BHARATI INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH & DEVELOPMENT (BIJMRD)

(Open Access Peer-Reviewed International Journal)

DOI Link : https://doi.org/10.70798/Bijmrd/03080005

Available Online: www.bijmrd.com|BIJMRD Volume: 3| Issue: 08| August 2025| e-ISSN: 2584-1890

Variations in Water Quality in Freshwater Aquatic Bodies in West Bengal

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Abstract:

Freshwater ponds in suburban Kolkata are vital to the ecosystem, aquaculture, groundwater recharging, and daily life. Rapid urbanization and unregulated human inputs are straining aquatic systems, necessitating systematic water quality monitoring. This study explores seasonal and geographical variability in water quality indicators in five typical ponds in North 24 Parganas, West Bengal: Birati, Madhyamgram, Panihati, and New Barrackpore. Leased for aquaculture, the ponds are also utilized for idol immersion, street cleaning, and domestic washing. The ponds, bordered by dense residential areas, receive organic and chemical loads from these activities. The water samples were tested for phosphate, nitrate,biological oxygen demand (BOD), pH, dissolved oxygen (DO), and chemical oxygen demand (COD). Results vary significantly seasonally for all metrics. The seasonal patterns of atmospheric and water temperatures, which peaked at 36°C in summer and dropped to 11°C in winter, showed the strong climatic influence. Dissolved organic matter (DO) concentrations ranged from 4.02 mg/L in New Barrackpore to 8.15 mg/L elsewhere, indicating uneven organic loading and environmental stress. Pond pH showed different trends. Birati was alkaline, but New Barrackpore 2 had lower values (~7.3), indicating acidic pollution or abundant organic pollutants. BOD and COD values fluctuated, peaking at 4.24 mg/L and 6.9 mg/L, respectively, indicating organic matter intake from household activities and runoff. Nutrient dynamics analysis found seasonal maxima for phosphate (0.17-0.45 mg/L) and nitrate (1.4-5.2 mg/L) during monsoon months, indicating runoff and wastewater discharge influence. Continual high phosphate and nitrate levels in New Barrackpore 2 and Panihati reflect human stress and may impair eutrophication and fish production. The study emphasizes the importance of ongoing monitoring of suburban ponds because nutrient levels, fluctuations in dissolved organic matter (DO), biological oxygen demand (BOD), and chemical oxygen demand (COD) directly affect water quality, aquatic biodiversity, and aquaculture viability. The results illustrate how seasonal rains, poor waste management, and localized pollution worsen biological imbalances in these vital waterways. Community engagement, trash removal, and water quality checks are needed to safeguard suburban Kolkata's freshwater ponds' ecological health, socio-cultural functions, and economic value.

Keywords: *Water Quality, Pollution, Seasonal Variation, Freshwater Pond, Suburban.*

Introduction:

Rapid urbanization, population development, and changing patterns of land use have made water quality parameter monitoring in suburban Kolkata's ponds all the more crucial. Many ponds dot the Kolkata suburbs and are used for a variety of reasons, including irrigation, aquaculture, drinking water, bathing, and washing clothes. But these ponds are very susceptible to contamination from urban runoff, industrial effluents, solid waste pollution, agricultural runoff, and household sewage. Problems with microbial contamination, nutrient levels (nitrates and phosphates), pH, dissolved oxygen, chemical oxygen demand (COD), and biological oxygen demand (BOD) are common outcomes of such inputs. The aquatic environment and water quality are both compromised when nutrients are allowed to enrich without control, leading to eutrophication, overabundance of algae, and oxygen depletion. In order to determine the origins of pollution, evaluate the state of the ecosystem, and create management plans, it is crucial to keep an eye on these criteria. Water quality is crucial for aquaculture because it affects fish survival, growth, and production. Communities that rely on fisheries suffer economically when water quality is low because diseases are more common. By keeping an eye on these classic bodies of water on a regular basis, we can keep invasive species from taking over and keep the aquatic ecosystem in check. Deteriorating water quality also poses a threat to public health through waterborne infections, since these suburban ponds are deeply connected to the cultural and social lives of the people who live there. Early contamination warnings and restoration help can be achieved through community-and government-led systematic water quality monitoring initiatives. Thus, it is critical to regularly evaluate the freshwater ponds in Kolkata's suburbs for environmental reasons, as well as to protect the public health, cultural heritage, and livelihoods that are dependent on these crucial aquatic resources.

