EVALUATING THE POTENTIAL OF TREATED WASTEWATER AS A SUSTAINABLE RESOURCE IN MEETING URBAN WATER NEEDS ACROSS BANGLADESH

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ABSTRACT

Amidst the ever-growing population and the increasing demand for water in urban areas, wastewater reuse has emerged as a vital component of sustainable water management. However, available studies provide limited information on Bangladesh's overall urban wastewater production and its reuse prospects. This research assessed the state of wastewater generation & treatment and its reuse possibilities in major cities of Bangladesh and proposed practical options for the reuse of reclaimed wastewater. Based on a comprehensive literature review, data on water demand, sewage generation, ongoing and future plans regarding wastewater treatment were collected and analyzed for several metropolitan cities. Primary and secondary data on treated effluent from the existing sewage treatment plants in Dhaka, as well as raw water sources for the water treatment plants in different cities were collected. The treated effluent quality of an existing sewage treatment plant in Dhaka has been compared with the surface water quality standards of ECR 2023. Also, a comparison between the treated effluent quality or the designed treated effluent quality for cities outside Dhaka and the quality of raw water sources has been made to determine the suitability of the treated effluent for potable/non-potable uses as well as the requirement of further treatment. Research findings show that in major cities of Bangladesh, the potential generation of treated wastewater could vary from 75 MLD (in Gazipur) to 1750 MLD (in Dhaka) by the year 2050, which can meet up to about 7.52% (in Gazipur) to 59.85% (in Chattogram) of daily water demand. The water quality parameters of the treated effluent from the Dasherkandi STP in Dhaka show favourable results, suggesting its suitability for water reuse applications both for potable and non-potable use. The design treated effluent quality for the planned wastewater treatment plants in Chattogram, Sylhet, and Khulna cities is also comparable to the quality of raw water sources of those cities, indicating potential for reuse applications. Recognizing the immense potential of treated wastewater reuse, restoration of waterbodies, creation of ecotourism facilities, etc., have been proposed as a substantial non-potable reuse application. Also, storing treated wastewater in environmental buffers through groundwater recharge or constructing water supply reservoirs can facilitate potable water supply to the cities. Water balance computations for the proposed treated wastewater-based Nasirabad reservoir cum eco-park clearly show the potential for a large-scale sustainable water supply source while preserving other functionalities of the eco-park. Overall, the research findings illustrate a holistic overview of the wastewater reuse possibilities in Bangladesh and emphasize the urgent need for policy interventions and investments in wastewater treatment and reuse infrastructures to support a transition towards a circular water economy.

Keywords: *Wastewater Generation, Treated Effluent, Wastewater Reuse, Sustainable Resource*

1. INTRODUCTION

Global water resources are diminishing due to the widening disparity between freshwater availability and demand; thus, access to clean and safe water has become a critical issue in contemporary society. According to the 2024 UN World Water Development Report, global freshwater demand is highest in the agricultural sector, accounting for about 70% of withdrawals, with roughly 20% and 10% in the industrial and municipal sectors, respectively. Over the years, water consumption in the municipal sector has significantly risen compared to other sectors (UN WWDR, 2024). Two primary factors contributing to the rising demand for water are population expansion and changing consumption patterns driven by socio-economic development. In addition, climate change is putting a strain on water resources in many urbanized areas, leading to water scarcity and conflicts over water allocation (Seow et al., 2016).

As part of urban water management, there is a rising global interest in wastewater treatment and reuse as a response to growing water scarcity and projected future demands (Tortajada & Bindal, 2020). To achieve the SDG Indicator 6.3, which articulates lowering the percentage of untreated wastewater and significantly enhancing recycling and safe reuse on a global scale, additional investments in treatment and improved infrastructure, as well as supportive policy and legislative frameworks are required. It is mentioned in the SDG 6 Progress Report that about 42% of global residential wastewater, amounting to 113 billion m^3 was inadequately treated before being released (WHO, 2024). A separate estimate reveals that globally 359.4 billion m^3 of wastewater is produced annually, of which around 48 % (172.5 billion m^3/year) is discharged directly without any treatment (Jones et al., 2021). This is equivalent to the household water consumption of about 2300 million people (roughly 50% of the Asian Continent), considering an average water consumption of 200 lpcd, which is enormous in terms of volume. Recycling and reuse of such an enormous volume of wastewater could contribute to addressing the challenges of water scarcity across the world.

Fundamentally, wastewater reuse is the process of transforming municipal wastewater (sewage) or industrial wastewater, or in a combined system mixed municipal/industrial with stormwater into treated water that can be reused for a variety of applications such as agriculture, potable water supplies, groundwater replenishment, industrial processes, and environmental restoration (US EPA, 2019). The practice of reusing treated wastewater has seen significant and rapid expansion, with volumes increasing by around 10 to 29% per year in Europe, the USA, China, and up to 41% in Australia (Kesari et al., 2021). Recycled wastewater (NEWater) currently meets 40 percent of Singapore's water demand, and this figure is expected to rise to 55 percent by 2060, according to the country's water agency (Tortajada & Rensburg, 2020). Extremely unpredictable climatic variability and stressed conditions of conventional water resources have led Australia to adopt recycled water as a legal source for non-potable uses, integrating it into a diversified water portfolio to mitigate climate-related risks (Apostolidis et al., 2011). Wastewater reuse as a potential alternative water resource could contribute significantly to overcome water scarcity challenges in one of the world’s most water-scarce MENA regions of the world (Asaad & Suleiman, 2023). Equally, it can serve as one of the pertinent water source alternatives in a climate-vulnerable country like Bangladesh.

