World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

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Sustainability and water quality management in Chaltia Beel: Addressing ecological and public health challenges

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World Journal of Advanced Research and Reviews, 2024, 23(01), 862–868

Publication history: Received on 31 May 2024; revised on 08 July 2024; accepted on 10 July 2024

Article DOI: https://doi.org/10.30574/wjarr.2024.23.1.2076

Abstract

This study evaluates the water quality of Chaltia Beel, a significant wetland in Murshidabad, West Bengal, India. Chaltia Beel serves as a crucial habitat for a variety of aquatic species and supports local communities through its use in agriculture and fisheries. The primary objective of this research is to assess the microbiological and chemical characteristics of the beel's water to determine its suitability for ecological and human use. Water samples were collected from three different sites within the beel during the post-monsoon season of 2023. The parameters analyzed include pH, temperature, total dissolved solids (TDS), turbidity, dissolved oxygen (DO), nitrate (NO3), phosphate (PO4), ammoniacal nitrogen, total alkalinity, and total coliform bacteria. Standard methods prescribed by the American Public Health Association (APHA) and the Indian Standards Institution (ISI) were employed for the analyses. The results indicate that the pH values (7.74 to 7.77) are within the neutral range, which is favorable for most aquatic life. The temperature of the water (28.1°C to 28.2°C) is stable and conducive to the ecosystem. TDS levels (398 mg/l to 406 mg/l) are within acceptable limits, though continuous monitoring is recommended to detect any potential increases. Turbidity levels (1.1 NTU to 1.4 NTU) are low, indicating good water clarity. DO levels (6.3 mg/l to 6.6 mg/l) are adequate to support aerobic aquatic organisms. Nitrate levels were consistently below 0.5 mg/l, suggesting minimal agricultural runoff impact. However, phosphate levels (1.38 mg/l to 1.41 mg/l) are relatively high, indicating a risk of eutrophication. Ammoniacal nitrogen levels (0.56 mg/l to 0.61 mg/l) are within acceptable limits but need monitoring to prevent potential toxicity. Total alkalinity (277.4 mg/l to 285 mg/l) provides a good buffering capacity, maintaining pH stability. Microbiological analysis revealed significant contamination with total coliform bacteria ranging from 190 to 204 CFU/100ml, which highlights potential health risks if the water is used for drinking or recreational purposes. The study concludes that while some water quality parameters of Chaltia Beel are within acceptable limits, others require attention to prevent environmental and health issues. Regular monitoring, pollution control, public awareness, habitat restoration, and sustainable practices are recommended to improve and maintain the water quality of Chaltia Beel. These efforts are essential for preserving the ecological health of the wetland and ensuring its continued benefit to the local communities.

Keywords: Water quality; Wetland; Chaltia Beel; Murshidabad; Microbiological and chemical parameters

1. Introduction

Wetlands are critical ecosystems that play a vital role in maintaining biodiversity, supporting a diverse array of plant and animal life, and providing essential ecosystem services such as water storage, flood control, and nutrient cycling (Mitsch & Gosselink, 2015). Among these valuable wetlands is Chaltia Beel, located in the Murshidabad district of West Bengal, India. Chaltia Beel is an important freshwater wetland that supports local communities through agriculture, fisheries, and other livelihoods (Gopal, 2013). The health of this wetland is directly influenced by its water quality, which affects both ecological functions and human use. Water quality in wetlands is a significant indicator of the overall health

