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Determination of water quality characteristics of river Yamuna at Baghpat, Uttar Pradesh, India during 2019-2021

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ABSTRACT

Water is the main source of life. The natural aquatic resources are the major habitat for a large group of individuals including nonchordates to chordates. As water are the most abundantly available and occupying 2/3 of the Earth and required by all kinds of life. Therefore, quality of water is of vital concern for mankind since it is directly linked with living beings in term of habitat, sustainability, economy and human welfare. The current study is designed to work out the quality characteristics and their oscillations in physicochemical attributes of river Yamuna water in the district Bhaghpat, Uttar Pradesh, India. The investigation was conducted during July, 2019 to June, 2021 and the sample was analysed in the Bioanalytical Laboratory, Department of Biotechnology, MM (DU), Mullana-Ambala (HR), India. The effects of monthly and seasonal possible attributes including discharge of industrial effluents and natural calamities for the spatial fluctuations in the hydrobiological parameters of river Yamuna water was assessed through the advanced numerical tools. The monthly physicochemical attributes showed the seasonality biased trends during the study. The mean value ± SE of water temperature (^{o}C), dissolved oxygen (mg/l), alkalinity (mg/l), acidity (mg/l) and hardness (mg/l) was recorded as 23.7±1.3 ^{o}C, 4.2±0.22 mg/l, 100.09±4.8 mg/l, 44.55±4.38 mg/l and 550.8±30.3 mg/l respectively during July 2019 to June, 2020. However, the physicochemical attributes during July 2020 to June, 2021 reflected augmented trends for water temperature (24.2±1.27 ^{o}C), dissolved oxygen (5.1±0.16 mg/l), alkalinity (103.95±5.25 mg/l). On the contrary, acidity (39.92±2.63 mg/l) and hardness (522.48±39.82 mg/l) recorded decline. The observation reflected the requirement of urgent and systematic management strategies to overcome these invisible scarce and conserve the natural quality of these water resources.

Key words : *Aquatic ecosystem, Yamuna river, Hydrobiological attributes, Physico-chemical parameters, Invaluable water resources.*

Introduction

Water is most abundantly available on Earth and required by all kinds of life. The quality of water is of vital concern for mankind since it is directly linked with human welfare (WHO, 2004). India is the country which has rich and wide history of social and economic prosperity and of environmental richness. Yamuna River is one of the most polluted rivers of India. Yamuna is the sub-basin of the Ganga river system. The river water is used for both abstractive and in stream uses like irrigation, domestic water supply, industries, etc. (CPCB, 2000). It has been subjected to over exploitative, both in quantity and quality. The discharge of untreated waste water is the main reason of the decreases in water quality. While emission source like dumping of waste material, religious offering of flowers or food, immersion of idols, holy baths, clothes washing or cattle bathing can lead to serious pollution, and industrial waste water pollution is a serious matter of concern as well (Bhatnagar and Sanghwan, 2009; Mehta, 2013; Bozorg-Hadded and Loaiciga, 2021). The prevailing condition of the river is of serious concern, and there is an urgent need to take strict measures to ensure cleansing of the river and prevent further contamination. The Yamuna river and its catchment together contribute to a total of 345848 km^2 area. The main stream of the river Yamuna river originated from the Yamunotri glacier near Bandar Punch (38° 59′ N; 78° 27′ E) in the mussourie range of the lower Himalayas at an elevation of about 6320 meter above mean sea level (MSL) in the district Uttarkashi (Uttranchal). Yamuna, also known as Jamuna and is known to be the second longest and one of the largest river of Ganga in North India. The catchment of the Yamuna river system covers parts of the states of Uttaranchal, Uttar Pradesh, Himachal Pradesh, Haryana, Rajasthan, Madhya Pradesh and the entire state of Delhi. Delhi constitutes less than 1% of the total catchment of Yamuna but contributes more than 50% of the total pollutant load which is discharged into the river over the urban stretch of 22 km between Wazirabad and Okhla barrages (Daniel, 2007; MOEF, 2013; Paul *et al.,* 2014). The industrial effluents, domestic wastes, urban and agriculture runoff are full of suspended solids, colored wastes, toxic substances and organic matter (Kaushik *et al.,* 2009: Suthar *et al.,* 2010; Mishra *et al.,* 2014; Rout, 2017; Mishra *et al.*, 2021). The organic pollutants from industrial waste water from pulp and paper mills, textiles and leather factories, steel foundries and petrochemical refineries are the major cause of illness to aquatic flora and fauna, societies dependent on the same, where regulations do not necessarily protect the people from such industrial outflows (Chaterjee *et al.,* 2002; Chatterjee *et al.,* 2010; Agarwal and Saxena, 2011; Chaurasia and Tiwari, 2011; Jena *et al.,* 2013; Angiro *et al.,* 2020). The investigation was aimed to evaluate selected water quality attributes of the Yamuna river along the Baghpat district of Uttar Pradesh, India; which may directly or indirectly influence the biodiversity of aquatic vertebrates and parasitic infracommunities associated to them. The present research paper deals with the determination of water quality profile of Yamuna river using selected physico-chemical parameters.

