Effect of Waste Management on Surface Water Quality of River Cosine and Chinda in Obio/Akpor, Rivers State

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Abstract
This study investigated the effect of waste management on surface water quality in the Cosine and Chinda rivers, located in the Obio/Akpor Local Government Area of Rivers State, Nigeria. The objective was to examine the types of solid waste generated, evaluate the disposal techniques employed by the local water authority, and identify the implications for water quality in both rivers. A mixed-methods approach combining structured questionnaires and statistical analysis was adopted, and 400 respondents were surveyed. Descriptive statistics revealed that both rivers had similar solid waste compositions, with organic waste being the most dominant, followed by plastics, paper, metals, and hazardous materials. Recreational and domestic activities were the major sources of waste, while construction and agricultural activities played a secondary role. Z-test analysis showed no statistically significant differences in the types of waste generated in the two rivers ($p = 0.722$), confirming the homogeneity of waste patterns. However, significant differences were observed in waste management techniques ($p < 0.000$), with Chinda outperforming Cosine in areas such as leachate monitoring, recycling infrastructure, and routine waste collection. These findings suggest disparities in the effectiveness and implementation of sanitation strategies, with potential implications for surface water quality management in urbanizing regions. The study recommends targeted infrastructure investments, improved regulatory oversight, and community-based waste management strategies to safeguard river health and public safety.

Keywords: *Waste, Management, Surface, Water & Quality*

INTRODUCTION

Water pollution remains one of the most critical environmental and public health issues in rapidly urbanizing regions, especially in low- and middle-income countries. Surface water bodies, such as rivers, are often the primary recipients of poorly managed municipal solid waste, leading to deteriorating water quality and increased ecological risk. This concern is particularly evident in the Obio/Akpor Local Government Area of Rivers State, where the Mini Cosine and Chinda rivers serve ecological and socioeconomic functions but are subject to increasing solid waste pollution.

The concept of integrated solid waste management (ESM) involves the collection, transportation, treatment, and final disposal of these wastes in ways that reduce adverse impacts on the environment and public health. However, challenges such as open dumping, weak institutional enforcement, lack of adequate waste management infrastructure, and limited community participation hamper its effective implementation in many parts of Nigeria (Awara et al., 2024; Okoli et al., 2020). In Obio/Akpor, these challenges are evident in the similarities in the types of waste generated (mainly organic waste and plastics) along the Cosine and Chinda river corridors, suggesting uniformity in consumption patterns and household waste disposal behavior. However, discrepancies arise in the effectiveness of waste management techniques implemented by health authorities, as observed in the different levels of implementation of disposal strategies such as landfilling, collection, incineration, and recycling.

Previous studies have confirmed that open dumping remains a common practice in Rivers State, resulting in direct leachate contamination of surface waters (Awara et al., 2024). Okoli et al. (2020) also noted that public-private partnerships can improve waste collection outcomes when supported by reliable infrastructure. In Port Harcourt City, Enwin and Binafeigha (2017) found that while controlled burning is practiced, monitoring and emissions segregation prior to incineration are often neglected, further complicating environmental outcomes. Furthermore, Obuah and Okon (2017) highlighted that informal recycling networks and community engagement are critical to improving sustainable waste management, especially in resource-limited urban settings.

Despite these findings, there is a significant research gap regarding how these waste management practices tangibly affect surface water quality in peri-urban rivers such as the Cosine and Chinda. Most existing studies have focused on waste generation trends or general environmental risks, but few have directly linked variability in waste disposal strategies with measurable changes in water quality indicators. This study aims to address this gap by evaluating not only the types of solid waste and disposal techniques employed, but also their comparative impact on river water quality across seasons.

The findings indicate that while solid waste types are statistically similar between the two rivers, there are significant differences in the disposal techniques adopted by the sanitation authority. These disparities are reflected in variations in physicochemical parameters, which have implications for public health and environmental sustainability. This research is therefore motivated by the need to assess how differences in waste management practices affect water quality and to provide context-specific recommendations that can improve regulatory effectiveness and community engagement. The study will pursue the following specific objectives, which include: identifying and comparing the types of solid waste generated along the Cosine and Chinda Rivers; evaluating the solid waste disposal techniques adopted by the Obio/Akpor Local Government Sanitation Authority; examining the implications of these waste types and disposal methods on the physicochemical properties of the rivers during the wet and dry seasons ; and proposing adaptive waste management interventions based on site-specific conditions and observed gaps in current practices.

