Locational Analysis and Management of Waste Dumpsites in Osun State, Nigeria

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Abstract

Waste Management is a significant environmental problem that has continued to threaten the sustainability of developing countries. Yet, the challenge of managing waste in these countries has been further threatened by the poor location of waste dumpsites. Focusing on Osun State Nigeria, this study evaluates the location and management of Egbedi and Asunle waste dumpsites and proffers recommendations towards the achievement of sustainable waste management in the state and other places with similar characteristics. For the study, both primary and secondary data were utilized. A structured questionnaire was used to obtain information on the management of waste dumpsites in the study area. Spatial data were used to identify and map the dumpsites as well as to analyze their locational characteristics. For the waste management analysis, a mobile GPS device was used to record the geographic locations of the two dumpsites. Data obtained were subjected to descriptive statistics. It was observed that both sites are open dumpsites without parking space and evident poor management. It is, therefore, recommended that the Osun State Government should establish sanitary waste dumpsites throughout the state. These dumpsites should adhere to proper sanitation standards and guidelines to ensure safe and efficient waste disposal. The findings of the study provide a framework for sustainable waste management in the state and other areas of the country

Keywords: Solid Waste, Waste Management, Dumpsites, Osun State

1. Introduction

Waste management is a significant environmental concern that is often linked to urbanization (Ugwuanyi and Isife, 2012). It has grown to be a significant challenge resulting from the dynamics of population increase and urban expansion. Waste is an inevitable consequence of the urban lifestyle yet, in most nations, it is growing more quickly

than urbanization (Hoornweg and Bhada-Tata, 2012). According to the United Nations (2017), the world's cities produced 2.01 billion tonnes of solid trash in 2017, or 0.74 kilograms per person every day. Over 90% of rubbish is often disposed of in uncontrolled landfills or burnt in the open in low-income nations.

Waste collection is one of the major problems surrounding solid waste management in developing nations (Olawale and David, 2020). Most low-income nations have waste collection rates that are less than 70% (United Nations, 2017). Due to a lack of spatial data, many institutions may not have the best locations for amenities like trash cans and proper disposal sites (Ugwuishiwu *et al*., 2020). To handle solid waste effectively, the location of waste dumpsites is a crucial and important factor. An in-depth analysis of the site is necessary to make the best choice for the disposal of solid waste (Hailu *et al*., 2019).

Due in part to a shortage of suitable dumpsites, waste managers in Osun state struggle with the collection and management of garbage from the urban environment (Adebara *et al*., 2016). As a result, the state's metropolitan areas share characteristics with other urban environments, including mountains of rubbish, overflowing trash cans, clogged drains, blocked streams, and foul-smelling gutters that have been compared to a nightmare. There is, therefore, a need to evaluate the locational characteristics and management of waste dumpsites in Osun State, Nigeria. This is aimed at proffering recommendations for the achievement of sustainable waste management in the metropolis and other areas with similar characteristics.

2. Literature Review

Discussions on solid waste management will remain incomplete without clarification on the definition of some of its related terms as put forward in the literature. Solid waste is defined by Yadav (2015) as useless, unwanted, or discarded material with insufficient liquid content to be free-flowing. It is any garbage or refuse, sludge from a wastewater treatment plant, water supply treatment plant, air pollution control facility, and other discarded materials, resulting from industrial, commercial, mining, and agricultural operations, and from community activities. Solid waste can be classified in a variety of ways (Gana and Ngoro, 2014), popular among such classifications include domestic and industrial wastes, and a simplified categorization into animals, plants, and minerals-related solid waste. Based on its chemical makeup, Ibrahim (2002) grouped solid waste into three (3) categories: biodegradable, semi-biodegradable, and non-biodegradable.

The topic of waste generation and management has piqued the interest of academics (Brunner & Rechberger, 2014; Nsirim *et al.,2018*). This may be because nearly no human activity generates zero waste (Brunner & Rechberger, 2014). In Port Harcourt, Rivers State, Nsirim *et al.* (2018) looked at the efficacy of the Rivers State Wastes Management Agency's (RIWAMA) waste management communication techniques. The study concluded that RIWAMA's communication strategies, such as the development of mobile applications, and the use of a combination of traditional and interpersonal media channels, as well as social media platforms, failed to instill adequate waste management awareness among the general public. Waste communications, according to the results, should go beyond just communicating information and defining the substance of waste management

operations by the agency's aims and objectives.

