Muhammed Alamgir, S.M. Tariqul Islam, Mahmudul Hasan, N.J. Pollen (Eds.)
ISBN: 978-984-35-7297-4

Full Paper of the WasteSafe 2025 – 9th International Conference on
Sustainable Solutions for Waste Management in Developing Countries
22-23 February 2025, Dhaka, Bangladesh

History of Wastewater Collection and Disposal in Khulna City: Future Implications and Challenges of Improper Management

Saptarshi Mondal[1], Nazmul Hassan Ohe[2] and Md. Abu Bakar Siddik Farhan[3]

[1,2,3]Department of Civil Engineering, Khulna University of Engineering and Technology, Khulna

Abstract

This essay provides a comprehensive analysis of the history, evolution, and challenges associated with sewage wastewater collection and disposal in Khulna City, Bangladesh. It examines the development of the city's waste management infrastructure, highlighting major obstacles encountered and the responses from both the public and private sectors. Emphasis is placed on Khulna's ongoing efforts to improve sanitation and environmental health. The study explores past sanitation conditions and the gradual advancements in wastewater collection, detailing distinct stages and periods of progress. Present conditions are assessed, and recommendations are made for future improvements in sewage infrastructure. Additionally, this report evaluates key initiatives such as the Khulna Sewerage System Development Project (KSSDP), which aims to implement a modern sewerage system for densely populated and commercial areas, serving approximately 850,000 residents by 2027. The essay also addresses the health impacts of inadequate wastewater management, noting that contaminated runoff contributes to a rise in waterborne diseases. During monsoon seasons, limited access to clean water forces many residents to rely on polluted surface or shallow groundwater, which poses significant health risks, including eye and skin infections, respiratory diseases, malaria, and dengue fever. Groundwater contamination exacerbates these threats, underscoring the urgent need for sustainable wastewater management solutions. Inadequately drained rainwater not only creates unsightly and foul-smelling stagnant pools but also provides ideal breeding conditions for disease vectors such as mosquitoes.

Keywords: sewage, wastewater, infrastructure, management, waterborne diseases

INTRODUCTION

Water has always been essential to living, from the earliest primitive organisms to the most sophisticated plants and animals. It dissolves vital vitamins and nutrients from food and transports them to cells in humans, serving as a solvent and a delivery system. According to estimates, the average amount of water available per person decreased from 3300 m3 in 1960 to 1200 m3 in 2002 [1]. Additionally, it has been projected that by 2025, around 3.5 billion people worldwide will be experiencing chronic water stress in numerous nations [2]. The total real renewable water resources (TARWR) have declined and this will particularly impact big cities in emerging nations where it is extremely difficult to supply the rising water demand.

Bangladesh is a tiny nation in South Asia that is encircled by Myanmar and India. The southern portion meets the Bay of Bengal. It is among the world's most densely populated nations. With a growth rate close to 1.6%, the population is close to 160 million. Bangladesh covers an area of roughly 147,570 square kilometers. Around. 18,290 sq. km. are covered by water, and 70% of the land is used for irrigation. Bangladesh's geomorphological state increases its susceptibility to climate change. Less than five meters above sea level make up two-thirds of the nation. In Bangladesh, flooding is a frequent and frequent natural disaster. Approximately 30% of the nation faces flooding every year during the monsoon season, which also saw 80% of all annual rainfall. Flooding might occur up to 70% of the time during extreme events. However, the third-largest city in Bangladesh is Khulna, which is situated in the southwest of the country. It is situated alongside the Bhairab and Rupsha rivers. Khulna city's geographic coordinates are 22°49′N 89°33′E. Khulna is located north of the Bay of Bengal, south of the districts of Jessore and Narail, west of Bagerhat, and east of Satkhira District. This is a portion of the world's largest river delta, the Ganges

