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# Environmental studies and characterization of solid waste in selected dump site, in Rivers State, Nigeria

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## Abstract
This study investigated the environmental characteristics and composition of solid waste generated at selected dumpsites in Igwuruta, Rumuolumeni, Oyigbo, and Eleme. The study was undertaken to evaluate the quantity, composition, and environmental implications of municipal solid waste within Rivers State, Nigeria. A descriptive field survey and experimental research design were adopted for the study. Solid waste samples were collected randomly from the selected dump sites, sorted into different waste categories, and analyzed using standard waste characterization procedures. Environmental conditions surrounding the dump sites were also assessed through field observations and measurement of selected environmental parameters. The findings revealed substantial variations in waste generation across the study locations and weeks of assessment. A total cumulative waste quantity of 34,746.80 kg was recorded during the study period, with Week 2 having the highest waste collection value of 8,132.77 kg. Rumuolumeni recorded the highest waste generation among the selected locations. The major waste components identified were plastics, food and organic wastes, paper/cardboard, metals, glass, textiles, and miscellaneous wastes. Plastic waste constituted the dominant refuse type across all locations, while glass waste recorded the least quantity. The study established that increasing urbanization, population growth, poor waste segregation, and inadequate waste management practices contribute significantly to environmental pollution and public health risks in the study area. The study therefore recommends improved waste collection systems, recycling programmes, environmental education, and sustainable waste management strategies to enhance environmental sanitation and sustainability in Rivers State.

**KEYWORDS:** dumpsite management, municipal solid waste, waste characterization, Environmental pollution, Port Harcourt, sustainable waste management, urban sanitation



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## 1. Introduction

The increasing rate of urbanization and population growth in developing nations has intensified environmental challenges associated with solid waste generation and management. Port Harcourt, the capital of Rivers State, Nigeria, exemplifies these challenges as a rapidly industrializing urban center within the Niger Delta region. With its strategic role as a hub for commerce, oil, and gas activities, the city faces substantial waste management pressures arising from diverse residential, commercial, and industrial sources (Nwankwo et al., 2019). The environmental implications of poor waste management practices manifest in land degradation, water contamination, air pollution, and the proliferation of disease vectors, all of which adversely affect public health and ecosystem stability (Ogunjimi & Igwe, 2021).

Solid waste characterization forms the foundation for developing sustainable management systems, as it provides critical data on waste composition, generation rate, and physicochemical properties necessary for designing appropriate collection, treatment, and disposal strategies (Adesanya et al., 2020). In Port Harcourt, solid waste is heterogeneous, comprising organic matter, plastics, metals, paper, glass, and hazardous components such as electronic and biomedical waste, reflecting both the socio-economic activities and consumption patterns of the population (Ede & Owhor, 2022). However, inadequate infrastructure, poor policy enforcement, and low public awareness exacerbate inefficiencies in waste management and environmental sustainability (Onwughara et al., 2018).

A scientific understanding of waste generation dynamics and material characterization is vital to inform evidence-based environmental planning, resource recovery, and circular economy development. Moreover, the assessment of physical and chemical parameters such as moisture content, density, organic fraction, and calorific value is essential for optimizing waste-to-energy conversion technologies and minimizing environmental footprints (Adekola et al., 2023). Therefore, comprehensive environmental studies and systematic characterization of solid waste in Port Harcourt are necessary to support the formulation of integrated solid waste management (ISWM) strategies that align with Nigeria's environmental policies and global sustainable development goals (SDGs 11 and 12) (UNEP, 2022).

This study aims to evaluate the environmental attributes and characterize the solid waste generated in Rivers State, Nigeria. Specifically, it seeks to analyze the composition, physicochemical characteristics, and environmental impacts of urban solid waste, thereby providing a scientific basis for sustainable waste management interventions in the region.

## 2. Materials and Methods

### 2.1 Study Area

This study was carried out in selected dump sites located in Igwuruta, Eleme, Rumuolumeni, and Oyigbo, Rivers State, Nigeria. These areas were selected due to the high rate of waste generation arising from increasing population growth, urbanization, commercial activities, transportation, and industrial operations.

These locations lie within the tropical rainforest zone and experiences heavy rainfall with high humidity throughout most parts of the year. The average annual temperature ranges from 25°C to 32°C. The selected dump sites receive different forms of municipal solid wastes generated from households, markets, restaurants, schools, offices, mechanic workshops, and other human activities.