Locational analysis has a long history in regional research and is regarded as a standard approach. The organization or arrangement of commodities, resources, services, or activities in space is the subject of location analysis. This type of study may be used to determine why certain activities/phenomena occur in particular locations and how to best position goods/services to achieve specific goals. Among the first to work on location analysis were Johann Heinrich von Thunen, Walter Christaller, August Lösch, Alfred Weber, and Harold Hotelling, among others. Von Thunen (1826) proposed a location theory to explain the principles that account for various agricultural land uses by integrating locational rent with agricultural output and transportation costs. Weber (1909) was interested in finding the optimal factory placement on the continuous plane that minimizes transportation costs, which is similar to profit maximization under production, labour supply, and demand assumptions. Hotelling (1929) examined the location strategy and pricing of two businesses, accounting for demand dispersion, transportation costs, and competition.

Locational determination of waste disposal sites in a particular area was started before the mid-1970s, the majority of solid waste disposal facilities in Ethiopian townships were located at the edges of metropolitan areas, next to water sources, agricultural fields, communities, and on the sides of roads (Weldeyohanis *et. al*, 2022). To handle solid waste properly, it is crucial to choose appropriate places for dumping it that are far from environmental resources, residential areas, water bodies, highways, faults, and towns. Wastes comprising plastics, glass, textiles, metals, and culinary garbage make up the majority of solid wastes in metropolitan areas. These wastes are complex in composition and slow to degrade, which causes more harm to the environment. The principles of reuse, recycling, reduction, and energy recovery are used in current waste management approaches (Ajay, 2019).

In the Lagos metropolitan area, Ayantoyinbo and Adepotu (2018) investigated solid waste management logistics and problems. The study's goal was to forecast the link between waste management logistics and the defined waste management performance matrix for the Lagos State Waste Management Agency (LAWMA). As a consequence of the findings, it is suggested that the volume of solid waste and employee dedication are critical to waste management and that garbage collection stations be increased. Hamad (2010) investigated the use of geographic information systems (GIS) in locating the optimal hazardous waste disposal location. The study identified hazardous waste management as a "present worldwide environmental problem" with "negative ecological repercussions." One of the most urgent environmental issues facing emerging-market nations is hazardous solid waste management.

As evidenced in the foregoing, there have been previous efforts at evaluating the location of waste facilities in some areas of Nigeria. However, none of such has been done in Osun State. Similarly, previous research efforts were not able to simultaneously evaluate the locational characteristics, management, and landuse impact of dumpsites which creates policy intervention challenges. This study is therefore posed to bridge these gaps.

3. Materials and Methods

Osun State is located between latitude 6.55^0 and 8.10^0 North and longitude 3.55^0 and 5.05^0 East of the meridian (Figure 1). It covers a total landmass of about 12,820 square kilometers. Politically, the state is divided into three Senatorial Districts and 30 Local Government Areas (Figure 2). It is situated within the cocoa belt of Southwestern Nigeria. Though there are patches of savannah in the Northern part of the state, much of the state areas are still under tropic rainforest vegetation type. When rain falls on landfill sites, organic and inorganic constituents dissolve, forming highly toxic chemicals leaching into groundwater. Water that rinses through these chemicals collects at the base of the landfill and usually contains high levels of toxic metals, ammonia, toxic organic compounds, and pathogens (Oman *et. al*, 2008; Samadder *et. al*, 2017).

For the study, data were collected from two major sources namely, primary and secondary. Primary data were collected through questionnaire administration, interviews, and field observation. A structured questionnaire was used to obtain information (like availability of waste recycling operation, waste disposal charges from users, and efforts rendered in the reduction of the environmental impact of the waste disposal site) on the management of waste dump sites in the study area. Spatial data were used to identify and map waste dump sites in the study area; as well as to analyze the locational characteristics of waste dump sites in the State. Secondary data such as information on the allocation of funds and management of waste disposal sites were obtained from Osun State Waste Management Agency. Other relevant materials and data were sourced from published documents such as journals, newspapers, textbooks, and the internet among others.

The two official dumpsites in the State (Egbedi waste disposal site) used and managed by the State, and Obafemi Awolowo University waste dump site which is operated privately by the institution were analysed. For the waste management analysis, a mobile GPS device was used to record the geographic locations of the two waste dump sites within the entire town through the O-Waste organization. Frequency, crosstabulations and Chi-square correlation test tools of the Statistical Package for Social Sciences (SPSS) were used to analyze the data collected from the field survey. Moreover, descriptive and explanatory techniques were the procedures by which the qualitative data from respondents were mathematically analyzed.

