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Challenges of Waste Management in African Cities: Assessment of Port Harcourt Metropolis

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Abstract
Waste management remains a challenge in African cities due to health hazards, rapid urbanization, population growth, and economic development. The study focuses on evaluation of waste management systems in Port Harcourt, Rivers State, Nigeria. Using critical and evaluative review, the study revealedthat Port Harcourt has made strides through public-private partnerships in waste management but that the community engagement has continued to remain a challenge. It also uncovered the challenges such as inadequate infrastructure, insufficient funding, limited access to advanced waste treatment technologies, low public participation and awareness, and weak regulatory enforcement affecting waste management. Bssides, insufficient waste collection and disposal facilities contribute to illegal dumpsites and open burning are problems. Consequently, financial constraints and social issues, and technological issues hinder municipal authorities' ability to invest in necessary infrastructure and services. Additionally, weak regulatory frameworks and institutional deficiencies complicate waste management efforts is equally big challenges. The paper recommends that addressing the challenges require a comprehensive and integrated approach involving all stakeholders. By using sustainable waste management practices and leveraging innovative solutions, African cities like Port Harcourt can achieve a cleaner and healthier urban environment.

Keywords: WasteTreatment Technology, Waste Management, Environmental Pollution, Recycling Plant, Waste Hierarchy,Integrated Waste Management.

Introduction

Waste management is a critical issue in urban areas globally, with African cities facing unique challenges due to rapid urbanization, population growth, and inadequate infrastructure. Port Harcourt, a prominent metropolis in Nigeria, exemplifies these challenges. The city's expanding population and industrial activities have exacerbated waste management issues, leading to severe environmental and health hazards (Ogbonna et al., 2007). Waste management refers to the systematic administration of activities that provide for the collection, source separation, storage, transportation, transfer, processing, treatment, and disposal of waste (EPA, 2020). Effective waste management is essential for maintaining public health and environmental quality and fostering sustainable urban development (Wilson et al., 2015). Unlike major cities in advanced countries, which leverage modern technology to convert waste to wealth, African cities like Port Harcourt struggle with littered streets due to insufficient waste management system.

Urban waste management in African cities often suffers from insufficient funding, poor planning, and lack of technical expertise. Informal settlements and the informal waste sector, which plays a substantial role in waste collection and recycling, often operate outside regulatory frameworks (Mwesigye et al., 2009). Integrating informal waste collectors into formal systems remains a significant challenge. Port Harcourt's waste management infrastructure is often outdated and unable to cope with increasing waste generation. Landfills are unmanaged, posing serious environmental risks due to the lack of proper lining, leachate control, and gas collection systems (Ogwueleka, 2009). Moreover, public awareness and participation in waste management practices remain low, further hindering efforts to establish effective systems in African cities (Babayemi & Dauda, 2009). This study aims to assess the current state of waste management in Port Harcourt Metropolis, contributing to the broader discourse on urban waste management in African cities and providing insights for policy and practical interventions.

Waste Management

Waste management refers to the systematic administration of activities that provide for the collection, source separation, storage, transportation, transfer, processing, treatment, and disposal of waste (EPA, 2020). It encompasses processes aimed at minimizing the impact of waste on the environment and human health. The primary objective is to reduce the volume and hazardous nature of waste materials through practices such as recycling, composting, and incineration (Tchobanoglous & Kreith, 2002).The waste hierarchy prioritizes actions that prevent waste generation and promote reuse, recycling, and recovery, with disposal being the least preferred option. It aims to extract maximum practical benefits from products and generate the minimum amount of waste (Gharfalkar et al., 2015). The five stages are prevention, minimization, reuse, recycling, and disposal. This definition is in tandem with the United States Environmental Protection Agency (EPA).

Environmental Protection Agency, (2024) defines waste hierarchy as a framework that prioritizes waste management practices based on their environmental impact. It ranks strategies from most to least preferred: prevention, minimization, reuse, recycling, energy recovery, and disposal. This hierarchy encourages sustainable practices to reduce waste generation and its harmful effects.Nevrtheless, integrated waste management (IWM) is a comprehensive approach that combines various waste management practices to achieve environmental sustainability. IWM involves coordinated use of practices to handle all aspects of waste holistically, considering the entire lifecycle of products from production to disposal. Techniques include waste prevention, recycling, composting, and energy recovery (Tchobanoglous & Kreith, 2002).