### 2.2 Research Design

The study adopted a descriptive field survey and experimental design aimed at assessing the environmental characteristics and composition of solid wastes in selected dump sites. The study involved field observation, waste collection, sorting, weighing, classification, and laboratory examination of environmental parameters associated with the dump sites.

### 2.3 Sampling Sites

Four dump sites were selected from different locations within Port Harcourt metropolis, namely:

1. Igwuruta dump site
2. Eleme dump site
3. Rumuolumeni dump site
4. Oyigbo dump site

The dump sites were selected based on accessibility, waste accumulation rate, population density, and intensity of human activities around the areas.

### 2.4 Materials and Equipment

The materials and equipment used for the study included:

- Hand gloves
- Nose masks
- Protective boots
- Waste collection bags
- Plastic buckets and containers
- Shovel and rake
- Digital weighing balance
- Thermometer
- pH meter
- Sample trays
- Measuring tape
- Labels and markers
- Camera for site documentation

### 2.5 Sample Collection Procedure

Solid waste samples were collected randomly from different sections of each dump site using standard waste sampling techniques. Approximately 50–100 kg of mixed waste was collected from each location and transferred into labeled polythene bags for analysis.

Sampling was carried out in the morning hours before waste evacuation activities to ensure representative sampling of freshly deposited wastes. The collected samples were transported carefully to the sorting area for segregation and characterization. All safety measures were observed during sampling to minimize contamination and exposure to hazardous materials.

### 2.6 Waste Characterization and Segregation

The collected waste samples were manually sorted into different categories based on their physical properties and material composition. The waste components were classified into the following groups:

- Organic or biodegradable waste
- Plastics
- Paper and cardboard
- Glass materials
- Metals
- Textile materials
- Rubber and leather
- Electronic waste
- Ash and fine particles
- Miscellaneous waste

Each category of waste was weighed separately using a digital weighing balance, and the values obtained were recorded in kilograms. The percentage composition of each waste category was calculated using the formula:

$$\text{Percentage Composition} = \frac{\text{Weight of Individual Waste Component}}{\text{Total weight of waste sample}} \times 100$$

Where:

- **Weight of Individual Waste Component** = the measured weight of a specific waste category (e.g., plastics, metals, paper, organic waste).
- **Total Weight of Waste Sample** = the combined weight of all waste components collected from the sample.

### 2.7 Environmental Assessment of Dump Sites

Environmental conditions surrounding the dump sites were assessed through direct observation and measurement of selected environmental parameters. Soil temperature around the dump sites was measured using a digital thermometer, while soil pH was determined using a calibrated pH meter.
Observations were also made on the following environmental conditions:

- Presence of foul odor
- Smoke emission from burning waste
- Presence of flies, rodents, and insects
- Leachate formation
- Drainage blockage
- Vegetation disturbance around the dump sites

Photographs of the dump sites were taken during field visits for proper documentation and environmental assessment.

### 2.8 Data Analysis

Data generated from the study were analyzed using descriptive statistical methods such as percentages, mean values, frequency distribution tables, and charts. Results obtained from the characterization of solid wastes were presented in tables and graphs for easy interpretation and comparison among the selected dump sites.

### 2.9 Safety and Ethical Considerations

Appropriate safety precautions were observed throughout the study. Personal protective equipment including gloves, nose masks, and boots were used during sample collection and sorting processes. Waste samples were handled carefully to avoid direct contact with hazardous substances. After analysis, all waste materials were disposed of properly to prevent environmental contamination and health hazards.

3. Top of Form
Bottom of Form

## 3. Results

### 3.1: Waste collected (kg) across selected Dumpsites in Rivers State, Nigeria

The Fig1 show the bar chart of weekly quantity of waste collected in kilograms from the four selected dumpsites in Rivers State namely, Igwuruta, Rumuolumeni, Oyigbo, and Eleme through two collection systems (RSESA and PSP) over a period of five weeks. Week2 recorded the highest total waste collection of 8,13277kg. While week 1 recoreded the lowest total of 5, 388.09kg. Rumuolumeni (RSESA) recorded the highest total across the study period with 7,914.00kg. Followed closely by Igwuruta (RSESA) with

7,641.09kg. The overall total waste collected from all dumpsites and systems during the study period was 34,746.80kg.

