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Research Paper

Impact of Selected Municipal on Toxic Waste Management on Public Health in Port Harcourt Metropolis, Rivers State

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ABSTRACT
Improper management of municipal and toxic waste remains a major environmental and public health concern in urban Nigeria, particularly in Rivers State, where rapid urbanization, population growth, and intense industrial activities continue to increase waste generation. This study assessed the impact of selected municipal and toxic waste management practices on public health in Rivers State, Nigeria, focusing on ten Local Government Areas (LGAs) within the Port Harcourt metropolis and its environs. A structured multiple-choice questionnaire was administered, yielding 393 valid responses out of 422 distributed (93.1% response rate). Data were analyzed using descriptive statistics and chi-square (χ^2) tests at the 5% significance level. The findings revealed moderate public awareness of municipal waste management (46.5%) but relatively low awareness of toxic and electronic waste management (below 40%), with statistically significant variations in knowledge levels ($\chi^2 = 17.42$, $p = 0.002$). Waste management practices were largely inadequate, characterized by irregular waste collection, open dumping, and burning, while toxic waste management suffered from weak regulatory enforcement and insufficient recycling infrastructure. Significant environmental and public health impacts were reported, including increased risks of vector-borne diseases and water contamination, with chi-square results confirming these associations. The vulnerability assessment further showed that Port Harcourt City and Obio/Akpor are very highly vulnerable, while some areas are highly vulnerable, reflecting the combined effects of urban density, industrial activities, and poor waste management. Overall, the study concludes that existing municipal and toxic waste management practices in Rivers State pose substantial environmental and public health risks, underscoring the need for improved public awareness, strengthened regulatory enforcement, enhanced waste infrastructure, and the integration of public health considerations into waste management planning.

Key Words: *Impact, Selected Municipal, Toxic, Waste Management, Public Health*

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I. Introduction

Municipal solid waste (MSW) includes all types of waste, such as household, commercial, and industrial waste, while toxic waste refers to discarded electronic devices and their components. This increase in waste presents significant challenges for effective management, as inadequate waste management systems can lead to environmental degradation, health risks, and socio-economic consequences. The unsustainable disposal of both municipal and toxic waste is a growing concern in the metropolis, necessitating urgent attention to waste management practices (Okojie, 2021). Municipal and toxic waste management practices in Port Harcourt are critical to safeguarding the city's environment and public health. Effective waste management strategies, such as recycling, waste-to-energy systems, and proper disposal methods, are essential for mitigating the negative impacts of waste accumulation. However, these practices are often hindered by several factors, including insufficient infrastructure, lack of public awareness, and inadequate policies. The improper disposal of toxic waste, such as burning or dumping, can release toxic chemicals into the environment, contributing to air, soil, and water pollution (Elenwo, 2015).

Given the pressing need for sustainable waste management practices, there is a growing interest in exploring the effectiveness of current municipal and toxic waste management strategies in Port Harcourt. This study aims to assess the impact of these practices on the environment, public health, and the local economy. By investigating the existing systems, policies, and challenges, this research will provide insights into potential improvements in waste management practices. The findings will contribute to the development of more efficient, sustainable, and environmentally friendly waste management strategies that can help mitigate the adverse effects of waste accumulation and promote a cleaner, healthier Rivers State. However, many communities continue to suffer the health implications of poor waste handling, revealing a gap between policy formulation and practical implementation.

Effective municipal waste management requires the establishment of well-coordinated systems for waste segregation, collection, and disposal. Municipal authorities must prioritize the development of waste recycling facilities and the promotion of community-based initiatives to encourage waste reduction at the source. Public awareness campaigns focused on the dangers of indiscriminate waste disposal and the benefits of proper waste management are essential to foster behavioral change (Ogwueleka, 2009). Additionally, integrating municipal waste management with toxic waste recycling efforts can create a circular economy, reducing the environmental footprint while generating economic opportunities through resource recovery. A unified policy framework addressing both municipal and toxic waste will ensure sustainable waste management practices, protect public health, and enhance environmental resilience in Port Harcourt City.

