Pen & Prosperity
Website: https://penandprosperity.vgcet.com
Volume 2 :: Issue 3 :: September 2025 :: e-ISSN- 3048-9555 :: DOI Link : https://doi.org/10.70798/PP/020300011

Seasonal Variation of Water Quality in Ichamati River at Basirhat Region

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ARTICLE INFO

Article history:
Received: 10 August 2025
Received in revised form 20 August 2025
Accepted 29 August 2025

Citation: Paul. S. & Khawas. Dr. K., (2025) "Seasonal Variation of Water Quality in Ichamati River at Basirhat Region", *Pen and Prosperity*, Vol. 2, Issue. 3, September 2025.

Abstract:

This study investigates the seasonal variation of water quality in the Ichamati River at Basirhat, a transboundary river system that sustains farming, fishing, domestic use, and small-scale industries. The ecological health of the river is vital for livelihoods, yet it is increasingly threatened by anthropogenic pressures and natural fluctuations. To evaluate its physico-chemical dynamics, water samples were collected monthly from three zones—upstream (Zone 1), midstream (Zone 2), and downstream (Zone 3)—between February 2022 and February 2023. Parameters including temperature, pH, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), electrical conductivity (EC), total dissolved solids (TDS), turbidity, alkalinity, hardness, chloride, nitrate, phosphate, sulphate, and salinity were analyzed using standard methods. The results reveal clear seasonal cycles: summer months recorded high temperatures, low DO, and increased BOD and COD, reflecting organic load stress; monsoon months showed peaks in turbidity, nutrient concentrations, and conductivity due to runoff; and winter months exhibited partial recovery but increased salinity and sulphate accumulation. Spatially, Zone 1 displayed the most stable water quality, Zone 2 moderate variability with episodic inputs, and Zone 3 the greatest instability, characterized by low DO, high organic and chemical demand, rising nutrient levels, and elevated salinity. These patterns underscore the ecological vulnerability of downstream stretches, where fish diversity is at greatest risk. Seasonal stresses and anthropogenic influences jointly drive fluctuations, threatening aquatic biodiversity, fisheries, agriculture, and domestic water use. The study concludes that the Ichamati River at Basirhat is under mounting ecological stress, with Zone 3 particularly degraded, and highlights the urgent need for continuous monitoring, effluent control, sustainable agricultural practices, and targeted conservation measures. Safeguarding water quality is essential to sustain fish populations, ecosystem services, and the socio-economic well-being of communities dependent on this river system.

Keywords: *Ichamati River, Ecological Health, Anthropogenic Pressures, Natural Fluctuations, Physico-Chemical Dynamics.*

1. Introduction

The water quality of the Ichamati River in the Basirhat region is becoming an important factor in deciding ecological balance and economic well-being, which in turn affects the livelihood of local residents. Many different types of work, including farming, fishing, small-scale manufacturing, and domestic chores, are sustained by this transboundary river that flows between Bangladesh and India. The productivity and health of these livelihood sources are directly impacted by the quality of the river water. The Basirhat region's farmers rely largely on river water for irrigation, which means that soil fertility and crop yields are negatively affected by any degradation in water quality, such as salt intrusion, an excessive chemical load, or untreated effluents. The decline in dissolved oxygen, the increase in turbidity, and the contamination of water sources with industrial and home waste all pose serious threats to the diversity and availability of fish, which in turn threatens food security and income for fishing communities. Furthermore, river water is frequently utilized for household tasks like as cleaning, bathing, and even drinking, which can put the population at serious danger of health problems when the water is polluted. Waterborne disease outbreaks are on the rise due to poor water quality, which in turn drives up healthcare costs for families and threatens economic stability. Deteriorated water quality has far-reaching effects on ecosystem services including biodiversity support and groundwater recharge, weakening community resilience to climate-induced disasters like droughts and floods. Thus, protecting the Basirhat region's means of subsistence necessitates keeping the Ichamati River's water quality high for reasons of both environmental sustainability and economic security. Protecting this vital resource requires strong measures to manage wastewater effectively, limit industrial discharges, and encourage community-led river conservation. Water quality control must be prioritized because the livelihood of thousands of people in Basirhat is highly dependent on the Ichamati River.

Seasonal changes have a significant impact on aquatic habitats, fish populations, and water quality indices. Much remains unexplored and undocumented regarding the diversity of life in the world's freshwaters, despite what we know now. This is due to a lack of resources, the difficulty of sampling, and the fact that other priorities have taken precedence over biodiversity conservation efforts. An in-depth investigation into the relationship between a body of water's ecological health and the sustainability of its fish supplies is necessary for understanding both. Researchers can monitor the impact of the seasons on fish populations by monitoring variations in water quality indicators such as temperature, pH, dissolved oxygen, turbidity, and nutrient levels. Research of this nature might help direct conservation initiatives by illuminating threats like pollution or habitat degradation and by identifying the optimal conditions for certain fish species. Examining fish migration patterns throughout the year sheds light on reproductive methods, dietary preferences, and ecological requirements. Applying these findings to the preservation of local Piscean biodiversity and the development of effective methods for the management of aquatic ecosystems is the ultimate aim. Further, it stresses the need for preventative conservation measures by fostering a deeper comprehension of the myriad factors influencing the health of our waterways and the fish that inhabit them. This study monitors the seasonal variations in the physico-chemical parameters of river water at different locations of Basirhat.

2. Study Area and methodology:

The three areas chosen for the study are approximately 5 kilometres apart (Figure 1). Zone 1, which is located upstream of the river, is the narrowest area and is bordered by agricultural lands and brick kilns. There are a lot more trees here than at the other two locations. Agricultural plains encircle Zone 2, which is one of the river's biggest sections midstream. Zone 3, which is located downstream of the river, is also a small area bordered by mostly farmland. Monthly water samples were taken at four different sites between February 2022 and February 2023 for a duration of two years. The physico-chemical tests required water samples, which were collected in the morning from the specified sites. The collected samples were kept in a dark place at low temperatures until they could be examined later. Using Mayer's methods, water samples were randomly collected from each site. From each location, at least six water samples were taken, all taken at or near the river's midway. In a designated region, the Mayer's water sampler was lowered to a depth of about 75% of its maximum. To prevent turbidity caused by disturbing the water, precautions were taken. After collecting water samples for BOD analysis, they were quickly frozen in ice packs. A few drops of powerful sulfuric acid were used to preserve the water samples for COD testing. Manganous chloride and alkaline iodide were used to quickly fix water samples after collection for dissolved oxygen analysis. The water samples were brought to the lab in plastic containers for further research, and as soon as they arrived, all the studies began. While collecting samples, a portable kit was used to evaluate parameters impacting water quality, including conductivity and pH, which were subsequently confirmed in the lab. In line with APHA (2017), samples were preserved with appropriate reagents and sent to the lab for thorough chemical analysis in order to determine further parameters. You may find the methods and tools that were used in Table 3.2. Analytical grade (AR) reagents were used in this work, and various solutions were prepared using double-distilled water.

