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The Impact of Seasonal Variation on Physiochemical Parameters in the Ganga River and Bhimsen Pond Water in Kanpur, India

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Abstract: The physiochemical characteristics of the Ganga River and Bhimsen Pond water in Kanpur, India, throughout the pre-monsoon, monsoon, and post-monsoon seasons are assessed in this study. Parameters including pH, temperature, electrical conductivity (EC), dissolved oxygen (DO), total dissolved solids (TDS), salinity, chloride, and nitrate concentrations were measured in water samples. The findings revealed notable seasonal differences in both bodies of water, with the pond's water exhibiting more noticeable changes because it is a closed system. During the monsoon season, the Ganga River's pH increased noticeably to 8.1, but the pH of the pond water remained continuously higher at 8.6. In both bodies of water, the temperature drastically decreased after the monsoon. During the monsoon, electrical conductivity dropped, demonstrating the diluting effect of rainwater, while the pond's sensitivity to variations in mineral composition increased. During the monsoon, dissolved oxygen levels rose in both bodies of water (6.3 mg/l in the river and 6.83 mg/l in the pond), indicating improved aeration. TDS levels dramatically decreased, especially in the Ganga River, suggesting a diluting impact. During the monsoon, salinity and nitrate concentrations also dropped, with pond water exhibiting greater baseline concentrations, probably as a result of reduced water exchange and agricultural runoff. The impact of surface runoff and decreased natural flushing processes are responsible for the pond water's higher fluctuation in physiochemical parameters, according to comparative analysis. This study advances knowledge of the ecological health of the Ganga River and Bhimsen Pond as well as the impact of seasonal variations on water quality by offering insightful information on their water quality dynamics.

Keywords: Ganga River, Bhimsen Pond, Physiochemical, pH, electrical conductivity, dissolved oxygen, total dissolved solids, salinity, chloride, nitrate, seasonal fluctuations, and environmental monitoring

Introduction

For a number of reasons, the physiochemical characteristics of river and pond water are important (Ashok, 2016; Bhagde et al., 2020). In order to evaluate pollution sources and the general health of aquatic ecosystems, it offers vital insights into water quality (Dwivedi, 2020; Kalal et al., 2021; Ogid'aka-Obende et al., 2025). The largest industrial hub and most populous city in Uttar Pradesh, India, Kanpur is well known for producing leather. However, by dumping untreated garbage into the Ganga and other rivers, countless tanneries, textile mills, distilleries, chemical factories, pesticides, and slaughterhouses greatly contribute to the pollution of these rivers (Katiyar, 2011; Madhulekha and Arya, 2016). Human health, living things, and biodiversity are all seriously threatened by water pollution and pesticides (Prakash and Verma, 2014, 2020a; Chaudhary et al., 2021; Singh et al., 2023). A balanced environment is essential for

the survival of all biota, and parameters like pH, temperature, dissolved oxygen, and turbidity affect the growth and reproduction of aquatic organisms (Kumar, 2018). By keeping an eye on physiochemical parameters, waterborne illnesses and pollutants are prevented, ensuring that the water is safe for human consumption.

By identifying and reducing problems like eutrophication, acidification, and thermal pollution, the current study will contribute to environmental protection, protecting delicate habitats and endangered species (Arya, 2024). In order to uncover microbial diversity from different habitats, metagenomics is a new trend in current research. In order to evaluate the health of the water, microorganisms can be discovered (Arya and Hemprabha, 2025). This information is useful for scientific studies, enhancing our knowledge of hydrology, biogeochemical cycles, and aquatic ecology, which influences the creation of environmental models and theories. In general, physiochemical parameter monitoring and analysis are crucial for maintaining and safeguarding water supplies for human communities and the environment (Chapman, 1996; Wetzel, 2001). Monitoring the physicochemical water quality is crucial for assessing the water environment, ecosystem, hydrochemistry, and ecology as well as for restoring water quality.

quality criteria (Whitehead et al., 2018; Islam et al., 2019; Sarkar et al., 2016). Frequent monitoring promotes efficient environmental management by assisting in adherence to legal requirements established by governments and environmental organizations. Additionally, by shedding light on how shifting conditions impact aquatic ecosystems, research on these characteristics advances our understanding of climate change.