4. Results and Discussion

4.1. Locational Characteristics of Dumpsites

The section focuses on providing a comprehensive understanding of the two selected dumpsites: Asunle Dumpsite of Obafemi Awolowo University (OAU) and Egbedi waste dumpsite. This section examines various locational aspects of the dumpsites, including their coordinates, area, establishment year, presence of buffer zones, distances to adjoining roads, types of adjoining land uses, and closest land use proximity. By analyzing these locational characteristics, we gain insights into the spatial attributes and contextual settings of the dumpsites, which are crucial in understanding their impact on the surrounding environment.

Figure 1: Osun State within the Context of Nigeria
Source: Olatugbo, 2021

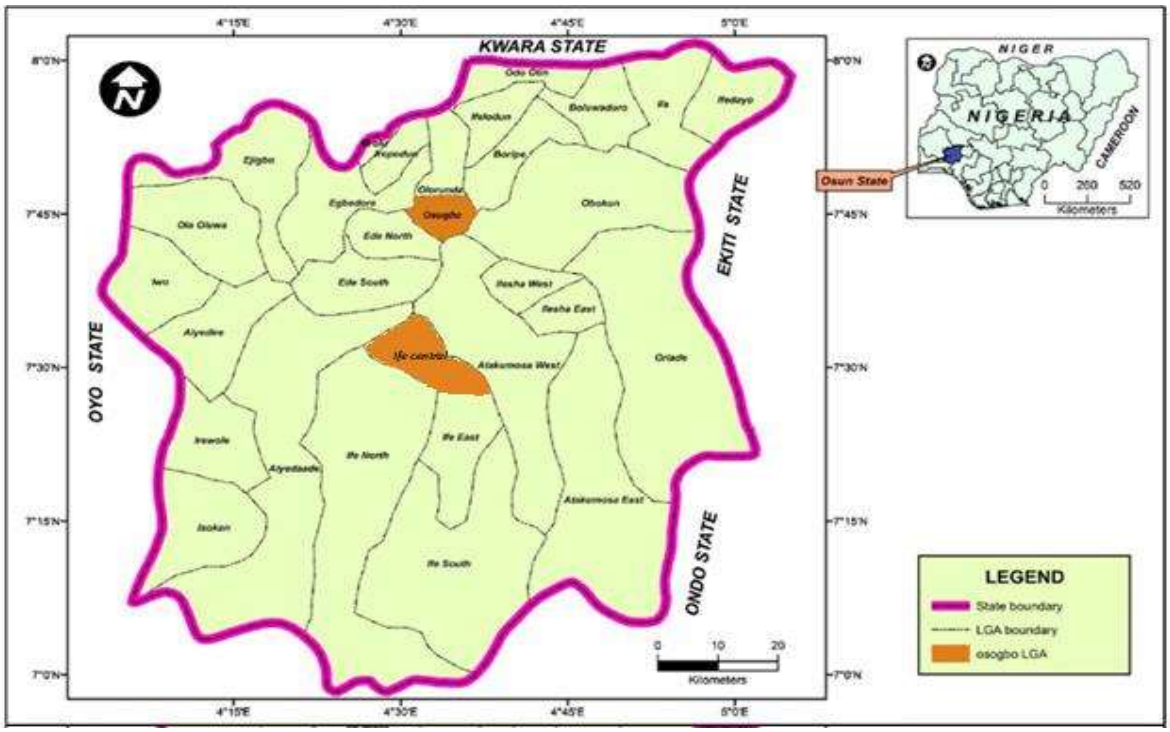

Figure 2: Ife Central and Osogbo within the Context of Osun State
Source: Olatugbo, 2021

The Asunle dumpsite, established in 1965, is situated at coordinates 7°32'00.0" N, 4°31'29.0" E. Spanning an area of 451.8m^2, it serves as a buffer within the surrounding area (Table 1). Vegetation is used as the buffer, covering approximately two plots of land and located at a distance of about 70 m from the adjoining access road. The dumpsite has no specific land uses, except for a security post within a 400 m radius. On the other hand, the Egbedi dumpsite, designated as the central waste dumpsite of Osogbo, was established in 2018. It features a prominent lighthouse at the front, serving as a distinct marker. Similarly, there is a security post within a 200 m radius of the dumpsite's service area. The Egbedi dumpsite is equipped with a vegetation buffer, spanning approximately two plots of land.