However, currently in Bangladesh, no policy mechanism exists that encourages wastewater reuse, though its importance is increasingly recognized in sectoral strategies, development partner-supported programs, and the industrial sector, particularly in the textile industry. In Bangladesh, particularly in the high-density urban centers, the prospects for water reuse are emerging in response to increasing population, rapid urbanization, industrial development, poor state of sanitation facilities, and the combined effects of these factors on the pollution of surface water resources. Also, because of the declining groundwater levels in megacities like Dhaka and Chattogram and the diminished water quality of surface water sources across urban centers of Bangladesh, reutilizing treated wastewater has become a focal point of discussion as it can effectively reduce pollution and boost water security at the same time.

Despite being a widely debated issue, current research on wastewater reuse in Bangladesh is limited to focusing on emphasizing industrial wastewater recycling and energy recovery potential (Nahar et al., 2024; Roy et al., 2013; Islam et al., 2023). There is a clear research gap in providing a holistic overview of the city-level wastewater production planned by respective authorities, characterizing the treated wastewater quality, identifying its potential as an alternative water source, and framing realistic solutions for its reuse.

This study aims to respond existing research gaps and provides quantification of wastewater production across five major cities in Bangladesh (Dhaka, Chattogram, Sylhet, Gazipur and Khulna), an assessment of treated wastewater quality in comparison to surface water sources, highlights the potential of wastewater reuse in meeting water demands in those cities and presents practical plans to use the treated effluent as valuable resources focusing on Dhaka city. The ultimate goal of this study is to encourage the integration of reuse schemes in national and local level water and sanitation strategies and frame out wastewater management in urban centers of Bangladesh, emphasizing reuse approach rather than the typical disposal and dilution approach.

2. METHODOLOGY

The study adopted a mixed-methods approach combining literature review, secondary data collection from government agencies, water sampling and testing, and comparative analyses of the gathered data.

2.1 Key Data Acquisition

Data collection on existing and future water demand of the cities (till 2050) was mostly based on review of available master plans and sectoral development plans, as well as mathematical computations based on population census and water consumption data. The projected water demand of Dhaka for the year 2050 was derived from the Updated Water Supply Master Plan for Dhaka City (IWM, 2025). For Chattogram, the 2050 population was estimated by trend analysis of Bangladesh Bureau of Statistics (BBS) census data from 2011 and 2022, supplemented by the 2020 and 2030 population projections adopted from the Chattogram Sanitation Master Plan (CWASA, 2017). Population projections for Gazipur, Sylhet, and Khulna were obtained from the Gazipur City Corporation Urban Development Plan (GCC, 2024), the Sylhet Sewerage Master Plan (IWM, 2022), and the Khulna WASA report (KWASA, 2024), respectively. The future development planning of sewage treatment plants (STPs) in different cities and the wastewater volume transferred to STPs for treatment purposes were sourced from relevant sewerage master plans and feasibility studies.

To assess the treated wastewater quality, an effluent sample from Dasherkandi STP of DWASA was collected in April 2024 in connection with an IWM project and the water quality test was conducted at the BUET laboratory. There is no wastewater treatment facility in other cities at present; however, there are ongoing and future plans to construct several treatment plants. The design treated wastewater quality for those cities was collected from the relevant feasibility studies and design documents. Water quality data of surface water sources across different cities were collected through a comprehensive review of project documents and published literature. Concerning Dhaka city, raw water quality data at Bishnandi point of Meghna River was taken from the DoE annual report and raw water quality of Padma Jashaldia Water Treatment Plant was collected from DWASA. Data on the quality of existing surface water sources in Chattogram, Sylhet, and Khulna cities were obtained from respective WASA and city corporations' published literature.

2.2 Estimation of Daily Water Consumption and Future Water Demand

Variations in water demand are influenced by the size of the area of interest, economic activities, climatic conditions, literacy rates, habits, economic and social status of inhabitants, water availability and quality, etc. The average daily water consumption for domestic purposes in Chattogram is estimated as 123.80 L in a research study (Datta et al., 2022). In Khulna city, regular water use is around 116 liters per person per day for personal hygiene, cleaning, and religious activities (Lewis et al., 2024). Water consumption in Dhaka exhibits significant spatial inequality, with higher usage in affluent zones, influenced by income, household size, and other socio-economic factors (Siddiquee & Ahamed, 2020). In Dhaka City, the average water consumption is 200 litres per capita per day (IWM, 2025). Overall, the reviewed studies estimated an average per capita water consumption in different cities of Bangladesh to range between 130 and 200 litres per capita per day (LPCD), with the Dhaka Metropolitan Area exhibiting the highest consumption levels. As an average value, 150 lpcd was considered as per capita water consumption for the cities of Chattogram, Khulna, Sylhet, and Gazipur. The projected population by 2050 in those cities was multiplied by the per capita water consumption rate of 150 lpcd to assess the future domestic water demand till 2050. An additional 15% demand was incorporated to account for commercial and institutional water demands as per the DWASA water supply master plan (IWM, 2025) to obtain the final water demand.

2.3 Estimation of Treated Effluent Amount

The influent and effluent flow data from the Dasherkandi STP of DWASA were collected and analyzed, which indicated an approximate 3.5% volumetric loss between influent and effluent, likely attributable to treatment and operational processes. This finding aligns closely with established engineering literature; notably, Metcalf & Eddy, Inc. (2014), which reports a standard volumetric loss range of 2% to 5% for similar wastewater treatment infrastructures. Adopting this 3.5% loss percentage for the existing and planned STPs in different cities, the treated wastewater volume for the year 2050 was estimated. Finally, using the projected water demand and corresponding treated wastewater volumes by 2050, the proportion of treated wastewater relative to total projected water demand was calculated.

2.4 Comparative Analysis of Treated Wastewater and Surface Water Quality

Test results of treated wastewater quality were compared with the ECR 2023 standard for surface water (drinking water with conventional treatment) as well as with different raw water sources of Dhaka, to assess the suitability of the treated effluent for alternative water use. Similarly, for other cities, the design effluent quality of the planned wastewater treatment plants was compared with the water quality of the surface water sources in those cities.

