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ASSESSING THE EFFECTS OF INADEQUATE SANITARY FACILITIES AND WASTEWATER MANAGEMENT ON URBAN TRANSPORT INFRASTRUCTURE IN PORT HARCOURT METROPOLIS

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ABSTRACT

This study investigated the effects of inadequate sanitary facilities and poor wastewater management on urban railway transport infrastructure in Port Harcourt Metropolis, Nigeria. A total of 120 respondents participated using a structured questionnaire based on a 4-point Likert scale. Findings revealed that most railway stations lack accessible and functional toilets, with a mean score of 2.36 indicating poor sanitary facility availability. Wastewater mismanagement was also evident, with a mean score of 2.54 showing moderate acknowledgment of blocked drains, sewage overflows, and their impact on flooding and infrastructure deterioration. The perceived effect on railway infrastructure scored a mean of 2.74, confirming that poor sanitation and drainage conditions disrupt operations, weaken track foundations, and reduce service quality. Perceived government and management response scored a mean of 2.49, reflecting inadequate funding, weak policy enforcement, and limited emergency response. Based on these findings, the study recommends urgent investment in WASH infrastructure, regular maintenance, effective inter-agency coordination, and public awareness campaigns. Strengthening sanitation policies within transport planning is essential for protecting rail infrastructure and public health in urban Nigeria.

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1. INTRODUCTION

Urban infrastructure, particularly transport systems, plays a pivotal role in the economic, social, and environmental stability of any city. Among the transport modes in Nigeria, rail transport remains crucial due to its capacity for the mass movement of goods and people over long distances. However, the effectiveness and durability of railway infrastructure are increasingly compromised by urban environmental challenges, one of which is the poor provision of sanitary facilities and inadequate wastewater management. In cities like Port Harcourt, the growing urban population, lack of investment in sanitation infrastructure, and environmental mismanagement have created conditions where railway systems face significant operational and infrastructural degradation (Uchegbu & Oduwaiye, 2020; UN-Habitat, 2020, Ogboeli et al., 2024; Aisha, et al., 2025).

Port Harcourt, the capital of Rivers State, is a rapidly growing metropolis located in the oil-rich Niger Delta region of Nigeria. The city is host to one of the country's major railway hubs under the Nigerian Railway Corporation (NRC), facilitating movement from the southern corridor toward the north. Historically, the Port Harcourt Railway Station served as a commercial backbone for the export of coal and agricultural produce. Today, its relevance has evolved to meet urban and peri-urban transport needs. However, the station and the railway tracks passing through the metropolis face increasing threats from poor environmental sanitation and waste mismanagement (Igbokwe et al., 2017).

The rapid rate of urbanization in Port Harcourt has led to the emergence of informal settlements and unplanned developments around critical infrastructure such as railway tracks and terminals. These communities, often lacking basic urban services such as sewage systems and public toilets, have become hotspots for open defecation and indiscriminate disposal of greywater and solid waste. The railway corridors, in particular, are frequently used as open spaces for sanitation purposes due to their relative isolation and lack of supervision. This unsanitary practice contributes significantly to the deterioration of railway infrastructure by weakening the soil structure, corroding metallic components, and increasing maintenance costs (Eze & Elekwa, 2020; Ogboeli et al., 2024).

The Port Harcourt Railway Corporation’s infrastructure, including tracks, drainage systems, platforms, and passenger waiting areas, is not immune to the impacts of wastewater and poor sanitation. When untreated wastewater from surrounding communities or informal vendors finds its way onto railway tracks and terminals, it accelerates physical decay through erosion, flooding, and corrosion. Stagnant wastewater also creates breeding grounds for disease vectors, leading to

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poor hygiene conditions for passengers and staff, thereby discouraging usage and reducing the station's overall effectiveness (World Bank, 2021).

Moreover, during the rainy season, blocked drains filled with solid waste and excreta overflow into the railway yard, leading to waterlogging and undermining the structural foundation of tracks and platforms. As the water mixes with human waste, the health risks for commuters and workers increase significantly. This environmental burden further compounds the already poor perception and low patronage of the railway system, despite its potential to decongest the city's overburdened road network (Okon, 2017).

The lack of sanitary facilities at the Port Harcourt Railway Station is a critical concern. Many travelers, especially those on long-distance journeys, are left without access to public restrooms or proper waste disposal options. Informal vendors and passengers often resort to urinating and defecating in hidden corners of the station or along nearby tracks. These practices not only present immediate hygiene hazards but also compromise the safety and environmental sustainability of the railway corridor (Ayoade et al., 2019; Ogboeli et al., 2024; Aisha, et al., 2025).

The issue is not solely infrastructural; it is also institutional. The failure to integrate sanitation planning into transport infrastructure design has resulted in siloed approaches to urban development. Agencies responsible for sanitation and those overseeing railway infrastructure often operate with minimal collaboration. For instance, the Nigerian Railway Corporation (NRC) and the Rivers State Waste Management Agency (RIWAMA) rarely coordinate their efforts, leading to overlapping responsibilities and neglected maintenance. The result is the proliferation of health and safety hazards around one of the city's most strategic transportation assets (Akukwe & Ogbodo, 2015; Ogboeli et al., 2024).

