UNIVERSITY OF ILORIN

THE THREE HUNDRED AND THIRD (303RD) INAUGURAL LECTURE

“MUNICIPAL SOLID WASTE: COMPLEXITIES IN THE TRANSITION FROM CRADLE TO GRAVE”

By

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DEPARTMENT OF WATER RESOURCES AND ENVIRONMENTAL ENGINEERING,
FACULTY OF ENGINEERING AND TECHNOLOGY,
UNIVERSITY OF ILORIN, NIGERIA

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Members of Staff (Academic and non-Academic),
My Lords Spiritual and Temporal,
Your Royal Highnesses,
Great students of University of Ilorin, particularly students of Water Resources and Environmental Engineering,
Esteemed Guests,
Gentlemen of the Press,
Distinguished Ladies and Gentlemen

Preamble

In the name of Allah, The Beneficent, The Merciful. All praises and adorations are due to Almighty Allah, our Creator, the Omnipotent, the Giver of life, and sustainer of the universe. May the peace and blessings of Allah be upon our noble Prophet Muhammed (SWT), whose teachings continue to guide, inspire, and shape our lives. Alhamdulilah Rabbil -alamin, I owe Thee unalloyed gratitude at all times, especially today, as one of my dreams is now a reality. I feel extremely honoured to stand before this distinguished audience to present an Inaugural Lecture.

Vice-Chancellor Sir, my blessings are numerous. I joined the service of the University of Ilorin on the 3rd of May, 1999 as a Graduate Assistant in the Department of Civil Engineering, Faculty of Engineering and Technology. I remember when I approached a senior staffer in the Registry Department for documentation, she said, perhaps out of obliviousness "welcome to our midst, baby lecturer". Yes, she was right, I was really an infant lecturer. I looked at the academic ladder with amazement; it has long finite steps that only the privileged and fortunate ones can reach the top. Alhamdulilah, I am happy to be counted today among the privileged and fortunate ones; rung by rung, the baby lecturer of yesterday has grown to be a full-fledged professor.

I was redeployed to the newly created Department of Water Resources and Environmental Engineering after serving meritoriously for 14 years and 4 months in the Department of Civil Engineering. To date, three inaugural lectures have been delivered from the Department of Civil Engineering. The first lecture titled "*Nation's Quest for Water*" was delivered by the second Vice-Chancellor of the Federal University of Technology, Minna; Prof. Suleyman Olatunji Adeyemi on the 27th of July, 1988, as the 31st Inaugural Lecture of the University. Our charismatic Oga, Prof. Bolaji AbdulFatai Sule, delivered the second on the 13th May, 2003 as the 65th Inaugural Lecture of the University, and was titled "*Water Security: Now and the Future*". The third was the 220th in the series, titled "*Exploring Local Materials for Building Development*", and delivered by Prof. Abdullahi Alao Jimoh on the 8th of December, 2022. Out of these inaugural lectures, only the first two are relevant to my area of specialisation, and both lectures dwelled on analyses and development of the water resources sector.

Vice-Chancellor Sir, today's inaugural lecture, which is titled "**Municipal Solid Waste: Complexities in the Transition from Cradle to Grave**", represents the **303rd** in the series of Inaugural Lectures to be delivered at the University of Ilorin and the **22nd** from the Faculty of Engineering and Technology. Incidentally, **page 303** of the glorious **Quran** (Suratul Kahf) is about pursuing excellence in one's work by using ingenuity to solve societal problems. It is indeed a blessed alignment with the above Qur'anic teaching and a profound honor for me as the founding Head of Department, to deliver the **1st** Inaugural Lecture from our highly rated Department of Water Resources and Environmental Engineering.

The title of this inaugural lecture was carefully selected to address issues pertaining to the life cycle of solid waste from its generation (***cradle***) through to its disposal point (***grave***). This could appear to many as an easy ***transition***, but it is actually much more complex, because it is laced with multi-faceted challenges. In this regard, I have made significant efforts in my research to address these challenges through scientific and engineering approaches.

Introduction

Vice-Chancellor Sir, water and several environmental problems are among the top emerging issues that have significance at local, national and global level. Water typifies the liquid state of matter and it is an abundant natural resource distinctively occupying about 75% of the Earth's surface and 50-90% of the weight of living organisms (**Aremu** *et al.*, 2013b; **Aremu**, 2015). Water generally sustains humans and the ecosystem, and its main uses include drinking, application in various domestic, spiritual or cultural, commercial and industrial activities, transportation, agriculture, livelihood, recreation and tourism, energy generation and fire-fighting.

The term "water resources" is used to represent the potential sources of water for use, and they include: surface water (e.g. lakes, rivers and streams), groundwater (e.g. springs, aquifers, wells and boreholes), and atmospheric water (water vapour). The Environment is the entirety of man's surroundings, and it includes natural forces and other living things, which provide conditions for development and growth as well as avenues of danger, disaster and damage. The natural environment encompasses all living and non-living things occurring naturally on Earth. However, when humans modify the natural environment for specific needs, the environment becomes man-made or “built environment”.

This continuous modification of the natural environment in addition to expanding global population and economy, presents several challenges to man and the environment. One of these challenges is discarded materials commonly known as *waste*, which result from daily domestic activities, manufacturing processes, commercial activities, agriculture, construction, institutional ventures and municipal services. *Waste* generally refers to an unwanted material, that is useless or worthless and of no value to the possessor (**Aremu** & Sule, 2017) while solid waste is a non-liquid, non-gaseous material which is of no use any longer to the owner. It includes food wastes, paper, cardboard, plastics, textiles, rubber, yard wastes, wood, straw, glass, tin cans, metals, and ashes. The term (solid waste) is *subjective* in nature because the possessor determines at a particular moment what is considered a waste (Adu & **Aremu**, 2012).

From this perspective, what one individual discards as waste can represent a highly valuable resource to another. This concept forms the core principle of scavenging in Nigeria, a practice identified by several descriptive terms. In the North, the Hausa people commonly refer to these scavengers as *Baban Boola*, *Kọndem Iron*, or *’Yan Ajaokuta*. The Yorubas in the South-Western part of Nigeria use terms such as *Bọ̀lọ̀-bọ̀lọ̀, Aṣalẹ̀*, or *Tulẹ̀tulẹ̀*. Similarly, in the South-East, the Igbo describe this group of people as *Akpakara* or *Otuturu Ota*.

Over the course of time, population growth and urban sprawl alongside intensified social and economic activities, have resulted in a phenomenal increase in the volume, diversity and burden of solid wastes globally (**Aremu** *et al.*, 2010; **Aremu** & Sule, 2010). As such solid waste is one of the most underestimated threats to human existence on Earth. The World Bank (2024), estimated that Nigeria produces approximately 44.5 million metric tonnes (MT) of solid waste each year, and a significant portion of this remains uncollected, contributing to soil contamination, climate change, and the pollution of air, water, and marine ecosystems. Also, it is estimated that the world generated about 2.6 billion tonnes of municipal solid waste in 2022 and as at this year, about 30 percent of global solid waste is still either openly dumped or left uncollected, thereby compounding the risks to local economies, public health, and the environment (Cook *et al*., 2026). The problems of unmanaged wastes are felt more by developing countries due to multidimensional issues (such as socio-economic crisis, governance and technology) and citizens often rely on crude forms of solid waste disposal (**Aremu** *et al*., 2012).

As an Engineer, I intend to look at the complexities which are related to the use of technology in the ***transition*** of municipal solid waste from the point of generation (***cradle***) to point of disposal (***grave***). These operational complexities include determining the optimal location, size and quantity of municipal waste bins; analyses of collection operation and route optimization; workload distribution; and evaluation of impacts on the society and the Government. In broad terms when these complexities are resolved, the roadmap to cleaner cities is guaranteed.

Water Resources and Environmental Engineering Discipline

Vice-Chancellor Sir, Water Resources and Environmental Engineering have long been two distinct specialist fields in Civil Engineering. However, the evolution of several water, sanitation and environmental challenges necessitate taking up new skills, capabilities, perspectives and more importantly a *categorised focus* approach to tackle these challenges. This informed the wisdom of the then Vice-Chancellor of University of Ilorin, Prof. AbdulGaniyu Ambali *OON*, to graciously approve in the year 2013, the creation of the Department of Water Resources and Environmental Engineering and subsequent redeployment of some seasoned academic and technical staff to the new Department including my humble self as the pioneer Head.

Water Resources and Environmental Engineering, as a branch of Engineering, is concerned with the prediction, planning, development and management of water resources, and the application of engineering principles to improve and protect the environment (**Aremu**, 2015). Hence, Water Resources and Environmental Engineers combine knowledge of physical and biological sciences with engineering to solve problems related to unfavorable natural phenomena, population growth, industrialisation and urbanisation. Areas of specialisation in Water and Environmental Engineering include hydraulics, hydrology, coastal engineering, flood and erosion control, reservoir operation and management, irrigation and drainage, water supply, sanitation, air pollution control, air, soil and water remediation, hazardous waste treatment and disposal, wastewater management, solid waste management and green engineering.

Municipal Solid Waste Management

The concept of a municipal (city) solid waste management system is the engagement of multiple activities to handle solid wastes from the point of waste generation to ultimate disposal point i.e. ***from cradle* to *grave***. In all societies, environmental, social, economic and health concerns have made solid waste management an integral part of developmental goal. The specific goals of municipal solid waste management are to:

i. Protect public health: prevention of transmission of diseases and spread of epidemics.
ii. Maintain and sustain the quality of the environment: prevention of degradation (pollution) of the quality of urban and natural environment.
iii. Furnish economic returns and act a source of livelihood: generation of employment, income from service provision, salvaged materials and energy.
iv. Conserve materials and generate energy: resource and energy recovery, reuse and recycling of materials.

