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SOLID WASTES MANAGEMENT METHODS IN SELECTED TERTIARY EDUCATIONAL INSTITUTIONS IN AKWA IBOM STATE, NIGERIA

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ABSTRACT

Purpose: This study examines solid waste management methods employed in selected tertiary educational institutions in Akwa Ibom State, Nigeria. It evaluates the efficiency of these methods to identify challenges and proposed strategies for improvement. The research aims to enhance waste management practices in higher education institutions and contribute to broader sustainability efforts.

Design/methodology/approach: A survey research approach was adopted, targeting waste management and sanitation staff as well as students in six selected tertiary educational institutions. A total of 330 respondents participated in the study. Data were collected using questionnaires and analysed using descriptive statistics, including mean score analysis and the Kruskal-Wallis H test, which was used to compare variations in waste management methods and their efficiency across the selected institutions.

Findings: The findings reveal significant variations in the waste management methods across institutions, with common methods including onsite sorting, recycling, crushing, and composting. More advanced methods, such as melting and manufacturing, were underutilized due to infrastructural and financial constraints. Institutional differences also influenced waste management efficiency, with some institutions performing better in areas such as recycling and shredding. The study highlights the need for improved recycling infrastructure, training, and awareness programmes to enhance waste management efficiency.

Research limitations/implications: The study focuses on tertiary educational institutions in Akwa Ibom State, which may limit the generalizability of the findings to other regions. Further studies incorporating comparative analyses across different States or Countries could provide broader insights into institutional waste management practices.

Practical implications: The findings underscore the need for tertiary institutions to invest in recycling infrastructure and adopt more sustainable waste management methods. Increased awareness, policy enforcement, and funding for advanced waste treatment facilities can significantly enhance waste management efficiency. Additionally, the introduction of incentives for sustainable practices and penalties for non-compliance can drive behavioural change.

Originality/value: This study provides empirical evidence on the state of waste management in Nigerian tertiary institutions, highlighting gaps in efficiency and areas for improvement. It contributes to the body of knowledge on institutional waste management and offers policy recommendations to enhance environmental sustainability in educational institutions.

Keywords: Solid waste management, tertiary educational institutions, sustainability, waste efficiency, Akwa Ibom State, Nigeria.

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1. INTRODUCTION

Wastes are residual materials that arises from human activities, which cannot be reused or recovered as a resource or recycled into material production processes, nor thermally/biologically utilized for energy production. Waste streams vary from country to country and may be aggregated as solid, liquid and gaseous wastes; hazardous and non-hazardous wastes or as industrial, commercial, residential or institutional waste streams (Maclaren, 2000; UNEP, 2005). The Oxford English Dictionary defines waste as any item that is no longer in use or cannot be used for any good purpose. Solid waste has been defined as any useless, unwanted or discarded material (American Public Work Association, 1975) with insufficient liquid content to be free flowing. Solid waste is sticky and weighty in nature and therefore has the capacity of accumulating and defacing the physical environment if not well managed (Sada and Odemoerho, 1988; Nnorom and Osibanjo, 2008).

Solid waste constitutes any moveable solid object which the owner wishes to dispose of because it is no longer useful to the immediate owner. Solid wastes are non-soluble materials ranging from municipal garbage to industrial wastes containing complex and sometimes hazardous substances (Osibanjo and Nnorom, 2007; Olafisoye *et al*., 2013). Man's activities today generate tonnes of thousands of refuses which are seen littered everywhere causing diverse environmental problems. This calls for urgent expertise in waste management as the importance of a healthy environment for meaningful and productive work is tied to proper waste management. In the past, waste was considered as resources. This was because the wastes that were generated were mainly agricultural and was bio-degradable and as such disposal was not a problem as the volume was low and these agricultural wastes were recyclable and utilized for soil enrichment. This is not the situation today as waste is a major problem that needs to be solved as urgently as possible.

There has been extensive empirical research on solid waste management in Nigeria, reflecting the country's ongoing challenges in handling solid waste effectively. The syntheses of key findings from various studies highlight community involvement, public perception, current management practices, and sociocultural dimensions influencing waste management in Nigeria. Fakunle and Ajani (2021) examined residents' perceptions of solid waste management in Ife Central Local Government Area, Osun State. The research revealed that while residents were aware of the health risks associated with improper waste management and expressed a desire to reduce household waste, several factors impeded effective management. These included inadequate methods, costs, lack of cooperation, and a nonchalant attitude among community members. The study underscores the importance of community involvement and the need to address these barriers to enhance waste management practices.