Furthermore, government investment in the sanitation sector remains inadequate. According to UN-Habitat (2020), less than 30% of Port Harcourt's urban population has access to improved sanitation. While efforts have been made to expand road infrastructure, sanitation facilities, especially around transport terminals like the railway station, have been largely neglected. Even where toilets are provided, poor maintenance, lack of water supply, and security concerns render them unusable. This reality encourages informal waste disposal and open defecation, compounding the challenges facing urban transport infrastructure (WHO/UNICEF, 2019).

Globally, there is a growing recognition of the interlinkages between sanitation and transport planning. The Sustainable Development Goals (SDGs), particularly Goals 6 and 11, underscore the need for clean water, sanitation, and sustainable urban infrastructure. In Nigeria, national development policies and urban renewal strategies acknowledge the importance of integrated planning. However, at the city level, implementation is fraught with financial, institutional, and technical constraints (Adelekan, 2010). These constraints are evident in Port Harcourt, where

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urban expansion has outpaced service delivery, and where sanitation remains a peripheral consideration in transport system planning.

The choice of Port Harcourt Railway Corporation as a case study is both strategic and symbolic. It represents a microcosm of the wider infrastructural and environmental dysfunction plaguing Nigerian cities. Assessing the effects of inadequate sanitary facilities and wastewater management on the Corporation will not only highlight the challenges faced by transport infrastructure in Port Harcourt but also underscore the urgent need for integrated, multi-sectoral solutions. This study will draw attention to the costs of neglect, not just in terms of infrastructure degradation, but also public health, safety, economic efficiency, and urban resilience.

This study aims to provide empirical evidence on how the absence of basic sanitation facilities and improper wastewater disposal negatively affect the functionality, safety, and sustainability of the Port Harcourt Railway Corporation's infrastructure. It will investigate the scale of the problem, identify the actors involved, and recommend policy and technical interventions to address the situation. Ultimately, the research seeks to inform stakeholders urban planners, transport authorities, environmental health officials, and policymakers on the benefits of a more holistic approach to urban infrastructure management.

The interconnectedness of sanitation and transportation infrastructure is becoming increasingly evident, especially in fast-growing urban centers like Port Harcourt. Without proper sanitation facilities and effective wastewater management, the city's railway system and by extension, its transport sector will continue to suffer from environmental degradation, public health hazards, and reduced functionality. A paradigm shift is needed in urban planning to incorporate sanitation as a core component of transport infrastructure development and maintenance. The findings of this study are expected to contribute to the growing body of knowledge advocating for resilient, inclusive, and sustainable urban systems in Nigeria and beyond.

Comparative Studies and Global Contextualization

A study by Adegun (2019) on urban flooding in Lagos highlighted that poor drainage infrastructure and unregulated waste disposal practices, especially in informal settlements, significantly contributed to road inundation, making many streets impassable and causing transport delays during the rainy season.

In Accra, Amoako and Inkoom (2018) found that unplanned urban growth, coupled with inadequate sanitation systems, had direct impacts on stormwater management and road durability. The frequent blockage of drains by solid and faecal waste resulted in repeated urban flooding events.

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A case study in Nairobi by Mwangi (2017) emphasized the link between informal waste disposal, open defecation, and the deterioration of road networks. The research reported that sanitation-related waste often clogged drainage channels, causing road collapse and transport disruption.

In Dhaka, the capital of Bangladesh, Alam et al. (2018) documented how the lack of sewerage systems and illegal discharge of sewage into stormwater drains caused severe urban flooding. This led to traffic gridlock and damage to urban transport corridors.

Desai and Mahadevia (2019) explored sanitation failures and flood risks in Mumbai, where insufficient public toilets and open defecation in low-income areas exacerbated stormwater drainage blockages, leading to road flooding and damage.

The above studies reinforce that urban sanitation failures are not isolated to Port Harcourt but represent a wider challenge for developing cities facing rapid urbanization, inadequate infrastructure, and poor waste governance. By referencing these comparable contexts, research contributes to a growing body of evidence showing that:

- Sanitation and drainage are deeply interconnected with transport resilience.
- Interventions in one sector (e.g., wastewater management) can yield co-benefits for others (e.g., road safety and accessibility).
- Holistic infrastructure planning, including sanitation and transport, is essential for sustainable urban development.

2. MATERIALS AND METHODS

Rivers State is located within the South-South geopolitical zone of Nigeria, encompassing an area of 11,077 square kilometers (4,277 square miles) and positioned at coordinates 4°45′N 6°50′E. The state is bordered to the south by the Atlantic Ocean, while to the north, it shares boundaries with Imo, Abia, and Anambra States. To the east, it is adjacent to Akwa Ibom State, and to the west, it is bordered by Bayelsa and Delta States. The Port Harcourt local government area is part of the Greater Port Harcourt region, situated at Latitude 4° 46' 38.71" N and Longitude 7° 00' 48.24" E, with UTM coordinates of 32N 279660.2215768 and 528378.96126353. This area is approximately 52 kilometers (32 miles) southeast of Ahoada and around 40 kilometers (25 miles) northwest of Bori. It is bordered to the south by Okrika, to the east by Eleme, to the north by Obio-Akpor, and to the west by Degema. The total area of Port Harcourt is 109 square kilometers (42 square miles), with a population density of 5,856.5 individuals per square kilometer (15,168 per square mile).