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of the ecosystem. Various factors, including agricultural runoff, industrial discharges, and domestic waste, can impact water quality, leading to issues such as eutrophication, loss of biodiversity, and health hazards for local populations. Therefore, regular monitoring and assessment of water quality parameters are essential to ensure the sustainability of wetland ecosystems (Smith et al., 2003). This study aims to evaluate the water quality of Chaltia Beel by analyzing a series of microbiological and chemical parameters. These parameters include pH, temperature, total dissolved solids (TDS), turbidity, dissolved oxygen (DO), nitrate (NO3), phosphate (PO4), ammoniacal nitrogen, total alkalinity, and total coliform bacteria. By assessing these parameters, the study seeks to provide a comprehensive understanding of the current state of the water quality in Chaltia Beel. The specific objectives of this study are to determine the suitability of Chaltia Beel's water for ecological and human use, identify potential sources of contamination, and recommend measures for improving and maintaining water quality. This research is particularly relevant given the increasing pressures on wetlands from human activities and climate change, which necessitate informed management and conservation strategies. Through systematic sampling and analysis conducted during the post-monsoon season of 2023, this study provides valuable insights into the water quality of Chaltia Beel. The findings will contribute to the development of effective conservation and management plans, ensuring the long-term sustainability of this vital wetland ecosystem and the well-being of the communities that depend on it.

2. Materials and Methods

2.1. Study Area

Chaltia Beel is located in the Murshidabad district of West Bengal. It is a prominent wetland that supports a diverse range of aquatic life and provides water for agricultural and domestic purposes (Mahanayak et al., 2020).

2.2. Sample Collection

Water samples were collected from Chaltia Beel during the post-monsoon season, from September to November 2023. The water samples were collected from three sites of the beel:

- Site-1: Near Bhakuri Fishermen Cooperative Office
- Site-2: Near Raghunathtala Temple
- Site-3: Near Radhamadhab Temple, Ajodhya Nagar

The samples were collected as per standard methods and marked as "Surface Water." The analysis of water quality parameters was done as per standard methods of APHA (2023).

2.3. Analytical Methods

2.3.1. Microbiological Analysis

Total Coliform Bacteria (CFU/100ml): Measured using the APHA 24th Edition 2023, 9222B method (APHA, 2023).

2.3.2. Chemical Analysis

- **pH:** Measured using the APHA 24th Edition 2023, 4500H+ method (APHA, 2023).
- **Temperature:** Assessed using the IS 3025 (Part 9)-1984 RA: 2006 method (ISI, 1984).
- **Total Dissolved Solids (TDS):** Determined using the APHA 24th Edition 2023, 2540 B method (APHA, 2023).
- **Turbidity:** Measured using the APHA 24th Edition 2023, 2130 B method (APHA, 2023).
- **Dissolved Oxygen (DO):** Analyzed using the APHA 24th Edition 2023, 4500-O-C method (APHA, 2023).
- **Nitrate (NO3):** Assessed using the APHA 24th Edition 2023, 4500 N method (APHA, 2023).
- **Phosphate (PO4):** Measured using the APHA 24th Edition 2023, 4500P-D method (APHA, 2023).
- **Ammoniacal Nitrogen:** Determined using the APHA 24th Edition 2023, 4500NH3-F method (APHA, 2023).
- **Total Alkalinity:** Analyzed using the IS 3025 (Part 23)-1986, RA: 2019 method (ISI, 1984).

3. Results and Discussion

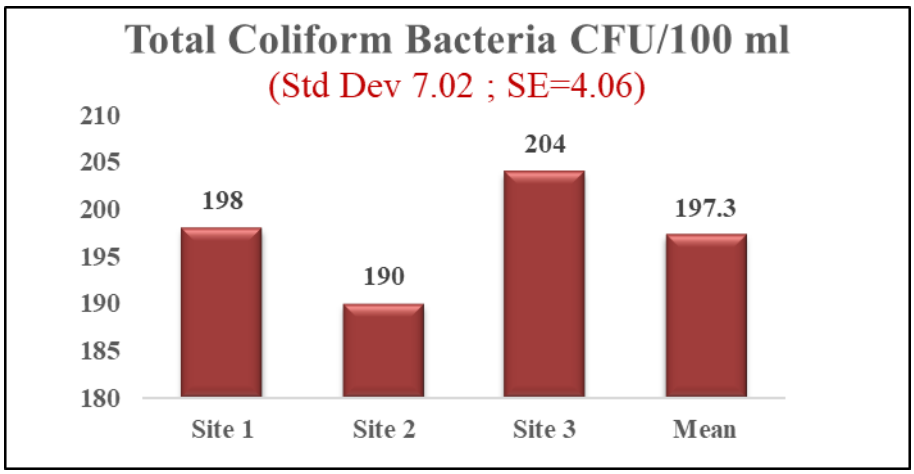
3.1. Microbiological Analysis

Table 1 Water Quality Parameter: Microbiological

Characteristic	Test Method	Result			Mean	Standard Deviation	Standard Error
		Site-1	Site-2	Site-3			
Total Coliform Bacteria CFU/100ml	APHA 24th Edition 2023,9222B	198	190	204	197.3	7.02	4.06