Location of the Study Area

Sub Urban Kolkata's natural balance relies on the numerous ponds found across the area. The ponds provide a habitat for a wide variety of fish, amphibians, insects, and birds. Many bird species, both year-round and those that migrate, rely on these ponds for their survival and breeding. Another crucial consideration is water conservation. The rate of subsurface water loss is slowed throughout the summer by nearby ponds, which promote groundwater recharging. There are several ponds in the district and across West Bengal, and they all play a significant role in the local environment and way of life. The study is taking place in the 24 Parganas (North) area of West Bengal. The objective of this study was monitor water quality parameters regularly in ponds located in suburban areas close to Kolkata so that localised and seasonal variations can be found out. Part of the investigation included one pond in Birati, two in New Barackpore, one in Madhyamgram, and one in Panihati municipality.

Table 1: Surface Area of different ponds in the study

S. No.	Name	Area (sq. m.)	Acronym
1	Birati pond	2,434.9	Birati
2	NewBarrackpore pond 1	11,730.5	NBE1
3	NewBarrackpore pond 2	1,126.7	NBE2
4	Madhyamgram pond	1,460.5	MMG
5	Panihati pond	3,044.6	Panihati

All five of the ponds that were taken into consideration have dense residential areas surrounding them. For aquaculture's sole purpose, the ponds have been leased by the city government. Additionally, only a few of houses use the pond water to wash clothes and dishes. The ponds are frequently used to drown the idols after religious ceremonies. On occasion, the water is pumped to wash the streets that are nearby. The water levels of the ponds are replenished by rainfall and overland movement. Even though the ponds aren't connected to any particular drainage, most of the debris that ends up in them is washed in during rainstorms from the houses in the surrounding residential neighbourhood. Ponds and other aquaculture facilities use a wide range of chemicals and foodstuffs, which adds to the artificial stress already felt by water bodies. Detergents and other chemicals from washing dishes and clothing do make it into the ponds, though seldom. The inhabitants also deposit their used dishes and plastic bottles into the ponds, or the water from the rains takes them there.

Methodology

Monthly water samples were taken at each of the five sites for a full year twice a month, starting in March 2022 and ending in February 2023. To begin the physicochemical investigations, first water samples was gathered from the specified sites first thing in the morning. The samples were stored in a dark, cold place until they were ready for analysis. All of the water samples were collected at random from each site using Mayer's procedures. Each location, approximately halfway up the river, had at least six water samples collected. A particular spot had the Mayer water sampler reduced to a level approximately 75% below its maximum capacity. Efforts were made to prevent turbidity that could be brought on by water disruption. Water samples were promptly preserved using ice packs after collection for BOD analysis. For chemical oxygen demand testing, it was necessary to preserve water samples with many drops of powerful sulfuric acid. As soon as water samples were collected, they were preserved for dissolved oxygen analysis using manganous chloride and alkaline iodide. Immediate testing commenced upon arrival at the laboratory following transportation of the water samples in plastic containers for further examination. Water quality indicators such as pH and conductivity were measured with a portable kit during sample collection. Afterwards, the findings were verified in the laboratory. The samples were preserved with the necessary reagents and were sent to the lab for comprehensive chemical analysis following APHA guidelines, allowing for the determination of additional parameters (APHA, 2017).

Table 2: Methodology and instruments used for quantifying different Physico-Chemical Parameters

S. No.	Parameter	Methods/Instrument	Unit
1	DO	Winkler's Iodometric Method.	mg/L
2	BOD	Winkler's Iodometric Method.	mg/L
3	COD (mg/lt)	Potassium Dichromate method	mg/L
4	Atmospheric temperature	Calibrated mercury thermometer	(°C)
5	Water temperature	Calibrated mercury thermometer	(°C)
6	Nitrate as NO_3	Brucine method.	mg/L
7	Phosphate	Ultraviolet Spectrophotometric Screening method	mg/L
8	pH	Digital pH meter. (Make: Eutech instruments)	

Results and Discussion

Atmospheric and Water Temperature Variations

The pattern of variation in Atmospheric Temperature can be seen in Figure 1. According to the data, there is a distinct seasonal pattern. During the summer (March to May), temperatures are at their highest, and during the winter (December to February), they are at their lowest. In between, from June to October, there is a transitional phase with moderate temperatures. Birati, NBE 1, and NBE 2 all have very consistent average temperatures of 27.0°C, MMG is somewhat higher at 27.3°C, and Panihati is slightly lower at 27.1°C, suggesting a fairly uniform distribution of temperatures over the region with small localized variances. During May 2022, NBE 1 and NBE 2 both reached 37.9°C on 30-May-22, while Birati and NBE 2 registered 14.1°C on 30-Dec-22, marking the lowest temperatures of the year.