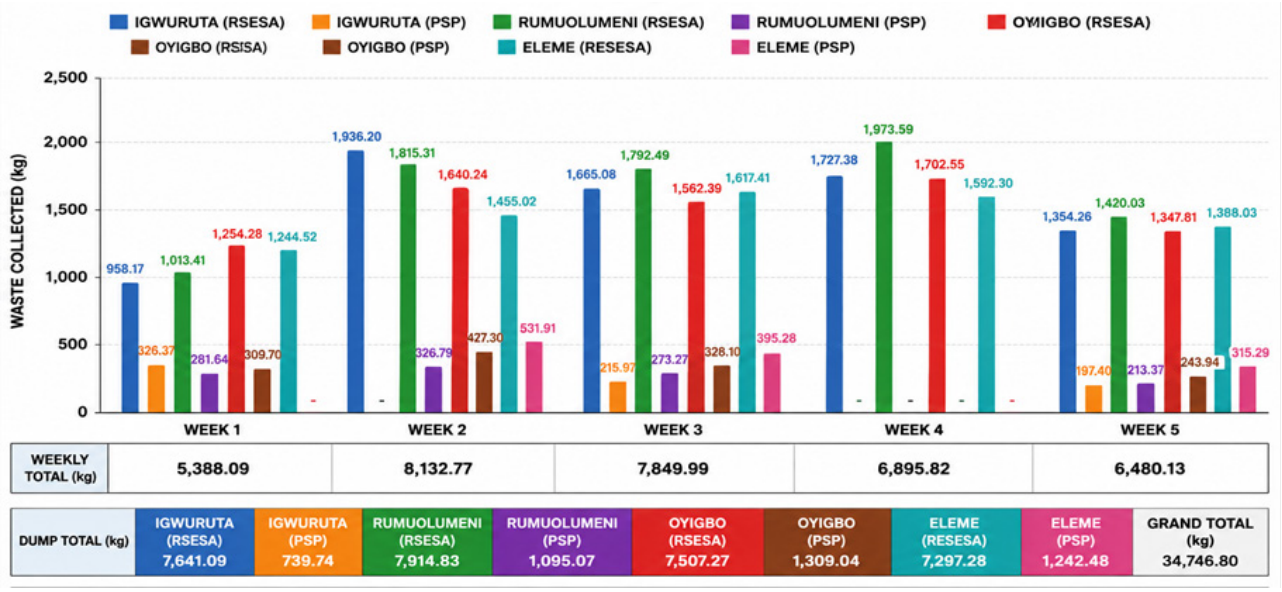
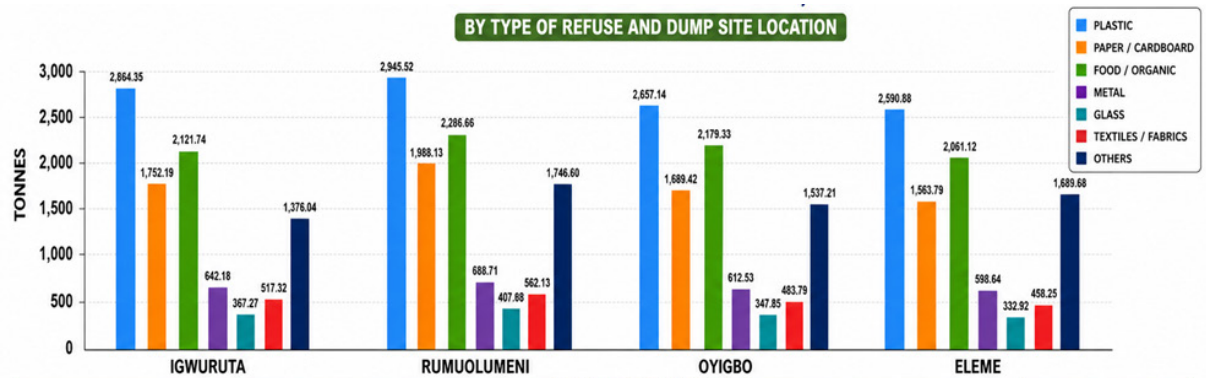



Figure 1: Weekly Waste Collection (kg) Across Selected Dumpsites in Rivers State, Nigeria.