The typical features of a municipal solid waste management system are shown in Figure 1. The system is a ***transitional*** process which comprises of the following stages:

1. *Solid waste generation*: This represents the ***Cradle***; i.e solid waste production from different sources such as

households, offices, shops, markets, schools, motor parks, street sweepings and litter, that end up in the municipal waste bin.

2. *Source separation*: It is the segregation of solid waste into various components. On-site segregation of solid waste is intended to assist in materials recovery, reduction in management costs, and elimination of hazardous wastes from the waste stream right from the point of generation.
3. *Storage:* This is the temporary containerisation of solid waste in a standard enclosure. Storage of municipal solid wastes prior to collection could be in household bins, disposable paper or polyethylene bags, trash bags, refuse chutes, waste baskets, dumpsters, depots or municipal storage bins.
4. *Collection*: It is the movement of wastes from the point of storage to a transfer station, processing facility or disposal site. The means of collecting wastes include trolleys, pushcarts, pedal tricycles, wheelbarrows, carts and wagons drawn by animals, wagon drawn by a motorcycle, skip trucks, mechanized collection vehicles, roll on- roll off trucks, compaction trucks, light and heavy-duty tractor trailers, container trains and conveyors.
5. *Transfer and transport*: This is movement of the collected wastes from small collection vehicles to large capacity vehicles or trailers. This activity occurs at a transfer station.
6. *Material processing and recovery*: This is the act of extracting secondary materials or energy out of solid waste. Material recovery from solid wastes could be in form of solid waste re-use, recycling or composting of the organic fraction of wastes.
7. *Solid waste disposal*: is the permanent place (***Grave***), where solid waste is placed after exhausting other processes in the chain of solid waste management.

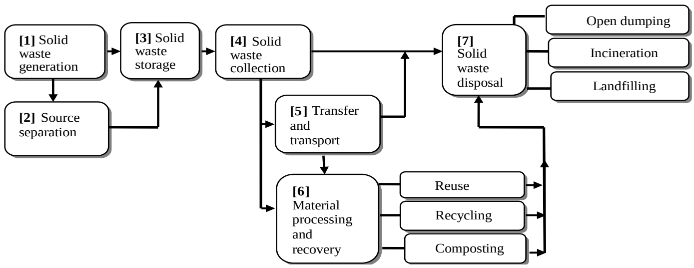

Fig. 1: Typical features of a municipal solid waste management system

The Stages commonly in use by municipal authorities in Nigeria, including Ilorin, are [1] - [3] - [4] - [7], while some cities in Nigeria, such as Lagos, have introduced Stage [5]. The Recovery part of Stage [6] is mainly done informally through scavenging and reselling of recovered items from waste bins and dumps, while some cities now have a formal arrangement for material processing and recovery under a Public-Private Partnership. Reuse of waste materials is mainly at household level while the informal sector is prominent in recycling and composting. Open dumping and landfilling are the most common form of disposal in Nigeria while incineration of wastes have been reported as used in some cities in Nigeria for medical and hazardous waste management.

Even with adoption of the least sophisticated method of solid management in Nigeria, there exist several operational complexities which include determining where to site municipal waste bins, the size and quantity to be sited, collection route optimization, workload distribution among workers, and evaluation of impacts of a strategic intervention on the society and the Government. In this lecture, I specifically intend to relay to this distinguished audience, step by step, how these complexities were resolved thereby reinforcing the roadmap to cleaner cities.

The Hauled Container System for Municipal Solid Waste Collection

Vice-Chancellor Sir, municipal authorities have over the years shifted from the use of open depots to the use of large containers which can be placed and emptied mechanically. This system is the Hauled Container System (HCS) and it requires solid waste generators to dump their pre-stored wastes into large containers provided by the municipal authority. The mode of operation of the HCS is either by the Conventional Mode or the Exchange Container Mode.

In the Conventional Mode (Fig. 2a), the day's collection operation starts with the departure of collection vehicle from the garage to pick up a full waste bin at the first service point, S_1. The full waste bin is then hauled to the disposal site where the contents are emptied and the empty waste bin is returned to the same service point, S_1. The collection vehicle then moves to next service point, S_2 and the sequence continues. After the last waste bin is brought back to the last service point S_n, the vehicle returns to the garage thereby completing the day's collection operation.

To start daily collection operation using the Exchange Container Mode (Fig. 2b), the vehicle leaves the garage with an empty waste bin, and drops it at service point S_1 in exchange for a full waste bin. The full waste bin is then hauled to the disposal site where its contents are emptied and the empty waste bin is taken to another service point, S_2. The cycle continues and after the last full waste bin at service point, S_n is emptied, the vehicle and empty waste bin are returned to the garage marking the end of the daily collection operation.

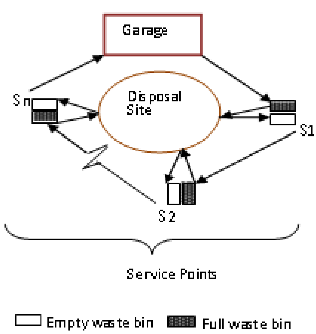

Fig. 2a: Operational Sequence for the Conventional Mode

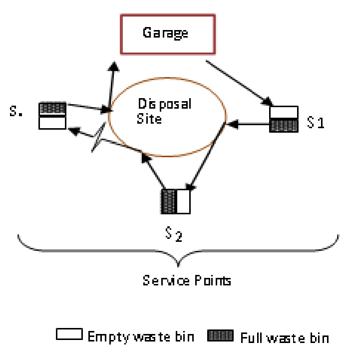

Fig. 2b: Operational Sequence for the Exchange Container Mode

Source: **Aremu** *et al.* (2011b)

The major difference between the two modes is that the Exchange Container Mode has zero inter-waste bin haul distance, reduced haul distance and time, but it requires an additional waste bin for its operations (**Aremu** *et al.*, 2013a). However, these two collection modes form a system that has several complexities which when investigated and incorporated into the solid waste management effort, could enhance service delivery in developing cities.

Development of a Model for the Hauled Container System

Vice-Chancellor Sir, my team and I thoroughly investigated the HCS of municipal solid waste collection, using developed baseline variables (**Aremu** *et al.*, 2010; **Aremu** *et al.*, 2011b; **Aremu**, 2013; **Aremu** *et al.*, 2013a). A simulation model was developed by **Aremu** *et al.* (2010) to calculate the time required for solid waste collection trips. To achieve this aim, collection operation was separated into unit operations (Pick-up, Haul to Site, Disposal, Haul from Site, and Drop-down) as shown in Figure 3. The time required to perform these unit operations was simulated from field data obtained from a diesel-engine medium- duty truck *Iveco Euro Cargo 100E18*, manufactured by Iveco Company, Turin, Italy. Series of time studies gave an idea of the time for the stationary operations (Pick-up, Disposal, and Drop-down) while motion studies provided an idea of Haul to Site, and Haul from Site time.

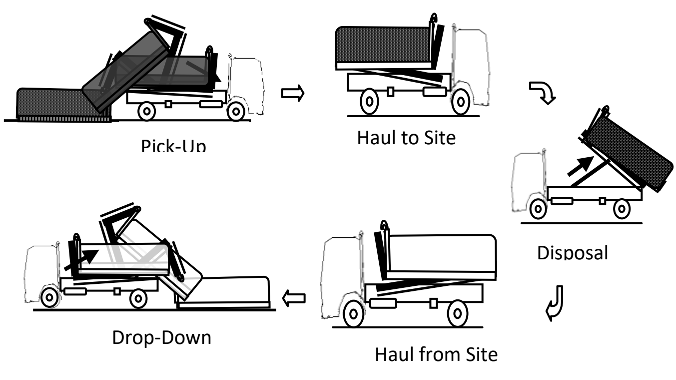

Fig. 3: Unit operations in a solid waste collection trip

Source: **Aremu** *et al.* (2010)

When the time to perform the different unit operations are aggregated with service and traffic conditions, the developed trip time for a collection operation is given as:

$$T_{tt} = \alpha\left(P_{ut} + P_{dt} + S_t + h_{ts} + h_{fs} + D_t\right)$$

Where,

T_{tt}= time for collecting solid waste, hr/trip

α = off - route factor, which accounts for the time spent on off-route activities

P_{ut} = Average pick-up time, hr/trip; P_{dt} = Average drop-down time, hr/trip;

s_t= Average at –disposal site time, hr/trip; h_{ts} = Haul time to disposal site, hr/trip;

h_{fs} = Haul time from disposal site per trip, hr/trip; D_t= Total delay

$$D_t = t_{turn} * N_{turn} + t_{inter} * N_{inter}$$

Where;

t_{turn} is the average time spent at turns; t_{inter} is the average time spent at intersections.

N_{turn} is the number of turns in a collection trip; N_{inter} is the number of intersections in a collection trip

Results from the studied collection vehicle showed that the average pickup, drop down, at-site time was 0.030h/trip, 0.029h/trip, and 0.023h/trip respectively while the average time spent at intersections and turns was 0.0064h and 0.003h respectively. The haul time to the disposal site represented 0.33×10^{-3}% of the travel distance to the disposal site while the haul time from the disposal site represented 0.30×10^{-3}% of the travel distance from the disposal site. The model was found to estimate the trip times from several runs to approximately 95.1% of the observed trip times when it was applied to municipal solid waste collection in Ilorin, Nigeria.

The developed trip time model can be used to estimate the total time for a collection cycle when the variables are inserted into Equation (1) and (2). The estimated collection time can then be used by municipal authorities to determine the fastest route, vehicles scheduling and fuel management, thereby solving major complexities in the area of municipal solid waste collection.