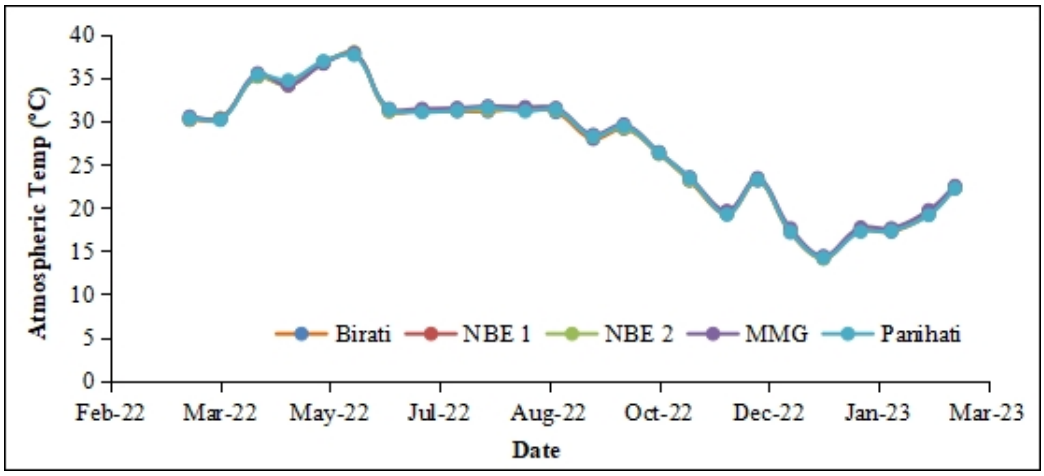

Figure 1: Atmospheric Temperature variations in all study locations

There was a fairly uniform distribution of water temperatures across the region with minor localized variations (Figure 2). Birati has an average of 25.83°C, NBE 1 at 25.18°C, NBE 2 at 25.39°C, MMG at 25.89°C, and Panihati at 26.18°C. December 2022 saw the coldest water temperatures, with NBE 2 hitting 11.4°C on 30-Dec-22, while May 2022 saw Birati peak 36.4°C on 30-May-22. Atmospheric conditions, solar radiation, and local environmental elements all contribute to the considerable seasonal variability in water temperatures, as shown by the approximately 25°C difference between the highest and lowest temperatures.

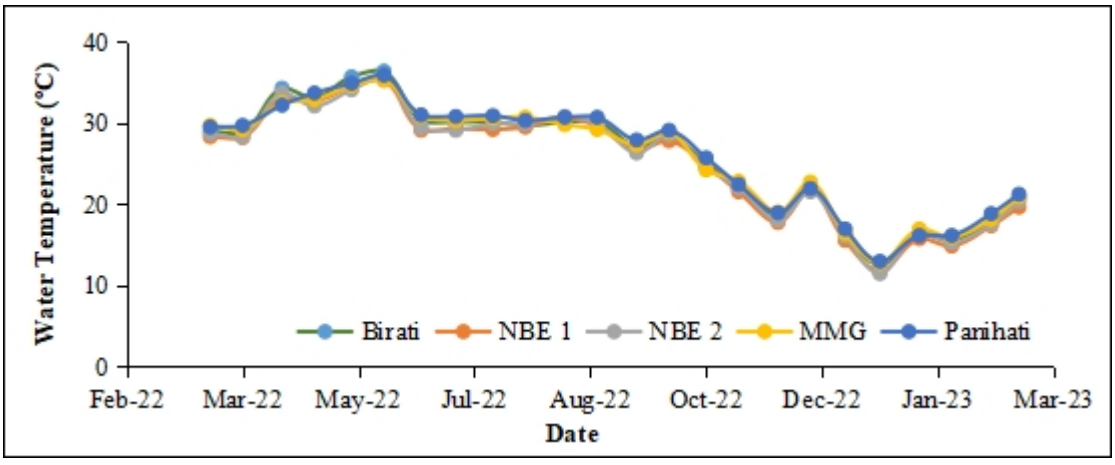

Figure 2: Variation of Water Temperature in all study ponds

Variations in Dissolved Oxygen (DO)

