ASSESSMENT OF ENVIRONMENTAL HEALTH IMPLICATION OF MUNICIPAL SOLID WASTE DUMP SITE MANAGEMENT IN ILORIN, KWARA STATE, NIGERIA

BY

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ABSTRACT

Solid waste in most Nigerian cities is a major environmental challenge, Ilorin being the state capital of Kwara State, Nigeria is experiencing population growth yearly, resulting in the increase in human activities which leads to high volume of wastes recorded. To enable a conducive environment for the residents to live in, it is extremely important to find the means of managing the waste. This thesis assesses the physical environmental implications of the municipal solid waste dump site in Ilorin, Kwara State. It ascertains the environmental physical implication of the municipal solid waste dump site in Ilorin, investigate the environmental chemical implication of the municipal solid waste dump site in Ilorin, identify the environmental health implication of the municipal solid waste dump site in Ilorin and determine the management system if final municipal solid waste dump site in Ilorin, Kwara State. The study adopts quantitative research approach, the identification of the dump site in Ilorin was done followed by the collection of data from the residents of the study area as well as from the agencies responsible for the management of final solid waste dump site in Ilorin through the use of structured questionnaires. For the environmental chemical implication of the final municipal solid waste, soil and water samples were collected through the use of plastic bottles while Crowcon Gasman Carbon dioxide was used to measure air quality. These data were subjected to descriptive statistics. The findings show that Foul odour, Dust at the beginning of rainy season and house flies falls with the average condition, which indicate that most of the just itemized hazard exist on an average scale in the study area a result of those refuse dump being present in that area. Physio-chemical analysis of water sources revealed that mean pH of the available water was found to be 7.68, with a maximum value of 8, minimum of 7.30 and a standard deviation 0.12. The result of the soil test shows that Cadmium was not detected which showed that cadmium made up materials were not dumped on the site. The pH values (5.81, 5.7, 5.69, 5.670 and 5.65) gotten reveals that the acidity of the soil was reducing and gradually becoming neutral further down the soil, heavy metals were detected such as Lead (average among the samples = 0.023), Copper (average among the samples = 2.87) and Zinc (average among the samples = 4.88) among the soil samples investigated which is an indication that industrial and hazardous materials were dumped on the site. The water quality index increased from 45.03 to 58.95 as one moved closer to the dump site with the highest metal index value to be 79.38 this implies that water quality at the dump site is negatively impacted. Malaria was discovered to constitute more than 60% of the illness predominate in the study area which is largely as a result of the presence of the dump site. The study concludes that waste final dump sites in Ilorin are uncontrolled and do not conform to international standards of operations. This non-compliance results into proliferation of insects and rodents, blowing of litter and causes odour and general environmental degradation. Thereby recommends that There is the need for municipal governments in Nigeria to recognize solid waste management as a major problem and allocate adequate financial and other resources to efficiently and effectively solve the problem.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Environmental health involves researching and implementing the understanding of environmental factors and their impacts on human health to protect human well-being, prevent harm, and improve health by managing and reducing exposures to harmful biological, chemical, and physical elements present in the soil, food, water, air, and various environmental contexts that may negatively impact human health. A healthy environment is crucial for maintaining the health of the population (WHO,2017), (World Health Organization regional office for South-East Asia, 2019).

In Nigeria, the amount of waste generated is significant, with an estimated average range of the annual waste generation ranges from 0.65 to 0.95 kg/capita/day, which is within the range of 42,000,000 tonnes of waste produced each year. This poses a major challenge for the nation in terms of effective waste management and finding suitable solutions for handling this environmental issue (Chinedu *et al*., 2018).

Solid waste management involves the collection, processing, and proper disposal of discarded materials after their purpose has been served or improper handling and disposal of municipal solid waste can create unhygienic and unsanitary conditions, environmental pollution, and health risks, including outbreaks of vector-borne diseases transmitted by rodents and insects (Ezeah *et al.*,2016).

Many countries, including some European nations, face difficulties in formulating appropriate and efficient schemes for managing municipal solid waste. The absence of a rational approach is often a significant factor in decision making regarding waste management programs (Hadjibiros *et. al.*, 2011).

As the state capital of Kwara State, Nigeria, Ilorin experiences an annual increase in population, leading to more human activities and subsequent waste generation. To create a favorable living environment for its residents, it is crucial to implement waste management measures (Olagunju and Adeniyi, 2018). The Kwara State Waste and Environmental Protection Agency (KWEPA) was established by the Kwara State Government under the Ministry of Environment to address waste management challenges faced by the residents of Ilorin metropolis.

Municipal solid waste management involves several phases, starting from the collection point to the final dumpsite. Waste pickers and pushcart boys play a role in collecting and separating valuable materials from the waste before it reaches the final dumpsite. Waste pickers often recover materials for reuse or sell them for their own consumption or commercial purposes (Dias, 2017).

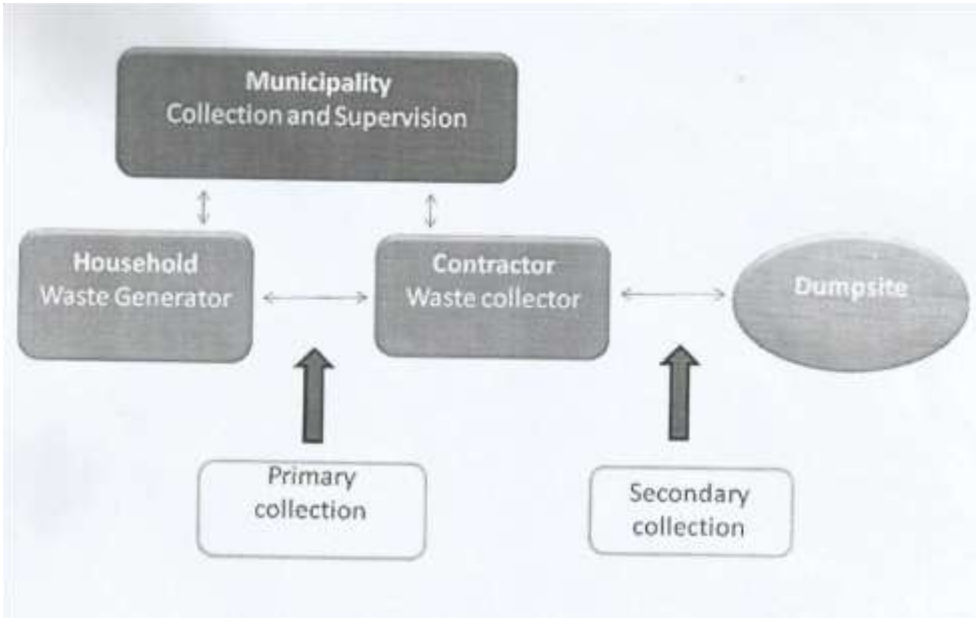

Figure 1.1: Municipal Solid Waste Management Relationships.

Source: Adapted from Olagunju and Adeniyi, (2018)

The diagram depicts the interconnections in solid waste management involving municipalities, households, and contractors, encompassing two stages of waste material collections.

1.2 Statement of the Research Problem

In countries like China, the rapid increase in Municipal Solid Waste (MSW) generation due to economic development and urbanisation poses significant challenges to human health, the environment, and waste management systems (Wang and Nie, 2001). In cities like Beijing and its suburbs, the daily MSW generation exceeds the capacity of existing waste treatment facilities, leading to the closure of landfill sites earlier than expected. To address this issue, plans are underway to establish new waste management facilities, but selecting suitable technologies and landfill locations has become complex and contentious, necessitating a science-based environmental assessment(Zhao *et. al.*,2007, Huang *et. al.,* 2007).

In Hong Kong and Singapore, substantial populations and economic growth contribute to significant waste generation, particularly from municipal solid waste and construction waste, causing environmental degradation and pollution. Implementing strategic waste management measures becomes crucial to enhance resource efficiency in these regions(Tanaka, 2007; Feng *et. al.,* 2009).

The United Kingdom has been implementing successive waste strategies aimed at setting ambitious goals to increase household and municipal waste recycling while also minimising the volume of waste transported to landfills. Each region, such as Wales and Scotland, has developed its specific waste strategies (Sloley, 2017). In Sri Lanka, a collective practice involves collecting solid waste from various sources and disposing of it in dumping sites within and outskirts of the town. South Africa has numerous sanitary landfill sites, of which a significant portion is formally designated, but the country still faces challenges in disposing of solid waste in environmentally safe sites.

Solid waste management remains a prominent issue in many third-world countries, including Ilorin, where the impact of waste management challenges is diverse. Several studies have focused on the environmental and health consequences of solid waste management in Ilorin, shedding light on the significance of addressing these issues.

This thesis aims to bridge the gap in research by reconciling the implications for health and the environment of the final municipal solid waste dump site in Ilorin and evaluating the activities undertaken to ensure a safe environment. The assessment involves the effects of the waste dump on the environment and human health evaluating the efforts made by the relevant ministry in management of waste.

1.3 Aim and Objectives

1.3.1 Aim of the Study

Primarily the aim of this thesis is to evaluate the environmental impact of the municipal solid waste dump site in Ilorin, Kwara State. The specific objectives of this study are as follows:

1.3.2 Objectives of the Study

The following are the objectives of the study:

1. Examine the physical environmental implications of the final municipal solid waste disposal site located in Ilorin, Kwara State.
2. Analyse the environmental chemical consequences or effects of the municipal solid waste dump site in Ilorin, Kwara State.
3. Examine the environmental and health implications associated with the municipal solid waste dump site in Ilorin, Kwara State.
4. Determine the management system of the final municipal solid waste disposal site located in Ilorin, Kwara State.

1.4 Justification of the Study

From their respective studies, Ike et al. (2018) and Karshima (2016) investigated the difficulties and possible opportunities of solid waste in Nigeria, encounters and potential prospects of managing solid waste in Nigeria. Ike et al. (2018) revealed that solid waste management in the country is largely monopolised by state government agencies, whose capacity to effectively handle waste management issues in their cities is limited. They emphasised the necessity of implementing strict policies, regulations, and establishing a robust waste database to enhance the efficiency of solid waste management in Nigeria.

On the other hand, Karshima (2016) examined the negligence of the government and environmental agencies in managing municipal solid waste in Nigeria, highlighting its adverse effects on public health, leading to various health concerns.

In conclusion, both studies underscore the significance of addressing solid waste management in Nigeria through better policies, regulations, data management, and proactive government and environmental agency involvement to mitigate the consequences for environmental and public health resulting from insufficient waste management practices. The research established that to protect public health, extra information are required by the government, environmental agencies which are equipped in the direction of public clarification, performance, and, implementation of policies and legislations on sanitation, enrichment of monitoring, funding and supervision, waste recycling and landfills development to enhance solid waste management standard in Nigeria.

In their study investigating the impact of disposal of solid waste at the Granville Brook dumpsite in Freetown, Sierra Leone, Sankoh *et. al.,* (2013) examined its effects on the nearby human settlements, both environmentally and in terms of public health. The study revealed that the inhabitants of the surrounding neighbourhood suffered health wise due to the location of the dumpsite close to their residence, this led to pollution, water and air pollution which was unbearable in the raining season and pollution of the underground water. In the dry season, the people living far away from the dumpsite are affected by the The smoke resulting from the burning of waste from the incineration of the dumpsite.

The research concluded that there should be proper location and management of the dumpsite to lessen its effect on the health of the people to enable the poor to live in an economical yet clean environment.

This study aims to reconcile the environmental and health implications related to the managing the final solid waste at the municipal level. The study focuses on the environmental and health effects of the waste dump site, along with the measures implemented by the relevant ministry to guarantee a secure environment.