Source: Primary survey

Total Coliform Bacteria: The total coliform count ranged from 190 to 204 CFU/100ml, with a mean of 197.3 CFU/100ml and a standard deviation of 7.02. These levels indicate significant microbial contamination, which may pose health risks if the water is used for drinking or recreational purposes (WHO, 2017).



Source: Primary Survey

Figure 1 Graphical Representation of Water Quality Parameter: Microbiological

3.2. Chemical Analysis

Table 2 Water Quality Parameters: Chemical

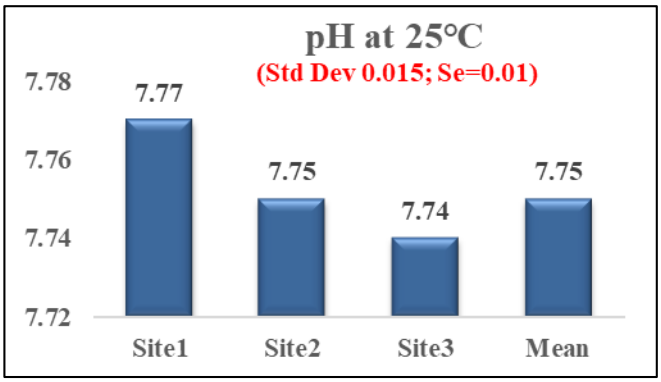
Sl. No.	Characteristic	Test Method	Result			Mean	Standard Deviation	Standard Error
			Site-1	Site-2	Site-3			
1	pH at 25˚C	APHA 24th Edition 2023,4500H+	7.77	7.75	7.74	7.75	0.015	0.01
2	Temperature in ˚C	IS 3025 (Part 9)-1984 RA:2006	28.1	28.2	28.2	28.17	0.058	0.03
3	Total Dissolved Solid in mg/l	APHA 24th Edition 2023,2540B	406	398	402	402	4.000	2.31
4	Turbidity in NTU	APHA 24th Edition 2023,2130B	1.1	1.2	1.4	1.23	0.153	0.09
5	Dissolved Oxygen (DO) in mg/l	APHA 24th Edition 2023, 4500-O-C	6.3	6.4	6.6	6.43	0.153	0.09

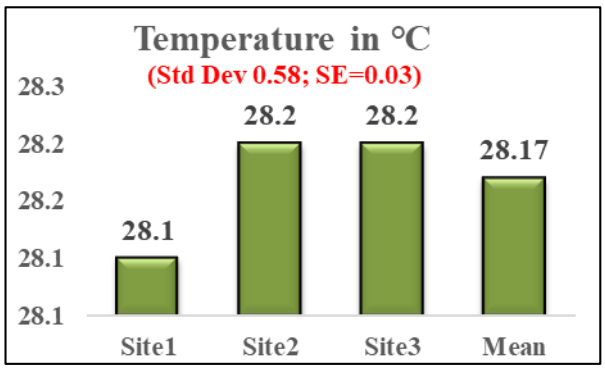
6	Nitrate (as NO_3) in mg/l	APHA 24th Edition 2023,4500N	<0.5	<0.5	<0.5	<0.5	0.00	0.00
7	Phosphate (PO_4) in mg/l	APHA 24th Edition 2023,4500P-D	1.41	1.38	1.40	1.40	0.015	0.01
8	Ammoniacal Nitrogen as in mg/l	APHA 24th Edition 2023,4500NH_3-F	0.58	0.56	0.61	0.58	0.025	0.01
9	Total Alkalinity as ($CaCO_3$) in mg/l	IS 3025 (Part 23)-1986,RA:2019	281.2	277.4	285	281.2	3.80	2.19

