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Patterns of Generation and Composition of Wastewater in Abuja Municipal Area Council, Federal Capital Territory, Nigeria.

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Abstract: The study assessed the patterns of generation and composition of wastewater in Abuja Municipal Area Council (AMAC), Federal Capital Territory, Abuja. This study is a response to Sustainable Development Goals 6 and 11, which addresses the provision of clean water, safe sanitation and the development of sustainable communities and cities. The study aims to determine the patterns of wastewater generation and composition in AMAC. The research methodology includes qualitative, quantitative and experimental examination. Thirty-six (36) samples of influents/effluents were collected and subjected to laboratory analysis to determine the compositions of the various parameters for both seasons (wet and dry) and the quality of treatment at the Wupa treatment plant in AMAC. The analysis returned r values of 0.995 and 0.882 for dry and wet seasons, respectively. These r values show significant variations between the influent and effluent samples. Specifically, there were substantial variations in the concentration of wastewater parameters such as turbidity, total suspended solids, oil and grease, dissolved oxygen, chemical oxygen demand, ammonia, nitrate, biological oxygen demand and total coliform. In contrast, the variations in the concentration of other parameters remain largely insignificant. The assessment further indicated that wastewater treatment for both seasons at the plant conformed to the World Health Organization standards for effluent discharge. The study established the poor state of wastewater facilities and the need to develop a more sustainable framework for providing and maintaining wastewater facilities in AMAC. The study, therefore, recommended the adoption of a closed-system efficiency model for the management of wastewater in the Federal Capital Territory, Abuja.

Keywords: Sustainable Development Goals (SDGs), Wastewater generation, Wastewater composition, Wastewater treatment, Closed-system efficiency model, Safe sanitation, Sustainable communities

I. Introduction

The growth in human population has led to the expansion of urban settlements, urban sprawl and attendant increase in the generation of wastewater in the cities of developing countries without a commensurate rise in the investment in wastewater management infrastructure. This situation has resulted in the increased exposure of city dwellers to water-borne diseases due to the poor handling of wastewater (Sisay and Berihus, 2017). A large amount of wastewater generated in cities across the world is discharged into the environment without proper treatment, despite the advancement in science, technology, engineering and legal frameworks in wastewater management. A stand-alone problem is the absence of wastewater management infrastructure in many cities in developing countries including Nigeria.

Overall, the improper collection, treatment and disposal of wastewater are the main contributors to major water quality problems and public health issues. Improperly managed wastewater adversely impacts the water quality of subsurface and surface water such as wells, boreholes, streams, rivers, lakes and coastal waters (Chuku, Okwuraiwe, Kunle-Ope, Emelda, Azuka, Chioma, Adewale, Kelwechi, Adetoun and Rosemary, 2024). Similarly, declining sewage and septic systems pose a direct risk to public health, adversely affecting property values, quality of air and life in any given community (Siddiqua, Hahladakis, and Al-Attiya, (2022).

Despite these obvious grave public health implications, Government Institutions charged with the responsibility of managing wastewater have continued to grapple with its poor management. While efforts are being made by Institutions in the developed world to progressively improve wastewater management practices, the high capital requirement for the operation and maintenance of wastewater management systems has caused a great setback for Institutions in developing countries as a result of the limited resources in their disposal (Sojobi, and Tarek, 2021).

To address the complexity and encumbrances arising from the collection, treatment and disposal of wastewater, most cities have adopted specific approaches or systems of wastewater management that are peculiar to their circumstances of evolution and development as well as other considerations. These may include, but are not limited to the status of the society/community, orientation, level of literacy, population, occupational distribution, housing density and type as well as the origin and developmental

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue VII, July 2025

evolution of the inner city (Matthew, Olusola, Bilainu and Peter 2023). This study therefore seeks to assess the Pattern of Wastewater Generation and Composition in Abuja Municipal Area Council, Federal Capital Territory, Nigeria to determine management options for the Council taking into consideration the peculiarities of its evolution.