Materials and Methods

The hydrobiological study of the Yamuna river was carried out at Baghpat district in Uttar Pradesh, India during July 2019 to June 2021. Three sampling stations were selected in the stretch of 10 km [5 km upstream (S2) and 5 km downstream (S3) from main primary sampling site (S1)] for the fortnight collection of samples and determination of riverine water quality characteristics (Fig. 1). Three samples were collected from each selected sites in every fortnight during the period of investigation. The onsite water temperature was recorded using digital thermometer. Simultaneously the samples were collected in air tight borosil sampler (250 ml) and processed for the assessment of dissolved oxygen (DO) as well after modified Winkler's method (Stricklandand and

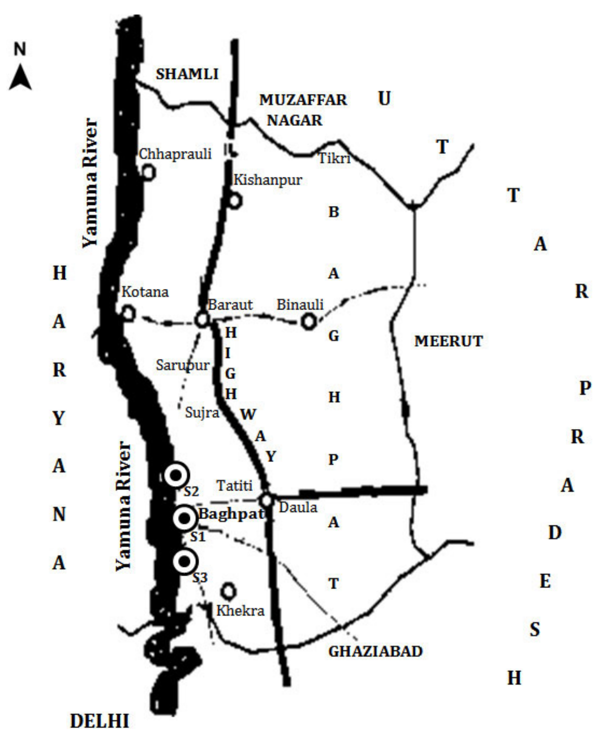

Fig. 1. The map of district Baghpat (Uttar Pradesh) showing the stretch of river Yamuna and sampling sites: S_1, S_2, and S_3. *Where:* ⊙, *Sites of sampling;* ○, *Major town;* , *Yamuna river;* , *State highway;* , *District boundary.* (The map not to scale bar).

Parsons, 1968; Shriwastav *et al.,* 2010; Upadhyay, 2012). The collected and processed water sample brought to the Bioanalytical Laboraory, Department of Biotechnology, Maharishi Markandeshwar (Deemed to be University), Mullana-Ambala (Haryana), India for the determination of dissolved oxygen after modified Winkler method and other hydrobiological attributes alkalinity, acidity and hardness) were analyzed by titirmetric/volumetric methods (APHA, 1998, 2001). The recorded readings were used to calculate the mean and standard error (SE) after Snedecor and Cochran (1967). The data was analyzed using advanced numerical tools to work out the patterns of oscillations in hydrobiological attributes during the period of investigation

