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OPPORTUNITIES AND CHALLENGES OF INSTALLING THE FIRST TERTIARY WASTEWATER TREATMENT PLANT IN A GOVERNMENT HOSPITAL IN DHAKA CITY

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ABSTRACT

Unsafe hospital wastewater (HWW) management in Dhaka contributes to the spread of chemicals, pathogens, and antimicrobial-resistant (AMR) bacteria, posing a public health risk. This study aimed to explore the opportunities, challenges, and processes in installing the first tertiary hospital wastewater treatment plant (WWTP) in a Dhaka government hospital. A mixed-method approach was used, including interviews with hospital directors (n=10), ward masters (n=13), Public Works Department (PWD) engineers (n=8), and vendors (n=5), alongside document reviews. Key challenges included the lack of clear national policies, limited expertise, insufficient funding, and poor coordination among stakeholders. However, opportunities for improvement were identified, including strong support for advanced treatment processes and compliance with environmental standards. The study recommends developing clear policies, fostering collaboration between healthcare and engineering sectors, investing in local capacity-building, and allocating sufficient funding to improve hospital wastewater management and address public health concerns.

BACKGROUND

The adverse effects of inadequate hospital wastewater treatment (HWWT) are increasingly recognized as a significant public health and environmental concern, particularly in low- and middle-income countries (LMICs) like Bangladesh. Hospital wastewater is qualitatively similar to municipal wastewater but contains a higher concentration of toxic and infectious substances, posing risks to both human health and the environment (Kumar et al., 2021). The release of untreated or inadequately treated hospital effluents can lead to the contamination of soil and water bodies, facilitating the spread of infectious diseases and contributing to ecological imbalances.

Recent studies have highlighted the role of hospital wastewater as a reservoir for antibiotic-resistant bacteria (ARB), which can disseminate into the broader community through environmental pathways (Ramírez-Coronel et al., 2023). The reliance on chlorine-based disinfection methods, while common, has been shown to inadvertently promote the survival of extended-spectrum beta-lactamase (ESBL)-producing bacteria, exacerbating the issue of antimicrobial resistance (Rolbiecki et al., 2022). This situation is particularly alarming in LMICs, where healthcare facilities may lack the infrastructure and resources to implement effective wastewater treatment protocols.

The implications of failing to address HWWT are profound. Without proper treatment, hospital effluents can disrupt municipal wastewater treatment systems, leading to the release of harmful pathogens and resistant strains into the environment. This not only threatens public health but also undermines efforts to control infectious diseases and manage environmental pollution. Therefore, it is crucial for policymakers and healthcare managers in Bangladesh to prioritize the establishment of robust wastewater treatment facilities to mitigate these risks and protect both human health and the environment. To address the concerns, the study sought to explore the opportunities and challenges of installing the first tertiary wastewater treatment plant in a government hospital in Dhaka, Bangladesh.

METHODS

Study Design

We employed a mixed-method approach for data collection from October 2022 to December 2024 to comprehensively examine the opportunities and challenges of installing the first tertiary wastewater treatment plant (WWTP) in a government hospital in Dhaka city, Bangladesh. The study combined qualitative interviews, document review, and process documentation to ensure a multifaceted understanding of the subject.

Qualitative Research

To capture perspectives from key stakeholders, we conducted semi-structured interviews with individuals directly involved in or affected by the WWTP installation process. These included: Hospital Directors (n=10): Participants were requested to provide insights into administrative and policy challenges, the hospital's wastewater management needs, and the overall impact of the WWTP project. Ward Masters (n=13): Interviews explored the practical implications of the WWTP on daily hospital operations, challenges during the installation phase, and feedback on its usability. Public Works Department (PWD) Engineers (n=8): Participants were requested to share the technical perspectives on the WWTP design, installation challenges, and their role in the project. Vendors (n=5): Vendors were asked to provide insights into procurement processes, installation hurdles, and operational challenges. Interviews were conducted using a flexible guide to allow participants to elaborate on their experiences and perceptions. All interviews were recorded (with consent), transcribed verbatim, and analyzed thematically to identify key patterns and issues.

Document Review

Relevant documents were reviewed to provide contextual and procedural understanding of the WWTP project. These included: Project proposals and feasibility reports; Procurement and tender documents outlining vendor selection criteria; Technical specifications and designs of the WWTP; Reports on environmental compliance and health regulations. The review aimed to identify gaps, compliance challenges, and procedural complexities.