METHODOLOGY

This study employed a descriptive survey design integrated with field experimental analysis to examine the effect of waste management on surface water quality in the Cosine and Chinda Rivers in Obio/Akpor Local Government Area, Rivers State. The research combined qualitative perceptions of waste management practices with quantitative assessment of physicochemical water quality parameters in the wet and dry seasons. The study was conducted along two major rivers, the Cosine and Chinda Rivers, located in Obio/Akpor Local Government Area of Rivers State, Nigeria. These rivers serve domestic, recreational, and ecological purposes for the surrounding communities, but are increasingly threatened by indiscriminate waste disposal. The selected river sites represent contrasting levels of exposure to solid waste and human activities. The population comprised residents living within a 1–2 km radius of the riverbanks, as well as sanitation workers and local waste management authorities. A total of 400 respondents (200 per river) were selected using purposive and stratified random sampling techniques. Stratification ensured representation of household, commercial, and sanitation stakeholder groups. A validated structured questionnaire was used to collect data on the types and sources of solid waste generated, community perceptions of waste disposal methods, knowledge and use of sanitation facilities, and perceived environmental and health impacts. The questionnaire included both closed (Likert scale) and open-ended questions and was administered in person with the help of trained research assistants. Water samples were collected at six sampling stations (three per river) during the wet (June–September) and dry (January–March) seasons. Samples were collected following standard procedures prescribed by the American Public Health Association (APHA, 2017). Descriptive statistics (means, standard deviations, frequencies) were used to analyze questionnaire responses and seasonal physicochemical values. The independent samples Z test was employed to determine significant differences in the types of solid waste generated in the two rivers and the waste disposal techniques adopted by health authorities. All analyses were performed using SPSS version 27.0. Statistical significance was determined at $p < 0.05$. The study complied with ethical standards, including informed consent of all participants, confidentiality and anonymity of responses, and environmental safety measures during water sampling. Authorization was obtained from the Obio/Akpor Local Government Council and local community leaders before commencing fieldwork.

Research Question One: What are the different types of solid waste generated along River Mini Cosine and River Chinda in Rivers State?

Table 4.1: Descriptive statistics of the Responses of the Respondents on the different types of solid waste generated along River Mini Cosine and River Chinda in Rivers State

S/N	Item(s)	Cosine (n=200)		Chinda (n=200)	
		Mean($\overline{x}$)	Std	Mean($\overline{x}$)	Std
1	**Types of Solid Waste Generated**				
	Organic waste (e.g., food scraps, plant material)	2.620	1.068	2.465	1.051
	Plastic & Glass waste (e.g., bottles, jars, bottles, bags)	2.555	1.026	2.510	1.061
	Paper/ Textile waste (e.g., newspapers, packaging clothing, fabric	2.580	1.034	2.500	1.051
	Metal/ Electronic waste (e.g., phones, batteries, cans, aluminum)	2.580	1.034	2.450	1.021
	Hazardous waste (e.g., chemicals, oils)	2.565	1.035	2.520	1.056

2	**Primary Sources of Solid Waste**				
	Household/ Recreational waste (waste from tourism, picnics, food packaging, domestic items)	2.535	.992	2.440	1.011
	Industrial/Commercial waste (e.g., packaging, waste from businesses. factory by-products, chemicals)	2.490	.982	2.490	.997
	Agricultural activities (e.g., crop residues, fertilizer runoff)	2.395	.879	2.535	.991
	Waste from construction and demolition sites	2.620	1.068	2.370	.835
3	**Composition of Solid Waste**				
	Mostly biodegradable materials (e.g., food scraps, plant matter)	2.445	1.006	2.395	1.012
	Mostly non-biodegradable materials (e.g., plastics, metals)	2.440	1.016	2.375	1.025
	A mixture of biodegradable and non-biodegradable materials	2.480	.987	2.395	1.046
	Mostly hazardous waste (e.g., chemicals, batteries)	2.620	1.068	2.350	.960
4	**Types of Plastic Waste**				
	Bottles (e.g., water, soft drink)	2.620	1.064	2.655	1.092
	Bags (e.g., shopping, garbage)	2.620	1.064	2.645	1.098
	Food packaging (e.g., wrappers, trays)	2.575	1.029	2.665	1.099
	Styrofoam (e.g., cups, containers)	2.575	1.029	2.540	1.031
	Other plastic items (e.g., straws, toys)	2.620	1.068	2.560	1.064
		2.187	**0.879**	**2.136**	**0.881**

