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Assessment of Wastewater Management in Kano Metropolis, Kano State, Nigeria

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Abstract Wastewater management has continued to become serious environmental issue. The study assessed the current practices and challenges of wastewater management in Kano Metropolis. Data were gathered through a survey conducted among the stakeholders, government officials, and community members through verbal and questionnaire administration 400. The survey results were analyzed using descriptive statistics and Pearson Chi Squares to show associations between infrastructures. The study found that the wastewater management system in Kano Metropolis is in a state of disrepair, with severe infrastructure gaps, poor sewerages, drainages, septic tanks, lack of centralized wastewater collection system and non-functional of wastewater treatment plants recorded standard deviation of 0.72, 0.73, 0.84, 0.68 and 0.56 respectively. The results of the Pearson Chi Square showed strong association between the wastewater management facilities. The practice is not in compliance with the wastewater disposal policies. The poor state of the wastewater management system has had a negative impact on public health, environmental quality and economic development in the Metropolis. Therefore, the study recommends improving the coordination between stakeholders and increasing the availability of resources for wastewater management, creates awareness for best practices for wastewater management. There is also a need for increased investment in wastewater-related infrastructure, such as wastewater treatment plants and sewerage systems.

Index Terms: Wastewater, management, pollution, diseases, sewerage.

I INTRODUCTION

Wastewater management is a holistic approach that requires care or the management of wastewater right from the source, immediately it is released into the environment, treatment and its reentry into the environment (Un-Waters, 2015). It all centred on sustainable management with utmost concern to the idea of 'reuse and dispos-

al' in the sanitation service chain that covers every segment of the environment. (Mshelia et al., 2020) were of the view that over the years, wastewater management in developing nations has not been giving the right accord and practice. The inadequate attention to environmental problems in developing nation such as Nigerian is keeping such countries behind in achieving the sustainable development goals (SDGs), 3, 6 and 11 among others. The cities are supposed to take part in the global trend of meeting the SDGs goals and targets as well as improving and sustaining the environment through the enhancements that place emphasis on designs like portable provision of water supply and environmental cleanliness projects towards healthy environment and provision of means of livelihood (Edward and Joanne, 2017; United Nations, 2016; Mshelia et al., 2022). Enormous wastewater is being generated in urban centres in Nigeria on daily basis.

About 75% of wastewater generated in urban areas often ends up in the community indiscriminately disposed. Sanjay and Sharma (2012) are of the view that wastewater management includes comprehensively all what it takes to ensure proper generation, disposal, treatment as well as the materials, tools, infrastructure require for handling and care of it. It requires stakeholders' absolute cooperation and involvement in the management (Adhiambo, 2014; Aneeba et al., 2020; Tilly et al., 2008).

1. Statement of Problem

In most Nigerian urban centres such as Kano, Aba, Enugu and Makurdi, there is no or functional wastewater centralized collection system and that most homes are without septic tanks or soakaways for housing wastewater (Mshelia et al., 2023; Nwachuckwu et al., 2019). Asiya and Ali (2017) also observed that Nigeria is currently facing serious and worsening wastewater management problems as a result of high annual growth in population, urbanization, inadequate capital and technological resources. One of the the greatest threats to improved water quality in Nigeria is the discharge of untreated sewage into fresh water bodies which cause waterborne diseases (Odurukwe, 2012; Idris-Nda et al., 2013). Enormous wastewater is being generated in urban centres in Nigeria on daily basis. In Lagos metropolis only, about 1.4 trillion Cm2 is generated daily and about 1 trillion Cm2 in Kano. The wastewater when disposed indiscriminately lead to environmental issues and waterborne diseases such as cholera, gastroenteritis, neurological disorder, Cyanosis/asphyxia, cancer, and heart diseases among others (Balamurugan and Dheenadayalan, 2012; Shaktibala and Bhagat, 2012; Valipour, 2015).

It is against this background that Laugesen et al. (2010) and Omosa et al., (2012) clearly pointed out the imperativeness to design systems that "work with rather than against natural ecosystem processes" and argued that there is the need to comprehend processes, techniques and environmental factors before designing any wastewater management infrastructure for sustainable ecosystem. Furthermore, under such situation, attitudinal change in wastewater management is of paramount importance for

sustainable water resources management. In addition, all the levels of government should practice the treatment of wastewater along with complying with policies and programmes or else we kiss environmental sustainability good bye (Giwa, 2014). Hence, there is the need for the study on the wastewater management in Kano Metropolis, Nigeria.