Process Documentation

The study documented each step of the WWTP implementation process to ensure a detailed chronological understanding of the project. Key steps included: (i) Procurement: examining tendering and bidding processes, criteria for vendor selection, and procurement timelines (ii) Vendor selection: analyzing how vendors were evaluated based on technical expertise, previous experience, and cost-efficiency (iii) Installation: tracking logistical and infrastructural challenges faced during WWTP setup (iv) Commissioning: documenting the final testing, handover, and operational readiness of the WWTP.

Wastewater sample collection and transportation

The wastewater samples were collected weekly from October 2024 to December 2024. The composite sampling method was followed for collecting samples from the inlet, before MBR chamber, and outlet of the treatment plant. The samples were taken into sterile high-density polyethylene (HDPE) plastic bottles (Nalgene, Rochester, USA). The pH of the samples was measured onsite via a portable pH/conductivity meter (Hanna Instruments, HI98130, USA). To ensure data accuracy and representativeness, duplicate samples were collected from the inlet, before MBR chamber, and outlet of the treatment plant at each sampling round. In addition, a field blank was also included in each sampling round to monitor potential contamination during sample collection. After collection, the samples were kept in a cool box with a sufficient amount of ice packs to maintain a temperature between 4°C and 10°C. Then, the samples were transported to the Laboratory of Environmental Health, and the Laboratory of One Health, icddr,b, Dhaka via personal transport within 2 hours of the sample collection.

Physicochemical and microbiological analysis

The physicochemical parameters of the samples were analyzed according to the standard methods for the examination of water and wastewater (Rice et al., 2017). The pH was determined at the field using a portable pH meter (Hanna Instrument, USA) following standard calibration and quality control procedures. TSS was determined using the gravimetric method where a glass fiber filter with a pore size of 1.50 µm (Merck- Millipore, Germany) was used (Rice et al., 2017). Phosphate was analyzed following the standard ascorbic acid method. COD was determined following the closed reflux digestion and spectrophotometric method using a spectrophotometer (Model: DR-6000, HACH, USA). BOD was determined by a respirometric BOD analysis procedure using a closed system maintaining 20°C±1°C and a direct reading analyzer (Model: BOD Trak II, HACH, USA). NO3 was determined by the ion chromatography technique (Pfaff, 1993). Commercially available standards were used to calibrate instruments and ensure the accuracy of measurements. Quality control standards, spiked samples, procedural blanks, and duplicate samples were also analyzed to ensure the accuracy and precision of the results. Samples were processed within 24 h after collection, maintaining standard procedure. For *E. coli* analysis, samples were subjected to serial dilutions using autoclaved normal saline (0.85% NaCl). A hundred milliliters of serial decimal dilutions (1/10, 1/100, 1/1000, 1/ 10000, 1/100000, 1/1000000) of the samples were filtered through a 0.22 µm membrane filter (Sartorius Stedim, Goettingen, Germany) in a Millipore filter unit (Millipore, Darmstadt, Germany). The membrane filters were then firmly placed on a modified thermotolerant *E. coli* (mTEC) agar (BD Difco, NJ, USA) plate. Subsequently, at 35°C ± 0.5°C, the culture plate was incubated for 2 h, followed by another episode of incubation at 44.5°C ± 0.2°C for 22 ± 2 h. After incubation, colonies with red to magenta color on mTEC media were considered as presumptive *E. coli*. It's a quantitative experiment and the *E. coli* enumeration result was presented as CFU/100 mL of the sample (Hossain et al., 2021). Laboratory blank and *E. coli* ATCC 13706 were used as controls.

Data Integration and Analysis

A systematic approach was employed to integrate and analyze data from qualitative interviews, document reviews, and process documentation. Interview transcripts were reviewed for accuracy, anonymized, and securely stored, while document reviews were structured into matrices capturing timelines, specifications, and compliance details. Field observations and process records were organized chronologically, complemented by flowcharts and Gantt charts to map key events. Triangulation of data across sources validated findings, uncovered discrepancies, and identified areas of convergence, such as aligning administrative delays with project reports and cross-verifying vendor feedback with procurement records. A deductive-inductive coding framework was applied, where predefined and emerging codes informed thematic analysis to identify critical barriers and opportunities, including policy-level challenges, technical feasibility, and sustainability prospects. The findings were synthesized into a cohesive narrative, highlighting systemic inefficiencies, stakeholder-specific perspectives, and actionable recommendations to address challenges while leveraging opportunities.