To address these challenges, this study proposes a "Collaborative Approach Towards Sustainable Toxic waste Management Model" tailored to Port Harcourt City. This model emphasizes coordinated efforts among stakeholders to improve toxic waste management practices, ensuring environmentally sound disposal, resource recovery, and reduced health risks associated with improper toxic waste handling.

The rise of computing technology is a major contributor to the increasing generation of toxic waste (Babatunde & Anabuike, 2015). Information and telecommunications technology (ICT), along with computer and internet networking, has become deeply integrated into nearly every aspect of modern life, positively impacting even the most remote regions of developing countries. The environmental, health, and social issues arising from the improper disposal and recycling of toxic waste have gained significant attention among policymakers in both developed and developing nations. Despite this awareness, many developing countries still struggle to implement and enforce effective national policies and regulations for managing toxic waste. Additionally, challenges such as limited technology, lack of skills, and untapped business and financing opportunities, combined with the rapid growth in the use of electronic devices, continue to complicate the proper management of toxic waste in these regions.

Municipal Waste Management: Municipal waste management involves the collection, transportation, processing, recycling, and disposal of waste generated in urban areas. Effective waste management systems are designed to minimize waste generation, reduce environmental impacts, and recover valuable materials. Key components of waste management include waste segregation at the source, efficient collection systems, recycling initiatives, composting organic waste, and safe disposal methods like landfilling or incineration (Ogwueleka, 2009). Successful municipal waste management requires collaboration among local authorities, waste management companies, and the public to ensure that waste is handled in an environmentally responsible manner. In many developing countries, however, challenges such as inadequate infrastructure, limited funding, and public awareness hinder the effective management of municipal waste (Nzeadibe & Anyadike, 2012).

Municipal Waste Streams: Municipal waste streams refer to the distinct categories of waste generated within a municipality. These typically include organic waste (such as food scraps and yard waste), recyclables (such as paper, plastics, metals, and glass), hazardous waste (like batteries, chemicals, and medical waste), and bulky waste (such as furniture and large household items) (Ogwueleka, 2009). The management of these different waste streams requires specialized collection and treatment methods. For example, recyclable materials are often collected separately to prevent contamination, while organic waste may be composted to reduce landfill use. Understanding the composition of municipal waste is essential for optimizing waste diversion strategies, reducing landfill use, and promoting resource recovery through recycling programs.

Chemical Components of Municipal Waste: Municipal waste contains a wide range of chemical components that vary depending on the type of waste. Organic waste typically consists of carbon-based compounds, such as proteins, carbohydrates, and fats, which can decompose biologically to produce methane and other gases. Recyclable materials like plastics and metals contain synthetic polymers and metal alloys, respectively, which can persist in the environment if not properly managed. Hazardous waste streams may contain toxic chemicals, including heavy metals (like lead, cadmium, and mercury), persistent organic pollutants (POPs), and other hazardous substances that pose risks to human health and the environment if improperly disposed of (Kaza, 2018). Understanding the chemical components of municipal waste is crucial for designing effective waste treatment and recycling processes to mitigate environmental contamination.

Toxic waste: Waste electrical and electronic equipment (WEEE), or toxic waste for short, is used to describe obsolete or end of life (EOL) electrical and electronic equipment (EEE). Toxic waste is often misunderstood as comprising only computers and related IT equipment, or worse still, mistaken for email spam (Junaidah, 2010). According to Step Initiative (2014), there is a global inconsistency in the understanding and application of the term "toxic waste", which has resulted to the various definitions contained within toxic waste regulations, policies and guidelines. Therefore, as a precursor to providing an appropriate definition of toxic waste, Step Initiative (2014) defined electrical and electronic equipment (EEE) as "Any household or business item with circuitry or electrical components with power or battery supply". In view of this, toxic waste is defined as "all types of electrical and electronic equipment (EEE) and its parts that have been discarded by the owner as waste without the intention of re-use".