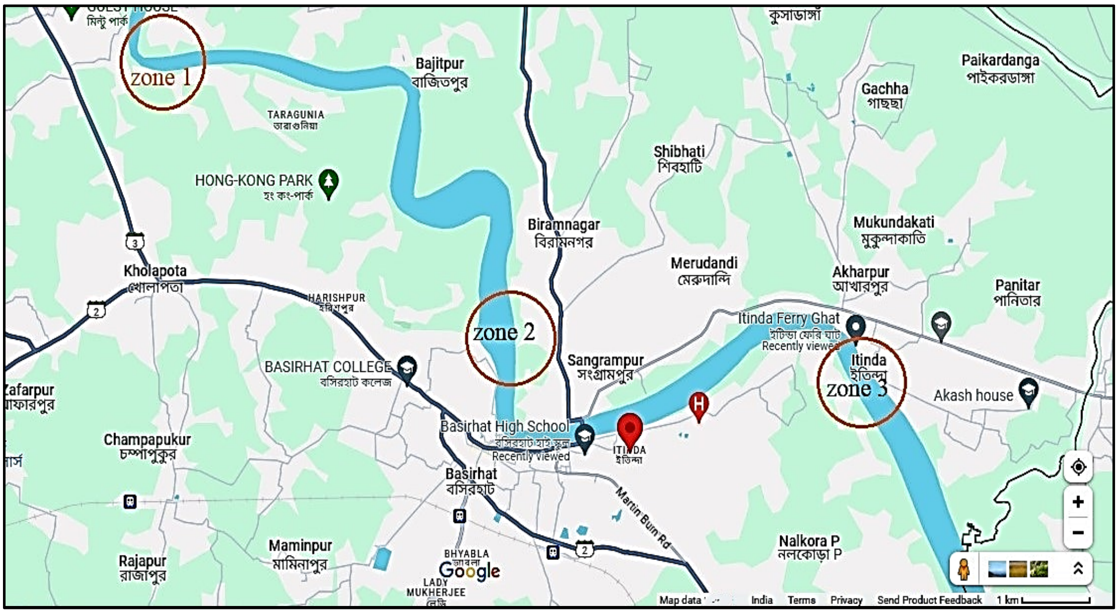


Figure 1: Location of the sampling Sites

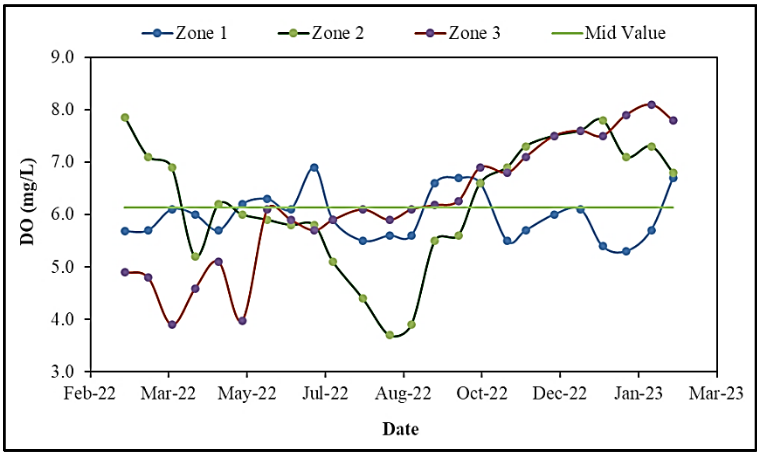
Table 1: Details of the sampling site

S. No.	Location and Geo Coordinates	Characteristics
Zone 1	Harishpur, Basirhat 22°42'36.3"N 88°48'42.3"E	Upstream, Located on the left bank of the Ichamati River in Block Basirhat-I
Zone 2	BasirhatBoardghar, 22°40'38.9"N 88°51'40.0"E	Middle Section. Widest portion of the river in the district. Surrounded by agricultural lands.
Zone 3	Itinda ferry ghat, 22°40'24.0"N 88°54'28.3"E	Downstream. Heavily populated area with a good number of Brick kilns.

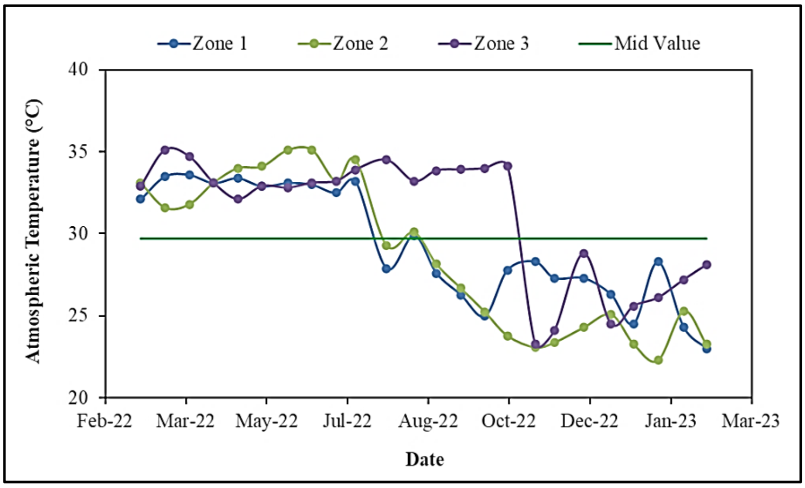
3. Results and Discussion

Seasonal studies on the Ichamati River's water quality at Basirhat provide a comprehensive description of the yearly cycle and the geographical and temporal fluctuations of many physicochemical parameters. The river's ecological rhythms and the pressures from both natural and human-made sources are shown by the examination of dissolved oxygen, water and air temperatures, electrical conductivity, total dissolved solids, pH, turbidity, and biochemical and chemical oxygen demand. Every other week from March 2022 to February 2023, recorded data on water quality, painting a detailed picture of how changing environmental factors affect fish populations and overall aquatic health.

There is a noticeable seasonal cycle and different changes in the dissolved oxygen concentrations across the three research zones. During the summer months of June through August, there is a significant decrease in oxygen levels due to the high water temperatures and increased biological demand. In the colder months of December and January, when metabolic consumption decreases and solubility increases, they recuperate. Of the three zones, Zone 1 is the most consistent with dissolved oxygen levels being around or slightly over the midpoint of 6.1 mg/L for the majority of the year. In contrast, Zone 2 shows the most extreme seasonal variation, with summer seeing sharp dips and winter seeing substantial increases. In Zone 3, the oxygen levels are consistently the lowest, following a pattern similar to Zone 2 but with a lower range. Zone 3 demonstrates the most variability, followed by Zone 2, according to the standard deviation numbers, which support this tendency. In contrast, Zone 1 remains rather constant. Based on these results, aquatic life in Zone 3 may be more stressed out due to its heightened susceptibility to oxygen deprivation episodes. Thermal stratification, photosynthetic cycles, organic decomposition, and pollution all contribute to oxygen changes, which in turn affect the river's ability to support varied fish populations.