Indigenous Footpath Modeling

Mr. Vice-Chancellor, the spatial structure of large cities today evolved from traditional core areas of old cities, which are characterised by footpaths, narrow roads and unplanned settlements. Before modern urban planning, indigenous footpaths served as the primary transit network. Many of these traditional routes persist today, integrating seamlessly with modern motorable routes. The increasing complexity of public facility planning has rendered facility location models essential decision-support tools (Teixeira & Antunes, 2008). While these models provide a robust framework for evaluating service coverage and refining locational alternatives, their accuracy in specific urban contexts is often compromised if indigenous footpaths are excluded from the distance impedance calculations.

It in this regard that **Aremu** and Vijay (2016) utilised Geographic Information System (ArcMap 10) to model some footpaths in Ilorin, Nigeria, aiming to identify the most accessible locations for placement of municipal waste bins while incorporating local walking habits. A network dataset was constructed from a high-resolution satellite imagery of an area in Ilorin, Nigeria to perform Location-Allocation analysis. This approach facilitated the identification of optimal bin sites and their respective command areas, constrained by a walking distance threshold of 175m to 350m. Figure 4 shows the catchment areas of waste bins when the maximum walking distance by residents (cut-off value) was set to 175m, 200m, 225m, 250m, 275m, 300m, 325m, and 350m. It was observed that as the maximum walking distance (cut-off values) increases the number of waste bins to be sited reduces but residents' satisfaction is likely to decline. Also, the solid waste captured by the waste bins is heterogeneous.

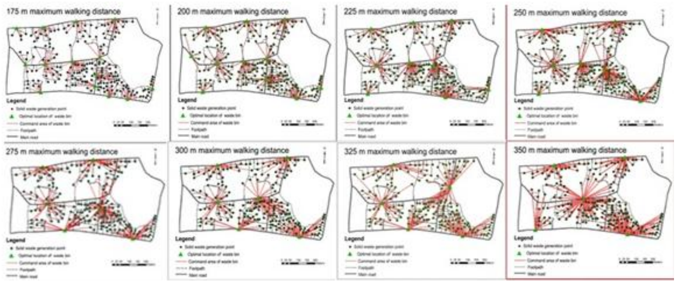

Fig. 4: Spatial display of Location–Allocation results for cut off values set from 175m and 350m

Source: **Aremu** & Vijay (2016)

However, by employing this empirical framework which has included the residents' local walking habits, municipal authorities will be able to estimate how much solid waste each area produces and how to capture them. This will allow for a predictive, self-adjusting collection technique tailored to each district's specific needs, thereby addressing complexities peculiar to slums, informal settlements, and other unplanned high-density areas of cities.

Optimisation of Municipal Solid Waste Collection

Finding the optimal route to collect waste containers from dispersed service points within an urban center is a difficult task for municipal authorities as a considerable number rely on trial-and-error approaches. **Aremu** (2013) and **Aremu** *et al.* (2014) proposed simple and efficient methods of sequencing waste collection operations and reported a real-world tour improvement in municipal solid waste collection.

In the first study (**Aremu**, 2013), the sequencing problem for collection of municipal solid waste bins in Ilorin, Nigeria was formulated as a Traveling Salesman Problem. It requires the creation of the shortest tour through the assigned service points (waste bin locations) seen as nodes within the digitised map of a city. An Origin-Destination (O-D) matrix for each route, which represents the Euclidean mileage matrix of all the nodes in the route, was created in Excel spreadsheet. Thereafter, the Solver Add-in tool (Fig. 5) in Microsoft Office

Excel© 2010 software was used for tour optimisation of solid waste collection.

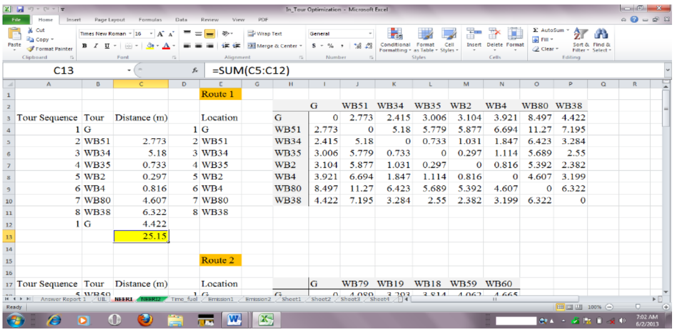

Fig. 5: The TSP Formulation on Excel Worksheet

The results obtained from the optimisation of some collection routes revealed that the optimization process reduced tour distance by 2.04-19.27 %, tour time by 0.33-22.80 %, and fuel consumption by 1.78-20.54 %. However, the Solver Add-in tool in Microsoft Office Excel© 2010 software can only perform optimisation problems with less than ten collection operations (nodes). Based on this shortcoming, **Aremu** *et al.* (2014) introduced the Premium Solver Platform V12.0 which is another powerful spreadsheet optimisation and simulation tool with built-in capability to solve small and large problems of collection route optimisation. For the collection optimisation problem, the city map was digitised and an Origin-Destination (O-D) matrix was created in Excel spreadsheet for each route. Then the Solver dialogs were activated to input solver parameters and provide an optimised solution. The generated results were similar to that of **Aremu** (2013), but showed reduction in tour distance in eight routes by 0.16 km (0.98%) to 3.3 km (14.61%). More importantly, the Premium Solver V12.0 Platform is suitable for optimization of municipal solid waste collection in mega cities because of the large amount of data to be processed. However, both tools have shown capacity to solve the complex problem of finding the fastest, most efficient and cost-effective path to follow when picking up municipal solid waste bins.

Optimal Location of Municipal Solid Waste Bins and Resultant Coverages

The location of waste bins for effective management of municipal solid waste is a difficult task because it is governed by safety, accessibility, and comfort. Location-Allocation models are highly suitable for solving decision problems involving siting facilities that provide social services such as potable water, healthcare, sanitation and security in developing countries (Oppong, 1996). In the context of solid waste management, the problem of locating waste bins (facility) is equally a Location-Allocation problem which requires siting optimally a predetermined number of waste bins among a set of locations (potential service points) to serve waste generation points.

Aremu *et al.* (2011a) applied the Facility Location Function, which is a Location-Allocation model in GIS package TransCAD v.5.0 for locating municipal waste bins in Ilorin, Kwara State. First, a digitised image of the study area was developed (to enhance query and analysis) from the satellite image and relevant information on the study area were incorporated. The information obtained included solid waste generation data and spatial features related to the study such as footpaths, road network, unsuitable service points (areas with infrastructural constraints or environmental sensitivity) and potential service points. Next, the algorithms in TransCAD software were used to solve the facility location problem (Figure 6). The client represents the waste generation point; the facility is the waste bin while the cost is the distance between the waste generation point and the waste bin.

The software then generated the best locations for the pre-determined number of waste bins, out of potential service points, with minimum sum of distance from waste generation points to the waste bins, and simultaneously allocates waste generation points to each waste bin. The output of each solution included the optimal location of each sited waste bin along with the attributes. For example, waste generation point captured and walking distance as presented in Table 1. With this result, a complexity is solved and the municipal Authority will be able to know the coverage of each wastebin in a city.

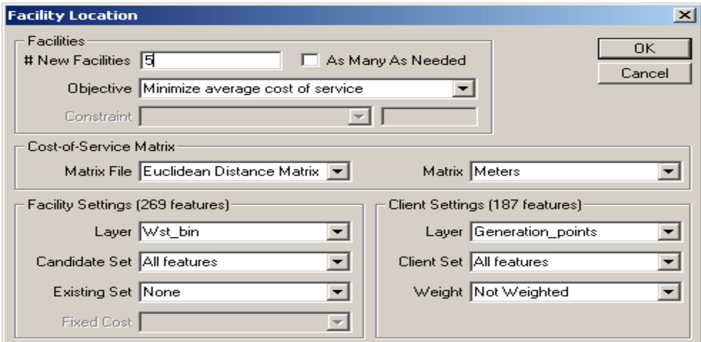

Fig. 6: Facility location function in TransCAD software

Table 1: Effective Coverage of the Optimally-located Quantities of Waste Bins

Quantity of waste bins	1	2	3	4	5	6	7	8	9	10
Walking distance to waste bin(m)	No. of solid waste generation points served									
0-50	10	16	17	28	33	37	46	42	51	57
51-100	28	41	53	65	74	78	76	105	103	103
101-150	31	52	62	61	59	63	56	37	30	26
151-200	25	31	30	22	20	9	9	3	3	1
201-250	27	26	20	10	1	0	0	0	0	0
251-300	14	8	4	1	0	0	0	0	0	0
301-350	19	12	1	0	0	0	0	0	0	0
351-400	18	1	0	0	0	0	0	0	0	0
401-450	9	0	0	0	0	0	0	0	0	0
451-500	5	0	0	0	0	0	0	0	0	0
501-550	1	0	0	0	0	0	0	0	0	0

Determining the Size of Waste Bins for Urban Areas

Vice-Chancellor Sir, underutilisation of large moveable containers may occur if the waste bins are too large compared to the turnout of wastes. On the other hand, if the waste bins are too small compared to the volume of wastes generated, overflow of the waste bins will occur. Striking a balance between underutilisation and overflow of waste bins represents a major complexity to municipal Authorities. Therefore, in order to improve municipal solid waste management, there is the need to determine the most effective location and specify the size of waste bins. Accordingly, a procedure for determining the size of waste bins for an area in Ilorin, Nigeria, was illustrated by **Aremu** and Sule (2012b).