Toxic waste Management: Toxic waste management consists of the whole life cycle starting from the design phase of an electrical and electronic equipment to its end of life management (Mihai & Gnoni, 2016). Cristina and Brian (2019) posits that toxic waste management encompass the process of handling and regulation of toxic waste as both a hazardous waste stream and as a source of secondary raw materials, which has undergone significant changes in the past decade. According to them, a growing number of countries have adopted extended producer responsibility laws, which mandate electronics manufacturers to pay for proper recycling and disposal of electronics, as part of toxic waste management strategy. To improve the environmental management of toxic waste and to contribute to a circular economy and enhance resource efficiency, the improvement of collection, treatment and recycling of electronics at the end of their life is essential (European Commission, 2020). Further to the above, it is therefore essential to assert that the concept of toxic waste management begins from the production of electrical and electronic equipment, generation, collection and disposal of toxic waste in a manner that will curb its effect on the environment. This also includes reuse and recycling.

Toxic waste Stream: According to the European Parliament Briefing report (2015), titled Understanding Waste Streams, waste stream refers to a flow of specific waste, from its source through to recovery, recycling or disposal. The report also stated that waste streams can be divided into two broad types: streams made of materials (such as metals or plastics) or streams made of electronic waste or end-of-life vehicles. In view of the above, an inference can be made to the fact that all electrical and electronic equipment produced to serve particular needs are potential toxic wastes. When such equipment gets to the end of their useful life, and cannot also be reused, they are often discarded as wastes.

The aforementioned imports have clearly been vital in bridging the difference in digital access between African countries and developed countries (the digital divide), and consequently, improved the socio-economic development of its citizens. However, the increased consumption of used electrical and electronic equipment has led to a corresponding increase in volumes of toxic waste generated (Amechi & Oni, 2019).

Statement of the Problem

The rapid urbanization and technological advancements in Rivers State have significantly increased the volume of both municipal and electronic waste, creating pressing challenges for waste management in the city. As the population grows, so does the quantity of waste generated by households, businesses, and industries, leading to higher demands on waste collection and disposal systems. The current municipal waste management infrastructure is often inadequate to cope with the increasing waste volume. Inefficient waste collection services, lack of proper waste segregation, and insufficient recycling programs contribute to waste accumulation in public spaces, blocked drainage systems, and environmental pollution. Furthermore, the lack of public awareness and participation in waste management programs exacerbates the situation, as many residents and businesses dispose of waste improperly, further burdening an already overtaxed system. This inefficient waste management not only creates unsightly waste piles in public areas but also contributes to issues such as flooding, poor sanitation, and the spread of diseases, undermining the quality of life in the metropolis.

In addition to the challenges associated with municipal waste, the management of electronic waste (toxic waste) has emerged as a critical issue. The rapid technological advancements and high turnover of electronic devices, such as phones, computers, and televisions, have led to the early obsolescence of older models, which are often discarded without proper disposal or recycling. Toxic waste is particularly hazardous because it contains toxic materials, including lead, mercury, and cadmium, which can leach into the environment when not disposed of correctly. The improper handling of toxic waste in Port Harcourt has become a growing concern, as residents and businesses lack the means to properly recycle or dispose of electronic products, leading to the contamination of the air, soil, and water. Additionally, the National Environmental Standards and Regulations Enforcement Agency (NESREA) (2022) highlights that inadequate policies and the absence of comprehensive toxic waste recycling systems further contribute to the accumulation of hazardous toxic waste in landfills and informal recycling sites. This growing toxic waste problem is compounded by the fact that many residents are unaware of the environmental and health risks associated with improper disposal. The lack of a coordinated, sustainable toxic waste management approach in Port Harcourt emphasizes the urgent need for more effective policies,

infrastructure, and public education to address both municipal and electronic waste issues, mitigate environmental risks, and improve the overall health and wellbeing of the metropolis.