The physiochemical characteristics of the Ganga River and Bhimsen Pond water in Kanpur, India, throughout the pre-monsoon, monsoon, and post-monsoon seasons are assessed in this study.

Materials and Methods

Samples were taken from the Bhimsen Fish Pond and the Ganga River's Atal Ghat. Atal Ghat is situated in Kanpur, Uttar Pradesh, India, on the banks of the Ganges River (Fig. 1a). The Atal Ghat is located at roughly latitude 26.5020N and longitude 80.3180E. This site is crucial for researching water quality and ecological health since the Ganges River is impacted by a number of anthropogenic factors, including as urban runoff, industrial discharges, and religious activities. The village of Bhimsen in the Kanpur district is home to Bhimsen Pond (Fig. 1b), a pond used exclusively for fish cultivation. The pond is located at roughly latitude 26.4160N and longitude 80.20000E. This pond is home to fish such as China carp, rohu, catla, naini, grass, and silver.

In 2023–2024, three replications of the experiments were conducted in RBD and CRD at the Department of Zoology at Dayanand Girls P.G. College in Kanpur. Pre-monsoon, monsoon, and post-monsoon water samples were taken from Bhimsen Pond and the Ganga River in Kanpur. To avoid any unanticipated changes in the physico-chemical characteristics, water samples were collected in sterile bottles and delivered into the lab that same day. A number of physical-chemical characteristics were calculated, such as pH, temperature, DO (dissolved oxygen), TDS (total dissolved solid), salinity, nitrate, and chloride.

(a) (b)

Fig. 1: (a) Atal ghat of Ganga River; and (b) Bhimsen fish pond. (Source: Google map)

The water temperature was measured with a glass thermometer, while pH and electrical conductivity EC) were recorded by pH meter and conductivity meter, respectively at the sampling site. Dissolved oxygen (DO) was determined by Winkler's method. Nitrate and chloride were estimated by standard methods (APHA, 2017).

Statistical analysis was performed using the Microsoft Excel-2010 (The mean, standard deviation (SD), ANOVA values were calculated, analyzed, and presented as mean ± standard deviation, Standard error and critical difference to illustrate spatial and temporal variations across different water and seasons. This analysis was conducted to identify any deviations in chemical parameters from WHO standards.

Results and Discussion

Present study revealed a comparative statistical analysis of the physiochemical parameters of Ganga River and pond water across three seasons: pre-monsoon, monsoon, and post-monsoon. The statistical parameters considered for evaluation include Standard Deviation (SD), Standard Error (SE), and Critical Difference (CD), offering insights into seasonal variations and significant differences between water bodies. Water quality (WQ) encompasses the chemical, physical, biological, and radiological properties of water. Under- standing the existence and distribution of flora and fauna over time requires knowledge of a number of characteristics, including pH, turbidity, temperature, acidity, alkalinity, hardness, D.O, nitrates and chloride. Data of these parameters were estimated and summarized in Tables 1 and 2.

The pH of pond and river water is a vital parameter that affects the overall health and balance of aquatic ecosystem. The pH of the Ganga River water increase during the monsoon season (8.1) compared to pre- monsoon (6.35) and post- monsoon (6.54) seasons. In contrast, pond water maintained a higher pH range overall, with the monsoon season recording the highest pH (8.6). The CD (0.589) for the river indicated a significant seasonal impact, whereas in the pond (1.523), the changes were more pronounced, reflecting greater variability and sensitivity to external factors. Anbu (2022) found similar results in their investigations. Ndebele *et al.* (2013) and (Khan *et al.*, 2017) observed that pH levels tend to decrease with increasing depth, particularly in water bodies with a high detritus load. The low pH recorded in pre-monsoon may be attributed to an increased concentration of free CO_2 in the water, which could result from the sudden submergence and decomposition of dry land weeds, leftover rice stalks from previous

seasons, and the accumulation of metabolic residues (Chowdhary *et al.*, 2000; Siddhartha *et al.*, 2012).