II Materials and Methods

2.1 Location and Extent

Kano Metropolis exists between latitudes 110 55′ 23.93″N to 120 3′ 53.10″N of the Equator and longitude 80 27′ 42.26″E to 80 3′ 41.62″E of the Greenwich Meridian (see Figure 1) and envelopes 499Km2 landmass with built up areas of about 238.42Km2 (Yunus, 2020). The Metropolis is made up of eight Local Government Areas and the most populated and industrialized city in Northern Nigeria. The 2022 projected population is 4,102,836 at growth rate of 2.8%. The high population and industrial activities give room for generation of high quantity of wastewater (UN-World Population Review, 2022).

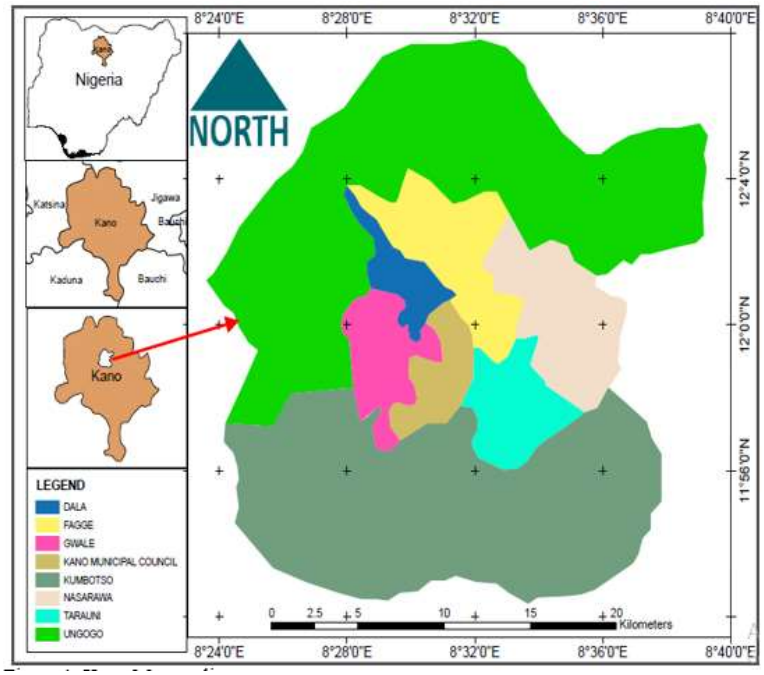

Figure 1: Kano Metropolis Source: GIS Unit, Department of Geography, Federal University Gashua (2022)

2.2 Weather and Climate

Kano's climate is tropical, having longer dry period compared to the wet season of about four months of rainfall from June – October with a mean annual temperature of 300C and average annual rainfall of 700mm. The wet and dry climate coded as ''Aw'' Koppen's classification system (NiMET, 2021). Kano Metropolis is often very hot almost throughout the year, though from December to February, the city is noticeably cooler especially in the night measuring average of 11°- 14 °C in some cases (NiMET, 2021).

Weather and Climatic factors play a crucial role in wastewater menace and management. For example, during the wet season, heat and humidity cause the wastewater to be more turgid, stinks and at the same time during the dry season when there is no rainfall to dilute and infiltrate the wastewater makes it stinks the more and as well affect the physicochemical parameters and productiveness of microbial parameters. Similarly, rainfall encourages percolation of debris and transports them to nearby rivers as well as facilitates infiltration, seepages and dissolution of elements in surface and groundwater (Mshelia et al., 2021; Mshelia et al., 2022).

2.3 Sample Frame and Sampling Size Determination for Questionnaire Administration

Taro Yamane (1967) formula of sample size was used and arrived at a manageable size of 400 for the study where questionnaires on wastewater management were administered.