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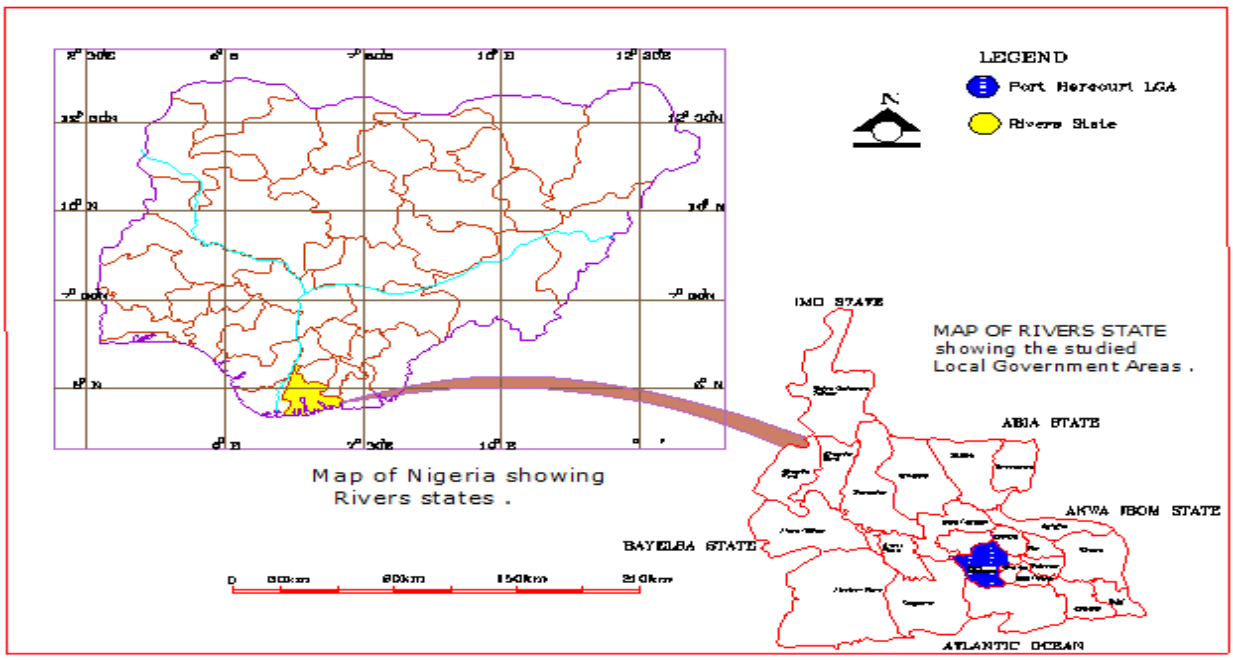

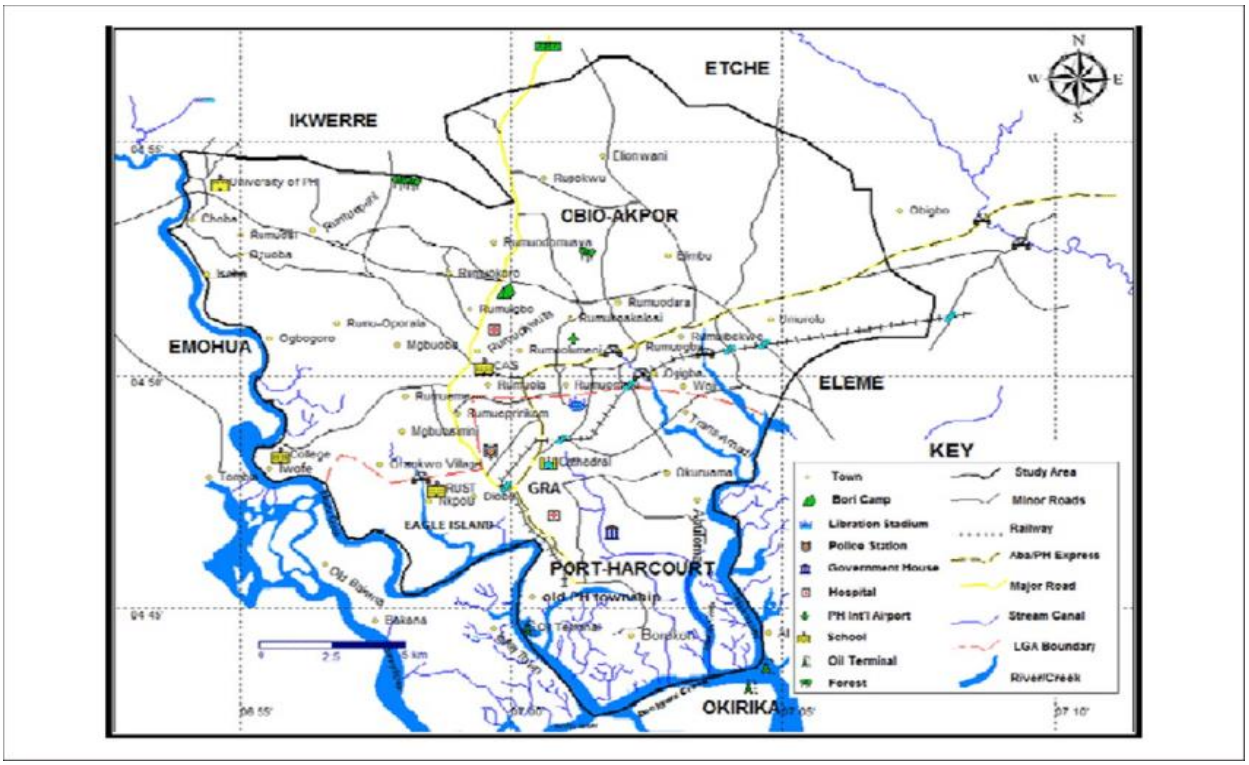

Figs 1 and 2 show the map of the study area.