Table 1: Physiochemical parameters of Ganga River water
: Physiochemical parameters of Pond water

Physiochemical parameters	Pre-monsoon		Monsoon		Post-monsoon		S.E.	C.D.
	Mean	S.D.	Mean	S.D.	Mean.	S.D.		
pH	8.3	0.26	8.6	0.25	6.9	0.56	0.323	1.523
Temperature (°C)	32.5	0.5	26.5	2.29	11.3	1.89	1.091	7.376
EC (µS/cm)	298.2	11.74	187.1	15.49	230.5	19.95	11.518	62.743
DO (mg/l)	4.36	0.4	6.83	0.6	6.8	0.8	0.462	2.484
TDS (mg/l)	378.9	25.57	298.9	21.67	236.9	35.41	20.444	103.128
Salinity (ppt)	1.0	0.2	0.2	0.1	0.3	0.1	0.058	0.351
Chloride (mg/l)	59.91	3.84	34.95	4.63	69.51	1.24	0.716	11.907
Nitrate (mg/l)	41.66	3.62	22.86	2.69	31.8	2.78	1.605	9.610

Temperature is a crucial physiochemical parameter that significantly influences the overall health and ecology of river and pond water. The temperature in both water bodies significantly dropped post-monsoon, with the Ganga River showing a reduction from 33.6°C (pre-monsoon) to 10.6°C (post-monsoon), while the pond showed a similar trend (32.5°C to 11.3°C). Jammel (2002), Kannel *et al.* (2007) and Katiyar (2011) found range of variation in temperature in pond and river water. They also reported that tannery effluents play in important role in variation of temperature in Ganga River. In the present study the SD was relatively low during the pre-monsoon for both water (1.52 in river, 0.5 in pond), indicating stable thermal conditions. However, the CD values suggest that the pond exhibited maximum temperature fluctuations, likely due to its minimum volume and reduced thermal buffering capacity (Li *et al.*, 2010; Wang *et al.*, 2012).

Electrical conductivity (EC) is a measure of a material's ability to conduct an electric current. It varies between different materials. It is also influenced by temperature and impurities etc. EC values revealed a significant decline during the monsoon season (160.1 µS/cm in river, 187.1 µS/cm in pond), highlighting the dilution effect of rainwater. The higher SD in pond water (19.95) during the post-monsoon season and a higher CD (62.743) indicate a strong seasonal influence on mineral content, with the pond being more prone to concentration changes compared to the river. Islam *et al.* (2019) and found high range of electrical conductivity in Buriganga in Bangladesh. Electrical conductivity is a fundamental property of materials that measures their ability to conduct electric current (Dixit *et al.*, 2015; Dey *et al.*, 2021).

Dissolved oxygen (DO) refers to the oxygen present in a water body, which can originate from the surrounding atmosphere as well as through photosynthesis occurring within the water (Kumar and Bahadur, 2009). In the foregoing study, DO levels increased during the monsoon in both water sources (6.3 mg/l in river, 6.83 mg/l in pond), suggesting enhanced aeration due to rainwater mixing. The lower SE (0.101) and CD (0.366) for the river indicate more stable oxygen levels, whereas the pond's higher SE (0.462) and CD (2.484) reflect greater variability, possibly due to stagnant water and higher biological activity.

