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

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Abstract: This study evaluates the seasonal variations in the physiochemical parameters of Ganga River and Bhimsen Pond water in Kanpur, India, during the pre-monsoon, monsoon, and post-monsoon seasons. Water samples were collected and analyzed for parameters such as pH, temperature, electrical conductivity (EC), dissolved oxygen (DO), total dissolved solids (TDS), salinity, chloride, and nitrate concentrations. The results showed significant seasonal fluctuations in both water bodies, with more pronounced variations in the pond water due to its closed-system nature. The pH of the Ganga River was found 8.1 a notable increase during the monsoon season, while the pond water maintained a consistently higher pH 8.6. Temperature dropped significantly post-monsoon in both water bodies. Electrical conductivity decreased during the monsoon, highlighting the dilution effect of rainwater, with the pond showing a higher sensitivity to mineral content changes. Dissolved oxygen levels increased in both water bodies during the monsoon 6.3 in river and 6.83 mg/l in pond, reflecting enhanced aeration. TDS concentrations dropped significantly, particularly in the Ganga River, indicating a dilution effect. Salinity and nitrate concentrations also decreased during the monsoon, with pond water showing higher baseline concentrations, likely due to agricultural runoff and limited water exchange. Comparative analysis indicated that the pond water exhibited greater variability in physiochemical parameters, which is attributed to the impact of surface runoff and reduced natural flushing mechanisms. This study provides valuable insights into the water quality dynamics of the Ganga River and Bhimsen Pond, contributing to a better understanding of their ecological health and the effects of seasonal changes on water quality.

Keywords: Ganga River, Bhimsen pond, Water quality, Seasonal variations, Environmental monitoring, Physiochemical, pH, electrical conductivity, dissolved oxygen, total dissolved solids, salinity, chloride, nitrate

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Introduction

Physiochemical parameters of river and pond water are vital for various reasons (Ashok, 2016; Bhagde *et al.*, 2020). It provides essential insights into water quality, which is crucial for assessing

pollution sources and the overall health of aquatic ecosystems (Dwivedi, 2020; Kalal *et al.*, 2021; Ogidìaka-Obende *et al.*, 2025). Kanpur, the most populous city and largest industrial center in Uttar Pradesh, India, is renowned for its leather production. However, numerous tanneries, textile mills, distilleries, chemical plants, pesticides and slaughter houses contribute significantly to the pollution of the Ganga and other rivers by discharging untreated wastes into the river (Katiyar, 2011; Madhulekha and Arya, 2016). Water pollution as well as pesticides is a serious threat to human health, living organisms and biodiversity (Prakash and Verma, 2014, 2020a; Chaudhary *et al.*, 2021; Singh *et al.*, 2023). Parameters, such as pH, temperature, dissolved oxygen, and turbidity, influence the growth, and reproduction of aquatic organisms thus maintaining a balanced ecosystem necessary for survival of all biota (Kumar, 2018). Monitoring physiochemical parameters ensures the water's safety for human use, preventing health risks from waterborne diseases and contaminants.

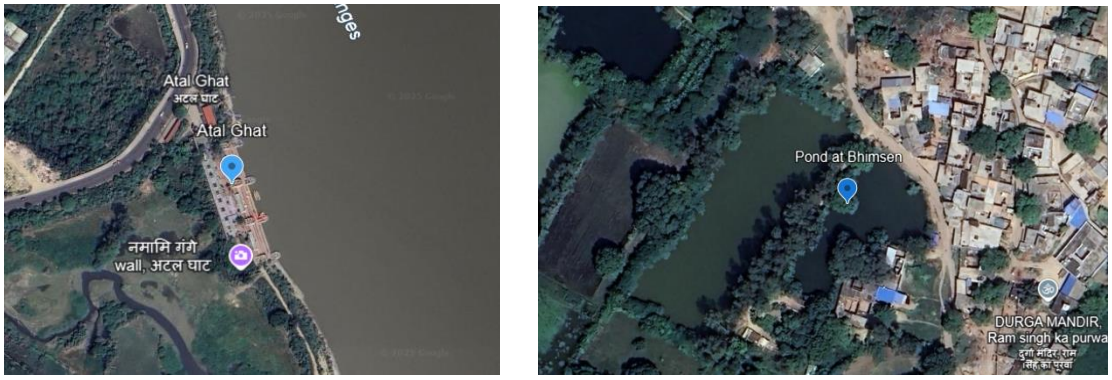
Present study will help in environmental protection by detecting and mitigating issues like eutrophication, acidification, and thermal pollution, thus conserving sensitive habitats and endangered species (Arya, 2024). Nowaday's metagenomics is an emerging trend in modern science to identify microbial diversity from various habitats. Microorganisms can be identified for the assessment of the water health (Arya and Hemprabha, 2025). This data is valuable for scientific research, enriching our understanding of aquatic ecology, hydrology, and biogeochemical cycles, and informing the development of environmental models and theories. Overall, monitoring and analyzing physiochemical parameters is essential for protecting and sustaining water resources for both the environment and human communities (Chapman, 1996; Wetzel, 2001). To evaluate the water environment, ecosystem, hydrochemistry, and ecology as well as to restore water quality, it is essential to monitor the physicochemical water quality parameters (Sarkar *et al.*, 2016; Whitehead *et al.*, 2018; Islam *et al.*, 2019). Regular monitoring helps comply with regulatory standards set by governments and environmental agencies, supporting effective environmental management. Furthermore, studying these parameters contributes to climate change research by providing insights into how aquatic ecosystems are affected by changing conditions.