Results and Discussion

The quality characteristics of river Yamuna water was analyzed and evaluated *in vitro* and *in situ* using standard protocol during investigation summarized in the Table 1. The water temperature ranged between 16.7-31.2 (23.7±1.30 °C) during 2019-2020; however, 15.9-31.2 (24.2±1.27 °C) during 2020-2021 with the highest peak in the month of September and October (Fig. 2). The trend of peak water temperature not corroborated to seasonality reflected the effect of anthropogenic and industrial interventions for the water quality in the riverine natural resources (Kanu and Achi, 2011; Khatri and Tyagi, 2015; Nyairo *et al.,* 2015; Sidabutar *et al.,* 2017; Dalzochio *et al.,* 2019). The dissolved oxygen (DO) was recorded between the ranges of 2.5-5.9(4.7±0.38 mg/L) during two years investigation with peak

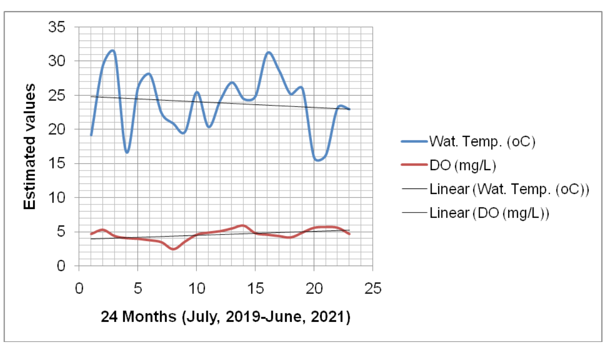

Fig. 2. Monthly oscillation and correlation in water temperature (°C), and Dissolved Oxygen (mg/L) of river Yamuna, Baghpat (Uttar Pradesh) during July, 2019 - June, 2021. Where: Wat. Temp. (°C), water Temperature (°C); DO (mg/L), Dissolved Oxygen (mg/L).

value during monsoon season in both the years of investigation. On contrary the abrupt decline was recorded during mid to late winter season (2.5-3.8±0.20 mg/l) (Fig. 2). The finding is supported by the earlier reported literatures, that the quality of an aquatic ecosystem not only depends upon the seasonality but also on biological diversity and availability of water quantity of the ecosystem (Odiete, 1999; Ghavzan *et al.*, 2006a,b; Nema, 2006; Tiwari and Chauhan, 2006; Tas and Gonulol, 2007; Verma *et al.,* 2011). It was evident that the declined concentrations of dissolved oxygen is negatively influenced by the suspended organic and toxic matter in the water reservoirs (Daniel *et al.,* 2002; Otokunefor and Obiukwu, 2005; Rim-Rukeh and Awatefe, 2006; Doi *et al.*, 2013; Sharma *et al.*, 2016). According to Indian Council for Medical Research (ICMR) the recommended level of dissolved oxygen in river should be greater than 5.0 mg/l (ICMR, 1975; CPCB, 2000; WHO, 2004). However, Chopra *et al.* (2012) were reported the mean concentration of dissolved oxygen below 5.0 mg/l in river Yamuna. It was documented that the dissolved oxygen and biochemical oxygen demand (BOD) has an opposite correlation (Chaurashiya and Pandey, 2007; Gupta *et al.,* 2011). Both these two attributes affected by the addition of organic pollutants and water toxicants in riverine system or due to organic matter decomposition and vice versa by the self-purification process of river (Ifabiyi, 2008; Chopra *et al.*, 2012; Upadhyay, 2012; Zubaidah *et al.,* 2019; Nugraha *et al.,* 2020; Kumar, 2021). On the other hand the water quality more specially the dissolved oxygen of standing or streaming water also showed the negative relationship with free CO_2 and water temperature (Fig. 2), that was evident from the present investigation corroborated by the earlier published data (Jaiswal *et al.*, 2013; Upadhyay *et al.*, 2015; Jaiswal *et al.*, 2014; da Silva and Gomes, 2017; Upadhyay, 2017; Upadhyay *et al.*, 2020).