Figure 3 displays the dissolved oxygen (DO) readings from the five research ponds, displaying a distinct seasonal trend. The DO levels exhibit considerable yearly changes due to variables like temperature, biological activity, and water velocity. There is a fairly regular distribution of DO levels over the region with noteworthy regional differences. Birati has an average of 6.61 mg/L, NBE 1 at 7.11 mg/L, NBE 2 at 4.36 mg/L, MMG at 6.12 mg/L, and Panihati at 6.30 mg/L. On January 16, 2023, the DO levels in NBE 1 peaked at 8.15 mg/L, while on the same date, NBE 2 recorded the lowest values, with a minimum of 4.02 mg/L. The wide variation in water quality throughout the region, caused by factors such as seasonal fluctuations, human activities, and local environmental conditions, is highlighted by the 4-mg/L difference between the highest and lowest DO values.

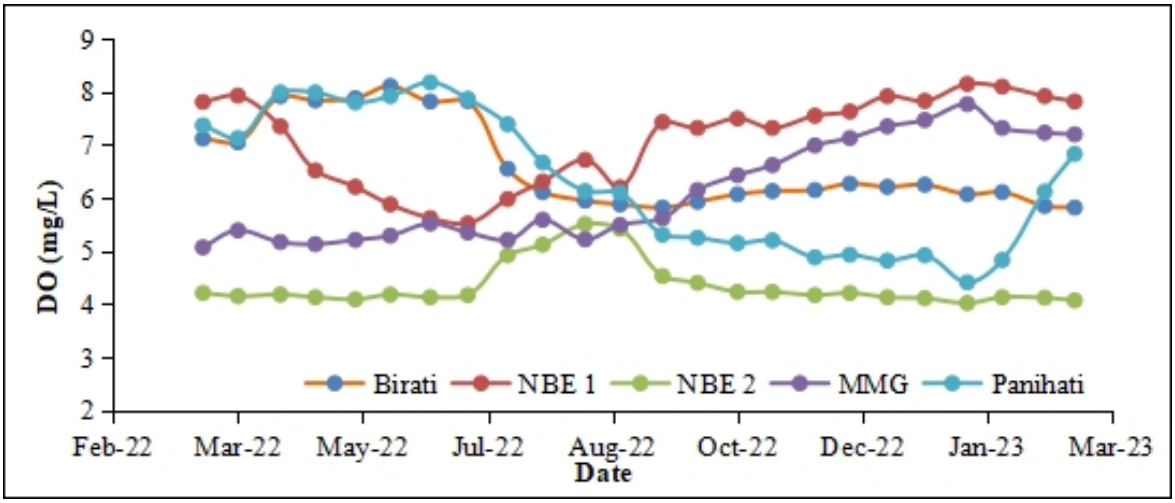

Figure 3: Variation of DO in all study ponds

Variation in pH level

Figure 4 shows the pH readings taken from each of the five research ponds, illustrating the seasonal changes and regional patterns. Because it affects chemical reactions, biological processes, and the general well-being of aquatic ecosystems, pH is an essential metric for water quality assessment. According to the data, there is a distinct seasonal pattern, and the pH levels change significantly throughout the year due to variables like weather, biological processes, and human activities. Consistently high pH levels in Birati point to the existence of factors that are conducive to alkaline environments. Alternatively, NBE 2's continuously low pH levels (7.3 on average) suggest problems such acidic pollution, inadequate buffering ability, or excessive organic matter content.