Technological advancements have significantly enhanced waste management practices. Innovations such as anaerobic digestion, waste-to-energy technologies, and advanced recycling processes have improved efficiency and effectiveness. Anaerobic digestion converts organic waste into biogas and nutrient-rich digest- ate (Appels et al., 2008). Waste-to-energy technologies convert non-recyclable waste into usable heat, electricity, or fuel (Tsilemou&Panagiotakopoulos, 2006), reducing waste volume and providing alternative energy sources.However**,** despite advancements waste management faces several challenges. In many developing countries, inadequate infrastructures, lack of funding and insufficient public awareness hinder effective practices. The informal sector plays a significant role in waste collection and recycling but often operates without proper regulation and support (Wilson et al., 2009). Addressing these challenges require policy interventions, community engagement, and investment in infrastructure and technology.Effective waste management is crucial for protecting environment, public health, and achieving sustainable development. By adopting comprehensive strategies and leveraging technological innovations, societies can better manage their waste and reduce its adverse effects.The development of waste management systems has evolved significantly over time, reflecting changes in technology, policy, and societal attitudes toward waste. This evolution can be traced through several key phases, from rudimentary disposal methods to sophisticated integrated waste management systems.

Historical Context Waste Management

In early human civilization, waste was predominantly organic and biodegradable, managed by simple burial or burning (Williams, 2005). As populations grew, the volume and complexity of waste increased, necessitating more organized methods. Ancient civilizations, like Rome and Athens, implemented rudimentary waste collection services and public sanitation systems (Miller, 2006).The Industrial Revolution marked a significant turning point in waste management. Rapid industrialization and urbanization in the 19th century led to a dramatic increase in solid waste production, including non-biodegradable materials. Cities faced severe waste management

challenges, resulting in unsanitary conditions and public health crises (Melosi, 1981). Municipal waste collection systems and public health regulations were established to manage waste more effectively. For example, the Public Health Act of 1875 in the UK mandated sanitary authorities for waste removal and disposal (Hamer, 2003).The mid-20th century saw further advancements driven by growing environmental awareness and new technologies. Landfills provided a low-cost solution for managing large volumes of waste, but concerns about contamination and emissions led to sanitary landfills with protective liners and leachate systems (Krook et al., 2012). Recycling gained momentum in the 1970s due to the oil crisis and environmental impact recognition. Governments promoted recycling programs, and technological advancements improved material recovery processes (Ackerman, 1997).In recent decades, Integrated Waste Management (IWM) has gained prominence. IWM represents a holistic approach combining various strategies, including waste reduction, recycling, composting, and energy recovery, to minimize environmental impact (Tchobanoglous&Kreith, 2002). It emphasizes waste prevention and minimization, followed by reuse, recycling, and energy recovery, with disposal as the last resort (European Commission, 2008).

Technological Innovations and Sustainable Practices

Technological innovations have played a crucial role in developing modern waste management systems. Advanced recycling technologies, such as mechanical-biological treatment (MBT) and automated sorting systems, have increased recycling efficiency (Pires et al., 2011). Waste-to-energy (WtE) technologies, such as incineration with energy recovery and anaerobic digestion, convert waste into valuable energy sources, reducing landfill waste and contributing to renewable energy production (Astrup et al., 2015).

Sustainable waste management practices are driven by efforts to combat climate change and promote resource conservation. Circular economy principles, which aim to design out waste and keep materials in use as long as possible, are increasingly integrated into policies and practices (Kirchherr et al., 2017). These principles encourage product and process development that facilitates recycling, reuse, and remanufacturing, reducing waste generation and conserving resources.