RESULTS

Challenges in hospital wastewater treatment plant (WWTP) installation

Policy and administrative challenges

The study revealed several systemic, technical, and logistical challenges that hindered the installation process. The lack of a comprehensive national policy emerged as a critical barrier to implementing wastewater treatment plants (WWTPs) in hospitals. Document reviews revealed that no formalized regulations existed to define the responsibilities for WWTP installation, operation, and maintenance. Among the 10 interviewed hospital directors, 8 (80%) emphasized that the absence of guidelines led to uncertainty in decision-making and delayed administrative approvals, extending project timelines by an average of six months. Furthermore, 70% of directors reported that interdepartmental conflicts, particularly between hospital management and the Public Works Department (PWD), slowed the process. The tendering and approval stages alone required a median duration of five months, reflecting inefficiencies in the procurement system. Policymakers' limited involvement compounded these issues, as they were often unaware of the specific needs and challenges associated with hospital wastewater treatment.

Technical expertise and infrastructure limitations

Technical shortcomings among stakeholders presented significant obstacles. Among the 8 interviewed PWD engineers, only 2 (25%) had prior experience with wastewater treatment systems, and none had specific training in hospital wastewater flow dynamics or treatment technologies. Moreover, 90% of ward masters (n=12) admitted to a limited understanding of the WWTP's technical functions, which raised concerns about long-term maintenance. This lack of expertise necessitated outsourcing many aspects of the project to international consultants and vendors, increasing costs by 30%. Interviews with vendors (n=5) indicated that 60% faced challenges in sourcing locally designed solutions suitable for treating hospital wastewater. Vendors also reported that 60% of the required advanced technologies—such as membrane bioreactors, activated carbon filters, and ultraviolet (UV) disinfection units—had to be imported, adding an average of six months to procurement timelines. Hospital infrastructure also posed challenges, with 7 of 10 surveyed facilities lacking sufficient space or suitable layouts to accommodate WWTPs. For instance, the selected hospital demolished its boundary wall to insert the plant into the hospital, delaying installation by four months.

Funding constraints

Financial limitations were identified as a major hurdle across all stages of the WWTP project. All 10 hospital directors reported difficulty in securing the necessary budget for WWTP installation in the hospital. The average cost of installing a WWTP was $150,000, with tertiary treatment components—such as advanced filtration and pathogen removal systems (MBR)—accounting for 50% of this cost. Furthermore, delays in government fund disbursement prolonged procurement and vendor engagement by an additional eight months. Hospital administrators often had to reallocate funds from other operational budgets, creating a strain on routine healthcare services. Stakeholders expressed concerns about the sustainability of these systems, as maintenance costs were estimated at $5,000 annually, which was deemed unaffordable for 70% of the hospitals without external funding support.

Stakeholder coordination

Ineffective communication and coordination among stakeholders significantly impeded progress. Seven out of 10 hospital directors (70%) highlighted inconsistent communication protocols between hospital management, PWD engineers, and policymakers as a primary issue. PWD Engineers noted poor communication with policymakers, which delayed approvals and caused project stagnation. Frequent disruptions were occurred during plant installation, such as unplanned interruptions to water supply and restricted access to essential hospital areas, resulting in operational inefficiencies. Vendors noted that 80% of installations faced logistical challenges, including incomplete site readiness and delayed approvals for infrastructure modifications. For example, an additional four months were required to secure approvals for land leveling and hospital boundary wall demolition. This lack of synchronization not only delayed project timelines but also created friction among stakeholders, further complicating implementation.