Formula: $n = N/(1 + N([e])^2)$

The formula was computed using the projected 2021 Kano metropolis population of 4,102,836 (Population Stat. 2021; National Bereau of Statistics, 2017) as shown on Table 1.

n = Sample size
N = Population size
e = Level of significance
1 = Constant

Base on the National Population Commission (2006) projected population

To determine the number of respondents in each LGA, the population of each was divided by the total population in the metropolis and then multiplied by the sample size (400) as shown on Table 4.8. Therefore, 400 questionnaires were used for the analysis.

Area/Ward = (Popn of LGA)/n ×Sample size
Where N = Population of Kano Metropolis, Sample Size = 400

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Table 1: Distribution of questionnaires according to population size

Local Government Area (LGA)	Population Census 2006	Population Projection 2021	Number of Questionnaires
Dala	481,719	684,098	67
Fagge	200,095	284,135	28
Gwale	357,827	508,114	50
Kano Municipal	371,243	527,165	51
Kumbotso	294,391	418,055	41
Nasarawa	596,411	846,904	82
Tarauni	221,844	315,019	31
Ungogo	365,737	519,347	51
	2,826,307	4,102,836	400

Descriptive statistical methods were employed in the analysis of the obtained data for the study are the arithmetic mean, standard deviation, charts, bar graph and tables. These have helped in preliminary interpretations of the results got from the observations and questionnaires.

Standard Deviation = Formula:

$$s^2 = \sqrt{S^2} = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}$$

Where X = arithmetic mean or individual value
$\bar{x}$ = Sample mean
n = sample size
∑ = summation
S = Standard deviation

Similarly, Likert Rating Scale of Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D) and Strongly Disagree (SD) was employed and used where necessary. Pearson's Chi-Square was also used to determine if there is a statistically significant association between the variables for wastewater management. The formula for the statistics is:

$$\frac{x^2 = \sum (O_i - E_i)^2}{E_i \quad |}$$

Where
⟦ x⟧^2 = Chi-Square

0i = Observed Count,
E i = Expected Count.

III Results and Discussion

The study took into cognizance the wastewater management towards SDGs 3, 6 and 11, existing policies and rules, facilities at homes and communities.

3.1 Wastewater Management and its Facilities in Kano Metropolis

The result of the investigation of wastewater management facilities at homes and the communities in Table 2 shows that 13.25% of the respondents are of the view that sewerage systems or facilities that convey wastewater from homes and other parts of the metropolis are available and functioning, 24% reported that the facilities are available but are not functioning and are in dilapidated state while the highest percentage of 62.75% is of the view that wastewater management facilities are not available. This defines the presence of wastewater at open spaces, flowing down slope from homes, abattoirs and markets. Most of the houses in the communities such as the Kano Municipal, Daurayi, Yankaba and Sabon Gari do not have good sewerage systems but rather use shallow hand dug hole as septic tank or narrow available paths between houses as shown in Plate 1 and 2.

Similarly, most of the respondents (54%) are of the view that drainages and gutters are not available; 23.7% reported that the facilities are available and functional while 22.3% opined that they are not available as was observed by Amoatey and Bani (2016) in Ghana on wastewater management. Shawai et al., (2019) posited that there is no centralized wastewater management system in the metropolis and facilities such as drainages, gutters and culverts are inadequate and very poor to function at average state. More still, 23.5%; 17.75% and 58.75% are of the view that septic tanks and soak aways are available and functional; available but are not functioning and wastewater management facilities are not available respectively. The 23.5% respondents might be those that reside in the choice parts of the metropolis such as the GRAs, State House roads and Estates where there are satisfactory wastewater management facilities.

Furthermore, the 17.75% respondents are those who resides in areas that have few drainages and culverts but are filled up with wastes of all sorts and no longer convey wastewater to designated areas as shown in Plates 3 and 4 while the majority of the respondents (56.75%) are those who live in the peri-urban (Mariri) parts of the town and in congested areas such as Kano city (Birni). On the aspect of centralized and decentralized facilities, 10.75% opined they are available and functioning. These respondents reside in the GRAs and good estates. In another perception, 22.25% recorded that the facilities are available but not functioning because of accumulated municipal solid waste in water ways while 67% is of the view that the facilities are not

available. This shows that the centralized and decentralized systems of conveying wastewater in the metropolis are not available. Hence, disposals are left at the mercies of the residents

Table 2: Wastewater management facilities in kano metropolis

Facilities	Available & Functional Frequency %		Available but not functional Frequency %		Not Available Frequency %	
Sewerage system	53	13.25	96	24	251	62.75
Drainages/Gutter/culverts	95	23.75	89	22.25	216	54
Septic tanks/ soak away	94	23.5	71	17.75	235	58.75
Centralized and Decentralized System	43	10.75	89	22.25	268	67
Wastewater Treatment Plants/ Effective Units and Vehicles	25	6.25	54	13.5	321	80.25

Figure 2: Poor wastewater channel in the metropolis.

