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OPERATIONAL AND INSTITUTIONAL ASSESSMENT OF WASTEWATER MANAGEMENT PRACTICES AT THE WUPA SEWAGE TREATMENT PLANT ABUJA, NIGERIA

HENRY AZUBUIKE CHUKE; I. K. SAMAILA; & A. T. OGAH

Department of Geography, Faculty of Environmental Science, Nasarawa State University, Keffi
Corresponding Author: henrychuke@yahoo.com
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Abstract

This study assessed wastewater management practices at the Wupa Sewage Treatment Plant, Abuja, using a descriptive, facility-based survey design complemented by direct field observation. Primary data were obtained through structured questionnaires administered to all relevant technical and management staff of the Wupa Sewage Treatment Plant and officials of the Abuja Environmental Protection Board (AEPB), yielding a total of 173 respondents (89 Wupa staff and 84 AEPB staff), while secondary data were sourced from plant records, design documents, and official reports. Data were analysed using descriptive statistics and supported with photographic evidence of treatment infrastructure. Findings revealed unanimous agreement (100%) among respondents that wastewater treated at the plant originates mainly from domestic, institutional, and small-scale industrial sources within phases one, two, and parts of phase three of Abuja, and is conveyed to the facility through a gravity-based sewer network. The treatment process effectively incorporates preliminary (screening and grit removal), primary (sedimentation), secondary (activated sludge biological treatment), tertiary (filtration and disinfection), and sludge management stages, indicating adherence to standard wastewater treatment protocols. However, despite the plant being designed to serve a population of about 700,000 with expansion capacity to

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one million, a significant proportion of Abuja's population remains unconnected to the central sewer system, relying instead on septic tanks. The study further established that the facility is maintained by AEPB with a regular maintenance budget of approximately ₦500 million per quarter in 2023, and operates continuously. Overall, the findings suggest that while wastewater management practices at the Wupa Sewage Treatment Plant are technically comprehensive and adequately maintained, broader sewer network coverage remains a critical challenge to maximizing the plant's effectiveness.

INTRODUCTION

Wastewater management remains a critical component of urban environmental health, particularly in rapidly expanding cities where infrastructure development struggles to keep pace with population growth and waste generation. In Abuja, Nigeria's capital city, the Wupa Sewage Treatment Plant serves as one of the principal facilities responsible for treating sewage from residential and commercial districts before discharge into the Wupa River Basin. Effective wastewater treatment is essential for protecting public health, preventing environmental degradation, and supporting sustainable urban development (Bature et al., 2025). Despite the presence of such infrastructure, operational challenges such as sewer blockages from improper waste disposal, insufficient connection to the central sewer network, and the potential presence of pathogenic microorganisms in effluents have raised concerns about the adequacy of current management practices (Abuja Environmental Protection Board [AEPB], 2024; Discover Water, 2025; Susana, 2025).

The Wupa Sewage Treatment Plant was commissioned to process domestic wastewater conveyed through the central sewer network, with the treatment process designed to remove physical, chemical, and biological contaminants before discharge (Susana, 2025). Though it operates continuously, only an estimated 30 % of Abuja's population is connected to central sewer infrastructure, meaning a significant portion of wastewater remains untreated or managed through alternative systems such as septic tanks and soak-away pits (Susana, 2025). This systemic under-utilization undermines the designed capacity and effectiveness of treatment facilities such as Wupa, contributing to environmental risks and public health threats in adjacent communities.

Operational and management practices at the Wupa plant are further complicated by socio-behavioural and infrastructural issues within the Federal Capital Territory. Reports have highlighted improper disposal of solid waste into sewer lines, which exacerbates blockages and increases maintenance burdens on wastewater infrastructure (AEPB, 2024). Vandalism of sewer covers and irregular maintenance of conduits have also been

identified as impediments to efficient wastewater conveyance and treatment (Guardian Nigeria, 2024). These challenges illustrate that wastewater management extends beyond treatment plant boundaries to encompass broader sanitation governance and community engagement.