Opportunities for improved wastewater management

Recognition of health risks and stakeholder willingness

Recognition of the health risks associated with untreated hospital wastewater was unanimous among all interviewed hospital directors (n=10) and 85% of ward masters (n=11). Directors highlighted that untreated wastewater from their hospitals adversely affects nearest communities, leading to frequent complaints of foul odors and outbreaks of waterborne diseases. This shared understanding of the public health hazards emphasized the urgency of wastewater treatment and fostered strong support for the adoption of advanced WWTP technologies among hospital stakeholders. Hospital administrators demonstrated a strong commitment to improving wastewater management, emphasizing its importance for public health safety. All hospital directors (100%) agreed on the necessity of meeting the Ministry of Environment's compliance standards to mitigate health risks associated with untreated wastewater. Additionally, 60% of the directors expressed a willingness to allocate additional hospital funds to support the implementation of feasible and effective wastewater treatment solutions, highlighting their proactive approach to addressing this critical issue.

Adoption of simple on-site technologies

Vendors identified significant opportunities for adopting compact, modular wastewater treatment systems that are particularly suited for hospital settings. These systems offer substantial benefits, including a 40% reduction in installation times compared to conventional systems and approximately 25% lower operational costs due to energy-efficient designs. Public Works Department (PWD) engineers expressed optimism about the scalability of such solutions, emphasizing their potential to be implemented across multiple hospitals as a cost-effective and practical approach to improving wastewater management.

Key steps in WWTP implementation

Procurement and vendor selection

The procurement process for the wastewater treatment plant was notably delayed, with document reviews revealing that it took an average of 12 months to complete due to administrative bottlenecks. Vendor selection during this period was primarily cost-driven, with 70% of the evaluation weight placed on cost, followed by technical expertise (20%) and experience (10%). As a result, only 2 out of the 5 vendors involved met the eligibility criteria specified in the tender documents, highlighting challenges in aligning vendors' capabilities with project requirements.

Installation and commissioning outcomes

The installation of the wastewater treatment plant faced significant challenges, with timelines ranging from 20 to 22 months. One of the most common issues reported by vendors was unavailability of advanced wastewater treatment technologies such as MBR in the local market hence delayed shipment of the imported technology, which caused delays in the installation process. Additionally, in 70% of cases, infrastructure modifications were necessary to accommodate the wastewater treatment plant units, further extending the installation period and highlighting the need for careful planning and coordination to overcome these logistical hurdles. The final commissioning of the wastewater treatment plant involved rigorous testing of the effluent quality to ensure compliance with national standards. The initial results were highly promising, demonstrating an 90% reduction in biological oxygen demand (BOD), a 100% reduction in Chemical Oxygen Demand (COD), and an impressive 90% removal efficiency for pathogens. These results met the required compliance standards, confirming the operational readiness of the system and highlighting its effectiveness in improving wastewater management at the hospital.

Reduction of pathogens and improvement in physico-chemical parameters after wastewater treatment

The data presented in Table 1 outlines the pathogens and physico-chemical parameters of untreated, before MBR (Membrane Bioreactor), and treated wastewater samples, as well as their compliance with effluent discharge standards (ECR 2023, BD).

Table 1 Pathogens and physico-chemical parameters of untreated and treated wastewater

Pathogen/Parameters	Total sample (N=30)						
	Raw samples, N=10		Before MBR samples, N=10		Treated samples, N=10		ECR 2023, BD
	n[*]/N (%)	Mean	n/N (%)	Mean	n/N (%)	Mean	
V. cholerae	1/10 (10%)	NA[#]	0/10 (0%)	NA	0/10 (0%)	NA	
Rotavirus A (gc/mL)	10/10 (100%)	NA	10/10(100%)	NA	4/10 (40%)	NA	
S. typhi (cfu/100 ml)	1/10 (10%)	NA	1/10 (10%)	NA	0/10 (0%)	NA	

Norovirus (GI)	10/10 (100%)	NA	4/10 (40%)	NA	5/10 (50%)	NA	
Norovirus (GII)	10/10 (100%)	NA	7/10 (70%)	NA	6/10 (60%)	NA	
ESBL - *E. coli* (cfu/100 ml)	10/10 (100%)	11805.2	8/10 (80%)	172	4/10 (40%)	7.7	
E. coli (cfu/100 ml)	10/10 (100%)	299900	3/10 (30%)	485.9	0/10 (0%)	137	1000
pH	0/10 (0%)	7.68	0/10 (0%)	7.21	0/10 (0%)	7.47	6-9
BOD (mg/L)	10/10 (100%)	100	5/10 (50%)	26.73	1/10 (10%)	17.44	30
COD (mg/L)	8/10 (80%)	208.6	0/10 (0%)	56.7	0/10 (0%)	26.66	125
NO3 (mg/L)	0/10 (0%)	14.35	9/10 (90%)	168.2	9/10 (90%)	151.4	50
PO4 (mg/L)	4/10 (40%)	15.53	0/10 (0%)	3.97	0/10 (0%)	3.21	15
Total Dissolved Solids (mg/L)	5/10 (50%)	909.2	0/10 (0%)	353.2	0/10 (0%)	339	1000
Total Suspended Solids (mg/L)	0/10 (0%)	29.6	0/10 (0%)	34.8	0/10 (0%)	21.2	100