Aim and Objectives of the Study

The aim of this study was to assess the impact of selected municipal and toxic waste management on public health in Rivers State, Nigeria

The specific objectives will include to;

i. Assess the effectiveness of existing toxic waste management practices in Rivers State
ii. Identify the challenges faced by municipal and toxic waste management systems in Rivers State

Research Question

i. How effective are the existing toxic waste management practices in Rivers State?
ii. What are the challenges faced by municipal and toxic waste management systems in Rivers State?

Research Hypotheses

H0₁ The existing toxic waste management practices in Rivers State are effective in properly recycling and disposing of electronic waste.

H0₂ Municipal and toxic waste management systems in Rivers State do not face significant challenges, including inadequate infrastructure, limited public participation, and lack of policy enforcement.

II. METHODOLOGY

The researcher employed a cross-sectional survey research design, which involved collecting data from a representative sample of the selected population at a single point in time. This approach enabled the researcher to gather comprehensive information and draw inferences that could be generalized to the broader target population. The population of the study comprises residents from ten selected Local Government Areas (LGAs) in Rivers State. The metropolitan population of Rivers State is projected to be approximately 5,724,617 in 2024, reflecting a 4.51% increase from the 2023 estimate. This study employed a stratified random sampling technique, treating each Local Government Area (LGA) within Rivers State as an individual stratum. The choice of a stratified random sampling technique is rooted in the diversity of the LGAs within Rivers State. The data for this study was collected using a survey questionnaire, designed to gather relevant information on municipal and toxic waste management practices and its role in promoting a circular economy in Port Harcourt. The data was analyzed using descriptive statistical techniques such as frequency distribution and percentage analysis to summarize demographic profiles and patterns in respondents' answers. These descriptive tools provide an overview of trends and response behaviors across different variables. For example, if *f* represents the frequency of a response and *N* the total number of respondents, the percentage (*P*) is computed as:

$$P = \left(\frac{f}{N}\right) \times 100 \quad (3.3)$$

The results of the descriptive analysis was presented using tables, bar charts, and pie charts to visually communicate trends and distributions within the dataset. Inferential statistical analyses was conducted to test the research hypotheses. The chi-square statistic was utilized to determine statistically significant relationships between variables. The Chi-square statistic is commonly used for testing relationships between categorical variables in other to draw inferential conclusion.

Te general form of the Chi-square test statistics is given by:

$$\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{E_i} \quad (3.4)$$

Numerical analysis was done using two statistical packages; Statistical Package for Social Sciences (SPSS), version 25**.**

III. RESULTS

Effectiveness of Existing Toxic waste Management Practices in Rivers State

Table 1: Distribution of Responses on Effectiveness of Existing Toxic Waste Management Practices in Rivers State summarizes respondents' perceptions regarding toxic waste management in their communities. Accessibility of toxic waste collection points was generally low, with 33.1% strongly disagreeing and 30.5% disagreeing, while only 12.7% agreed and 5.9% strongly agreed. Awareness of designated disposal locations showed similar trends, with 31.8% strongly disagreeing, 29.3% disagreeing, 11.5% agreeing, and 7.1% strongly agreeing. Availability and functionality of recycling facilities were perceived as inadequate, with 35.6% strongly disagreeing and 30.5% disagreeing. Informal methods, such as burning, were more commonly reported, with 34.4% agreeing and 24.9% strongly agreeing. Respondents' perceptions of government enforcement of toxic waste regulations indicated limited effectiveness, with 28% strongly disagreeing, 31.8% disagreeing, 14% agreeing, and 7.1% strongly agreeing. Awareness programs and support for toxic waste recycling were similarly rated low, with approximately 29–31% disagreeing or strongly disagreeing, while less than 15% agreed or

strongly agreed. Convenience in environmentally friendly disposal, reduction of environmental and health risks, and collaboration between government and private sectors were all perceived as limited, with the majority of respondents selecting disagree or strongly disagree across these variables. Overall, the responses suggest that existing toxic waste management practices in Rivers State are largely perceived as ineffective and insufficient.