The Asunle dumpsite is an open dumpsite, lacking any partitions within its premises (Table 2). The content of the dumpsite is visible, contributing to its overall lack of obscurity. In terms of water source, the Asunle dumpsite relies on stream/river water. However, it does not have designated parking space, and there is no tarred road leading to the dumpsite. Similarly, the Egbedi waste dumpsite is an open dumpsite, without any partitions. Unlike the Asunle dumpsite, the content of the Egbedi dumpsite is not visible, thus providing some level of obscurity. It also utilizes stream/river water as a water source. Similar to the Asunle dumpsite, the Egbedi dumpsite lacks a parking space, but it benefits from the presence of a tarred road leading to the dumpsite (Table 2). These structural characteristics shed light on important aspects of the dumpsites, such as their openness, the visibility of their contents, and their accessibility. Understanding these characteristics is crucial for assessing the potential environmental impacts associated with the dumpsites and formulating appropriate management strategies.

As summarized in Table 3, a comprehensive analysis of the condition of various dumpsite facilities at both locations was done. The facilities assessed include tanks, drip pads, containment buildings, incinerators, injection walls, electricity supply, containers, recyclers, composting facilities, vans, access roads, drainage systems, contract haulers, street lights, and waste brokers. The findings reveal notable differences in the condition and availability of facilities between the two dumpsites. Asunle dumpsite at OAU shows a lack of several essential facilities, with only a fairly conditioned incinerator and transporters, along with a poor road leading to the dumpsite. On the other hand, the Egbedi dumpsite exhibits a greater presence of facilities; however, they are predominantly in poor condition. These facilities include containers, recyclers, vans, access roads, drainage systems, and contract haulers.

It is noteworthy that both dumpsites lack several critical facilities. Tanks, drip pads, containment buildings, injection walls, electricity supply, composting facilities, street lights, and waste brokers are absent at both locations. This raises concerns about the adequacy of infrastructure and resources for effective waste management and environmental protection. By analyzing the condition of these dumpsite facilities, we gain insights into the limitations and challenges faced in waste disposal and management. The findings highlight the need for infrastructure improvement, resource allocation, and strategic planning to enhance the operational capabilities and environmental sustainability of the dumpsites

Table 1: Locational Characteristics of Dumpsites

CHARACTERISTICS	Asunle Dumpsite, OAU	Egbedi waste dumpsite, Osogbo
Coordinate of the dumpsite	7°32'00.0" N, 4°31'29.0" E	7°42'00.0" N, 4°38'21.0" E
Area of the waste dumpsite (m^2)	451.8	478.5
Year of establishment of the dumpsite	1965	2018
Availability of buffer	Yes	Yes
Type of buffer	Vegetation	Vegetation
Distance of buffer	2 Plots	2 Plots
Distance of waste dumpsite to adjoining road (m)	70	55
Type of adjoining road	Access	Major
Adjoining land uses on the waste dumpsite	None	Light house at the front
Closest land-use to the waste dumpsite	Security Post	Security Post
Distance of the closest land use	Within 400 m	Within 200 m

Source: Authors' work, 2023

Table 2: Structural Characteristics of Dumpsites

CHARACTERISTICS	**Asunle Dumpsite, OAU**	Egbedi **waste dumpsite, Osogbo**
Type of waste dumpsite	Open	Open
Presence of partition in dumpsite	No	No
Visibility of waste dumpsite content	Yes	No
Is the waste dump site obscure?	Yes	Yes
Use of stream/River water as water source	Yes	Yes
Presence of Parking Space	No	No
Presence of tarred road to dumpsite	No	Yes

Source: Authors' work, 2023

Table 3: Condition of dumpsite facilities

Facilities	**Asunle Dumpsite, OAU**					Egbedi **waste dumpsite, Osogbo**				
	Very Good	**Good**	**Fair**	**Poor**	**Unavailable**	**Very Good**	**Good**	**Fair**	**Poor**	**Unavailable**
Tanks					*					*
Drip pads					*					*
Containment buildings					*					*
Incinerators			*							*
Injection walls					*					*
Electricity					*					*
Containers					*				*	
Recycler					*				*	
Composting facilities					*					*
Vans			*						*	
Access Road				*					*	
Drainage					*				*	
Contract haulers					*				*	
Street light					*					*
Waste Broker					*					*

Source: Authors' work, 2023

4.2. Mode of Operation and Management of dumpsites

This section explores the mode of operation and management practices employed at both Egbedi Dump Site and the Asunle Dumpsite at Obafemi Awolowo University (OAU). The mode of operation and management of dumpsites play a crucial role in determining the efficiency and effectiveness of waste disposal and environmental protection measures.