With a focus on adopting sustainable measures, the research evaluates the process of managing the final dump site of solid waste municipally in alignment with the Sustainable Development Goals (SDGs) to protect public health and preserve the surrounding environment.

1.5 Scope of the Study

This research was held in Ilorin, the capital of Kwara State. The study primarily concentrates on the environmental implications of the municipal final waste dump site in Ilorin. The data analysis will be based on information collected from field observations. Specifically, the study will centre on the chemical implications of the final waste dump site and its potential health impact.

1.6 Study Area

1.6.1 Location

The final municipal solid waste dump site is located at Eiyekorin expressway in Ilorin. Ilorin, situated in Northern Nigeria, serves as the state capital of Kwara State. The city is positioned at a latitude of 8.496640 and a longitude of 4.542140 (Figure 1.1). It covers an area of 765 square kilometres and is situated at an elevation of 320 metres above sea level.

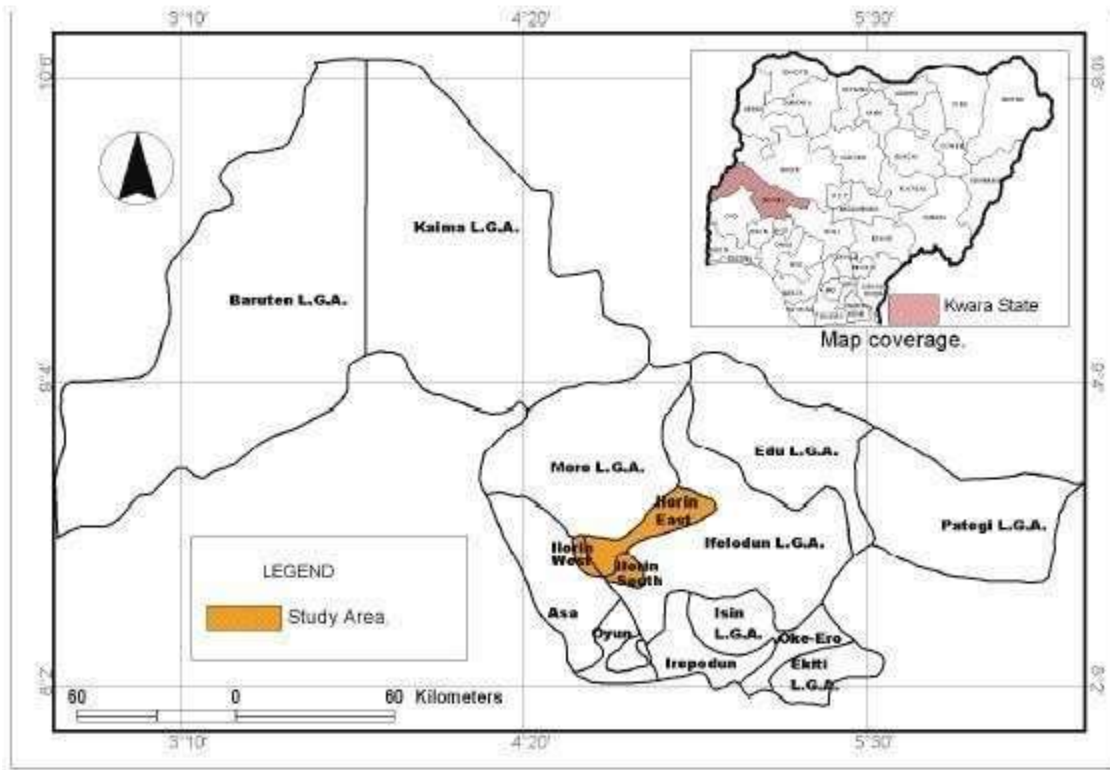

Figure 1.2: Location of Ilorin in Kwara State, Nigeria.

Source: Ministry of Land and Housing, Ilorin, 2022

1.6.2 Climate

Ilorin experiences a tropical continental climate characterised by consistently high temperatures throughout the year, encompassing both wet and dry seasons. The city is surrounded by a landscape featuring dry savannah vegetation and pockets of dry lowland rainforest cover. The wet season lasts from March to October, while the dry season spans from November to February. There is an average annual rainfall of 1200mm.

1.6.3 Population Characteristics

Ilorin is partitioned into three Local Government Areas: Ilorin South, Ilorin East, and Ilorin West. As per the 2006 census, the city's total population stands at 777,667, making it in Nigeria the seventh largest city.

1.6.4 Socio - Economic Activities

Since its establishment in 1967, Kwara State's political economy has undergone various development initiatives, primarily influenced by the centralised federal system in Nigeria. Development policies and programs have been driven mainly by the federal government, originating from the centre. The state is endowed with abundant fertile agricultural land and valuable natural resources, including dolomite and limestone in Oreke, clay and kaolin near Ilorin, pure gold in Patigi and Kaiama, and a significant tantalite deposit in Iporin, making it rich in primary resources.

In the past, there were a few key companies industrially, such as Global Soap (now defunct), detergent industries Nigeria Limited, and the International Tobacco Company. However, governmental administrations over the years have made efforts to entice industrialists to the State. As a result, Ilorin has emerged as a significant centre for processing cashew in Nigeria, with Olam International establishing Africa‘s largest processing plant of cashew. This processing capacity of the plant is 100 MT of cashews daily and employs over 2000 workers, contributing to the state's economic growth.

1.6.5 Transportation Pattern

Ilorin takes great pride in its well-established intra-city public transportation system, which ensures seamless mobility with major roads in excellent condition within the city. Travelling within Ilorin can be done through three primary modes of transportation: car-hire services accessible at prime hotels, conventional taxis and commercial motorcycles, locally known as ―Okada‖. Additionally, commercial tricycles, commonly called ―Keke Napep‖ have become a popular means of transport which are given to National Poverty Eradication Programme recipients. Taxis in Ilorin are easily identifiable by their yellow and green paint.

Being centrally located, Ilorin enjoys smooth access to all parts of the country via whatever means of transportation. The city boasts a well-connected with road networks, air transportation facilities and railways linking other commercial and industrial centres in Nigeria. Cost oftransportation within Ilorin is reasonably priced, with the cost of moving from one place to another often being less than 100 naira. The city is served by scheduled daily commercial flights operated by Arik Air and Overland Airways at Ilorin International Airport, which also functions as an international cargo airport. Although Capital Airlines is now defunct, other airlines continue to connect Ilorin to major cities in Nigeria. For road transport, Ilorin provides reliable services to and from various states, including Niger, Osun, Kaduna, Ekiti, Lagos, Ondo, Plateau, Oyo, Kogi, and Ogun. Convenient transportation options are also available to Aba, Port Harcourt, Onitsha, Abuja, and other destinations.

1.6.6 Cultural Settings

Ilorin is a vibrant city that serves as a melting pot of diverse cultures, with its population comprising people from different tribes from various regions of Nigeria, including foreign nationals. The city is characterized by significant Christian and Islamic communities, giving rise to numerous ceremonial activities, often with religious significance, taking place throughout the year.

Referred to as the "Home of Peace," Ilorin prides itself on creating a welcoming environment that embraces various religious practices and fosters numerous educational institutions. One notable institution is the United Missionary Theological College, allied with both The University of Ibadan and the University of Ilorin, where degrees are granted. This college plays a crucial role in producing Teachers, Church Ministers, And Theologians of different Denominations. Additionally, The Adeta area is home to The College Of Arabic And Islamic Legal Studies, which provides comprehensive training for Muslims in disciplines such as Islamic studies, Arabic, and social sciences.

1.6.7 Arts and Tourism

Ilorin offers a variety of attractions for Tourists, including The historic Sobi Hill, Which Is believed To Have provided protectioIlorin offers an array of captivating tourist attractions, starting with the historic Sobi Hill, believed to have served as a protective fortress During Intertribal Wars In Ancient Time. Another intriguing site Is Okuta Ilorin, Located In Asaju's Compound, Idi-Ape Quarters. This stone was utilized by Ojo Isekuse, One Of The city's ||Founders, to sharpen his metal tools. The town derived its name, "Okuta ilo irin," from this stone, which held deep religious significance and was once deified and worshipped, even serving as an object of sacrifice.

The city boasts a thriving pottery industry, with the largest Traditonal Pottery Workshop In Nigeria found In areas like Ita Merin, Abemi, Eletu in Oju-Ekun, Okekura, Oloje, Okelele and Dada. Additionally, Ilorin excels in the traditional textile industry, particularly in producing aso-oke, woven by hand and textiles created on traditional looms. Aso-oke is highly sought after by fashion designers and traders both within and outside State of Kwara and internationally also.

For recreation, visitors can enjoy the Metropolitan Park sited on Unity road and the Kwara State Stadium Complex, which features swimming pool of Olympic standard in terms of size with diving platforms. In the Adewole area, there is a dedicated baseball park. Furthermore, Ilorin houses the National Commission for Museums and Monuments, which hosts a centre showcasing fascinating ethnographic and cultural objects from Nigeria‘s diverse cultures. The Esie Museum, a notable cultural highlight, is well worth exploring.

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CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

In this chapter, we will conduct a comprehensive review of relevant literature associated to this study. The review will be crucial in associating the challenges and methodologies of the management of solid waste from the past to the current practice in management of waste. Additionally, we will emphasise important case studies to gain valuable insights into the subject.

2.2 Theoretical Framework

The theoretical framework for this research draws inspiration from Mushtaq's (2014) "Organisational System Structure for waste management," as presented in the book "National Health Care Waste Management Assessment." This theory serves as a valuable tool to comprehend waste management as a multifaceted issue.

Ahmad *et al.* (2016) elaborate on the Organisational System Structure Approach, defining a structural system of allocation of tasks to different working units, wherein some units are directly dependent on others within the hierarchical structure. The framework encompasses three crucial aspects: (a) the relationships between two or more attributes, (b) the connections between these attributes and the environmental context, and (c) the level of interdependence among different structural organisations.

The phenomenon of solid waste attributes encompasses various components and variations that exhibit discernible relationships with each other. These components function cohesively as a complex whole, following observed patterns. With this understanding, waste management can be comprehended within the context of system characteristics, as illustrated underneath.

2.2.1 Component parts of a structure in solid waste management: Within the domain of managing solid waste the structure comprises several distinct component parts, known as sub-structures. These sub-structures encompass a range of essential aspects, including the steps of generating waste, storage of waste, collection of waste, transportation, discarding, recovery and cost analysis, conservation, and administration. Each of these elements plays a vital role in the comprehensive management of waste.

2.2.2 System of operation: A system functions within a specific environment and comprises distinct sub-structures, where changes in one sub-structure can have an impact on the entire organisational structure. Additionally, the structure can be categorised as either open, isolated, or closed based on its exchange of energy and mass with the broader environment. In the context of management of waste, it is considered an open system since it involves the exchange of energy and biomass with the wider environment (Sener *et. al.,* 2017). For example, improving or upgrading the maintenance component can positively influence the overall performance of the waste management structure. Conversely, if inexperienced and unqualified workforce dominates the structure of the management, it could lead to the dysfunction of the system in its entirety.

2.2.3 Goal of the adopted framework: The fundamental objective behind the organizational structure of the management of waste is to achieve a healthy, safe, and clean environment, filth free, while embracing sustainability and aesthetic appeal. Presently, the emphasis lies in developing clean and green cities to encourage positive living habits and alleviate the burden of medical healthcare expenses.

Within this structure, a hierarchy of function is established to ensure effective workability and seamless flow of activities, from waste generation to disposal. Regardless of the type of municipal solid waste (MSW), which includes paper, broken glass, polythene bags, food remnants, fruits, and vegetables, the process begins with their generation in households.