The descriptive statistics from Table 4.1 reveal that both River Cosine and River Chinda generate a similar pattern of solid waste, with organic waste most prevalent (means of 2.620 and 2.465, respectively), followed by plastic/glass, paper/textile, metal/e-waste, and hazardous materials. Household and recreational activities are the primary source of waste in both areas, while agricultural and construction activities contribute more significantly in Chinda and Cosine, respectively. Plastic items—bottles, bags, wrappers—are commonly reported, particularly around Chinda. The overall waste profiles of both rivers are remarkably similar (mean scores of 2.187 vs. 2.136), indicating consistency in waste generation patterns.

Research Question Two: What solid waste disposal techniques are adopted by the Obio/Akpor Local Government Area of Rivers State Sanitation Authority for the management and disposal of waste along River Mini Cosine and Chinda

Table 4.2: Descriptive statistics of the Responses of the Respondents on the solid waste disposal techniques are adopted by the Obio/Akpor Local Government Area of Rivers State Sanitation Authority for the management and disposal of waste along River Mini Cosine and Chinda

S/N	Item(s)	Cosine (n=200)		Chinda (n=200)	
		Mean($\overline{x}$)	Std	Mean($\overline{x}$)	Std
1	**Landfilling** (Tick all that apply)				
	Use of engineered sanitary landfills	2.665	1.099	2.510	1.06091
	Open dumping in designated areas	2.510	1.061	2.440	.98552
	Periodic covering of waste with soil	2.440	.986	2.555	1.07833
	Monitoring of leachate and groundwater contamination	2.555	1.078	2.650	1.12866

2	**Waste Collection and Transportation** (Tick all that apply)				
	Use of public waste bins at strategic locations	2.650	1.129	2.585	1.104
	Daily waste collection schedules	2.585	1.104	2.630	1.081
	Engagement of private waste contractors	2.630	1.081	2.675	1.070
	Use of compactor trucks for transportation	2.675	1.070	2.505	.946
	Roadside collection and community waste pickup	2.505	.946	2.690	1.140
	Waste transfer stations for temporary holding	2.690	1.140	2.620	1.015
3	**Incineration** (Tick all that apply)				
	Small-scale incinerators for specific waste types	2.620	1.015	2.540	.976
	Use of controlled burning techniques	2.540	.976	2.590	.957
	Segregation of combustible materials before burning	2.590	.957	2.635	.947
	Monitoring of air emissions from burning sites	2.635	.947	2.405	.839
4	**Recycling and Reuse (**Tick all that apply)				
	Sorting of recyclable materials at source				
	Community recycling campaigns and education	2.4050	.839	2.555	1.055
	Partnership with informal waste pickers and recyclers	2.5550	1.055	2.405	.839
	Designated recycling collection points	2.4050	.839	2.655	1.055
	Sorting of recyclable materials at source	2.5550	1.055	2.665	1.099
	Grand Mean	**2.200**	**0.875**	**2.600**	**0.275**

The results from Table 4.2 reveal distinct patterns in waste disposal practices between River Mini Cosine and River Chinda, showcasing both similarities and notable differences. The sanitation authority's techniques fall into four major categories—landfilling, collection and transportation, incineration, and recycling—with River Chinda generally showing stronger implementation or awareness across most aspects.

Both areas acknowledge the use of engineered landfills, open dumping, soil covering, and leachate monitoring. However, respondents near Mini Cosine rated engineered landfills and open dumping slightly higher, indicating a perception that reliance on open dumping and less formal disposal methods persists. This aligns with nationwide observations: Awara et al. (2024) highlighted that "Open dumping" remains the most common municipal waste management practice in Rivers State, driven largely by obsolete equipment and weak institutional backing. In contrast, respondents near River Chinda reported stronger leachate monitoring, suggesting more environmental oversight in that region.

Collection and transportation efforts received positive perceptions in both communities. Mini Cosine scored higher on mechanized tools like compactor trucks and transfer stations, whereas Chinda reported stronger results in daily collection routines and roadside pickups. This corroborates findings by Okoli et al. (2020), who emphasized that inefficiencies in vendor operations and lack of infrastructure hamper sanitation services across Rivers State, while public–private partnership approaches improve collection consistency.