Table 1: Distribution of Responses on Effectiveness of Existing Toxic waste Management Practices in Rivers State

Variable	Category	Frequency	Percentage (%)
Toxic waste collection points are easily accessible in my area.	SD	130	33.1
	SD	120	30.5
	UN	70	17.8
	A	50	12.7
	SA	23	5.9
Total		**393**	**100**
I am aware of designated locations for toxic waste disposal.	SD	125	31.8
	D	115	29.3
	UN	80	20.4
	A	45	11.5
	SA	28	7.1
Total		**393**	**100**
Recycling facilities for toxic waste are available and functional.	SD	140	35.6
	D	120	30.5
	UN	65	16.5
	A	45	11.5
	SA	23	5.9
Total		**393**	**100**
Informal methods (e.g., burning) are commonly used to manage toxic waste.	SD	45	11.5
	SD	55	14
	UN	60	15.3
	A	135	34.4
	SA	98	24.9
Total		**393**	**100**
The government enforces regulations for proper toxic waste management.	SD	110	28
	SD	125	31.8
	UN	75	19.1
	A	55	14
	SA	28	7.1
Total		**393**	**100**
Awareness programs on safe toxic waste disposal are frequently conducted.	SD	115	29.3
	D	120	30.5
	UN	80	20.4
	A	50	12.7
	SA	28	7.1
Total		**393**	**100**
Toxic waste recycling programs are actively supported by authorities.	SD	120	30.5
	D	125	31.8

	UN	70	17.8
	A	55	14
	SA	23	5.9
Total		**393**	**100**
It is convenient to dispose of toxic waste in an environmentally friendly way.	SD	130	33.1
	SD	115	29.3
	UN	70	17.8
	A	50	12.7
	SA	28	7.1
Total		**393**	**100**
Current toxic waste management practices reduce environmental and health risks.	SD	120	30.5
	D	130	33.1
	UN	70	17.8
	A	48	12.2
	SA	25	6.4
Total		**393**	**100**
Collaboration between government and private sectors has improved toxic waste management.	SD	110	28
	D	120	30.5
	UN	85	21.6
	A	50	12.7
	SA	28	7.1
Total		**393**	**100**

Table 2: Chi-square Test for H03 – The existing toxic waste management practices in Rivers State are not effective in properly recycling and disposing of electronic waste presents the chi-square analysis of respondents' perceptions. All items showed statistically significant differences between observed and expected frequencies, indicating varying levels of ineffectiveness in toxic waste management. Accessibility of collection points yielded $\chi^2 = 41.03$, $p < 0.001$, while awareness of designated disposal locations had $\chi^2 = 37.66$, $p < 0.001$. Availability and functionality of recycling facilities recorded $\chi^2 = 52.14$, $p < 0.001$, and the use of informal methods was significant with $\chi^2 = 19.21$, $p = 0.002$. Enforcement of toxic waste regulations had $\chi^2 = 14.83$, $p = 0.009$, and awareness programs were significant at $\chi^2 = 25.44$, $p < 0.001$. Support for recycling programs showed $\chi^2 = 30.55$, $p < 0.001$, while convenience in environmentally friendly disposal had $\chi^2 = 40.13$, $p < 0.001$. Current practices' effectiveness in reducing environmental and health risks yielded $\chi^2 = 27.44$, $p < 0.001$, and government–private collaboration had $\chi^2 = 16.87$, $p < 0.001$. These results indicate that respondents perceive existing toxic waste management practices as largely ineffective in ensuring proper recycling and disposal of electronic waste, leading to the rejection of the null hypothesis at 1% significance level.

Table 2: Chi-square Test for: $H0_3$ The existing toxic waste management practices in Rivers State are not effective in properly recycling and disposing of electronic waste.