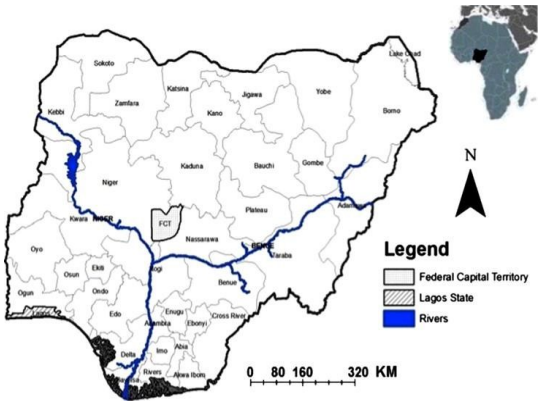
Recent scientific investigations into the Wupa facility have drawn attention to wastewater quality concerns relating to both treated and untreated effluents. A study examining the plant's influent and effluent characteristics revealed significant differences in key physicochemical parameters after treatment, indicating the potential for remediation interventions such as bacterial biostimulation to enhance pollutant removal, particularly of heavy metals (Ibrahim et al., 2025). Concurrently, microbiological assessments have detected pathogenic Vibrio species, including *Vibrio cholerae*, in effluent samples and downstream waters, underscoring significant public health implications associated with inadequate treatment and monitoring regimes (Discover Water, 2025).

Understanding the complexities of wastewater management at the Wupa Sewage Treatment Plant is therefore vital for crafting actionable strategies that improve treatment effectiveness, safeguard environmental quality, and enhance health outcomes for Abuja's residents. This study aims to critically analyse existing management practices at the Wupa facility, identify operational and systemic challenges, and propose recommendations for sustainable wastewater governance in line with regulatory standards and urban growth trajectories in Nigeria's capital city. The insights derived from this analysis are expected to contribute to broader efforts toward achieving resilient and efficient wastewater systems in rapidly urbanising African contexts.

MATERIALS AND METHODS

The Wupa Sewage Treatment Plant is a Federal Government project located in Abuja Municipal Area Council, also called AMAC. It is one of the six Local Government Areas in Abuja FCT, it is located west of Abuja at the lowest altitude in the Capital City and it lies between latitudes $8^{o}25^{1}$ and $9^{o}\ 25^{1}$ North of the equator and longitude $6^{o}\ 45^{1}$ and $7^{o}\ 45^{1}$ East of the Greenwich Meridian (Abuja Master Plan, 2000).

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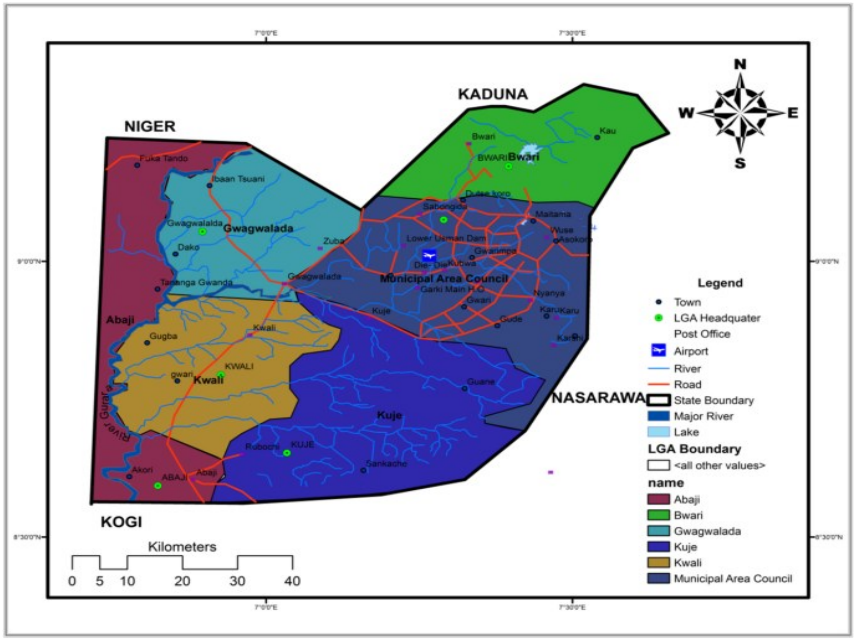




Figure 1 Abuja showing the location of Wupa Sewage Treatment Plant and Wupa River Source: Modeling Earth Systems and Environment (2023).

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This study adopted a descriptive and facility-based survey design combined with direct field observation to assess wastewater management practices at the Wupa Sewage Treatment Plant, Abuja. Primary data were obtained through structured questionnaires administered to all available technical and management staff of the Wupa Sewage Treatment Plant and officials of the Abuja Environmental Protection Board (AEPB), yielding a total of 173 respondents (89 Wupa staff and 84 AEPB staff), representing a census of relevant personnel rather than a sampled population. The questionnaire captured information on sources of wastewater, collection methods, stages of treatment (preliminary, primary, secondary, tertiary), facility maintenance, budgetary provisions, and future expansion capacity. In addition, systematic field observations were conducted to document the operational processes and infrastructure across all treatment stages, including inlet chambers, screens, grit chambers, aeration tanks, clarifiers, sludge handling units, and effluent discharge points, with photographic evidence collected to support observations. Secondary data were obtained from plant operational records, design documents, and official reports to validate respondents' claims regarding plant capacity, design population, inflow volumes, lifespan, and maintenance budgets. Data were analyzed using descriptive statistics (frequencies and percentages) and presented in tables and plates to clearly illustrate wastewater management practices and infrastructure conditions at the facility.