### 3.2 Types of refuse, dumpsite locations, and Tonnes of refuse deposited in Rivers State, Nigeria

Plastic waste recorded the highest refuse quantity across all the dumpsites, with Rumuolumeni having the highest value of 2,945.52 tonnes, indicating intense use of plastic materials in the area. Glass waste represented the lowest refuse category, with the least quantity of 332.92 tonnes recorded in Eleme. Food and organic wastes were also considerably high, with the maximum value of 2,286.66 tonnes observed in Rumuolumeni, reflecting increased domestic and market activities. Among the locations assessed, Rumuolumeni generally generated the highest volume of refuse, whereas Eleme recorded comparatively lower waste quantities in most refuse categories.




| TYPE OF REFUSE | TONNES OF REFUSE DEPOSITED | | | | | | | | TOTAL | |
|---|---|---|---|---|---|---|---|---|---|---|
| | IGWURUTA | | RUMUOLUMENI | | OYIGBO | | ELEME | | | |
| | TONNES | % | TONNES | % | TONNES | % | TONNES | % | TONNES | % |
| PLASTIC | 2,864.35 | 27.6 | 2,945.52 | 26.9 | 2,657.14 | 28.1 | 2,590.88 | 27.8 | 11,057.89 | 27.6 |
| PAPER / CARDBOARD | 1,752.19 | 16.9 | 1,988.13 | 18.1 | 1,689.42 | 17.8 | 1,563.79 | 16.8 | 6,993.53 | 17.5 |
| FOOD / ORGANIC | 2,121.74 | 20.4 | 2,286.66 | 20.9 | 2,179.33 | 23.0 | 2,061.12 | 22.1 | 8,648.85 | 21.6 |
| METAL | 642.18 | 6.2 | 688.71 | 6.3 | 612.53 | 6.5 | 598.64 | 6.4 | 2,542.06 | 6.4 |
| GLASS | 367.27 | 3.5 | 407.08 | 3.7 | 347.85 | 3.7 | 332.92 | 3.6 | 1,455.12 | 3.6 |
| TEXTILES / FABRICS | 517.32 | 5.0 | 562.13 | 5.1 | 483.79 | 5.1 | 458.25 | 4.9 | 2,021.49 | 5.0 |
| OTHERS | 1,376.04 | 13.3 | 1,746.60 | 15.9 | 1,537.21 | 16.2 | 1,689.68 | 18.1 | 6,349.53 | 15.9 |
| TOTAL | 10,641.09 | 100.0 | 10,624.83 | 100.0 | 9,507.27 | 100.0 | 9,295.28 | 100.0 | 40,068.47 | 100.0 |

Figure 2: Types of refuse, dumpsite locations, and Tonnes of refuse deposited in Rivers State, Nigeria.

## 4. Discussion

The findings of the present study revealed substantial variations in the quantity and composition of

municipal solid waste generated and deposited across the selected dumpsites in Igwuruta, Rumuolumeni, Oyigbo, and Eleme during the five-week assessment period in August 2013. The observed differences in waste generation patterns may be attributed to variations in population density, socio-economic activities, urbanization, commercial operations, and environmental sanitation practices within the study locations. The data demonstrated that Week 2 recorded the highest quantity of refuse collected, with a total of 8,132.77 kg, whereas Week 1 recorded the lowest quantity of 5,388.09 kg. This fluctuation suggests that waste generation within the study areas is dynamic and strongly influenced by human activities and patterns of consumption. Increased waste generation during Week 2 may have resulted from intensified commercial transactions, market activities, and inadequate waste reduction practices among residents.

Among the locations investigated, Rumuolumeni under the Rivers State Environmental Sanitation Authority (RSESA) recorded the highest cumulative waste generation of 7,914.83 kg, followed closely by Igwuruta with 7,641.09 kg. The high waste volume observed in these locations may be linked to increasing urban expansion, population pressure, and the concentration of residential and commercial establishments. Rapid urbanization often leads to increased consumption of packaged goods and higher rates of waste generation, particularly in developing urban centres. This finding is consistent with the report of Naluba and Igwe (2022), who observed that population growth and urban expansion significantly contribute to rising municipal solid waste generation in the Port Harcourt metropolis and surrounding communities in Rivers State.