Public perception plays a crucial role in the success of waste management initiatives. Research indicates that in many Nigerian communities, there is a significant gap between awareness and action regarding waste disposal practices. Studies by Adekola *et al*. (2021) revealed that factors such as educational background, cultural beliefs, and economic status influence how individuals perceive and engage with waste management systems. Enhancing public awareness through targeted educational programmes is essential for fostering proactive waste management behaviours. Bassey *et al.* (2024) reported that the efforts by waste pickers are insufficient to effectively reduce the quantity of available waste in the landfills. Consequently, the study canvassed the valorisation of other methods which are more desirable.

The management of municipal solid waste (MSW) in Nigeria is characterized by inefficient collection and transportation systems. A comprehensive review by researchers highlighted that collection services often fail to reach unplanned areas and slums due to poor street networks (Iorhemen *et al*., 2016; Kofoworola, 2016; Jerumeh *et al*., 2022, Bassey *et al*., 2024). Additionally, there is a heavy reliance on open dumping and open burning, leading to environmental pollution and health hazards. The study advocates for the adoption of sustainable MSW management systems, including improved collection infrastructure, investment in recycling facilities, and the implementation of waste-to-energy technologies. However, studies focusing on the sociocultural aspects of Nigeria's solid waste management revealed a paucity of scholarly work in this area. The study emphasized that sociocultural factors, such as traditional beliefs, community norms, and social practices, significantly influence waste management behaviours. Understanding these dimensions is crucial for designing interventions that are culturally sensitive and more likely to be accepted by local communities. The review calls for more in-depth research to explore these sociocultural factors and their impact on waste management practices.

Pan *et al*. (2022) investigates the influencing factors of domestic solid waste generation among university students in Shanghai, China, and offers policy suggestions for waste management on campus. The study captured the magnitude of average waste generated per student, the influencing factors of waste generation on university campus, the gender and major impact on waste generation, the waste policies issues, and established the challenge and offered feasible solutions. Such studies are wanting in Nigeria and the study area of this study. Hence, the attempt by this study reflecting on tertiary educational institutions as quintessence of the society for provision of policy suggestions for the waste management and the demonstration effect to other communities due to its high social status and wide impacts.

The rapid growth of population in tertiary institution campuses as people go in pursuit of higher learning and exposure for a better tomorrow is posing a serious problem as regards waste generation (Srivastava *et al*., 2015). Dumping of refuse along street corners around the campus and their nearness to hostels, offices, lecture rooms and halls, and the time lag in evacuating them constitutes another serious environmental health hazard in the study area. These refuse dumps serve as home for vermin such as flies, mosquitoes, cockroaches and other vectors of infectious disease. One of the major problems in solid waste management in tertiary institution campuses is determining the composition and quantity of solid waste generated (Armijo de Vega *et al*., 2003; Mbuligwe, 2002; Starovoytova, 2018). The sources, quantity, characteristics and composition of solid waste generated, and the management practices was not studied and documented.

Though the environmental sanitation and protection unit in most tertiary institution campuses are trying to maintain environmental sanitation, more needs to be done to manage the waste that has been generated. The introduction of disposal containers and bins is a right step in solving or reducing the problem of waste management. However, the containers are often left to fill and spill garbage on the ground causing a very unpleasant sight and possibly associated health risks. This results in irritation not to mention the offensive odours coming from such garbage area with the infestation of rats, cockroaches, insects, flies and other disease vectors and rodents, especially in areas close to office and residential buildings (Ifegbesan *et al*., 2017). The dearth of information regarding the strategies for coping with these menaces prompts an extensive study of this nature and engineers the need for examining the approaches to containing the problem in tertiary educational institutions in Akwa Ibom state.

1.1. Objectives of the Study

This study aims to assess wastes management strategies in selected tertiary educational institutions in Akwa Ibom State which is to be achieved through two objectives including:

i. Assessing the methods of waste management adopted by selected tertiary educational institution in Akwa Ibom State.
ii. Examining the efficiency of waste management methods adopted by selected tertiary educational institutions in the study area.

1.2. Research Hypotheses

Sequel to the objectives of the study, two hypotheses were postulated for the study with one each accruing from each objective of the study.

H_{01}: There is no significant variation in the methods of waste management adopted by the tertiary educational institutions in the study area.

H_{02}: There is no significant variation in the efficiency of waste management strategies adopted by the tertiary educational institutions in the study area.