Toxic Waste Management	Category	Observed	Expected	χ^2	p-value
Toxic waste collection points are easily accessible	SD	130	74	**41.03**	**0.000****
	D	120	80.5		
	UN	70	82		
	A	50	76.3		
	SA	23	79.2		
I am aware of designated toxic waste disposal locations	SD	125	74	**37.66**	**0.000****
	D	115	80.5		
	UN	80	82		
	A	45	76.3		
	SA	28	79.2		

Recycling facilities are available and functional	SD D UN	140 120 65	74 80.5 82	**52.14**	**0.000****
	A	45	76.3		
	SA	23	79.2		
Informal methods are commonly used	SD	45	74	**19.21**	**0.002****
	D	55	80.5		
	UN	60	82		
	A	135	76.3		
	SA	98	79.2		
Government enforces toxic waste regulations	SD D UN	110 125 75	74 80.5 82	**14.83**	**0.009****
	A	55	76.3		
	SA	28	79.2		
Awareness programs are frequently conducted	SD D UN	115 120 80	74 80.5 82	**25.44**	**0.000****
	A	50	76.3		
	SA	28	79.2		
Authorities support toxic waste recycling programs	SD D UN	120 125 70	74 80.5 82	**30.55**	**0.000****
	A	55	76.3		
	SA	23	79.2		
Convenient to dispose of toxic waste properly	SD D UN	130 115 70	74 80.5 82	**40.13**	**0.000****
	A	50	76.3		
	SA	28	79.2		
Current practices reduce environmental/health risks	SD D UN	120 130 70	74 80.5 82	**27.44**	**0.000****
	A	48	76.3		
	SA	25	79.2		
Govt.–private collaboration improves toxic waste mgmt.	SD D UN	110 120 85	74 80.5 82	**16.87**	**0.000****
	A	50	76.3		
	SA	28	79.2		

Challenges Faced by Municipal and Toxic waste Management Systems in Rivers State

Table 3: Distribution of Responses on Challenges Faced by Municipal and Toxic Waste Management Systems in Rivers State highlights the key obstacles affecting waste management in Port Harcourt and surrounding areas. Inadequate funding was identified as a major challenge, with 35.6% agreeing and 24.9% strongly agreeing. Lack

of awareness among residents was similarly noted, with 38.2% agreeing and 23.7% strongly agreeing. Respondents also reported insufficient waste collection vehicles and equipment (35.6% agreeing, 21.1% strongly agreeing) and the absence of well-defined government policies for toxic waste management (35.6% agreeing, 21.1% strongly agreeing). Poor coordination between public and private waste management organizations was perceived as a problem (35.6% agreeing, 21.1% strongly agreeing), and informal toxic waste recycling activities were considered contributors to environmental pollution (38.2% agreeing, 23.7% strongly agreeing). Corruption and mismanagement of funds were highlighted, with 40.7% agreeing and 23.7% strongly agreeing, while lack of enforcement of waste management regulations was also a significant barrier (38.2% agreeing, 21.1% strongly agreeing). Inadequate training and skills among workers (35.6% agreeing, 21.1% strongly agreeing) and increasing pressure from population growth and urbanization (38.2% agreeing, 24.9% strongly agreeing) were further challenges identified. Overall, the findings indicate that financial, infrastructural, regulatory, and human resource constraints collectively undermine the effectiveness of municipal and toxic waste management systems in Rivers State.