II. Study Area

Abuja Municipal Area Council in the Federal Capital Territory of Nigeria was created in October 1984. It is located on the eastern wing of the Federal Capital Territory and comprises twelve wards namely; City Centre, Garki, Gui, Gwagwa, Gwarimpa, Jiwa, Karshi, Kabusa, Karu, Nyanya, Orozo and Wuse. The City Centre is situated within the Abuja Municipal Area Council and serves as the administrative hub of the Federal Capital Territory of Nigeria. Importantly, it is located between latitudes 8^0 40' and 9^0 20' North of the equator and longitudes 6^0 40' and 7^0 40' East of the Greenwich Meridian, a land mass of 8000 km^2 of which Abuja Municipal Area Council occupies 250 km^2

The climate in Abuja is generally known to be tropical. The wet season has a good deal of rainfall, while the dry season is characterized by sunny skies with little cloud cover due to a low amount of moisture and dry prevailing winds coming from the Sahara Desert up North which is referred to as Harmattan in Abuja (Itiowe, Hassan, and Victor, (2019). The geology of Abuja Municipal Area Council is underlain by two main types of rocks that are sedimentary rock and basement complex rocks in the southern and southwestern ends of the Council. Sedimentary rock covers 48% while basement complex rocks cover 52% of the land area (Matthew, Olusola., Bilainu and Peter, 2023).

The drainage system within Abuja Municipal Area Council is predominantly artificial water channels constructed to collect wastewater and run-off within the districts and other wards in the Area Council. Jabi Lake serves as a collection point for these artificial distributaries or water channels situated within green belts or areas traversing Garki District, Wuse District, Utako District, Wuye District and Jabi District as well as the suburban areas of Nyayan, Karshi, Jokwoyi and Orozo. Other sources of water within the Abuja Municipal Area Council that are not publicly provided for are private water supply. Within the Abuja Municipal Area Council, some households personally exploit the underground basin for water supply. In this case, boreholes and wells are dug to supply water to households, especially in locations where public water supply is not available.

