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Assessment Of Water Quality In The Dry Season: A Case Study In The Little Feni River, Bangladesh

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Abstract:
Background: *The Little Feni River, a vital freshwater source in southeastern Bangladesh, supports the Musapur Reservoir for domestic, agricultural, and industrial needs. Dry season (December to May) salinity intrusion and pollution necessitate water quality assessment to guide sustainable management. This study evaluates physicochemical and biological parameters to determine suitability for drinking, irrigation, industrial use, and fisheries.*
Materials and Methods: *During the 2022–2023 dry season, water samples from seven Musapur Reservoir locations were analyzed. Parameters included salinity, electrical conductivity (EC), dissolved oxygen (DO), pH, chloride, color, turbidity, total dissolved solids (TDS), total suspended solids (TSS), ammonium-nitrogen (NH4-N), ammonia-nitrogen (NH3-N), total coliform (TC), fecal coliform (FC), chemical oxygen demand (COD), biological oxygen demand (BOD), chlorophyll, oil and grease, and heavy metals, measured using standard methods (APHA, USEPA, IS, ECR). Results were compared against Environment Conservation Rules (ECR) 2023, Indian Standard Codes (IS 10500:2012), World Health Organization (WHO), and United States Environmental Protection Agency (EPA) standards.*
Results: *High salinity (1.5–8.03 ppt), EC (3.58–11.71 mS/cm), chloride, turbidity (13.1–21.9 NTU), TDS (3084–5541 mg/L), NH4-N (1.19–1.76 mg/L), NH3-N (0.184–1.89 mg/L), TC (610–1160 CFU/100 mL), FC (330–440 CFU/100 mL), and heavy metals (lead, cadmium) exceeded drinking and industrial standards. DO (6.45–11.3 mg/L) and TSS (64–89 mg/L) met standards, supporting fisheries. Most locations were suitable for irrigation, except high-salinity downstream sites.*
Conclusion: *The Little Feni River's water is unsuitable for drinking and industrial use without treatment but viable for irrigation and fisheries in most areas. Targeted treatment is critical for safe use.*
Key Word: *Water Quality, Little Feni River, Salinity, Heavy Metals, Microbial Contamination.*

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I. Introduction

Water quality assessment is crucial for sustainable resource management, especially in coastal regions where salinity and pollution compromise usability (Chapman, 1996). The Little Feni River, a 112-km waterway in southeastern Bangladesh, supports communities, agriculture, and potential industrial activities via the Musapur Reservoir. During the dry season (December to May), reduced freshwater flow and tidal influences elevate salinity and contaminants, limiting its suitability for various uses (Islam et al., 2017). This study assesses the river's water quality to determine its applicability for drinking, irrigation, industrial use, and fisheries, contributing to global water security efforts (Rahman et al., 2020). Coastal rivers face salinity intrusion, microbial contamination, and heavy metal pollution, impacting human health and ecosystems (Khan & Mohamed, 2021). Key parameters like salinity, electrical conductivity (EC), dissolved oxygen (DO), pH, chloride, turbidity, total dissolved solids (TDS), and microbial indicators (total coliform, fecal coliform) which are essential for evaluating water quality (Paul et al., 2021). In Bangladesh, the Environment Conservation Rules (ECR) 2023 provide standards, complemented by Indian Standard Codes (IS 10500:2012), World Health Organization (WHO), and United States Environmental Protection Agency (EPA) guidelines (ECR, 2023; IS 10500, 2012; WHO, 2017; EPA, 2020). Studies on similar water bodies, like the Narta Lagoon and Nam River, highlight the importance of monitoring these parameters (Beqaj, 2023; Kwon & Jo, 2023). This study analyzes water quality at seven Musapur Reservoir locations to inform treatment and management strategies, addressing coastal water challenges (Ghenai et al., 2020).

II. Material And Methods

Study Design: Prospective observational study.

Study Location: Musapur Reservoir, Little Feni River, Noakhali District, Bangladesh.

Study Duration: December 2022 to May 2023.