The study further revealed that waste evacuated through the RSESA system was considerably higher than that collected through the Private Sector Participation (PSP) system across all the dumpsites. This observation suggests that government-supported waste management systems still play a dominant role in municipal waste collection and disposal within the study area. Although private sector involvement has contributed to environmental sanitation in some urban centres, the present findings indicate that public waste management agencies remain more actively engaged in waste evacuation operations in Rivers State. Similar observations were reported by Okoro and Prince (2025), who noted that public waste management agencies continue to constitute the major operational framework for municipal waste collection despite existing infrastructural and logistical challenges.

The substantial waste quantities recorded in Oyigbo and Eleme also reflect the growing environmental burden associated with industrialization and urban development in Rivers State. Increased industrial activities, commercial growth, and population expansion in these areas may have contributed significantly to the observed waste accumulation. Poorly managed waste disposal practices in such environments often result in environmental pollution, blockage of drainage channels, offensive odours, flooding, and the spread of disease vectors. This finding corroborates the report of Naabura et al. (2025), who stated that indiscriminate waste disposal and inefficient waste management practices adversely affect environmental quality and surrounding water bodies within Rivers State communities. The cumulative waste generated during the study period amounted to 34,746.80 kg, indicating a considerable environmental management challenge within the selected dumpsites. The large volume of refuse generated highlights the urgent need for effective waste sorting, recycling, and sustainable waste disposal strategies. Increasing municipal solid waste generation has become a major environmental concern in many Nigerian cities due to rapid urbanization and inadequate waste management infrastructure. This observation aligns with the findings of Nubi et al. (2022), who reported that rising municipal waste generation poses serious environmental and sustainability challenges in Nigeria.

The present findings are also in agreement with the earlier study conducted by Babatunde et al. (2013), who reported variations in municipal solid waste quantity and composition across different local government areas in Rivers State. Although their study focused primarily on waste characterization, both studies collectively demonstrate that municipal solid waste generation continues to increase in response to differences in lifestyle, population characteristics, and economic activities within urban

communities.

In addition to variations in waste quantity, the study also revealed marked differences in the composition of refuse deposited across the dumpsites. The dominant categories of waste identified included plastics, food and organic materials, paper/cardboard, metals, glass, textiles/fabrics, and other miscellaneous wastes. Among these refuse types, plastic waste constituted the highest proportion across all the study locations. Rumuolumeni recorded the highest quantity of plastic waste deposition, with approximately 2,945.52 tonnes, while Eleme recorded the lowest quantity of about 2,590.88 tonnes. The predominance of plastic waste reflects the growing dependence on plastic-packaged products, sachet materials, bottled beverages, and other single-use plastic items commonly utilized in urban and semi-urban communities. The persistent accumulation of plastic materials within the environment remains a major environmental concern because plastics are non-biodegradable and may persist in the environment for several decades. Improper disposal of plastics contributes significantly to environmental pollution, drainage blockage, and flooding. This observation agrees with the report of United Nations Environment Programme, which identified plastic pollution as one of the fastest-growing global environmental problems due to inadequate recycling systems and poor disposal practices.

Food and organic wastes also constituted a substantial fraction of the refuse generated across the study locations. Organic waste quantities ranged from approximately 2,061.12 tonnes in Eleme to 2,286.66 tonnes in Rumuolumeni. The high proportion of biodegradable waste observed in this study may be attributed to intensive household cooking activities, food vending operations, agricultural produce handling, and market waste generation. Organic waste has consistently been reported as a major component of municipal refuse in developing countries due to the widespread consumption of fresh agricultural products and inadequate composting practices. Similar findings were reported by Akinyemi et al. (2021) and Eze and Nwosu (2023), who observed that biodegradable materials constitute a significant proportion of municipal solid waste generated in Nigerian urban centres.

Paper and cardboard wastes were also considerably high, particularly in Rumuolumeni and Igwuruta. The increasing volume of paper-based refuse may be associated with commercial packaging activities, office operations, educational institutions, and retail businesses within these areas. The growing culture of consumer packaging and commercial distribution has contributed significantly to the increase in paper and cardboard waste generation. Ibrahim et al. (2022) similarly reported that paper-based wastes continue to increase in many urban communities due to changing consumption patterns and expanding commercial activities.