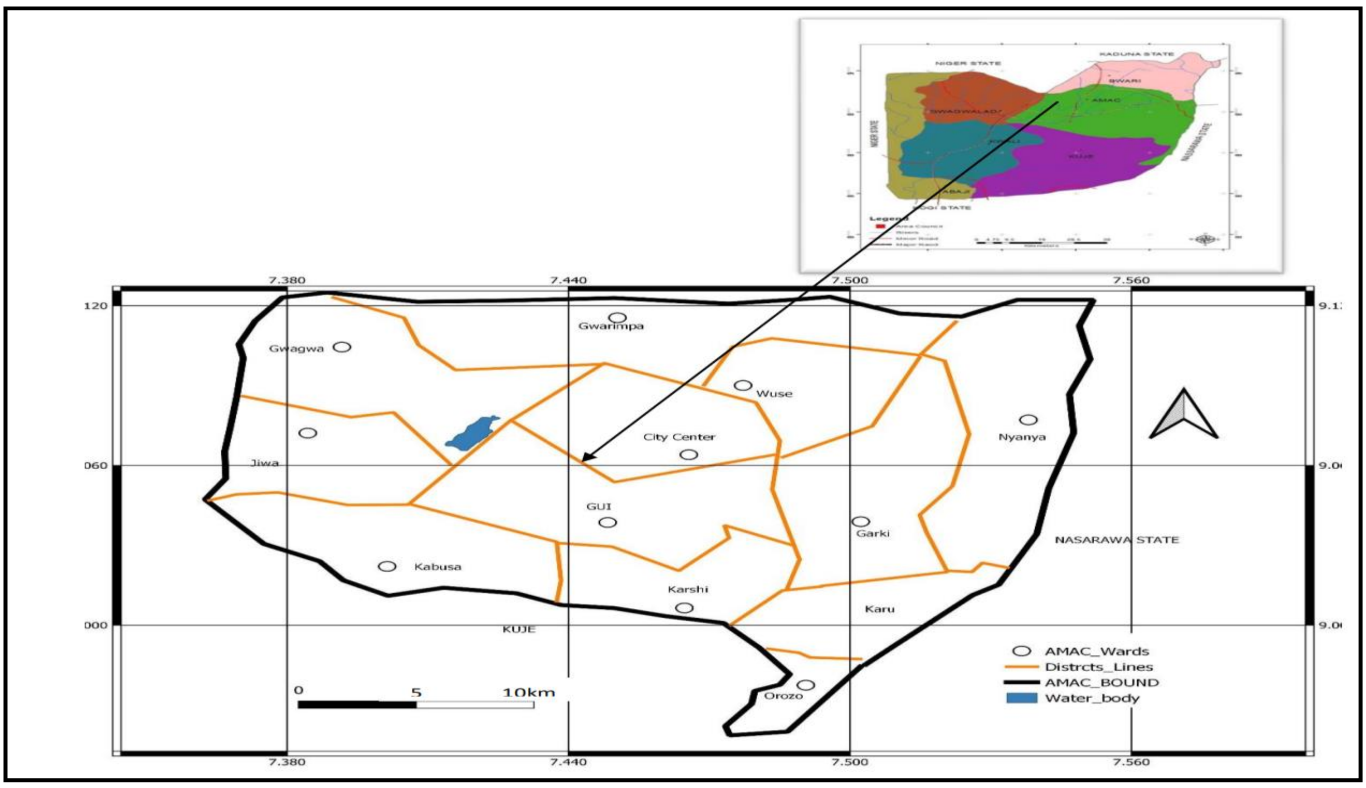

Figure 1: Federal Capital Territory and Abuja Municipal Area Council

Source: Author's Work, 2023

III. Methodology

The study adopted a survey design format. A reconnaissance survey was embarked upon to enable the researcher to examine the pattern of wastewater generation and composition. The reconnaissance survey enables the researcher to observe patterns, and layouts and make notes on the existing conditions of wastewater generation and composition as well as make an informed opinion on the best approach for the successful conduct of the study.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue VII, July 2025

In the course of the reconnaissance survey, preliminary interviews were held with wastewater administrators and facility managers at the respective locations visited. Also, photographs of some of the facilities visited were taken.

Data for the study were obtained both directly through fieldwork and indirectly through published sources. The direct approach included field observations of the various wastewater treatment plants, collection of influent and effluent samples from inlets and outlets of treatment plants and discharge outlets, and laboratory experiments of wastewater samples obtained from collection and discharge points. Indirect data were obtained from published articles, journals, internet resources and records from relevant Government Institutions.

Field Survey

Field surveys of wastewater management infrastructure within Abuja Municipal Area Council were carried out. These surveys were carried out to ascertain the locations and also assess the state of functionality of the existing wastewater management infrastructure. This was aimed at providing the study with in-depth and broader perspectives on the functionality and distribution of wastewater management systems in the Abuja Municipal Area Council.

The field surveys involved visits to treatment plants, aerators and random tours of locations of other wastewater management infrastructure. The surveys provided the study with ample opportunity to carry out an on-the-spot examination of wastewater management infrastructure.

Wastewater Sample Collection

Samples of both influent and effluent were collected from the treatment plants/facilities. At each point of collection, the samples were labelled to ensure proper presentation and safe transportation to the laboratory for storage at the prescribed holding temperature and subsequent experimental analysis. Samples were collected in clean disposable plastic water bottles of 500ml at two points in each of the wastewater treatment plants/facilities. The bottles were properly cleaned to avoid external impurities that may compromise the samples for laboratory analysis. Also, the samples were collected in the required volume per established standards. The established guidelines for wastewater sample collection were observed and all samples were presented for analysis within the stipulated timelines in order not to compromise the results.

Laboratory Analysis

The samples collected were analyzed at the Wupa Wastewater Treatment Plant Laboratory. Laboratory analysis was carried out on samples of influents and effluents collected from wastewater treatment plants and other facilities in Abuja Municipal Area Council. The samples were subjected to the requisite laboratory analysis using basic experimental methods.

In total, 18 samples of influent and effluent were collected each for the dry and wet seasons from the nine treatment plants in Abuja Municipal Area Council. The 18 samples for the dry season included nine for influent and nine for effluent taken at the point of inflow and outflow of wastewater from the respective treatment plants. In the same vein, 18 samples were collected during the wet season involving nine influent and nine effluent samples each. The influent samples were collected at the point of wastewater inflow, while the effluent samples were collected from the point of wastewater outflow from the respective treatment plants.

The collection and laboratory analysis of influent and effluent samples at the respective wastewater treatment plants was carried out to determine the variability in the concentration of the constituents or composition of wastewater at the point of entry and exit and by extension the quality or effectiveness of treatment procedures in each of the facilities. On the other hand, the collection of influent and effluent samples for dry and wet seasons was to determine the variability in the concentration of the constituents or properties of wastewater based on seasonal conditions.

The laboratory analysis involved the determination of physical, chemical, and biological properties of influent and effluent samples covering parameters such as Total Dissolve Solids (TDS), Total Suspended Solids (TSS), Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), Ammonia, Total Phosphorus, Nitrogen, Faecal Coliform Bacterial, Alkalinity, PH, Dissolve Oxygen (DO), Total Organic Carbon (TOC), Chlorides Absorbable Organic Halides, Oil and Grease.

Determination of Wastewater Treatment Plant Efficiency

The wastewater treatment plant efficiency was calculated using the standard formula given:

$$\text{Efficiency} = \{(\text{IN-OUT})/\text{IN}\}\text{X } 100 \text{ or } \quad = \text{IN-OUT x } 100\% \div \text{IN}$$

Where: IN = BOD of Influent

OUT = BOD of Effluent

The equation involves subtracting the BOD of the influent from the BOD of the effluent, then dividing the result by the BOD of the influent and multiplying the outcome by 100%. This gives the level of efficiency of the wastewater treatment plants under assessment.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue VII, July 2025

The aftermath of the calculation gives the performance efficiency of wastewater treatment plants. A higher percentage indicates that the wastewater treatment plant has a higher BOD removal efficiency from wastewater. However, since the Wupa Wastewater Treatment Plant is the only Plant in AMAC where treatment procedures are carried out, the calculations of performance efficiency were limited to the samples collected from the treatment plant.