RESULTS

The analysis regarding various wastewater management practices in Wupa Sewage Treatment Plant is presented in Table 1, are preliminary practices, primary practices, secondary practices and tertiary practices. 173(100%) of both Wupa and AEPB staff expressed that wastewater is from homes, businesses, medical facilities and more, discharged into a network of sewers, and are transported gravitationally to the central wastewater plant for varying levels of treatment through the inlet chamber, and preliminarily undergoes a physical process of screening to filter out large objects like plastics, leaves and other debris using the coarse screen and screw pump machine. This is followed by Grit removal to eliminate sand, gravel and silt through the Grit removal basin. Primary practice is designed to slow down the flow of wastewater allowing heavier particles settle-able or floating objects to settle to the bottom due to their varying densities and extracted from the chambers. Secondary practice is to remove dissolved organic matter and nutrients by a biological process known as activated sludge. Wastewater enters the aeration chamber, where it is mixed and oxygen is provided to the microorganisms. The tertiary practice is designed to further remove stubborn contaminants like nutrients (nitrogen & phosphorus), pathogens, and dissolved solids to

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produce high quality water for reuse or discharge, which is achieved by method of filtration, and disinfection using UV light or Chlorination.

Respondents were asked about the sources of Sewage (or Wastewater). 173(100%) agreed that its source of sewage or wastewater is from phases one, two, and part of phases three of Abuja. The primary wastewater generation sources in Abuja include domestic wastewater from houses, schools and small-scale industries. It is crucial to remember that, according to the 2006 census, the city is home to around two million people. Still, the majority of them are not attached to the sewage systems that supply the treatment facility. This is because other government bodies are in charge of planning and development control. Because of this, septic tanks are used by the majority of homes in some large estates and neighborhoods.

Respondents were asked about the collection of Sewage (or Wastewater). 173(100%) shared a common opinion that collection of Sewage or Wastewater is by gravitational force in which sewage or wastewater from homes, businesses, medical facilities and more are discharged into a network of sewer charnels, and transported to a central wastewater plant in Wupa for varying levels of treatment.

Table 1: Analysis of the Practices of Wastewater Management in Wupa Sewage Treatment Plant Abuja

S/N	Management Practices	Respondents	Response	Wupa Staff	100%	AEPB Staff	100%
1	Management practices in Wupa Sewage Treatment Plant	173	Preliminary practices Primary practices Secondary practices Tertiary practices	89	100%	84	100%
2	Sewage Sources (or Wastewater)	173	Domestic homes Schools Small scale industries	89	100%	84	100%
3	Sewage Collection (or Wastewater)	173	Gravitational force	89	100%	84	100%
4	Collection system to accommodate future expansion	173	Yes No Not sure	52 28 9	58% 32% 10%	64 0 20	76% 0% 24%
5	Facility maintenance	173	AEPB	89	100%	84	100%
6	Yearly/monthly provisional maintenance budget	173	Yes No	89 0	100% 0%	84 0	100% 0%

Source: Field work 2023

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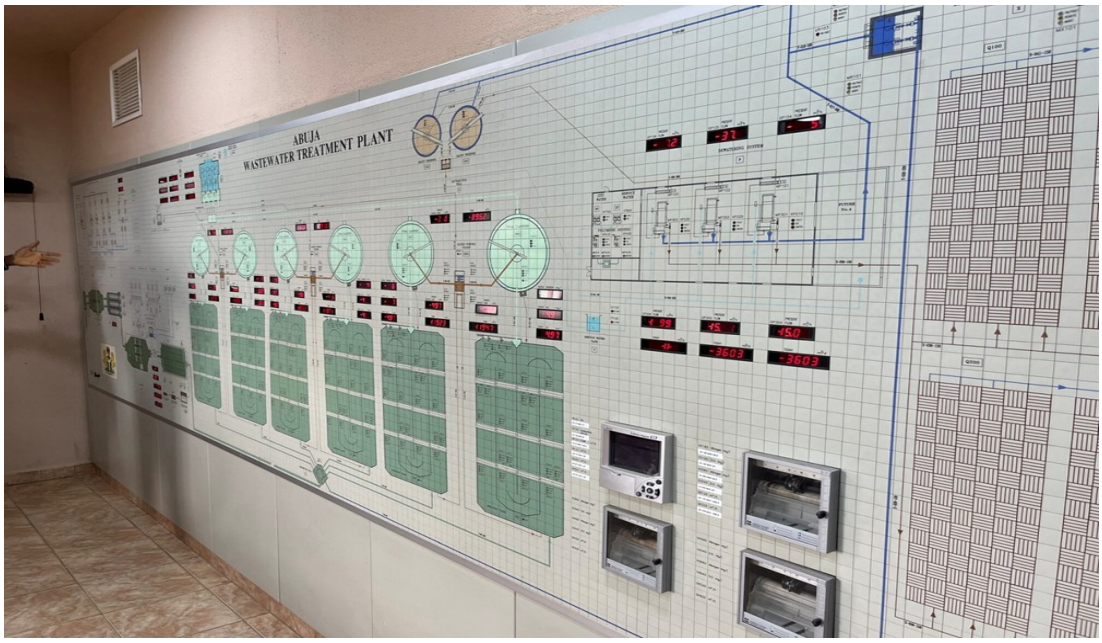


