxygen demand, chlorides were estimated to see the changes occurred during the largest holy mass event in the whole world. Biological parameter include the total bacterial population was calculated by standard plate count method (SPC).This study helps in the understanding of the limits and features of river water body and its aquatic life which can be affected by human interruption and further proper standards can be assigned for betterment of both the water body and the human life.

Keywords: Dissolved oxygen, biological oxygen demand, chemical oxygen demand, standard plate count, alkalinity

Introduction
Prayagraj is considered the holiest of pilgrimage centers of India. It is situated at the confluence of three rivers- Ganges, Yamuna and the Saraswati. Here the muddy and pale-yellow water of the Ganges merge with the green water of Yamuna and invisible Saraswati that is said to flow underground and conjoins the other two rivers from below. All three rivers Ganges, Yamuna, and Saraswati are highly revered rivers in Indian mythology, and hence the confluence point of these rivers holds tremendous religious importance. The meeting point of rivers is known as Triveni Sangam and is very sacred place to Hindus. This is a place of piety and a site for a great historic festival "Kumbh" to which are held the deep faiths of Hindu community.
Water is an invaluable resource and the benefits to mankind from proper management of this resource as well as the disastrous consequences of its mismanagement are very well known. Water quality monitoring is defined as the process of sampling measurement and subsequent recording of various water quality parameters [2].

Study area
Allahabad, officially recognized as Prayagraj is a city, situated in Uttar Pradesh, India. It is one of the most populous city of India Geographically, Prayagraj city is located at 25°26' N / 81°50' E in the southern part of the Uttar Pradesh and spread in the area of about 82 sq. km. As per 2011 census of India, the recorded population in Prayagraj was 1,117,094 with12.8% population growth rate over a decade of 2001-2011.

Climate
The city has a humid subtropical climate common to cities in the plains of North India with Summer lasting from March to September and Winter running from December to February. The summers are hot and dry with temperature ranging from 40 ^{0}C to 48 ^{0}C whereas winter season has the temperature range between 25 ^{0}C to 30 ^{0}C. The monsoons, though irregular, bring some respite from the heat but are warm and extremely humid.
The site(s) is for present study are part of Kumph mela bathing pilgrimages, water assessment here is important. Organic and inorganic stress on rivers is reflected in active microbial growth

[7] and change in physic-chemical parameters [1]. In India, rivers Ganga and Yamuna assumes great importance both from socio-economic as well as religious point. Keeping these facts in view the present study was conducted to assess the physic-chemical characteristics of Sangam water samples and to enumerate the microorganisms, present in Sangam water samples during Kumbh 2019 at Prayagraj.

Materials and Methods

India where Kumbh Mela is celebrated and a large mass of people congregate to take the ritual dip at the Triveni Sangam. The bathing ritual although involves taking a dip anytime during the Kumbh Mela, but there were some specific auspicious bathing dates such as 15th January, 2019 (Makar Sankranti, 1st Royal Bath); 21st January, 2019 (Paush Poornima); 4th February, 2019 (Mauni Amavasya, 2nd and main Royal Bath); 10th February, 2019 (Basant Panchami 3rd Royal Bath); and; 4th March, 2019 (Maha Shivratri) were selected as sampling dates. The samples were collected from the days after specific auspicious baths.

The samples were brought to the laboratory and preserved as per standard methods [1]. Excluding biological oxygen demand (BOD) all the other parameters were completed within 48 h. The samples were analyzed using AR grade chemicals. The glasswere and containers used foe sample collection were thoroughly washed and cleaned by soaking in detergent water followed by 10% HNO_3 and finally rinsed double distilled water.

The physic-chemical analyses were carried out as per standard methods [1, 10]. The temperature, pH, electrical conductivity (EC), dissolved oxygen (DO), total dissolved solids (TDS), total suspended solids (TSS), total hardness, alkalinity, acidity, biological oxygen demand (BOD), chemical oxygen demand (COD) were measured. The EC values are expressed in microsiemens/cm at 25 ^{0}C and DO, BOD, COD, alkalinity, acidity, hardness, chlorides are measured in mg/l.

Results and Discussion

The analysis of samples revealed the presence of high amount of several constituents that could be harmful for the aquatic system while some parameters showed no such results as shown in Table 1.

Table 1: Physio-chemical and biological characteristics of Sangam water (post samples).

S. No.	Parameters	Sampling dates				
(a)	**Physical characteristics**	**16th January**	**22nd January**	**5th February**	**11th February**	**5th March**
1.	Temperature (^{0}C)	13.1	20.2	20.1	21.2	21.2
2.	Electrical conductivity (microsiemens/cm)	937.5	1093.75	2187.5	2343.75	17187.5
3.	TDS (mg/l)	600	700	1400	1500	11000
4.	TSS (mg/l)	2000	700	300	300	200
(b)	**Chemical characteristics**	**16th January**	**22nd January**	**5th February**	**11th February**	**5th March**
5.	Hardness (mg/l)	120	60	50	110	40
6.	Alkalinity (mg/l)	68	74	58	58	50
7.	Acidity (mg/l)	290	150	100	120	200
(c)	**Organic constituents**	**16th January**	**22nd January**	**5th February**	**11th February**	**5th March**
8.	DO (mg/l)	0.5	0.6	1.4	0.3	0.9
9.	BOD (mg/l)	1.0	1.2	2.8	0.6	1.8
10.	COD (mg/l)	336	416	468	412	404
(d)	**Inorganic constituents**					
11.	Chloride (mg/l)	2.6	2.4	1.8	1.0	3.0
(e)	**Biological parameter**					
12.	Standard plate count method (cfu/ml)	107	122	1520	168	188

Temperature is the most importance environment factor with effect on plants and animals. Water has several unique thermal properties which combine to minimize temperature change [4]. The temperature recorded was ranged from 13.1 ^{0}C to 21.2 ^{0}C. The lowest value of temperature was observed 10.1 ^{0}C in month of January and highest value was 22.7 ^{0}C shown in month of February.