Challenges of Waste Management

Effective waste management is crucial for environmental health and sustainability but faces numerous challenges, particularly in developing regions like Port Harcourt. These challenges include infrastructural, financial, technological, social, and regulatory issues.In many developing cities, waste collection and disposal infrastructure are outdated or insufficient for growing waste volumes (Hoornweg &Bhada-Tata, 2012). Port Harcourt infrastructures struggle with inefficiencies due to limited resources and poorly maintained equipment. Uncontrolled dumpsites
pose significant environmental and health risks due to improper lining and leachate management systems (Ogwueleka, 2009).Financial constraints severely limit municipalities' capacity to manage waste effectively. Funding is often insufficient to cover waste collection, transportation, treatment, and disposal costs (Kojima et al., 2020). This shortfall is exacerbated by high costs associated with modern technologies and the need for continual maintenance. In Port Harcourt, budgetary constraints hamper comprehensive waste management programs, leading to inconsistent services and inadequate facilities (Babayemi & Dauda, 2009).Technological advancements are crucial in modern waste management, yet many cities lack access to these technologies. Advanced waste treatment technologies like incineration with energy recovery, mechanical-biological treatment, and sophisticated recycling systems are expensive and require technical expertise that is often unavailable (Pires et al., 2011). Additionally, developing cities

struggle to integrate informal waste sectors into formal systems, limiting efficiency and effectiveness in recycling and recovery efforts (Wilson et al., 2009).

Public participation and awareness are essential for effective waste management. However, low levels of awareness and engagement can significantly hinder these efforts. In many cities, including Port Harcourt, residents often lack knowledge about proper waste disposal practices, recycling, and waste segregation (Henry et al., 2006). This leads to indiscriminate dumping and low participation in recycling programs. Socio-economic factors, such as poverty and lack of education, further exacerbate these issues, making it challenging to promote sustainable waste management practices.Effective waste management requires robust regulatory frameworks and institutional support. However, in many developing regions, regulations related to waste management are either insufficient or poorly enforced (Mwesigye, et al., 2009). The lack of clear policies can lead to inconsistent practices and difficulties in holding waste management entities accountable. Additionally, institutional weaknesses, such as lack of coordination among different government agencies and insufficient capacity for monitoring and enforcement, complicate waste management efforts (Kasozi & von Blottnitz, 2010).Improper waste management is a critical issue that can result in severe environmental and public health consequences. One of the most pressing concerns is the impact of open dumping and poorly managed landfills. These practices can lead to the contamination of soil and water resources, as hazardous chemicals and waste seep into the ground and nearby water bodies. This not only threatens ecosystems but also poses significant risks to human health. Contaminated water supplies, for instance, can lead to outbreaks of waterborne diseases and other serious health issues in affected communities (Ogwueleka, 2009).

In areas where waste collection services are inadequate or nonexistent, burning waste is a common method of disposal. However, this practice has detrimental effects on air quality. The combustion of waste materials releases a range of harmful pollutants, including particulate matter, dioxins, and heavy metals, into the atmosphere. These pollutants contribute to air pollution and have been linked to respiratory problems, cardiovascular diseases, and other health issues. Vulnerable populations, such as children and the elderly, are particularly at risk from the adverse health effects of poor air quality (Solomon, 2011).

Addressing these environmental and health impacts require comprehensive improvements in waste management practices and infrastructure. This includes the implementation of more effective waste collection systems, the development of sanitary landfills, and the promotion of recycling and composting initiatives. Moreover, public awareness campaigns and education programs are essential to encourage proper waste disposal and reduce the generation of waste at the source. By investing in sustainable waste management solutions, we can mitigate the negative impacts of improper waste disposal and protect both the environment and public health for future generations.

Theories of Waste Management

Waste management in Port Harcourt poses significant challenges, necessitating a strategic and well-structured approach. This study references two primary theories identified by Whiteman et al. (2021): Integrated Sustainable Waste Management (ISWM) and the Nine Development Bands (9DBs) framework. Developed by UNEP & ISWA (2015) and Rodic & Wilson (2017), these frameworks provide valuable insights into managing waste in various contexts, especially in urban settings.ISWM emphasizes the importance of balancing technical components, such as infrastructure, with governance aspects like policies, regulations, and community engagement. This approach aims to create adaptable and effective waste management systems that align with global sustainability goals, particularly the Sustainable Development Goals (SDGs). While

ISWM is comprehensive, addressing both "hard" infrastructure and "soft" governance elements, its implementation can be resource-intensive and complex, particularly in regions where technical capacity and governance structures are underdeveloped. The need for substantial investments and stakeholder coordination often poses challenges in applying ISWM effectively in low- and middle-income regions.