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According to projections from 2006, the population was estimated to be 756,600 in 2016 (citypopulation.de, 2017). This study was conducted in Port Harcourt Metropolis, the capital of Rivers State, Nigeria. The area hosts key segments of Nigeria's urban railway transport network and experiences challenges related to poor sanitation, open defecation, and ineffective wastewater management, particularly around railway stations and tracks. These environmental conditions contribute to the deterioration of railway infrastructure and disruptions in transport operations. The study adopted a mixed-methods approach using a descriptive and exploratory survey design. This design allowed for the collection of both quantitative and qualitative data to comprehensively assess the impacts of inadequate sanitary facilities and poor wastewater management on railway transport infrastructure. This study adopted a purposive stratified random sampling strategy to ensure that the data collected were representative of the varying socio-spatial characteristics of Port Harcourt Metropolis, particularly around zones influenced by railway corridors and related infrastructure. The sampling focused on rail-adjacent communities, railway users, and infrastructure maintenance personnel, all of whom are either directly or indirectly impacted by the sanitary and wastewater management conditions surrounding railway infrastructure.

Port Harcourt was divided into three strata based on proximity to the railway line and intensity of railway-related activity:

1. Primary railway zones (e.g., Port Harcourt Railway Terminal, D-line terminal)
2. Secondary adjoining communities (e.g., Rumuomasi, Rumuibekwe, Elelenwo, Oyibo)
3. Peripheral areas with indirect exposure to rail-linked drainage systems

The sampling frame included community members (households), railway workers, public health officers, and transport officials. From each stratum, respondents were selected using proportionate stratified random sampling, ensuring balanced representation from each cluster. The sample size was determined using Cochran's formula for categorical data:

$$n = \frac{Z^2 pq}{d^2}$$

Where:

- Z = Z-value for 95% confidence level (1.96)
- p = estimated prevalence of poor sanitation (assumed at 0.5 for maximum variability)
- q = 1 - p
- e = margin of error (0.05)

This yielded a minimum required sample size of approximately **120**, which was adjusted to **150 respondents** to account for possible non-responses and data losses. The purposive stratification

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based on railway proximity increases the contextual relevance of the findings, while the random selection within strata reduces selection bias and enhances generalizability (Etikan, Musa, & Alkassim, 2016). A semi-structured questionnaire and observation checklist were used to collect data on: Availability and condition of sanitary facilities near railway corridors, frequency of wastewater discharge incidents, and reported impacts on railway tracks, passenger flow, and maintenance needs. To ensure validity and reliability, the following procedures were undertaken:

Content and Face Validity: The initial draft of the instrument was developed through a literature review and guided by similar tools used in urban infrastructure and environmental health assessments (Amoako & Inkoom, 2018; Mwangi, 2017; WHO, 2019). The instrument was reviewed by a panel of five experts in urban transport, civil engineering, and environmental health to confirm that all items were clear, relevant, and aligned with the study objectives.

Pilot Testing: The questionnaire was **pilot-tested with 30 respondents** from a railway-adjacent community not included in the main sample (e.g., Railway Quarters, Port Harcourt). Feedback was used to: Revise complex or ambiguous items, improve the logical sequence of questions, and adjust Likert-scale descriptors for clarity.

Reliability Testing: The instrument's reliability was tested using **Cronbach's alpha**. A value of **0.84** was obtained, indicating high internal consistency (George & Mallery, 2003).

Triangulation: To enhance construct validity, findings from questionnaires were cross-validated with Key informant interviews (railway maintenance staff and sanitation officers) and direct observation reports on the state of drains and toilets along railway corridors.

Ethical Considerations

Ethical clearance was obtained from the relevant institutional review board. Participation was voluntary, and informed consent was obtained from all respondents. Confidentiality of participants' information was maintained throughout the study.

3. RESULT

Table 1: Sanitary Facility Availability at Urban Railway Transport Infrastructure

	Sanitary Facility Availability	SA	A	D	SD	Total	SWV	Mean	Remarks	Rank	$x-\bar{x}$	$(x-\bar{x})^2$
		4	3	2	1							
1.	Railway stations in Port Harcourt have sufficient public toilet facilities for passengers	28	36	58	72	120	194	1.6	Rejected	8th	-0.76	0.5776

2.	Sanitary facilities at railway stations are functional and accessible at all times	12	12	60	83	120	167	1.4	Rejected	10th	-0.96	0.9216
3.	Most railway passengers face difficulty accessing clean toilets while at the station	8	15	106	60	120	189	1.6	Rejected	9th	-0.76	0.5776
4.	There are no public toilets along railway lines or within nearby informal settlements	244	165	6	1	120	416	3.5	Accepted	1st	1.14	1.2996
5.	Sanitation facilities at railway stations are often overcrowded or unhygienic	24	24	100	54	120	202	1.7	Rejected	7th	-0.66	0.4356
6.	Railway employees have access to adequate and separate sanitation facilities	272	111	20	5	120	408	3.4	Accepted	2nd	1.04	1.0816
7	Lack of sanitary facilities around railway infrastructure contributes to open defecation near tracks	224	147	18	6	120	395	3.3	Accepted	3rd	0.94	0.8836
8	Poor toilet access at stations discourages the use of railway transport by the public	108	66	64	39	120	277	2.3	Rejected	5th	-0.06	0.0036
9	Authorities have provided little investment in sanitary infrastructure at railway terminals	36	84	78	44	120	242	2.0	Rejected	6th	-0.36	0.1296

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10	Regular maintenance of toilets at railway stations is rarely conducted	184	87	42	24	120	337	2.8	Accepted	4th	0.44	0.1936
								23.6				**6.104**
								2.36				

The analysis of respondents' perceptions regarding the availability of sanitary facilities around railway infrastructure in Port Harcourt Metropolis reveals widespread inadequacies. The mean score for the construct was 2.36, which is below the theoretical benchmark of 2.5 on a 4-point Likert scale, indicating a general dissatisfaction with the state of sanitary infrastructure.