At the Egbedi Dump Site, waste collection occurs daily for the majority of respondents (51.5%), while in the Asunle Dumpsite, the frequency of waste collection is considerably lower, with only 9.1% reporting daily collection. Additionally, the Egbedi Dump Site shows a higher presence of facilities such as billing and crushing machines, while the Asunle Dumpsite lacks these facilities. In terms of waste management methods, Egbedi Dump Site is managed through landfilling whereas in the Asunle Dumpsite, waste removal is the primary management method. Furthermore, Egbedi Dump Site is publicly managed through collaborative efforts of the Association of Waste Managers and Osun State Waste Management Agency while the Asunle Dumpsite is privately managed by Obafemi Awolowo University, Ile-Ife.

Interestingly, the Asunle Dumpsite had a higher number of staff members involved in the waste management process (15 staff members) compared to the Egbedi Dump Site (8 staff members). Recycling practices were not reported at either dumpsite, with the majority of respondents at both locations indicating no recycling activities (78.8% at Egbedi Dump Site and 21.2% at Asunle Dumpsite). Financial aspects related to dumpsite management also varied. The Egbedi Dump Site relied more on internally generated revenue (72.7%) as a source of funding, while the Asunle Dumpsite had a higher percentage of respondents who did not provide a response regarding funding sources.

These findings shed light on the operational and management practices at the selected dumpsites, highlighting areas of similarity and divergence. By examining these aspects, waste management authorities, policymakers, and stakeholders can identify strengths, weaknesses, and potential areas for improvement in managing dumpsites effectively, ensuring sustainable waste disposal practices, and safeguarding the environment and public health.

4.3 Dumpsite Monitoring and its effect

In this section, we examine the monitoring practices carried out by health and safety officials at the dumpsites under study. Effective monitoring plays a crucial role in ensuring compliance with health and safety regulations, identifying potential risks and hazards, and implementing appropriate measures to protect the well-being of workers, nearby communities, and the environment.

Figure 3 presents an overview of the monitoring activities conducted by health and safety officials at the dumpsites. All managers reported that health safety official monitor the two dumpsites. By closely examining the monitoring practices, authorities and stakeholders can identify gaps, strengths, and potential areas for enhancement in ensuring the safe and compliant operation of dumpsites. This information can inform the development and implementation of targeted interventions, training programs, and regulatory measures to mitigate risks and improve health and safety outcomes

Table 4: Mode of Operation and Management of dumpsites

Criteria	Options	Egbedi Dump Site	Asunle OAU
What is the frequency of the waste collection?	Daily	51.5%	9.1%
	Weekly	18.2%	0.0%
	No Response	9.1%	12.1%
List of the facilities that are available in the dumpsite	Billing Machine	Available /functional	Not available
	Crushing Machine	Available/functional	Not available
	Incinerator	Not available	Not available
Number of staff on the waste dumpsite	8 staffs	78.8%	0.0%
	15 staffs	0.0%	21.2%
Do you recycle the wastes?	Yes	0.0%	0.0%
	No	78.8%	21.2%
	No Response	6.1%	0.0%
How much does it cost to manage the dumpsite?	250,000 per Quarter	12.1%	0.0%
	300,000 per month	0.0%	21.2%
	No Response	66.7%	0.0%
Do you collect money from the waste dumpers	Yes	78.8%	0.0%
	No	0.0%	21.5%
If yes, do you scale waste before dumping?	Yes	3.0%	18.2%
	No	72.7%	3.0%
	No Response	3.0%	0.0%
If yes, kindly provide the rate of waste collection?	Yes	0.0%	0.0%
	No	0.0%	0.0%
	No Response	78.8%	21.2%
Do you sort waste in the waste dumpsite?	Yes	78.8%	18.2%
	No	0.0%	0.0%
	No Response	0.0%	3.0%
Source of funding for management of waste dumpsite	Internally Generated Revenue	72.7%	18.2%
	No Response	6.1%	3.0%

Source: Authors' work, 2023

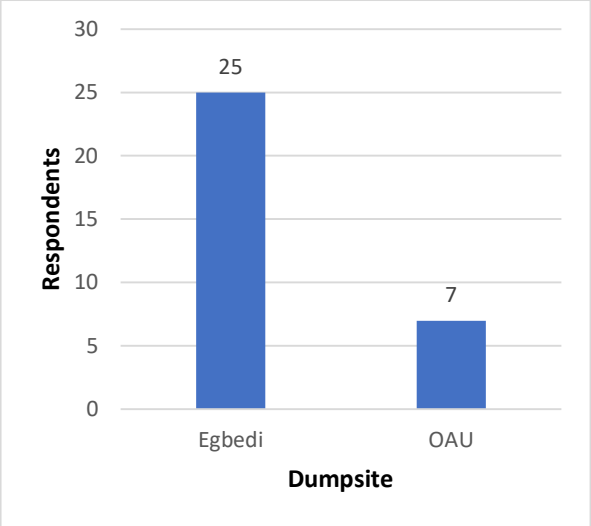

Figure 3: Monitoring of dumpsite by Health Safety Officials
Source: Authors' work, 2023

In this section, we explore the frequency at which the waste dumpsites under study are cleaned. Regular clearing of dumpsites is essential for maintaining hygienic conditions, preventing the spread of diseases, and minimizing the negative environmental impacts associated with waste accumulation.