2.5 Reservoir Water Balance Computation

This study presents a long-term wastewater reuse proposal utilizing the urban wetland concept, focusing on Dhaka city. In the recently updated Detailed Area Plan of Dhaka, (DAP 2022-2035), several regional parks, water parks, and water-based eco parks have been proposed across the Dhaka metropolitan area to enhance urban livability. The potential of building a treated wastewater reservoir in one such planned Nasirabad Eco Park, located in close proximity to the Dasherkandi STP (Figure 1), was examined in this context. In that respect, a simple water balance model was developed. Effluent discharge from DSTP and precipitation over the reservoir were considered positive balance parameters. Evaporation and seepage loss were considered as the negative balance parameters.

The area and storage volume of the reservoir were estimated using data from the DAP, Digital Elevation Model (DEM) of Dhaka city available at IWM, and the highest recorded water level of the Balu River sourced from BWDB. As per the DAP, the total area of the proposed reservoir is about 488 hectares, and the land level varies from -5.8 mPWD to 1.68 mPWD. Analyzing the water level data of the Balu River, the maximum observed water level was found to be 5.9 mPWD. Considering a standard free board of 0.8 m, the high-water level of the proposed reservoir was estimated at 5.1 mPWD and accordingly, the maximum storage volume was computed as 14000 m^3. To ensure eco park activities in the reservoir, dead storage volumes with respect to 2.0 mPWD and 1.0 mPWD were estimated. A constant inflow of 450 MLD from Dasherkandi treatment plant effluent was considered as a positive influx and different levels of withdrawal rule (e.g., 450 MLD, 470 MLD etc.) were tested as outflux. To assign the negative water balances components, evaporation loss and seepage loss, data from the Soil Resource Development Institute (SRDI), Bangladesh Water Development Board

(BWDB), and the Bangladesh Meteorological Department (BMD) were utilized. According to SRDI classifications, the selected area is dominated by calcareous dark grey and calcareous brown floodplain soil having low permeability with a seepage rate of 2mm/day, which was considered for calculating seepage loss. The influx of water due to rainfall and loss of water due to evaporation were computed based on precipitation and evaporation data of the Dhaka station from BWDB and BMD. The water balance model computation was made for the year 2023. Finally, contingent upon the assumption that the maximum permissible abstraction level will uphold the dead storage volume in the reservoir, the optimum level of water withdrawal from the reservoir was estimated.

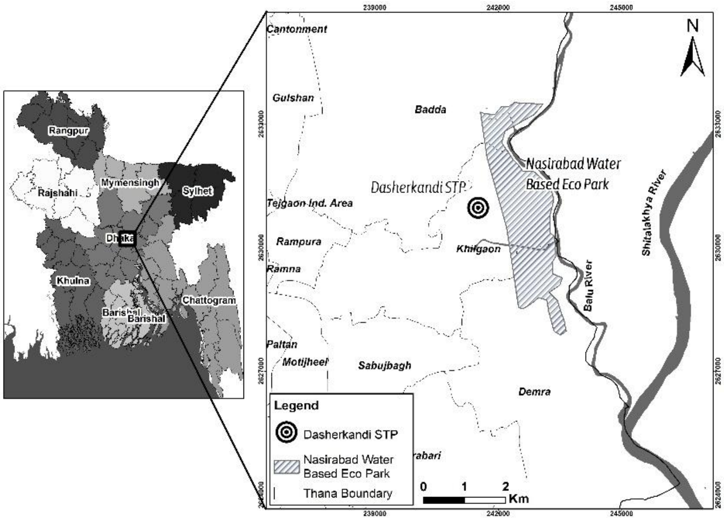


Figure 1 : Proposed Water-based Eco Park near Dasherkandi Sewage Treatment Plant

3. RESULTS AND DISCUSSIONS

3.1 Recoverable Effluent Quantity

Data analysis suggests that in Chattogram and Sylhet cities, the volume of treated wastewater is expected to exceed 50% of the total projected water demand for 2050, whereas in Dhaka and Khulna, the corresponding proportion surpasses 30% and 20%, respectively. In Gazipur city, limited planning for a centralized sewer and sewage treatment plant results in a lower volume of treated effluent compared to future water demand (Table 1). This clearly indicates that by adopting large-scale wastewater treatment reuse projects, a significant part of future water demand in major cities of Bangladesh can be met. This implies that the reuse of treated wastewater has high potential to enhance the urban water security in Bangladesh.

Table 1: Wastewater Generation in Major Cities

Area	Water Demand in 2050 (MLD)	Wastewater transferred to STP in 2050 (MLD)	Treated Wastewater in 2050 (MLD)	Percentage of Treated Wastewater compared to water demand in 2050
Dhaka	5,343	1,750	1,689	31.61 %
Chattogram	790	490	473	59.85 %
Sylhet	344	189	182	53.01 %
Gazipur	963	75	72	7.52 %
Khulna	356	80	77	21.66 %
Total	7,797	2,584	2,494	31.98 %

3.2 Treated Effluent Quality Assessment

The country has been investing recently in installing, expanding, and upgrading its wastewater treatment plants to produce higher quality treated effluent. At present, in Dhaka city, a 500 MLD capacity advanced sewage treatment plant (DSTP) at Dasherkandi is operational, for which water quality parameters of the tested sample of treated effluent are quite impressive. The test results of the collected effluent from Dasherkandi STP satisfy the safe disposal limit to open surface waterbody, indicating effective wastewater treatment performance. Additionally, most of the key physicochemical and microbiological parameters, including heavy metal concentrations, are well within or close to the limits set by the ECR 2023 standards for raw water sources for drinking water supply with conventional treatment (Table 2).