For this purpose, relevant data were obtained from field study and digitised map of the study area. The study area was divided into enumeration areas and the canvasser method was used to obtain information such as land use category, number of people per household, type of business and floor area occupied by the business. Also, solid waste generated from sixty randomly selected residential land use types and commercial land use types within Ilorin was collected in triplicates and analysed. The built-in solver for p-median problems in TransCAD v. 5.0 (Caliper, Corp.) software was used to determine the optimal location of waste bins for p=1 to 10 while the one-sample *z*-interval procedure was used to determine the range of waste bin sizes appropriate for the study area based on the waste generation rates.

Figure 7 shows the digitised image of the study area containing 187 waste generation points, which have 113 residential, 30 commercial, and 44 mixed land use type. As a rule, when the maximum acceptable walking distance to the waste bin was set at 200m, only siting 6 to 10 waste bins (*p*=6 to 10) entirely covered the study area. Also, for each value of *p*, each waste bin is expected to be emptied once in 3 days so as to prevent odor, pests and health risks.

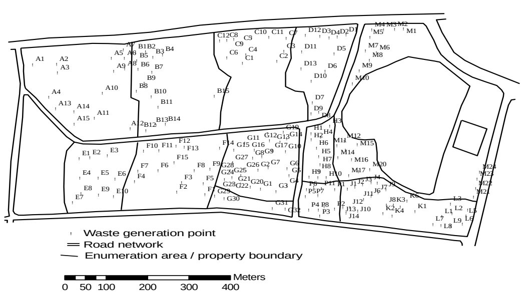

Fig. 7: Digitised Map of the Study Area showing the Enumeration Areas, Waste Generation Points, and the Road Network

Based on the above criterion, waste generation rates and catchment area of each waste bin, the minimum required waste bin capacity for the study area was estimated as 0.50 m^3 while the maximum was 3.56 m^3. Using a capacity utilisation of 70% (30% free board), then the modified minimum and maximum waste bin capacity is 0.65 m^3 and 4.63 m^3 respectively. The arithmetic probability plot of the modified volume of solid waste from all the service areas when three major outliners (observations that fall outside the pattern of the data) are removed is shown in Fig. 8.

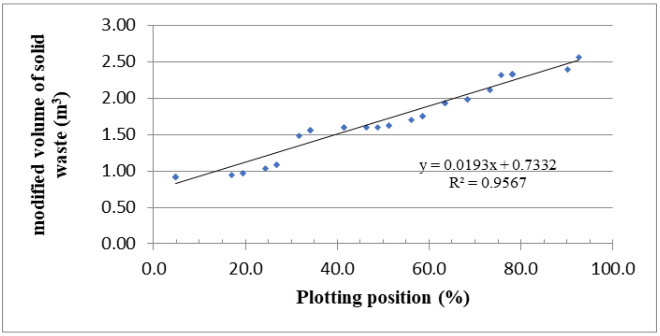

Fig. 8: Arithmetic probability plot of the modified volume of solid waste from service areas

The statistical analysis of several waste bin sizes, using the *z*-interval procedure, showed that at 95% confidence level, the most appropriate size of waste bin for the study area was between 1.47 and 1.8 m^3. Hence, a normalised size of 1.74 m^3 , which is slightly above the median (1.6 m^3) and occupies the 59th percentile, is appropriate for the study area. The remaining 41% of service points would require the same waste bin size, but in multiples according to the quantity of solid waste emanating from the catchment area. With this scientific technique, a balance has been struck and the wastebins will no longer be too full or too empty thereby resolving a major complexity to municipal authorities. Also, to accommodate the specified waste bin size (1.74 m^3), a one-ton hook lift truck is proposed for collection operations within the study area in accordance with the recommendation of Tchobanoglous *et al.* (1993).

Impact of Located Waste Bins

Public amenities at strategic points within a municipality often have direct or indirect impacts on the government and the society. It is therefore presumptive to evaluate the impacts of a service provided by a government authority through scientific means so as to gauge service delivery and improve efficiency of such service. In the case of municipal solid waste management within a city, **Aremu** and Sule (2012a) evaluated the impacts of optimised waste bins at strategic locations in Ilorin, Nigeria. This is in furtherance of the research on optimisation of waste bin locations by **Aremu** *et al.* (2011a).

Social impact was measured, using service coverage, public satisfaction and waste bin utility as indices. The economic impact assessment was based on information on unit cost of waste bin, prevailing pump price of diesel and overall collection cost, while environmental impact was limited to evaluation of the major Greenhouse gases (N_2O, CH_4 and CO_2) and Criteria Air Pollutants (NO_x, CO and PM_{10}) associated with the transportation industry. The different waste bin quantities and associated social, economic and environmental impacts are presented in Table 2. It can be seen that as the number of waste bins increases, the service coverage (i.e. percentage of inhabitants served and amount of waste collected) increases progressively up to 100% when six waste bins were sited. However, two waste bins became underutilised (inability to fill up to at least 70% of its capacity per week) when six waste bins were sited and increased to seven underutilized waste bins when ten waste bins were sited.

The cost for provision of the waste bins and the weekly cost of fuel for collection operation, despite varying locations, collection frequency and traffic conditions, increases as the number of wastebin increases. It shows that the more the number of waste bins provided the more the financial burden on the municipal authority.

Table 2: Waste Bin Quantities and Associated Impacts

Impact	No. of waste bins	1	2	3	4	5	6	7	8	9	10
Social	% Served	50.27	74.87	86.63	94.12	99.47	100	100	100	100	100
	% Solid waste collected	55.83	62.64	78.09	93.5	98.2	100	100	100	100	100
	No. of waste bins underutilized	0	0	0	0	0	2	2	3	6	7
Economic	Cost of fuel per week (₦ $x10^3$)	1.72	2.20	3.01	3.06	3.08	3.10	3.53	3.94	3.94	4.40
	Cost of waste bin (million ₦)	1.2	2.4	3.6	4.8	6	7.2	8.4	9.6	10.8	12
Environmental	Emissions GHG (g/week)										
	N_2O	1.37	1.76	2.41	2.45	2.46	2.48	2.82	3.15	3.10	3.52
	CH_4	0.22	0.29	0.39	0.40	0.40	0.40	0.46	0.51	0.51	0.57
	CO_2 ($x10^3$)	46.89	59.96	82.08	83.55	84.05	84.62	96.25	107.59	107.48	120.01
	Emissions CAP (g/week)										
	NO_x ($x10^3$)	0.55	0.71	0.96	0.99	1.00	1.01	1.14	1.27	1.27	1.42
	CO ($x10^3$)	1.39	1.78	2.43	2.48	2.49	2.51	2.85	3.19	3.19	3.56
	PM_{10}	12.17	15.63	21.30	21.83	22.00	22.19	25.56	28.11	28.09	31.36

For environmental impact during waste collection, within the Greenhouse gases (GHGs), the amount of CO_2 emissions was about 10^4 times more than N_2O and CH_4 emissions. Also, within the Criteria Air Pollutants (CAPs), CO and NO_x emissions were enormous compared to PM_{10} emission. Greenhouse gases trap the sun's heat in the atmosphere causing global warming and climate change. Its effects are enormous including increased exposure to water stress, ecosystem instability, damage from floods and storms, morbidity and mortality, and decrease in cereal production (Mihelcic & Zimmerman, 2010).

CAPs are also responsible for asphyxiation and several cardiovascular problems, formation of ozone, acid rain, or snow, and visibility reduction. However, the calculated emissions in this study only presented a platform for comparison of expected emissions when different numbers of waste bins were sited without measuring the direct effects of the ambient concentration of these emissions. The emissions altogether (GHGs and CAPs) increase as the number of wastebins increases.

Tradeoffs among Impacts of Sited Waste Bins

Vice-Chancellor Sir, once the social, economic and environmental impacts are noted, to arrive at the optimal solution requires complex tradeoffs among competing social, economic and environmental factors. Setting up tradeoff among competing preferences is a decision-making problem in which the Analytic Hierarchy Process (AHP) is a suitable tool (Kao & Lin, 2002). In the AHP approach, competing factors are arranged in a hierarchic structure as a means of modeling the problem for a consistent solution (Saaty, 1980). Within this context, **Aremu** *et al.* (2012) developed a framework which combined the traditional Geographic Information System (GIS) Location-Allocation modeling with AHP.

This approach incorporated the multi-faceted factors of sustainable waste management into the decision-making process to reach a definitive solution. First, a digitised image of the study area was developed from data from the study area (satellite imagery and field study) using GIS. Secondly, the waste bin location problem was decomposed into three levels of AHP as shown in Figure 9. The decision goal is on *Level 1*, the criteria for this decision (Impacts) are at *Level 2* while *Level 3* is the set of potential alternatives for reaching the final decision.

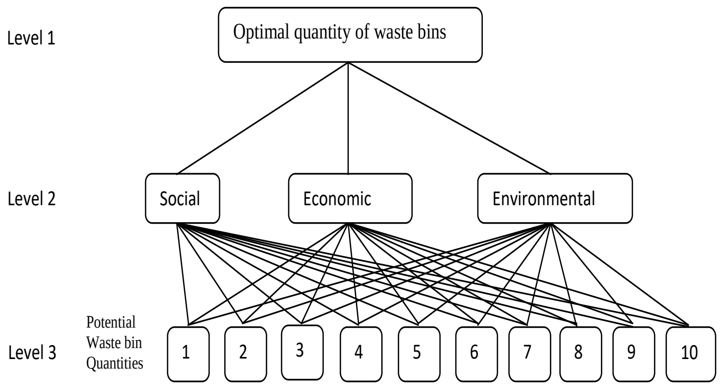

Fig. 9: Different Levels of Hierarchy used in AHP Model

In line with the AHP framework, we assigned weights to three distinct impacts to determine the optimal quantity of waste bins. This evaluation process involved testing different combinations of impacts under four Prioritization platforms to see how each influenced the final goal of the study (**Aremu** & Sule, 2011).