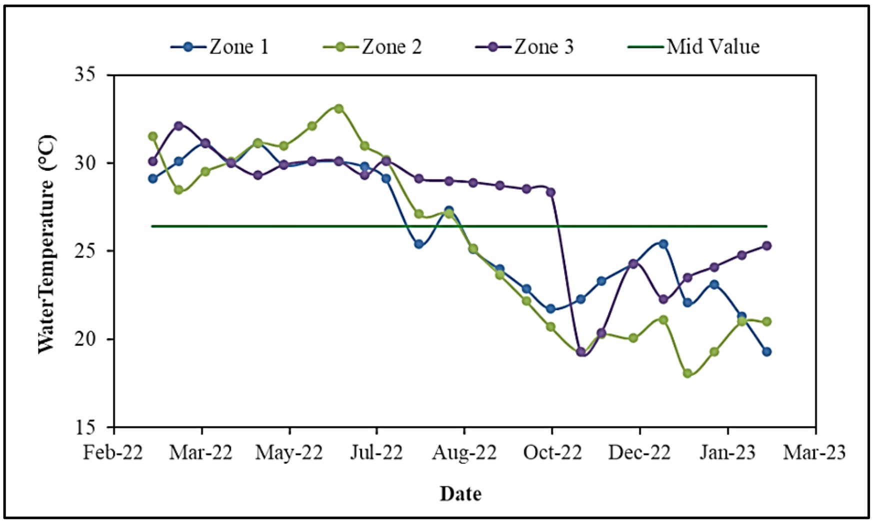


The results of the atmospheric temperature measurements are in agreement with the region's seasonal climate, as expected. During the summer, especially from May to August, with peaks around July, the air temperatures in all three zones reach their maximum points. The winter months of December through February, on the other hand, have the lowest levels. Zone 1 is always the hottest, with temperatures that go above 30 degrees Celsius on a regular basis, while Zone 3 is always the coldest. Zone 1 is probably located in a warmer microclimatic pocket, although the differences across the zones are explained by their different exposures, elevations, and geographical settings. Zone 3 has more consistent weather than Zone 1, and the largest temperature swings occur in Zone 1, according to the standard deviation numbers. Even while these trends are not surprising,

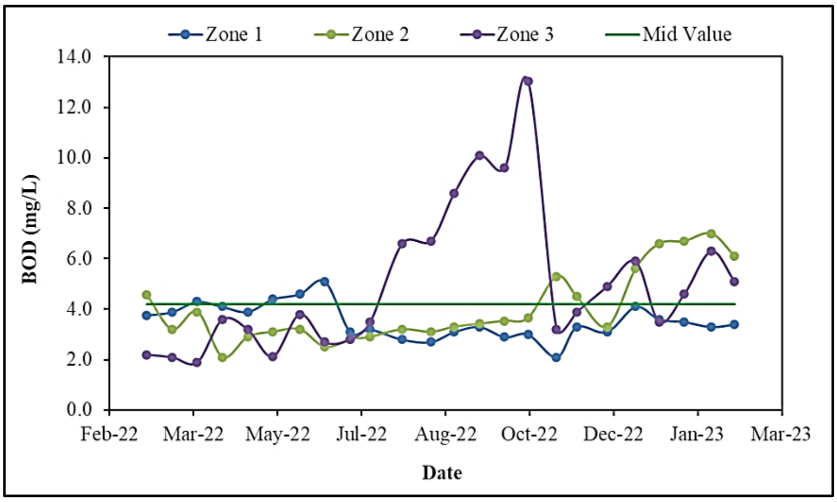


they are significant because the air we breathe has a direct impact on the river's water temperature, evaporation, dissolved oxygen levels, and gas solubility.

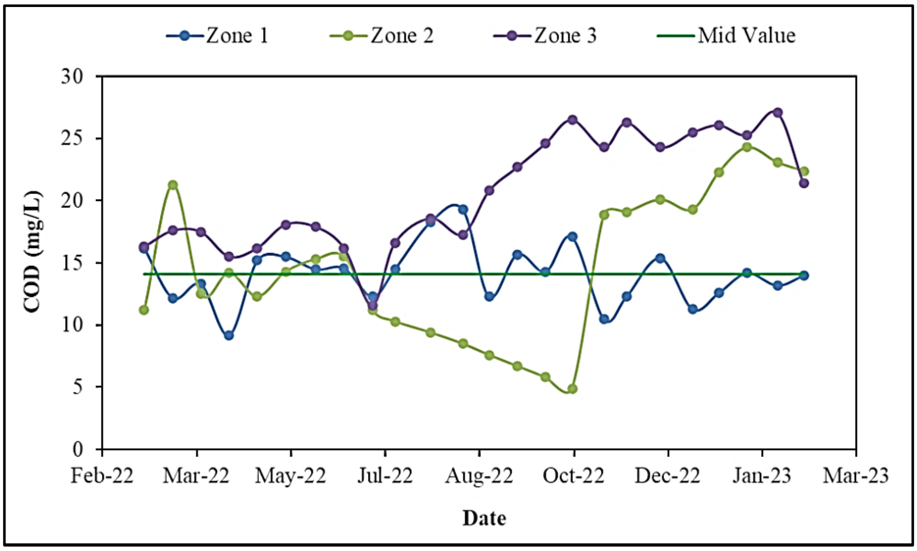
The water temperature data is in perfect agreement with the weather records, showing that summer is when the water is warmest and winter is when it is coldest. Zone 3 shows better stability and continuously lower levels, whereas Zone 1 reaches its peak in July. Zone 2 is still in the middle. A combination of factors, including depth, flow velocity, and localized human influences like water withdrawals and discharges, which can intensify cooling or heating, contribute to these variations. For aquatic creatures, especially fish, the changes are crucial as they determine the metabolic rate of life in the river. Oxygen demand increases in warmer water for a number of reasons, including a decrease in the solubility of dissolved oxygen and an acceleration of respiration and breakdown. Based on the standard deviation values, Zone 1 has the highest level of variability, Zone 2 has a somewhat lower level of variability, and Zone 3 has the lowest level of variability. Shaded circumstances, slower heating, or more consistent hydrology could be the reason for this stability in Zone 3. A good example of how thermal conditions govern oxygen dynamics and impact aquatic ecosystem health is the interplay between air and water temperatures and dissolved oxygen.