Table 2: Treated Wastewater Parameters in Dasherkandi Sewage Treatment Plant

Parameter	Unit	Effluent Concentration	ECR 2023 Standard	Parameter	Unit	Effluent Concentration	ECR 2023 Standard
pH	-	7.36	6 to 9	**Nitrate (NO3)**	mg/l	0.89	45*
Temperature	°C	32	-	**Phosphate PO4 (as P)**	mg/l	2.58	0.5
EC	µS/cm	985	-	**COD**	mg/l	31	≤25
DO	mg/l	6.93	≥5	**BOD5**	mg/l	8	≤3
Color (True)	Pt-Co	26	6 to 9	**Total Hardness (as CaCO3)**	mg/l	160	500*
Turbidity	NTU	1.83	5*	**Total Alkalinity (as CaCO3)**	mg/l	234	-
TDS	mg/l	524	1000	**Sulphate**	mg/l	<MDL	-
TSS	mg/l	8	-	**Cr**	mg/l	0.006	0.02
NH3-N	mg/l	0.02	-	**Ni**	mg/l	<MDL	-
NH4-N	mg/l	0.41	0.3	**Pb**	mg/l	0.002	0.03
TC	CFU/100 mg/l	1900	≤5000	**Cd**	mg/l	<MDL	-
FC	CFU/100 mg/l	1000	-	**Hg**	mg/l	<MDL	0.001

Note: MDL refers to method detection limit

DoE ECR 2023 standards for treatment of surface water source for drinking purposes (Schedule -2 Serial No. 3)

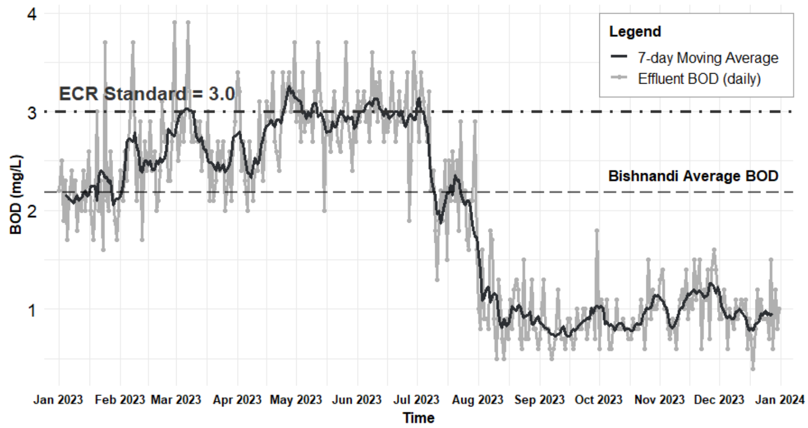
* Refers to DoE ECR 2023 standards for drinking water quality

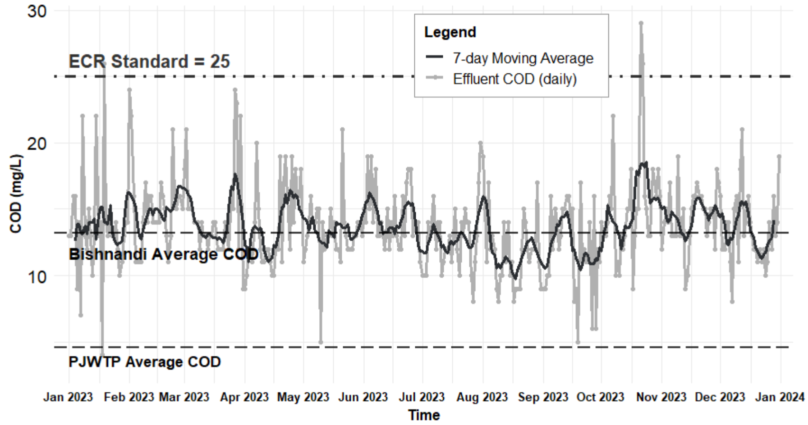
The pH, dissolved oxygen (DO), and Total coliform (TC) level confirms safe release of sewage treatment plant effluent in the nearby waterbody. There is little concern about harmful contamination, as the concentrations of heavy metals (Cr, Pb, Ni, Cd, Hg) are well below or close to detection thresholds. Few parameters, i.e., Turbidity, Nitrate, and total hardness, are well within the permissible range of DoE regulation for drinking water quality. However, slightly higher BOD_5, COD, Ammonia-N, FC, and phosphate levels suggest the need for further treatment.

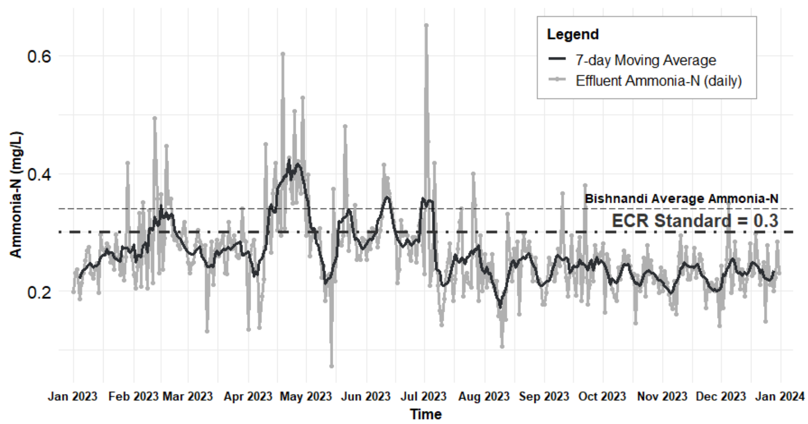
3.3 Comparative Assessment of Treated Wastewater with Surface Water Source

