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Environmental Impact Assessment of Sewage Treatment Plants (STPs) construction under the Khulna Sewage System Development Project: Towards Sustainable Wastewater Management

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ABSTRACT

Construction of Two Sewage Treatment Plants Including a Faecal Sludge Treatment Plant under the Khulna Sewerage System Development Project (KSSDP) is a comprehensive initiative aimed at addressing sanitation challenges and promoting sustainable urban development in Khulna, Bangladesh. The total project worth $160 million to establish a modern and sustainable sewerage system in Khulna. The project will help meet people's basic needs amid rapid urbanization and growth through effective sewage management. The KSSDP focuses on establishing a robust sewerage system to improve sanitation, protect the environment, and enhance public health. By constructing and rehabilitating sewage collection networks, treatment plants, and wastewater disposal systems, the project aims to eliminate open defecation, prevent waterborne diseases, and reduce environmental pollution. Latest technologies including supervisory control and data acquisitions, and online data systems for automatic data logging, as well as energy-efficient pumps and equipment with a low carbon footprint will be used to deliver a state-of-the-art sewerage system. The Khulna Sewerage System Development Project will develop a centralized sewerage system that will benefit 880,000 residents in the city. Additionally, the KSSDP incorporates climate-resilient infrastructure and capacity building initiatives to strengthen the system's sustainability and resilience. Environmental Management Plan (EMP) developed in order to minimize the project's impact on the environment and natural resources. Continuous monitor and assess the project's environmental impacts to ensure the safety to the environment. Through community awareness and behavior change programs, the project fosters local ownership and responsible wastewater management practices. Overall, the Khulna Sewerage System Development Project aims to create a cleaner, healthier, and more sustainable city, ensuring a better quality of life for the residents while preserving the environment for future generations.

Key words: Sewage Treatment Plants (STPs), Sewage System, Wastewater Management

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INTRODUCTION

Rapid urbanization in Khulna, Bangladesh has led to significant sanitation challenges as the city grapples with meeting the growing demand for adequate sanitation services. The influx of people from rural areas seeking

better economic opportunities has resulted in the rapid expansion of urban areas, placing immense strain on existing sanitation infrastructure. According to the Bangladesh Bureau of Statistics (BBS), the urban population in Khulna has been increasing at an average annual growth rate of 3.3% [1]. This rapid urbanization has outpaced the development of sanitation facilities, leading to unsanitary conditions and increased health risks for the population. The inadequate sanitation situation in Khulna is evident in the prevalence of open defecation and the limited access to improved sanitation facilities. According to the World Health Organization (WHO), around 4.2 billion people worldwide lack access to safely managed sanitation facilities. The United Nations (UN) projects that by 2050, approximately two-thirds of the global population will reside in urban areas, further straining sanitation infrastructure. The World Bank estimates that about 15% of the urban population in Bangladesh practices open defecation, contributing to the spread of waterborne diseases and environmental pollution [2]. Furthermore, a study conducted by Ahmed et al. (2018) in Khulna revealed that only a small percentage of households have access to improved sanitation facilities, such as flush toilets or septic tanks [3]. The case of Khulna highlights the urgent need to address the sanitation challenges associated with rapid urbanization. By prioritizing investments in sanitation infrastructure, promoting hygiene education, and implementing effective governance mechanisms, Khulna can improve the living conditions and well-being of its residents, while also safeguarding the environment for future generations. Ullah et al. (2023) and Molla et al. (2023&2024) with Rahman et al. (2014 & 2023) undertake a comprehensive investigation to determine the optimal scenario for job shop production for operational improvement. Some of them also consider supplier selection weightage with ergonomics factor [25,26,27,28,29,30,31]. Some people's findings have significant implications, particularly in the realm of reducing state-by-state accident rates for effective accident mitigation strategies. Building on this foundation, they also employ the Value Stream Mapping (VSM) method, incorporating a robust and effective arithmetic process. This method proves instrumental in our ongoing research, especially in the development of a laboratory platform tailored for students with a keen interest in production activities. The insights gleaned from these studies not only contribute to the enhancement of production processes but also align with our broader goals of promoting safety and efficiency in manufacturing environments, ultimately fostering a rich learning experience for our research [34-37,42-45,48,52,51].