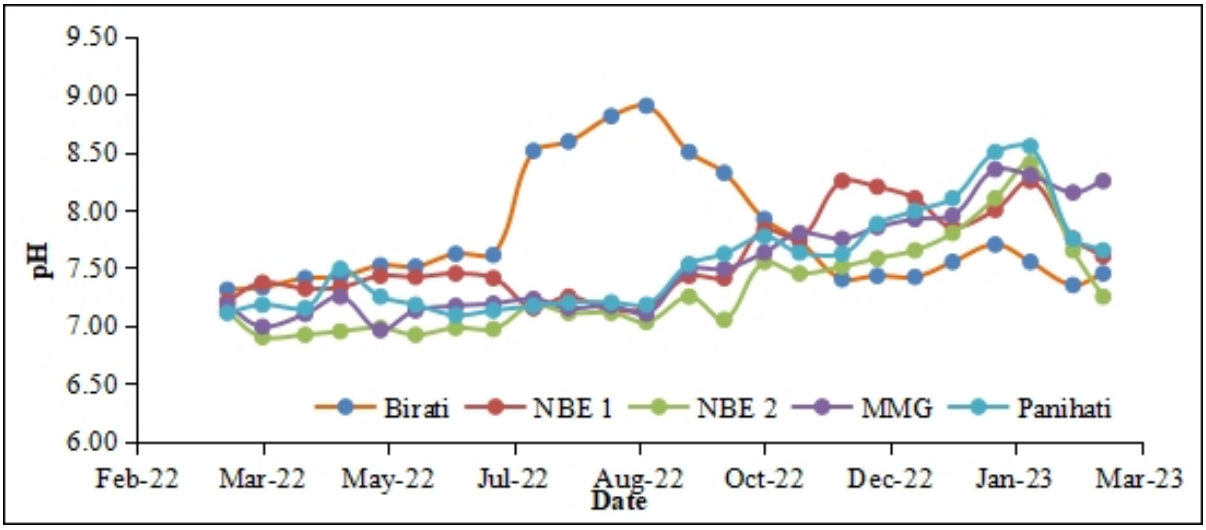

Figure 4: Variation of pH in all study ponds

Variation in Biological Oxygen Demand (BOD):

Figure 5 displays the biological oxygen demand (BOD) readings from all five research ponds, showing both regional and seasonal trends. The biochemical oxygen demand (BOD) is an important indicator of water quality because it shows how much oxygen microbes are consuming while they break down organic materials in water.

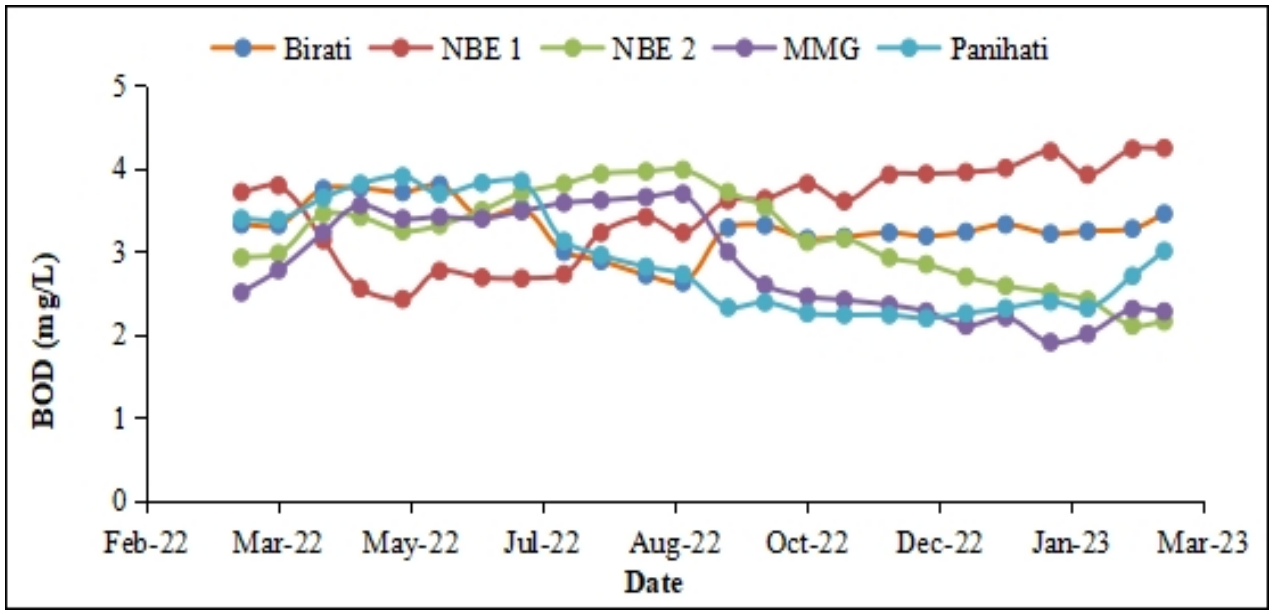

Figure 5: Variation of BOD in all study ponds

Depletion of dissolved oxygen, injury to aquatic life, and degradation of water quality are all consequences of organic pollution, which is indicated by high BOD levels. Temperature, precipitation, organic matter input, and human activities are some of the variables that affect BOD levels, which exhibit substantial annual changes, according to the data. There is a very equal distribution of BOD levels over the region with