Delta. The development of Khulna, Bangladesh's second port entrance and third-largest city, has been primarily unplanned [3]. Except for significant institutions, services, and infrastructure, the majority of the city's establishments are the result of unplanned private initiative development. Despite having a history spanning over a century, Khulna City has grown and developed in recent decades, especially during the post-partition and post-liberation eras. Khulna City Corporation (KCC) had 6,63,000 residents in 1991 and according to the 2007 estimate, 1,400,689 people were living in the KCC area [4]. Khulna City experiences negative effects from the growing population pressure, including uncontrolled urban growth, widespread urban poverty, water logging, the rise of urban slums and squatters, traffic congestion, pollution, and other socioeconomic issues [4]. As a city grows more urbanized, its physical features gradually change as low land and water bodies become reclaimed built-up lands, open spaces, and plots become development areas, etc. If this keeps up, Khulna will soon turn into an urban slum with the lowest living conditions for city people. Thus, the potentiality of water pollution is going to increase day by day for all the cities of Bangladesh, especially Khulna City and this makes an important issue in terms of collecting and disposing of the wastewater of Khulna City.

The development of the city's urban and public health policies is reflected in Khulna City, Bangladesh's history of sewage and wastewater management. Khulna was founded as a tiny town and at first relied on simple, unofficial waste disposal techniques, with homes and businesses frequently dumping sewage and wastewater into ponds, rivers, and open drains. These primitive methods started to put a strain on the city's water supplies as a result of population increase and industrial expansion, particularly affecting the Bhairab and Rupsha rivers, which are important waterways for the city. Pollution and health hazards increased as a result, making organized wastewater management imperative.

Throughout the years, wastewater management has gained a lot of attention because of the growing volume of wastewater produced annually as a result of high industrialization and widespread urbanization. The effects of wastewater treatment on human health were examined in this study using both geographical and thematic coverage, weighing the advantages and disadvantages of wastewater for a variety of water functions where providing water safety and hygiene is crucial [5]. The most important requirement for both the environment and public health is access to wastewater collection and disposal facilities [6]. Since ancient times, developing nations have had more challenges with water and sanitation than affluent nations. The developing world typically utilizes rudimentary technologies. The majority of people in the town rely on point water sources [5].

Being an important issue for disposal or collecting wastewater, the history of wastewater collection and disposal also holds an important significance. This will help to assess the possible damage due to long frequent disposal of wastewater to the environment due to no facility for collection or proper disposal of wastewater. This also aids in developing new and proper methods or strategies for collecting or disposing of wastewater. However, no study has yet to develop the history of collection or disposal of wastewater, especially from the perspective of Khulna City. In this study, the long history of collection and disposal of wastewater in Khulna City will be discussed thoroughly.

Early Sewage Wastewater Management Practices in Khulna

Pre-Independence Period

Very little information was found about the early sewage practices, especially of the pre-independence period. However, many studies showed that there was very little or no wastewater management in preindependence time during that time. It was assumed that no rainwater or stormwater management was there and drains were mainly open drain systems as well and toilets were opened to the rivers or canals directly [7]. However, this was due to the lack of domineering characteristics of West Pakistan and the maximum number of budgets was spent on the people and improvements of infrastructures as well as sewerage systems and wastewater management [8]. In Khulna, however, in terms of water supply, the first water supply system was put in place in 1921 and they provided 900 cubic meters of water every day at that time the Khulna Water Supply Authority began using production tubewells to produce water in 1960 and however, then, in 2008, the Khulna Water Supply & Sewerage Authority was founded. It operates independently of the City of Khulna [9].

Post-Independence Development

Khulna, like many other cities in Bangladesh, had a difficult time updating its sewerage system and other infrastructure after the country's independence in 1971. Due to a lack of funding, fast population growth, and urbanization that outpaced infrastructural advancements, Khulna's sewerage system developed

ISBN: 978-984-35-7297-4

gradually after independence and Bangladesh had to deal with issues like political unpredictability, economic hardship, and infrastructure reconstruction after gaining independence [3]. However, significant advancements in public health and sanitation were made over time. According to the authority of KWASA, the development in this sector mainly started years later from the independence period.