Addressing the sanitation problem in Khulna requires comprehensive strategies that encompass infrastructure development, behavior change campaigns, and policy interventions. Efforts are underway to improve sanitation services in Khulna, such as the Khulna Sewage System Development Project represents a significant endeavor in addressing the pressing sanitation challenges faced by the rapidly growing city of Khulna, Bangladesh [4-6]. With the aim of improving wastewater management and sanitation services, the project holds great potential for enhancing public health, reducing pollution, and promoting sustainable development. Moreover, GIS technology is used in this project for environmental assessment and impact analysis [7-11]. However, it is crucial to conduct a thorough feasibility assessment of the project from an environmental perspective to ensure its compatibility with environmental sustainability goals and to identify potential impacts that may arise during its implementation. However, there is a need for sustained investment and coordinated efforts from government agencies, local communities, and development partners to ensure the successful implementation of these initiatives. The purpose of this paper is to present the findings of a comprehensive feasibility assessment conducted on the Khulna Sewage System Development Project from an environmental standpoint. The research specifically focused on the environmental impacts of two-sewage treatment and one fecal sludge treatment plant construction part. The assessment examines the project's potential environmental impacts, evaluates its alignment with environmental regulations and standards, and explores opportunities for enhancing its environmental sustainability. By conducting a laborious feasibility assessment, we can ensure that the Khulna Sewage System Development Project realizes its objectives while minimizing environmental impacts and contributing to the long-term sustainability and well-being of Khulna's residents [12-14]. The Khulna Sewage System Development Project encompasses various components, including the construction or rehabilitation of sewage collection networks, the establishment or upgrading of wastewater treatment plants, and the implementation of efficient wastewater disposal systems. While these initiatives hold the promise of significant benefits in terms of public health and environmental protection, it is essential to critically evaluate their potential environmental implications and identify measures to mitigate any adverse effects.

PROJECT OVERVIEW

The Khulna sewage system development project is a crucial initiative aimed at addressing the pressing sanitation challenges faced by the rapidly growing city of Khulna in Bangladesh. With a focus on improving wastewater management infrastructure, the project seeks to enhance public health, protect the environment, and promote sustainable urban development (Khulna Development Authority, 2019). The project objectives encompass upgrading and expanding the existing sewage system to meet growing demand and improve efficiency, ensuring proper collection, treatment, and disposal of wastewater to prevent environmental pollution and mitigate health risks, enhancing the resilience of the sewage system against climate change impacts and natural disasters, and ultimately improving the overall quality of life for the residents of Khulna by providing a cleaner and healthier living environment [15]. The project components involve infrastructure development, including the construction and rehabilitation of sewage collection networks, pumping stations, treatment plants, and associated facilities, as well as capacity building to strengthen the technical and operational capacity of local authorities, utility staff, and community members [16]. Furthermore, institutional strengthening efforts are undertaken to enhance the institutional framework for wastewater management, while community engagement programs promote behavioral change, responsible wastewater disposal practices, and foster a sense of ownership among the residents of Khulna [17]. Implementation of the project is facilitated through close collaboration between government agencies, local authorities, development partners, and relevant stakeholders, with detailed feasibility studies, engineering designs, and environmental impact assessments ensuring its viability and sustainability (Khulna Water Supply and Sewerage Authority, 2021). The project's environmental considerations are paramount, integrating environmentally friendly technologies, such as advanced wastewater treatment processes and energy-efficient systems, as well as conducting environmental impact assessments to identify risks and develop mitigation measures to safeguard natural resources, water bodies, and biodiversity [18,19].

The proposed Khulna Sewerage System Development Project (KSSDP) will develop a new sewerage system in Khulna, covering commercial and densely populated areas with about 850,000 population by 2027. The project will specifically support (i) establishment of two sewage treatment plants with a capacity of 80,000 cubic meter (m3) per day and one fecal sludge treatment plant of 160 m3 per day; (ii) construction of 269 kilometers of sewer network; (iii) around 27,000 property level sewer connections; (iv) capacity development of the Khulna Water Supply and Sewerage Authority; and (v) awareness-raising on sanitation and hygiene. The budget of total project $160 million, from which $54,309,800 will expense to build sewage treatment plant. The project aims to establish a sustainable and inclusive sewerage system in Khulna, the third largest city in Bangladesh. K