Electrical conductivity (EC) is a measure of the ease with which electrical current can pass through water. Electrical conductivity usually used for indicating the total concentration of ionized constituents of water [3]. The observed EC was ranged from 937.5 m mho/ l to 17187.25 m mho/ l. The lowest value of EC was observed 937.5 m mho/ l in month of January and highest value was 17187.5 m mho/ l in month of March.

The total dissolved solids (TDS) in water comprise inorganic salts and small amount of organic matter. The principle ions contributing to TDS are carbonate, bicarbonate, chloride, sulphate, nitrate, sodium, potassium, calcium and magnesium. The observed TDS was ranged from 600-1100 (mg/l). The lowest value of TDS was observed 200 (mg/L) in month of February and highest value was 11000 (mg/l) in month of March.

Total suspended solids (TSS) are a major pollutant that affects waterways all over the world. Predicting the values of TSS is of interest to quality control of wastewater processing [9]. The observed TSS was ranged from 300-2000 (mg/l). The lowest value of TDS was observed 300 (mg/l) in month of February and highest value was 2000 (mg/L) in month of January.

Hardness, a physicochemical property of water, is generally a measure of calcium and magnesium ions in water. Zinc, iron, strontium, aluminum, and manganese can also contribute towater hardness; however, they are generally present in very low concentrations [8]. The observed hardness was ranged from 40-120 $CaCO_3$ (mg/l). The lowest value of hardness was observed 58 $CaCO_3$ (mg/l) in month of March and highest value was 120 CaCO3 (mg/ l) in month of January.

The alkalinity of water sample is determined by titrating it against standard acid solution using indicators like phenolphthalein and methyl orange. The alkalinity is the quantitative capacity of water to neutralize a strong acid to a designated pH [6]. The observed alkalinity was ranged from 50-74 $CaCO_3$ mg/l the lowest value of alkalinity was observed 50 $CaCO_3$ mg/l in month of March and highest value was 74 $CaCO_3$ mg/l in month of January.

Acidity is caused by the presence of excess carbon dioxide in water. The observed acidity was ranged from 100-290 mg/l. The lowest value of acidity was observed 100 mg/l in month of February and highest value was 290 mg/l in month of January.

The observed dissolved oxygen concentration was ranged from 0.84mg/l to 2.60 mg/l. The lowest value of dissolve oxygen was observed 0.84mg/l in month of February and highest value was 2.60mg/l colony in month of February.

Biological oxygen demand (BOD) is a widely used parameter to assess the organic pollution in water systems [5]. The observed Biochemical oxygen demand was ranged from 1.2mg/l to 2.0 mg/l. The lowest value of BOD was observed 1.2mg/l in month of February and highest value was 2.0mg/l colony in month of January and February.

COD is defined as the number of oxygen equivalents required to oxidize organic materials in water. The chemical oxygen demand was observed in the Triveni Sangam was ranged from 336mg/l to 468mg/l. The lowest value of COD was 336 mg/ml in month of January and the highest value was 468 mg/l in month of February.

Chloride occurs naturally in all types of waters. High concentration of chlorides is considered to be the indicators of pollution due to organic wastes of animal or industrial origin. Chlorides are troublesome in irrigation water and also harmful to aquatic life [3]. The chloride was observed in the Triveni Sangam was ranged from 1.8mg/l to 2.6mg/l. The lowest value of Chloride was 1.8 mg/ml in month of January and the highest value was 2.6 mg/l in month of February and March.

The standard plate count method is used to determine the bacterial population. The observed bacterial population was ranged from 107cfu/ml to 188 cfu/ml.

Conclusions

The post bath samples of Sangam water were used to conduct quality assessment experiments of Sangam river water during the Kumbh Mela 2019, the largest religious gathering in the world. The holy event "Divya kumbh Bhavya kumbh" from January-March, 2019, at Prayagraj which was held at Triveni Sangam.This study is essential for checking on pollution control and simultaneously maintaining the water body standards in order to save the aquatic flora and fauna of the region. The values of water quality parameters that were temperature, electrical conductivity, TDS, TSS, total hardness, alkalinity, acidity, DO, BOD, COD, chloride and microorganisms were found to be 21.2 ^{0}C, 17,187.5m mho/ l, 11000mg/l, 2000mg/l, 120 $CaCO_3$(mg/ l), 290$CaCO_3$ mg/l, 290 mg/l,. 40mg/l, 2.80 mg/l, 468 mg/l, 3 mg/l, 1520 cfu/ml respectively.

In future, this study would be helpful to conduct massive holy events involving the river water bodies and further in maintaining the standards for safety purposes for both the aquatic system and human life.

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