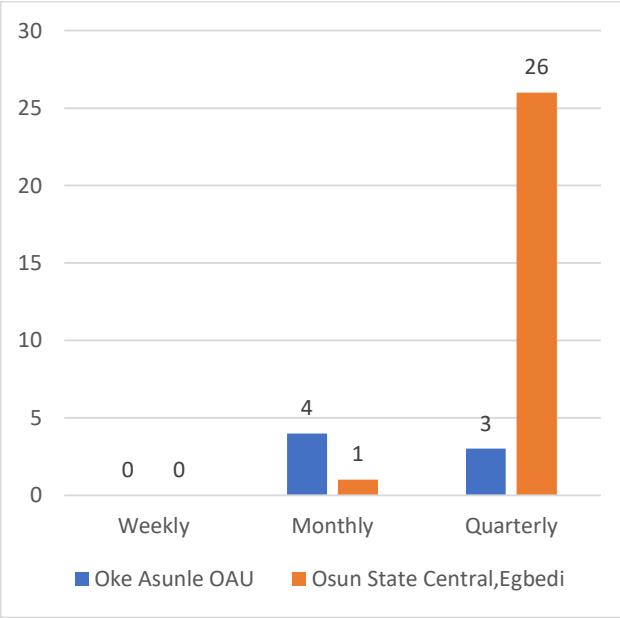

Figure 4: Frequency of Waste Dumpsite Cleaning
Source: Authors' work, 2023

Figure 4 provides an overview of the cleaning frequency reported by the dumpsite managers. Understanding the frequency of cleaning operations sheds light on the commitment and effectiveness of waste management practices at the dumpsites. The findings reveal that the majority of managers (72.1% for Egbedi dumpsite and 9.1% for Asunle dumpsite) reported cleaning the dumpsites quarterly. Furthermore, 12.2% of managers stated that the Asunle dumpsite is cleaned monthly, while 3.1% of managers reported monthly cleaning for the Egbedi dumpsite. These variations in cleaning frequency indicate the diverse approaches adopted by dumpsite managers in addressing waste accumulation.

Interestingly, neither of the dumpsites implements waste scaling or sorting practices. Waste scaling involves weighing the waste before disposal to monitor the quantity, while waste sorting refers to the separation of different types of waste for appropriate disposal or recycling. The absence of these practices suggests potential areas for improvement in waste management strategies to enhance efficiency and environmental sustainability.

Table 5: Effect of Dumpsites on its environment

Criteria	Options	Egbedi dumpsite	Asunle OAU
What are the efforts put in place to adjust the environmental impact of the waste dumpsite?	Waste Treatment Technologies	33.3	10.0
	Environmental Monitoring	18.1	12.3
Do residents complain of waste dumpsites?	Yes	36.3	18.2
	No	9.1	0.0
	No Response	33.3	3.0
Presence of Vermin	Yes	100	0

Source: Authors' work, 2023

Table 5 presents key indicators related to the environmental impact of the Egbedi and Asunle dumpsites, as well as the efforts undertaken to address these impacts. Efforts to mitigate the environmental impact of the waste dumpsites include the adoption of waste treatment technologies and the implementation of environmental monitoring practices. These measures aim to reduce the negative consequences associated with waste disposal and ensure proper management of the dumpsites. Approximately 33.3% of managers at Egbedi dumpsite and 18.1% of managers at Asunle dumpsite reported employing waste treatment technologies and conducting environmental monitoring.

Residents' complaints regarding the impact of the dumpsites on their surroundings were also considered. It was found that 36.3% of managers at Egbedi dumpsite reported receiving complaints from residents, while 18.2% of managers at Asunle dumpsite acknowledged similar complaints. These concerns voiced by residents highlight the potential disturbances and disruptions caused by the presence of dumpsites in residential areas. Furthermore, the presence of vermin, including bugs, rodents, snakes, flies, maggots, cockroaches, worms, mosquitoes, birds, and weasels, was observed at both dumpsites. All managers surveyed reported the existence of these vermin, indicating the associated ecological challenges and health risks.