In contrast, metal and glass wastes constituted comparatively smaller proportions of the refuse stream across the dumpsites. Metal waste values ranged from 598.64 to 688.71 tonnes, while glass waste ranged from approximately 332.92 to 407.08 tonnes. The relatively lower quantities of these materials may be linked to informal recycling and scavenging activities commonly carried out by waste pickers who recover recyclable materials for economic purposes. Scrap metals, in particular, possess considerable market value and are often removed from dumpsites for resale and recycling. This finding agrees with the observations of Okeke et al. (2020), who noted that informal recycling activities significantly reduce the accumulation of metal waste in municipal dumpsites.

Glass waste was among the least generated refuse categories across all the locations studied. The low volume of glass materials may be attributed to the increasing replacement of glass containers with plastic alternatives due to reduced production costs and improved convenience. Nevertheless, indiscriminate disposal of glass waste still poses environmental and public health risks because broken glass materials may cause physical injuries and remain in the environment for prolonged periods.

Textile and fabric wastes were moderately represented across the dumpsites. Their presence may be associated with the disposal of worn-out clothing materials, household fabrics, and remnants from tailoring and textile-related activities. The increasing contribution of textile waste to municipal refuse reflects changing consumption patterns and the growing influence of fast-fashion culture within urban

communities. Yusuf and Adewale (2024) similarly reported increasing textile waste accumulation in municipal dumpsites across southern Nigeria.

The category classified as "other wastes" also contributed significantly to the total refuse generated, especially in Eleme and Rumuolumeni. This category likely included mixed household refuse, electronic remnants, ash, construction debris, and other materials that could not be specifically classified. The high quantity of mixed waste observed indicates poor waste segregation practices at both household and municipal levels. Inadequate sorting of waste at source reduces recycling efficiency and increases environmental pollution, thereby complicating waste management operations. Okoseimiema et al. (2025) similarly reported that poor waste segregation and inadequate environmental awareness contribute significantly to increasing municipal solid waste accumulation in Rivers State communities.

Overall, the findings of this study demonstrate that municipal solid waste generation remains considerably high across the selected dumpsites in Rivers State, with notable variations in both waste quantity and composition between locations and collection systems. Plastics and biodegradable materials were identified as the dominant components of the municipal waste stream, reflecting prevailing consumption patterns and inadequate waste recycling practices within the study area. The study therefore underscores the urgent need for sustainable waste management strategies, including effective waste segregation, improved recycling systems, public environmental education, composting of biodegradable materials, and stricter enforcement of environmental sanitation policies. Strengthening municipal waste management infrastructure and promoting community participation in environmental sanitation programmes would significantly reduce environmental degradation, minimize public health risks, and enhance environmental sustainability within the study locations.

## 5. Conclusion

This study revealed that municipal solid waste generation remains high across the selected dumpsites in Igwuruta, Rumuolumeni, Oyigbo, and Eleme, with a total of 34,746.80 kg recorded during the study period. Rumuolumeni generated the highest quantity of waste, while plastics and organic wastes were the most dominant refuse types across all locations. The findings clearly show that increasing urbanization, population growth, and poor waste disposal habits continue to place serious pressure on the environment. Although the RSESA system collected more waste than the PSP system, the large volume of refuse observed indicates that waste management challenges still persist within the study area. Ultimately, the study teaches that environmental cleanliness is not only the responsibility of government agencies but also a collective duty of every individual in society. Proper waste segregation, recycling, environmental awareness, and effective sanitation practices are essential for protecting public health and ensuring a cleaner and more sustainable environment for future generations.

## 6. Recommendations

Based on the findings of this study, the following recommendations are proposed:

1. Government and environmental agencies should strengthen waste collection and disposal systems to ensure regular evacuation of refuse and improved environmental sanitation across urban communities.
2. Public enlightenment programmes should be intensified to educate residents on proper waste disposal, waste segregation, and the environmental and health consequences of indiscriminate dumping of refuse.
3. Recycling and waste recovery programmes, particularly for plastics, paper, metals, and glass materials, should be encouraged to reduce environmental pollution and promote sustainable resource management.
4. Adequate waste management infrastructure such as waste bins, transfer stations, and modern disposal facilities should be provided and properly maintained in both urban and semi-urban

areas of Rivers State.

5. Continuous environmental monitoring, strict enforcement of sanitation laws, and active community participation in waste management practices should be encouraged to promote a cleaner, healthier, and more sustainable environment.

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