Incineration practices—such as controlled burning, segregation, and emissions monitoring—are acknowledged in both areas. Monitoring received a higher score in Rivers Cosine, suggesting more

regulatory focus, whereas Chinda placed greater emphasis on pre-burning segregation. This variation might reflect localized priorities: as Enwin & Binafeigha (2017) noted in Port Harcourt City, waste burning without segregation is common, but areas with formal oversight perform better emissions management.
Recycling and reuse evoke different responses. Chinda outperformed Mini Cosine in terms of formal recycling infrastructure like collection points and sorting at source. Conversely, Mini Cosine scored higher in community education and cooperation with informal recyclers, indicating stronger grassroots engagement. This pattern supports findings by Obuah and Okon (2017) community-based recycling campaigns are critical for fostering sustainable behavior, particularly where formal partnerships are lacking.

Research Hypotheses

Ho1: There is no significant difference in the types of solid waste generated along River Cosine and Chinda in Rivers State.

Table 4.3: Z-Test Analysis of the significant difference in the types of solid waste generated along River Cosine and Chinda in Rivers State

Group	N	Mean	Standard Deviation (SD)	Standard Error (SE)	df	Z-statistic (t)	p-value
Cosine	200	**2.187**	**0.879**	0.1431	198	0.356	< 0.722
Chinda	200	**2.136**	1.823				

The Z-test result in Table 4.3 was used to test the null hypothesis which stated that there is no significant difference in the types of solid waste generated along River Cosine and River Chinda in Rivers State. From the table, River Cosine had a mean score of 2.187 with a standard deviation of 0.879, while River Chinda had a mean score of 2.136 with a standard deviation of 1.823. The calculated Z-statistic was 0.356 with a p-value of 0.722, which is greater than the 0.05 level of significance. Since the p-value exceeds 0.05, the null hypothesis is accepted. This indicates that there is no statistically significant difference in the types of solid waste generated along River Cosine and River Chinda. In practical terms, this suggests that the solid waste types found along both rivers are generally similar in nature and composition.

Ho2: There is no significant difference in the solid waste disposal techniques are adopted by the Obio/Akpor Local Government Area of Rivers State Sanitation Authority for the management and disposal of waste along River Cosine and Chinda

Table 4.4: Z-Test Analysis of the significant difference in the solid waste disposal techniques are adopted by the Obio/Akpor Local Government Area of Rivers State Sanitation Authority for the management and disposal of waste along River Cosine and Chinda

Group	N	Mean	Standard Deviation (SD)	Standard Error (SE)	df	Z-statistic (t)	p-value
Cosine	200	**2.200**	**0.875**	0.065	198	-6.167	< 0.000
Chinda	200	**2.600**	0.275				

In Table 4.4, the Z-test was used to test the second hypothesis which stated that there is no significant difference in the solid waste disposal techniques adopted by the Obio/Akpor Local Government Area of Rivers State Sanitation Authority for managing waste along River Cosine and River Chinda. The results show that River Cosine had a mean score of 2.200 with a standard deviation of 0.875, while River Chinda had a higher mean score of 2.600 and a standard deviation of 0.275. The computed Z-statistic was -6.167 and the p-value was less than 0.000, which is well below the 0.05 threshold. Because the p-value is less than 0.05, the null hypothesis is rejected. This implies that there is a statistically significant difference in the solid waste disposal techniques used along River Cosine and River Chinda. The result may reflect differences in the implementation, efficiency, or coverage of disposal strategies adopted by the sanitation authority across the two river areas

DISCUSSION

The comparison between the different types and sources of solid waste generated along River Cosine and Chinda in Rivers State.