Over the monitoring period, daily measurements & 7-day moving averages (which reduce noise of daily values) of BOD_5, COD, Ammonia-Nitrogen, and phosphate levels show seasonal variation but remain close to regulatory compliance (Figure 2**)**. Elevated phosphate levels, frequently exceeding the regulatory standard, indicate excess nutrient loading in the effluent throughout the observation phase. For these four crucial parameters, a comparative analysis has been conducted among the Dasherkandi STP effluent quality, the raw water quality withdrawn from Meghna River at Bishnandi point for the Gandharbapur Water Treatment Plant of DWASA, and the raw water quality of Padma water treatment plant of DWASA. Results show consistently low BOD values in the effluent of Dasherkandi

STP, mostly below 1 mg/L during the later period of the year. The average BOS during the dry season is higher than the Bishnandi intake point; however, it is close to the ECR guideline. Stable and low COD levels, very similar to Bishnandi intake, remain mostly below the ECR limit but are higher than the intake point values of Padma Jashaldia Water Treatment Plant (PJWTP). Similarly, ammonia-N level is quite similar to the average ammonia-N level of Bishnandi intake across the year. Highly variable phosphate levels remain higher than Bishnandi intake but are lower than PJWTP intake throughout the analysis period. Overall, the treated wastewater quality of Dasherkandi STP is quite comparable to the raw water quality of DWASA water treatment plants, indicating the suitability of the Dasherkandi STP effluent as an alternative water source.







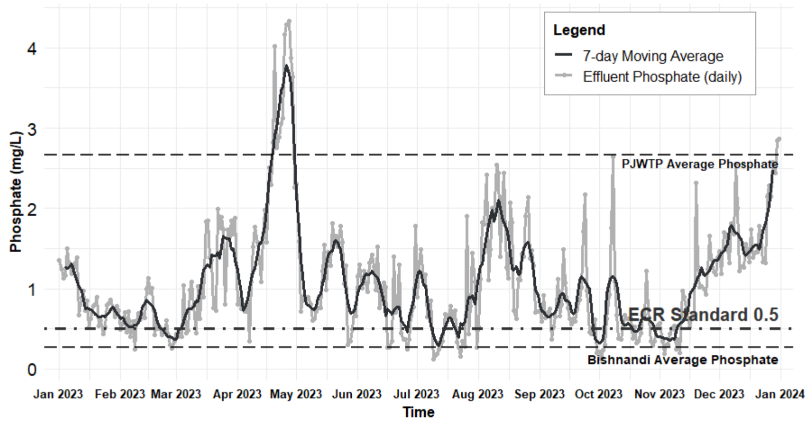


Figure 2 : Temporal Variation of Treated Effluent Quality of Dasherkandi STP and Comparison with Raw Water Quality of the Water Treatment Plants of DWASA

Design treated effluent quality of Halishahar STP at Chattogram city will achieve the desired level of pollutant removal as compared to ECR 2023 guideline; however, other parameters will not be comparable with the city's raw water source (e.g. Halda River at Mohora Intake). Designed STPs of Sylhet and Khulna cities will also meet the ECR standard for safe water disposal; however, they will still exceed the quality parameters of respective surface water sources (Table 3). But with the design effluent quality, as shown in Table 3, the treated wastewater from those STPs could still be used for non-potable purposes. For all cities, although the designed effluent will meet safe disposal standards with good organic and nitrogen removal rates, further biological polishing or other additional treatment steps are required if considered for potable reuse alternatives or non-potable reuse in households.

Table 3: Comparison of Raw Water Sources with Designed Treated Effluent Quality

WQ Parameter	**Halda River (Mohora, Chattogram)**	**Halishahar STP (Chattogram)**	**Surma River Sylhet**	**Sylhet STP**	**Madhumoti River, Khulna** (Shome & Khondoker, 2024)	**Khulna STP**
pH	6.98	6-9	7.27	6-9	8.1	
BOD (mg/l)	0.5	20	0.2	30	0.72	≤15
TSS (mg/l)	65	30	10	30	94	≤20
COD (mg/l)	3.75	100	4	120	-	
Ammonia Nitrogen (NH_3-N) (mg/l)	0.475	2	0.1	-	-	
Nitrate Nitrogen (NO_3-N) (mg/l)	0.45	5	0.8	-	-	
Phosphate (PO_4-P)			-	35	-	
Total Phosphorus TP (mg/l)	-	10		-	-	≤1
Total Nitrogen TN (mg/l)	-	10	-	15	-	≤15

3.4 Wastewater Reuse Possibilities & Planning

The collection and treatment of sewage water under STPs have immense potential for water reuse across various sectors. Potential applications include non-potable domestic uses (car washing, gardening, toilet flushing), municipal services (e.g., road cleaning, firefighting), landscaping, ecological enhancement, agricultural irrigation with appropriate safeguard measures, recreational purposes, restoration of water quality in the surrounding waterbodies, etc. For non-potable uses, the international utility industry has adopted purple as the standard pipe color for transporting treated reclaimed water (Vandertulip, 2009). Strict plumbing requirements consisting of purple-colored pipes

& fittings have been introduced in several Australian cities to distinguish reclaimed water pipes from drinking water pipes (Leeuwen et al., 2003). Up to 2 GL of tertiary-treated wastewater are supplied annually to 32,000 residences in Australia's largest household water recycling system for outdoor purposes such as vehicle washing, gardening, and toilet flushing (McFarlane, 2018). Similarly, in major cities of Bangladesh, treated wastewater can be supplied through a separate color-coded water network to nearby residential localities for non-potable uses.