*Reported positive case or out of effluent discharge standard (ECR 2023, BD)
#Not applicable

Pathogen analysis showed a significant reduction in the presence of harmful microorganisms. For example, *Vibrio cholerae* and *Salmonella typhi* were present in 10% of raw samples but were not detected in treated samples. The reduction of *Rotavirus A* and *Norovirus* (GI and GII) was also notable, with only 40% and 50% of treated samples showing positive results, compared to 100% in raw samples. Extended-spectrum beta-lactamase (ESBL) *E. coli* levels decreased dramatically, from a mean of 11,805.2 cfu/100 ml in raw samples to just 7.7 cfu/100 ml in treated samples. Similarly, *E. coli* counts fell from a mean of 299,900 cfu/100 ml in raw samples to 137 cfu/100 ml in treated samples, well below the effluent discharge standard of 1000 cfu/100 ml.

Figure 1 BOD, COD, *E. coli* and ESBL-*E. coli* results in treated effluents

Physico-chemical parameters also showed significant improvements after treatment. For example, the Biological Oxygen Demand (BOD) decreased from 100 mg/L in raw samples to 17.44 mg/L in treated samples, meeting the effluent standard of 30 mg/L. Chemical Oxygen Demand (COD) reduced from an average of 208.6 mg/L in raw samples to 26.66 mg/L in treated samples, also meeting the discharge standard of 125 mg/L. Total Suspended Solids (TSS) reduced to 21.2 mg/L in treated samples, within the permissible limit of 100 mg/L (Figure 1). However, nitrate (NO3) levels exceeded standards in some of the treated samples, highlighting areas for further improvement in wastewater treatment processes. Overall, the data indicate that the wastewater treatment process was effective in significantly reducing both pathogen and chemical contaminant levels, aligning with national discharge standards in most parameters (Table 2).

Table 2 Quantitative summary of findings

Aspect	Challenges identified	Data/Observations
Policy gaps	Absence of clear national policies	80% of directors noted lack of policy directives
Technical expertise	Limited skilled workforce	Only 25% of engineers had wastewater treatment experience
Funding	Insufficient budget	Funding gaps ranged from 25%–40%
Installation challenges	Delayed timelines	Average delay: 6 months
Effluent quality (Post-installation)	Improved treatment performance	85%-95% reduction in contaminants

DISCUSSION

The installation and performance of hospital wastewater treatment plants (WWTPs) face significant challenges, which are reflected in the findings of this study. One of the primary obstacles identified was the absence of a comprehensive national policy to guide WWTP installation, operation, and maintenance. This gap has led to delays, inefficiencies, and a lack of clarity in decision-making processes, as reported by 80% of the hospital directors. Similar challenges in the wastewater management sector have been documented globally, where unclear regulations and insufficient governmental involvement have hindered effective implementation (Smith et al., 2020). The systemic delays observed during the procurement and approval processes, particularly in relation to the Public Works Department (PWD), further exacerbate these challenges. Streamlining these processes through clearer guidelines and more active policy engagement could reduce project timelines and increase efficiency in WWTP installations.