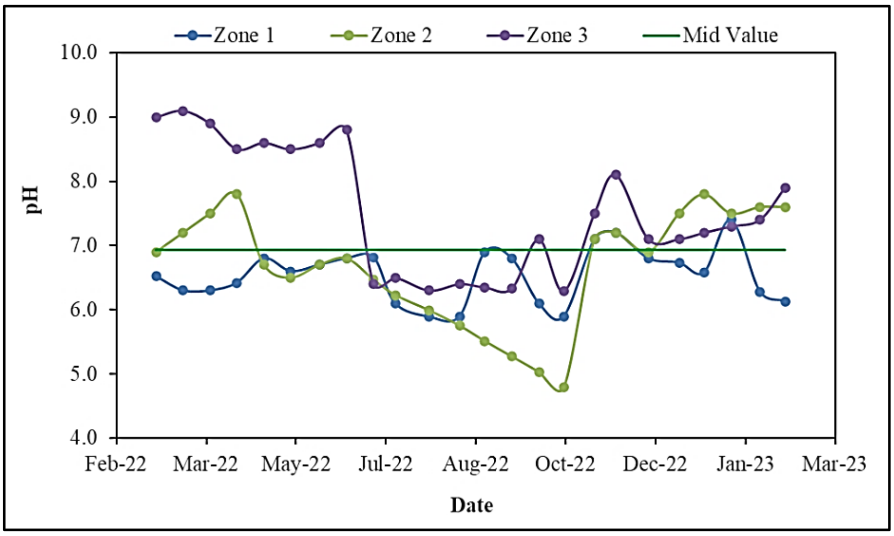
Biological oxygen demand measurements show extremely varied patterns between zones without a discernible seasonal pattern; these measurements reflect the quantity of oxygen needed to breakdown organic materials. Zone 1 stays rather consistent, staying around 4.2 milligrams per liter, which is close to the mid-value line. Zone 2 shows clear variations, with increases in the middle of the year and subsequent significant drops, which may indicate that organic material or effluents are introduced intermittently. Zone 3 is the most unstable, with noticeable highs and lows, including a notable rise in October 2022 that suggests organic load or pollution events. This instability is supported by the standard deviation data, which reveal that Zone 3 is the most variable, Zone 2 is somewhat variable, and Zone 1 is the most stable. The low dissolved oxygen levels and high biochemical oxygen demand in Zone 3 are clear signs that organic loading, such as that from sewage, farms, or factories, is a major problem there. The effects on fish populations are substantial, as hypoxia may become more common in Zone 3.



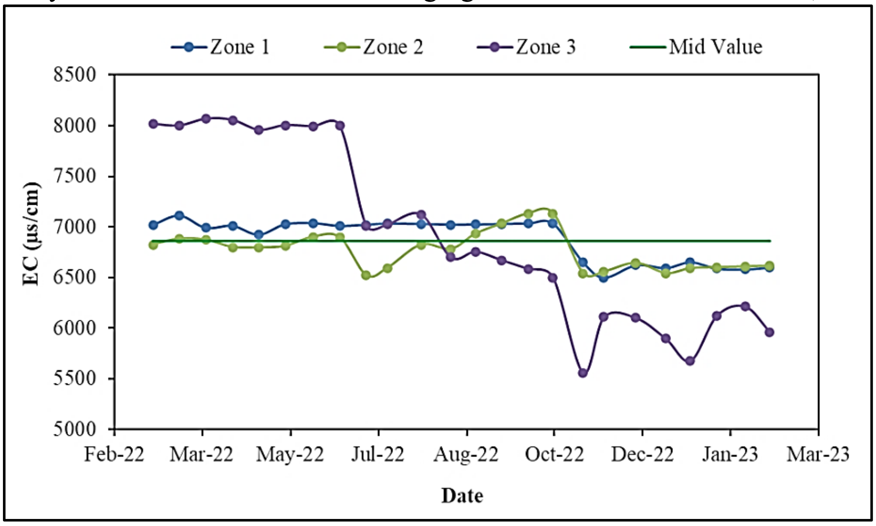
This depiction of chemical and organic stress in the river is further supported by the results of the chemical oxygen demand. Levels of COD, like those of BOD, rise and fall dramatically throughout the year, however they do not follow a predictable seasonal pattern. Zone 1, with its relatively small fluctuations around the midpoint of 14.1 mg/L, is the most consistent. Zone 3 has the biggest swings again, with high peaks in October 2022, and Zone 2 is more unpredictable overall, with some noticeable spikes around the middle of the year. The standard deviation numbers show that Zones 2 and 3 are considerably more variable than Zone 1. Heavy chemical or organic pollutant loads, as indicated by elevated COD levels, may be originating from sources such as agricultural inputs, surface runoff, or domestic wastewater. The COD study, in conjunction with the BOD data, suggests that Zones 2 and 3 are more susceptible to pollution events, and that ecological stress is anticipated to be higher in those zones compared to Zone 1. These areas may have less variety because of the combination of high COD and low dissolved oxygen, which is bad for fish species that are particularly vulnerable.



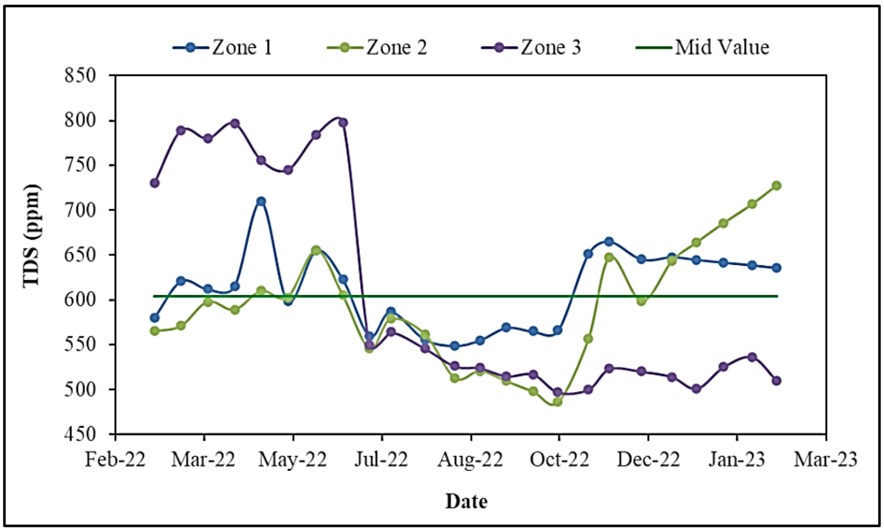
The pH study reveals information about the river's acid-base balance, which impacts the bioavailability of chemicals and the solubility of nutrients and toxicants. Zone 1's pH ranges from about 6.0 in January 2023 to about 9.0 in March 2022, covering a rather large range from acidic to alkaline values. The most variation may be seen in Zone 2, which goes as low as 5.0 in October 2022 and as high as 8.0 in March 2022, whilst Zone 3 stays within the range of 6.0 to 8.0. From March 2022 through January 2023, all zones show a downward tendency, then slightly up again towards March 2023, suggesting a seasonal effect. Zone 3's pH values are more variable and closer to neutral, whereas Zone 1's pH values are typically higher. It is confirmed by the standard deviations that Zone 3 is the least variable, Zone 2 is fairly variable, and Zone 1 is the most variable. Zone 2's acidic swings, which can drop as low as 4.8, might be particularly hard on aquatic life. Rainfall, runoff, decay, and human activity within the catchment area could all have a role in these fluctuations. A change in community composition and a decrease in fish reproductive success at very acidic or basic pH values highlight the significance of pH as a regulator of aquatic biodiversity.