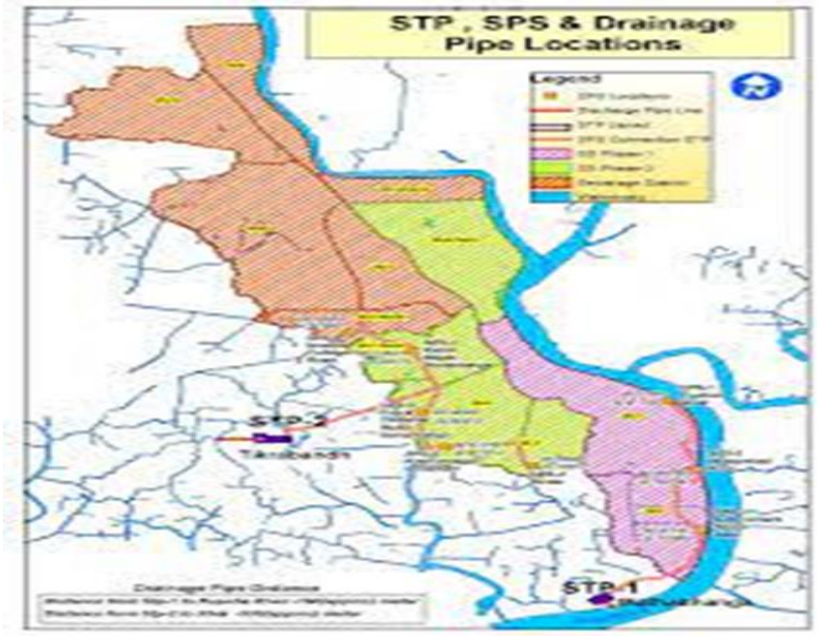

Figure 1: Project Locations Map

hulna's residents have been experiencing persistent urban service limitations, particularly in sewage management. As there is no sewerage system in Khulna, vast quantities of sewage and fecal sludge enter

groundwater or surface drains causing clogging and serious environmental problems as well as public health risks. The Khulna sewage system development project is a significant step towards improving sanitation infrastructure, protecting public health, and fostering sustainable urban development in Khulna, reflecting the commitment to create a healthier and more livable city for its residents while preserving the environment for future generations (Khulna Development Authority, 2019).

METHODOLOGY

The feasibility assessment of the Khulna sewage system development project from an environmental perspective involved the following steps:

Identification of Relevant Data Sources

Extensive research was conducted to identify the relevant sources of data for the assessment. This included government reports, environmental impact assessments, project documents, and studies related to similar sewage system development projects. The data sources were selected based on their reliability, relevance to the project, and alignment with the environmental perspective.

Collection of Secondary Data

Secondary data on various environmental aspects, such as water quality, air emissions, solid waste management, and ecological factors, was collected. Data collection involved accessing relevant databases, government records, research publications, and reports from reputable institutions and organizations. The collected data provided insights into the existing environmental conditions and potential impacts of the sewage system development project.

Analysis of Environmental Aspects

The collected secondary data was analyzed to assess the environmental aspects associated with the project. Key environmental indicators, such as water quality parameters, air pollutant concentrations, waste management practices, and ecological factors, were evaluated. Analytical methods and tools were applied to derive meaningful insights from the data and identify potential environmental impacts. Some researchers have undertaken a commendable and noteworthy project, showcasing a robust data retrieval approach coupled with an advanced framework for predicting data accuracy. This project stands as a valuable augmentation to our continuous efforts in virtual lab research, introducing an array of supplementary features poised to enrich the learning experiences of upcoming students, specifically catering to those pursuing studies in the fields of software engineering and computer science [23,32,33,38,40,41,46,47,50,55,57].

Evaluation of Environmental Impacts

The assessed environmental aspects were further evaluated to determine the potential impacts of the sewage system development project. Both short-term and long-term impacts were considered, taking into account the magnitude, spatial extent, duration, and significance of the identified impacts. The evaluation process involved comparing the project's activities and potential impacts with established environmental standards, guidelines, and regulations.

The above steps facilitated a comprehensive assessment of the Khulna sewage system development project from an environmental perspective. The collection and analysis of secondary data from various sources, along with stakeholder engagement, provided a robust foundation for evaluating the project's feasibility and its potential environmental impacts.

RESULTS AND DISCUSSIONS

Safeguard Implementation Arrangements of KSSDP authority

The implementation of environmental measures at the field level for the Khulna Sewage System Development Project (KSSDP) is overseen by two tiers of safeguard implementation arrangements. The Project Director of the KSSDP, as part of the top tier, holds the responsibility for overseeing and implementing environmental measures at the field level. Additionally, KWASA (Khulna Water Supply and Sewerage Authority) appoints an Executive Engineer as the project's environmental focal point. This focal point is responsible for enforcement and collaborates with consultants, contractors, and other organizations to ensure the implementation of safeguards. Supporting the focal point is a dedicated environmental officer who conducts regular field visits,

assists in capacity building for the project team, and takes necessary actions for a corrective action plan when required.