Figure 3: Wastewater released from home

Figure 4: Municipal solid waste dumped into canal

Figure 5: Wastewater containing dumped

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3.2 Associations between the Wastewater Management Facilities using Chi-Square

Variables 'A - D' were compared with 'E' using Pearson Chi-Square to shows association between the wastewater management facilities in a descriptive statistic as shown in Table 3.

Table 3: Statistical summary of wastewater management facilities at homes and communities

Facilities	N	Min.	Max.	Mean	Std. Deviation
Sewerage system	400	1	3	2.50	0.719
Drainag-es/Gutter/culverts	400	1	3	2.50	0.719
Septic tanks/ soak away	400	1	3	2.50	0.719
Centralized and De-centralized System	400	1	3	2.50	0.719
Wastewater Treatment Plants/ Effective Units and Vehicles Valid N (list wise) 398	400	1	3	2.50	0.719

The computation of the availability of sewerage systems and wastewater treatment plants, effective units and wastewater management machines showed the value of the Chi Square statistic is 473.212a and the P -value = 0.001. On the aspect of the facilities such as drainages, gutter and culverts and the variable; wastewater treatment plants, effective monitoring units and wastewater management machines in the metropolis using the Pearson Chi Square test table also showed statistic value as 456.052a and the P-value is 0.001.

The values showed that there positive association between the wastewater management facilities required for proper management of wastewater in the metropolis (see Table 4).

Table 4: Sewerage systems and wastewater treatment pants

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	473.212[a]	4	0.001
Likelihood Ratio	375.531	4	0.000
Linear-by-Linear Association	166.543	1	0.000
N of Valid Cases	400		

Similarly, using the Person Chi Square the availability of wastewater management facilities such as septic tanks and soakaways in the Metropolis and wastewater treatment plants, effective monitoring units and wastewater management machines or vehicles in the Metropolis in which the value of the statistic is 69.119a and the P – value is 0.000, Furthermore, the observed association between centralized and decentralized availabilities and the wastewater treatment plants, effective monitoring units and wastewater management machines or vehicles in the metropolis using the Pearson Chi Square shows the statistic value as 69.119a and the p-value is 0.000 are affirmatives as shown on Table 5 and 6.

Table 5: Drainages, gutter, culverts and wastewater treatment plants

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	456.052 [a]	4	0.001
Likelihood Ratio	311.393	4	0.000
Linear-by-Linear Association	210.159	1	0.000
No of Valid Cases	400		

0 cells (.0%) have expected count less than 5. The minimum expected count is 5.56**.**

Table 6: Septic tank and soak ways availabilities and the wastewater treatment

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	529.632 [a]	4	0.010
Likelihood Ratio	401.387	4	0.000
Linear-by-Linear Association	196.111	1	0.000
No of Valid Cases	400		

2 cells (22.2%) have expected count less than 5. The minimum expected count is 3.33.

Table 7: Centralized and decentralized in the metropolis and wastewater treatment plants

	Value	df	Asymptotic Significance (2- Sided)
Pearson Chi-Square	69.119 [a]	4	0.000
Likelihood Ratio	97.456	4	0.000
Linear-by-Linear Association	51.025	1	0.000
No of Valid Cases	400		

1 cell (11.1%) has expected count less than 5. The minimum expecte count is 4.44.

The associations of asymptotic significance of 0.00 – 0.010 at 0 cells – 2 cells and all having expected count of <5 (see Table 7) showed that there were significant associations between the availability of facilities: sewerages, drainages, septic tanks, centralized and decentralized and wastewater treatment plants, effective monitoring units and wastewater management machines in the metropolis.