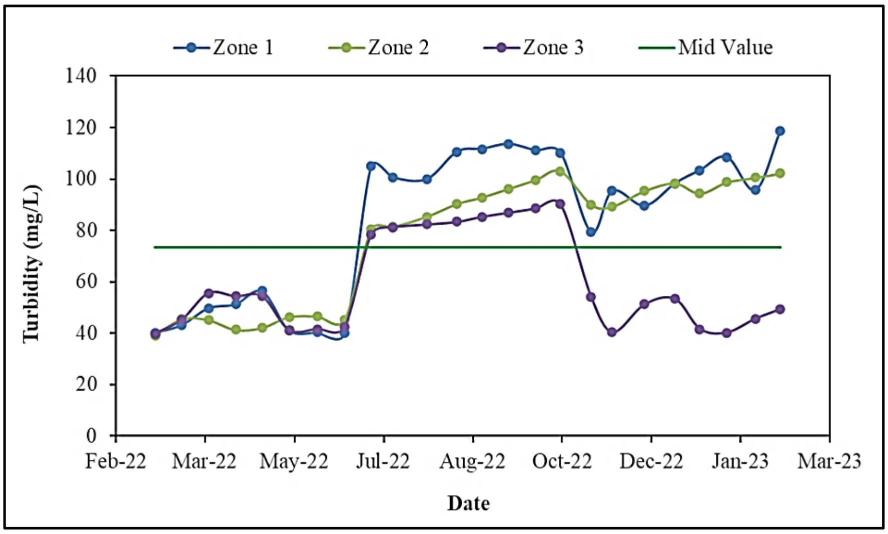
There is a great deal of variation between the zones in the electrical conductivity values, which represent the concentration of dissolved ions. Zone 1 experiences values reaching 8000 mS/cm in March 2022, falling to approximately 7000 mS/cm in January 2023. Zone 2 has values ranging from 7000 to 6500 mS/cm, and Zone 3 has values between 8000 and 5500 mS/cm. Seasonal effects, perhaps associated with cycles of precipitation dilution and evaporation, may explain why conductivity tends to decline for the majority of the year before rising again around March 2023. Although it starts high, Zone 3 records the lowest minimum, whereas Zone 1 continually maintains the highest numbers. According to the measurements of variability, Zone 3 is the least variable, Zone 2 is fairly variable, and Zone 1 is the most scattered. Natural mineral dissolution, tidal influence, or human inputs like fertilizers and effluents could all be contributing to the high conductivity levels in the water. The species makeup of freshwater fish populations can be impacted by salinity and total dissolved solids, which are commonly associated with high conductivity. Salinity and TDS can favor more tolerant species over sensitive ones.



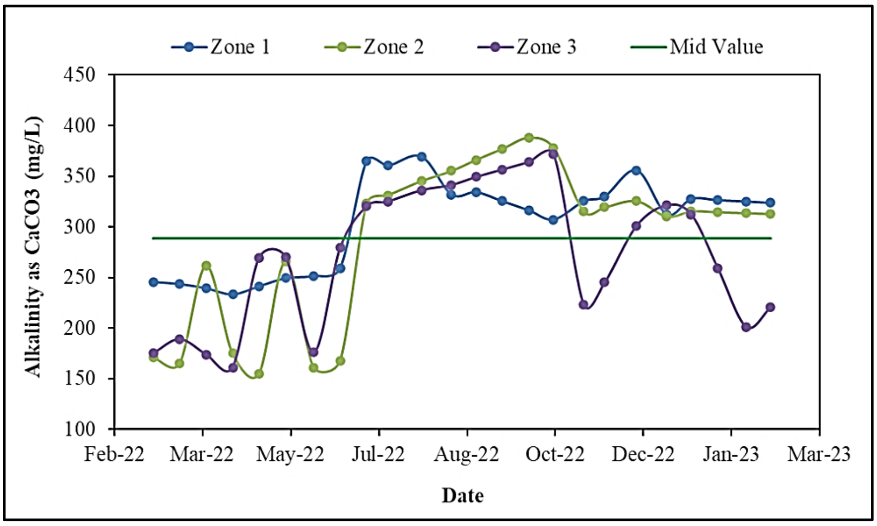
The trends in conductivity are supported by total dissolved solids measurements, which are reported in parts per million. The first zone documents readings between 800 and 550 ppm, the second between 700 and 500 ppm, and the third between 800 and 500 ppm. The total dissolved solids (TDS) also follows a seasonal fall and subsequent rebound by March 2023, similar to the conductivity. According to the variability analysis, Zone 3 displays the most constant pattern, Zone 2 is somewhat variable, and Zone 1 has the biggest fluctuations. High total dissolved solids (TDS) levels indicate that the water contains a significant amount of inorganic salts, which can be caused by either natural processes or human actions. Fish osmoregulation and species distribution are both impacted by elevated TDS. Their strong association is confirmed by the same pattern between TDS and conductivity. While most freshwater creatures can tolerate these ranges, some delicate species may be stressed out by them, which could explain why there are noticeable variations in fish variety across zones.



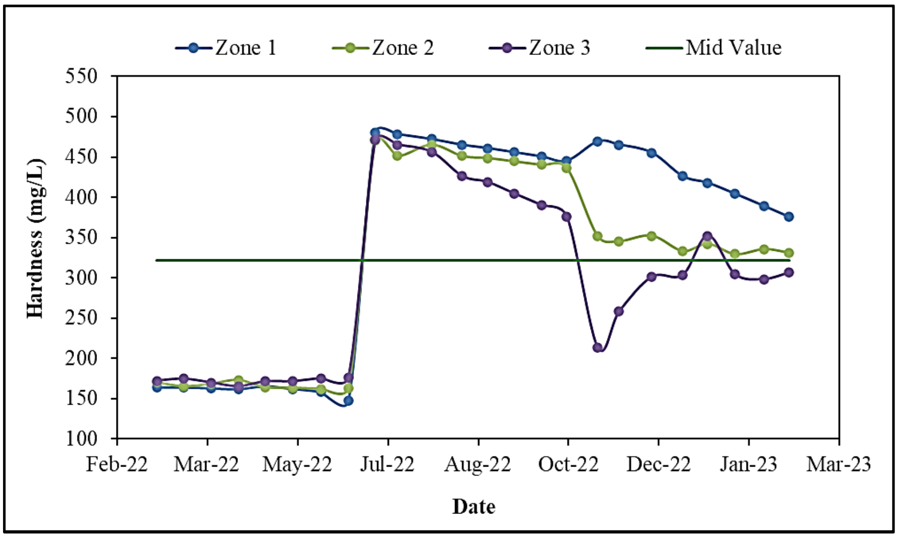
Starting in June 2022, turbidity levels reach a clear seasonal peak throughout all zones. The first zone begins in February at about 50 milligrams/liter and climbs dramatically to over 120 in June, remaining elevated until September, and then falls. Zone 3 begins at roughly 40, rises to around 100 in June, and then falls back to below 60 by October. Zone 2 follows a similar trend, peaking around 110. Zone 1 had the greatest turbidity reading of approximately 125, while Zone 3 had the lowest reading of less than 40. According to the standard deviation values, Zone 3 is the least variable, Zone 2 is intermediate, and Zone 1 is the most variable. In mid-2022, turbidity spiked across the board, suggesting a widespread environmental factor—probably monsoonal rainfall and the accompanying runoff that carried suspended sediments. Because less light can reach the water's surface, photosynthesis suffers, fish gills become clogged, and habitat quality changes due to high turbidity. Zones 1 and 2 show continuous stress on aquatic life due to their long periods above the mid-value of 80, while Zone 3 has generally clearer circumstances, with the exception of the monsoon peak.