The second tier of safeguard implementation involves the role of the environmental specialist from the project management and supervision consultant team. This specialist assumes overall responsibility for strengthening the environmental management plan and coordinating and directing contractors to adopt sound environmental management techniques. Each contract package within the project will have a dedicated Environment, Health, and Safety (EHS) officer appointed by the contractor. These officers are responsible for implementing the environmental safeguard requirements during the construction phase and undertaking corrective actions based on the recommendations of the project management and supervision consultant team (PMSC) and Project Management Unit (PMU). The staffing of the safeguard implementation arrangements is outlined in Figure 2 of the project documentation.

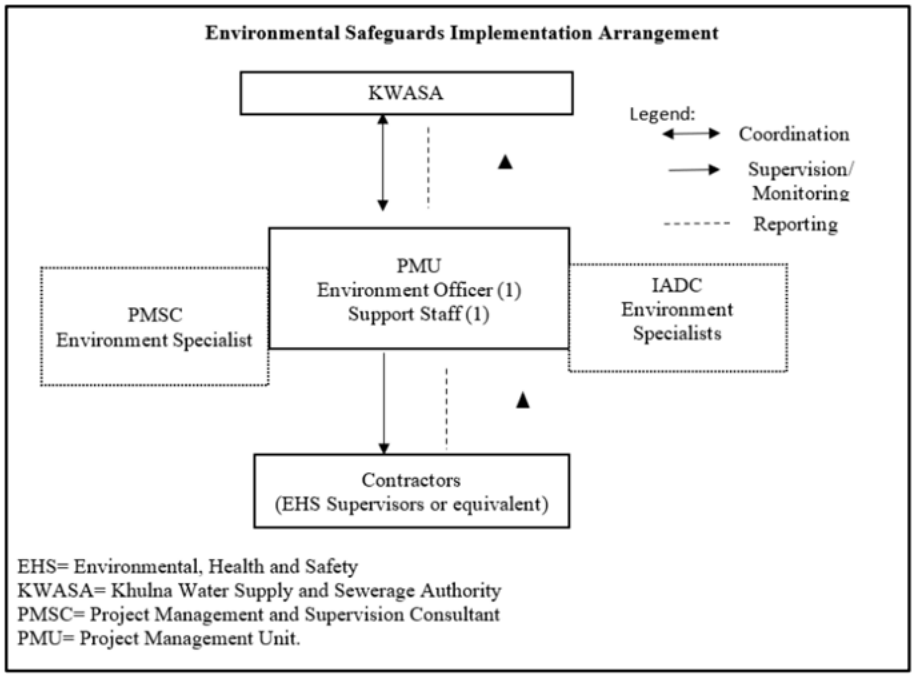

Figure 2: Safeguard Implementation Organogram of the project

Assessing Compliance with Regulatory Environmental Standards

The GOB's environmental legislation strongly emphasizes minimizing the detrimental effects of infrastructure development projects and enhancing the beneficial effects. The Bangladesh Environmental Conservation Act (ECA) of 1995, as amended in 2000, 2002, and 2010, and the Bangladesh Environmental Conservation Rules (ECR) of 1997, as amended in 2002, 2003, and 2017, both conform to the National Environmental Policy of 1992, which was adopted based on Agenda 21 of the Rio Conference. Following are the national laws that are being followed:

Table 1: Compliance status with national environmental requirements

No.	Statutory Environmental Requirements	Status of Compliance	Action Required
1.	Requires strengthening and new construction projects for sewerage system development to obtain an Environmental Clearance (EC) as per ECA 1995 and ECR 1997.	The Department of Environment (DOE) has already approved the project's Environmental Impact Assessment (EIA) Report, it is valid for one year and will be renewed every year before 30 days of expiration. ECC was issued on 06 June 2022, which will be expired in June 2023.	Timely renewal of environmental clearance will be required per DOE requirements. ECC was issued on 06th June 2022, which will be renewed yearly, next renewal date is May 2023, (before 30 days of expire).