The four Prioritisation platforms and combinations (scenarios) under them are:

1. Prioritisation of Social impact over other impacts
   - **Soc>Eco>Env**: Social impact is slightly preferred to economic impact and economic impact is preferred to environmental impact.
   - **Soc>Env>Eco**: Social impact is slightly preferred to environmental impact and environmental impact is preferred to economic impact.
2. Prioritisation of Economic impact over other impacts
   - **Eco>Soc>Env**: Economic impact is slightly preferred to social impact and social impact is preferred to environmental impact.
   - **Eco>Env>Soc**: Economic impact is slightly preferred to environmental impact and environmental impact is preferred to social impact
3. Prioritisation of Environmental impact over other impacts
   - **Env>Soc>Eco**: Environmental impact is slightly preferred to social impact and social impact is preferred to economic impact.
   - **Env >Eco> Soc**: Environmental impact is slightly preferred to economic impact and economic impact is preferred to social impact.
4. Equal prioritisation of impacts
   - **Soc=Eco=Env**: Social, economic and environmental impacts are of equal preference

The impacts were scaled using the fundamental scale described by Saaty (1980). A programme was developed in Microsoft Office Excel 2007 to perform pairwise comparisons, calculate the matrix eigenvalue, verify judgment consistency, and rank the alternatives for each considered scenario. The overall weight of different number of waste bins under the established seven combinations of impact prioritisation is presented in Table 3. These weights represent the order of choice of waste bin quantities by the Analytic Hierarchy Process model under each combination of impact prioritisation. In explicit terms, each number of waste bins has its place on the scale of preference.

Table 3: Overall Weight of Different Number of Waste Bins under each Scenario

Scenario	1	2	3	4	5	6	7
No. of wastebins	**Soc>Eco >Env**	**Soc>Env >Eco**	**Eco>Soc>Env**	**Eco>Env >Soc**	**Env>Soc>Eco**	**Env >Eco > Soc**	**Soc=Eco =Env**
1	0.0999	0.1019	0.1512	0.1829	0.1567	0.1864	0.1458
2	0.1135	0.1141	0.1432	0.1610	0.1448	0.1620	0.1391
3	0.1108	0.1075	0.1213	0.1240	0.1122	0.1182	0.1151
4	0.1133	0.1087	0.1087	0.1014	0.0960	0.0934	0.1031
5	0.1221	0.1256	0.1237	0.1280	0.1331	0.1340	0.1272
6	0.1130	0.1151	0.1058	0.1037	0.1114	0.1072	0.1089
7	0.0989	0.0969	0.0787	0.0650	0.0732	0.0615	0.0786
8	0.0817	0.0816	0.0660	0.0567	0.0655	0.0564	0.0677
9	0.0820	0.0838	0.0611	0.0510	0.0662	0.0542	0.0661
10	0.0646	0.0649	0.0403	0.0264	0.0409	0.0268	0.0438

Consequently, if priorities or available resources are established, the results in Table 3 serve as strategic guides for municipal solid waste managers in determining the optimal number of waste bins to deploy. By tackling this major complexity through this data-driven strategy, we have laid the foundation for more reliable and informed waste management decisions.

Other Scholarly Contributions to Knowledge in the Field of Water Resources and Environmental Engineering

The Vice-Chancellor Sir, while this inaugural lecture specifically addresses the complexities in the transition of municipal solid waste, permit me to present other significant contributions to the field of Water Resources and Environmental Engineering. In order to familiarize undergraduate students of the Faculty of Engineering and Technology, University of Ilorin, with a broad view of engineering disciplines, I contributed a chapter (**Aremu,** 2015) titled "Water Resources and Environmental Engineering Discipline" to a book produced by the Faculty. Therein, I introduced the reader to the key aspects of Water Resources and Environmental Engineering discipline, such as professional training, areas of specialization, affiliated professional organisations, prospects, job opportunities, duties and ethics.

I have also worked on some other generalised issues related to solid waste policy, siting of landfill, solid waste characterisation, material/energy recovery, climate variability, water resource planning, air and noise pollution, and sanitation.

Solid Waste Policy and Landfill Siting

Aremu and Sule (2010) studied the policies, practices and challenges of municipal solid waste management in Nigeria. It was found out that though the Integrated Solid Waste Management technique is proliferating in Nigeria, municipal solid waste management authorities are still faced with a lot of challenges. A comprehensive solid waste Master Plan which should be geared towards waste reduction, collection optimisation, intensification of material and energy recovery, and sanitary landfilling, was proposed for Nigeria.

Aremu and Yusuff (2015) also used a combination of Geographic Information System (GIS) and Analytic Hierarchy Process to select the most suitable location for a landfill in Ilorin, Nigeria. A total of eleven potential landfill sites were identified from GIS analysis and an AHP model was developed to rank these sites. The most preferable landfill site was determined by trading-off key environmental factors such as slope, area and proximity to major road, pipeline, airport, railway line, built-up area and water body. This illustrated approach can easily be adopted by environmental planners to spatially buffer unsuitable locations for landfills, identify criteria priorities, and select the most suitable site for a landfill.

Solid Waste Characterisation

Aremu and Sule (2017) gave an overview of solid waste generation rates, characteristics, and management practices across the globe. It was observed that there is an apparent unevenness in the generation rates and composition of solid waste across the globe. High-income countries tend to generate more solid waste per capita than Low-income countries and their solid waste contains higher proportions of recyclables and inorganics. Solid waste management techniques are equally diverse across the globe, and fashioned according to local conditions, technology, funding, national policy and municipal goals.

Similarly, Ojowuro, Olowe and **Aremu** (2019) sampled and analyzed solid waste from the four main disposal facilities in bid to characterize solid waste in Lagos State, Nigeria. The results of the study showed slight disparity in all the solid waste samples sorted by land use type, population density, and income level. Solid waste from residential land use type contained organics (33.06–46.25%), plastics (12.73–20.7%), paper (4.61–10.3%), and textiles (1.66–12.33%). On the other hand, solid waste from commercial land use types was composed majorly of 14% paper, 29% plastics, 22% organics, and 14% textiles. The study recommended source separation of these wastes so that it will be easy to recover resources and energy from them.

Mokuolu, Iji and **Aremu** (2021) also quantified and characterised solid waste generated from selected areas in Ilorin, Nigeria. Municipal solid waste was collected, sorted, analyzed by weight and percentage composition using the quantitative approach. The results of the study showed that the average rate of solid waste generation was 0.66 kg/capita/day, while the distribution was 57.53% food waste, 9.07% nylon (flexible films), 5.98% plastic (rigid containers), 4.95% textile, 10.51% paper and 11.96% miscellaneous wastes. The average moisture content was 46.16%, 20.63%, 18.65%, 36.67%, 18.45%, and 42.89% for food waste, nylon, plastic, textile, paper and miscellaneous wastes respectively. The chemical analysis showed that volatile matter ranged from 20.55 to 24.10%,Ash content 3.10 to 3.90%, Fixed Carbon 7.5 to 9.8%, Calorific value 14820 to 18360 (kJ/kg), Nitrogen 0.40 to 0.50%, Hydrogen 4.38 to 5.80%, Carbon 40.90 to 44.30%, Oxygen 30.80 to 34.60%, Sulphur 0.19 to 0.24%, Fusing point of Ash 3.12 to 4.38 °C, and Heating value of 13.52 to 13.64 KJ/Kg. Based on these results, the energy potential of these wastes is promising, especially when sorted at source.

Material/Energy Recovery from Solid Waste

Timber processing operations generate enormous amount of wood wastes which need to be efficiently managed. Lasode, Balogun and **Aremu** (2011) conducted fieldwork to determine the amount of wood waste generated from sawmills and plank markets in Ilorin, Nigeria. The study revealed that 394.8m^3 of planks offload weekly at plank markets, 179.2m^3 of planks are produced from logs that offload at sawmills, while 119.52m^3 of wood waste is generated daily. The current wood waste disposal method was found to constitute serious environmental and health hazard. Alternatively, the study proposed that the generated wood waste be utilized directly as biomass energy in dedicated power systems to power public and private facilities. They can also be converted to torrefied fuel pellets for cooking, barbecue fuel and co-firing of steam boilers.

In another study, **Aremu** and Ganiyu (2019) explored the waste-to-energy potentials of solid waste emanating from developing countries. It was observed that urban centres in developing countries generate about 4.2 million tons of solid waste daily, most of which are disposed in open dumps and uncontrolled landfills. These wastes are composed of renewable energy materials with energy value of about 9.87 x 10^9 kWh/day. Capturing the energy embedded in these wastes is one of the sustainable ways of reducing the quantity of wastes to be landfilled while producing electricity, heat and fuel to meet basic needs. The study therefore recommended upgrading the predominant open dumps in developing countries to sanitary landfills and investment in waste-to-energy technologies.

Climate Variability and Water Resource Planning

Climate change is a complex problem that affects a sizeable aspect of human life. **Aremu** *et al.* (2013b) assessed climate variability, changes in stream flow and water supply over a long period in Ilorin, Nigeria. Meteorological and hydrological data in Ilorin between 1989 and 2008 show that the patterns of temperature, rainfall, evaporation and stream flow have changed over the years. Analysis of fluctuations in these variables using Regression and Reduction Pattern methods suggests that in future Ilorin is likely to experience increase in rainfall and stream flow, while temperature and evaporation are expected to slightly reduce. The major impacts of climate change are domiciled in water resources, agriculture, health, and other aspects of human endeavors. Therefore, there is need for all stakeholders to apply mitigation methods or adapt to changes that are expected from climate change.