Discharging treated water from operational and planned STPs in nearby rivers can augment flow in the dry season and significantly improve the water quality of the polluted river system around Dhaka city. Irrigation water demand meet-up initiatives using treated wastewater with controlled application and proper guidelines can be planned in Khulna city, where salinity intrusion is a major environmental challenge (Hashem & Qi, 2021). With further purification techniques such as ultrafiltration, reverse osmosis, and UV disinfection of treated wastewater from STPs across the country, an aquifer recharge scheme can be introduced to replenish the continuously depleting groundwater level (Khan & Anderson, 2018). Sewage-fed aquaculture and fisheries near the STP facility could offer additional benefits, including reduced fertilizer use and a constant water supply source (Kumar et al., 2014). Moreover, reclaimed water can be distributed to industrial settings, i.e., production, cleaning, washing, cooling machineries, etc., to metro hubs, bus depots, railway stations for vehicle wash, to sport stadiums, to city corporations for watering roadside vegetation & dust suppression, to revitalizing ornamental ponds and lakes in public parks, and to establish artificial wetlands, etc (Lv et al., 2020; Tyagi et al., 2024; Yi et al., 2011; Zaneti et al., 2012).

Creating a wetland as a multifunction landscape tool is a new approach to wastewater management that sustainably combines traditional landscape features with human interventions (Haron & Feisal, 2020). As an example, Nasirabad Water Recreation Eco Park, proposed by DAP, covering about 1,206 acres next to the Dasherkandi STP, presents significant potential for reuse activities. The concept envisions using the treated effluent from DSTP to create a treated wastewater-based reservoir cum recreational park. Based on the water balance model results, it is evident that by constructing a reservoir with a maximum storage volume of 14000 m^3, a continuous supply of at least 450-470 MLD from the proposed reservoir throughout the year is a feasible option, while still maintaining the recreational purpose of the reservoir. With this substantial withdrawal rate, a large-scale water treatment plant can be easily implemented. Alternatively, the reservoir could serve as a source of non-potable water for surrounding residential areas. Nevertheless, for both potable and non-potable uses of treated wastewater, a tertiary level of treatment would be required to ensure compliance with water quality standards and to address aesthetic aspects of wastewater reuse.

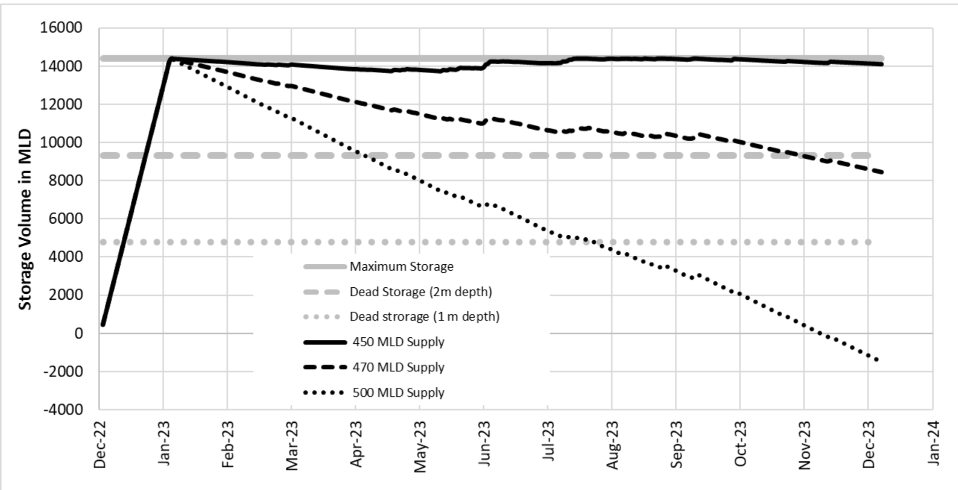


Figure 3: Storage Volume in Proposed Nasirabad Treated Wastewater Reservoir over time with Different Supply Levels

4. CONCLUSIONS

Bangladesh's major metropolitan cities are facing significant challenges in meeting rising water demand. In the quest for suitable raw water sources, city authorities are delving into mega projects bringing water from long distances, which is impacting the economy as well as the inhabitants, who have to pay a higher water tariff. Treated wastewater from the existing/planned STPs in different cities can be considered as an alternative water source, both for potable and non-potable use. Data analysis in this study proved that a substantial proportion of future water demand in different cities of Bangladesh can be met simply by promoting the reuse of treated wastewater. Reclaimed wastewater has considerable potential to supplement the surface water sources in different cities of Bangladesh undergoing low flow conditions, salinity intrusion and/or extreme pollution, particularly during dry periods. In the case of Dhaka city, Dasherkandi STP, designed with sophisticated and advanced treatment technologies, produces high-quality treated wastewater comparable to existing drinking water sources such as the Meghna and Padma rivers. With further tertiary treatment, the effluent will offer suitability for most reuse applications. However, to supplement this finding, further analysis of the treated effluent from the Dasherkandi STP, particularly the chemical substances and emerging contaminants, would be necessary. Also, distributing treated wastewater via a dedicated water supply network (e.g., purple pipe network) or establishing water supply reservoirs for potable reuse requires meticulous attention to public acceptance. Treated wastewater from the proposed treatment plants in other metropolises, enhanced with tertiary treatment procedures, has the potential to support non-potable reuse initiatives such as agricultural use, use in industrial processes, groundwater replenishment, and urban landscaping. Further data collection and analysis after the construction of STPs in those metropolises would be necessary to strengthen the findings.

Eventually, effective reuse of treated wastewater could maximize the efficiency of wastewater treatment efforts, enhance urban water security, improve the living environment in cities, and thereby advance smart water management for a sustainable future. Nevertheless, alongside proactive reuse initiatives, precautionary measures should also be taken to safeguard public health. Accordingly, it is imperative to take prompt action to formulate a guideline for the safe and sustainable reuse of treated wastewater in Bangladesh.