2	As per Bangladesh Labor Act, 2006, Every laborer must be provided with a contract and an identification card (section 5). While child labor is clearly defined in section 34, the nature of the activities will prohibit any child labor (below 14 years of section 40).	Child laborers are not allowed on the project site as per the labor act and regulations. Contracts for employment of contract labor are regularly reviewed.	Strictly monitoring is required.
3	According to Wildlife (conservation & Security) Act 2012, hunting, trapping, and killing of wildlife are strictly prohibited. There are certain provisions kept in this Act, e.g., entrance, management, rules, and regulation of the protected area etc. If any person without a license performs any kind of trade, he will be jailed or punished for at least a year.	On the project working sites, catching, hunting, or killing any wildlife is completely prohibited. There is no case to date. KSSDP, however, is taking the matter seriously.	Monitoring is required.
4	According to National 3R Strategy for Waste Management, 2010 and Solid waste management rules 2021, complete elimination of waste disposal on open dumps, rivers, and flood plains through mandatory segregation of waste at source as well as to create of a market for recycled products and provide incentives for recycling of waste.	KSSDP is maintaining National 3R (Reduce, Reuse, Recycle) Strategy to manage all kinds of Waste.	Monitoring is required and updated Solid waste management rules 2021 shall be followed.
5	The Forest Act (1927) was enacted to control trespass, and illegal resource extraction from forests and to provide a framework for the forestry revenue collection system. It is the main legislative context for forestry protection	A detailed tree plantation plan (TPP) has been developed including identifying the loss and damage of tree species	Updated TPP shall be implemented as per plan.

Status of Contractors' Compliance with Statutory and Contractual Requirements

The status of contractors' compliance with statutory and contractual requirements on the Khulna Sewage System Development Project (KSSDP) project plays a crucial role in addressing environmental concerns. The project aims to improve wastewater management infrastructure in Khulna while ensuring adherence to both legal regulations and contractual obligations. Contractors involved in the project are required to comply with environmental guidelines and standards set by the relevant authorities. This includes following proper waste management practices, implementing measures to mitigate pollution, and adopting environmentally friendly technologies during construction and operation phases. Regular monitoring and inspections are conducted to assess the contractors' compliance with these requirements and to identify any deviations or non-compliance. Efforts are made to address these issues promptly through corrective actions and enforcement measures. By ensuring contractors' compliance with statutory and contractual environmental requirements, the KSSDP project strives to protect the environment, minimize negative impacts, and promote sustainable development in Khulna. Table 2 shows the details overview on overall Compliance of sub-project (Construction of Two Sewage Treatment Plants Including a Faecal Sludge Treatment Plant) under KSSDP project [20].

Table 2: Overall Compliance with CEMP/EMP

No	Sub-Project Name	EMP/ CEMP Part of Contract Documents (Y/N)	CEMP/ EMP Being Implemented (Y/N)	Status of Implementation	Action Proposed and Additional Measures Required
1	Construction of Two Sewage Treatment Plants Including a Faecal Sludge Treatment Plant	Waste Management	Y	Waste is managed as per WMP prepared by PMSC	To be followed and monitored regularly.
		Hazardous Goods Management	Y	Management of hazardous waste is planned in WMP prepared by PMSC	To date, no hazardous substances are used.
		Water Resources Management	Y	Surface water sources are only used at construction sites if required.	No groundwater will be allowed for the construction works at the site.
		Soil Quality Management	Y	Excavated soil will be managed at the designated disposal site selected by KWASA.	Shall follow the EMP.
		Erosion and Sediment Control	Y	Dredging activities is just started at STP sites and sediment controlling is being monitored as per plan.	Rigorously monitoring is required.
		Protection of Fisheries	Y	Fisheries of the river (near STP 1) can be impacted due to sand-filling discharge. The discharged water is monitored visually regularly.	Dredging leachate should be monitored at the dredging sites at the final disposal points.
		Traffic Management	Y	The traffic management plan has been prepared and will be implemented at the construction sites.	Need to deploy traffic/flag man for proper traffic management near the access road.
		Construction Camp	Y	CEMP has	Monitoring is to be required at the

Management		proposed a detailed construction camp management which will be implemented.	campsites.
Cultural and Religious Issues	Y	Cultural and religious issues are maintained at the sites.	No issue is yet with the site.
Worker's Health and Safety	Y	Partially maintained at the sites as the sand filling has been started at STP 1 only.	
Air Quality Management	Y	Air quality sampling was carried out at the site as a baseline.	Air quality sampling will be carried out quarterly as per ADB guidelines.
Noise Quality Management	Y	Noise level monitoring was carried out as a baseline.	To be followed and monitored regularly.
Water Quality Management	Y	Water quality parameter testing was carried out as a baseline.	To be followed and monitored regularly.