Plate 1 Flow Chat of Wupa Treatment Plant (mimic panel)

Source: Field work 2023



Plate 2 Inlet Chamber of Wupa Treatment Plant – primary treatment

Source: Field work 2023

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Respondents were questioned on if the collection system will accommodate future expansion. Majority 52(58%), & 64(76%) for Wupa & AEPB staff respectively, expressed responds 'Yes' followed by 28(32%) & (0%), responded 'No' and 'Not sure' by 9(10%) & 20(24%) of the respondents. Further discussions explained that the plant covered an area of 297,960 square meters (m^2) and is designed to serve a population of about 700,000 populations and expandable to 1,000,000, meaning that the plant can accommodate an annual dry weather inflow of 5,500 cubic meters per day and capable of accommodating future expansion as the average lifespan of a wastewater treatment plant is between 40 and 50 years. After the passage of the 1972 Clean Water Act, treatment plants and other wastewater infrastructure around the world were built to comply with the new law.

The steps in the treatment plant are mechanical (physical) and biological treatment processes, involving screens, coarse screen, low lift pump or screw pump, fine screen trap debris, grit chambers, aeration tanks with solid retention time (SRT) of 20 days, clarifiers and sludge drying bed.

Preliminary treatment objective: This is to remove large debris and solids by method of Screening to filter out large objects like plastics, leaves, and other debris as displayed in plate 3, 4. Heavier solids sink to the bottom like metal & sand, trapped & eliminated via a conveyor belt to a compactor chamber as displayed in plate 4.5, 4.6/7 & 4.8. Grit, scum & grease removal takes place at the Agitation Tank as displayed in plate 4.5, 4.6/7, & 4.8.



Plate 3 Coarse Screen of Wupa Treatment Plant (Physical Treatment)
Source: Field work 2023

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Plate 4: Low Lift or Screw Pump of Wupa Treatment Plant
Source Field work 2023



Plate 5: Fine Screen Trap Debris of Wupa Treatment Plant
Source: Field work 2023

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Plate 6: Conveyor Belt 1 (one) of Wupa Treatment Plant



Plate 7: Conveyor belt 2 (two) of Wupa Treatment Plant

Source: Field work 2023

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Plate 8: Compactor Chamber of Wupa Treatment Plant

Source: Field work



Plate 9: Grit, Scum & Grease Removal Tank (Agitation & Separation Tank) of Wupa Treatment Plant

Source: Field work 2023

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Plate 10: Agitation & Separation Tank of Wupa Treatment Plant
Source: Field work 2023



Plate 11: Distribution Well of Wupa Treatment Plant
Source: Field work 2023

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Plate 12: Distribution Well 3 & 4 of Wupa Treatment Plant
Source: Field work 2023

Primary treatment objective: This is to reduce suspended solids and organic load Sedimentation of wastewater in large tanks to allow solids to settle at the bottom, and formation of primary sludge which is then removed.



Plate 13: Bioreactor 3 of 6 of Wupa Treatment Plant



Plate 14: Bioreactor 4 of 6 of Wupa Treatment Plant

Source: Field work 2023

Secondary treatment objective: This is to remove dissolved organic matter and nutrients using biological processes (e.g., activated sludge, trickling filters) to break down organic material, and nutrient removal to address nitrogen and phosphorus levels. There are six clarifiers of 8,364 m^3 capacity each as displayed in plate 4.15/16, totaling 50,184 m^3 capacities.