IV. Result and Discussion

Patterns of Wastewater Generation in AMAC

Results revealed that, the patterns of wastewater generation in Abuja Municipal Area Council vary from one district to another and one suburban area to the other. Wastewater generation within the Municipal Council is affected by seasonal variations. The volume of wastewater generated all through the seasons in the City Centre, which is the administrative Headquarters of the Council and the Federal Capital Territory is higher than other parts of the Abuja Municipal Area Council.

The variation is due to the population density, access to water and existence of large corporate entities such as government buildings, hotels and other private business concerns, whose water consumption remains fairly constant throughout the year. The water usage pattern demonstrates diversity in the respective areas/locations within Abuja Municipal Area Council, in terms of functionality of space, the mode of water supply and ease of access to water as a resource. This is in line with the study carried out by (Widyarani, Wulan, Hamidah, 2022) on the generation, characteristics and treatment of domestic waste water in urban areas. The study pointed out that, there is remarkable variation in the composition of wastewater generated and patterns in the city, and these variations are mainly as a results of the various sources of wastewater in the urban area.

The high rate of wastewater generation in the City Centre is generally due to the availability of modern sanitary facilities such as water control systems (WC) and other contemporary sanitary wares that require heavy usage of water for their operations. The wastewater volume trajectory in the City Centre compared to the other areas of Abuja Municipal Area Council further confirms the supposition that wastewater generated is equivalent to the water used in the individual facilities, locations or neighbourhoods.

In suburban neighbourhoods such as Nyanya, Karshi, Karu, Jikwo, Gwagwa, Karmo and Orozo water usage is relatively low. This is due to the types of sanitary systems in existence and the lack of access to an uninterrupted water supply. In these neighbourhoods, toilet facilities are predominantly pour-flush toilet systems and pit latrines with very few water closet systems. Even where water closets exist, water usage is low due to the reduced frequency of usage in the bid to minimize the waste of scarce water resources. In Gwagwa, Orozo and Nyanya neighbourhoods, most households indicated that their toilet needs were met by pour flush and pit latrines and in very rare cases open defecation. The preference for open defecation was said to be a result of the liberty the open environment provides as against the confined and usually dirty toilets available for use.

In addition, the compound nature of dwellings in these areas, where residents are compelled to share sanitary facilities encourages individuals to opt for open defecation in most instances. These considerations, amongst others, are largely responsible for the highly reduced frequency of the use of toilet facilities beyond the City Centre. This state of affairs significantly limits the volume of wastewater generation within other wards. In the same vein, most wastewater-generating activities such as laundry, dish-washing and other kitchen utensils are carried out outdoors and the used water is directly disposed of onto open grounds or fields that instantly absorb the wastewater. These occurrences, therefore, reduce the quantity of wastewater generated, collected, treated and subsequently disposed of in the Municipal Council Wards outside the City Centre.

Although there are clear indications that wastewater generated in the Wards outside the City Centre is much lower, the sanitary systems operated outside the city such as the pour-flush toilets and water closets that are connected directly to septic tanks or soakaways, do not provide the basis for proper assessment of the volume of wastewater generated. This is so because sludge that collects in septic tanks or soakaways over time is treated through natural processes and only evacuated when the pit is filled up, while the effluent gradually seeps into the surrounding soil within the pit's walls.

Given this context, it is crucial to note that attempting to accurately quantify the volume of wastewater generated outside the City Centre solely based on field observations and questionnaire responses may be potentially misleading. In the case of the City Centre, where households are linked directly to the central sewage system, wastewater generated in homes collects directly into the network of pipes through which the influent is transported to the respective wastewater treatment plants for treatment and safe disposal. Moreover, the receiving treatment plants cannot accurately track or record the volume of influent received and effluent discharged from their facilities. Furthermore, the majority of wastewater treatment plants and aerators in the Abuja Municipal Area Council are currently non-operational due to various operational challenges, with many undergoing rehabilitation.

Despite the uncertainty surrounding wastewater volumes received at treatment plants, this study estimated the likely wastewater generation in each location using Abuja Municipal Area Council's 2022 projected population. The calculation assumes a minimum daily water usage of 150 litres per person, aligned with the globally recognized minimum household water use rate.