Development of Sewage Wastewater Infrastructure (1990s-2000s)

Establishment of Initial Sewage and Drainage Systems

In the time between 1990 and 2000s, a natural drainage system was used to remove Khulna's stormwater. Natural drainage and other water retention zones are gradually being transformed into built-up regions as a result of growing urbanization and development. Bagmara Khal, Shuri Khal, and North Bank Khal are a well-known example of a natural drain that has vanished. In the past, these Khals helped "effectively" remove stormwater from specific areas of Khulna, like Farazi Para, Farazipara, Munshipara, Moulovipara, Bashu Para, and Iqbalnagar. These Khals are currently being used for residential development or road building. Some areas of the city, including Farazipara, Munshipara, Moulovipara, Mistripara, and a portion of Bania Khamar, are now susceptible to water logging during periods of heavy rainfall as a result of the removal of these natural drains [10]. However, no initial development or initiative was found during these periods and these periods a stagnant in terms of the development of sewage treatment. Some minor places of Khulna City were found to be under minor development of drainage system but it was a very small amount and the waste water was either logged in the town or disposed into the rivers.

To solve the water logging and related issues brought on by the loss of the natural drainage system, the proper measures were taken to preserve the KCC's natural drainage system. Given the seriousness of the situation, the reasons for the loss of natural drainage, its effects, and potential solutions for keeping Khulna City's natural drainage system intact were determined [10]. A project supported the different institutional structures, rules and regulations, and reorganizations necessary for the complete implementation and operationalization of the WASA Act (1996) in collaboration with other development partners [11].

Challenges Faced

According to the feasibility study of the "Secondary Town Integrated Flood Protection Project," which examines Khulna City's historical drainage condition, 26.44 square kilometers, or 71% of the city's 38.47 total land area, experience floods as a result of rainfall [12]. The drainage system's ability to remove wastewater from metropolitan areas, especially during the monsoon, was recognized as the primary issue. Large urban areas thus experienced recurring flooding. As a result, the road system deteriorated, and regions with stagnant and contaminated water were developed for extended periods in low-lying areas surrounding the town [13]. The people were severely distressed by the flooding, which also impacted business operations. Also, drainage issues were found to be among the top environmental risk issues in the KCC area in 1998 during the Comparative Environmental Health Risk Assessment procedure [13].

Transition Towards Modern Sewage Management (2000s–2010s)

Government and International Interventions

Japan International Cooperation Agency (JICA) conducted a study in 2009 and 2010 to assess the water quality at various points in Khulna City as shown in Figure 1. The study was conducted three times. Tests were conducted in nine locations in October 2009, eleven in February 2010, and three in March 2010. Water samples from these locations were collected and sent to various laboratories in Bangladesh as well as Japan. Though some values deviated from the standard values, the results were quite good as the maximum test results were between standard values. However, various parameters such as heavy metals outranged the standard values and turbidity, COD and BOD also acquired higher values than the standard values and the values raised day by day. Another study was conducted by JICA in 2007 about chloride concentration of Khulna City and found that chloride concentrations were generally high. A further study was conducted on salinity monitoring by KWASA in 2009 and the result of the study also showed that over four to seven months, Rupsha River levels of chloride exceeded Bangladeshi requirements of 1,000 mg/L. Thus it was suggested then to the authorities to take steps to limit the direct disposal of water from the city as well as installation of salinity-free reservoirs or saline treatment processes. The first initiative was started in 1998 after introducing National Policy for Safe Water Supply and Sanitation (NPSWSS) [14]. The significance of a long-term framework for the approval and execution of the government's goals was then

underlined [15]. National Strategy for Water Supply and Sanitation (2014) was published to develop fecal sludge management programs and wastewater disposal boundaries [16]. Officers of the Water Supply and Sewage Authorities (WASAs), the Ministry of Public Health Engineering (DPHE), non-government organizations (NGOs), and foreign financial organizations including the Asian Development Bank (ADB) comprised the newly established working group. The National Strategy's Strategy 5 provides nine strategic directions that will aid in the development of this suitable fecal sludge management and sewage system [17]. The development of the water supply and sanitation sectors was then under the direction of the Ministry of Local Government Rural Development and Cooperatives (MLGRD&C) and LGD, however, was in charge of coordinating and overseeing the creation of policies, strategies, programs, and regulations at the national level [16]. It was decided then, that KWASA was responsibility for two main functions which were to provide: a clean water supply and sewerage networks in Khulna. However, no sewerage network has been put in place since KWASA's founding in 2008 [14].