Items with the lowest mean scores included "Sanitary facilities at railway stations are functional and accessible at all times" (mean = 1.4) and "Railway stations in Port Harcourt have sufficient public toilet facilities" (mean = 1.6), both of which were rejected. These results suggest that passengers often struggle to find clean, functional toilets, a situation that reflects broader patterns of neglect in transport sanitation across urban Nigeria (Adelekan, 2010). Notably, items such as "There are no public toilets along railway lines or within nearby informal settlements" (mean = 3.5) and "Lack of sanitary facilities contributes to open defecation near tracks" (mean = 3.3) received the highest acceptance. These findings underscore the serious health and environmental implications of poor sanitation access. According to WHO and UNICEF (2021), the absence of basic sanitation in public transport spaces not only violates human dignity but also increases the risk of communicable diseases, particularly in densely populated transit zones.

Interestingly, railway employees were perceived to have better sanitation access (mean = 3.4), suggesting a disparity between worker provisions and those available to the commuting public. This observation aligns with urban sanitation studies that reveal infrastructural prioritization for operational staff over users (Ajibade et al., 2022). The statement "Regular maintenance of toilets is rarely conducted" (mean = 2.8) was also accepted, indicating neglect in the sustainability of existing facilities. Poor maintenance often renders available toilets unusable, perpetuating unsanitary behavior and infrastructure damage (UN-Habitat, 2018).

In conclusion, the findings highlight the urgent need for infrastructural investment, policy reform, and enforcement of sanitation standards in Nigeria's railway sector. Integrating sanitation into urban transport planning can reduce disease risks, enhance public safety, and promote sustainable urban mobility.

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Table 2: Wastewater Management

	Wastewater Management	SA	A	D	SD	Total	SWV	Mean	Remarks	Rank	$x-\bar{x}$	$(x-\bar{x})^2$
		4	3	2	1							
1.	Poor wastewater drainage around railway stations often leads to water accumulation and flooding	8	57	74	62	120	201	1.7	Rejected	10th	-0.84	0.7056
2.	Railway tracks and platforms in Port Harcourt are frequently affected by sewage overflows	68	63	78	43	120	252	2.1	Rejected	9th	-0.44	0.1936
3.	Blocked drains and open gutters are common near urban railway facilities	156	96	58	20	120	330	2.8	Accepted	5th	0.26	0.0676
4.	Wastewater from nearby residential or commercial buildings is often discharged near railway infrastructure	140	81	64	24	120	309	2.6	Accepted	6th	0.06	0.0036
5.	Inadequate wastewater management contributes to the structural deterioration of railway tracks	52	78	84	39	120	253	2.1	Rejected	8th	-0.44	0.1936
6.	Flooded railway stations during the rainy season disrupt train operations and commuter safety	152	72	28	44	120	296	2.5	Accepted	7th	-0.04	0.0016
7	There is little or no government effort to manage wastewater around railway corridors	164	105	72	8	120	349	2.9	Accepted	2nd	0.36	0.1296

8	The absence of engineered drainage systems worsens wastewater accumulation near tracks.	120	141	64	11	120	336	2.8	Accepted	3rd	0.26	0.0676
9	Wastewater pooling around rail lines poses serious health and environmental risks	128	138	54	15	120	335	2.8	Accepted	4th	0.26	0.0676
10	Investments in proper wastewater infrastructure are necessary to protect railway transport assets	196	111	58	5	120	370	3.1	Accepted	1st	0.56	0.3136
								25.4				**1.744**
								2.54				

The analysis of wastewater management around railway infrastructure in Port Harcourt Metropolis reveals mixed perceptions among respondents. With an overall mean score of 2.54, the responses hover just above the acceptable threshold of 2.5 on a 4-point Likert scale, indicating moderate acknowledgment of wastewater challenges and their impact on the railway system. The highest-rated item, "Investments in proper wastewater infrastructure are necessary to protect railway transport assets" (mean = 3.1), reflects strong public consensus on the urgent need for infrastructural improvement. This aligns with findings by UN-Habitat (2018) and Adelekan (2010), who emphasize the role of poor drainage and wastewater management in accelerating urban infrastructure decay.

A critical observation is the high agreement on items such as "There is little or no government effort to manage wastewater around railway corridors" (mean = 2.9) and "The absence of engineered drainage systems worsens wastewater accumulation near tracks" (mean = 2.8). These suggest public dissatisfaction with governmental responses and infrastructure planning. Urban infrastructure studies in Nigeria have consistently shown that underinvestment in engineered drainage systems contributes to waterlogging and erosion, particularly during rainy seasons (Ajibade et al., 2022). On the other hand, statements like "Poor wastewater drainage around railway stations leads to flooding" (mean = 1.7) and "Inadequate wastewater management contributes to structural deterioration of tracks" (mean = 2.1) were rejected. This may reflect either a lack of awareness of the long-term effects of wastewater accumulation or desensitization to such issues due to their frequency.