This further means that their availability and uses the wastewater management facilities in the Metropolis will enhance effective wastewater management in line with SDGs 3, 6 and 11 which are good health and well-being for people; clean water and sanitation, and sustainable cities and communities. It is on this basis that the Federal Government in collaboration with the Kano State Government flag off "Central Effluent Plants in Kano metropolis" on 2nd December, 2019 to ensure effective wastewater management in the metropolis which has been neglected for long. The need for the wastewater treatment plant is ideal for effective wastewater management as spelt out in the associations by the Chi Square Statistical analysis carried out as also observed by Ternes et al. (2007) in the use of irrigation treated water in Braunschweig, Germany

3.3 Adherence to National Environmental Standard Regulation Enforcement Agency's (NESREA) Wastewater Disposal Policies

The investigation in Figure 2 showed the responses of the residence on the view that industries, households and other institutions treat wastewater in line with NESREA's policies before disposal into the environment (river, streams, ponds, open lands) showed that 3.5% strongly agreed, 4.5% agreed, 2.75% did not indicate any response while 65.5% and 23.75% (a total of 89.25%) disagreed and strongly disagreed respectively. This showed that most of the large, medium and small-scale industries do not treat wastewater before disposal into river, streams, ponds and open lands in accordance to the rules, regulations and policies set by Ministry of Environment under the supervision of NESREA. The study further showed that households discharge wastewater through small channels and pipes to the front or back of their houses (see Figure 7).

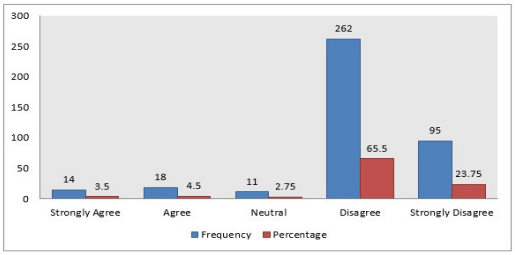

Figure 6: Industries Treat Wastewater in line with (NESREA) Policies before Disposal.

Figure 7: Wastewater from toilets and bathrooms being discharged from household Kano Metropolis.

3.4 Wastewater Management ln Line with Sdgs 6: Clean Water and Sanitation by 2030

One important goal and target of the SDGs is the goal 6: getting clean water and sanitation for all by the year 2030. The 400 respondents interviewed showed that only 2.25% strongly agreed and 6.25% agreed while 5.5% reported neutral. The highest percentage 72.5% disagreed and 12.5% also strongly disagreed (see Figure 3) with the view that the kind of wastewater management in the metropolis is geared towards achieving SDGs 6 of clean water and sanitation by 2030 which was also viewed by UN-Water (2019).

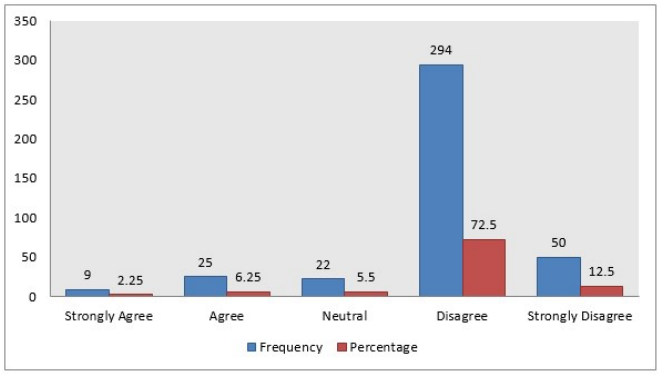

Figure 8: Wastewater management types in Kano Metropolis in line with SDG 6: clean water and sanitation.

3.5 Challenges of Wastewater Management in Kano Metropolis

Management of wastewater generally has many challenges which hinder effective services. This has led to enormous volume of wastewater freely discharged in the environment. The study examined the views of residents, stakeholders on challenges

of wastewater management as shown in Table 8. To this, 17% and 60.25% strongly agreed and agreed respectively that inadequate knowledge on the effects and health impacts of wastewater is a challenge in waste management.

This view defined the presence of wastewater at homes and its disposal without recourse to environmental law in most of the remote, congested and ancient settlements in the metropolis as also reported by Nabegu (2010) and Mshelia and (Mbaya 2022) who studied domestic of management in peri-urban settlement of Kano Metropolis and effects of industrial wastewater at Challawa industrial area.