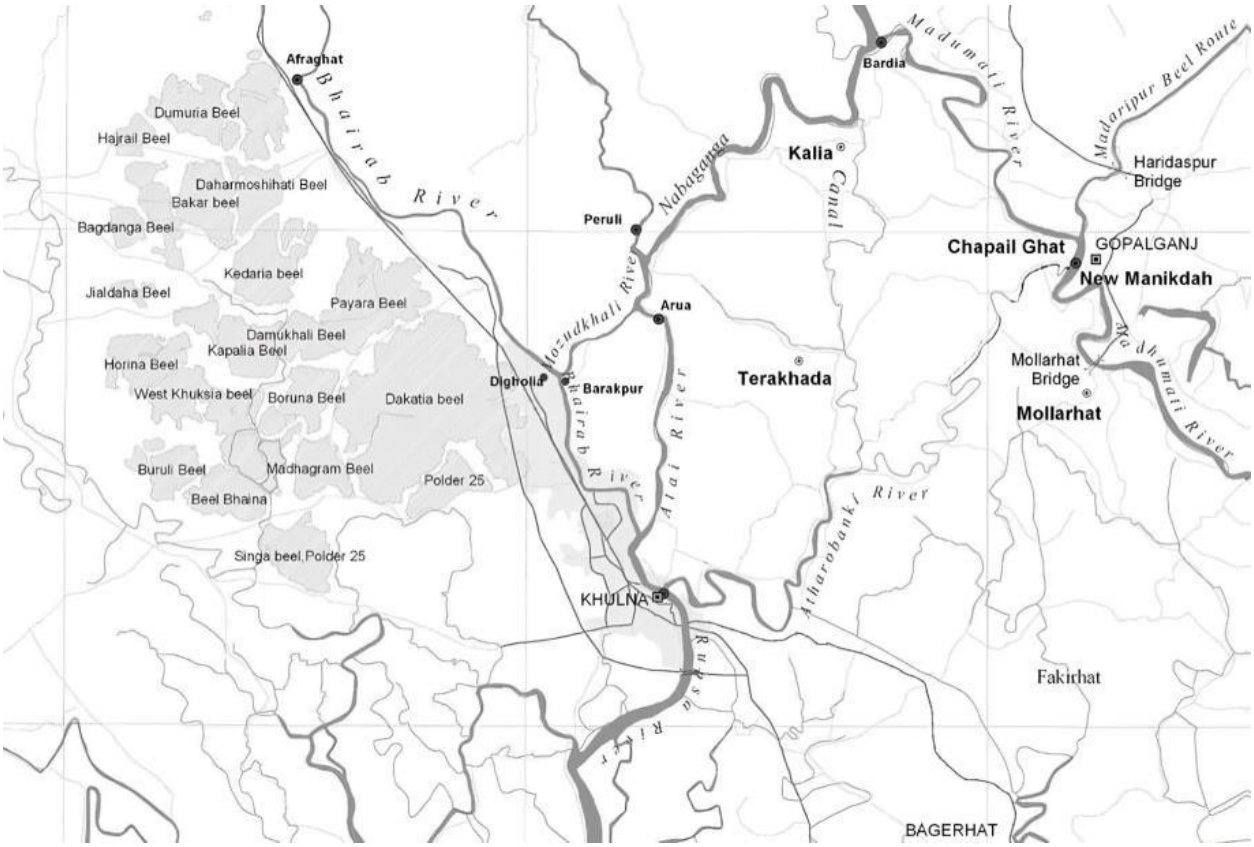

Figure 1 Locations of Water Quality Analysis by JICA Study Team [18]

Challenges and Limitations in Implementation

Urban planning and management was under the purview of city corporations, such as the Khulna City Corporation (KCC). During 2001 to 2011 population of Khulna increased by 37%. Nevertheless, these organizations frequently failed to create or carry out long-term spatial planning despite their constitutional authority. For example, although KCC offered vital services to slum regions, it had little engagement in squatter communities because they were considered illegal. KCC was entrusted with carrying out development plans, although it hardly ever executed the Khulna Development Authority's (KDA) master plans. As a result, KCC continued to focus on its core duties and paid little attention to other general concerns including housing, industrialization, economic growth, and development control.