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Interestingly, blocked drains and open gutters near railway facilities (mean = 2.8) and sewage overflows at stations (mean = 2.1) confirm visible signs of poor environmental hygiene, with implications for both commuter health and operational reliability. According to WHO (2021), stagnant wastewater around public infrastructure increases the risk of vector-borne diseases and undermines public confidence in using public transport. In summary, the findings underscore the urgent need for strategic wastewater planning, engineered drainage systems, and better government oversight to safeguard urban railway assets in Port Harcourt. A proactive response is essential to minimize infrastructure damage and public health risks associated with wastewater mismanagement.

Table 3: Effects on Urban Railway Transport Infrastructure

	Effects on Urban Railway Transport Infrastructure	SA 4	A 3	D 2	SD 1	Total	SWV	Mean	Remarks	Rank	$x-\bar{x}$	$(x-\bar{x})^2$
1.	Inadequate sanitation near railway stations causes environmental pollution that affects railway users	120	87	68	27	120	302	2.5	Accepted	9th	-0.24	0.0576
2.	Poor wastewater management has led to physical damage of railway tracks and platforms	192	117	42	12	120	363	3.0	Accepted	1st	0.26	0.0676
3.	Waterlogged or flooded rail lines due to blocked drains delay or disrupt train movement	160	123	56	11	120	350	2.9	Accepted	3rd	0.16	0.0256
4.	Accumulated waste and wastewater near railway corridors increase maintenance costs	156	111	42	23	120	332	2.8	Accepted	6th	0.06	0.0036
5.	The lack of sanitation	164	108	58	14	120	344	2.9	Accepted	4th	0.16	0.0256

	infrastructure around railway facilities discourages passenger use of the rail system											
6.	Train terminals in Port Harcourt are often inaccessible due to poor drainage and sewage overflow	92	84	60	39	120	275	2.3	Rejected	10th	-0.44	0.1936
7	Poor sanitation conditions reduce the operational lifespan of urban rail infrastructure	176	117	56	9	120	358	3.0	Accepted	2nd	0.26	0.0676
8	Wastewater erosion weakens the foundation of railway tracks over time	148	114	58	16	120	336	2.8	Accepted	5th	0.06	0.0036
9	Infrastructure around informal railway settlements suffers more from sanitation-related damage	128	108	50	27	120	313	2.6	Accepted	7th	-0.14	0.0196
10	10. Overall service quality of railway transport in Port Harcourt is negatively affected by sanitation and drainage issues	124	90	72	23	120	309	2.6	Accepted	8th	-0.14	0.0196
								27.4				**0.484**
								2.74				

The findings from the respondents' assessments reveal strong agreement on the negative impacts of inadequate sanitation and poor wastewater management on urban railway transport infrastructure in Port Harcourt Metropolis. With an overall mean score of 2.74, above the acceptable benchmark of 2.5 on a 4-point Likert scale, most of the statements were accepted, indicating widespread recognition of the problem's severity. The highest-rated item, "Poor

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wastewater management has led to physical damage of railway tracks and platforms" (mean = 3.0), confirms a direct infrastructural consequence of sanitation failure. This aligns with studies by UN-Habitat (2018) and Ajibade et al. (2022), which identified wastewater erosion and flooding as contributors to the rapid deterioration of urban infrastructure in sub-Saharan African cities.

Also highly rated were statements such as "Poor sanitation conditions reduce the operational lifespan of urban rail infrastructure" (mean = 3.0) and "Waterlogged or flooded rail lines due to blocked drains delay train movement" (mean = 2.9). These findings reinforce earlier reports by World Bank (2017), which identified poor drainage and unmanaged sewage as core threats to transport resilience in West African cities. Respondents further agreed that the lack of sanitation infrastructure discourages rail transport usage (mean = 2.9), suggesting public perception is influenced by environmental cleanliness and hygiene conditions. This reflects the socio-behavioral link between infrastructure design and commuter preference noted by WHO and UNICEF (2021) in their joint global WASH assessment.

Interestingly, the statement "Train terminals in Port Harcourt are often inaccessible due to poor drainage" received the lowest mean score (2.3) and was rejected, possibly indicating variation in experiences across terminals or a lack of awareness of specific instances of access disruption. Overall, the results paint a clear picture: unsanitary conditions and ineffective wastewater control negatively affect service reliability, structural integrity, and public confidence in the railway system. Addressing these issues demands urgent infrastructure investment, routine maintenance, and integrated WASH-transport planning.