ACKNOWLEDGEMENTS

The authors wish to express gratitude to the Dhaka WASA, Chattogram WASA, Khulna WASA, Gazipur City Corporations, and Sylhet City Corporations for contributing information regarding sewage treatment facilities and data used in this study.

AI USAGE DECLARATION

The authors acknowledge the use of the AI language model for grammatical refinement and enhancing the readability of the manuscript.

REFERENCES

Apostolidis, N., Hertle, C., & Young, R. (2011). Water Recycling in Australia. *Water*, *3*(3), 869–881. https://doi.org/10.3390/w3030869

Asaad, S., & Suleiman, A. (2023). Socio-demographic factors and treated wastewater reuse in the MENA region: Insights and implications. *Desalination*, *565*, 116830. https://doi.org/10.1016/j.desal.2023.116830

Azharul Haq, K. (2006). Water Management in Dhaka. *International Journal of Water Resources Development*, *22*(2), 291–311. https://doi.org/10.1080/07900620600677810

Biswas, S., Al-Muyeed, A., & Rahaman, Md. T. (2023). *SFD Lite Report Gazipur City Corporation Bangladesh*. https://doi.org/10.13140/RG.2.2.25925.12000

Biswas, S. K., Rahman, Md. M., Rahman, Md. Y. A., & Rahman, Md. M. (2012). Applicability of domestic grey water reuse for alleviation of water crisis in Dhaka City. *Journal of Water Reuse and Desalination*, *2*(4), 239–246. https://doi.org/10.2166/wrd.2012.077

Bussi, G., Shawal, S., Hossain, M. A., Whitehead, P. G., & Jin, L. (2023). Multibranch Modelling of Flow and Water Quality in the Dhaka River System, Bangladesh: Impacts of Future Development Plans and Climate Change. *Water*, *15*(17), Article 17. https://doi.org/10.3390/w15173027

Campos, H. M., & von Sperling, M. (1996). Estimation of domestic wastewater characteristics in a developing country based on socio-economic variables. *Water Science and Technology*, *34*(3), 71–77. https://doi.org/10.1016/0273-1223(96)00558-6

CWASA (2017). Sanitation Master Plan. Volume 1: Main Report. Grontmij A/S, AQUA, and IWM.

Datta, S., Karmakar, S., Islam, M. N., Karim, M. E., Kabir, M. H., & Uddin, J. (2022). Assessing landcover and water uses effects on water quality in a rapidly developing semi-urban coastal area of Bangladesh. *Journal of Cleaner Production*, *336*, 130388. https://doi.org/10.1016/j.jclepro.2022.130388

Ezugbe, E. O., & Rathilal, S. (2020). Membrane Technologies in Wastewater Treatment: A Review. *Membranes*, *10*(5), 89. https://doi.org/10.3390/membranes10050089

GCC (2024). Preparation of Urban Development Plan for Gazipur City Corporation Area. Consultancy Research & Testing Service Office, CE Dept, DUET, Gazipur.Haron, A., & Feisal, Z. (2020). Constructed Wetland Parks: A Pathway to Sustainability For Cairo. *Journal of Urban Research*, *36*(1), 61–81. https://doi.org/10.21608/jur.2020.90103

Hashem, M. S., & Qi, X. (2021). Treated Wastewater Irrigation—A Review. *Water*, *13*(11), 1527. https://doi.org/10.3390/w13111527

Hoque, M. A., Hasan, M. A., Banik, B. K., & Kabir, M. I. (2024). *Investigating the Compatibility of Existing Sanitation Services with Sustainable Development Goal Using GIS and SFD Graphic: A Case Study on Sylhet City Corporation*. 216–233. https://doi.org/10.2991/978-94-6463-478-5_17

Indicator|SDG 6 Data. (n.d.). Retrieved Dec 29, 2025 from https://sdg6data.org/en/indicator/ 6.3.1

Islam, A. K., Pineda-Mora, D., Del Carmen-Niño, V., & Iris Balbuena-Hernández, R. (2023). Domestic and industrial wastewater generation and its energy recovery potential in Bangladesh. *Cleaner Energy Systems*, *6*, 100092. https://doi.org/10.1016/j.cles.2023.100092

Islam, A. K., Pineda-Mora, D., Del Carmen-Niño, V., & Iris Balbuena-Hernández, R. (2023). Domestic and industrial wastewater generation and its energy recovery potential in Bangladesh. Cleaner Energy Systems, 6, 100092. https://doi.org/10.1016/j.cles.2023.100092

IWM (2022). Sewerage Master Plan for Sylhet City. Final Report. Sylhet City Corporation.

IWM (2025). Updated Water Supply Master Plan for Dhaka City. Draft Final Report. DWASA.

Jones, E. R., van Vliet, M. T. H., Qadir, M., & Bierkens, M. F. P. (2021). Country-level and gridded estimates of wastewater production, collection, treatment and reuse. *Earth System Science Data*, *13*(2), 237–254. https://doi.org/10.5194/essd-13-237-2021

Kesari, K. K., Soni, R., Jamal, Q. M. S., Tripathi, P., Lal, J. A., Jha, N. K., Siddiqui, M. H., Kumar, P., Tripathi, V., & Ruokolainen, J. (2021). Wastewater Treatment and Reuse: A Review of its Applications and Health Implications. *Water, Air, & Soil Pollution*, *232*(5), 208. https://doi.org/10.1007/s11270-021-05154-8

Khan, S. J., & Anderson, R. (2018). Potable reuse: Experiences in Australia. *Current Opinion in Environmental Science & Health*, *2*, 55–60. https://doi.org/10.1016/j.coesh.2018.02.002