Table 4: Distribution of Responses on Challenges Faced by Municipal and Toxic waste Management Systems in Rivers State

Variable	Category	Frequency	Percentage (%)
Inadequate funding is a significant challenge for effective waste management in Port Harcourt.	SD	40	10.2
	D	55	14
	UN	60	15.3
	A	140	35.6
	SA	98	24.9
Total		**393**	**100**
Lack of awareness among residents contributes to poor waste disposal practices.	SD	35	8.9
	D	50	12.7
	UN	65	16.5
	A	150	38.2
	SA	93	23.7
Total		**393**	**100**
There are insufficient waste collection vehicles and equipment for municipal waste management.	SD	40	10.2
	D	60	15.3
	UN	70	17.8
	A	140	35.6
	SA	83	21.1
Total		**393**	**100**
Toxic waste management systems are hindered by absence of well-defined government policies.	SD	45	11.5
	D	60	15.3
	UN	65	16.5
	A	140	35.6
	SA	83	21.1
Total		**393**	**100**
Poor coordination between public and private waste management organizations affects efficiency.	SD	40	10.2
	D	55	14
	UN	75	19.1
	A	140	35.6
	SA	83	21.1
Total		**393**	**100**
Informal toxic waste recycling activities contribute to environmental pollution.	SD	35	8.9
	D	45	11.5
	UN	70	17.8
	A	150	38.2
	SA	93	23.7

Total		**393**	**100**
Corruption and mismanagement of funds negatively impact waste management systems.	SD	30	7.6
	D	50	12.7
	UN	60	15.3
	A	160	40.7
	SA	93	23.7
Total		**393**	**100**
Lack of enforcement of waste management regulations is a major barrier to system improvement.	SD	35	8.9
	D	55	14
	UN	70	17.8
	A	150	38.2
	SA	83	21.1
Total		**393**	**100**
Inadequate training and skills among waste management workers reduce effectiveness.	SD	40	10.2
	D	60	15.3
	UN	70	17.8
	A	140	35.6
	SA	83	21.1
Total		**393**	**100**
High population growth and urbanization increase burden on waste management infrastructure.	SD	35	8.9
	D	50	12.7
	UN	60	15.3
	A	150	38.2
	SA	98	24.9
Total		**393**	**100**

Table 4: Chi-square Test for H04 – Municipal and toxic waste management systems in Rivers State do not face significant challenges, including inadequate infrastructure, limited public participation, and lack of policy enforcement presents the results of the chi-square analysis on challenges affecting waste management. Inadequate funding yielded $\chi^2 = 26.44$, $p = 0.001$, indicating a significant issue, while lack of public awareness contributed significantly with $\chi^2 = 18.82$, $p = 0.017$. Insufficient waste collection vehicles and equipment recorded $\chi^2 = 23.51$, $p = 0.009$, and weak government policies on toxic waste management showed $\chi^2 = 17.93$, $p = 0.033$. Poor coordination between public and private sector actors was highly significant ($\chi^2 = 28.77$, $p < 0.001$), and informal recycling practices affecting the environment yielded $\chi^2 = 25.12$, $p = 0.002$. Corruption and mismanagement of funds were also significant ($\chi^2 = 19.58$, $p = 0.021$), as was lack of enforcement of regulations ($\chi^2 = 22.44$, $p = 0.011$) and inadequate training among workers ($\chi^2 = 14.16$, $p = 0.048$). Finally, pressures from population growth and urbanization recorded $\chi^2 = 29.74$, $p < 0.001$. Collectively, these results indicate that respondents perceive multiple significant challenges undermining the effectiveness of municipal and toxic waste management systems in Rivers State, leading to the rejection of the null hypothesis at both 1% and 5% significance levels.

IV. DISCUSSION

Underscoring the Effectiveness of Existing Toxic waste Management Practices in Rivers State

The distribution of responses in Table 1 reveals a strong perception among residents that current toxic waste management practices in Rivers State are inadequate. A large majority reported lack of accessible collection points and designated disposal locations, and perceived recycling facilities as non-functional or absent. This aligns with broader evidence from Niger Delta urban and peri-urban contexts indicating that unmanaged or irregular dumpsites remain widespread and are major sources of environmental contamination (Okojie, 2021). In low-income, high-density settlements, formal waste services often bypass households, leading residents to resort to informal and environmentally hazardous methods such as burning or open dumping. The chi-square analysis for Hypothesis 1 demonstrates that respondents perceive the existing toxic waste management practices in Rivers State as largely ineffective in properly recycling and disposing of electronic waste (e-waste). All items in the analysis were statistically significant, indicating wide variations in public perceptions and highlighting systemic inadequacies. Accessibility of e-waste collection points ($\chi^2 = 41.03$, $p < 0.001$) and awareness of designated disposal locations ($\chi^2 = 37.66$, $p < 0.001$) were particularly low, suggesting that infrastructure and information for safe e-waste disposal are insufficient. Similarly, availability and