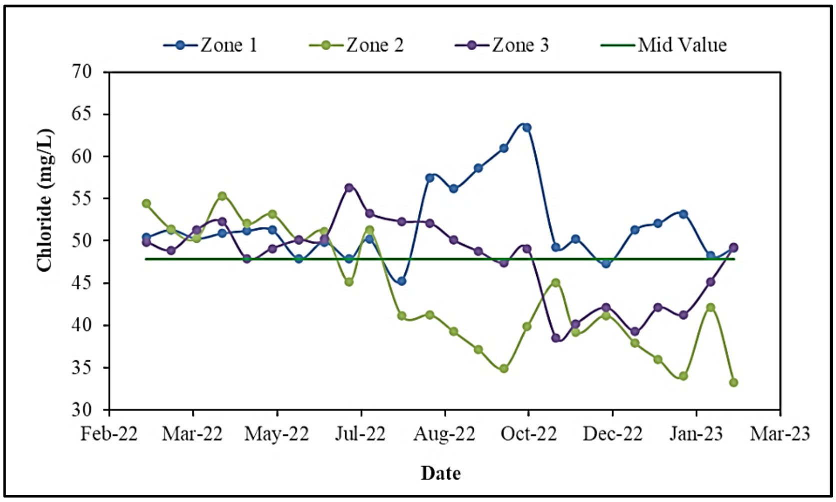
The fluctuations in alkalinity across the three zones offer further insights into the buffering capacity of the Ichamati River waters. Zone 1 recorded its maximum alkalinity in July 2022, approaching 369 milligrams per liter, and its minimum in March 2022 at around 233. Zone 2 rose even higher to nearly 388 in October 2022, with a low point of 155 in March. Zone 3 peaked at about 371 in July and dropped to around 161 in March. A mid-value of 275 provides a useful reference, with all zones crossing above and below it over the course of the year. Variability analysis shows Zone 2 to be the most unstable, with the widest swings, followed by Zone 3, while Zone 1 remains relatively steadier. The pattern indicates an increasing trend in the first half of the study year, culminating in peaks during monsoon and post-monsoon, followed by declines into early 2023. These fluctuations are likely influenced by rainfall, runoff, photosynthetic uptake of carbon dioxide, and human activities such as agriculture and urban discharge. Higher alkalinity can enhance the buffering capacity of the river, preventing drastic pH shifts, but the pronounced variability, especially in Zone 2, indicates a system experiencing strong inputs of external material. For aquatic life, moderate alkalinity helps stabilize habitat conditions, but extreme swings could destabilize ecological processes.



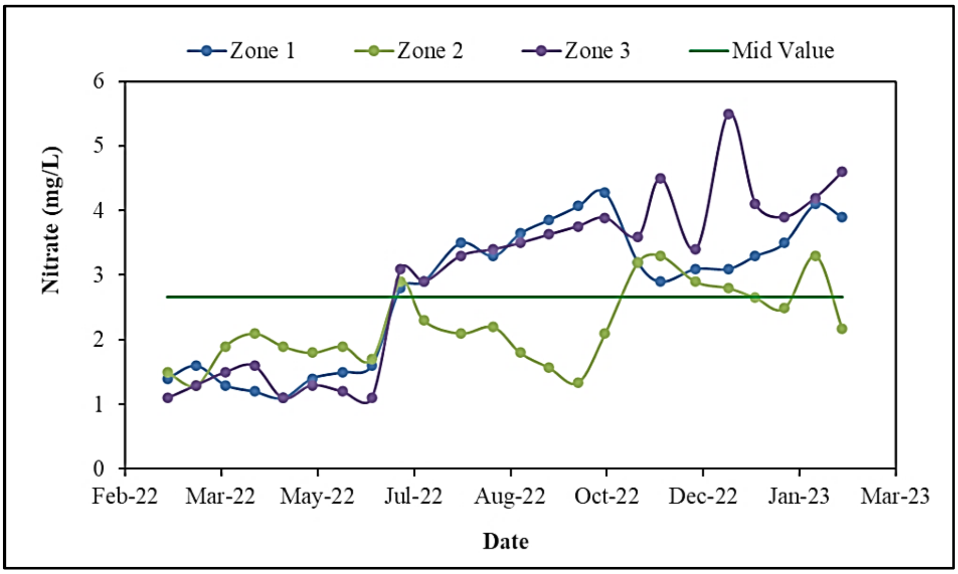
The hardness results show a general downward trend through the year across all zones. In Zone 1, hardness values decreased from a maximum of 480 in March 2022 to around 376 in February 2023, while the minimum rose from 147 to over 331 during the same period, suggesting a narrowing range. Zone 2 also declined, with maximum values dropping from 470 to 336 and minimums rising from 162 to 331. Zone 3 experienced the steepest decline, with maximum hardness falling from 471 to 306 and minimums rising from 165 to nearly 298. These values indicate that although overall hardness is falling, the lower bound is rising, reflecting less variability. The mid-value of 325 again acts as a reference, with all zones alternating above and below it. Zone 1 exhibited the widest range of hardness values, with the highest standard deviation, while Zones 2 and 3 were more consistent, with Zone 3 being the most stable. Hardness is governed by concentrations of calcium and magnesium salts, and its decline could be attributed to dilution by rainfall, seasonal hydrological processes, or reduced inflows of mineral-rich waters. From an ecological perspective, hardness influences shell formation, osmoregulation, and tolerance ranges for fish and invertebrates. Moderate hardness is generally favorable, while extreme values or large fluctuations may disrupt biological processes. The decreasing trend could signal changing geochemical contributions or anthropogenic alterations in water sourcing.