Irrigation practices are best done by estimating the crop water requirement in order to avoid over or under irrigation which may negatively affect crop yield. **Aremu** *et al.* (2018) analysed weather information from weather stations in each Geopolitical zone of Nigeria. The data obtained are minimum and maximum temperature, relative humidity, wind speed, sunshine and radiation. The FAO Penman-Monteith model was used to compute the mean monthly reference evapotranspiration (ET_o). The mean monthly ET_o estimated for each weather station by the FAO Penman-Monteith model was then multiplied by the average crop coefficient to determine the crop water requirement. The results of the analyses showed that the average monthly crop water requirement for maize in North-East, North-West, North-Central, South-East, South-West and South-South

Geopolitical zones was 15.8, 14.1, 12.3, 10.3, 9.1, and 7.4 mm/day, respectively. The result of this study is therefore useful to the irrigation water management and regional water resources planning.

Air and Noise Pollution

Abdulraheem, **Aremu** and Adeniran (2022) investigated the ecological risks and sources of heavy metals emissions from burned grasses by simulating open burning in the laboratory. Forty species of grasses common in Nigeria were analysed for heavy metals using energy-dispersive X-ray fluorescence (EDXRF). The pollution assessment with enrichment factor, geo-accumulation index, and contamination factor showed that *Panicum repens* and *Sorghum bicolor* were heavily contaminated with lead (Pb). Principal component analysis identified metal industries and crustal origin as the possible pollutant sources. This study recommends that the activities of metal industries in Ilorin be regulated, particularly regarding the discharge of their effluents which accumulate and stain natural grasses. The pollutants are subsequently released to the environment during bush burning.

Aremu *et al.* (2015a) evaluated noise pollution generated from sawmill operations in Ilorin metropolis, Nigeria. Noise measurements were made using a sound level meter while a structured questionnaire was used to obtain noise related information. The results of the study showed that the background noise within the sawmills was 58.1-64.86 dB(A) while machine equivalent noise was 81.1-112.3 dB(A). About 73% of all the noise measurements were above the recommended limit of 85 dB(A) and these high noise intensities can initiate or perpetuate some work-related health challenges. From the subjective responses from sawmill workers in this study, most of the workers are unprotected, disturbed and complain of noise-related ailments such as tinnitus (96.6%), headache (86.6%) and hearing impairment (71.9%). Therefore, noise prevention and control strategies are suggested in addition to frequent audiometric tests, training, education, and enforcement of noise regulations.

Aremu *et al.* (2015b) assessed indoor noise levels at the University of Ilorin Main Library, Nigeria. A semi-structured questionnaire and sound level meter were used to obtain both subjective and objective data on noise conditions at different sections of the library. The findings of the study indicated that noise levels varied by location and time, with many daytime measurements exceeding the recommended maximum of 45 dB(A) for a library indoor environment. The identified major sources of noise in the library were students, library equipment, cell phones, and staff members, while minor distractions and aggravations come from footsteps, personal stereo, trolley wheels, and doors. It is suggested that the University Management should formulate a policy which will either control or prevent noise in the library. Also, equipment in the library should be maintained to prevent noise, and sound screens or absorbers should be provided in areas where an interior noise source is unavoidable.

Aremu *et al.* (2020) investigated the effect of different particle sizes of sand-bed anti-vibration mounts on noise intensity from a portable electricity generator (popularly called *I better pass my neighbor*). Ten anti-vibration mounts (650 mm × 650 mm × 75 mm) with particle sizes ranging from 0.09 to 2.30 mm were prepared, and noise levels were measured using an Extech HD600 digital sound level meter. Results obtained from the study reveal that noise emitted from the portable electricity generator without any anti vibration mount varies from 65.73 to 82.93 dB(A). These values exceeded the acceptable limit recommended by the World Health Organization for residential, commercial and industrial areas. Upon introduction of sand beds, noise intensity from the portable generator was reduced by 0.11 to 2.78 dB(A), however, fine sand bed of particle size 0.09mm and 0.15mm exhibited superiority in noise reduction over all other sand beds. Therefore, based on this study, the use of ISO 14688-1:2002 fine sand as an anti-vibration mount is recommended, alongside other damping methods, in order to achieve appreciable noise damping.

Sanitation

Appropriate sanitation in primary schools is fundamental for effective learning and prevention of pediatric diseases. A study by Aremu (2012) was undertaken to assess the state of sanitation facilities in primary schools within Ilorin, North Central Nigeria. Data for the study was obtained from physical inspection of sanitation facilities and semi structured questionnaire administered to 200 schools. The result of the study revealed that 5.5% - 26.5% of the assessed schools have sanitation facilities in adequate quantity, quality or usage; 23% have a smaller number of facilities compared to pupil population, 42% have grossly inadequate facilities, and 12.5% have no sanitation facility. The quality of facilities in 24.5% of the schools was tolerable while the facilities in 57.5 % of the schools were in deplorable condition. Also 26.5% of the schools effectively used the toilets and urinals, 22.5% seldom use them while 38.5% do not use them at all because they were objectionable or risky. Therefore, raising the status of schools lacking behind in quantity, quality or usage of sanitation facilities should be a top priority in order to achieve universal primary education goals.

Proper management of wastewater has become an important sanitation issue across the globe. Amoo and **Aremu** (2012) evaluated the effectiveness of using Waste Stabilization Pond (WSP) to remove pollutants from wastewater at the main campus of the University of Ilorin, North-central, Nigeria. Grab samples were obtained from wastewater influents and effluents from a laboratory model of the designed WSP and tested to determine quality parameters of the wastewater. The test results showed that the WSP was able to reduce Biochemical Oxygen Demand, Total Solids, Ammonia, oil and grease, turbidity and colour by 91.3%, 50.5%, 92%, 99.9%, 65.1% and 70%, respectively. The final effluent was found to comply with FEPA's guidelines for discharges into surface water and irrigation. Hence the effluent could be used for unrestricted irrigation of crops, including salads and vegetables. The humus which is a bye product from the treatment process of the WSP can find useful applications as organic manure, feedstock for energy generation or processed for further use.

My Odyssey and Service at the University of Ilorin

Vice-Chancellor Sir, I have been in the employment of the University of Ilorin for 27 years, starting as a Graduate Assistant in the Department of Civil Engineering, Faculty of Engineering and Technology before being redeployed to the Department of Water Resources and Environmental Engineering about 13 years ago. Since assumption of duty, I have at various times held several academic/administrative positions and contributed my quota in areas of teaching, research and community service.

In the area of teaching, I have over the years taught several undergraduate and postgraduate courses. I have guided numerous undergraduate, Master and Ph.D. researchers to graduation and my research footprint spans the full spectrum of Water Resources and Environmental Engineering with primary focus on solid waste management.

I have held significant leadership roles in university including Pioneer Acting Head of the Department of Water Resources and Environmental Engineering (2013-2015) and Coordinator of the National Water Resources Capacity Building Network for North Central Nigeria (2015-2017). I have played a central role in shaping academic curricula and professional training programmes. This includes serving on the panel that developed the academic programme for the Department of Water Resources and Environmental Engineering and the Postgraduate Degree in Engineering curriculum. I equally chaired the Local Organizing Committee for the public lecture on Integrated Water Resources Management (IWRM) and its modular M.Sc. curriculum in 2014.

My career is defined by a strong commitment to student development, evidenced by my work as a committed lecturer, Staff Adviser to Students' Associations, my role twice as Level Adviser (2001-2006; 2007–2012), and Departmental Examination Officer (2006/2007 Session; 2011/2012 Session).

Beyond students' mentorship, I have contributed to the University's operations as a Faculty Representative for the Admissions Committee, Senior Staff Housing Allocation Committee, Environmental Protection Committee, Oyun Research Team and Unilorin Dam Committee.

I have also demonstrated extensive institutional oversight through roles such as Chairman, Penultimate Year Screening Committee for the Faculties of Basic Medical and Clinical Sciences (2013–2016), member Faculty of Engineering and Technology Screening Committee, Faculty Coordinator for the Students' Work Experience Programme (SWEP), Group Coordinator for Community Based Experience (COBES) in both Ajase Ipo and Ikotun Ile, Centre Coordinator for JAMB-UTME, and most recently, the Co-Chairman of the 4th Faculty of Engineering and Technology International Conference (FETiCON 2026).

I have equally served as a distinguished University of Ilorin Ambassador through two prestigious international honors: the INSA JRD-TATA Fellowship (administered by India's Centre for International Cooperation in Science) and Fulbright Scholarship in the United States of America, which was sponsored by the United States Department of State. In every role and responsibility shared above, I have remained diligent in fostering student growth, supporting staff development, and driving the University towards excellence.

Sojourn at Lower Niger River Basin Development Authority

Vice-Chancellor Sir, permit me to specifically relay my sojourn at Lower Niger River Basin Development Authority to this distinguished audience, because this national service took away eight years of my precious academic life, but the experience was worthwhile. I was appointed the Managing Director of Lower Niger River Basin Development Authority (LNRBDA) for a period of four years from 5th January, 2017 to 4th January, 2021. Upon completion of my tenure, I resumed back to the University, but after spending two weeks, I was reappointed for another four years (5th January, 2021 to 4th

January, 2025). Incidentally, I served as the youngest Managing Director in the history of LNRBDA and the first person to serve consecutively for eight years.