Sample Size: Seven sampling locations.

Sample Size Calculation: Locations were selected to represent upstream, midstream, and downstream segments of the Musapur Reservoir for comprehensive coverage.

Subjects & Selection Method: Sampling sites were chosen for accessibility and representativeness: Little Feni Bridge, Ahsan Majhir Ghat, River Point-1, River Point-2, Musapur Closure Dam, Musapur Regulator Upstream, and Musapur Regulator Downstream.

Inclusion Criteria:
Surface water samples from the Musapur Reservoir.
Collected during the dry season (December 2022–May 2023).

Exclusion Criteria:
Samples contaminated during collection.
Samples from outside the Musapur Reservoir.

Procedure Methodology: Water samples were collected from seven locations (Table 1). In-situ tests measured salinity, EC, DO, pH, color, and turbidity. Laboratory tests for chloride, TDS, TSS, NH4-N, NH3-N, TC, FC, COD, BOD, chlorophyll, oil and grease, and heavy metals were conducted at the Institute of Water Modelling, Dhaka, using standard methods (APHA, 2017). Results were compared against ECR 2023, IS 10500:2012, WHO, and EPA standards (ECR, 2023; IS 10500, 2012; WHO, 2017; EPA, 2020).

Table 1: Water Quality Sampling Locations

Location	Easting	Northing
Little Feni Bridge	329033	2525514
Ahsan Majhir Ghat	328543	2523650
River Point-1	328451	2520799
River Point-2	329455	2520377
Musapur Closure Dam	330960	2520035
Musapur Regulator U/S	330595	2519043
Musapur Regulator D/S	330584	2518792

Statistical Analysis: Data were analyzed using R software. Descriptive statistics summarized parameter values. Compliance with standards was assessed via threshold comparisons. Differences between locations were evaluated using ANOVA, with $p < 0.05$ considered significant.

III. Result

Water quality parameters were measured at seven Musapur Reservoir locations. Results are summarized in Table 2 and compared against standards.

Table 2: Water Quality Parameters Before Treatment

Parameter	Range (ECR 2023)	IS 10500:2012	WHO/EPA	Permissible Limit	p-value
Salinity (ppt)	1.5–8.03	-	-	-	<0.001
EC (mS/cm)	3.58–11.71	2.25	-	1	<0.001
DO (mg/L)	6.45–11.3	>6	-	>0.05	0.032
pH	6.5–8.85	6.5–8.5	6.5–8.5	6.5–9	0.045
Chloride (mg/L)	1200–3500	250–1000	250–1000	250	<0.001
Color (Pt-Co)	40–63	-	5–15	15	<0.001
Turbidity (NTU)	13.1–21.9	<5	1–5	1–5	<0.001
TDS (mg/L)	3084–5541	<1000	500–2000	500	<0.001
TSS (mg/L)	64–89	-	100–600	-	0.128

Parameter	Range (ECR 2023)	IS 10500:2012	WHO/EPA	Permissible Limit	p-value
NH4-N (mg/L)	1.19–1.76	0.3	0.5	0.01–2	<0.001
NH3-N (mg/L)	0.184–1.89	0.3	0.5	0.01–2	<0.001
TC (CFU/100 mL)	610–1160	<5000	0	0	<0.001
FC (CFU/100 mL)	330–440	<5000	0	0	<0.001
COD (mg/L)	30–105	<25	250	10	<0.001
BOD (mg/L)	2.4–6.8	<3	-	<5	<0.001
Chlorophyll (mg/L)	0.002–1.8	0.1	-	-	0.015
Oil and Grease (mg/L)	<2	0.01–5	10–20	50–450	0.342
Lead (mg/L)	0.031–0.058	-	0.01	0.015	<0.001
Cadmium (mg/L)	0.04–0.06	-	0.003	0.005	<0.001
Iron (mg/L)	0.1–0.3	0.3–1.0	0.3	0.3	0.087
Chromium (mg/L)	0.01–0.03	0.05	0.05	0.05	0.156
Zinc (mg/L)	0.02–0.05	5	5–15	5	0.214
Mercury (mg/L)	<0.001	0.001	0.001	0.002	0.465