noteworthy localized differences. Birati, NBE 1, NBE 2, MMG, and Panihati all have pretty constant average BOD values, with 3.28 mg/L, 3.47 mg/L, 3.16 mg/L, 2.84 mg/L, and 2.90 mg/L, respectively. At a peak of 4.24 mg/L on 28-Feb-23, NBE 1 had the highest BOD levels recorded, while MMG had the lowest, with a minimum of 1.9 mg/L on 16-Jan-23. Seasonal shifts, regional environmental factors, and human activities all contribute to the wide variation in water quality across the area, as shown by the 2.3 mg/L gap between the lowest and highest BOD levels.

Variation in Chemical Oxygen Demand (COD)

The most prominent variations are observed in the COD values in the five study ponds (Figure 6). The localized patterns of the variations are attributed to the pollution generated from nearby residential homes which discharge into the ponds. The data shows a distinct seasonal pattern, with COD levels fluctuating significantly throughout the year due to variables like organic matter supply, temperature, rainfall, and human activity. Birati has an average COD of 5.17 mg/L, NBE 1 of 5.74 mg/L, NBE 2 of 6.25 mg/L, MMG of 6.19 mg/L, and Panihati of 5.03 mg/L, demonstrating a fairly consistent distribution of COD levels throughout the region with noticeable localized variances. On 16-Jul-22 and 16-Aug-22, the COD levels in NBE 2 peaked at 6.9 mg/L, while on 16-Sep-22 and 16-Oct-22, the levels in Panihati dropped to a minimum of 4.2 mg/L. Seasonal shifts, regional environmental factors, and human activities all contribute to the wide variation in water quality across the area, as seen by the COD levels, which can vary by more than 2.7 mg/L. The average COD level of 6.25 mg/L is continuously recorded at NBE 2, the highest of the five sites. This could be due to causes such increased industrial discharge, agricultural runoff, or restricted water flow, among others.

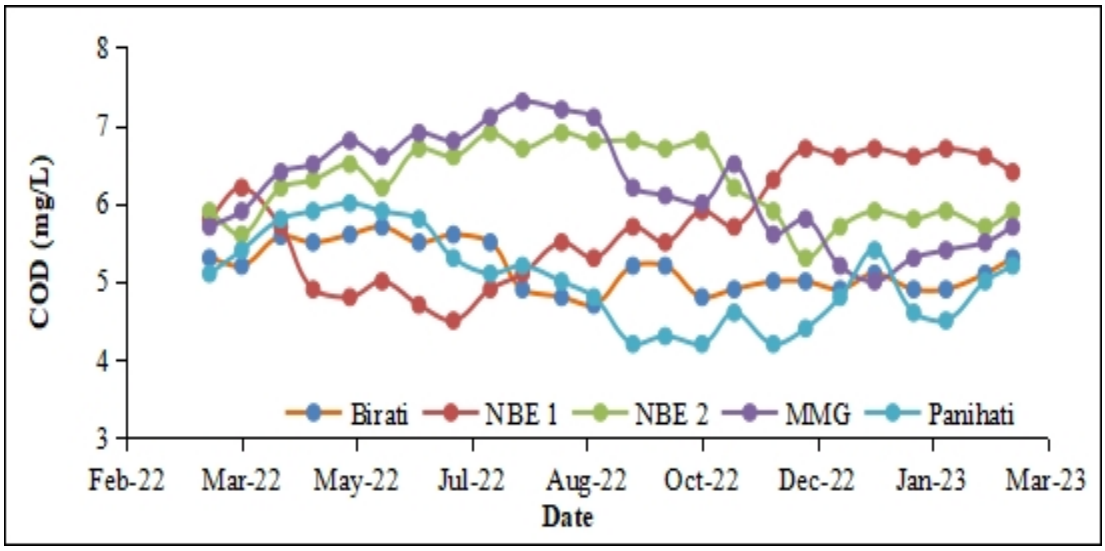

Figure 6: Variation of COD in all study ponds

Variations in Phosphate

As a crucial nutrient that affects aquatic ecosystems, phosphate is an essential metric for water quality assessment. Though phosphate is necessary for plant and algal growth, eutrophication occurs when there is too much of it. This causes oxygen levels to drop, aquatic life to suffer, and water quality to deteriorate. Rainfall, agricultural runoff, wastewater discharge, biological activity, and other factors cause phosphate levels to fluctuate significantly throughout the year, as shown by the data's evident seasonal pattern. Generally speaking, the phosphate levels are rather consistent throughout the region, with notable localized