Anyone who has tasted or is tasting executive position in Nigeria knows that the Nigerian leadership system is often laced with unseen pitfalls and deep-seated institutional intricacies. Running an impactful tenure requires more than just administrative control; it demands an unwavering resilience to transform a complex organisation into a development tool for the country. I navigated this journey through prayers (most important), sheer hard work and discipline, strategically fostering cordial relationships with my staff, our parent Ministry, legislators and masterfully aligning with Mr. President's Agenda. I focused on transforming challenges into opportunities for growth from a professional and academic perspective, while establishing collaboration with other government agencies and oversight bodies, so that every milestone was anchored in accountability.

In the eight years of my tenure, I ensured that the Authority turned towards expertise and impact at the grassroot level. During my leadership, we tackled some of the greatest water challenges in Nigeria through the construction of over 1,100 borehole projects, eight mini water works, and seven dams, as well as the revitalisation of six irrigation projects. Apart from the development in water infrastructure, I emphasised the importance of environmental protection/sustainability by ensuring that 115 flood and erosion control structures were built in areas prone to floods. Staff capacity building was made a priority and our headquarters, units, and area offices were improved aesthetically and equipped.

My vision for sustainable growth led to the acquisition of a Liaison Office in Abuja and a decisive shift toward green energy, including the construction of a 150kWp micro-grid solar system for independent power supply and the deployment of solar-powered irrigation pumps to replace fossil fuel-based systems. Mr. President’s directive on ensuring food security was also fulfilled by developing more than 2,000 hectares of irrigable land and creating the Songhai Model Integrated Farms. These were complemented by building the capacity of over 200 youths through the Graduate Youth Empowerment Scheme (GYES), thereby shifting away from conventional bottlenecks to agribusinesses based on merit.

These achievements were acknowledged through a ministerial recognition at Uyo, Akwa Ibom State and the award of Platinum Prize for my contributions to the Authority's development. As an outstanding leader, I was recognised with the Special Recognition Award, Award of Excellence, and Kwara State Icon Award, in addition to being conferred with the Distinguished Administrator of the Year Award. Furthermore, my contribution to the engineering profession and humanity was celebrated through the Certificate of Excellence as Distinguished Alumnus, Award of Credence as Ambassador of Humanity Services, and different Merit and Entrepreneurial Promoter Awards. This affirms in me a fulfilment of purpose, which is dedicated to professional integrity and serving as an inspiration to upcoming generations.

Other National and International Assignments

While my tenure at the Lower Niger River Basin Development Authority was only one chapter in my diverse portfolio, I have undertaken a wide array of other professional, national, and global engagements. My career has advanced technical engagements in strategic planning and Engineering regulations across national and international sphere.

In the realm of International technical engagements and Global Water Security, my work began with a focus on regional cooperation as a UNESCO Country Expert in 2015, where I developed transboundary water management materials for the West African sub-region. This global reach expanded in 2016 through my service on the International Scientific Committee of the 6th International Conference on Solid Waste Management (IconSWM2016) in India, and reached a high point in 2023 when I served as a Nigeria Adviser and Delegate at the landmark United Nations Water Conference in New York.

Domestically, I have been a key contributor to national strategic planning and governance. My early involvement was with the National Environmental Standards and Regulations Enforcement Agency (NESREA) in 2013, where I chaired the critique session for draft Energy Sector Regulations. I have equally contributed to national governance and oversight, by serving as a Collation and Returning Officer for INEC during the 2015 elections. In 2017, I was a member of the Federal Ministry of Environment's Technical Review Panel for the Environmental Impact Assessment (EIA), on the proposed Integrated Poultry and Fish Mill in Kwara State, while in 2020 I was appointed a Board Member of the Nigeria Hydropower Professional Association.

In the area of assignments on national policies, I served as a member of the Sector Working Team of the Federal Ministry of Water Resources, where I made insightful contributions to the water sector's component of the Economic Recovery and Growth Plan (MTSS-ERGP) of Mr. President. In a separate capacity, I provided technical contributions to the National Water Resources Bill before and during its legislative engagement at the 8th and 9th Assemblies.

Throughout this timeline, I have maintained a steady commitment to academic and professional regulatory excellence. Since 2015, I have served as an External Moderator and Examiner for institutions such as the Federal University of Technology, Minna, and the Kwara State College of Education (Technical) Lafiagi. As a dedicated Resource Person for COREN, I have guided the accreditation of engineering programmes across Nigeria such as Bayero University, Kano; Federal Polytechnic Offa; and Niger Delta University, Wilberforce, Bayelsa State. Looking ahead, this commitment continues with my current appointment to the Kwara State Technical Committee on Engineering Regulation Monitoring and Enforcement (ERME) for the 2026 term, alongside my ongoing role as a Peer Reviewer for leading engineering journals including Journal of Research Information in Civil Engineering (RICE); Nigerian Journal of Technology (NIJOTECH);

Umudike Journal of Engineering and Technology (UJET); Journal of Engineering Research (JER); International Journal of Civil Engineering (JCE), and Nigerian Journal of Technological Research (NJTR).

Service to the Community

Driven by volunteering, faith and my profession, I have, over the years, served my immediate and extended community in numerous capacities. My dedication to local welfare led me into taking up key executive positions in some associations/committees such as Secretary at Managing Directors' Forum, Federal Ministry of Water Resources; Ilorin Emirate Community, University of Ilorin; and the Supervisory Committee, Academic Multipurpose Cooperative Society, University of Ilorin. Other roles include Deputy Mayor, University of Ilorin Senior Staff Quarters Residents' Association, University of Ilorin; Chairman, Water Supply Monitoring & Development Committee, Unilorin Senior Staff Quarters Residents' Association, University of Ilorin; and Chairman, Madarasat Building Committee, Agric Estate Muslim Community, Ilorin.

I have equally served as an active member of the following associations and committees: the prestigious Ilorin Eid Praying Ground Management and Development Committee; the Kwara State Government Committee on Food Security; and the Kwara State Technical Committee (STC) of the Council for the Regulation of Engineering in Nigeria (COREN). Others include Agric Estate Residents' Association; BEC Development Committee, Nigerian Society of Engineers, Ilorin Branch; Popo Giwa Development Association; Growth and Welfare Committee, Nigerian Society of Engineers Ilorin Branch and a host of others. Additionally, I have leveraged my expertise for public education as a Resource Person at the USF's Patel Center for Global Solutions and Africa Initiatives Faculty Group, University of South Florida, U.S.A., Olli Group, University of South Florida, U.S.A.; as well as the Kwara State Radio Cooperation, Kwara TV, and TVC.

Conclusion

The Vice-Chancellor Sir, the management of the large volume of solid waste generated from Nigerian cities, is a highly complex task, shaped by technical, social, economic, and environmental factors. This lecture has vividly addressed some unresolved *complexities* associated with moving these discarded items from the point of generation to the final disposal place which I described as "*cradle-to-grave*" and provided insightful solutions.

Many of these complexities revolve around determining the optimal location, size and quantity of municipal waste bins, improvement of collection operation and route optimisation, workload distribution, and siting of disposal site. Even when management decisions are made, the impacts of the management strategies needed to be gauged based on the three pillars of sustainability. This entails tradeoff among competing preferences related to costs, service coverage, public satisfaction, and degree of waste bin utilisation. Other important indices are associated with environmental concerns such as emission of Greenhouse gases and Criteria Air Pollutants from collection vehicles.

Hence, the roadmap to cleaner cities is guaranteed by incorporating existing spatial attributes such as indigenous footpaths, road characteristics, land use distribution, and waste generation pattern into achievable technical goals. Ultimately, by breaking *complexities* into structured and actionable goals, and applying engineering principles, a smooth *transition* of municipal solid waste from *cradle* to *grave* is guaranteed.

Recommendations

Vice-Chancellor Sir, distinguished ladies and gentlemen, based on this presentation, the following recommendations are proposed:

1. *Promotion of on-site segregation of solid waste*: Government should promote at-source sorting/separation so as to assist in materials recovery, reduction in management costs, and elimination of hazardous wastes from the waste stream right from the point of generation. The waste bins should also be color-coded and separation should be at household level or at the location of the municipal waste bin.

2. *Adoption of integrated smart waste management system*: Government should invest in modern solid waste management infrastructure such as Internet of Things (IoT) enabled smart waste bins, recycling, material recovery and waste-to-energy facilities, sanitary landfills, transfer stations, greener and fuel-efficient collection vehicles, and other local engineering solutions geared towards to a clean and healthy society. The facilities should have sensors for real-time tracking, monitoring and transmission of information to a designated server for analyses by experienced professionals.

3. *Integration of spatial dynamics with periodic data auditing:* Strategic spatial assessment, planning and analyses should be carried out by municipal authorities before siting waste bins and landfills so as to maximise service coverage, and minimise economic and negative environmental impacts. Also, data on solid waste should be documented and audited periodically in order to monitor the existing solid waste management system and to make financial, regulatory and logistic decisions.

4. *Provision of suitable and adequate waste collection equipment/vehicles*: There is the need to optimise vehicle

capacity with waste bin size in order to ensure that multiple waste bins are picked up in a single collection operation. Government should also promote the use of push carts, wheelbarrows, tricycles, animal-drawn carts and wagons, trolleys, bicycle trailers, and locally fabricated equipment for pre-collection operations at inaccessible and narrow roads.

5. *Utilisation of standardised daily operational schedule for collection activities*: Since most of a city's expenses is on collection operation, formulation of a standard operational schedule with digital routing before assigning collection vehicles to trips will assist in minimising collection time and cost, and equally aid workload distribution. The collection period by the collection crew should be early in the morning or late in the night to minimize time lost due to delay and high traffic.