4.4. Impact of dumpsites on adjoining land uses

Social and political opposition to selecting dumpsites has been indicated as the single greatest impediment to successfully locating waste disposal facilities (Lober, 1995). The Not in My Backyard "NIMBY" phenomenon, described in greater detail by Erkut & Moran (1991) is both an important consideration and restraint to dumpsite siting. The external cost and undesirable characteristics of dumpsites often cause people to perceive the hazards and risks as outweighing the long-term benefits (Chandra *et. al*, 2016). Transportation, noise and congestion, lower property values, and lessening of community or personal self-image are the high costs perceived by the public (Lober, 1995). Costs and benefits are found to be directly proportional to the extent that an increase in the distance at which one lives from an undesired facility reduces the amount of perceived costs.

Although there is no land use close to the dumpsites, studies have shown that the visibility of waste dumpsite content influences aesthetic distaste conditions (Cooremans et al., 2019; Mazarra, 2015). Asunle dumpsite content is visible while Egbedi dumpsite's contents are obscure. The absence of partition and

infrequent clearing of dumpsites results in the accumulation of waste on open lands, in drains, and residential areas causing nuisance and foul-smelling pools, environmental pollution, and through leachates from piles (water and soil pollution), burning of waste (air pollution) and clogging of drains (Liyala, 2011). Similar to the findings of Liyala (2011), there is vermin on the two dumpsites and they pose a great health danger to the health of the residents of close land use. The vermin that roam the sites are disease vectors which increase the health cost of the society if not controlled as fast as possible. The presence of these is similar to a report by Egun *et al*. (2016).

5. Conclusion and Recommendations

This study assessed the locational characteristics and management of waste collection sites in Osun state. The locational analysis of this study establishes that the locations of the two dumpsites as unsuitable for their purpose and calls for relocation while the management of the dumpsites should be reassessed and modified to provide standard operational scheme of waste dumpsite and health protecting facilities. Hence, it is concluded that none of the existing dumpsites within the study area is properly located. In other words, none of them met the stipulated locational and management standards.

Upon identifying various shortcomings in the location and management of the waste dumpsites, the following recommendations have been proposed:

1. Construction of Sanitary Waste Dumpsites: It is recommended to establish sanitary waste dumpsites throughout the state. These dumpsites should adhere to proper sanitation standards and guidelines to ensure safe and efficient waste disposal.
2. Provision of Essential Infrastructure: Waste dumpsite management should prioritize the provision of necessary infrastructure, including recycling plants. The establishment of recycling facilities can contribute to the state's economy by reducing waste volume and promoting sustainable waste management practices.
3. Regular Cleaning Process: Waste dumpsites should implement more frequent cleaning processes, ideally on a weekly basis. This measure aims to prevent excessive waste accumulation and minimize the presence of vermin and pests at the site, ensuring a healthier environment.
4. Implementation of Pay-as-You-Throw Policy: To secure funding for waste dumpsite management, it is recommended that the government implements a pay-as-you-throw policy. This policy would require residents or waste generators to pay based on the amount of waste they dispose of, thereby generating revenue to support waste management operations.
5. Adequate Resource Allocation: The government should allocate sufficient resources to waste dumpsites to ensure efficient and effective waste management. As waste management is an integral part of government development initiatives, adequate funding, equipment, and personnel should be provided to sustain the operations of waste management institutions.
6. Coordination with National Waste Management Bodies: National waste management bodies should collaborate with waste dumpsites in each state to provide

technical support and financial resources. This coordination can strengthen the capabilities of waste management institutions and facilitate knowledge exchange for improved waste management practices.

7. Emphasis on Leachate Management: Given the potential risks of waste polluting groundwater in landfill areas, there is a critical need for effective leachate management. Implementing appropriate measures to minimize leachate and prevent its contamination of groundwater is highly recommended.

By implementing these recommendations, the state can enhance its waste management infrastructure, promote sustainability, and mitigate environmental and health risks associated with waste dumpsites.

References

Adebara, S. A., Afolayan, A., Omajali, D. I., & Olatunji, A. A. (2016). Assessment of The Effects of Solid Waste Dumpsite on Groundwater in Osogbo and Ede Metropolis Osun State, Nigeria. *International Journal of Engineering Technologies and Management Research*, *3*(2), 1-21.

Ajay, S. (2019). Remote sensing and GIS applications for municipal waste management. *Journal of Environmental Management*, 243, 22−29.

Ayantoyinbo and Adepotu (2018) Analysis of Solid Waste Management Logistics and Its Attendant Challenges in Lagos Metropolis. Logistics, 2-11.

Brunner, P.H. and Rechbaga, H. (2014). Waste to Energy-Key Element for Sustainable Waste Management. Waste Management Journal: 3(7), 3-12.