variations (Figure 7). For example, Birati has an average of 0.28 mg/L, NBE 1 0.23 mg/L, NBE 2 0.36 mg/L, MMG 0.29 mg/L, and Panihati 0.32 mg/L. At a peak of 0.45 mg/L on 16-Aug-22, phosphate levels were highest in NBE 2, while Birati had the lowest levels, reaching a minimum of 0.17 mg/L on 30-Sep-22. Seasonal shifts, regional environmental factors, and human activities all contribute to the wide variation in water quality across the area, as seen by the 0.28 mg/L gap between the lowest and highest phosphate levels. Extremely high phosphate levels in NBE 2 on a regular basis point to heavy discharge of wastewater or agricultural runoff, which may be worsened by overdevelopment or ineffective waste management. In a similar vein, the fact that phosphate levels vary seasonally everywhere shows how susceptible aquatic ecosystems are to things like rising temperatures and changed rainfall patterns. It is crucial to reduce pollution and preserve natural water flow in order to promote healthy aquatic ecosystems, as the high phosphate levels observed in MMG during the monsoon months further demonstrate.

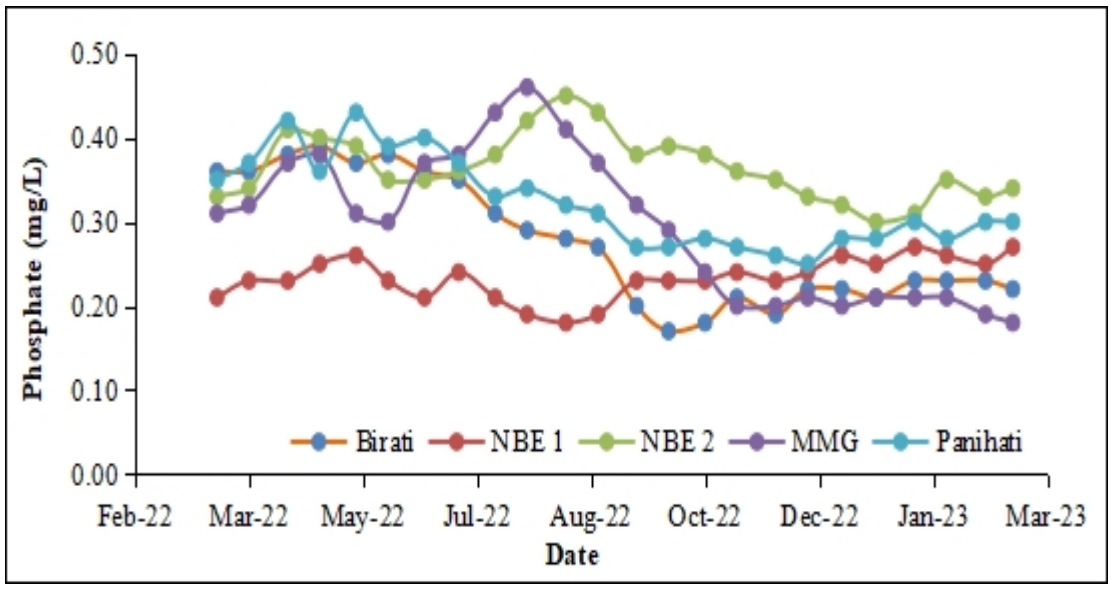

Figure 7: Variation of Phosphate levels in all study ponds

Variation in Nitrate levels

While nitrate, like phosphate, is necessary for plant growth, too much of it can cause eutrophication, in which an overabundance of algae and other aquatic plants depletes oxygen levels, harms aquatic life, and lowers water quality. Further, high nitrate levels can be detrimental for the growth of fish and other aquatic species. The data shows a distinct seasonal pattern, with nitrate levels fluctuating significantly throughout the year due to variables like biological activity, wastewater outflow, rainfall, and agricultural runoff. Birati has an average nitrate level of 2.16 mg/L, NBE 1 of 1.67 mg/L, NBE 2 of 2.35 mg/L, MMG of 2.26 mg/L, and Panihati of 3.45 mg/L, suggesting a fairly uniform distribution of nitrate levels throughout the region with noticeable localized variations. Nitrate levels ranged from 1.4 mg/L in NBE 1 to 5.2 mg/L in Panihati, with the former having the highest peak. The wide variation in water quality throughout the region, caused by factors such as seasonal fluctuations, local environmental conditions, and human activities, is highlighted by the 3.8 mg/L difference between the highest and lowest nitrate levels. Urbanization or inadequate waste management methods may have worsened the already high nitrate levels in Panihati, which indicate the existence of substantial agricultural runoff or wastewater discharge.