2. LITERATURE REVIEW

2.1. Methods of Solid Waste Management

Solid waste management is a critical environmental and public health issue that involves systematic control of waste generation, storage, collection, transfer, processing, and disposal. Various methods are employed to manage solid waste effectively, each with its own advantages and challenges. The choice of method often depends on factors such as waste composition, environmental impact, economic feasibility, and regulatory frameworks. Some of the primary methods of solid waste management such as landfilling, incineration, recycling, composting, integrated waste management (IWM), and gasification and pyrolysis have been discussed by various authors. Landfilling is the most common method of municipal solid waste (MSW) disposal, particularly in the United States and Russia. It involves depositing waste in designated areas, often with measures to minimize environmental impact, such as soil cover, leachate collection, and gas recovery systems (Ouedraogo *et al*., 2024; Kolibaba *et al*., 2024; Samreen *et al*., 2024). While landfills are cost-effective and can handle large volumes of waste, they pose significant environmental risks, including groundwater contamination and greenhouse gas emissions if not properly managed (Gueboudji *et al*., 2024; Samreen *et al*., 2024).

Incineration involves controlling the burning of waste at high temperatures, reducing its volume and generating energy. This method is effective in minimizing land use for disposal and can produce electricity from waste heat (Singh, 2024; Javed & Malik, 2022). However, incineration can lead to air pollution and requires significant infrastructure investment. It is often used in conjunction with other methods to manage waste more sustainably (Gueboudji *et al*., 2024; Javed & Malik, 2022). Recycling is a key component of sustainable waste management, focusing on recovering and reusing materials from waste. It conserves resources, saves energy, and reduces environmental pollution (Singh, 2024; Gueboudji *et al*., 2024). Effective recycling requires substantial infrastructure and public education to ensure proper waste segregation and processing (Gueboudji *et al*., 2024). Composting uses microorganisms to decompose organic waste into nutrient-rich compost, enhancing soil fertility. Anaerobic digestion breaks down organic matter in the absence of oxygen, producing biogas and digestate (Singh, 2024; Samreen *et al*., 2024). These methods are environmentally friendly and reduce the volume of organic waste, but they are limited to biodegradable materials (Ouedraogo *et al*., 2024; Javed & Malik, 2022). Gasification and pyrolysis are advanced thermal processes that convert waste into syngas, bio-oil, and char. These methods are effective in reducing waste volume and recovering energy (Ouedraogo et al., 2024; Javed & Malik, 2022). They require sophisticated technology and are more suitable for specific waste types, such as plastics and biomass (Javed & Malik, 2022).

Integrated Waste Management (IWM) combines multiple waste management methods to optimize environmental and economic outcomes. It often includes recycling, gasification, and anaerobic digestion, significantly reducing the environmental impact compared to traditional methods like landfilling and incineration (Ouedraogo *et al*., 2024). Implementing IWM requires policy reforms, technical innovation, and social engagement to shift the waste management paradigm (Ouedraogo *et al*., 2024). While these methods offer various benefits, they also present challenges that need to be addressed for effective implementation. For instance, financing solid waste management operations is a significant hurdle, as municipalities often struggle with funding due to barriers in sustainability and operational flexibility (Ezeudu & Bristow, 2024). Additionally, the effectiveness of each method can vary based on local conditions, such as waste composition and regulatory frameworks, necessitating a tailored approach to waste management (Kolibaba *et al*., 2024; Deka, 2023).

Ouedraogo *et al*. (2024) evaluates various methods of solid waste management, specifically comparing landfilling, incineration, and composting with more sustainable alternatives like recycling, gasification, and anaerobic digestion. The research highlights that adopting an integrated waste management (IWM) approach, which includes these sustainable methods, significantly reduces environmental impacts such as global warming potential, acidification, and ecotoxicity. The findings advocate for a shift towards IWM to mitigate the negative effects associated with traditional waste disposal methods. Ezeudu and Bristow (2024) reviews various financing methods for municipal solid waste management, categorizing them into a typology based on factors like location, technical possibilities, and regulatory frameworks. It highlights the importance of understanding these methods to ensure operational flexibility and sustainability. The classification system presented combines different waste finance strategies, addressing their pros and cons, and emphasizes the implications for financial sustainability and the circular economy, ultimately aiding municipalities in making informed financing decisions for waste management operations.