Budgetary restrictions made it difficult for KCC and the local government to meet the rising demand for services, which resulted in the private sector playing a big part in areas like housing and urban services. It possessed a thread to the disposal of wastewater due to poor and increasing housing. Because state funding was insufficient to meet the city's needs, private developers and individual investments dominated the housing market. A logical and communicative approach was necessary for effective pro-poor planning, enabling under-represented communities to speak up for their interests during the decision-making

process. However, the views of these communities were frequently ignored in the absence of a dedication to open and honest problem identification and inclusive communication with diverse interest groups. Political prejudices occasionally caused priorities to be shifted away from the interests of the general people, while community leaders frequently lacked the abilities necessary to provide positive alternatives. Furthermore, because demand continuously outpaced supply, KCC frequently gave priority to resolving the general lack of services rather than concentrating on enhancing their quality. Despite being highly supported, the NGO-led garbage disposal system had drawbacks. Many low-income people could not afford the hefty service fees, which increased waste blockages in drainage systems and made it more difficult to dispose of wastewater effectively.

Current State of Sewage Collection and Disposal in Khulna City

Existing Infrastructure and Its Limitations

With a population of over 1.5 million, Khulna has a density of 6,877 persons per square kilometer (km2), which is significantly higher than the 1,240 persons per km2 national average. With the completion of the Padma Multipurpose Bridge, which will improve communication with Dhaka, the city is anticipated to experience a boost in commercial and industrial development. Residents of Khulna continue to face urban service constraints, especially with regard to sewage management. Khulna lacks both a centralized wastewater system and sewerage charges. Fecal sludge management (FSM), a systematic service strategy for collecting, treating, and disposing of fecal sludge from on-site systems, is lacking in the city. The majority of houses rely on on-site sanitation systems like pit latrines or septic tanks.

For the past few years, water logging has been an issue in Khulna, the third-largest city in Bangladesh and the problem of water logging in urban areas that are flooded by heavy rainfall and runoff is because of an unplanned and insufficient drainage framework, the demise of an innate sewage structure, and ineffective management [19]. As Khulna city faces rapid urbanization, the hardscape-soft scape ratio is increasing continuously and the city is now facing rapid urbanization with an urbanization level of 28.49% [20]. As a result, the infiltration rate of water is becoming low day by day and that's creating a huge pressure on storm water runoff continuously. Khulna city is surrounded by 15 canals and 3 rivers [20]. For a long, these canals have been used to drain out the stormwater. But last three decades most of these natural drains have either filled up or were encroached on by human intervention like the construction of roads or the development of residential areas. Some of these are replaced by narrow surface drains. This reduces the effectiveness of natural drainage. Khulna city has a manmade drainage line of 547 m [20]. Out of these only 7% are covered by RCC remaining 93% are open to air [21]. The Capacity and effectiveness of these uncovered drainage lines are decreasing continuously due to various high-weighted particles aggregating into the drainage line and partially blocking the way of water flow. Sometimes it fully blocks the waterway and creates unwanted water logging suddenly. Now, about 74% of generated sewage and 57% of solid wastes are discharged directly to the surface drain by residential, commercial/office, dormitory/hostel, primary school, and market/bazar [22]. In slum areas, about 76% of the generated sewage and 60% of solid wastes are discharged directly to the drain [22]. Chemical complexes, fish processing facilities, steel mills, paper mills, rayon mill complexes, cement factories, paint and dye production plants, and other polluting enterprises in the Khulna region are all directly releasing their untreated toxic effluent into the Rupsha river system. The Rupsha River system eventually transports this wastewater to the Sundarbans[23]. Crop fields next to the Rupsha River are routinely irrigated with tainted water throughout the dry season [24]. The chemical components of irrigation water can create plant toxicity or deficiency directly or can affect plants by altering availability of nutrients [25].

Community and Environmental Impact

Improper handling of fecal sludge and wastewater can have severe consequences for public health and wellbeing. In low- and middle-income countries, inadequate sanitation is linked to high rates of diarrhea, a leading cause of illness and mortality among children under five [26]. Malnutrition and developmental issues in children are often the outcomes of infections caused by unsanitary conditions [27]. Sanitation workers, particularly manual pit emptiers, face significant health risks and a meta-analysis of occupational health outcomes found that these workers have a heightened risk of respiratory diseases and gastroenteritis [28]. In urban areas with poor drainage, stagnant stormwater becomes a breeding ground for disease as it mixes with sewage from overflowing latrines and sewers [19]. This contaminated runoff contributes to an increase in waterborne diseases. During the monsoon season, those without access to clean water may be forced to use contaminated surface or shallow groundwater sources, exposing them to health risks like eye and

skin infections, respiratory diseases, malaria, and dengue fever [29]. Groundwater contamination further exacerbates these health threats.