To determine the volume of wastewater generated, the estimated population of Abuja Municipal Area Council, which stands at 1,967,500 people as of 2022 was multiplied by 150 litres. In line with this assumption, a daily wastewater volume of 295,125,000 litres was computed as being generated within Abuja Municipal Area Council. Nonetheless, the theoretical outcome of the computation of the daily volume of wastewater generated in the Municipal Council may differ significantly or insignificantly from

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue VII, July 2025

the actual volume generated as a result of other considerations such as availability of water, sources of water, sanitary wares in use and toilet systems predominantly used within the respective locations and neighbourhoods.

The variability in the volume of wastewater generated based on these parameters is supported by the findings of Aliyu (2019) in his study which investigated water consumption, domestic wastewater generation and organic matter concentration based on socio-economic status and some meteorological parameters including temperature. The study noted that socio-economic status and other meteorological parameters could greatly affect water usage and hence, the volume of water generated within a specific neighbourhood. The study opined that while the availability of water is one of the major determinants of its use, parameters such as temperature and socioeconomic status of the individual, were the main drivers of the usage of water resources.

As a result, individuals with greater economic stability tend to consume more water daily, regardless of weather conditions or access to water sources. In contrast, economically disadvantaged individuals may adjust their water usage in response to meteorological factors and also seek to minimize costs associated with high water consumption

In practical terms, individuals residing in neighbourhoods in the City Centre have high rates of wastewater generation as a result of their socio-economic status not necessarily because of access to water sources. This promotes the understanding that the City Centre dweller uses the bathroom or other sanitary facilities more than once a day irrespective of the meteorological conditions and visits the laundry for the cleaning of single-used or one-time-used personal fabrics and garments. This scenario may not be obtainable in the situation of an economically unstable individual, although with few exceptions, as other reasons may suffice for the frequency of the use of the bathroom and number of visits to the laundry or personal engagement in laundry activities, which are the major sources of wastewater generation.

Seasonal Variation in Wastewater Generation

Seasonal variations affect the volume of wastewater generated from individual households, corporate organizations, commercial outlets and government institutions. Results of the study revealed that, while the seasonal variation in wastewater generation in corporate organizations, commercial outlets and government institutions is not very significant, that of the households substantially varies. This is because access to water supply is limited, in most households, during the dry season. The water level in wells and boreholes decreases as a result of low or zero precipitation during the dry season.

At this time, households are forced to reduce the level of water usage or consumption to ensure the sustainability of the limited water resources available. However, in the wet season, the volume of water in wells and boreholes rises, thereby increasing water consumption or usage rates in households. This directly impacts wastewater generation.

In the treatment plants, interactions with the operators reveal that the volume of wastewater received at the plants increases geometrically during the wet season. The increase is largely attributed to runoffs/stormwater finding its way into the central sewage system which conveys influents to the various treatment plants. As provided for by the Wastewater Master Plan, the City Centre has separate conveyance systems for runoffs/stormwater and sewage collected from households and other abodes.

Nevertheless, runoff frequently infiltrates the central sewerage system through vulnerabilities such as stolen manhole covers and damaged pipes. Furthermore, the pervasive theft of metallic manhole covers from Abuja Municipal Area Council's (AMAC) sewerage system by scavengers and vandals enables substantial runoff entry. This illicit influx unnecessarily escalates the volume of influent received at wastewater treatment facilities during wet seasons.

The misdirection of runoffs into the central sewage system not only increases the volume of influent received in the existing wastewater treatment plants but also poses a great threat to the efficient treatment of wastewater delivered to the facilities. Also, the over-dilution of influents, reduces the composition of their organic matter, thereby affecting the ability to activate microbial activities required for the crucial processes involved in the treatment of influents before disposal.

As regards corporate organizations, commercial outlets and government institutions, water usage is fairly constant irrespective of the season or time of the year. Generally, the water consumption or usage in these premises is not affected by seasonal variations because they are serviced by the public water supply agency, Abuja Water Board or have in place industrial boreholes that are more dependable and ensure sustainability all year round.

Seasonal Variation in Composition of Wastewater at AMAC

The results obtained revealed that there are no variations in wastewater parameters during the wet and dry seasons in AMAC. However, while the parameters remain the same, the concentration of the respective properties differs as it is reduced during the wet season due to dilution from runoffs that find their way into the sewerage system. The concentrations of wastewater in septic tanks or soakaways are also affected during the wet season as runoffs find their way into the septic tanks through seepages from openings around the tanks and infiltrations. Table 1 is the physical, chemical and biological parameters of domestic wastewater samples collected from the Wupa Wastewater Treatment Plant, Abuja. The table presents experimental results of parameters of domestic wastewater collected during the dry and wet seasons.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue VII, July 2025

Table 1: Variation in Physical, Chemical and Biological Composition of Wastewater in AMAC.