The organisational structure serves as a framework for solid waste management schemes, allowing for adjustments and reformations to suit the specific needs of the area where it is implemented. It is important to emphasise that the subsystems within the waste management system can be self-governing. As a result, the effectiveness and efficiency of the procedures heavily depend on regulatory bodies for regulation of solid waste management.

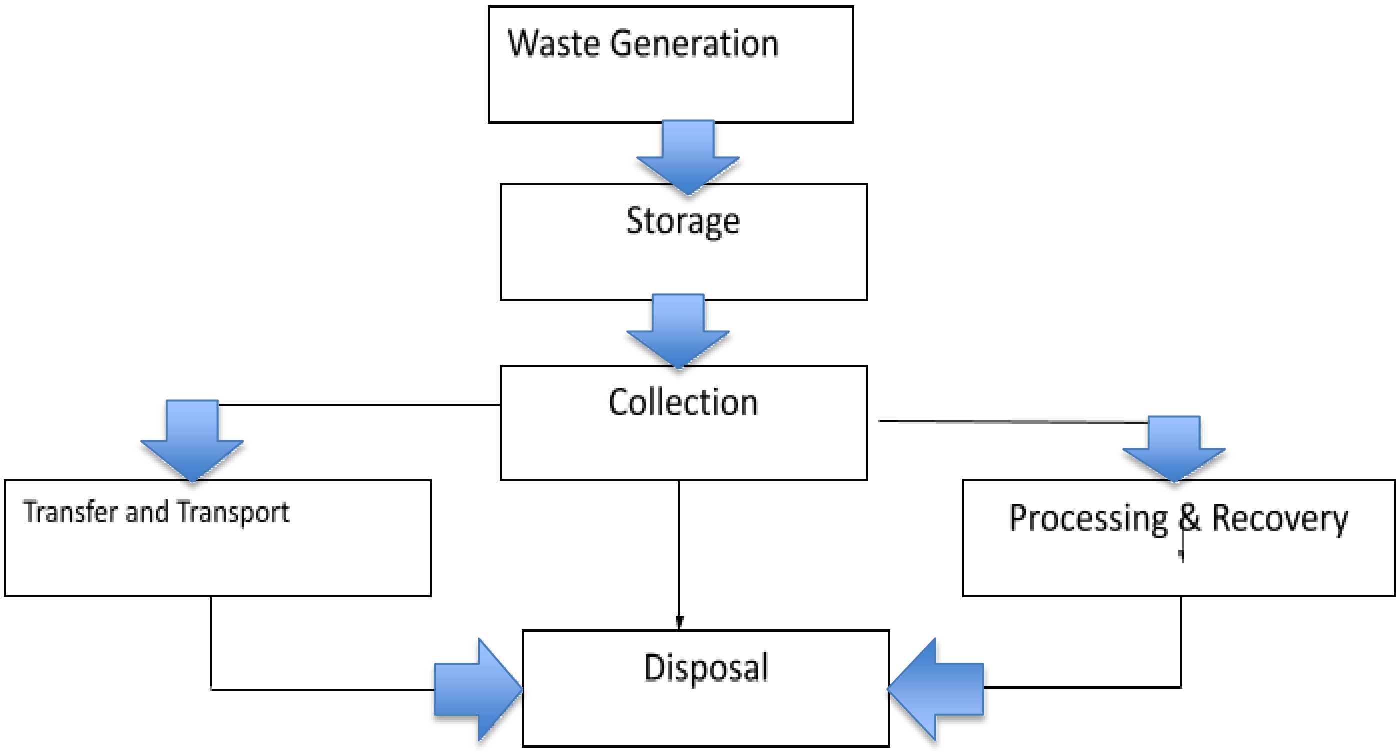

Figure 2.1: Organisational Framework Concept.

Source: Adopted from: Ahmad *et. al.*, 2016.

2.3 General concept of waste

Waste is an inescapable outcome of human endeavours, arising in various forms such as solid (effluence), liquid (foul water), semi-liquid, and gaseous (Biogas). Although there isn't a universally precise definition for waste, it is commonly understood as any undesirable material (Sener *et. al.*, 2017).

2.4 Solid Waste

Solid waste refers to non-liquid and non-gaseous materials that are discarded or considered unwanted. It may manifest as garbage, refuse, or sludge (Leton and Omotosho, 2014). Additionally, solid waste encompasses materials that have become obsolete encompassing household garbage as well as unwanted materials from commercial and mining activities. Based on their composition, solid wastes are categorised into three types:

i. Biodegradable: This category comprises yard waste, rubbish and junk

ii. Non-biodegradable: It includes remnants and man-made or artificial materials such as polymer based materials well as metals.

iii. Semi-biodegradable: This category encompasses materials like fibrous materials.

Furthermore, Solid waste can be defined as materials produced or originated from various human activities that are neither in the form of liquid nor gas but exist in compact and substantial forms.

2.4.1 Types of solid waste

i. **Domestic Solid Waste**: Solid waste, specifically municipal waste, includes rubbish and garbage generated from households. This category encompasses various items such as remnants Solid waste includes a variety of items such as old newspapers, food materials, spoiled kitchen utensils, cartons, baby toys, and numerous other discarded objects. Throughout history, managing municipal solid waste has remained a primary focus of waste management efforts. In Sabon Wuse,The responsibility for collecting and disposing of municipal solid waste management falls under the jurisdiction of The Niger State Environmental Protection Agency (Sener et al., 2017).

ii. **Agricultural Solid Waste:** These wastes originate from various farming activities and encompass waste from farm produce such as weeds, as well as harvested waste from tree crop residues, field, and plants. Additionally, animal dung production and waste from the operation of feedlots contribute to agricultural waste.

iii. **Commercial Solid Waste :** These solid wastes comprise all the byproducts generated from profit-making and business activities, including financial institutions like banks, markets, and stores, as well as educational institutions such as theatres, lecture halls, and classrooms. Hospitals also contribute to this category of solid waste.

iv. **Industrial solid waste:** They include waste products from goods manufacturing and encompass all the waste resulting from heavy and light industries. Majority of the advanced countries, solid waste from industries constitutes a large amount of the total harmful waste produced. For instance, industries in United State of America contribute 1/3 of the entire waste generated. These waste materials mainly arise from various industrial processes involved in manufacturing operations, such as processing plants, refineries, mining, repair and clearing establishments, and mineral operations (UNEP, 2014).

v. **Special Solid Waste:** Special waste encompasses a variety of waste types, including waste from street sweeping, dead animals, debris, roadside litter, store drain litter and abandoned vehicles. These wastes are termed "special" because their location and occurrence are unpredictable..

2.5 Management of Solid Waste

Solid waste management comprises a series of systematic procedures aimed at controlling and mitigating solid waste in our environment. It involves efficiently and conveniently collecting, treating, managing solid waste by processing and ultimately disposing of the refuse in an environmentally sanitary manner. and environmentally acceptable ways, all at the most cost-effective level. This comprehensive and integrated approach to solid waste management aims to achieve convenience, sustainability, and acceptable environmental health. The process encompasses various stages, including refuse material generation, the entire cycle of managing both organic and inorganic waste, which involves collection, storage on-site, transfer, transportation, processing, and discarding of materials (Ezeah *et al.*, 2016).

2.5.1 Solid waste generation

Solid waste generation is an inherent consequence of human activities, resulting in waste being produced on a daily basis by all individuals. Managing this waste has become a significant challenge in many societies today. Population growth further exacerbates the complexities of waste management, as more people in a given area lead to a higher volume of waste generation, presenting a greater challenge for waste management in that region. Poorly managed waste is recognized as a significant environmental hazard, and the inability of societies to effectively manage waste generation contributes to increased environmental pressures (Alam *et al.*, 2017).

The production of solid waste is an unavoidable facet of human existence., intricately linked with population dynamics. Additionally, factors such as income levels, urbanisation, and industrialization also influence waste generation (Clark *et. al.*, 2015). As reflected in Table 2.1, various countries around the world record substantial volumes of the generation of solid waste, as documented by the United Nations Environmental Programme (UNEP, 2015).

Table 2.1: Solid Waste Generation (in Tonnes) in some Countries of the World.

Country	Volume in Million Tonnes
USA	255.00
Malaysia	49.12
Vietnam	36.18
Singapore	5.05
Philippines	1.47

Source: United Nations Environmental Programme (2015).

The Environmental Protection Agency of the USA has demonstrated that approximately 98.5% of waste is well managed via the three Rs (Recycling, Reuse, and Reduce methods). On the other hand, the condition in Nigeria presents a different scenario. Urbanisation process in the nation is largely unintended, leading to a rapid population explosion and decentralisation of government, with villages transforming into the headquarters of local government, attracting extra people to urban centres (Okpala, 2014). This give rise to a significant increase in solid waste production. Additionally, traditional attitudes, poverty, and a lack of effective waste management practices by the relevant agencies have contributed to turning towns and cities into garbage-ridden areas, rather than serene environments (AbdiRazack *et al.,* 2013). Table 2.2 showcases the height of generation of waste in certain cities in Nigeria, indicating that the amount of waste produced far exceeds the capacity of the State's Environmental Protection Agencies. Numerous landfills have emerged around the cities, and the population is grappling with the health and environmental risks linked with an unhealthy environment. This situation has resulted to pathogenic breeding conditions, becoming a ground for breeding mosquitoes, airborne diseases and rodents. (Ogwueleka, 2019).

Table 2.2: Volumes of solid waste generated in some Nigerian cities (Tones/year)

Cities	Population	Tonnage/Month	Density	Kg/Capita day
Lagos	8,029,200	255,555	293	0.632
Onitsha	509,500	84,137	310	0.53
Ibadan	307,841	135,390	330	0.50
Kaduna	1,458,900	114,432	320	0.57
Kano	3,248,700	156,675	290	0.55
Makurdi	249,000	24,241	340	0.47
Abuja	159,900	14,784	280	0.65
Nsukka	100,700	12,000	370	0.43
Port Harcourt	1,058,900	117,25	300	0.60

Source: Ogwueleka, 2019

According to Table 2.2, the city of Lagos stands out as the highest waste generator among all cities in Nigeria, primarily due to its significant population. Interestingly, despite Kano having a land mass that is large when compared to Lagos, though Lagos still produces additional waste when compared to Kano. Ogwueleka's study revealed that the Southern part of the country on the average generates approximately 0.63kg/capita/day/person of waste, meanwhile in the North waste produced amounts to about 0.56kg/capita/day/person. Overall, the entire country averages around 0.60kg/capita/day/person of waste. In conclusion, Lagos state outperforms other cities such as Kano, Ibadan, Kaduna, Port Harcourt, Makurdi, Onisha, Nsukka, and Abuja in waste generation, despite some of these cities having larger populations.

2.5.2 Solid waste storage

After waste is generated, the next step involves storing the solid waste in several types of facilities for storage, such as solid waste storage materials or containers like refuse bins (such as dustbins, sack bags, baskets, drums, communal dustbins, or wheeled bins). These containers may be supplied by household owners or government/public agencies in charge for the management of solid waste. However, inadequate provision of storage containers by the responsible public agencies can cause challenges for residents in properly collecting their refuse, potentially resulting in the indiscriminate dumping of waste in open spaces (Merrill, 2015).

2.5.3 Solid waste collection

The exclusion of solid waste from its point of creation is a crucial aspect of urban solid waste management. This process is cost-intensive and requires a significant amount of labor. When this waste removal system fails to function effectively, it leads to the accumulation of refuse in unauthorized areas, negatively impacting the aesthetics of the surroundings (Hussain, 2013).

2.5.4 Solid waste collection techniques

The management of solid waste techniques refer to the procedures and approaches employed to collect and dispose of solid waste, either from households or organized communal sources.