Salinity (1.5–8.03 ppt) indicated brackish water, unsuitable for drinking. EC (3.58–11.71 mS/cm) exceeded EPA (1 mS/cm) and ECR 2023 (2.25 mS/cm) limits ($p < 0.001$). DO (6.45–11.3 mg/L) met standards, supporting aquatic life. pH (6.5–8.85) occasionally exceeded IS and WHO limits but complied with EPA. Chloride, color, turbidity, TDS, NH4-N, NH3-N, TC, FC, COD, BOD, chlorophyll, lead, and cadmium exceeded drinking standards. TSS and oil and grease complied. Most locations met irrigation and fisheries standards, except downstream high-salinity sites ($p < 0.05$).

IV. Discussion

The Little Feni River's water quality during the dry season (December 2022–May 2023) at the Musapur Reservoir reveals significant challenges for its use due to elevated salinity, microbial contamination, and heavy metal levels, as shown in Table 2. These findings align with broader coastal water quality issues in Bangladesh, where tidal influences and reduced freshwater inflow exacerbate pollutant concentrations (Islam et al., 2017; Rahman et al., 2020). The high salinity (1.5–8.03 ppt) and electrical conductivity (EC, 3.58–11.71 mS/cm) indicate brackish conditions, driven by saline intrusion from the Bay of Bengal, a common issue in coastal rivers like the like the Meghna and Karnaphuli (Khan & Mohamed, 2021). Chloride levels (1200–3500 mg/L) exceed ECR 2023 (250–1000 mg/L), IS 10500:2012 (250–1000 mg/L), and WHO/EPA (250 mg/L) standards, rendering the water corrosive for industrial use and unpalatable for drinking (ECR, 2023; Rahman et al., 2017). Similarly, total dissolved solids (TDS, 3084–5541 mg/L) surpass all standards, reflecting high ionic content that restricts potable and agricultural applications (Uddin & et al., 2022). Microbial contamination is a critical public health concern, with total coliform (TC, 610–1160 CFU/100 mL) and fecal coliform (FC, 330–440 CFU/100 mL), exceeding IS 10500:2012 and WHO/EPA (0 CFU/100 mL) drinking water standards ($p < 0.001$). These levels, though within ECR 2023 fisheries limits (<5000 CFU/100 mL), suggest contamination from urban runoff, agricultural activities, or sewage discharge, consistent with findings in the Buriganga River (Akter et al., 2020). Ammonium-nitrogen (NH4-N, 1.19–1.76 mg/L) and ammonia-nitrogen (NH3-N, 0.184–1.89 mg/L) exceed ECR 2023 (0.3 mg/L) and IS 10500:2012 (0.5 mg/L), indicating organic pollution, likely from fertilizers or wastewater, which can cause eutrophication and aquatic toxicity (Hossain et al., 2018; Islam et al., 2020). Heavy metals, particularly lead (0.031–0.058 mg/L) and cadmium (0.04–0.06 mg/L), exceed WHO/EPA limits (0.015 mg/L and 0.005 mg/L, respectively), posing risks of neurological and renal damage if consumed untreated (Karim, et al., 2019). However, iron, chromium, zinc, and mercury levels comply with standards, suggesting minimal industrial effluent from these metals in the in the study area (Hossain et al., 2019).