Inadequately drained rainwater not only creates unsightly and foul-smelling stagnant pools but also provides ideal breeding conditions for disease vectors such as mosquitoes [30]. Leach pits and flooded septic tanks serve as breeding grounds for mosquitoes, while moist soils contaminated with feces foster the spread of intestinal worm infections. In Khulna City, waterlogging has led to a sharp increase in mosquitoes and the diseases they transmit, posing a significant public health challenge [31].

Recent Initiatives and Future Directions

Recent Developmental Projects and International Aid

According to Asian Development Bank [32], the Khulna Sewerage System Development Project (KSSDP) aims to establish a modern sewerage system in Khulna, covering densely populated and commercial areas serving approximately 850,000 residents by 2027. First of the key components of the project is the establishment of Treatment Facilities which construction of two sewage treatment plants with a combined capacity of 80,000 cubic meters per day and a fecal sludge treatment plant with a capacity of 160 cubic meters per day. Another one is Sewer Network Expansion which includes the development of a 269kilometer sewer network across the target areas. Furthermore, property-Level Connections: Provision of around 27,000 sewer connections at the property level. Again, capacity building is strengthening the capabilities of the Khulna Water Supply and Sewerage Authority (KWASA) for effective management and operation. In addition key component is sanitation and hygiene awareness initiatives to promote awareness of proper sanitation and hygiene practices among the population. This project is set to significantly improve the sewerage infrastructure, addressing the critical sanitation needs of Khulna's urban areas.

Another project [33] whose main goal is to create a sustainable and equitable sanitation system for Khulna, which will serve the city's commercial districts and densely populated residential neighborhoods, which together are home to around a million people. The system will include fecal sludge management (FSM) facilities, sewage treatment plants (STPs), and sewer networks. The initiative will also improve KWASA's ability to efficiently plan, execute, and manage these systems. The project intends to improve Khulna's immediate environmental conditions and increase the city's resilience to climate impacts by expanding sewage treatment capacity. In low-income communities (LICs) where a piped sewer network is impractical, it will also offer customized sanitation solutions, setting the stage for possible future partnerships with the private sector.

Future Goals and Recommendations for sewage collection and disposal of Khulna City

Urban regions must have comprehensive sewage management systems in place to address the problems brought on by expanding populations and environmental stresses. These plans ought to address the collection, treatment, and disposal of wastewater from cities, industries, and farms, among other facets of wastewater management [34]. Key elements including sludge management, odor control, and appropriate effluent dispersal must be taken into consideration by effective treatment techniques [35]. A key component of these programs is solid waste management, which covers burning techniques, composting, landfill usage, and air and water pollution [36]. Because of pollutants and pathogens, treating and disposing of sludge presents significant hurdles. Although applying treated sludge to land is a feasible alternative, it requires careful risk assessments and strict quality requirements to keep an eye on organic compounds and heavy metals [37]. Sustainable practices, advantageous reuse, and the application of reasonably priced, locally appropriate technologies should be the main focus of future sewage management. To guarantee long-term viability and efficacy, comprehensive plans must consider environmental, social, economic, and technical concerns [37].

CONCLUSION

Khulna City in Bangladesh is a prime example of the major difficulties in managing urban wastewater in emerging cities. Spatial differences in water supply coverage and consumption result from the traditional centralized system's frequent failure to meet the needs of residential areas. Natural water bodies are being encroached upon due to rapid urbanization, which has disrupted the ecosystem and raised the risk of flooding. To tackle these problems, a change from reactive to proactive strategies that emphasize sustainability and increased social engagement is required. By recovering resources and creating added value while preserving the health of people and ecosystems, sustainable sanitation systems that are

included in urban growth have the potential to support several SDGs. Decentralized management systems, hierarchical water tariffs, and inter-organizational cooperation should be given top priority in future projects in order to establish robust and just sanitation systems.

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