These techniques encompass five common methods predominantly utilized in developing countries, alongside one primary approach predominantly employed by developed nations.

2.5.4.1 Types of solid waste collection technique

- Communal,
- Block,
- Kerbside,
- Door to door

Mostly used in developing countries

- Envac.

These are majorly used in 3rd world countries than Envac which is predominantly used in developed countries.

2.5.4.2 Communal depot waste collection technique

The waste collection method entails the utilization of waste storage facilities strategically positioned within easily accessible distances for collection vehicles, ensuring convenient operations. In this approach, households dispose of their solid waste at specified locations equipped with communal storage facilities. Refuse collection vehicles then visit these communal depots at regular intervals to empty the accumulated waste. This communal technique of collection of solid waste is predominantly employed in developing countries, including South Africa, Nigeria, Cameroon, Senegal, Kenya, Ethiopia, among others. Plate I and II exemplify the communal waste collection technique in Kenya, as demonstrated by Sener *et. al.* in 2017.

Plate I: Communal practise
Source: Kenya Institute of EPA (2018)

Plate II: Communal practise

2.5.4.3 Block (Set-Out) collection technique:

In this waste collection method, a dedicated vehicle follows a regular route, making two to three trips per week. At each stop, the vehicle collects waste from containers placed at every street leading to the intersection. Residents bring their waste containers to the vehicle, where the crew empties them. This approach typically requires a driver and a two-person crew since they can manage the collection without leaving the vehicle.

Frequent operation of this block collection system is essential to ensure that the waste quantity doesn't exceed the vehicle's capacity or residents' ability to carry their waste. One of the significant advantages of this method over Kerbside collection is that the waste containers are not left on the streets for extended periods, reducing clutter and inconvenience for residents. In America, residents are expected to place all waste items out for collection by 7:00 am. The garbage bin (blue bin) and yard waste bin (green bin) should be positioned half a meter apart from each other. Additionally, there should be a clearance of 3 meters above the bins to accommodate the mechanical lift arm used for automated collection in toronto.

2.5.4.4 Kerbside collection technique

Curb collection is a waste removal service offered to homes in urban and suburban areas, but the way it is implemented can vary significantly depending on the country. For instance, in Europe, households typically place bins or polythene bags at the curb for collection, whereas in countries like Nigeria, Ghana, USA, and Canada, households openly place their waste at the roadside, and state agencies for environmental protection and private firms handle the collection. In Nigerian cities, this waste collection technique is widely used (Aguwamba, 2018).

This method of waste collection is prevalent in both developed and developing countries. For example, in Nigeria, state agencies and private firms are involved in waste collection, while in Canada, many municipalities have mandatory curbside recycling programs. Some Canadian cities, such as Moncton, have implemented wet/dry waste separation and recovery programs alongside traditional curb collection.

2.5.4.5 Door-To-Door Waste Collection Technique:

This method of waste collection involves entering the premises (garden or backyard) of each household by the collector, carrying the vessel to the vehicle, discharges it, and replaces it to its designated location. The process is a little bit task-yarding and expensive especially as it relates to labour due of the high amount of time expended moving in and out of locations one residence to another. This method is predominantly done in properly planned and low density regions with high income levels; it is mostly found in advanced countries like England, USA and Germany etc.

Accra has piloted projects to advance the collection of waste and management in the Okaikoi South sub-metro of Accra and is on the verge of launching it in Avenor. A theme tagged ‖Pilot Door-to-Door Household Waste Collection‖, the project seems to mobilise the youths into a group comprising of eleven people to collect household waste which will be discharged at a central container location which is cooperatively manned by its members. Plate III shows the door to door technique of waste collection in California USA(Sener *et al.*, 2017).

2.5.4.6 Envac solid waste collection technique:

The process commences with deposition of waste into portholes, which are waste specialised, compost or recycling. Portholes are sited in open communal areas also on properties that are privately owned where the owner has agreed. From here the waste is convalesced via a subversive pipe line through air compression change formed by heavy industrial fans. Sensors in the porthole will indicate when the waste is required to be disposed and it helps to guarantee only one kind of waste is drifting via the tube per time. A central processing facility where the pipe lines converges is automated through a software to guide the waste to the right container, after which it is conveyed to the final location, which is either a composting plant or landfill. The structure requires small amount of staff to maintain it, and is remotely managed by Envac from their headquarters in Stockholm London in England (Stockholm, 2017).

Using Envac, collection Hygiene is enhanced noticeably for shopkeepers, waste collection operatives and populaces. The system being hermetically sealed, waste attracts insects no longer or pest or unpleasant odour emitted. The only disadvantage of Envac waste collection technique is, it is expensive.

2.5.5 Primary and secondary collection of solid waste

Primary Collection:

In this waste collection process, the primary collection is conducted door-to-door using a small, non-motorized vehicle like a handcart or animal cart. Once the primary collection container is full, its contents are directly transferred to a large motor vehicle, specifically designed for high-speed transport of full loads.

Secondary Collection:

The evaluation of this waste collection system can be based on the assumption that trailers used have a capacity of 6m3 and are replaced with full ones using an agricultural tractor. These full trailers are then transported to the disposal site by the tractor, which can travel at an 15 km/hr on an average speed. The number of trailers needed for this service primarily depends on the population density, as stated by UNEP in 2005.

2.5.6. Transfer and transport

The orthodox methods of conveying refuse to the discarding site include the implementing of baskets or wheelbarrows, as well as various types of vehicles, such as:

i. Close-top non-compacting trucks

ii. Open-top truck tippers

iii. Pulverizing trucks

Efficient planning and organization are crucial in the transportation of waste to achieve optimal results. Scheduling waste collection and transportation during periods when there are fewer people on the streets, such as at night or early morning, can enhance operational efficiency. Trucks and tippers may be employed for waste transportation whenever feasible (Onibokun and Adedipe, 2006).

2.5.7 Solid waste collection and storage

The techniques of solid waste collection can be classified into two main types:

i. Human labour: These methods involve using human-powered equipment and are particularly suitable for areas with limited access. Examples include two-wheeled dollies, push carts (scavengers), wheelbarrows and pedal cycles.

ii. Mechanical Driven Machines: These techniques utilise mechanical-driven collection equipment and are more practical in regions with better access. Examples include tricycles with hydraulic tripping containers mounted on the back, dinosaurs, mammoths, tippers, pay loaders, and trucks.

Regarding storage systems, there are two primary classifications:

i. Communal storage: This system includes stationary or portable communal refuse stations (depots) where common neighbourhood dumps are established. Each household in the neighbourhood is expected to transport and deposit its refuse at these designated locations (WHO, 2017).

ii. Household separate units: This system involves individual households managing their own waste separation and storage. It can be either temporary or permanent in nature. Temporary storage may consist of items like cardboard, cartons, and plastic bags, while permanent storage typically involves standardised containers such as plastic or metal bins with lids. However, it should be noted that these containers may be susceptible to damage from scavenging animals, leading to littering issues (Babayemi, 2019).

2.5.8 Solid waste disposal:

The disposal of solid waste involves the total removal of refuse from its initial point of generation to a designated disposal site. The process of waste disposal includes collection, transportation, treatment, and ultimately disposing of the waste in a manner that does not pose environmental nuisances (Sener *et al*., 2017).

The primary objective of refuse collection and disposal, particularly in the case of garbage, is to significantly reduce the risk of diseases and minimise the impact of hazardous waste on both the inhabitants and the environment. This requires active participation from residents in maintaining a clean and healthy environment (Sener *et al*., 2017).

To achieve effective waste disposal, various solid waste management methods are employed to promote a healthier environment. One of these methods is the use of sanitary landfills, which can also be referred to as controlled tipping. Sanitary landfills are considered the most satisfactory solid waste disposal system. They involve engineering a system where solid wastes are spread in layers, compacted to minimise their volume, and then covered with earth daily or more frequently to reduce environmental pollution (EPA, 2017). The process typically includes spreading a layer of refuse, compacting it with a bulldozer, covering it with a thin layer of soil, and repeating the process until the pit is filled (Olubori, 2016).

Merit of Sanitary landfills

Sanitary landfill, as a waste disposal method, does not require high technology to implement. It effectively addresses issues related to disease-carrying insects, rodents, and fire outbreaks that are commonly associated with open dump systems. It also significantly reduces odour problems and is relatively cost-effective to practise and maintain. Moreover, it helps avoid pollution issues to a great extent.

However, despite its importance, sanitary landfills still have some shortcomings, including vulnerability to weather conditions, which can impact their efficiency. Transporting large quantities of refuse over long distances can be more challenging and expensive. In urban centres, the scarcity of available land poses a significant challenge. Additionally, there is a risk of adulteration of underground water via leaching, and if the landfill is not rightly managed or checked, it could worsen into a regular open dump.

Another waste disposal method is composting, which involves the controlled biological decomposition of organic material to produce relatively stable humus-like material (Adebisi, 2015). This process generates heat through biological activities, which helps destroy pathogenic organisms and convert organic matter into a useful and odour-free product.

Composting offers several benefits, including a reduction in environmental pollution compared to landfilling and incineration. It also minimises leaching losses of added fertilisers as they are more effectively bound. Compost improves soil texture and water-holding capacity, and it provides essential trace elements like copper, zinc, and molybdenum that promote plant growth (Sener *et al*., 2017).

Shortcomings composing are as follow;

1. Composting, despite its benefits, has some shortcomings, which include the following:

2. Contamination: Composting mixed waste can lead to issues of contamination, making it challenging to ensure a consistently high-quality compost product.

3. High Costs: Both capital investment and operating costs for composting facilities are relatively high, which can pose financial challenges for implementation and maintenance.

4. Pathogens and Odour: Centralised composting facilities may face problems with pathogens and odours, as municipal solid waste can contain disease-causing bacteria, contributing to potential health risks.

5. Inorganic Waste Separation: Separating inorganic waste from organic waste with a high degree of accuracy can be a challenging task, making the composting process more complex and time-consuming.

Addressing these shortcomings requires careful management and investment to ensure that composting operations are efficient, cost-effective, and capable of producing high-quality compost while minimising potential health and environmental risks.

Demerits of Composing

(iii) Incineration

Solid waste incineration is a significant physical process of managing solid waste disposal and may simply be defined as a process whereby refuse are burnt to ashes and the ashes are taken to landfill sites for disposal (Adebisi, 2015). Incineration of solid waste is more of reduction technology than disposal technology: it has been observed in recent time that it accounts for about 80% -85% of the overall volume of solid waste within the municipality and about 98% -99% waste weighing off the combustible portion are possible through incineration (USEPA, 2015) Olubori (2016) stated that incineration has the following advantages.

i. High temperature processes kill disease vectors (flies, and rodents as well as other pathogens).

ii. It is compact and does not occupy much space.

iii. It does not endanger ground water quality.

iv. It results in volume and weight reduction and this improves the useful life of the available land disposal facilities.

Regardless of the fact that the method of incineration happens to be one of the most favoured techniques of disposal of waste, it also brings about air pollution (emitted during refuse burning) and it does not handle all types of waste, examples of inflammable objects like scraps, metal, iron etc.

(iv) Recycling

Solid waste incineration is a significant physical process used in waste disposal management, involving the burning of refuse to ashes, which are then taken to landfill sites for final disposal (Adebisi, 2015). Incineration is considered more of a waste reduction technology than a disposal method, as it can significantly reduce the volume and weight of municipal solid waste. It has been observed that about 80%-85% of the entire volume of solid waste municipally and approximately 98%-99% of the combustible portion can be reduced through incineration (USEPA, 2015). The advantages of incineration, as pointed out by Olubori (2016), include disease vector and pathogen eradication due to the high-temperature processes, compactness, non-endangerment of groundwater quality, and improvement of the useful life of landfill facilities.