Kulshrestha, R., Sisodiya, A., & Tiwari, S. (2023). Overview of Methods and Processes Used in Wastewater Treatment. In R. Soni, D. C. Suyal, L. Morales-Oyervides, & J. Sungh Chauhan (Eds.), *Current Status of Fresh Water Microbiology* (pp. 289–301). Springer Nature. https://doi.org/10.1007/978-981-99-5018-8_12

Kumar, D., Hiremath, A. M., & Asolekar, S. R. (2014). Integrated Management of Wastewater through Sewage Fed Aquaculture for Resource Recovery and Reuse of Treated Effluent: A Case Study. *APCBEE Procedia*, *10*, 74–78. https://doi.org/10.1016/j.apcbee.2014.10.019

KWASA (2024). Khulna Sewerage System Development Project (KWASA/KSSSDP/CS-2). GKW Consult, GFA, IWM, VCL.Leeuwen, J. van, Pipe-Martin, C., & Lehmann, R. M. (2003). Water Reclamation At South Caboolture, Queensland, Australia. *Ozone: Science & Engineering*, *25*(2), 107–120. https://doi.org/10.1080/713610665

Lewis, R., Scott, R., Bala, B., Jahan, H., Bartram, J., & Radu, T. (2024). Household water use and greywater management in Khulna city, Bangladesh. *International Journal of Hygiene and Environmental Health*, *259*, 114376. https://doi.org/10.1016/j.ijheh.2024.114376

Lv, C., Zhang, W., Ling, M., Li, H., & Zhang, G. (2020). Quantitative analysis of eco-economic benefits of reclaimed water for controlling urban dust. *Environmental Geochemistry and Health*, *42*(9), 2963–2973. https://doi.org/10.1007/s10653-020-00537-y

Martínez-Orgániz, Á., Herrera-Navarrete, R., Pineda-Mora, D., Del Carmen-Niño, V., & Iris Balbuena-Hernández, R. (2022). *3. Reuse of Treated Water from Municipal Treatment Plants in Mexico*. https://doi.org/10.5772/intechopen.107204

McFarlane, D. (2018). The potential for managed aquifer recharge, third-pipe and direct piping systems in the Perth-Peel region. *Report to the Dept. of Water and Environmental Regulation*.

Metcalf & Eddy, Inc. (2014). Wastewater Engineering - Treatment and Resource Recovery (5th Edition).

Mondal, P. Kumar, Liu, Y., Kateryna, S., Zeng, L., & a, H. (2017). Water Pollution Situation and Applied Wastewater Treatment Strategies In Bangladesh. *International Journal of Advanced Research*, *5*, 2072–2083. https://doi.org/10.21474/IJAR01/3380

Nahar, N., Haque, Md. S., & Haque, S. E. (2024). Groundwater conservation, and recycling and reuse of textile wastewater in a denim industry of Bangladesh. Water Resources and Industry, 31, 100249. https://doi.org/10.1016/j.wri.2024.100249

Roy, S., Banna, L. N., Mamun, S. A., & Farukh, M. A. (2013). Effects of industrial wastewater reuse for crop production: A case study in Tejgaon metropolitan area of Dhaka, Bangladesh. Journal of the Bangladesh Agricultural University, 11(2), 183–188. https://doi.org/10.3329/jbau.v11i2.19860

Seow, T. W., Lim, C. K., Nor, M., Mubarak, M. F. M., Lam, C. Y., Yahya, A., & Ibrahim, Z. (2016). *Review on Wastewater Treatment Technologies*. https://api.semanticscholar.org/CorpusID:141060298

Shome, D., & Khondoker, M. (2024, February). *Integrated Performance Assessment of Bangabandhu Water Treatment Plant in Khulna*.

Siddiquee, M. S. H., & Ahamed, R. (2020). Exploring Water Consumption in Dhaka City Using Instrumental Variables Regression Approaches. *Environmental Processes*, *7*(4), 1255–1275. https://doi.org/10.1007/s40710-020-00462-3

Tortajada, C., & Bindal, I. (2020). *Water Reuse in Singapore: The New Frontier in a Framework of a Circular Economy?* (pp. 55–67).

Tortajada, C., & Rensburg, P. (2020). Drink more recycled wastewater. *Nature*, *577*, 26–28. https://doi.org/10.1038/d41586-019-03913-6

Tyagi, R. S., Singh, S. K., & Goyal, P. K. (2024). Rejuvenation of water bodies with recycled water. *Water Practice and Technology*, *19*(3), 839–851. https://doi.org/10.2166/wpt.2024.055

UN WWDR. (2024). *Statistics|UN World Water Development Report*. https://www.unesco.org/reports/wwdr/en/2024/s

US EPA, O. (2019, August 13). *Basic Information about Water Reuse* [Announcements and Schedules]. https://www.epa.gov/waterreuse/basic-information-about-water-reuse

Vandertulip, D. (2009). *Purple Pipe for All Waters?* 1831–1843. https://www.accesswater.org/publications/proceedings/-296282/purple-pipe-for-all-waters-

World Health Organization. (2024). *Progress on the proportion of domestic and industrial wastewater flows safely treated–Mid-term status of SDG Indicator 6.3. 1 and acceleration needs, with a special focus on climate change, wastewater reuse and health*. World Health Organization. https://www.unwater.org/sites/default/files/2024-08/SDG6_Indicator_Report_631_Progress-on-Wastewater-Treatment_2024_EN_0.pdf

Yi, L., Jiao, W., Chen, X., & Chen, W. (2011). An overview of reclaimed water reuse in China. *Journal of Environmental Sciences*, *23*(10), 1585–1593. https://doi.org/10.1016/S1001-0742(10)60627-4

Zaneti, R., Etchepare, R., & Rubio, J. (2012). More environmentally friendly vehicle washes: Water reclamation. *Journal of Cleaner Production*, *37*, 115–124. https://doi.org/10.1016/j.jclepro.2012.06.017