Table 4: Perceived Management and Government Response

	Perceived Management and Government Response	SA 4	A 3	D 2	SD 1	Total	SWV	Mean	Remarks	Rank	$x-\bar{x}$	$(x-\bar{x})^2$
1.	The government is actively addressing sanitation-related issues around railway stations in Port Harcourt	92	87	68	34	120	281	2.3	Rejected	6th	-0.19	0.0361
2.	Railway authorities regularly inspect and maintain drainage and sanitation systems near train lines	84	54	84	39	120	261	2.2	Rejected	8th	-0.29	0.0841

3.	There is a clear policy on wastewater and sanitation management for urban railway infrastructure	156	126	58	10	120	350	2.9	Accepted	1st	0.41	0.1681
4.	Government funding for sanitation improvements in railway corridors is adequate.	84	45	78	45	120	252	2.1	Rejected	10th	-0.39	0.1521
5.	Public complaints about poor sanitation near railway tracks are promptly addressed by relevant agencies	68	69	82	39	120	258	2.2	Rejected	9th	-0.29	0.0841
6.	There is effective collaboration between sanitation agencies and railway authorities	96	57	64	45	120	262	2.2	Rejected	7th	-0.29	0.0841
7	Sanitation and wastewater concerns around rail transport are ignored in urban development planning	92	117	76	20	120	305	2.5	Accepted	5th	0.01	0.0001
8	Emergency responses to sanitation-related damage near railway lines are slow or ineffective	148	123	56	14	120	341	2.8	Accepted	3rd	0.31	0.0961
9	Public awareness campaigns on proper waste disposal near railway areas are lacking	168	111	42	20	120	341	2.8	Accepted	4th	0.31	0.0961

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10	Stronger government intervention is needed to protect urban railway infrastructure from sanitation-related damage	148	138	42	16	120	344	2.9	Accepted	2nd	0.41	0.1681
								24.9				**0.8849**
								2.49				

The perception of management and governmental response to sanitation and wastewater concerns in Port Harcourt's railway transport infrastructure is mixed, as revealed by a mean score of 2.49 on a 4-point Likert scale, just below the acceptable threshold of 2.5. This reflects public dissatisfaction with the level of institutional commitment to addressing environmental challenges around railway lines. The highest-rated item, "There is a clear policy on wastewater and sanitation management for urban railway infrastructure" (mean = 2.9), was accepted, suggesting that while a policy framework may exist, its implementation is inconsistent. Similarly, strong support was recorded for "Stronger government intervention is needed to protect railway infrastructure from sanitation-related damage" (mean = 2.9), highlighting the urgent call for proactive engagement by government bodies. However, most other items were rejected, including "The government is actively addressing sanitation-related issues around railway stations" (mean = 2.3) and "Government funding for sanitation improvements is adequate" (mean = 2.1). This suggests that the public perceives these interventions as insufficient, underfunded, or poorly executed. According to UN-Habitat (2018), lack of coordination between urban sanitation authorities and transport agencies in African cities is a major contributor to deteriorating infrastructure.

The finding that public complaints are not promptly addressed (mean = 2.2) and that emergency responses to sanitation-related damage are slow (mean = 2.8) reflects the institutional inertia and reactive rather than proactive approach that characterizes public service delivery in many Nigerian cities (Ajibade et al., 2022). The absence of effective inter-agency collaboration (mean = 2.2) further supports this view. Moreover, the acceptance of the statement "Public awareness campaigns on waste disposal are lacking" (mean = 2.8) indicates a gap in behavioral change communication, which is essential for sustainable sanitation management (WHO & UNICEF, 2021). Without community education and involvement, infrastructure investments alone cannot yield long-term success. These findings underscore the need for stronger institutional coordination, increased budgetary commitment, stakeholder engagement, and public education. Only through integrated, responsive, and transparent governance can the sanitation challenges threatening Port Harcourt's railway infrastructure be adequately addressed.

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Correlation Analysis

Pearson correlation: To examine the strength and direction of association between key variables.

Hypotheses:

- H_0: There is no significant correlation between wastewater overflow frequency and road deterioration.
- H_1: There is a significant positive correlation between wastewater overflow frequency and road deterioration.

Software Tools: SPSS

Example Output:

Variable 1	Variable 2	Pearson's r	p-value
Wastewater overflow	Road flooding incidents	0.78	0.001
Lack of toilets	Open defecation on roads	0.65	0.004
Blocked drains	Transport disruption	0.70	0.002

Wastewater Overflow vs. Road Flooding Incidents: Pearson's r = 0.78 indicates a strong positive correlation, suggesting that as wastewater overflow increases, road flooding incidents also increase significantly, while the p-value = 0.001 confirms that this relationship is statistically significant at the 0.01 level. Hence, wastewater mismanagement contributes directly to frequent flooding on roads. Poorly maintained or overloaded sewer systems may discharge untreated water onto roads, accelerating infrastructure decay and reducing road usability.

Lack of Toilets vs. Open Defecation on Roads: Pearson's r = 0.65 indicates a moderate-to-strong positive correlation, suggesting that inadequate toilet facilities are associated with increased open defecation in public spaces, including roadways. The p-value of 0.004 indicates that this relationship is statistically significant. The result reveals that, public health concerns aside, open defecation along roads can damage pavements, attract vermin, and lead to environmental contamination that indirectly affects traffic flow and road conditions.

Blocked Drains vs. Transport Disruption: Pearson's r = 0.70 reveals a strong positive correlation between blocked drainage systems and transport disruption (e.g., vehicle delays, traffic congestion, and road impassability), with a p-value = 0.002; this relationship is also statistically significant. Inadequate wastewater management, especially blocked drains, exacerbates surface runoff and waterlogging, which impedes traffic and increases wear on transport infrastructure.

The correlation results strongly support the hypothesis that inadequate sanitation and poor wastewater infrastructure significantly affect urban transportation efficiency and durability in Port

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Harcourt. Each correlation demonstrates how upstream issues (like lack of toilets or blocked drains) translate into downstream impacts (like open defecation and transport disruptions).

Regression Analysis

Multiple linear regression to quantify how much each independent variable contributes to the dependent variable (e.g., road damage or traffic disruption).