Source: Primary survey

3.2.1. Chemical Analysis

- **pH:** The pH values were between 7.74 and 7.77, averaging 7.75 with a standard deviation of 0.015. These values are within the neutral range, suitable for most aquatic life (APHA, 2023; Boyd, 2020).
- **Temperature:** The water temperature ranged from 28.1°C to 28.2°C, averaging 28.17°C with a standard deviation of 0.058, indicating a stable thermal condition conducive to aquatic habitats (ISI, 1984; Bhatnagar & Devi, 2013).
- **Total Dissolved Solids (TDS):** TDS levels ranged from 398 mg/l to 406 mg/l, with an average of 402 mg/l and a standard deviation of 4.000. High TDS levels can affect water taste and health, but these levels are within acceptable limits for most uses (APHA, 2023; Kumar et al., 2019).
- **Turbidity:** Turbidity values ranged from 1.1 NTU to 1.4 NTU, with an average of 1.23 NTU and a standard deviation of 0.153. Low turbidity indicates good water clarity, beneficial for light penetration and photosynthesis in aquatic systems (APHA, 2023; Singh & Rai, 2022).
- **Dissolved Oxygen (DO):** DO levels were between 6.3 mg/l and 6.6 mg/l, with an average of 6.43 mg/l and a standard deviation of 0.153. Adequate DO is critical for aerobic aquatic life (APHA, 2023; Wetzel, 2001).
- **Nitrate (NO3):** Nitrate levels were consistently below 0.5 mg/l, indicating minimal nitrogen pollution and suggesting that agricultural runoff is not significantly impacting the beel (APHA, 2023; WHO, 2011).
- **Phosphate (PO4):** Phosphate levels ranged from 1.38 mg/l to 1.41 mg/l, averaging 1.40 mg/l with a standard deviation of 0.015. High phosphate levels can lead to eutrophication, promoting excessive growth of algae that can deplete oxygen levels in the water (APHA, 2023; Smith et al., 2003).
- **Ammoniacal Nitrogen:** Ammoniacal nitrogen ranged from 0.56 mg/l to 0.61 mg/l, averaging 0.58 mg/l with a standard deviation of 0.025. Elevated levels can be toxic to fish and other aquatic organisms (APHA, 2023; Sawyer et al., 2003).
- **Total Alkalinity:** Alkalinity levels ranged from 277.4 mg/l to 285 mg/l, averaging 281.2 mg/l with a standard deviation of 3.80. Alkalinity helps buffer pH changes, supporting a stable aquatic environment (ISI, 1984; Boyd, 2020).