However, despite being a preferred waste disposal technique, incineration has its drawbacks. It can cause air pollution due to emissions during the burning of refuse, and it is not suitable for handling all types of waste, particularly inflammable objects like scrap metal and iron.

Recycling, on the other hand, is the process of using solid waste as raw materials repeatedly for the same or different purposes (Olubori, 2016). It involves the processing of waste materials to retrieve useful raw materials for further use. Examples of recyclable solid waste include cans, scrap metals, glass, plastics, and paper. Recycling these materials helps conserve energy compared to using virgin materials for new products (Sener et al., 2017).

Advantages of Recycling

I. Recycling plays a crucial role in protecting the environment by mitigating the associated hazards with disposal of waste and reducing their impact on water, air, and land (Adesina, 2018). Furthermore, it contributes to the conservation of natural resources by lessening the demand for primary raw materials, resulting in significant resource savings. Additionally, recycling aids in the conservation of water resources, further promoting sustainable environmental practices.

(v) Solid Wastes Dumping at Sea

This waste disposal system involves treating the refuse before it is dumped into the sea. The treatment process uses chemicals that are non-toxic to aquatic life. However, there is a controversial aspect to this method, as the treated waste serves as food for marine animals. This has raised concerns among people, as they fear consuming fish that may have already been contaminated by feeding on the toxic waste.

(vi) OnSite Disposal

On-site disposal refers to the occasional practice of disposing certain kinds of refuse directly at the location of origin or on the site itself. The objective of on-site disposal is to minimize the size of waste that needs to be transported to the central disposal site. The most commonly utilised methods for on-site disposal are incineration and garbage grinders.

(vi) Animal or Swine Feeding

Animal feeding on garbage was very profitable system of disposal of solid waste at a time a in the United States. The problem connected with this technique is the separation of the garbage from the inedible materials. Animal or swine upbringing has not been large-scale in 3rd world country like Nigeria, so this technique is discouraged (Sener *et al.,* 2017).

2.6 Solid Waste Hazard Identification

Solid waste hazards can be described as substances possessing material goods that make them dangerous, leading to harmful effects on livestock, environment or human health or. Unfortunately, harmful wastes are produced from various sources, such as industrial and commercial manufacturing processes to items like batteries and fluorescent light bulbs. These hazardous wastes can exist in various states such as solids , gases, sludges and liquids. Which encompass diverse range, the Environmental Protection Agencies (EPA) have established a system to categorise specific hazardous materials and offer objective conditions including other materials in this category. Worldwide, it has been observed that industrial wastes contribute to approximately 80% of the total hazardous waste generated.

2.6.1 Municipal waste hazard

While industrial and manufacturing companies are major contributors to hazardous waste globally, it is essential to recognize that households can also generate solid wastes that may qualify as hazardous wastes. Examples of such household hazardous waste include spoilt food, old solvents, poultry dung, paints, pesticides, poisons, and expired drugs or fertilizers. However, attempting to control every household in the United States that rarely disposes of items like a paint thinner can or rat poison bottle would be impractical.

To address this issue, the Environmental Protection Agency (EPA) established the household waste exclusion. This exclusion excludes generated waste from usual household activities, such as yard maintenance and routine house, are exempted from being classified as harmful waste. This exclusion helps simplify waste management regulations and focuses on more significant sources of hazardous waste generation while acknowledging that occasional household disposal of certain items should not be subject to the same stringent regulations as industrial hazardous waste.

2.7 Global examples of solid waste management in both developed and developing countries

2.7.1 Solid Waste Management in United Kingdom

Solid waste management practices in the United Kingdom have evolved over the years, with successive waste management strategies in different regions setting ambitious goals for municipal waste and household recycling, as well as diverting waste from landfills. The UK government has been dedicated to aligning Municipal Solid Waste (MSW) in accordance with the EU's definition, including steady inclusion of commercial waste. This led to a reduction in the proportion of MSW being landfilled beginning in 2001 at 80% to 2010 at 49%. Recycling, both organic and material, has amplified significantly during this period, although growth slowed near the close of the decade. Regional differences in recycling charges have been observed.

The UK made significant progress in achieving its derogated 2010 diversion target for BMW (Biodegradable Municipal Waste) as stipulated in the Landfill Directive by 2006, and the 2013 derogated target was surpassed by 2009. The cumulative downstream and upstream involvement of MSW treatment in greenhouse gas emissions has come down from 12,400,000tonnes CO2-equivalent in 2001 to 4,300,000tonnes in 2010 based on a life-cycle approach.

The Landfill Allowance Trading Schemes (LATS) and the landfill tax escalator for vigorous waste played crucial roles in rapidly diverting waste from landfills and increasing recycling rates. The Packaging Waste Regulations, alongside the resilient Asian market for packaging waste and recyclers, has significant factors contributing to higher recycling rates. The development of WRAP UK has been an central programme for building capacity in waste management.

Overall, there is a high level of assurance the UK will meet its 50% MSW recycling target by 2020, but there are concerns regarding achieving the 2020 Landfill Management Directive target due to potential challenges in building the required recycling and recovery structures for waste that are organic.

2.7.2 Solid waste management in Sri Lanka (Sri Lanka environmental pollution control division 2012).

The management of solid waste is a significant challenge in Sri Lanka, particularly in urban areas like Colombo, where around 1500 tons of solid waste are generated daily. A large portion, around 80-85%, of the domestic solid waste in the municipal area of Sri Lanka comprising of organic waste, including municipal, garden waste and food. This organic fraction poses environmental hazards, contributing to erosion, flooding, and environmental degradation.

Solid waste disposal methods in Sri Lanka include collection from residential, commercial, and industrial sources, with waste being dumped in the outskirts of towns and cities in dumping sites. Indiscriminate composting, haphazard on-site refuse disposal, and illegal dumping on roadsides, open spaces, or water bodies are common practices. Collection methods vary, ranging from hand cart collection to tractor and trailer systems, but often suffer from poor sanitary conditions due to the presence of domestic animals foraging for food in the waste.

Composting is another system of disposing solid waste, but it is not widely employed due to misunderstandings and concerns, particularly during the rainy season. Landfill conditions are poor, and there is public opposition to landfill projects due to improper digging and planning. Food and kitchen waste from hotels often go to piggeries as an alternative disposal method.

Solid waste management is the responsibility of local authorities in Sri Lanka, and efforts are being made at the national level to develop a strategy for better waste management. The campaign towards minimal waste generation is ongoing.

In South Africa, solid waste management varies in nature and procedures. There are about 540 sanitary landfill sites, but only 61% of them are formally designated. The rest, approximately 15,000 sites, include communal sites and environmentally unsafe dumping areas. Of the 5 million tons of solid waste produced annually in South Africa, only 5% is disposed of on designated sites, leading to a significant amount of waste being disposed of in inappropriate locations.

The South African government has taken steps to control illegal refuse dumping, encouraging businesses to introduce reusable shopping bags and dishes. A program aimed at reducing plastic bag and disposable dish disposal achieved a reduction rate of 31% and 68% respectively. The involvement of the government has been instrumental in managing waste disposal practices.

2.8 Lessons Learnt from Case Studies

Governments and people worldwide recognize the importance of prioritizing waste management using available techniques to address the challenges of recycling and reusing solid waste materials. Solid waste management has become a critical aspect of public policy in many municipalities around the world. Recycling of waste is extensively acknowledged as an effective form of managing waste as it not only helps clear the surrounding of garbage but also generates income for the government and participating establishments.

While governments are aware of the environmental impact of unclear and improperly disposed wastes, they may face challenges in effectively managing the issue. Increasing private-public partnerships in waste collection, sorting, and disposal could be a reasonable approach to address this problem.

The 3R slogan (Reduce, Reuse, and Recycle) remains prevalent in many places, and it continues to be seen as one of the finest method employed in managing solid waste that both the public and governing bodies can adopt to guard the environment and human health. In regions like Europe, America, Asia, and the Australia, another use of solid waste as a source of energy is further prominent. However, in Africa, no country currently utilizes solid waste as a form of energy, despite proposals being passed in countries like Botswana and South Africa.

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Introduction

The technique(s) used in acquisition of data and information used in this research is considered. It explains the types of sources of data, sample size, procedures in data analysis, sampling procedure/method, and instruments/techniques for analysing data. The kinds of data used in this research was obtained from reconnaissance surveys, collection of soil and water samples, administration of structured questionnaires and referencing of associated secondary sources of data that improves the value of this thesis.

3.2 Research Design

This study is empirical in nature and necessitates steps in achieving it. The first feature of the research was gathering of secondary information for the research which form the foundation for the study. The design of a structured questionnaire that was used to obtain the relevant primary data relating to physical environmental implication of the final dump site. The procedure was done sequentially thus: identification of the final dump sites in Ilorin (Figure 3.1). It was followed by collection of soil and water samples around the final dump site information from the populaces of the study area including the agencies in charge of managing of the final solid waste dump site in Ilorin. The data was put to a reliability test and establish the level of reliability of this study. The process of this research followed the study objectives as seen below in Table 3.1.

The process is such that at the end of the research, the aim is achieved because all aspects of the objectives will be analysed sequentially.

Table 3.1 shows the objectives of the study, the data required and methods of data acquisition and analysis.

Table 3.1: Research Methodology Table

S/N	Research Objectives	Data Required	Method of Data Acquirement	Method of Data Analysis and Presentation
1	Examine the physical environmental implications of the final municipal solid waste disposal site located in Ilorin, Kwara State.	Physical characteristics of the dump site	Through the use of physical observation, photograph and structural questionnaires.	Descriptive analysis. The data was presented using pictures, table, and charts to interpret the information gotten from the site.
2	Analyse the environmental chemical consequences or effects of the municipal solid waste dump site in Ilorin, Kwara State.	Soil, water and air samples	Through the help of collection of primary data, by use of Crowcon Gasman $Co_{2,}$ plastic bottle and base to fetch water and soil samples to the laboratory for physico-chemical analysis, GPS and Camera to take Photography.	Laboratory analysis and Linear Correlation. The data was presented using Tables, Pie chart and Bar charts.
3	Examine the environmental and health implications associated with the municipal solid waste dump site in Ilorin, Kwara State.	Environmental and Health data	Through Hospital data, questionnaire administration and oral interview	Descriptive analysis. The data was presented using Tables, Pie chart and Bar charts.
4	Determine the management system of the final municipal solid waste disposal site located in Ilorin, Kwara State.	Management system on final municipal solid waste disposal.	Questionnaire administration, personal observation, face to face interview with relevant stakeholders coupled with household inventory.	Descriptive analysis. The data was presented using tables, pictures and charts to deduce the information acquired from the site.

3.3 Population and sampling techniques

The study focuses on the immediate settlement surrounding the final dump site, which is considered to be more vulnerable. However, determining the population of the residents proved challenging as many settlements did not exist during the last National Population and Housing Census in 2006. To overcome this, purposive sampling techniques were employed to select people living close to the final solid waste dump. A total of 400 well-structured questionnaires were distributed, and 370 were successfully collected.

3.4 Methods / Sources of Data Collection

For this study, the primary data collected includes the following:

3.4.1 Reconnaissance Survey

Reconnaissance Survey: This crucial step provided a comprehensive understanding of the study area, identifying potential challenges and ensuring accurate project execution. It helped in familiarizing with the entire sampling area.

3.4.2 Questionnaire

Questionnaire: A total of 400 well-structured questionnaires were administered to both male and female residents in the vicinity of the solid waste final dump site in Ilorin. The focus was on the settlements surrounding the final dump site.