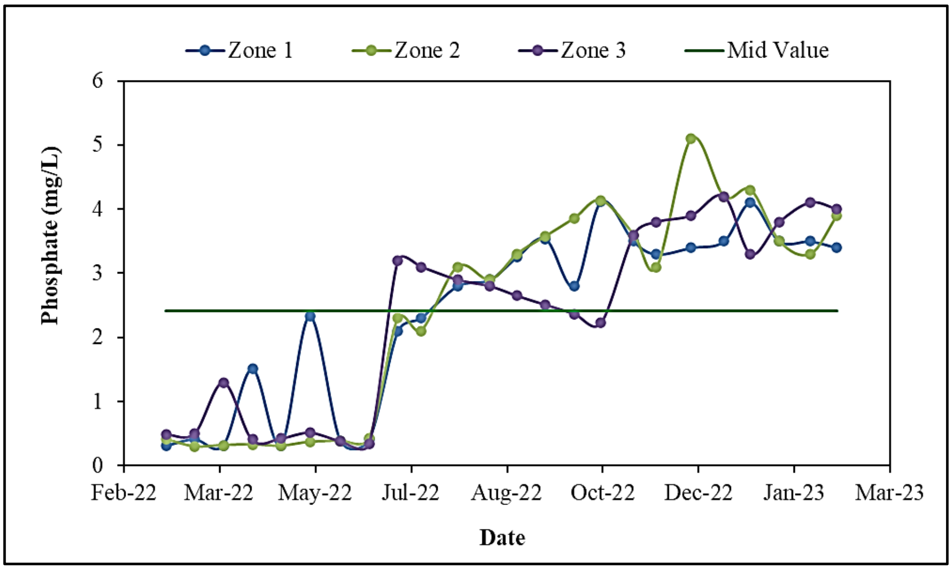
Chloride levels in the river remained comparatively stable but showed important differences among zones. Zone 1 fluctuated between about 50 and 65 milligrams per liter, with a maximum in October 2022. Zone 2 ranged from a low of 33 to a high of 58, while Zone 3 varied between 40 and 55. The mid-value reference of about 47 shows that Zone 1 consistently maintained higher baseline chloride concentrations, Zone 2 showed the widest swings, and Zone 3 remained moderate. The standard deviation analysis confirms this, with Zone 2 recording the highest variability and Zone 1 the lowest. These values are well within freshwater tolerances, but the fluctuations suggest episodic chloride inputs, likely from anthropogenic sources such as agriculture or wastewater. Chloride is a conservative ion, often tracing sewage or saline intrusion. Its relatively stable presence, with occasional rises, provides a signal of external inputs into the river. For aquatic life, chloride at these levels is not directly harmful but serves as a proxy for human impact, particularly in Zone 2 where variability is greatest.



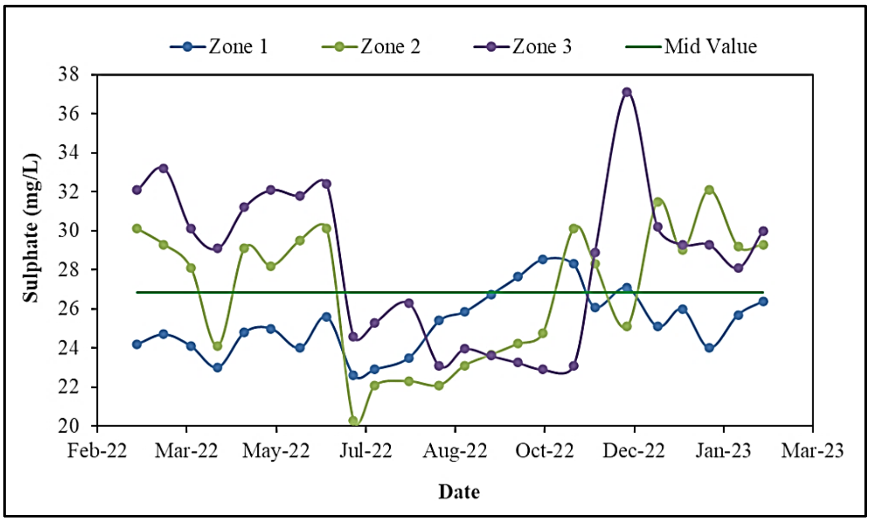
The nitrate results present a different picture, with clear evidence of increasing levels across the study period. Zone 1 rose from a maximum of 1.6 in March 2022 to 4.1 by February 2023, while the minimum increased from 1.1 to 2.7. Zone 2 also rose, though less steeply, with maximum values going from 2.1 to 3.3 and minimums from 1.3 to 2.2. Zone 3 recorded the sharpest increases, with maximum nitrate climbing from 1.6 to 5.5 and minimums from 1.1 to 3.4. This general upward trend indicates increasing nutrient enrichment of the river, particularly evident in Zone 3. Standard deviation figures again show Zone 3 as the most variable, Zone 1 moderately so, and Zone 2 the least. Peaks observed around August 2022 suggest agricultural runoff or episodic discharges during the monsoon season. Elevated nitrate levels pose risks of eutrophication, algal blooms, and oxygen depletion, all of which degrade habitat quality for fish. The increasing trend throughout the year underscores growing anthropogenic nutrient inputs into the Ichamati, which could significantly alter the river's ecological balance if sustained.



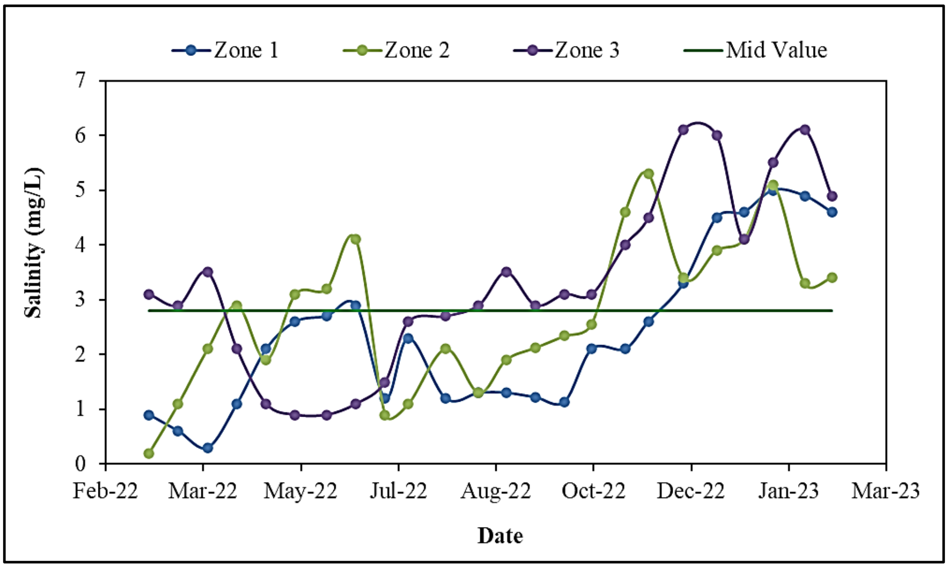
Phosphate results also demonstrate seasonal variability, with a tendency for higher levels in warmer months and declines in winter. Zone 1 ranged between 0.3 and 4.1 milligrams per liter, with the highest in October 2022. Zone 2 exhibited the greatest range, from 0.3 to 5.1, with peaks in December. Zone 3 ranged from 0.4 to 4.2, peaking in December as well. A mid-value of 2.4 provides a threshold reference, with all zones surpassing it at times. Variability analysis confirms Zone 2 to be the most unstable, followed by Zone 3 and then Zone 1. The seasonal rise in phosphate coincides with increased biological activity and potential inputs from fertilizer runoff during the monsoon and post-monsoon. Elevated phosphate, combined with rising nitrate, creates conditions conducive to eutrophication. The differences among zones suggest localized inputs, with Zone 2 receiving the highest nutrient loads. Such nutrient enrichment, while stimulating productivity, risks destabilizing aquatic ecosystems and reducing fish diversity if unchecked, as excessive algae growth and oxygen depletion follow.