This study evaluates the seasonal variations in the physiochemical parameters of Ganga River and Bhimsen Pond water in Kanpur, India, during the pre-monsoon, monsoon, and post-monsoon seasons.

Materials and Methods

Samples were collected from Atal ghat of Ganga River and Bhimsen fish pond. Atal ghat is located along the banks of the Ganges River in Kanpur Uttar Pradesh, India (Fig. 1a). The Atal ghat is situated with approximately 26.502^0N latitude and 80.318^0E longitude. The Ganges River at this location is subject to various anthropogenic influences, including urban runoff, industrial discharges and religious activities, making it an important site for studying water quality and ecological health. Bhimsen pond (Fig. 1b) is a purely fish culture pond, located in the village of Bhimsen in the Kanpur district. The pond is situated at approximately 26.416^0N latitude and 80.2000^0E longitude. Fishes like Rohu, Catla , Naini, Grass, Silver and China carp are cultivating in this pond.

Experiments were carried out in Department of Zoology, Dayanand Girls P.G. College, Kanpur during 2023-2024 in RBD and CRD with three replications. Water samples were collected from Bhimsen pond and Ganga River Kanpur during pre-monsoon, monsoon and post- monsoon. Water samples were taken in sterile bottles and were brought into the laboratory same day to prevent any unexpected changes in the physico-chemical properties. Various physical-chemical parameters, including pH, temperature, DO (dissolved oxygen), TDS (total dissolved solid), salinity, nitrate and chloride were estimated. The water temperature



(a) (b)

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

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. Understanding 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).

Temperature is a crucial physiochemical parameter that significantly influences the overall

Table 1: Physiochemical parameters of Ganga River water

Physiochemical parameters	Pre-monsoon		Monsoon		Post-monsoon		S.E.	C.D
	Mean	S.D.	Mean	S.D.	Mean	S.D.		
pH	6.35	0.13	8.1	0.79	6.54	0.39	0.125	0.589
Temperature (°C)	33.6	1.52	29.2	1.13	10.6	1.6	0.506	1.301
EC(µS/cm)	288.7	11.75	160.1	18.63	247.6	24.52	7.753	20.459
DO (mg/l)	5.4	0.78	6.3	0.45	6.03	0.32	0.101	0.366
TDS (mg/l)	688	87.51	323	25.61	215	4.65	1.470	17.292
Salinity (ppt)	0.76	0.25	0.2	0.1	0.36	0.15	0.047	0.119
Chloride (mg/l)	53.54	6.04	31.68	3.55	53.18	11.13	3.519	7.761
Nitrate (mg/l)	29.63	3.45	18.56	2.41	22.13	8.2	2.593	5.678

Table 2: 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

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.

Author Contributions

Hemprabha: Collection of water samples from the Ganga River and fish pond across different seasons, analysis of physicochemical parameters, data interpretation, statistical analysis and drafting the initial manuscript; *Arya Sunita*: conceptualized the research problem, guided the research design and methodology, critical revisions, interpretation of results, and finalized the manuscript for publication. All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

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