3.4.3 Water Sampled and Soil Quality Sampled

Water and Soil Sampling: Water and soil samples were collected to assess their quality. Six plastic bottles of water were collected from near and far well water close to the final dump site at intervals of 25 meters, 45 meters, 55 meters, and 100 meters. Soil samples were also taken at the same points where water samples were collected, at intervals of 20 meters, 40 meters, and 60 meters, and labeled as Sample Point 1 Soil Sampled (SASS-A), Peke Soil Sampled (PSS-B), Point 2 Soil Sampled (ESS-C), and Point 3 Soil Sampled.

3.4.3.1 Laboratory Analysis

The study measured various parameters to assess the environmental impact of the final municipal solid waste dump site. For the water samples, the parameters tested for were: conductivity, biochemical oxygen demand (BOD), temperature, PH, chemical oxygen demand (COD), total dissolved solids (TDS), chloride, iron, calcium, copper, phenol (CPD), manganese, arsenic, cadmium, sulfate, lead, coliform, dissolved oxygen (DO), E. coli, fecal, mercury, and total plate count.

For the soil quality samples, the parameters tested for in the soil samples were: soil pH, total organic carbon, conductivity (siemens), organic matter, soil nitrogen, chloride, soil nitrate, sulfate, phenolic cpd, cadmium and arsenic. These parameters were analyzed using standardized techniques in the Central Services Laboratory of the Lower Niger River Basin Development Authority, Ilorin.

The coordinates of the sampled points' locations are presented in Table 3.2 and Table 3.3.

Table 3.2: Water Sample Points with Coordinates

S/N	Sample codes	Coordinates	
		Easting	**Northing**
1.	Point 1	8.46551	4.44666
2.	Point 2	8.46535	4.44646
3.	Point 3	8.46448	4.44608
4.	Point 4	8.46499	4.44628

Table 3.3: Soil Sample Points with Coordinates

S/N	Sample codes	Coordinates	
		Easting	**Northing**
1.	Point 1	8.46332	4.44223
2.	Point 2	8.46461	4.44111
3.	Point 3	8.46771	4.44071
4.	Point 4	8.46888	4.44883

3.5 Method of Data Analysis

Descriptive statistics, linear correlation and laboratory tests were used in analysing the collected data, and presented in tables, charts, and graphs for better clarity. This statistical method was chosen because it is suitable for analysing questionnaires and describing the opinions of respondents for each question. The environmental implications resulting from the final dump sites were categorized into three groups: Highly significant, Significant, and Not significant. These categories were presented in a table named "Definition of significance categories used in the Risk Assessment and Impact Assessment Matrix." For the analysis of questionnaires and the presentation of laboratory results for water, soil, and air quality, the Statistical Analysis Software (SAS, version 9.0) was used. This software facilitated the statistical analysis of the administered questionnaires and the presentation of the laboratory results in an organized manner.

CHAPTER FOUR

4.0 RESULT AND DISCUSSION

4.1 Physical Environmental Implications

This section focuses on specific problems associated with the presence of the solid waste final dump site. These problems include contaminated water, dust during harmattan, dust at the start and end of the rainy season, rodents and rats infestations, marring the environment‘s physical form, mosquitoes and houseflies, injuries from sharp objects in the dumps, smoke from burning waste and pollution from contaminated water. Table 4.1 presents the numerous exposures to solid waste hazards in the area of study, and the exposure is weighed using a Likert Scale. The scale ranges from strongly agreed (SA) to strongly disagreed (SD).

Table 4.1: Exposure to solid waste final dump site hazards

S/No	Hazard	Fixed Hazard Grade (1-5)					Grand Total
		Strongly Agree	Agree	Fair	Disagree	Strongly Disagree	
1	Foul water	48	88	60	134	40	370
2	Dust in the course of harmattan	4	16	19	180	151	**370**
3	Dust at the start of rainy season	27	24	200	62	57	**370**
4	Dust after the rainy season	201	26	105	16	22	**370**
5	Rats and other Rodents	7	50	40	53	220	**370**
6	Houseflies	30	45	40	65	190	**370**
7	Mosquitoes	6	16	51	122	175	**370**
8	Marring the physical form of the environment	7	30	47	86	200	**370**
9	Injuries from sharp objects of the dumps	150	70	48	85	17	**370**
10	Water pollution	15	10	12	133	200	**370**
11	Smoke from burning of the waste	29	9	52	55	225	**370**

Table 4.2 presents the responses regarding the exposure to solid waste hazards at the final dump site. The data includes Fixed Hazard Grade (FHG) and the Variable Numbers of Respondents (VRR), which ranges from 1 to 5, with 5 indicating the highest level of danger.

Table 4.2: Responses to Exposure to solid waste final dump site hazards

S/N	HAZARD	1 Poor	2 Fair	3 Average	4 Very Bad	5 Extremely Bad	Actual Grade
1	Foul water	0.15	0.47	0.50	1.42	0.57	**3.07**
2	Dust in the course of harmattan	0.01	0.09	0.15	1.95	2.03	**4.23**
3	Dust at the start of rainy season	0.09	0.13	1.65	0.63	0.72	**3.22**
4	Dust after the rainy season	0.53	0.15	0.85	0.19	0.33	**2.05**
5	Rats and other rodents	0.04	0.27	0.29	0.59	3.00	**4.19**
6	Houseflies	0.11	0.28	0.30	0.71	2.55	**3.95**
7	Mosquitoes	0.03	0.11	0.36	1.34	2.33	**4.17**
8	Marring the physical form of the environment	0.04	0.19	0.36	0.92	2.67	**4.18**
9	Injuries from sharp objects of the dumps	0.42	0.41	0.42	0.84	0.25	**2.34**
10	Water pollution	0.03	0.06	0.10	1.39	2.78	**4.36**
11	Smoke from burning of the Waste	0.11	0.07	0.40	0.63	2.95	**4.16**

$$AG = \frac{\sum FHG \times VNR}{(SSo)} \quad (1)$$

Actual Grade (AG) = $\frac{\text{Fixed Hazards Grade (FHG) X Variable Numbers of Respondents (VNR)}}{\text{Sample Size (SSo)}}$

Fixed Hazards Grade (FHG) – They are those fixed ranges from 1 to 5, where _1‘ means Very Good; _2‘ Good; _3‘ Average; _4‘ Very Poor and 5 is Extremely Dangerous.

Variable Numbers of Respondents (VRR) denotes the total figure for each grade based on the response.

Sample Size (SSo) denotes the study area‘s sample size, which is 370.

4.1.1 Measurements of physical implication of residing near the final waste dump site

i. 1.99 = Good State (Desirable)

ii. 2- 2.99 = Fair State

iii. 3- 3.99 = Average State

iv. 4- 4.99 = Very Bad State (Undesirable)

v. 5.0 = Extremely Bad (Extremely Undesirable)

Similarly, Table 4.1 shows that dust at the start of the rainy season, foul odour, and house flies are categorized as average, suggesting that these hazards exist to a moderate extent in the study area due to the presence of refuse dumps.

However, Table 4.1 further specifies that dust during harmattan, outbreak of rats and other rodents, mosquitoes, pollution of water, marring the environment‘s physical form, and smoke from waste burning are rated as very bad conditions on the ranging scale. This implies that there is a significant presence of health hazards resulting from the refuse dump site. Urgent measures are necessary to address these issues, as they pose a serious threat to the well-being of the residents, and if left unaddressed, the situation may worsen in the future.

Table 4.2 reveals that the conditions of dust at the end of the rainy season and injuries from sharp objects of the dumps are rated as fair, indicating that their impact on the people around the area is relatively minor.

4.1.2 Measurement of concern on environmental hazard of solid waste disposal

This aspect focuses on the hazard and effects of solid waste, taking into consideration various factors. Table 4.3 presents the measures of concern regarding the risk of exposure to the final dump site in Ilorin.

Table 4.3: Health Hazard

S/N	Measure of Risk	1 Poor	2 Fair	3 Average	4 Very Bad	5 Extremely Bad	Actual Grade
1	Dread of disease	16	35	100	143	76	**370**
2	Distress from foul Stench	20	25	125	50	150	**370**
3	Irritation from the view of the dump site	26	22	56	139	127	**370**
4	Fear of people leaving the neighbourhood	43	74	110	80	63	**370**
5	Dread of persecution by the environmental sanitation body	20	89	74	80	107	**370**
6	The neighbourhood being repulsive to needed businesses	35	15	43	127	150	**370**
7	Friends and relations not wanting to visit my family	26	14	67	123	139	**370**
8	Road blockage	21	46	53	151	99	**370**

Table 4.3 displays the residents' responses regarding their level of concern about the exposure to solid waste hazard from the final dump site. The data is categorized as Variable Numbers of

Respondents (VRR), and the Fixed Hazard Grade (FHG) ranges on a scale ranging from 1 to 5, with 5 indicating the most severe level of danger.

$$AG = \frac{\sum FHG\ X VNR}{(SSo)} \qquad (2)$$

Actual Grade (AG) = $\frac{\text{Fixed Hazards Grade (FHG) X Variable Numbers of Respondents (VNR)}}{\text{Sample Size (SSo)}}$

Fixed Hazards Grade (FHG) – They are those fixed ranges from 1 to 5, where ‗1' means poor,

‗2' is Fair , ‗3' is average, ‗4' is Very Poor and 5 is Extremely Dangerous. Variable Numbers of Respondents (VRR) – refers to the total number of responses for each grade. Sample Size (SSo) it is referred to as the sample size of the study area, which is 154.

Ranging Scale unit of Grading (from 1 to 5) are rated as

i. 0 - 1.99 denotes Very Good State (Desirable)
ii. 2 - 2.99 denotes Fair State
iii. 3 - 3.99 denotes Average State
iv. 4 - 4.99 denotes Very Bad State (Undesirable State)
v. 5.0 denotes Extremely Bad State (Undesirable State)

Table 4.3 indicates that concerns related to dread of disease, irritation from the view of the dump site, dread of persecution by the environmental sanitation body, distress from foul stench, dread of persecution by the environmental sanitation body, friends and relations not wanting to visit and road blockage within the average condition. This suggests that the presence of the refuse dump in the area leads to the occurrence of these health hazards in a relatively moderate manner, with minimal but existing impact on the residents.

4.2 Chemical Implications of final municipal solid waste dump site

4.2.1 Physio-chemical analysis of water source

The average of water pH was 7.67, while having a maximum value of 8, minimum of 7.29 and a standard deviation 0.11 (Table 4.4). EC and TDS show a similar pattern. The mean EC was 815.20µS/cm with a standard Error of 133.71µS/cm while a mean of 408.80mg/L was recorded for TDS with a Standard Error of 133.71mg/L.

Table 4.4. Summary Statistics of Water quality characteristics of the sample location and standard values for water quality.