Table 8: Challenges of Wastewater Management in Kano Metropolis

Challenges of wastewater management	SA		A		N		D		SD	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Inadequate knowledge and health effects of wastewater	68	17	241	60.25	45	11.25	40	10	6	1.5
Illiteracy, religious and cultural beliefs	48	12	202	50.5	58	14.5	62	15.5	30	7.5
Poor waste management habit / attitude	73	18.25	249	62.25	27	6.75	43	10.8	8	2
Insufficient and poor use of fund	85	21.25	256	64	23	5.75	28	7	5	1.25
Poor government own high capacity and functional treatment plant	85	21.25	258	64.5	21	5.25	28	7	5	1.25
Non-compliance to wastewater management policies and laws	83	20.75	261	66.75	17	4.25	31	7.8	8	2
Poor enforcement of the policies rules and regulations	76	19	273	68.25	16	4.0	23	5.8	12	3
Inadequate wastewater management facilities (such as drainage channels)	71	17.75	263	65.75	23	5.75	26	6.5	7	1.75
Poor urban planned structures in city centres and peri-urban	67	16.75	259	64.75	31	7.75	32	8	11	2.75
High population and congestion	64	16	261	66.5	21	5.25	42	10.5	12	3

In addition, 12% and 50.5% strongly agreed and agreed respectively, that is a total of 62.5% keyed into the views that illiteracy; religious and cultural beliefs are challenges of wastewater management in the Metropolis as also studied by Butu and Mshelia, (2017) who studied municipal waste management practices in Kano Metropolis while 11.5% disagreed and 10% sat on the fence.

More still, 18.25% and 62.25% of the respondents strongly agreed and agreed respectively to the view that poor waste management habit/attitude serve a one of the many

challenges of wastewater management in the metropolis, 21.25% and 64% also strongly agreed and agreed (82.24%) respectively that insufficient and poor use of fund affects wastewater management while 21.25% and 64.5% strongly agreed and agreed respectively that non-compliance to wastewater management policies and laws affects wastewater management. This view is supported by the indiscriminate disposal of wastewater in the metropolis.

Furthermore, 19% and 68.25% (a total of 87.24%) of the respondents agreed to the view that poor enforcement of the policies rules and regulations and this shows that people are or reprimanded accordingly for not complying with the rules and regulations on wastewater while 4.0% showed no response and 8.8% disagreed. Similarly, the highest percentage of the respondents of 65.75% agreed and 17.75% strongly agreed (83.5%) are of the view that inadequate wastewater management facilities (such as drainage channels) compound the problems of wastewater management for many serve as municipal solid waste dumping place as also reported by Mshelia et al. (2020).

More still, majority of the respondents with scores of 64.75% and 16.75% agreed and strongly agreed that poor urban planned structures in the city centres and peri-urban affects wastewater management. For instance, it is usually difficult to even access some houses by bicycle at places such as Danmarke and Kano cities (Birni).

Wastewater generated at such areas is often difficult to manage because they are not properly planned and also highly populated as reported by 82.5% while 13.5% disagreed. The peri-urban areas also often emerge without plans and as such provide an avenue for indiscriminate discharge of wastewater which serves as breeding place for mosquitoes and other vectors (Mshelia et al. 2021; Nabegu, 2010).

IV Conclusion

The management of wastewater has become a serious challenge in Kano Metropolis, Nigeria. The lack of adequate infrastructure and capacity to manage the large quantities of wastewater generated and discharged into the environment has caused pollution and deteriorating water quality in the area. The management practices in the metropolis is generally poor and inadequate infrastructure such as centralized wastewater collection system, drainages, poor and dilapidated soak ways and septic tanks lack of qualified personnel. Others are non-functional of wastewater plants and facilities, insufficient funding and limited public awareness as well as non-compliance with environmental management policies. Additionally, one of the greatest threats to improved water quality in Nigeria is the discharge of untreated sewage into fresh water bodies which cause waterborne diseases. The study recommends improved infrastructure, increased funding and further research to gain a better understanding of the challenges and improve the existing wastewater management system.

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