The 9DBs framework complements ISWM by categorizing the stages of waste management development, from basic self-management of waste to the aspirational goal of a zero-waste, circular economy. This framework aids in identifying the current stage of waste management and planning the necessary steps for progress. While flexible and useful for setting milestones, the 9DBs framework also requires significant resources and long-term commitment to advance through its stages, making it challenging to implement quickly in areas with limited infrastructure.

While both ISWM and 9DBs provide robust theoretical approaches, the framework by Pongracz, Philip, and Keiski (2004) is particularly relevant to Port Harcourt‘s context. This framework emphasizes resource optimization and harm prevention, offering practical solutions to the city‘s specific challenges, such as scavenger activities and inadequate waste collection infrastructure. The framework‘s focus on addressing root causes of waste generation and disposal makes it particularly suited to the unique issues faced by Port Harcourt, including the health risks associated with improper waste disposal and the complications caused by scavengers.In conclusion, while ISWM and 9DBs are valuable for guiding waste management practices, the Pongracz, Philip, and Keiski (2004) framework is selected as the most appropriate approach for this study. Its emphasis on practical, context-specific solutions tailored to Port Harcourt‘s challenges makes it the best choice for addressing the city‘s waste management issues. By focusing on resource optimization and harm prevention, this framework offers effective strategies for mitigating the adverse effects of waste on public health and the environment in Port Harcourt.

Development of Waste Management in Port Harcourt, Rivers State

Port Harcourt, the capital of Rivers State in Nigeria, has experienced significant growth and urbanization over the past few decades. This rapid development has brought about various challenges, including those related to waste management. The evolution of waste management in Port Harcourt reflects broader trends in urbanization and environmental management in developing cities.In the early stages, waste management in Port Harcourt was largely informal and unorganized, relying on open dumping and burning of waste due to the lack of formal infrastructure (Ogbonna et al., 2007).As the city expanded, the Rivers State government established the Rivers State Environmental Sanitation Authority (RSESA) in 1990 to oversee waste collection, transportation, and disposal (Abah &Ohimain, 2010).Rapid urbanization led to increased waste generation, overwhelming existing infrastructure and services. Inadequate funding, lack of technical expertise, and insufficient capacity resulted in irregular waste collection services and the proliferation of illegal dumpsites (Babayemi & Dauda, 2009; Ogbonna et al., 2007).Recent efforts to modernize waste management practices include public-private partnerships (PPPs), which have improved waste collection and disposal services (Adewale, 2011). NGOs and community-based organizations have promoted recycling and proper waste management practices (Ikpeze, 2020).Technological advancements, such as waste-to-energy (WtE) technologies and modern waste treatment facilities, have contributed to better waste management practices (Nzeadibe & Anyadike, 2012). Nevertheless, the significant challenges remain, including infrastructural deficiencies, financial constraints, and regulatory weaknesses. Addressing these challenges require comprehensive policy interventions, increased investment in infrastructure, and stronger enforcement of waste management regulations.Moving forward, waste management in Port Harcourt must focus on creating an integrated and sustainable system,

enhancing public awareness and participation, improving waste segregation at the source, and fostering collaboration among government agencies, private sector actors, and local communities.