TDS is a measure of the combined content of all inorganic and organic substances present in liquid in molecular ionized or micro granular suspended form. In the present study TDS levels dropped significantly in both water bodies during the monsoon season, with the Ganga River showing a sharp decline from 688 mg/l (pre- monsoon) to 323 mg/l (monsoon), and the pond showing a reduction from 378.9 mg/l to 298.9 mg/l. The low SE (1.470) and CD (17.292) for the river indicate minimal variation, while the pond's high CD (103.128) suggests a higher sensitivity to seasonal influences, likely from surface runoff and limited water exchange. Li *et al.* (2010) and Riskin and Lee (2021) analyzed the water quality and found high levels of TDS in river water which was very alarming for aquatic life. Shukla *et al.* (2017) and Khan *et al.* (2017) also reported that mineral content below 50 ppm is not ideal for drinking water. 50-150 ppm is excellent for drinking, typically found in natural mineral water. Above 500 ppm is not recommended for drinking as it may contain excessive salt and impurities. Whitehead *et al.* (2018) reported that high TDS leads to scaling in kettles, pipes and water purifier. Some dissolve solids like lead, arsenic, and nitrates can be harmful for health of water body and aquatic animals including fishes (Prakash and Verma, 2019, 2020b; Rani *et al.*, 2024). The most effective method to lower TDS is reverse osmosis system, distillation, and deionization.

Salinity refers to the concentration of the dissolved salts in water and measured in parts per thousands (ppt) or practical salinity units (psu). It plays a crucial role in aquatic ecosystems, agriculture and water quality management (Wang *et al.*, 2012). In this study salinity in both water bodies decreased significantly during the monsoon (0.2 ppt in both cases),demonstrating the dilution effect of rainwater. The lower SE (0.047) and CD (0.119) in the river compared to the pond show that the river had more consistent salinity levels, while the pond exhibited greater variability, possibly due to evaporation effects in its closed environment. Devi *et al.* (2024) used hydrochemical dynamics for physiochemical parameters of pond and found similar results in their studies. High salinity can reduce crop yield and degrade soil quality and hinder plant growth. However, many species are adapted to specific salinity levels.

Changes in physiochemical parameters can disrupt ecosystem (Islam *et al.*, 2019). Rivers, lakes, and artificial reservoirs serve as sources of water for household, industrial, agricultural, and fish farming purposes. Fresh water, which makes up the remaining 3% and has a salinity of less than 1%, is suitable (Riskin and Lee, 2021).

Chloride concentrations were generally higher in pond water, with significant seasonal differences. In the present study the pond water chloride was higher than that of the river water, indicating a more significant impact of seasonal changes on chloride levels in the pond, possibly due to localized pollution sources or reduced water exchange (Mishra *et al.*, 2023). Nitrate levels showed a significant decrease during the monsoon season for both water bodies, with pond water exhibiting higher baseline concentrations (41.66 mg/l pre-monsoon) compared to the river (29.63 mg/l). The higher value of nitrate for pond water suggests a greater fluctuation in nitrate levels, potentially due to agricultural runoff and nutrient loading in a stagnant water body. Sahu *et al.*(2024) found similar results in their investigation.

In comparative analysis of Ganga River vs. Pond Water, the monsoon season significantly influenced

pH, temperature, EC, DO, TDS, salinity, chloride, and nitrate levels in both water bodies, with higher variability observed in pond water. Pond Water exhibited greater seasonal variability, highlighted by higher CD values in parameters such as temperature (7.376 °C), EC (62.743 µs/cm), TDS (103.128), and nitrate (9.610 mg/l). This is associated with the closed system of the pond, higher exposure to surface runoff, and reduced natural flushing mechanisms. Present finding exhibited close conformity with the findings of Arya and Dubey (2017). The physiochemical parameters of the water are vital in assessing and maintaining water quality, as these influence the health of aquatic ecosystems, human uses and industrial applications (Verma, 2019). However, anthropogenic activities, wastes, microplastics etc. are dangerous for fresh water body (Prakash and Verma, 2022; Verma and Prakash, 2022).

Ethical Statement

No animal or microbes have been used or sacrificed for this study, hence Ethical Approval not required.

Conflict of Interest

The authors declare no conflicts of interest.

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