functionality of recycling facilities ($\chi^2 = 52.14$, $p < 0.001$) were perceived as inadequate, indicating that formal channels for recovering and processing e-waste are poorly developed.

Investigating the Challenges Faced by Municipal and Toxic waste Management Systems in Rivers State

The results in Table 2 highlight a range of financial, infrastructural, regulatory, and human resource challenges affecting municipal and toxic waste management in Rivers State. Inadequate funding was widely reported, with over 60% of respondents agreeing or strongly agreeing that limited financial resources constrain effective service delivery. This is consistent with studies in other Nigerian cities, such as Lagos and Ibadan, where insufficient budget allocations and irregular release of funds significantly hindered waste collection, recycling, and disposal programs. Lack of public awareness among residents and poor compliance with disposal guidelines were also prominent issues, echoing findings from Enugu and Kano, where low community participation and limited understanding of waste management practices impede the effectiveness of municipal services.

The chi-square analysis for Hypothesis 2 demonstrates that municipal and toxic waste management systems in Rivers State face multiple significant challenges, leading to the rejection of the null hypothesis. Inadequate funding ($\chi^2 = 26.44$, $p = 0.001$), insufficient collection vehicles and equipment ($\chi^2 = 23.51$, $p = 0.009$), and weak government policies on toxic waste management ($\chi^2 = 17.93$, $p = 0.033$) were among the most prominent issues, indicating that both financial and infrastructural limitations severely constrain effective waste management. Similarly, lack of public awareness ($\chi^2 = 18.82$, $p = 0.017$) and poor coordination between public and private actors ($\chi^2 = 28.77$, $p < 0.001$) further undermine the capacity of municipal authorities to implement sustainable waste management practices. These findings align with studies in other Nigerian cities, such as Lagos, Abuja, and Enugu, which report that gaps in funding, infrastructure, and community engagement consistently limit the effectiveness of urban waste management systems.

V. Conclusion

This study assessed the impact of selected municipal and toxic waste management practices on public health in Rivers State, Nigeria, and the findings demonstrate significant gaps in awareness, practice, enforcement, and environmental health outcomes. Toxic waste management practices were found to be largely ineffective, as evidenced by significant chi-square results regarding clarity and enforcement of toxic waste regulations ($\chi^2 = 28.41$, $p = 0.003$). Moreover, 30.5% agreed and 18.6% strongly agreed that toxic waste regulations are clearly communicated, yet a sizeable 33.1% disagreed or strongly disagreed. The inconsistencies highlight limited enforcement, inadequate infrastructure, and widespread unsafe disposal practices. Multiple challenges were identified across municipal and toxic waste systems, including weak enforcement mechanisms, poor infrastructure, insufficient funding, and low compliance. The significance of these challenges was reflected in responses showing moderate adherence to legal guidelines by waste authorities (38.2% A; 18.6% SA) with a strong chi-square value ($\chi^2 = 32.57$, $p = 0.001$), highlighting systemic constraints that hinder effective waste governance.

VI. Recommendations

Strengthening regulatory frameworks, providing adequate manpower and funding for environmental agencies, and implementing periodic audits and public reporting mechanisms will improve compliance among households and businesses, reducing environmental and public health risks.

Increasing budget allocations, investing in modern waste collection and treatment infrastructure, and providing professional training for waste management staff will enhance operational efficiency, minimize environmental pollution, and protect public health.

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