Parameter	Mean	Standard Error	Minimum	Maximum	Standard	Recommending Agency
pH	7.68	0.12	7.30	8.00	< 8	WHO
EC (µS/cm)	816.20	134.71	298.00	1049.00	1000.00	WHO
TDS (mg/L)	409.80	67.55	149.00	525.00	500.00	WHO
DO (mg/L)	0.53	0.13	0.25	0.85	5.00	WHO
BOD (mg/L)	0.17	0.07	0.05	0.40	5.00	WHO
NO_3-N (mg/L)	2.58	0.55	0.90	3.80	10.00	WHO
PO_4-P (mg/L)	0.44	0.17	0.02	1.00	5.00	WHO
Temp. (°C)	29.20	0.66	27.00	31.00	NA	NA
Fe (mg/L)	0.47	0.12	0.29	0.89	0.30	SON
Cu (mg/L)	BDL	BDL	BDL	BDL	1.00	SON
Cr (mg/L)	BDL	BDL	BDL	BDL	0.05	SON
Zn (mg/L)	0.39	0.05	0.25	0.56	3.00	SON
Ni (mg/L)	0.40	0.04	0.33	0.50	0.02	SON
Cd (mg/L)	0.09	0.02	0.06	0.16	0.003	SON

EC= Electrical Conductivity, TDS= Total Dissolved Solids, DO= Dissolved Oxygen, BOD= NO3-N= NitrateNitrogen, PO4-P= Phosphate-Phosphorus, Temp.= Temperature, BDL= Below Detectable Limit, SON= Standard Organisation of Nigeria, NA= not available

The Water quality index and Metal Index showed a similar pattern of distribution in sample point 1, and sample point 2 increasing from 52.45 and 38.1 to 58.95, the lowest water quality index (WQI) of 45.03 was observed while in contrast sample point 3 recorded the highest MI value of 79.38 (Table 4.5).

Table 4.5 Water Quality and Metal indices of the three sampling locations

Sample point	Water Quality Index	Metal Index
1	52.45	38.5
2	58.95	56.11
3	55.25	49.51

Significant positive correlation was observed between Fe concentration and pH (r=0.76(P<0.01); Electrical Conductivity and BOD (r=0.46)(P<0.05), NO3-N (r=0.83)(P<0.01), Surface Water Temperature (0.68)(P<0.05) and Zn (0.57)(P<0.05); TDS with BOD (r=0.45)(P<0.05) and N03-N (r=0.83)(p<0.01), Surface Water Temperature (0.69)(P<0.01) and Zn (r=0.58)(P<0.01); DO with BOD (r=0.40)(p<0.05); N03-N with P04-P (r=0.56), Temperature (r=0.69)(P<0.01) and Zn (r=0.82)(P<0.01); PO4-P with Zn (r=0.62)(P<0.01) and Ni (r=0.50)(P<0.05); Temperature with Zn (r=0.86)(P<0.01); and Ni with Cd (r=0.74)(p<0.01), this data can be seen in table 4.6.

Table 4.6 Pearson Correlation Coefficient of physicochemical characteristics of sample water.

	pH	*EC*	*TDS*	*DO*	*BOD*	*$N0_3$-N*	*PO^1-P*	*Temp.*	*Fe*	*Zn*	*NI*	*Cd*
pH	1.00											
EC	0.37	1.00										
TDS	0.36	1.00	1.00									
DO	-0.23	-0.53*	-0.53*	1.00								
BOD	0.34	0.46*	0.45*	0.40*	1.00							
$N0_3$-N	-0.19	0.83**	0.83**	-0.50*	0.26	1.00						
PO_4-P	-0.15	0.30	0.30	-0.73**	-0.20	0.56*	1.00					
Temp.	-0.05	0.68*	0.69**	-0.64**	-0.24	0.69**	0.21	1.00				
Fe	0.76**	0.21	0.21	-0.15	-0.05	-0.31	-0.52*	0.27	1.00			
Zn	-0.35	0.57*	0.58*	-0.73**	-0.33	0.82**	0.62**	0.86**	-0.21	1.00		
NI	-0.10	-0.43*	-0.44*	0.06	0.03	-0.25	0.50*	-0.74**	-0.60**	-0.33	1.00	
Cd	-0.11	-0.89**	-0.90**	0.34	-0.33	-0.80**	-0.03	-0.83**	-0.23	-0.64**	0.74**	1.00

EC= Electrical Conductivity, TDS= Total Dissolved Solids, Temp.= Surface Water Temperature, DO= Dissolved Oxygen, BOD = Biochemical

Oxygen Demand, PO_4-P= Phosphate-Phosphorus, $N0_3$-N = Nitrate-Nitrogen, *Significant P<0.05, **Significant P<0.01

4.2.2 Implication of solid waste final dump site on soil

In analysing the soil samples, Gabriel and Stephen, 2009 method was used. The first step was to air dry the soil samples overnight in an oven at 32 ^{o} C. 200 mesh size sieve was used to mechanically ground and sieve the dried soil samples. Five grams of each sieved sample was placed in an Erlenmeyer flask and 2.5 ml of extracting solution (0.05NHCl + 0.024 H2S04) was added to the mixture and was placed in a mechanical shaker for 15 minutes. Whatman filter paper was used to filter the resulting solution through a 50 ml volumetric flask and diluted to 50 ml with the extraction solution. Atomic Absorption spectrophoto meter was used to analyse the treated samples for heavy metals. PHmeter was used for the analysis of pH. The results of the analysis can be seen in table 4.7.

Table 4.7: Characteristics of Soil samples

Parameters (mg/kg)	S1A	S2A	S3A	S4A	S5A	Maximum Acceptable concentration by WHO mg/l	Maximum Acceptable concentration by NAFDAC mg/l
PH	5.81	5.7	5.69	5.67 0	5.65 0	0.010	0.010
PB	0.029	0.024	0.020	0.016	0.024	0.003	-
CD	ND	ND	ND	ND	ND	5.000	5.000
CA	11.531	11.692	12.181	11.594	11.617	2.000	-
CU	2.701	2.816	2.983	3.007	2.864	-	-
NI	4.65 0	4.78 0	5.61 1	4.99 0	5.08 6	0.050	-
CR	0.271	0.264	0.27 9	0.272	0.270	0.050-0.300	-
ZN	12.40 0	12.56 0	11.98	12.39 0	12.461	0.500	-
NA	15.35 0	14.98 0	15.61	14.68 0	15.46	50.000	30.000
MN	6.70 0	5.99 6	6.42 1	6.22 6	5.98 1	50.000	75.000
MG	13.051	13.021	12.520	12.75 0	13.52 5	-	-
FE	39.65 0	37.47 5	37.52 5	37.771	37.80 0	1.000-2.000	10.000
K	6.100	6.050	6.020	6.000	6.030	200.000	200.000
CI	5.421	11.704	22.506	17.803	21.221	50.000	50.000

Table 4.7 presents the characteristics of the surface of the soil samples, at a depth of 0.5 m and a depth of 1.0 m respectively. Cadmium was not identified which indicated that cadmium made up resources were not dumped on the site. The pH values ranged from 5.65 to 5.81 which indicates that the surface of the dumpsite is slightly acidic. Heavy metals were identified among the soil samples examined which is an indication that industrial and hazardous materials were dumped on the site (Plate III and IV). This reveals that as we move

from the surface to a depth of 0.5 m, the pH tends to be neutral which can be ascribed to sorption among the soil particles in the region (Plate IV). The pH values ranged from 4.70 to 4.98 which was less compared to pH value range. This may be caused by some acid genic activities which may have occurred between the depth of 0.5m and 1.0m.

Plate III: Evidence of biomedical waste dump at solid waste dump sites

Plate IV: Evidence of biomedical waste dump at solid waste dump sites in Peke

Plate V Soil sample collected at 5m depth.

4.3 Environmental Health Implication of solid waste at final dump site

Uncontrolled final waste dump site is a grave danger to its immediate environment because it leaves the environment dirty and polluted hence posing threats to the health of the inhabitants (Table 4.8).

Table 4.8: Environmental Effects of final waste dump site

S/No	Method of Refuse Disposal	Environmental Effects
1	Burning (Plate VI)	- Release of Co2 -Air quality reduction -Global warming
2	Controlled Tipping	-No adverse effect -Clean environment for the residence
3	Landfills (Plate iv)	-Air pollution -Degradation of soil -Ground water contamination -Constitutes breeding grounds for rodents and other harmful creatures
4	Road side/ drainage	- Flooding of the environment due to drainage channels blockage -Air pollution -The environment becomes a Breeding ground for mosquitoes and other harmful insects -Contributes to prevalence of diseases such as cholera, typhoid, malaria, dysentery, etc

Clean environment etiquette needs to be imbibed so that future generations would be able to benefit opyimally from the environment. There is a need for upgrading of this environment in order to forestall degradation of the environment.

4.3.1 Environmental Related Illness

According to hospital (Sobi Specialist Hospital, Lifefount Hospital, Olarewaju Hospital, Olatayo Hospital and Delniks Hospital) records, the prevalence of typhoid, malaria and diarrhea is higher in the Aiyekale, Peke, and Eiyekorin areas, which provides evidence of the adverse effects of the final solid waste dump site in these regions. Many of the dumpsites create blemish on the landscape and emit bad odours due to organic matter decomposition, leading to significant impacts on the environment's aesthetics and public health.

From the available records, five major illnesses were identified as environmentally related: cholera, malaria, measles, typhoid and infections. Exposure to substances or toxins in the environment expose people to sickness. Increased exposure to infection increases the likelihood of getting ill. Environmental features such as waste dumps create favorable conditions for the breeding of malaria vectors and the reproduction of parasites within them. However, it is noted that the rate of Anopheles breeding tends to reduce as urbanization increases.

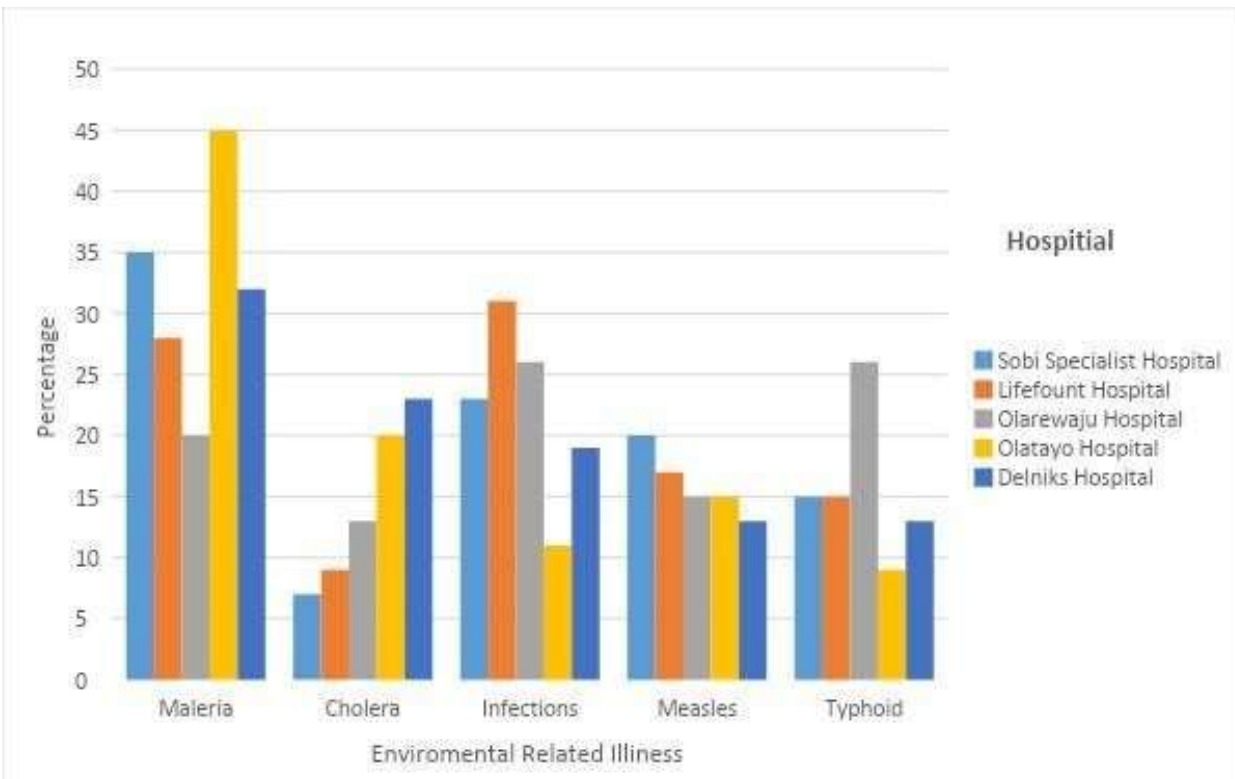

Figure 4.1: Environmental illness attended to by each hospital in the area
Source: Authors analysis 2022

From the available records collected from five different hospital close to the final dump sites in

Ilorin, the hospitals are: Sobi Specialist Hospital, Lifefount Hospital, Olarewaju Hospital, Olatayo Hospital and Delniks Hospital. From Sobi specialist hospital 33% of frequent ailments in the area is Malaria, 21% Measles, 8% Cholera, 15% Typhoid, 23% infections. In Lifefount Hospital, 17% Typhoid 29% is Malaria, 31% infection, 5% Cholera, 18% Measles. Olarewaju Hospital, 13% Cholera, 22% is Malaria, 27% infection, 24% Typhoid, 14% Measles, Olatayo Hospital, 21% Cholera, 49% is Malaria, 9% is infection, 8% Typhoid 13% is Measles. Delniks Hospital, 24% is Cholera, 19% is infection, 33% is Malaria, 11% Measles while 13% is Typhoid.