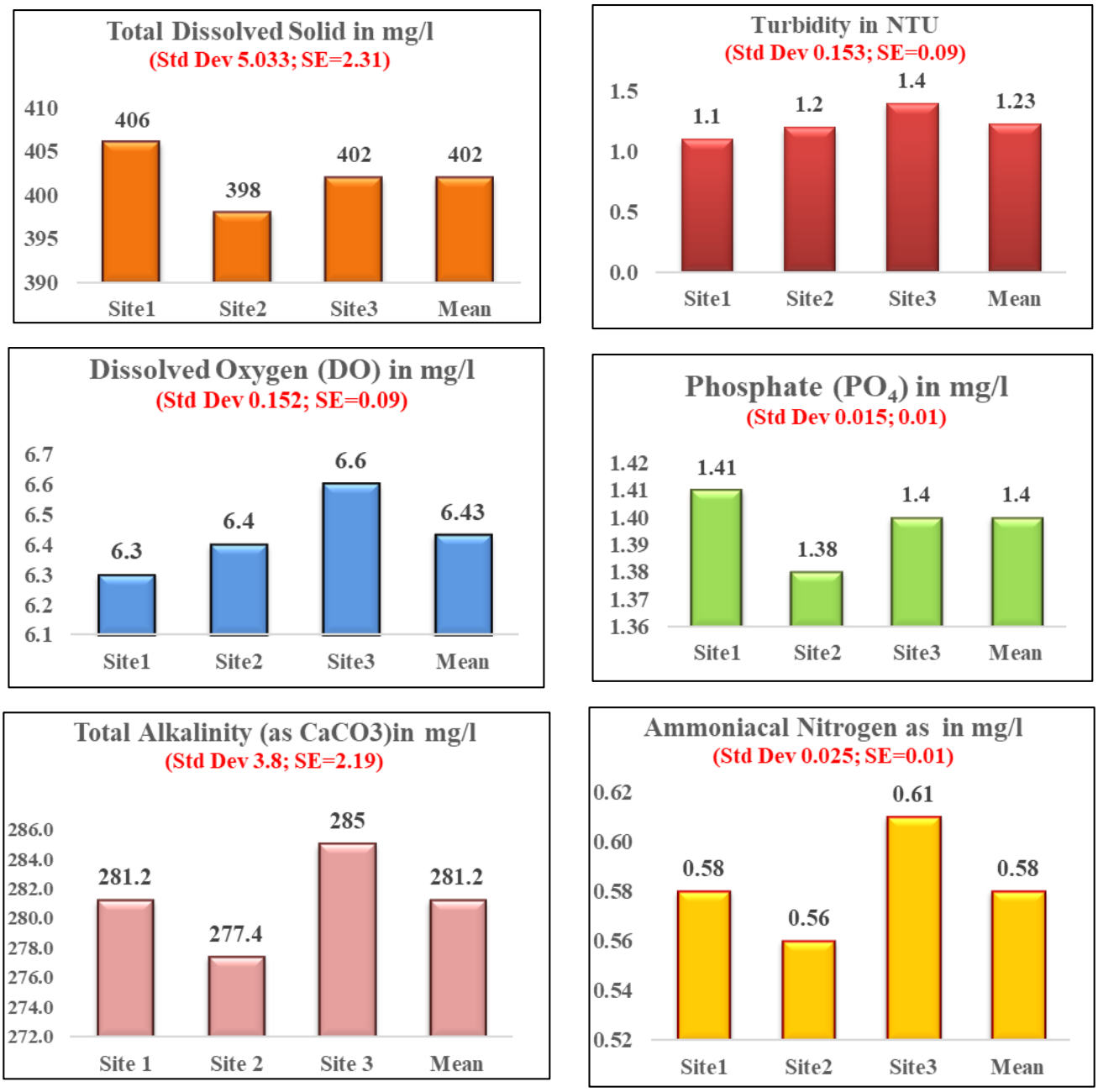


Figure 2 Graphical representation of Water Quality Parameters: Chemical

3.3. Microbiological Quality

The presence of coliform bacteria in Chaltia Beel suggests contamination from human or animal waste. While the levels are not alarmingly high, they do indicate a need for regular monitoring and potential remediation measures to prevent health risks (APHA, 2023; WHO, 2017).

3.4. Chemical Quality

- **pH:** The neutral pH of Chaltia Beel is suitable for most aquatic life, indicating a balanced aquatic environment (APHA, 2023; Boyd, 2020).
- **Temperature:** The stable temperature range observed is conducive to the growth and reproduction of aquatic organisms. Seasonal variations should be monitored to ensure that extreme temperatures do not adversely affect the ecosystem (ISI, 1984; Bhatnagar & Devi, 2013).
- **Total Dissolved Solids (TDS):** While the TDS levels are within acceptable limits, continued monitoring is necessary to detect any potential increases that could affect water quality (APHA, 2023; Kumar et al., 2019).