The methods of solid municipal waste (SMW) management discussed by Kolibaba *et al*. (2024) include waste disposal (landfilling), recycling, incineration, anaerobic digestion, and thermal destruction. Each method's effectiveness depends on factors such as the morphological composition of the waste, implementation costs, and environmental impact. The research emphasizes that thermal destruction is the most effective method, while waste disposal is considered less preferable due to its negative environmental consequences and failure to utilize the resource potential of the waste. Thamilmaraiselvi *et al*. (2024) noted that methods of solid waste management include composting, salvage, fermenting, and incineration, alongside open burning, marine dumping, and sanitary landfills. Waste is categorized into hazardous and non-hazardous types, necessitating separate regulations for their disposal. Landfills are specifically designed and managed to minimize risks to public health and the environment. Current solid waste management programs in developed countries focus on utilization and reduction at the source, prioritizing these methods over burning and land disposal. Similarly, Singh (2024) explained that methods of solid waste management include incineration, which involves controlled burning to reduce waste volume; pyrolysis, which decomposes waste into carbon-enriched residues and gases; composting, where microorganisms degrade organic waste into compost; and vermicomposting, utilizing earthworms to create nutrient-rich vermicompost. Sanitary landfills are designed with impervious linings to prevent groundwater contamination, while waste recovery and recycling are essential for conserving resources and reducing pollution. These methods collectively aim to manage waste effectively and sustainably.

Gueboudji *et al*. (2024) observed that the most common methods of municipal solid waste (MSW) management include landfilling, incineration, and recycling. Landfilling is the predominant disposal method but poses environmental risks if not properly managed. Incineration reduces the volume of waste and can generate energy, though it may produce air pollution. Recycling helps conserve resources and decrease waste volume, but it requires substantial infrastructure and public education to be effective. A multifaceted approach is essential for effective MSW management, considering environmental, public health, and economic factors. Samreen *et al*. (2024) outlines several methods of solid waste management, including landfill disposal, recycling, composting, and waste-to-energy practices. Landfilling is commonly preferred, where waste undergoes chemical, biological, and physical transformations. Composting and anaerobic digestion are highlighted for reducing the environmental impact of biological waste. Additionally, effective hazardous waste disposal is crucial for pollution control and resource recovery. Emerging trends include intelligent garbage collection systems, reuse and recycling concepts, and sustainable packaging solutions to enhance waste management effectiveness and sustainability. Comparably, Deka (2023) observed that solid waste management encompasses various methods including generation control, storage, collection, transfer, transport, processing, and disposal of solid wastes. Effective management should align with principles of public health, economics, engineering, conservation, aesthetics, and environmental considerations. It involves administrative, financial, legal, planning, and engineering functions to address the challenges posed by solid waste in urban societies, ensuring minimal pollution of air, land, and water at both local and global levels.

Relatedly, Javed and Malik (2022) reported that methods of solid waste management include incineration, composting, pyrolysis, gasification, and landfilling. These procedures aim to manage waste effectively by reducing its volume or recovering useful products. Incineration involves burning waste to generate energy, while composting transforms organic waste into nutrient-rich soil. Pyrolysis and gasification convert waste into gas or oil, and landfilling involves burying waste in designated areas. Each method has its advantages and is chosen based on the type of waste and environmental considerations. In the same vein, *A Fuzzy Logical based Artificial Intelligence Method for Designed to Effectively Predict and Manage the Solid Waste.* (2023) described waste management methods to include collecting, transporting, converting waste into a harmless form, recycling, and disposal. Each type of waste such as liquid, solid, or hazardous requires specific handling techniques, often necessitating expert involvement. In urban areas, municipalities manage non-hazardous residential and office waste, while generators are responsible for the recovery and disposal of non-hazardous commercial and industrial waste. Effective waste management aims to minimize the impact on human health and the environment while recovering resources from waste.

2.2. Efficiency of Waste Management Methods

The efficiency of waste management methods is critical for promoting sustainable practices and minimizing environmental impacts. Recent studies highlight various innovative approaches, including machine learning techniques and comprehensive assessments of treatment methods, which enhance the effectiveness of waste management systems. The Efficiency Analysis Tree (EAT) method for eco-efficiency in municipal solid waste management has been shown to improve eco-efficiency assessments in municipal solid waste (MSW) management. A study of 98 Chilean municipalities revealed that average eco-efficiency scores ranged from 0.561 to 0.566, indicating potential reductions in unsorted waste by over 1.6 million tons annually, translating to significant cost savings (Sala-Garrido *et al*., 2024).