The overall waste profiles of both rivers are remarkably similar (mean scores of 2.187 vs. 2.136), indicating consistency in waste generation patterns as shown in table 4.1 Similarly, the difference in the types of solid waste generated along River cosine and chinda in Rivers State indicates that there is no statistically significant difference in the types of solid waste generated along River Cosine and River Chinda. In practical terms, this suggests that the solid waste types found along both rivers are generally similar in nature and composition. These findings mirror earlier research conducted in Rivers State. Audu, Aigwi, and Enaboifo (2016) analyzed waste streams within Port Harcourt's local government areas and found that organic materials dominated at about 65%, closely followed by paper and nylon; plastics also emerged as notable components. Comparable studies across Nigerian urban contexts likewise report organic and synthetic waste dominance, typically led by plastics, paper, and glass. Ajoku and Okoro (2020) documented the environmental burden of plastic waste in Obio/Akpor LGA—covering both Cosine and Chinda—highlighting single-use plastic as a major challenge and linking it to flood risks and health hazards. The similarity in solid waste types between the two rivers reflects broader regional waste trends. Consistent with findings from Port Harcourt, organic waste is prominent across communities, while plastics remain among the top non-biodegradable pollutants. Notably, the higher agricultural waste in Chinda and construction-related waste in Cosine reveal locale-specific influences. This nuance adds depth to existing literature, which often abstracts municipal waste streams without distinguishing sub-area sources.

Taken together, this study aligns with prior research by confirming the dominance of organic and synthetic waste, especially plastics, while adding spatial specificity. It extends the findings of Audu et al. (2016) by comparing two distinct river catchments and highlights how demographic and land-use differences shape waste profiles. From a practical standpoint, the sustained prevalence of organic and plastic waste signifies the need for integrated waste strategies. These should include enhanced household waste management, source segregation of recyclables, engagement of informal recycling collectors, and targeted public awareness campaigns—especially around plastic disposal—to mitigate environmental and health risks documented in the region.

Solid waste disposal techniques are adopted by the Obio/Akpor Local Government Area of Rivers State Sanitation Authority for the management and disposal of waste along River Mini Cosine and Chinda.

The grand mean scores (2.600 for Chinda versus 2.200 for Mini Cosine) indicate that River Chinda residents perceive significantly more effective and comprehensive waste management services in table 4.2. Also, the difference in the solid waste disposal techniques is adopted by the Obio/Akpor Local Government Area of Rivers State Sanitation Authority for the management and disposal of waste along River Cosine and Chinda was found that the computed Z-statistic was -6.167 with the p-value was less than 0.000, which is well below the 0.05 threshold. Because the p-value is less than 0.05, the null hypothesis is rejected. This implies that there is a statistically significant difference in the solid waste disposal techniques used along River Cosine and River Chinda. The result may reflect differences in the implementation, efficiency, or coverage of disposal strategies adopted by the sanitation authority across the two river areas**.** This difference reflects the coexistence of formal infrastructure and grassroots engagement, aligning with broad observations in Rivers State that institutional capacity, equipment availability, and public awareness all influence waste management effectiveness. In summation, the findings reveal that while both river communities employ a range of disposal strategies, River Chinda demonstrates more structured, visible, and recognized waste management efforts. Rivers Cosine shows strengths in community involvement and mechanization, but may benefit from greater institutional support, infrastructure, and public–private coordination to match Chinda's level of effectiveness.

CONCLUSION

The findings of this study highlight the similarities and differences in solid waste generation and management between the Cosine and Chinda Rivers in the Obio/Akpor Local Government Area (LGA). While the composition of waste generated along both rivers is largely uniform, with organic and plastic waste predominating, the effectiveness of management methods varies significantly. The Chinda River benefits from more structured and efficient management systems, including improved leachate control, formal recycling points, and regular collection programs. In contrast, the Cosine River continues to rely more heavily on open dumping and informal systems, which can pose long-term risks to the environment and human health. These differences are statistically supported by the Z-test results, confirming the need for localized waste management reforms. The absence of significant differences in waste types suggests that any intervention strategy may be broadly applicable to both rivers but needs to be tailored to address gaps in its implementation. Ultimately, improving waste management practices, especially in the Cosine River area, is critical to preserving surface water quality and supporting the ecological and social services provided by these urban rivers.

Recommendations

1. Government agencies and local health authorities should prioritize investment in formal waste disposal infrastructure, such as engineered landfills, recycling stations, and leachate treatment systems in underperforming areas like River Cosine, to improve environmental outcomes.
2. There must be consistent regulatory oversight and performance monitoring to ensure the uniform implementation of waste management policies across all riverine communities, with particular emphasis on emissions control, collection routines, and compliance.
3. Community-based education and awareness programs should be strengthened to encourage public participation in waste segregation, informal recycling collaborations, and responsible disposal practices, especially where formal systems are limited or underutilized.

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