Despite these issues, some parameters support specific uses. Dissolved oxygen (DO, (6.45–11.3 mg/L), meets DO, meets ECR 2023 (>6 mg/L) and EPA (>0.05 mg/L), standards, indicating suitability for fisheries, particularly upstream where DO is higher ($p = 0.032$, Paul et al., 2021). Total suspended solids (TSS, (64–89 mg/L), below TSS, below IS 10500:2012 (100–600 mg/L), supports irrigation and fisheries, as low sediment loads reduce clogging and habitat disruption (IS 2490, 1980). Most locations meet irrigation standards, except downstream where salinity exceeds 2 ppt, potentially stressing crops like rice (Uddin et al., 2022). The low oil and grease levels (<2 mg/L) comply with all standards, posing no significant risk to aquatic ecosystems or industrial processes (Hossain et al., 2020). Comparisons with regional studies, such as the Narta Lagoon (Beqaj, 2023) and Nam River (Kwon & Jo, 2023), highlight similar challenges with salinity and microbial pollution in coastal and urban-influenced waters. However, the Little Feni River's heavy metal contamination (lead, cadmium) is more pronounced than in the Nam River, possibly due to localized industrial or agricultural inputs (Karim et al., 2019). Globally, coastal water quality issues, as seen in studies from India and Vietnam, underscore the need for integrated management to address saline intrusion and pollution (Chaudary et al., 2023; Ghenai et al., 2020). The significant spatial variation ($p < 0.05$ for most parameters) across the seven sampling locations, with downstream sites (e.g., Musapur Regulator D/S) showing worse quality, suggests tidal and anthropogenic influences that require targeted interventions (Rahman et al., 2020).

Limitations of this study include the focus on the dry season, which may not reflect wet season dynamics when freshwater inflow dilutes contaminants (Islam et al., 2017). The sample size (seven locations) provides a snapshot but may miss micro-scale variations. Future research should incorporate wet season data, additional pollutants (e.g., pesticides), and socio-economic impacts on local communities dependent on the river (Uddin et al., 2022). The absence of local industrial effluent data limits attribution of heavy metal sources, necessitating further investigation (Hossain et al., 2019). The findings have significant socio-economic implications. The Little Feni River supports Noakhali District's agriculture and potential industrial growth (e.g., Banghabandhu Sheikh Mujib Shilpa Nagar), but poor water quality threatens these sectors (IWM, 2023). Untreated water use for drinking poses health risks, particularly for rural communities with limited access to treatment facilities (Akter et al., 2020). Irrigation constraints downstream may reduce crop yields, affecting food security (Uddin et al., 2022). Fisheries, a key livelihood, remain viable but require monitoring to prevent NH3-N and chlorophyll-related stress (Akter et al., 2019). Advanced treatment technologies, such as reverse osmosis for desalination and activated carbon for heavy metal removal, are essential but costly, posing challenges for implementation in resource-constrained settings (Tonner & Tonner, 2004; Ghenai et al., 2020).

Management strategies should include:

- Installing desalination and filtration systems for drinking water,
- Regulating agricultural runoff to reduce NH4-N and NH3-N,
- Enhancing wastewater treatment to curb microbial pollution, and
- Constructing upstream reservoirs to mitigate saline intrusion (Rahman et al., 2021). Community-based monitoring, as suggested by Bhuiyan et al. (2018), could improve data collection and awareness.

These measures align with Bangladesh's water security goals and global sustainable development objectives (WHO, 2017).

V. Conclusion

The Little Feni River's water in the dry season is unsuitable for drinking and industrial use due to excessive salinity (1.5–8.03 ppt), chloride (1200–3500 mg/L), TDS (3084–5541 mg/L), microbial contamination (TC: 610–1160 CFU/100 mL; FC: 330–440 CFU/100 mL), and heavy metals (lead: 0.031–0.058 mg/L; cadmium: 0.04–0.06 mg/L), exceeding ECR 2023, IS 10500:2012, and WHO/EPA standards. However, adequate DO (6.45–11.3 mg/L) and compliant TSS (64–89 mg/L) support fisheries, and most locations meet irrigation standards, except downstream high-salinity sites. These findings underscore the need for targeted treatment, including desalination, filtration, and heavy metal removal, to ensure safe use. Continuous monitoring, wastewater management, and upstream reservoirs are critical to mitigate pollution and saline intrusion. Integrating community-based approaches and advanced technologies will enhance sustainable water use, supporting Noakhali's agricultural, industrial, and domestic needs while aligning with national and global water quality goals.

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