4.4 Management System for final waste dump site in Ilorin

Ilorin has three major designated locations for solid waste final dump sites, namely point 1, point 2, and point 3, located along the Ilorin-Ogbomoso express road as shown in figure 4.2.

Figure 4.2 Map showing the three designated solid waste final dump sites in Ilorin

These sites were originally open swamps that were gradually reclaimed by disposing of waste. The primary focus was on getting rid of the waste rather than considering the environmental implications of waste management activities. Kwara Environmental & Protection Agency (KWEPA) oversees the operations of these three final waste dump sites in Ilorin, where wastes from various parts of the city are deposited.

KWEPA is responsible for managing these final dump sites, and it is essential that they adhere to international standards to minimize their negative effects on the surrounding communities. Lee and Jones (2016), the key variance between a final dump site and a waste dump lies in the daily covering of each day's waste with a thin layer of soil. This practice helps reduce unpleasant odors associated with previously deposited waste and also restricts vermin and disease vectors like birds, rodents, and flies from accessing the waste.

During visits to the three dump sites in Ilorin and interviews with KWEPA officials, it was discovered that this soil-covering practice is not yet implemented due to financial and technical challenges. Moreover, it was found that the dump site at Peke is mainly reserved for use by private refuse collectors, indicating poor management practices at the sites. Refuse burning is still a common practice at two sites, and the resulting smoke has become a major complaint among some residents (Plate VI).

Plate VI: Burning of waste at Ayenkori dump site

The presence of human scavengers is highly noticeable at the final dump sites. These scavengers often approach cart pushers and convince them to dispose of their waste nearby so that they can scavenge for reusable materials in the discarded waste (Plate VII).

Plate VII: Activities of scavengers at the dump sites

Plate VIII: Activities of scavengers at Peke dump sites

Plate IX: Human activities of at Peke dump sites

This has worsened the aesthetics of the management of the final waste dump sites. However, some steps have been taken by KWEPA to reduce the impact of the final dump site. These include covering with different chemicals to lessen odour and insects as well as pests at the site, among others(Plate X).

Plate X: Waste being sprayed with chemicals

The final dump sites are staffed with personnel responsible for monitoring the waste disposal activities and maintaining records of the site's operations Plates XI, XII and XIII shows such at the site. Table 4.10 provides details about the available facilities and the labor force at these dump sites.

Table 4.10. Available facilities and labour at the final dump site.

Property	**Site**
Capability (Tonnes annually)	1,000,000 3 CAT Bulldozers
Type and number of facilities	1 CAT 215 excavator
	1 CAT 950 pay loader
Daily waste received per volume (Metric tonnes)	5,000
Staff at the landfill site	15

Plate XI: Existing facility used by KWEPA at the dump sites

Plate XII: Existing facility used by KWEPA at the dump sites

Plate XIII: Existing facility used by KWEPA at the dump sites.

Conversations with key KWEPA officials unveiled that the existing facilities and personnel at the final dump sites are severely insufficient to ensure effective management. The inadequacy of personnel and facilities can be attributed to the lack of adequate funding from the State Government. As a result, the management of these locations does not meet standards internationally for proper final dump site management. This deficiency has exacerbated the adverse impacts stemming from the location and management of the final dump sites.

CHAPTER FIVE

5.0 CONCLUSION, RECOMMENDATIONS AND CONTRIBUTION TO KNOWLEDGE

5.1 Conclusion

The final municipal solid waste dump sites have significant environmental and physical implications. These include the presence of foul water, dust during the harmattan season, dust at the beginning and end of the rainy season, attacks by rats and rodents, the abundance of houseflies and mosquitoes and the degradation of the overall appearance of the environment. Injuries caused by sharp objects within the dump are also a concern. Furthermore, the dumping of waste results in the pollution of water bodies, and the burning of waste contributes to the emission of harmful smoke.

Regarding the physico-chemical analysis of water sources, the mean pH of the available water was measured at 7.68, with a maximum value of 8, a minimum of 7.30, and a standard deviation of 0.12 (Table 4.5). The total dissolved solids (TDS) and electrical conductivity (EC) followed a similar pattern across the three sample locations. In site 1, EC increased from 1000 to 1049 µS/cm, while in site 2, it reached 500 mg/L. Then, both EC and TDS decreased steadily in site 3. The mean EC was calculated to be 816.20 µS/cm with a standard error of 134.71 µS/cm, while the mean TDS recorded was 409.80 mg/L with a standard error of 134.71 mg/L.

The study further analyzed the water quality index (WQI) and metal index (MI) in relation to the solid waste final dump sites. The WQI and MI showed a similar trend in site 1 and site 2, with the WQI increasing from 52.45 to 58.95. The lowest WQI value of 45.03 was observed, while Peke recorded the highest MI value of 79.38. These findings indicate that the water quality at the dump sites is negatively impacted by waste disposal activities, with certain locations showing higher levels of contamination and degradation.

Regarding the soil analysis, Cadmium was not detected, indicating that materials containing cadmium were not dumped on the site. The pH values alternated from 5.65 to 5.81, suggesting that the surface of the dumpsite is slightly acidic. Heavy metals were detected in the soil samples, indicating the dumping of industrial and hazardous materials on the site. The pH values ranged from 6.20 to 6.81 at a depth of 0.5m, showing a tendency towards neutral pH due to sorption among the soil particles in the region. However, between the depth of 0.5m and 1.0m, the pH values ranged from 4.70 to 4.99, indicating some acidogenic activities in that layer.

The study also highlighted the environmental health implications of uncontrolled solid waste final dump sites, which pose a severe threat to human health and the immediate environment. These dumpsites make the environment dirty and polluted, leading to health risks for the inhabitants. Records indicate that five major illnesses related to the environment were identified, including cholera, malaria, measles, typhoid and infections. These illnesses occur due to exposure to toxins or harmful substances in the environment, which can make people sick. Waste dumps create favorable conditions for the breeding of malaria vectors and parasites, while urbanization tends to reduce Anopheles breeding rates.

The designated location for solid waste final dump sites is primarily along the Ilorin-Ogbomoso express road, covering an area of about 20 hectares. Unfortunately, the environmental effects of waste management activities at these sites were of minor significance to simply disposing of the waste. The Kwara Environmental & Protection Agency (KWEPA) is responsible for managing these final dump sites, but it was revealed that the facilities and personnel at the sites are grossly inadequate for proper management. Conforming to international standards is crucial to mitigate the adverse impacts on the communities surrounding these dump sites.

This study has highlighted the inadequate and non-compliant operations of waste final dump sites in Ilorin, Nigeria, with international standards. Consequently, there is an increase in the population of insects and rodents, litter blowing around, and the occurrence of odors, leading to environmental degradation. This finding aligns with earlier research by Arimah and Adinnu (2005). The implications of this revelation have practical implications for the siting of solid waste final dump sites in Nigerian urban areas.

Although it might be tempting to propose locating final waste dump sites far away from human settlements to minimize negative impacts, this approach may not be feasible due to the scarcity of urban land, especially in cities like Ilorin. Over time, new settlements could emerge around the dump sites, exacerbating the problem. Instead, a more pragmatic solution involves adopting proper design and management practices for dump sites within urban areas.

This approach should focus on enhancing the sanitary and aesthetic conditions of the dump sites, reducing the generation of greenhouse gases like methane, and mitigating the production of leachates that can contaminate underground water sources. By implementing such measures, final dump sites in Nigerian urban areas can become environmentally acceptable.

5.2 Recommendations

To address waste management practices in Nigeria, the following recommendations are suggested: municipal government in Nigeria should recognise solid waste management as a significant problem and allocate sufficient financial and other resources to address it efficiently and effectively

In cases where municipal resources internally are insufficient, establishments can consider studying the cost and benefits of waste collection and disposal processes contracting to private operators. Environmental Impact Statements (EIS) should be produced for all new large-scale dump sites in the country. These statements should not only consider the material features of environment and development but also assess the potential impact on the affected communities. Existing and future dump sites must adhere to appropriate physical planning and engineering standards. These standards should cover aspects such as solid waste transportation, tipping, availability, the quantity, and depth of sand (e.g. 15cm) to be spread within 24 hours of tipping, and fencing around the sites.

By implementing these recommendations, the management of solid waste final dump sites in Nigerian urban areas can be significantly improved, leading to better environmental protection and public health.

5.3 Contribution To Knowledge

The research was able to establish that the Physio-chemical analysis of water sources revealed that mean pH of the available water was found to be 7.68, with a maximum value of 8, minimum of 7.30 and a standard deviation 0.12 (Table 4.5). EC and TDS showed a similar trend across the three-sample location, increasing from concentrations of 1000 to 1049 and 500 mg/L in site 1 and site 2, respectively and then decreasing steadily in site 3. The mean EC was 816.20μS/cm with a standard Error of 134.71μS/cm while a mean of 409.80mg/L was recorded for TDS with a Standard Error of 134.71mg/L. The Water quality index and Metal Index showed a similar pattern of distribution in site 1, and site 2 increasing from 52.45 and 38.1 to 58.95, the lowest water quality index (WQI) of 45.03 was observed while in contrast Peke recorded the highest MI value of 79.38

Secondly, the research reveals that Cadmium was not detected which showed that cadmium made up materials were not dumped on the site. The pH values ranged from 5.65 to 5.81 which revealed the surface of the dumpsite is slightly acidic.Heavy metals were detected among the soil samples investigated which is an indication that industrial and hazardous materials were dumped on the site. The pH value ranged from 6.20 to 6.81 which were higher than the pH values range at the surface. This pointed out that as we move from the surface to a depth of 0.5 m, the pH tends to neutral which can be attributed to sorption among the soil particles in the region. The pH values ranged from 4.70 to 4.99 which was less compared to pH value range. This may be caused by some acidogenic activities which may have occurred between the depth of 0.5m and 1.0m.

Thirdly, the research also established the environmental Health Implication of solid waste final dump site uncontrolled of final waste dump site as a serious threat man and its immediate environment because it leaves the environment dirty, polluted thus posing threats to the health of the inhabitants from the available records, five major illness were identified as environmental related, these are Malaria, Cholera, Measles, Infections and Typhoid. These illnesses occur when people are exposed to toxins or substances in the environment that make them sick. The more people are exposed to infection the more they are likely to get ill. Environmental features such as waste dumps favour the breeding of malaria vectors, as well as parasite reproduction within them, while increased urbanisation tends to reduce the rate of Anopheles breeding.

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