ENVIRONMENTAL QUALITY MONITORING

The objective of Environmental Quality Monitoring is to identify standard guidelines and approach to preserving environmental aspects by preventing and controlling environmental pollution and the management of nuisance, resulting from Construction of Two Sewage Treatment Plants Including a Faecal Sludge Treatment Plant under the Khulna Sewerage System Development Project (KSSDP). The objectives of Environmental Monitoring are listed below-

- To detect any disruption of the environment according to national / project standards.
- To identify the impact sources due to the construction of two sewage treatment plants including the fecal sludge treatment plant and its ancillary works.
- To evaluate the quantitative (Air Quality Monitoring, Noise Level Measurement, Vibration Level Measurement and Surface Water Sampling) activities during the construction stage.
- To mitigate the identified impacts and promote best environmental on-site practices during the construction phase.

AIR QUALITY MONITORING

Air Quality Monitoring methodology

The ambient status of major air pollutants viz. Particulate Matter (SPM, PM10 and PM2.5), Gaseous substance (NO2, SO2 and CO) has been assessed. All the parameters (SO2, NOx, PM10 and PM2.5) have been sampled for 8 hours and data is converted to 24 hours as well as (CO and SPM) 8 hours. An equation has been used to convert the air monitoring results from 8 hours to 24 hours. Haz-ScannerTM (HIM 6000) has been used to

monitor ambient air quality. The particulate and gaseous samples have been monitored and analyzed as per the procedures specified in the following table.

Table 3: Methodology for Analysis of Ambient Air Quality

Sl. No.	Parameters	Analysis Method
1.	Particulate Matter (PM10)	Light Scattering Nephotometer
2.	Particulate Matter (PM2.5)	Light Scattering Nephotometer
3.	Sulphur Dioxide (SO2)	High Sensitivity Electrochemical
4.	Oxides of Nitrogen (NO2)	High Sensitivity Electrochemical
5.	Carbon Mono-Oxide (CO)	High Sensitivity Electrochemical
6.	Suspended Particulate Matter (SPM)	Light Scattering Nephotometer

Ambient Air Quality Monitoring results analysis of Package STP

Suspended Particulate Matter (SPM): The 8-hours, highest SPM concentration in ambient air in the study area has been recorded in AQ2 area (matha banga, STP-1) was 128.52 µg/m3. The lowest SPM concentration has been found in AQ1 (Tikraband, STP-2) as 95.88 µg/m3. There has no standard found for SPM in Air Pollution Control Rules of Bangladesh 2022 and IFC/WHO.

Particulate Matter (PM10): The 24-hours, PM10 concentration in ambient air in the study area was recorded in the range of 61.86 to 85.53 µg/m3. During the monitoring period, the maximum PM10 concentration was reported from AQ2 area was 85.53 µg/m3. All the monitoring point's value within the national standard level of Bangladesh and the WHO standard.

Particulate Matter (PM2.5): The 24-hours, PM2.5 concentration was recorded 27.24 µg/m3 at AQ1 and 34.06 µg/m3 at AQ2. During the monitoring period, the maximum PM2.5 concentration was reportthe ed from AQ2, and lowest concentration found from AQ1. All the monitoring point's value was within the national standard level.

Sulphur Dioxide (SO2): The 24-hours, SO2 concentration was recorded in the range of 16.20 - 22.85 µg/m3. Concentration of SO2 is reported low at AQ2. During the monitoring period, the maximum SO2 concentration is reported at AQ1 (Tikraband, Galma, Batiaghata, Khulna; STP-2) was 22.85 µg/m3. SO2 concentrations at all the monitoring locations were reported well below 80 µg/m3, which is Air Pollution (Control) Rules: 2022 (APR) for SO2 in Bangladesh.

Nitrogen Dioxide (NO2): The 24-hours, NO2 concentration was recorded in the range of 21.91 to 25.74 µg/m3. Concentrations of NO2 were reported moderate due to their rural setting. During the monitoring period, the maximum NO2 concentration is reported at AQ2 was 25.74 µg/m3. According to Bangladesh Standard Air Pollution (Control) Rules, 2022 the standard for NO2 is 80 µg/m3. The Air Pollution (Control) Rules: 2022 (APR) standard values for NOX are 80 µg/m3 and WHO have 200 µg/m3 for 1 hour. The present concentrations at all the locations are well below these values.