S/N	Parameters	Dry season	Wet season
		Influent	Influent
1	Temperature (ºc)	25.70	26
2	Conductivity(µʃ/cm)	286.00	304.00
3	Total Dissolved Solids (mg/l)	140.00	147.00
4	Turbidity (mg/l)	56.00	189.00
5	Total Suspended Solids (mg/l)	157.00	250.09
6	Oil and Grease (mg/l)	180.0	250.90
7	Ph	7.12	7.00
8	Dissolved Oxygen (mg/l)	2.00	4.00
9	Total Alkalinity (mg/l)	56.00	68.90
10	Chemical Oxygen Demand (mg/l)	400.00	300.00
11	Ammonia as nitrogen (mg/l)	0.35	4.50
12	Nitrate as nitrogen (mg/l)	4.00	1.20
13	Nitrite as nitrogen (mg/l)	0.14	0.16
14	Phosphate (mg/l)	2.70	1.00
15	Chloride (mg/l)	38.90	39.20
16	Biological Oxygen Demand (mg/L)	180.00	120.00
17	Total coliform (cfu/100ml)	5000	3000
18	Faecal coliform (mpn/100ml)	1600	1600

Source: Author's Work, 2023.

The concentrates of the respective wastewater parameters are therefore reduced as a result of the volume of water mixed with the sewage. This does not affect the onsite treatment process, as the septic tanks can self-regulate. Also, influent in septic tanks or soakaways seeps into the surrounding soil, hence checking the occurrence of overflows that may result from runoffs finding their way into the soakaway pits. As seen from the table, there are variations in the parameters of wastewater samples collected during the two seasons. In some instances, the variations were insignificant, while in others the variations were very significant. However, in the case of a single parameter, which is the faecal coliform, there was no variation at all, for both the dry and wet seasons. To further confirm the variations in the seasonal concentration of wastewater, statistical analysis using the Pearson Correlation Coefficient was carried out on the experimental data gathered as seen in Table 2.

Table 2: Pearson Correlation Coefficient Calculation

S/N	Parameters	Dry season Influent {X}	Wet season Influent {Y}	XY	X^2	Y^2
1	Temperature (ºc)	25.70	26	668.2	660.49	676
2	Conductivity(µʃ/cm)	286.00	304.00	86944	81796	92416
3	Total Dissolved Solids (mg/l)	140.00	147.00	20580	19600	21609
4	Turbidity (mg/l)	56.00	189.00	10584	3136	35721
5	Total Suspended Solids (mg/l)	157.00	250.09	39391.3	24649	62545.0081
6	Oil and Grease (mg/l)	180.0	250.90	45162	32400	62950.81

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XIV, Issue VII, July 2025

7	pH	7.12	7.00	49.84	50.6944	49
8	Dissolved Oxygen (mg/l)	2.00	4.00	8.00	4.00	16.00
9	Total Alkalinity (mg/l)	56.00	68.90	3858.4	3136	4747.21
10	Chemical Oxygen Demand (mg/l)	400.00	300.00	700.00	160000	90000
11	Ammonia as nitrogen (mg/l)	0.35	4.50	1.575	0.1225	20.25
12	Nitrate as nitrogen (mg/l)	4.00	1.20	4.8	16.00	1.44
13	Nitrite as nitrogen (mg/l)	0.14	0.16	0.0224	0.0196	0.0256
14	Phosphate (mg/l)	2.70	1.00	2.70	7.29	1.00
15	Chloride (mg/l)	38.90	39.20	1524.88	1513.21	1536.64
16	Biological Oxygen Demand (mg/L)	180.00	120.00	21600	32400	14400
17	Total coliform (cfu/100ml)	5000	3000	15000000	2250000	9000000
18	Faecal coliform (MPN/100mL)	1600	1600	2560000	2560000	2560000
	$\sum$	8135.91	6312.95	17791 80	5169369	11946689

Source: Author's work, 2023.

The result shows a significant variation in the concentration between dry season and wet season influent. The r value 3.9 shows a very strong variation in the composition of influent in the two season types. Domestic wastewater temperature for the dry season is 25.70^0c and 26^0c for the wet season. For the other parameters, conductivity is 286uf/lcm and 304uf/cm, Total Dissolved Solids are 140mg/l and 147mg/l, pH 7.12 and 7.0, Nitrite as nitrogen is 0.14mg/l and 0.16mg/l, chloride 38.90mg/l and 39.20mg/l for dry and wet seasons respectively.