The next hydrobiological parameters alkalinity was estimated between 65.4–137.9 (101.84±4.28 mg/l) during 2019-2021 with mean value 100.09±4.8 mg/l and 103.95±5.25 mg/l for the investigation year 2019-2020 and 2020-2021 respectively (Fig. 3). The alkalinity peak was recorded in the moth of early winter with abrupt decline in the month of monsoon reflected the seasonality biased oscillation of alkalinity in the riverine water. Thus, concentration of those ions that overcome the effect of the hydrogen ion is known as alkalinity. The key well-known alkalinity apparatus are bicarbonate, carbonate, and hydroxide which can be obtained from the decomposition or breakage of the minerals from the rocks, and soil (Upadhyay, 2020; Bozorg-Hadded and Loaiciga, 2021). The higher level of alkalinity leads to bitter taste to water that make it unfit for drinking.

On the contrary acidity thumps the uppermost position 57.7-63.7 (60.8±2.05 mg/l) in the spring season in both the years of investigation with swift decline in the month of monsoon (Fig. 3). This pattern of acidity parameter in the riverine water showed that the high flow of water in the river stream contributing significantly, while the lower the level of water quantity higher the concentration of acidity trends were well marked during investigation. The augmentation in the water acidity level caused by intensive agricultural practices and its outflow in the riverine water, acid mine drainage, industrial effluents, and municipal wastewater can alter pH and carbonate buffering conditions (Jansson and Ivarsson, 1994; Howland *et al.*, 2000; Meybeck, 2003; Shashi *et al.*, 2009; Stets *et al.*, 2014). Large rivers also display optimistic trends in alkalinity concentration and flux, along with greater buffering potential than small catchments. Therefore, the larger rivers are less susceptible to direct ecological effects of acidity but the uncontrolled administration of industrial

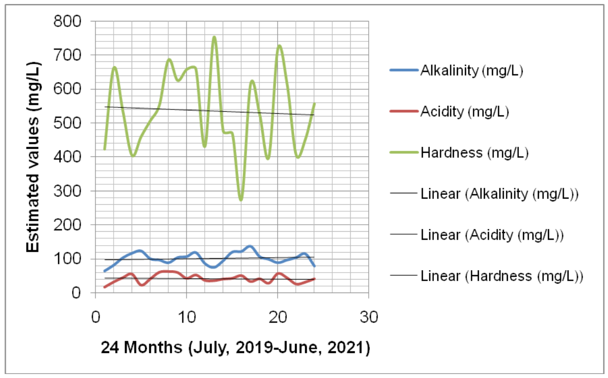

Fig. 3. Monthly oscillation and correlation in Alkalinity (mg/l), Acidity (mg/l), and Hardness (mg/l), of river Yamuna, Baghpat (Uttar Pradesh) during July, 2019 - June, 2021.

Table 1. Monthly qualitative estimation of hydrobiologyical characteristics of river Yamuna at Baghpat, Uttar Pradesh, India during 2019-2021(Mean -± S.E.).