- **Turbidity:** Low turbidity indicates good water clarity, which is beneficial for photosynthetic aquatic plants. However, it is important to monitor for any sudden increases in turbidity, which could indicate pollution or sediment runoff (APHA, 2023; Singh & Rai, 2022).
- **Dissolved Oxygen (DO):** Adequate DO levels are a positive indicator of water quality, supporting the survival of aerobic organisms. It is crucial to maintain these levels to prevent hypoxic conditions that could harm aquatic life (APHA, 2023; Wetzel, 2001).
- **Nitrate (NO3):** The consistently low nitrate levels suggest minimal agricultural runoff, which is beneficial for preventing eutrophication and maintaining water quality (APHA, 2023; WHO, 2011).
- **Phosphate (PO4):** The relatively high phosphate levels indicate a risk of eutrophication, which can lead to algal blooms and oxygen depletion. Efforts should be made to reduce phosphate inputs into the beel (APHA, 2023; Smith et al., 2003).
- **Ammoniacal Nitrogen:** The levels of ammoniacal nitrogen are within acceptable limits, but it is important to monitor for any increases that could indicate contamination from sewage or agricultural runoff (APHA, 2023; Sawyer et al., 2003).
- **Total Alkalinity:** High alkalinity levels help buffer pH changes, supporting a stable aquatic environment. Maintaining these levels is important for the overall health of the ecosystem (ISI, 1984; Boyd, 2020).

Recommendations

Based on the findings, the following recommendations are made to improve and maintain the water quality of Chaltia Beel:

- **Regular Monitoring:** Continuous monitoring of microbiological and chemical parameters is essential to detect any changes in water quality and take timely corrective measures (Gopal, 2013; Wetzel, 2001).
- **Pollution Control:** Efforts should be made to reduce sources of pollution, such as sewage discharge and agricultural runoff, to prevent contamination of the beel (Smith et al., 2003; WHO, 2017).
- **Public Awareness:** Raising awareness among local communities about the importance of protecting wetlands and reducing pollution can contribute to the conservation of Chaltia Beel (Mitsch&Gosselink, 2015; Mahanayak et al., 2021).
- **Habitat Restoration:** Implementing habitat restoration projects, such as planting native vegetation and creating buffer zones, can help improve water quality and support biodiversity (Mahanayak et al., 2020; Wetzel, 2001).
- **Sustainable Practices:** Promoting sustainable agricultural practices and waste management can reduce the impact of human activities on the wetland (Gopal, 2013; Kumar et al., 2019).

4. Conclusion

The water quality assessment of Chaltia Beel reveals a mix of favorable and concerning findings, underscoring the need for targeted interventions to safeguard this vital wetland in Murshidabad, West Bengal. The analysis of various microbiological and chemical parameters has provided a comprehensive picture of the current state of Chaltia Beel's water quality, which is crucial for both ecological balance and human usage. The study found that the pH values (7.74 to 7.77) are within the neutral range, suitable for most aquatic life. The stable temperature (28.1°C to 28.2°C) supports a conducive environment for aquatic organisms. Total dissolved solids (398 mg/l to 406 mg/l) and turbidity (1.1 NTU to 1.4 NTU) levels are within acceptable limits, indicating good water clarity and overall health. Dissolved oxygen (6.3 mg/l to 6.6 mg/l) levels are adequate for supporting aerobic organisms, reflecting a healthy aquatic ecosystem. However, the presence of total coliform bacteria (190 to 204 CFU/100ml) indicates significant microbial contamination, posing potential health risks for human consumption and recreational use. The consistently low nitrate levels (<0.5 mg/l) are encouraging, suggesting minimal agricultural runoff. Conversely, phosphate levels (1.38 mg/l to 1.41 mg/l) are relatively high, raising concerns about the risk of eutrophication, which can lead to algal blooms and subsequent oxygen depletion. Ammoniacal nitrogen levels (0.56 mg/l to 0.61 mg/l) are within acceptable limits but require ongoing monitoring to prevent toxicity. Total alkalinity (277.4 mg/l to 285 mg/l) supports a stable pH environment, essential for the health of aquatic organisms. To address these findings, Regular Monitoring, Pollution Control, Public Awareness, Habitat Restoration, and Sustainable Practices are recommended. In conclusion, while Chaltia Beel exhibits several favorable water quality parameters, significant concerns regarding microbial contamination and nutrient levels necessitate ongoing monitoring and remediation efforts. By implementing the recommended measures, it is possible to improve and maintain the water quality of Chaltia Beel, ensuring its ecological health and the well-being of the local communities reliant on this crucial wetland.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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