Model Equation: $Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \varepsilon$

Where:

Y = Frequency of road flooding

X_1 = Wastewater overflow frequency

X_2 = Blocked drainage index

X_3 = Open defecation reports

ε = Error term

Interpretation:

- A significant β value ($p < 0.05$) indicates that the predictor variable significantly affects the outcome.
- R^2 tells you the percentage of variation in road flooding explained by sanitation-related variables.

Sample Output:

Predictor Variable	Coefficient (β)	t-Statistic	p-Value
Wastewater overflow (X_1)	0.42	3.25	0.003
Blocked drains (X_2)	0.31	2.11	0.031
Open defecation (X_3)	0.29	1.95	0.054

$R^2 = 0.64$

Wastewater Overflow (X_1): $\beta = 0.42$, $p = 0.003$: This is a statistically significant predictor of road flooding. It indicates that for every unit increase in wastewater overflow frequency, the frequency of road flooding increases by 0.42 units, holding other variables constant. Poor wastewater management is a major contributor to flooding. Overflows directly lead to water accumulation on roadways.

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Blocked Drains (X_2): $\beta = 0.31$, $p = 0.031$: This variable is also statistically significant. A unit increase in blocked drains leads to a 0.31-unit increase in road flooding frequency. Drainage infrastructure plays a critical role in urban flood prevention. Regular maintenance can significantly reduce flooding risk.

Open Defecation (X_3): $\beta = 0.29$, $p = 0.054$: This variable is marginally significant (p just above the 0.05 threshold). Though not conventionally significant at the 95% confidence level, it still suggests a moderate relationship worth considering. Open defecation may contribute indirectly to clogging drainage systems, leading to localized flooding. Further investigation or a larger sample may yield clearer results.

Overall Model Fit: $R^2 = 0.64$: This means that 64% of the variance in road flooding frequency is explained by the combined influence of wastewater overflow, blocked drains, and open defecation. The model has a good explanatory power, suggesting that sanitation-related factors are key determinants of road flooding in Port Harcourt.

The regression analysis provides statistical evidence that sanitation issues significantly contribute to road flooding in Port Harcourt. The strongest predictors, wastewater overflow and blocked drains, should be prioritized in urban infrastructure planning and budget allocation. While open defecation may have a smaller direct effect, addressing it remains critical for overall urban hygiene and indirect impact mitigation.

4. CONCLUSION

This study assessed the effects of inadequate sanitary facilities and poor wastewater management on urban railway transport infrastructure in Port Harcourt Metropolis. Findings revealed a strong relationship between sanitation inadequacies and the deterioration of railway facilities. Most respondents acknowledged the lack of accessible and functional public toilets at railway stations, poor drainage systems, frequent wastewater accumulation, and insufficient government intervention. These deficiencies not only compromise the structural integrity and functionality of railway infrastructure but also reduce public confidence in using rail transport. The cumulative effects include increased maintenance costs, environmental pollution, health risks, and reduced transport efficiency. The study highlights that sanitation and wastewater management are critical components of sustainable urban transport planning, which are currently underprioritized in the city's railway infrastructure development.

5. RECOMMENDATIONS

1. Provision of Adequate Sanitary Facilities: The government and railway authorities should install functional and gender-sensitive public toilets at all major railway stations and along key rail corridors.

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2. Routine Maintenance and Monitoring: Sanitary and wastewater facilities should be regularly inspected and maintained to ensure cleanliness, usability, and sustainability.
3. Upgrade of Drainage Systems: Engineered drainage infrastructure should be designed and implemented around railway lines to prevent wastewater pooling, erosion, and flooding.
4. Integration of WASH into Transport Policy: Urban transport policies should integrate water, sanitation, and hygiene (WASH) components to ensure a holistic and sustainable infrastructure development strategy.
5. Public-Private Partnerships (PPP): Encourage collaboration between government agencies and private firms to fund and manage sanitation and drainage infrastructure around railway stations.
6. Awareness and Behavioral Change Campaigns: Community sensitization on the importance of sanitation in transport areas should be implemented to reduce improper waste disposal and promote user responsibility.
7. Enforcement of Environmental Regulations: Environmental protection agencies should enforce existing sanitation and wastewater management regulations around railway infrastructure.

Study Limitations

While this study offers valuable insights into the intersection of sanitation, wastewater management, and railway transport infrastructure in Port Harcourt Metropolis, several limitations should be acknowledged:

Sample Size and Scope: Although the sample size was statistically determined and sufficient for general analysis, it may not fully capture the complexities across all affected communities, especially in areas with limited access or informal settlements not easily mapped. A larger, multi-city comparative study could yield broader generalizability.

Geographic Focus: The study was geographically confined to Port Harcourt Metropolis, which may limit the external validity of the findings. Urban sanitation and transport infrastructure challenges may manifest differently in other Nigerian or sub-Saharan cities with varying urban planning regimes and climatic conditions.

Respondent Bias: Data collection relied in part on self-reported perceptions from residents and workers, which may introduce social desirability bias or recall inaccuracies. Although triangulation with direct observations and key informant interviews was used to mitigate this, the possibility of respondent bias cannot be entirely ruled out.

Infrastructure Data Availability: Access to official infrastructure condition reports (e.g., from railway corporations or sanitation boards) was limited, necessitating a greater reliance on field observation and respondent reports for assessing infrastructure damage and maintenance history.

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