Plate 15: Final Clarifier 3 of 6 of Wupa Treatment Plant

Tertiary treatment objective: This is to further purify wastewater for reuse or safe discharge by process of filtration to remove remaining solids, and disinfection (e.g., chlorination, UV treatment) to eliminate pathogens as displayed in plate 15/16.



Plate 16: Final Clarifier 4 of 6 of Wupa Treatment Plant
Source: Field work 2023



Plate 17: Treated Water Effluent (discharge) of Wupa Treatment Plant
Source: Field work 2023

Sludge treatment objective: This is to manage and stabilize the sludge produced during treatment by method of Thickening to reduce volume as displayed in plate 4.18/19, digestion (aerobic or anaerobic) to break down organic matter and reduce pathogens, and dewatering to prepare sludge for disposal or use as fertilizer.



Plate 17: Sludge Pumping Station 2 of 3 of Wupa Treatment Plant



Plate 18: Sludge Pumping Station 2 of 3 of Wupa Treatment Plant

Source: Field work 2023

Respondents were asked who maintains the facility. 173(100%) shared a common perspective and expressed that the treatment plant is operational 24 hours, and it is regularly maintained by the Federal Government of Nigeria (AEPB) yearly.

Respondents were questioned if there is a yearly/monthly provisional maintenance budget, if yes, what is the average budget for wastewater management per quarter. 173(100%) gave a complete view which was a 'Yes' that there is yearly/monthly provisional maintenance budget, and it is regularly maintained by the Federal Government of Nigeria (AEPB) yearly, with an average budget per quarter of N500,000,000 (Five Hundred Million Naira) for the year 2023.

CONCLUSION

This study analyzed the wastewater management practices at the Wupa Sewage Treatment Plant in Abuja, Nigeria, with the aim of evaluating operational processes, management systems, and institutional arrangements that influence treatment performance. The findings show that the plant has established wastewater handling and treatment procedures that contribute to the management of urban sewage within the Federal Capital Territory. These practices demonstrate the strategic importance of the facility in supporting urban sanitation and environmental protection in Abuja.

The analysis revealed that core operational practices, including preliminary screening, sedimentation, biological treatment, and sludge handling, are generally in place. However, the effectiveness of these practices is constrained by operational inefficiencies, aging infrastructure, and intermittent maintenance challenges. These factors affect process stability and reduce the consistency of treatment outcomes, particularly during periods of high influent flow and increased pollutant loading.

The study further identified gaps in institutional and managerial practices, including limited technical staffing, inadequate routine training, and weak coordination among responsible agencies. These management-related challenges reduce the overall efficiency of wastewater treatment operations and limit the plant's ability to respond proactively to emerging technical problems. As a result, wastewater management practices at Wupa are functional but not fully optimized.

In addition, the study highlights the influence of rapid urbanization and population growth in Abuja on wastewater generation and system pressure. The increasing volume of wastewater places additional demand on the plant's capacity and operational systems. Without corresponding expansion and modernization of wastewater management practices, the sustainability of current operations may be compromised.

Overall, the study concludes that wastewater management practices at the Wupa Sewage Treatment Plant are moderately effective but require significant improvement to

meet best practice standards. Strengthening operational procedures, management systems, and institutional support is essential to enhance the reliability, efficiency, and long-term sustainability of wastewater management in Abuja.

Recommendations

Based on the findings of this study, it is recommended that standard operating procedures for wastewater treatment processes be reviewed and updated to reflect current best practices. Clear and well-documented operational guidelines will improve process control, reduce variability in treatment performance, and support consistent application of treatment protocols by plant personnel.

There is a need to prioritize preventive and corrective maintenance programs for all treatment units and equipment. Establishing a structured maintenance schedule will reduce equipment downtime, extend the lifespan of infrastructure, and minimize the risk of system failures. This will enhance overall operational efficiency and ensure more stable wastewater treatment performance.

Capacity development for technical and operational staff should be strengthened through regular training and professional development programs. Improving staff skills in wastewater treatment technologies, process optimization, and health and safety practices will enhance operational competence and improve responsiveness to technical challenges.

It is also recommended that institutional coordination and regulatory oversight be strengthened among relevant agencies responsible for water and environmental management in Abuja. Improved collaboration will enhance compliance monitoring, enforcement of effluent standards, and alignment of wastewater management practices with national environmental policies.

Finally, long-term planning for system expansion and modernization should be integrated into Abuja's urban development strategy. Investments in treatment capacity expansion, advanced treatment technologies, and improved sewer network coverage will help accommodate increasing wastewater volumes and improve the overall effectiveness of wastewater management practices at the Wupa Sewage Treatment Plant. These measures will contribute to improved urban sanitation, environmental protection, and public health outcomes in the Federal Capital Territory.

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