Advanced technologies for waste segregation (machine learning), particularly convolutional neural networks, has been employed to enhance waste segregation processes. This technology allows for efficient classification of waste materials, reducing human error and improving operational productivity (Chauhan *et al*., 2023; "Efficient Garbage Management System Using Machine Learning", 2022). "Efficient Garbage Management System Using Machine Learning", 2022 emphasizes that efficient waste management methods, such as the proposed machine learning-based segregation system, enhance productivity by sorting garbage into Bio-Degradable and Non-Biodegradable categories at the source, facilitating better treatment and disposal of waste materials.

A comparative analysis of food waste treatment (Sustainable Food Waste Treatment, SFWT) methods indicated that anaerobic digestion is the most effective in terms of greenhouse gas emissions and energy recovery, outperforming other methods like incineration and aerobic composting (Liu *et al*., 2023). A study utilizing directional data envelopment analysis (DEA) assessed the waste management efficiency across European Union countries, revealing significant disparities and the potential for tailored strategies to enhance recycling and reduce landfill use (D'Adamo *et al*., 2024). While these advancements present promising solutions, challenges remain in implementing these methods universally, particularly in regions with varying socio-economic contexts. Addressing these disparities is essential for achieving global waste management efficiency.

The study by Sala-Garrido *et al*. (2024) reveals that the average eco-efficiency scores for Chilean municipalities from 2015 to 2019 range between 0.561 and 0.566, indicating significant potential for reducing unsorted waste and achieving economic savings in municipal solid waste management. In contrast, Chauhan *et al*. (2023) highlights that traditional waste monitoring methods are inefficient and time-consuming. By employing a convolutional neural network (CNN) for waste classification, the proposed system significantly enhances productivity and cost-effectiveness, overcoming major barriers to efficient waste management. Likewise, Nagalin geswari and Satamraju (2017) highlights inefficiencies in current waste management methods due to a lack of standard operating procedures. It proposes an IoT-based system that optimizes collection routes and monitors bin status, enhancing fuel efficiency and resource management in smart cities.

According to Liu *et al*. (2023), anaerobic digestion is the most efficient waste management method, avoiding −71.3 kg CO2 eq/FU and recovering −223 kWh/FU. Co-treatment with sewage also shows benefits, while incineration's efficiency is influenced by combined heat and power unit performance. D'Adamo *et al*. (2024) evaluates waste management efficiency using directional data envelopment analysis (DEA), categorizing countries based on their performance. It highlights disparities in waste generation and recycling, with Central European nations generally demonstrating better efficiency in managing waste. Similarly, Molinos-Senante *et al*. (2024) assesses the eco-efficiency of municipal solid waste services using a common set weights DEA model, revealing that only one out of 36 municipalities were eco-efficient, highlighting the need for robust benchmarking methods in waste management.

Bonala *et al*. (2024) proposed a waste management solution that enhances efficiency by utilizing Deep Learning and IoT for real-time waste categorization and data collection, optimizing collection routes, and reducing operational costs, while promoting sustainability through reduced manual sorting and improved resource management. Relatedly, P (2024) proposed a waste management system that enhances efficiency through real-time monitoring, adaptive scheduling, and automated processes using sensors like ultrasonic and IR. This reduces overflow, optimizes collection routes, and minimizes operational costs, contributing to cleaner and more sustainable urban environments. However, Bhagat *et al*. (2023) focuses on optimizing municipal solid waste management efficiency by employing the VRPTW model in GIS and GA environments, enabling effective transportation routing, resource management, and utilization of vehicles and labour, ultimately enhancing sustainability and reducing health hazards.

3. METHODOLOGY

The study employed a survey approach. The population of study consists of waste management and sanitation staff of the selected tertiary educational institutions Akwa Ibom State. As at the time of this study, there were 21 accredited tertiary educational institutions in Akwa Ibom State. The tertiary institutions comprise six universities, 12 polytechnics and 3 colleges. Questionnaires were randomly distributed in sampled selected tertiary educational institutions to waste management staff as well as students on the strategies adopted for waste management in the institutions. It also involved the students and occupants of the tertiary educational institutions. A total of six (6) tertiary educational institutions were sampled through a purposive sampling technique. Two universities, two polytechnics and two colleges were selected for the study. The sampled tertiary educational institutions are University of Uyo, Obong University, as sampled universities; Akwa Ibom State Polytechnic and Heritage Polytechnic as sampled polytechnics; and Akwa Ibom State College of Education and Akwa Ibom State College of Arts and Science. A total of 330 respondents participated in the study. The data collected were analysed descriptively using mean score (MS) while Kruskal-Wallis H test was used to compare waste management methods across institutions. Kruskal-Wallis H test is the non-parametric version of analysis of variance (ANOVA) used to test the hypothesis that there is no significant variation in the waste management strategies adopted across the tertiary educational institutions in the study area.