Carbon Monoxide (CO): The 8-hours, CO concentration was recorded in the range of 0.111-0.161 ppm. Concentration of CO is reported low at AQ1 area. During the monitoring period, the maximum CO concentration is reported at AQ2 was 0.161 ppm. Concentrations at all the monitoring locations were reported well below 9 ppm, which is Air Pollution (Control) Rules: 2022 (APR) in Bangladesh.

Table 4: Ambient Air Quality Monitoring Location of Package STP

SL. No.	Code	Ambient Air Pollutants Concentration (µg/m3)					CO mg/m^3
		SPM	PM_{10}	$PM_{2.5}$	SO_2	NO_3	
1	AQ1	95.88	61.86	27.24	22.85	21.91	0.111
1	AQ2	128.52	85.53	34.06	16.2	25.74	0.161
Sampling Duration (hrs.)		8	24	24	24	24	8
*Bangladesh Standard Air Pollution (Control) Rules, 2022		-	150	65	80	80	5
IFC/WHO Standard		-	50	25	20	1 Hour (200) Annual (40)	-

Method of Analysis Instrument Use: Lata Envirotech APM-250	Light Scattering Nephotometer	Light Scattering Nephotometer	Light Scattering Nephotometer	High Sensitivity Electrochemical	High Sensitivity Electrochemical	High Sensitivity Electrochemical

Source: Air quality sampling done by EQMS Consulting Limited, August 2022 (14th and 16th December 2022); Date of analysis: 26th December 2022; Note: "Regular Checkup and calibration of the equipment are done by the manufacturers and EQMS personnel to avoid any error".
The Bangladesh National Ambient Air Quality Standards have been taken from the Environmental Conservation Rules, 1997 which was amended in 2022, the Bangladesh Standard Air Pollution (Control) Rules.

WATER QUALITY

Water Quality Monitoring methodology

The surface water samples were analyzed for parameters covering bacteriological and physio-chemical characteristics which include certain heavy metals and trace elements. Water samples were collected as grab water sample in a standard sampling bottle and 250 ml sterilized clean PET bottle to complete physio-chemical and bacteriological tests respectively. The samples were analyzed as per the standard procedure/method given in Standard Method for Examination of Drinking Water Edition 20, published by APHA as well as using an on-site field test kit.

The samples were analyzed as per the standard procedure/method given in Standard Method for Examination of Water and Wastewater Edition 20, published by APHA as well as using a site field test kit. Details of the analysis method and protocol are presented in the following table.

Table 5: Analysis Method for Surface Water Samples

Sl. No.	Parameters	Unit	Analysis Method
1	Temperature	mg/L	Ion electrode method
2	Dissolved Oxygen (DO)	mg/L	Ion Electrode Method
3	Biological Oxygen Demand (BOD)	mg/L	5day Incubation
4	Chemical Oxygen Demand (COD)	ppm	USEPA 410.4
5	Nitrate	mg/L	Cadmium Reduction followed by photometric method
6	Phosphate	N/100ml	Amino acid Method followed by photometric method
7	Salinity	N/100ml	Ion Electrode Method
8	Fecal Coliform (FC)	--	AFNOR approved method compared to
9	Chromium (Cr)	mg/L	NF V08-017 method
10	Cadmium (Cd)	Ppt	Diphenyl carbohydrazide Method
11	Lead (Pb)	mg/L	AAS

Table 6: Surface Water Quality Results of Package STP

Sl. No.	Parameters	Unit	Sampling Code		*Bangladesh Standards
			SW1	SW2	
1.	Temperature	°C	22.3	22.2	--
2.	Dissolved Oxygen (DO)	mg/L	5.2	6.1	5 or more
3.	Biological Oxygen Demand (BOD)	mg/L	1.6	0.6	6 or less
4.	Chemical Oxygen Demand (COD)	mg/L	23	18	--
5.	Nitrate	mg/L	<0.01	<0.01	--
6.	Phosphate	mg/L	0.02	0.01	--
7.	Salinity	ppt	0.98	0.21	--
8.	Fecal Coliform (FC)	N/100ml	32	46	--
9.	Chromium (Cr)	mg/L	<0.01	<0.01	--

Surface water quality over the project sites both sewer network and STP sites are withing the standard limit according to the ECR'97, schedule-3.