Challenges of Waste Management in Port Harcourt, Rivers State

The challenges of waste management in Port Harcourt, Rivers State, are multifaceted and complex, reflecting broader issues faced by many rapidly urbanizing cities in developing countries. These challenges can be grouped into infrastructural, financial, technological, social, and regulatory categories, each contributing to the overall difficulty of maintaining an effective waste management system.The city's waste collection and disposal systems are often outdated and insufficient, leading to illegal dumpsites and open burning of waste, posing significant environmental and health risks (Ogwueleka, 2009; Ogbonna et al., 2007).Besides, insufficient funding restricts the ability of municipal authorities to invest in necessary infrastructure, equipment, and personnel, resulting in irregular and inadequate waste collection services (Babayemi & Dauda, 2009). In addition, lack of advanced waste treatment technologies limits the efficiency of waste management. Integrating the informal waste sector into the formal system remains challenging, as this sector often operates without adequate regulation and support (Pires et al., 2011; Wilson et al., 2009). Also, low public participation and awareness hinder waste management programs. Many residents are unaware of proper waste disposal practices, recycling, and waste segregation, leading to indiscriminate dumping and low participation in recycling initiatives (Henry et al., 2006). Consequently, weak regulatory frameworks and institutional deficiencies hinder effective waste management. Inconsistent practices and challenges in holding waste management entities accountable contribute to illegal dumping and other unsustainable waste disposal practices (Mwesigye, Mbogoma, Nyakang'o, 2009).Improper waste management has severe environmental and health consequences. Uncontrolled dumpsites and open burning of waste contaminate soil and water resources, posing significant risks to public health (Ogwueleka, 2009; Solomon, 2011). To this end, political instability and governance issues further exacerbate waste management challenges. Frequent changes in government and political leadership can disrupt waste management policies and initiatives, leading to inconsistent and ineffective implementation (Nnaji, 2015). Corruption and lack of transparency in waste management contracts and operations can undermine efforts to improve the system.

Conclusion

The central focus of this study is on waste management with specific reference to Port Harcourt metropolis. The intricate dynamics and persistent challenges of waste management in Port Harcourt reflect broader trends across major African cities. Various strategies, including public-private partnerships, community engagement, recycling initiatives, waste-to-energy projects, and regulatory frameworks, have led to notable improvements in waste collection and disposal practices. However, significant challenges remain, such as infrastructural limitations, financial constraints, technological and logistical issues, social and behavioral barriers, and regulatory deficiencies. The paper concludes that addressing these challenges requires a comprehensive and integrated approach involving all stakeholders.

Recommendations

Based on the findings and analysis, the following recommendations are proposed to enhance waste management practices and address the identified challenges:

1. Municipal authorities and stakeholders should prioritize investment in modern waste collection, transportation, and disposal infrastructure, including sanitary landfills, waste transfer stations, and recycling facilities.
2. Governments should explore innovative financing mechanisms to secure adequate funding for waste management initiatives, such as public-private partnerships (PPPs),

municipal bonds, or international development assistance. As earlier enunciated, the system of evacuation encourages residents of the city to dump at dusk from 6:00pm to 5:00am. This system is ineffective, as it litters the city. This study recommends that the city should be divided into clusters to be managed by firms that would collect refuse at residents and business areas.

3. Embrace and deploy advanced waste treatment technologies, such as waste-to-energy (WtE) plants, composting facilities, and automated sorting systems to reduce waste volumes and promote resource recovery. In addition, launch comprehensive public awareness campaigns to educate residents about proper waste segregation, recycling practices, and environmental stewardship. Collaborate with community-based organizations (CBOs) and NGOs to foster community participation in waste management initiatives.
4. Develop strategies to integrate informal waste pickers and recyclers into the formal waste management system. Provide training, support, and legal recognition to enhance their occupational health and safety standards and improve overall waste collection and recycling rates.Bsides, strengthen waste management regulations and enforcement mechanisms to ensure compliance with environmental standards. Establish monitoring and reporting systems to track progress, enforce penalties for non-compliance, and incentivize adherence to regulations. More so there should be laws on scavenger.
5. Encourage research and innovation in waste management technologies and practices tailored to local contexts. Foster partnerships between academic institutions, research organizations, and industry stakeholders to develop and pilot-test new solutions. Moreso, invest in capacity-building programs to enhance the technical skills and capabilities of waste management personnel. Strengthen institutional frameworks and governance structures to improve coordination among government agencies, enhance transparency, and facilitate effective waste management planning and implementation. Implementing these recommendations can help Port Harcourt and other African cities overcome waste management challenges and achieve cleaner, healthier, and more sustainable urban environments.

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