4. PRESENTATION AND DISCUSSION OF RESULTS

4.1 Demographic Attributes of Respondents

Analysis and interpretations of the data collected were carried out. Presentations and analyses of data are categorized chronologically according to the objectives of the study. A total of three hundred and thirty (330) useful questionnaires were retrieved for analysis. At the onset of the analysis, the socio-demographic characteristics of the respondents were analysed and the result presented in Table 1.

Table 1: Socioeconomic Characteristics of Respondents

Survey Items	Characteristics	Frequency	Percentage
Gender	Male	129	39.09
	Female	201	60.91
Age	15-25	206	62.42
	26-35	69	20.91
	36-45	15	4.55
	>46	40	12.12
Marital status	Married	78	23.64
	Single	231	70.00
	Widow	10	3.03
	Widower	11	3.33
Household size	2-4	197	59.70
	5-7	118	35.76
	8-10	15	4.55
Educational Background	Primary	18	5.45
	Secondary	26	7.88
	Tertiary	286	86.67
Occupation	Staff	35	17.58
	Students	272	82.42
Monthly Income (N)	5,000-10,000	206	62.42
	10,000-20,000	20	6.06
	20,000-50,000	79	23.94
	>50,000	25	7.58

The data presented in Table 1 is the percentage analysis of the socioeconomic characteristics of respondents. From the analysis, 60.91% of the respondents were female while males were made up of 39.09%. The analysis also revealed that respondents between the age groups of 15-25 years made up 62.42%, followed by 26-35 age group making up 20.91%. Respondents greater than 46 years made up 12.12%, while those between the age groups of 36-45 made up 4.55%. Similarly, the analysis also presents marital status of the respondents: while 70% were single, 23.64% were married, 3.33% were widowers while 3.03% were widows. Furthermore, the result revealed that 59.70% of the respondents had a household size of 2-4 people; 35.76% had 5-7 persons in their household, while 4.55% had a household size of 8-10 persons. Subsequently, the analysis showed that 86.67% of the respondents had tertiary educational background; 7.88% had secondary educational background, while 6.97% had primary educational background. In terms of occupation, 82.42% of the respondents were students; 17.68% were staff. Finally, the analysis showed the monthly income group of the respondents. The result revealed that 62.42% earned between N5,000 – N10,000 monthly; 23.94% of the respondents earned between N20,000

- N50,000 monthly; 7.58% earned more than N50,000 monthly while 6.06% earned between N10,000 – N20,000 monthly.

In summary, the analysis in Table 1 showed that most of the respondents were female (60.91%); between the age group of 15-25 (62.42%); mostly single (70%); with a household size of 2-4 persons (59.70%); had tertiary educational background (86.67%); mostly students (82.42%) and mostly earned N5,000 – N10,000 monthly. The analysis revealed that highly educated respondents with low income earned. Hence, income generated activities should be introduced in the campuses to augment students' earnings.

4.2 Methods of Waste Management

The analysis in Table 2 shows the distribution of wastes management methods adopted in the study area implemented by the different surveyed tertiary educational institutions. The wastes management methods examined were onsite sorting, recycling, crushing, melting, shredding, composting, resource recovery, and manufacturing.

Table 2: Mean Score Analysis of Methods of Wastes Management by Category of Waste in the Study Area

Category of Wastes	MWM	1	2	3	4	5	Sum	Mean	Std. Dev.
Municipal Wastes	Onsite sorting	0	0	11	15	15	168	4.10	0.80
	Recycling	1	1	14	14	11	156	3.80	0.95
	Crushing	3	2	15	12	9	145	3.54	1.12
	Melting	15	16	10	0	0	77	1.88	0.78
	Shredding	0	3	13	12	13	158	3.85	0.96
	Composting	9	7	3	10	12	132	3.22	1.57
	Resource Recovery	3	6	8	18	6	141	3.44	1.14
	Manufacturing	12	20	9	0	0	79	1.93	0.72
Industrial wastes	Onsite sorting	13	18	7	2	1	83	2.02	0.96
	Recycling	5	10	17	7	2	114	2.78	1.04
	Crushing	8	6	9	14	4	123	3.00	1.30
	Melting	24	12	5	0	0	63	1.54	0.71
	Shredding	14	13	13	0	1	84	2.05	0.95
	Composting	13	17	1	7	3	93	2.27	1.29
	Resource Recovery	11	21	3	6	0	86	2.10	0.97
	Manufacturing	18	16	7	0	0	71	1.73	0.74
Hazardous Wastes	Onsite sorting	17	18	3	0	2	72	1.80	0.97
	Recycling	10	8	12	7	3	105	2.63	1.25
	Crushing	9	6	10	10	5	116	2.90	1.35
	Melting	21	16	3	0	0	62	1.55	0.64
	Shredding	16	11	13	0	0	77	1.93	0.86
	Composting	14	22	0	2	2	76	1.90	1.01
	Resource Recovery	15	17	7	1	0	74	1.85	0.80
	Manufacturing	12	22	6	0	0	74	1.85	0.66