Chandra, M., Kohn, C., Pawlitz, J., & Powell, G. (2016). Real cost of styrofoam. *St. Louis University*.

Cooremans, K., & Geuens, M. (2019). Same but different: Using anthropomorphism in the battle against food waste. *Journal of Public Policy & Marketing*, *38*(2), 232-245.

Delgado OB, Mendoza M, Granados EL, Geneletti D (2008) Analysis of land suitability for the siting of inter-municipal landfills in the Cuitzeo Lake Basin, Mexico. Waste Manag 28:1137–1146.

Erkut, E., & Moran, S. R. (1991). Locating obnoxious facilities in the public sector: An application of the analytic hierarchy process to municipal landfill siting decisions. *Socio-economic planning sciences*, *25*(2), 89-102.

Gana, A.J., & Ngoro, D. (2014). An Investigation into Waste Management Practices in Nigeria (A Case Study of Lagos Environmental protection Board and Abuja Environmental protection Board). *West African Journal of Industrial and Academic Research, 12*, 112-126.

Hailu, Y., Hanchiso, T., & Bereta, A. (2019). Municipal solid waste source identification, characterization and physical composition analysis, case study Wolkite town, Ethiopia. *Am. J. Environ. Prot*, *8*(2), 48-53.

Hamad H. A. (2010). Application of GIS in the Selection of a Suitable Site for Hazardous Waste Landfills. 2010.

Hoornweg D, and Bhada-Tata, P. (2012). A global review of solid waste management. Urban Development and Local Government Unit, World Bank, Washington.

Ibrahim, M. A. (2002). Solid Waste Management. Introduction to Environmental Problems and Management.

Kontos TD, Komilis DP, Halvadakis CP (2003) Siting MSW landfills on Lesvos island with a GIS-based methodology. Waste Manag Res 21:262–277.

Lober, D. J. (1995). Resolving the siting impasse: modeling social and environmental locational criteria with a geographic information system. *Journal of the American Planning Association*, *61*(4), 482-495.

Liyala, C. M. (2011). Modernising solid waste management at municipal level: institutional arrangements in urban centres of East Africa (Doctoral dissertation). Wageningen: Wageningen University.

Mazzara, F. (2015). Spaces of visibility for the migrants of Lampedusa: The counter narrative of the aesthetic discourse. *Italian Studies*, *70*(4), 449-464.

Nsirim, H.U, Oluomoyor, I.C. and Nwachukwu, G. F. (2018). Assessment of RIWAMA's Communication Strategies for Waste Management in Port Harcourt. International Journal of Innovative Research and Development, 7(10), 19-79.

Olawale J. A. and David O. O. (2020). Facility Location Problems: Models, Techniques, and Applications in Waste Management. Recycling 2020, 5, 10.

Öman, C. B., & Junestedt, C. (2008). Chemical characterization of landfill leachates–400 parameters and compounds. *Waste management, 28* (10), 1876-1891.

Samadder, S. R., Prabhakar, R., Khan, D., Kishan, D., & Chauhan, M. S. (2017). Analysis of the Contaminants released from Municipal Solid Waste Landfill Site: a case study. *Science of the Total Environment*, *580*, 593-601.

Ugwuanyi, R., & Isife, T. (2012). Urbanization and solid waste management challenges in Nigeria. *Technoscience Review*, *3*(1/2), 13-26.

Ugwuishiwu, B. O., Nwoke, O. A., Okechukwu, C. H., & Echiegu, E. A. (2020). GIS-based system analysis for waste bin location in Enugu municipality. *Agricultural Engineering International: CIGR Journal*, *22*(4), 250-259.

United Nations (2017). The sustainable development goals report New York: UN - Department of Economic and Social Affairs (DESA).

Von Thünen, J. (1826). Isolated State. Translated by Carla M. Wartenberg.

Weber, A. (1922). *Ueber den Standort der Industrien: Reine Theorie des Standorts, mit einem mathematischen Anhang, von Georg Pick* (Vol. 1). JCB Mohr (Paul Siebeck).

Weldeyohanis, Y. H., Aneseyee, A. B., & Sodango, T. H. (2022). Evaluation of current solid waste disposal site based on socio-economic and geospatial data: a case study of Wolkite town, Ethiopia. *GeoJournal*, *87*(2), 585-601.

Yadav, R. E. S. H. U. (2015). Solid Waste Management. *Pollution Research*, *34*(1), 111-120.

Yesilnacar MI, Cetin H (2008) An environmental geomorphologic approach to site selection for hazardous wastes. Environ Geol 55:1659–1671.