NOISE QUALITY

Noise Quality Monitoring methodology

The ambient noise level has been measured within the project area for 1 hour at every location. One Noise data logger sound level meter (Techoplus, Model: SLM25K) was used to collect the ambient noise levels. After getting all the noise it has been downloaded to the computer. The noise meter was settled in a tripod and will keep it 2-3 m away from the sources. Only sensitive areas have been covered. The noise level has been analyzed according to the methodology and compared with the Environment Conservation Rules (ECR), 1997- Schedule 4 and Noise Pollution Control Rules, 2006. Noise level measurement data has been measured during the daytime [21,22].

In all cases, the sound level meter (SLM) was mounted on a tripod at 1.5 m above ground level and at least 3.5 m away from any sound-reflecting surfaces. The SLM was oriented towards the facility of interest for each measurement taken. The measurements were made using a Noise data logger. The SLM was calibrated before the noise monitoring survey was carried out. The sound level was recorded in form of A-weighted equivalent continuous sound pressure level (Leq) values with the use of A-weighting filters in the noise measuring instrument. Then noise level data has been analyzed to Leqday, Leqnight, Lmax and Lmin.

Table 7: Noise Quality Results of Package STP

Sl. No.	Code	Noise level [dB(A)]				Standard		Remarks
		Leq_{day}	Leq_{night}	L_{max}	L_{min}	Day	Night	
1.	NL1	52.6	37.2	63.4	32.7	55	45	Within the Standard Limit
2.	NL2	54.7	38.6	65.2	35.5	55	45	Within the Standard Limit

Noise quality over the project sites both sewer network and STP sites are withing the standard limit according the ECR'97, (Schedule 4) (subsequent amendment in 2006).

AUTHORS' RECOMMENDATIONS

The rapid urbanization in Khulna, Bangladesh has led to significant sanitation challenges, including open defecation and limited access to improved sanitation facilities. The Khulna Sewage System Development Project is an initiative aimed at addressing these challenges by improving wastewater management infrastructure. The project includes the construction or rehabilitation of sewage collection networks, wastewater treatment plants, and wastewater disposal systems. To ensure the safety of environment, the project authority recruited an environmental safeguard officer (ESO) to monitor environmental safeguard issues during construction to ensure essential improvement and high-quality implementation. The ES officer will frequently communicate with both the PMSC and the contractor's representative to coordinate projects. However, from the PMSC site, an environmental expert is also working at the project sites and looking after all environmental safeguard issues regularly on an intermittent basis. Environmental Expert from PMSC and Environmental Officer from PMU will monitor throughout the project to ensure environmental safety issues. Also, there are several guidelines for contactors that compliance statuses with statutory environmental requirements which includes the waste management, soil quality management, hazardous goods management, air and water quality management. Contractors need to follow the Environmental Management Plan (EMP) accordingly to make the project successful. From air, water, and noise quality monitoring data analysis, it can be concluded that the project is not hazardous for environment though before starting the project necessary environmental impact assessment completed. However, the success of the project without creating problem to environment depends on continuous monitoring and run the work as a way in proposed.

CONCLUSION

Under the proposed Khulna Sewerage System Development Project (KSSDP) will develop a new sewerage system in Khulna including two Sewage Treatment Plants Including a Faecal Sludge Treatment Plants, covering commercial and densely populated areas with about 850,000 population by 2027. The KSSDP aims to establish

a comprehensive sewerage system in Khulna, addressing the existing sanitation challenges. By providing access to improved sanitation facilities and promoting responsible wastewater management practices, the project significantly contributes to improving public health and reducing the spread of waterborne diseases. It eliminates the practice of open defecation, which improves overall hygiene and sanitation conditions in the city. The project includes the construction and rehabilitation of sewage collection networks, treatment plants, and wastewater disposal systems. By properly collecting, treating, and disposing of wastewater, the project helps prevent environmental pollution and protects water bodies from contamination. It reduces the discharge of untreated sewage into groundwater and surface drains, safeguarding the environment and preserving natural resources. Overall, the Project brings a range of benefits, including improved sanitation, environmental protection, health benefits, sustainable urban development, climate resilience, institutional strengthening, and community awareness. The project's benefits include a cleaner, healthier, and more sustainable city for Khulna residents, improving their quality of life and safeguarding the environment for future generations.

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