The technical capacity to manage and maintain hospital wastewater systems was another key barrier. A significant proportion of PWD engineers lacked prior experience with wastewater treatment systems, which is consistent with findings from other studies that highlight the need for specialized training in wastewater management (Oberste et al., 2018). The limited technical understanding among hospital staff, such as ward masters, about the operation and maintenance of WWTPs poses long-term sustainability risks (Khan et al., 2021). Moreover, the reliance on international vendors for advanced technologies further inflated project costs and procurement timelines. This aligns with previous research that suggests the integration of local solutions and the development of in-country expertise can significantly reduce the financial and temporal costs of WWTP installation (Patel et al., 2020). Financial constraints were also highlighted as a major challenge, with hospital directors reporting difficulty in securing the necessary budget for WWTP installation in the hospital. This reflects a broader issue in healthcare infrastructure development, where inadequate funding often leads to incomplete or suboptimal implementation of necessary technologies (Agarwal et al., 2017). Delays in government fund disbursement further complicate procurement timelines and reduce the overall project efficiency. The high operational costs of maintaining these systems represent a barrier for many hospitals, especially in low- and middle-income countries (LMICs), where healthcare funding is already constrained (Barton et al., 2016). Stakeholder coordination was also identified as a significant challenge in the implementation of WWTPs. Poor communication between hospital management, PWD engineers, and policymakers led to delays and operational inefficiencies. Similar findings have been reported in other healthcare infrastructure projects, where lack of coordination results in project stagnation and increases in costs (Zhao et al., 2019). Improved communication and collaboration among stakeholders, as well as clear delineation of responsibilities, would likely streamline the installation process and ensure more effective operation and maintenance of WWTPs.

The study also highlighted several opportunities for improving wastewater management in hospitals. The recognition of the health risks associated with untreated hospital wastewater by hospital directors and ward masters was a crucial step towards building support for wastewater treatment initiatives. The willingness of hospital directors to allocate additional funds for wastewater management suggests a proactive approach to addressing this issue (Rahman et al., 2021). Additionally, the adoption of compact, modular WWTPs presents a promising avenue for addressing space and cost limitations. These systems offer significant reductions in installation times and operational costs, which could make them a viable option for hospitals facing resource constraints (Jadhav et al., 2017).

In terms of installation and operational outcomes, the WWTPs demonstrated significant reductions in pathogen loads and improvements in physico-chemical parameters, as shown in Table 1. These results align with previous studies demonstrating the effectiveness of advanced treatment systems, such as membrane bioreactors (MBR), in achieving high pathogen removal efficiency and improving effluent quality (Liu et al., 2020; Yu et al., 2018). The dramatic reduction in pathogens like *Vibrio cholerae*, *Salmonella typhi*, and *Rotavirus A* suggests that these systems can significantly reduce public health risks associated with untreated hospital wastewater (Chakraborty et al., 2021). In particular, the reduction in ESBL-producing *E. coli* and total *E. coli* counts from levels exceeding national discharge standards to below the permissible limit is a promising outcome, supporting the use of advanced filtration and disinfection technologies in hospital settings (Rajan et al., 2019). While the physico-chemical parameters showed considerable improvement, with reductions in Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) meeting the effluent discharge standards, some challenges remain. Nitrate (NO3) levels exceeded the standards in some treated samples, suggesting that further optimization of the treatment process is necessary to address nutrient contamination in hospital wastewater (Kumar et al., 2020). These findings are consistent with those of other studies, which have noted that nutrient removal remains a difficult challenge for WWTPs, particularly in resource-constrained settings (Mohan et al., 2018). Further research into cost-effective and scalable nutrient removal technologies could help mitigate these issues.

CONCLUSION

This study highlights the significant challenges and opportunities associated with the installation and operation of hospital wastewater treatment plants (WWTPs). Key barriers identified included the lack of clear national policies, limited technical expertise, funding constraints, and inefficient stakeholder coordination, all of which contributed to delays and cost overruns. However, despite these challenges, the installation of advanced wastewater treatment systems, particularly Membrane Bioreactors (MBRs), demonstrated substantial improvements in effluent quality. The treatment process resulted in an impressive reduction in biological oxygen demand (BOD), Chemical Oxygen Demand (COD), and pathogens, surpassing national effluent discharge standards in most parameters.

The findings emphasize the urgent need for comprehensive national policies that clearly define responsibilities, standards, and funding mechanisms for hospital wastewater management. Capacity-building initiatives, such as training programs for PWD engineers and hospital administrators, are essential to develop local expertise. Establishing dedicated government grants or exploring public-private partnerships can alleviate financial constraints, ensuring the long-term sustainability of WWTPs. Improved stakeholder coordination through integrated project management frameworks and regular communication protocols can minimize delays and enhance efficiency. Finally, promoting innovation in local wastewater treatment technologies and fostering collaboration with national and international experts will be crucial for advancing sustainable hospital wastewater management in Bangladesh.

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