6. *Implementation of cost recovery strategies*: Sustainable cost recovery strategies should be in place by the government to offset the cost of solid waste management. These strategies include imposition of reasonable user fees, extended producer responsibility, reuse or recycling of solid wastes, and material/energy recovery. Also, markets should be provided for recycled goods and generated energy.

7. *Strengthen capacity of the informal sector*: Informal solid waste pickers, scavengers and the small-enterprise waste collectors should be encouraged by the government and incorporated into the Renewed Hope Agenda of the government. Public education by all stakeholders should be geared towards denouncing the stigma attached to workers in the solid waste management industry especially the scavengers.

8. *Encouragement of more private sector participation*: More private sector involvement in solid waste collection, material/energy recovery, and landfill management is encouraged. Also, community-based organisations should be inspired to participate in various aspects of solid waste management. A decentralised system is proposed wherein government's role is that of an overseer, regulator or financial supporter while private enterprises should be the service providers.

9. *Public enlightenment and fostering collaboration*: There should be public awareness campaigns by government using social media platforms, and electronic and print media on solid waste management strategies and dangers of indiscriminate dumping of wastes. Also, collaboration among all stakeholders in the waste management industry should be strengthened in areas such as knowledge and technology transfer, information sharing, raising awareness, funding and policy formulation.

10. *Development of solid waste master plan and regulatory framework*: A comprehensive master plan should be developed for solid waste management in Nigeria to reflect sustainable management options, targets, benchmark for improvements, robust regulations and financial sustainability. Also, there is the need by all stakeholders in the waste management industry to move towards circularity in our waste management efforts, i.e. switching from *Cradle-to-Grave* to *Cradle-to-Cradle.*

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REFERENCES

Abdulraheem K. A., **Aremu, A. S.**, & Adeniran J. A. (2022). Ecological risk and sources of metals in open-burned grasses in Guinea Savanna of Nigeria. *Environmental Quality Management, 31*(3), 313-327.

Adu, D. A., & **Aremu, A. S.** (2012). Solid waste composition: impetus for recycling activities. In B. F. Sule, A. A. Adedeji, and Y. A. Jimoh (Eds.), *Proceedings of the 4th Annual & 2nd International Conference of Civil Engineering* (pp. 23-29). Department of Civil Engineering, Faculty of Engineering and Technology, University of Ilorin, Nigeria.

Amoo, O. T., & **Aremu, A. S.** (2012). Treatability of institutional wastewater using waste stabilization pond system. *Journal of Applied Technology in Environmental Sanitation*, *2*(4), 217-222.

Aremu, A. S. (2012). Assessment of sanitation facilities in primary schools within Ilorin, Nigeria. *Journal of Applied Sciences in Environmental Sanitation, 7* (1), 29-33.

Aremu, A. S. (2013). In-town tour optimization of conventional mode for municipal solid waste collection. *Nigerian Journal of Technology*, *32*(3), 443-449.

Aremu, A. S. (2015). Water resources and environmental engineering discipline. In Y. A. Jimoh & M. O. Sunmonu (Eds.), *An introduction to engineering disciplines* (pp. 115-123). Faculty of Engineering & Technology, University of Ilorin.

Aremu, A. S., Adeleke, O. O., & Sule, B. F. (2011a). A GIS-based optimization technique for spatial location of municipal waste bins in a developing city**.** *Ethiopian Journal of Environmental Studies and Management, 4*(3), 66-72.

Aremu, A. S., Amao, T. K., & Mokuolu, O. A. (2020). Effects of sand bed anti-vibration mount on transmitted noise from portable on-site electricity generator. *Nigerian Journal of Technological Research, 15*(2), 8-12.

Aremu, A. S., Aremu, A. O., & Olukanni, D. O. (2015a). Assessment of noise pollution from
sawmill activities in Ilorin, Nigeria. *Nigerian Journal of Technology*, *34*(1), 72-79.

Aremu, A. S., & Ganiyu, H. O. (2019). Waste to energy: Developing countries' perspective. In: S. Ghosh (Ed.), *Proceedings of the 6th International Conference on Solid Waste Management (IconSWM2016)* (pp. 167–176). Springer.

Aremu, A. S., Mihelcic, J. R., & Sule, B. F. (2010). Time and motion analysis of hauled container system for municipal solid waste collection in Ilorin, Kwara State, Nigeria. In Ronald L. Mersky and Wen K. Shieh (Eds.), *Proceedings of the 25th International Conference on Solid Waste Technology and Management* (pp. 1144-1151). Department of Civil Engineering, Widener University School of Engineering, Philadelphia, U.S.A.

Aremu, A. S., Mihelcic, J. R., & Sule, B. F. (2011b). Trip time model for municipal solid waste collection applicable to developing countries. *Environmental Technology*, *32*(15), 1749–1754.

Aremu, A. S., Omoniyi, J. O., & Saka, T. (2015b). Indoor noise in academic libraries: A case study of University of Ilorin Main Library, Nigeria. *African Journal of Library, Archives and Information Science*, *25*(1), 5–14.

Aremu, A. S., & Ritesh Vijay. (2016). Modeling indigenous footpath and proximity cut-off values for municipal solid waste management: A case study of Ilorin, Nigeria. *Procedia Environmental Sciences*, *35*, 51–56.

Aremu, A. S., Vijay, R., & Adeleke, O. O. (2013a). Trip time comparison of conventional and exchange container mode for solid waste collection: A case study of Ilorin, Nigeria. *Journal of Environmental Science and Engineering*, *55*(1), 1–8.

Aremu, A. S., Vijay, R., & Tijani, M. A. (2014). Optimisation of solid waste collection routes using premium solver platform. *International Journal of Environment and Waste Management, 14*(3), 222–231.

Aremu, A. S., Salami A.W., & Ayanshola, A.M. (2013b). Historical climate variability and water supply in Ilorin: Perceptions and predictions. In A.G.A.S. Oladosu, Z.I. Oseni, M.A. Adedimeji, A.L. Azeez (Eds), *Ilorin: History Culture and Lessons of Peaceful Co-existence* (pp.213-227). Unilorin Press, Ilorin, Nigeria.

Aremu, A. S., Salami, A. W., Ayanshola, A. M., & Dauda, K. A. (2018). Evaluation of crop water requirements of maize in Nigeria using FAO Penman-Monteith model. *Nigerian Journal of Hydrological Science, 6*, 102–108.

Aremu, A. S., & Sule, B. F. (2010). Policies, practices and challenges of municipal solid waste management in Nigeria. *Environmental Issues, 3*(1), 1–10.

Aremu, A. S., & Sule, B. F. (2011). An analytic hierarchy process framework for determining appropriate number of municipal waste bins. *NSE Technical Transactions, 46*(1), 71–78.

Aremu, A. S., & Sule, B. F. (2012a). A case study evaluation of the impacts of optimized waste bin locations in a developing city. *Journal of Civil Engineering and Environmental Systems, 29*(2), 137–146.

Aremu, A. S., & Sule, B. F. (2012b). Optimization of waste bin location and size for Ilorin, Nigeria. *Nigerian Journal of Engineering, 18*(2), 7–18.

Aremu, A. S., & Sule, B. F. (2017). Snapshot of global solid waste management practice. *Environmental Issues, 7*(1), 94–110.

Aremu, A. S., Sule, B. F., Downs, J., & Mihelcic, J. R. (2012). Framework to determine the optimal number and spatial location of municipal solid waste bins in a developing world urban neighborhood. *Journal of Environmental Engineering, 138*(6), 645–653.

Aremu, A. S., & Yusuff, A. A. (2015). A GIS-AHP based approach for siting municipal landfill in Ilorin. *Journal of Engineering Research, 20*(1), 23–30.

Cook, E., Ionkova, K., Bhada-Tata, P., Yadav, S., & Van Woerden, F. (2026). *What a waste 3.0: Global snapshot of solid waste management toward circularity until 2050*. World Bank. https://doi.org/10.1596/978-1-4648-2309-1

Kao, J., & Lin, T. (2002). Shortest service location model for planning waste pickup locations. *Journal of the Air & Waste Management Association, 52*, 585–592.

Lasode, O. A., Balogun, A. O., & **Aremu, A. S.** (2011). Generation, management challenges and prospects of wood waste in Ilorin, Nigeria. *The Nigerian Engineer*, 42–45.

Mihelcic, J. R., & Zimmerman, J. B. (2010). *Environmental Engineering: Fundamentals, Sustainability, Design*. John Wiley and Sons, Inc. U.S.A.

Mokuolu, O. A., Iji, J. O., & **Aremu, A. S.** (2021). Solid waste generation and characterization in Ilorin, Nigeria. *Arid Zone Journal of Engineering, Technology & Environment*, *17* (3), 279-288.

Ojowuro, O. M., Olowe, B., & **Aremu, A. S.** (2019). Characterization of municipal solid wastes from Lagos metropolis, Nigeria. In S. S. Sadhan, G. Krishna, & S. K. Ghosh (Eds.), *Waste Management and Resource Efficiency* (pp.147–155). Springer, Singapore.

Oppong, J. R. (1996). Accommodating the rainy season in third world Location-Allocation applications. *Socio-Economic Planning Science, 30*(2), 121-137.

Saaty, T. L. (1980). *The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation*. McGraw-Hill, New York, U.S.A.

Tchobanoglous, G., Thiesen, H., & Eliassen R. (1993). *Solid Wastes: Engineering Principles and Management Issues*. McGraw-Hill, Inc., New York, U.S.A.

Teixeira, J. C., & Antunes, A. P. (2008). A hierarchical location model for public facility planning. *European Journal of Operational Research*, *185*, 92–104.

World Bank (2024). *Improving solid waste and plastics management in Lagos State: A way forward*. World Bank, Washington DC.