Sulphate levels followed a distinct upward trajectory through much of the study year. Zone 1 ranged between 22.6 and 28.6 milligrams per litre, Zone 2 between 20.3 and 32.1, and Zone 3 between 22.9 and 37.1. The highest concentrations occurred in December 2022 across all zones, followed by a decline and stabilization into February 2023. Zone 3 consistently recorded the highest sulphate values and the widest range, while Zone 1 remained the lowest and most stable. The seasonal pattern of higher sulphate in winter months may be linked to reduced dilution, concentration effects, and runoff containing sulphate compounds. Elevated sulphate at these levels is not acutely toxic but may affect taste, scaling, and indirectly influence aquatic ecology. The variability across zones again highlights Zone 3 as more impacted by chemical changes. Fish and invertebrates sensitive to ionic composition may find fluctuating sulphate stressful, though moderate levels are typically tolerated. Nonetheless, the increasing trend, especially in Zone 3, suggests cumulative inputs of sulphate-bearing materials, potentially from fertilizers, industry, or geology.



Salinity, closely related to conductivity and TDS, displayed significant variation across the zones. Zone 1 ranged between 0.3 and 5 parts per thousand, Zone 2 between 0.2 and 5.3, and Zone 3 between 0.9 and 6.1. Peaks occurred in winter months, particularly December 2022 and January 2023, while minimums were observed in February 2022. The variability was greatest in Zone 3, which consistently showed higher average salinity and wider swings, while Zone 2 recorded the lowest minimum. This indicates that Zone 3 is more subject to saline intrusion or concentration processes. Seasonal patterns show salinity declining in summer with freshwater inflows and rising in winter with reduced flow and increased evaporation. The elevated salinity in Zone 3 may affect freshwater fish diversity, favoring more tolerant species while excluding sensitive ones. The implications are significant for livelihoods dependent on freshwater fish, as changes in salinity may shift the community composition and reduce productivity.



When taken together, the results of dissolved oxygen, biochemical and chemical oxygen demand, pH, conductivity, total dissolved solids, turbidity, alkalinity, hardness, chloride, nitrate, phosphate, sulphate, and salinity paint a complex picture of the Ichamati River's ecological dynamics in the Basirhat region. The data show that Zone 1 remains the most stable across most parameters, maintaining relatively favorable conditions with fewer extreme fluctuations. Zone 2 consistently exhibits moderate to high variability, with several parameters such as pH, phosphate, and chloride showing pronounced swings, suggesting localized anthropogenic inputs. Zone 3 emerges as the most stressed zone, with the lowest dissolved oxygen, highest biochemical and chemical oxygen demand, elevated and rising nitrate and sulphate levels, higher salinity, and greater variability across most parameters. This indicates that Zone 3 is the most vulnerable and potentially degraded section of the river, with ecological consequences for fish diversity and water quality.

The seasonal influences are also clear. Summer months, characterized by high temperatures, low dissolved oxygen, and increased demand, represent stressful conditions for aquatic organisms. Monsoon months bring spikes in turbidity, nutrient loads, and variability due to heavy runoff. Winter months offer some recovery in oxygen levels but also coincide with peaks in conductivity, sulphate, and salinity, potentially concentrating pollutants. Thus, the river undergoes a cyclical pattern of stress and recovery, shaped by both natural hydrology and human activities.

The implications of these findings for the diversity of piscean species are significant. Fish require stable conditions for spawning, feeding, and growth. Fluctuations in oxygen, high turbidity, nutrient enrichment, and salinity intrusion all limit the availability of suitable habitats. Sensitive species are likely to be excluded from Zones 2 and 3, leaving more tolerant species dominant. This reduction in diversity impacts livelihoods, as local communities depend heavily on fisheries for food and income. Declines in fish availability and shifts in species composition reduce economic returns and undermine food security. Furthermore, the deteriorating water quality parameters also threaten agriculture, domestic water use, and overall ecological resilience.

The discussion emphasizes the need for continued monitoring and management of water quality in the Ichamati River. Identifying sources of pollution, regulating effluents, managing agricultural runoff, and restoring ecological balance are crucial steps. The clear zonal differences highlight that interventions may need to be targeted, with Zone 3 requiring urgent attention. The seasonal patterns also suggest that particular times of year, such as summer low flows and monsoon high flows, are critical for management to prevent ecological degradation.

Overall, the results and discussion of the study reveal that the Ichamati River at Basirhat is under considerable ecological stress, with clear evidence of anthropogenic influence on water quality parameters. While natural seasonal cycles drive predictable variations, the magnitude and variability observed, particularly in nitrate, phosphate, sulphate, salinity, and oxygen dynamics, indicate external pressures that threaten aquatic health and fish diversity. These findings provide a foundation for developing strategies to improve water quality, safeguard fish populations, and sustain the livelihoods of communities dependent on the river.

4. Conclusions:

The detailed examination of water quality parameters in the Ichamati River at Basirhat reveals a system influenced by natural seasonal patterns and human activities, showcasing clear spatial differences across the three study zones. The levels of dissolved oxygen, temperature, turbidity, biochemical and chemical oxygen demand, along with nutrient dynamics, demonstrate consistent cycles associated with summer stress, monsoon runoff, and winter recovery. However, the extent of these fluctuations indicates considerable human impact. Zone 1 is characterized by relative stability, while Zone 2 shows moderate fluctuations associated with episodic inputs. In contrast, Zone 3 is notably degraded, exhibiting persistently low oxygen levels, high organic loads, increased nutrient concentrations, and heightened salinity intrusion. The conditions exert a direct influence on the river’s capacity to support a variety of fish populations, leading to a decline in sensitive species while only tolerant forms endure in compromised habitats. The results highlight that ecological resilience is diminishing, putting at risk the livelihoods of communities reliant on fisheries and agricultural productivity. The investigation emphasizes the critical necessity for efficient management of water quality, encompassing the regulation of effluents, oversight of agricultural runoff, and the implementation of community-driven conservation efforts. Protecting the ecological health of the Ichamati is crucial, not just for biodiversity, but also for maintaining the sustainability of the socio-economic structure of the Basirhat region.

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