Category of Wastes	MWM	1	2	3	4	5	Sum	Mean	Std. Dev.
Biomedical wastes	Onsite sorting	15	22	3	0	2	78	1.86	0.93
	Recycling	6	9	16	8	3	119	2.83	1.12
	Crushing	11	6	8	11	6	121	2.88	1.43
	Melting	26	13	3	0	0	61	1.45	0.63
	Shredding	15	11	15	0	1	87	2.07	0.97
	Composting	16	16	0	5	5	93	2.21	1.39
	Resource Recovery	10	19	8	5	0	92	2.19	0.94
	Manufacturing	17	19	6	0	0	73	1.74	0.70
E-wastes	Onsite sorting	17	19	3	1	2	78	1.86	1.00
	Recycling	9	8	12	8	5	118	2.81	1.31
	Crushing	8	7	13	10	4	121	2.88	1.25
	Melting	17	21	4	0	0	71	1.69	0.64
	Shredding	20	14	6	0	2	76	1.81	1.02
	Composting	10	17	0	4	11	115	2.74	1.58
	Resource Recovery	13	17	7	5	0	88	2.10	0.98
	Manufacturing	14	23	5	0	0	75	1.79	0.65
Construction and Demolition Wastes	Onsite sorting	7	7	10	6	11	130	3.17	1.45
	Recycling	5	3	17	11	5	131	3.20	1.14
	Crushing	9	3	8	16	5	128	3.12	1.36
	Melting	26	9	6	0	0	62	1.51	0.75
	Shredding	3	8	19	3	8	128	3.12	1.17
	Composting	11	14	4	9	3	102	2.49	1.31
	Resource Recovery	3	7	15	15	1	127	3.10	0.97
	Manufacturing	17	19	5	0	0	70	1.71	0.68
Agricultural Wastes	Onsite sorting	18	20	3	0	1	72	1.71	0.81
	Recycling	6	5	18	10	3	125	2.98	1.12
	Crushing	14	10	9	7	2	99	2.36	1.25
	Melting	25	13	4	0	0	63	1.50	0.67
	Shredding	17	9	13	0	3	89	2.12	1.17
	Composting	12	22	0	4	4	92	2.19	1.23
	Resource Recovery	16	18	5	3	0	79	1.88	0.89
	Manufacturing	17	21	4	0	0	71	1.69	0.64
Waste water	Onsite sorting	27	12	0	0	2	61	1.49	0.93
	Recycling	16	11	10	2	2	86	2.10	1.14
	Crushing	17	13	3	5	3	87	2.12	1.29
	Melting	28	12	1	0	0	55	1.34	0.53
	Shredding	17	15	8	0	1	76	1.85	0.91
	Composting	16	17	0	4	4	86	2.10	1.30
	Resource Recovery	14	22	3	2	0	75	1.83	0.77
	Manufacturing	16	21	4	0	0	70	1.71	0.64

MWM = Method of Wastes Management

Table 2 evaluates the mean scores of different waste management methods categorized by the type of waste. In the category of municipal wastes, onsite sorting and shredding methods with mean scores of 4.10 and 3.85 respectively, were the most consistently used methods. recycling and composting methods also had notable mean scores, indicating moderate adoption. The industrial waste category shows crushing method with mean score of 3.00 was the most common method, followed by recycling and shredding. Manufacturing and melting methods scored low, suggesting limited use in managing industrial waste. Like industrial wastes category was the Hazardous Waste category as crushing with a mean score of 2.90 as the most prominent method, while onsite sorting, recycling, and shredding methods were applied with lower frequency. Biomedical Waste category analysis shows that crushing and recycling with mean scores of 2.88 and 2.83 correspondingly were slightly preferred. Other methods like onsite sorting and resource recovery had limited application. The result in Table 2 revealed that in the E-waste category recycling with mean score of 2.81 and crushing with mean score of 2.88 were dominant. On the other hand, onsite sorting and manufacturing had less usage. The management of construction and demolition wastes were mostly addressed by onsite sorting, recycling, and shredding with all their mean scores above 3.0, indicating diverse methods employed. Agricultural waste was managed mostly by recycling with a mean score of 2.98 as the leading method. Other methods like onsite sorting and shredding had moderate applications. The wastewater category shows that crushing, recycling and composting with mean scores of 2.12 and 2.10 (repeated) were the most used methods, though with low mean scores, while onsite sorting has least overall mean scores across all methods in the category which is a reasonable result because onsite sorting is reasonably not applicable to wastewater management.