The variations in the concentrations of the properties of these parameters are not very significant for both dry and wet seasons. The other parameters with significant variations for the two weather types are Turbidity- 56mg/l and 189mg/l, Total Suspended Solids- 157mg/l and 250.09mg/l, Oil and Grease- 180mg/l, and 250mg/l, Dissolved Oxygen-2mg/l and 4mg/l, Total Alkalinity-56mg/l and 68.90mg/l, Chemical Oxygen Demand-400mg/l and 300mg/l, Ammonia as nitrogen- 0.35mg/l and 4.50mg/l, Nitrate as nitrogen- 4mg/l and 1.20mg/l, Phosphate- 2.70mg/l and 1mg/l, Biological Oxygen Demand- 180mg/l and 120mg/l and Total Coliform- 5000cfu/100ml and 3000cfu/100ml for dry and wet seasons respectively. However, for faecal coliform, the concentration of the property of the parameter remains constant at 1600mpn/100ml for both dry and wet seasons.

From the experimental data, the domestic wastewater temperature for the dry season is 25.7^0c, while that of the wet season is 26^0c. For other parameters such as conductivity is 286uf/cm and 304uf/cm, Total Dissolved Solids is 140mg/l and 147mg/l, pH is 7.12 and 7.0, Nitrite as Nitrogen is 0.14 and 0.16, Chloride is 38.9mg/l and 39.2mg/l, Total Alkalinity is 56mg/l and 68mg/l for dry and wet season respectively. The variations observed in the properties of these parameters are not very significant as seen in Table 1.

On the other hand, parameters with very significant variations in properties are Turbidity 56mg/l and 250.09mg/l, Total Suspended Solids 157mg/l and 250.09mg/l, Oil and Grease 180mg/ and 250.09mg/l, Dissolved Oxygen 2mg/l and 4mg/l, Chemical Oxygen Demand 400mg/l and 300mg/l, Ammonia as Nitrogen 0.35mg/l and 4.50mg/l, Nitrate as Nitrogen 4mg/l and 1.20mg/l, Biological Oxygen Demand 180mg/l and 120mg/l, Total Coliform 5000cfu/100ml and 3000cfu/100ml respectively.

The seasonal variations noticed in the volume and concentration of wastewater generation within AMAC are in alignment with the conclusions of Ali et al 2006 that there are significant variations in the volume and concentration of wastewater generated at AMAC during the wet season and dry season.

Composition of Wastewater within AMAC

Wastewater at AMAC is derived largely from domestic sources, with little industrial wastewater from the very few industries in the city. Also, another form of wastewater at AMAC is stormwater which results from runoffs caused by seasonal rainfall/precipitation. Generally, domestic wastewater compromises human excreta including faeces and urine and used water from toilets, kitchens, laundry and bathrooms. Wastewater samples were collected from the different treatment plants in the City Centre (FCC) and analyzed.

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The composition/parameters of wastewater are categorized into physical, chemical and biological. The physical parameters include temperature, conductivity, total dissolved solids, turbidity and total suspended solids. The physical parameters of wastewater may easily be determined through physical examination and other not-very tedious laboratory analyses. On the other hand, the chemical parameters include pH, dissolved oxygen, total alkalinity, chemical oxygen demand, ammonia as nitrogen, nitrate as nitrogen, phosphate and chloride. The properties and concentration of the chemical parameters can only be determined through rigorous laboratory analysis.

The third category comprises biological parameters: Biological Oxygen Demand (BOD), Total Coliform, and Faecal Coliform. Notably, while the untreated discharge of physical parameters has relatively mild environmental impacts, chemical and biological parameters pose severe environmental and public health risks if not properly managed.

Physical Composition/Parameters of Domestic Wastewater

The physical appearance of domestic wastewater in AMAC as observed from the samples collected, is a grey turbid liquid containing small suspended solids with various particles of disintegrated faeces, toilet tissues, and other sanitary materials used in the toilets or dumped in the sewer systems. The concentration of the respective physical parameters of domestic wastewater in AMAC as obtained from influents and effluent samples collected during dry and wet seasons are presented in Table 3.