Year	Months	Wat. Temp. (°C)	DO (mg/l)	Alkalinity (mg/l)	Acidity (mg/l)	Hardness (mg/l)
2019	July	19.2±1.59	4.7±0.50	65.4±4.64	17.0±6.96	423.7±22.70
	August	29.4±1.56	5.3±0.30	82.5±7.00	32.5±3.96	662.5±30.42
	September	31.2±1.87	4.4±0.33	104.1±4.71	45.3±4.35	536.2±38.26
	October	16.7±0.65	4.1±0.09	117.4±3.22	55.9±2.29	405.7±23.90
	November	26.2±1.5	4.0±0.25	124.1±3.30	23.1±1.62	460.5±36.33
	December	28.1±3.71	3.8±0.27	101.3±4.54	41.4±5.65	506.9±23.40
2020	January	22.4±2.89	3.5±0.24	97.7±9.60	61.4±8.6	552.8±39.26
	February	20.9±2.40	2.5±0.14	89.6±5.35	63.7±6.33	686.2±54.60
	March	19.7±0.91	3.6±0.40	104.7±5.34	60.5±3.04	625.8±40.32
	April	25.5±2.53	4.6±0.13	107.7±5.34	43.3±1.8	658.1±25.02
	May	20.4±2.39	4.9±0.31	119.4±4.28	53.3±4.47	659.9±56.20
	June	24.3±3.19	5.1±0.08	87.18±4.19	37.2±3.53	432.0±31.03
	July	26.9±5.68	5.5±0.33	75.9±3.74	36.4±3.23	753.5±51.70
	August	24.5±1.11	5.9±0.27	95.5±4.98	41.2±2.75	477.2±25.10
	September	24.9±1.75	4.8±0.42	120.8±6.13	43.4±3.57	470.1±45.67
	October	31.2±3.9	4.6±0.38	122.7±4.55	51.4±2.71	276.2±23.87
	November	28.7±1.1	4.4±0.34	137.9±5.37	33.7±3.82	614.4±37.02
	December	25.2±1.77	4.2±0.32	107.4±6.14	41.8±3.25	525.9±37.90
2021	January	26.0±1.25	4.9±0.24	99.6±5.40	28.8±3.64	400.7±47.80
	February	15.9±0.63	5.6±0.43	89.6±5.85	57.7±4.21	719.7±50.30
	March	16.3±0.53	5.7±0.38	97.7±5.23	44.6±3.42	615.9±52.35
	April	23.2±0.36	5.6±0.34	104.8±6.14	26.2±3.27	406.6±16.95
	May	23.0±1.30	4.7±0.35	115.7±5.71	32.0±3.39	452.2±16.94
	June	24.5±0.68	5.3±0.51	79.8±5.30	41.9±2.97	557.4±13.76

Where: S.E., Standard Error; Wat. Temp., Water Temperature; DO, Dissolved Oxygen; mg/l, Milligram per Litre effluents and other activities may alter the water quality significantly (Johnson, 1979; Raymond and Cole, 2003; Stets *et al.,* 2014).

The hardness in the samples collected from river Yamuna was enumerated between 405.7–686.2 (550.63±30.3 mg/l) during 2019-2020, however ranged between 76.2–753.5 (522.48±39.82 mg/l) during 2020-2021 (Fig. 3). There were dual peak of hardness recorded in mid monsoon and spring season with abrupt decline in the month of October in both years of investigation (Fig. 3). The finding showed correlation to the natural calamities, landslides, rigorous flow of water streams along the rocks and farming activities and fertilizers application during monsoon responsible for the addition of factors to river stream contributed to the augmented spatial and temporal hardness level (Kannel *et al.,* 2007; Upadhyay, 2012; Shabalala *et al.,* 2013; Yadav *et al.,* 2016). According to Bhatnagar *et al.* (2009), hardness and alkalinity decrease during June (heavy monsoon) while increase during July (Bhatnagar and Garg, 1998). The interaction in hardness, alkalinity and acidity calculated and substantiated through the numerical tools reflected extraordinary contrast association to each other and well illustrated (Fig. 3) (Ghosh *et al*., 2000; Kaur *et al*., 2001; Khaiwal *et al*., 2003; Upadhyay *et al.,* 2013; Upadhyay, 2017; Upadhyay and Singh, 2018; Upadhyay *et al*., 2019). Variation in total hardness was observed by different workers which showed that total hardness amount was high in rainy season than summer season (Dalal and Arora, 2007; Deshmukh and Sonawane, 2007; Chopra *et al*., 2012, Kumar *et al*., 2016). It was evident that Ca and Mg amount is high during rainy season possibly positively influencing the total hardness well (Pandey and Soni, 1993; Usha and Ramalingam, 2006; Singh *et al*., 2008; Bhatnagar *et al*., 2009; Upadhyay, 2012; Stets *et al.,* 2014; Upadhyay, 2020).

Conclusion

The differences in various parameters were statistically significant (P<0.05) when compared from upstream and downstream stretches of the river in deferent season during the investigation. Thus the hydro biological conditions were not congenial/optimum for the survival/production of sensitive fish fauna; therefore, proper and efficient treatment of the effluents and sewage should be carried out before discharging into the main stream. Changes in the biotic communities more especially in parasitic infracommunities among icthyofauna showed accelerated oscillations in terms of population and diversity with an increase in pollution, along with a correlation with physico-chemical attributes.

Declaration

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Conflicts of Interest

The authors declare no conflict of interest.

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