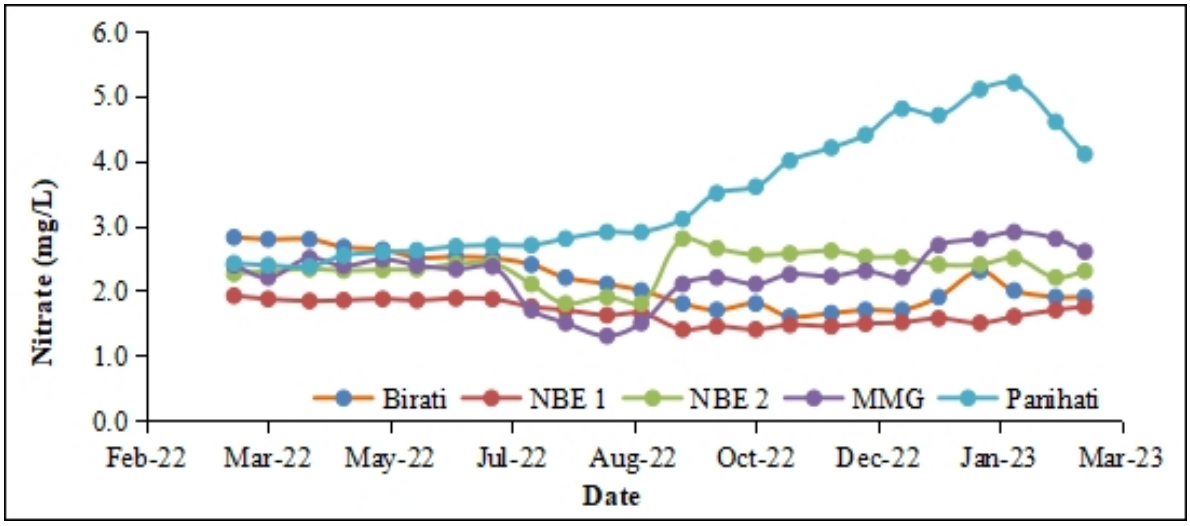

Figure 8: Variation of Nitrate levels in all study ponds

Conclusions:

This study examines seasonal and geographical variability in water quality indicators in five typical ponds in North 24 Parganas, West Bengal: Birati, Madhyamgram, Panihati, and New Barrackpore. These operations deposit organic and chemical burdens into the ponds, which border dense residential areas. All water quality measurements fluctuate greatly seasonally. Seasonal atmospheric and ocean temperatures peaked at 36°C in summer and decreased to 11°C in winter, demonstrating considerable climatic effect. The concentration of dissolved organic matter (DO) varied from 4.02 mg/L in New Barrackpore to 8.15 mg/L elsewhere, indicating uneven organic loading and environmental stress. Pond pH varied. While Birati was alkaline, New Barrackpore 2 had lower values (~7.3), indicating acidic pollution or high organic pollution. BOD and COD peaked at 4.24 mg/L and 6.9 mg/L, indicating household and runoff organic matter ingestion. Nutrient dynamics study showed monsoon phosphate (0.17-0.45 mg/L) and nitrate (1.4-5.2 mg/L) maxima, indicating runoff and wastewater discharge effects. High phosphate and nitrate levels in New Barrackpore 2 and Panihati may indicate human stress and reduce eutrophication and fish production. The study stresses the need of monitoring suburban ponds since nitrogen levels, DO, BOD, and COD directly affect water quality, aquatic biodiversity, and aquaculture feasibility. Results show how seasonal rains, inadequate waste management, and local pollution cause biological imbalances in key waterways. Suburban Kolkata's freshwater ponds' ecological health, socio-cultural functions, and economic worth depend on community engagement, rubbish collection, and water quality inspections.

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Citation: **Chakraborty. D.,** (2025) "Variations in Water Quality in Freshwater Aquatic Bodies in West Bengal", *Bharati International Journal of Multidisciplinary Research & Development (BIJMRD)*, Vol-3, Issue-08, August-2025.