Table 3: Physical Composition of Domestic Wastewater

		Wet Season		Dry Season	
S/NO	Physical Parameters	Influent	Effluent	Influent	Effluent
1	Temperature (ºC)	26	25.60	25.70	26.00
2	Conductivity (µʃ/cm)	304.00	300.00	286.00	267.00
3	Total Dissolved Solid (mg/l)	147.00	143.12	140.00	130.00
4	Turbidity (mg/l)	189.00	8.10	56.00	6.00
5	Total Suspended Solids (mg/l)	250.09	12.00	157.00	11.00
6	Oil and Grease(mg/l)	250.90	16.02	180.0	10

Source: Author's Work 2023

Chemical Composition/Parameters of Domestic Wastewater

Table 4 shows the concentration of the respective chemical composition/parameters of wastewater at AMAC as obtained from influents and effluents samples for dry and wet seasons. The chemical composition/parameters comprise pH, dissolved oxygen, total alkalinity, chemical oxygen demand, ammonia as nitrogen, nitrate as nitrogen, phosphate and chloride. The concentration of the properties of the parameters slightly differs from one weather type to another. The disparity between the concentration of the properties of the chemical parameters of the influents and effluents for both weather types is a result of the effect the treatment process is said to be.

The chemical parameters of influent samples collected from the various treatment plants at AMAC are similar with just slight variations, which could be explained by other factors, which include a high level of dilution, the ratio of water to the available sludge and the introduction of contaminants into the wastewater in the neighborhood where the wastewater treatment plants are located.

Table 4: Chemical Composition of Domestic Wastewater at AMAC for Dry Season and Wet Season

		Dry Season		Wet Season	
S/NO	Chemical Parameters	Influent	Effluent	Influent	Effluent
1	pH	7.12	7.01	7.00	7.11
2	Dissolved Oxygen(mg/l)	2.00	7.00	4.00	8.39
3	Total Alkalinity(mg/l)	56.00	46.00	68.90	33.91
4	Chemical Oxygen Demand(mg/l)	400.00	20.00	300.00	20.00
5	Ammonia as nitrogen(mg/l)	0.35	0.14	4.50	0.08
6	Nitrate as nitrogen(mg/l)	4.00	7.00	1.20	4.00

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7	Nitrite as nitrogen(mg/l)	0.14	0.24	0.16	0.05
8	Phosphate(mg/l)	2.70	0.98	1.00	0.57
9	Chloride(mg/l)	38.90	35.0	39.20	30.9

Source: Author's Work 2023.

Biological Composition/Parameters of Domestic Wastewater

The biological composition of domestic wastewater at AMAC is shown in Table 5. Biologically, AMAC wastewater is composed of disease and non-disease-causing pathogens such as bacteria, algae, nematodes, and rotifers, amongst others. The biological composition of the wastewater is derived from faeces and urine, which contains intestinal bacteria and smaller organisms which are mostly harmful to the environment and humans.

From the laboratory analysis of influents and effluents samples collected in the Abuja Municipal Area Council for dry and wet seasons, the biological composition of domestic wastewater includes biological oxygen demand, total coliform and faecal coliform. The concentration of the properties of the respective biological parameters is indicated in Table 5.

Table 5: Biological Composition of Domestic Wastewater

		Dry Season		Wet Season	
S/NO	Biological Parameters	Influent	Effluent	Influent	Effluent
1	Biological Oxygen Demand(mg/L)	180.00	8.00	120.00	7.0
2	Total coliform(cfu/100ml)	5000	3000	3000	2000
3	Faecal coliform(MPN/100mL)	>1600	150	>1600	100

Source: Author's Work, 2023

Plate 1: Runoff/Stormwater in Jabi

Enclosed Manhole at Utako

Source: Fieldwork, 2023

V. Conclusion and Recommendations

The provision and maintenance of wastewater treatment facilities in Abuja Municipal Area Council (AMAC) necessitate a renewed commitment to institutional development and funding from the Federal Capital Territory Administration (FCTA) and stakeholders to operate optimally. This conclusion stems from the finding that only one of the nine identified wastewater treatment facilities in AMAC is functional, and even that one operates below-installed capacity. To address this challenge, the study recommends the adoption of a three-pronged strategy. Firstly, a closed-system efficiency model should be implemented to enhance wastewater management. Secondly, an autonomous agency should be established to oversee wastewater management in the Federal Capital Territory, Abuja, Nigeria. Lastly, alignment with Sustainable Development Goals is crucial to providing clean water, effective sanitation, developing safe, sustainable and resilient cities globally.

To ensure effective implementation, the Federal Capital Territory Administration (FCTA) and Abuja Environmental Protection Board (AEPB) must prioritize strategic imperatives. These include allocating adequate funds for the rehabilitation and

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operationalization of dysfunctional and abandoned wastewater treatment plants, engaging skilled manpower, and providing training and retraining programs for personnel to enhance their capacity for holistic wastewater management. By adopting these measures, AMAC can ensure sustainable wastewater management and promote a healthier environment.

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