The practical implications of the results revealed institutional differences in the management of waste. The variance in waste management methods reflects differences in institutional priorities, resources, and waste profiles. For example, crushing is prevalent for hazardous and industrial waste, which aligns with safety and regulatory compliance requirements. Secondly, method suitability is pronounced as methods like recycling and onsite sorting are widely applicable and scalable. However, the low adoption of advanced methods like melting and manufacturing may indicate a gap in technology or funding. Thirdly, the result shows a practical implication of public health and environmental risk. Limited use of effective waste management methods like shredding and recycling for hazardous and biomedical waste could pose health and environmental risks to the surveyed campuses.

Conclusively, deductions from the result depict heterogeneity in practice of waste management on the surveyed campuses in the study area. This is similar to the findings of Deka (2023). Waste management practices are not uniformly implemented, with significant variations across institutions and waste categories. The challenges may be due to barriers such as financial constraints, lack of infrastructure, and low public awareness. However, methods like recycling and onsite sorting show potential for broader application. It is, therefore, recommended that enhanced infrastructure for recycling and advanced methods like manufacturing for specific waste types be employed for managing waste on the campuses. Increasing awareness and training for waste management staff and students should be given much attention. Implementation of penalties for non-compliance and provision of incentives for sustainable practices can be introduced.

4.2.1 Test of Hypothesis One (H_{01})

The variance in waste management methods observed in the previous section, reflecting differences in institutional priorities, resources, and waste profiles, necessitates the test of hypothesis one analysis on tertiary educational basis such that hypothesis one (H_{01}) can be tested to discern if variation exists among the institutions. Notwithstanding, as an initial step, it is essential to descriptively depict the scenario of the waste management methods on institutional basis to appreciate the different approaches to waste management adopted by the different selected tertiary educational institutions. The descriptive analysis of the waste management on institutional basis is presented in Table 3.

Table 3: Mean Score Analysis of Methods of Wastes Management by Selected Tertiary Institution

Methods of Waste Mgt	Institution	1	2	3	4	5	Sum	Mean	Std. Dev.
Onsite sorting	AKCOA	16	17	7	6	9	140	2.55	1.44
	AKCOE	17	21	8	3	6	125	2.27	1.27
	AKPOLY	24	15	9	3	4	113	2.05	1.22
	HEPOLY	21	22	4	4	4	113	2.05	1.19
	OBUNI	16	23	7	5	4	123	2.24	1.19
	UNIUYO	20	18	5	3	9	128	2.33	1.44
Recycling	AKCOA	8	7	20	15	5	167	3.04	1.17
	AKCOE	4	4	26	15	6	180	3.27	1.01
	AKPOLY	10	7	21	12	5	160	2.91	1.21
	HEPOLY	6	9	21	12	7	170	3.09	1.16
	OBUNI	16	14	15	5	5	134	2.44	1.26
	UNIUYO	14	14	13	8	6	143	2.60	1.31
Crushing	AKCOA	11	12	8	13	11	166	3.02	1.44
	AKCOE	13	6	14	17	5	160	2.91	1.32
	AKPOLY	11	6	14	18	6	167	3.04	1.30
	HEPOLY	17	10	9	13	6	146	2.65	1.42
	OBUNI	14	6	16	13	6	156	2.84	1.34
	UNIUYO	13	13	14	11	4	145	2.64	1.25
Melting	AKCOA	29	17	9	0	0	90	1.64	0.75
	AKCOE	30	22	3	0	0	83	1.51	0.60
	AKPOLY	32	20	3	0	0	81	1.47	0.60
	HEPOLY	33	16	6	0	0	83	1.51	0.69
	OBUNI	30	19	6	0	0	86	1.56	0.69
	UNIUYO	28	18	9	0	0	91	1.65	0.75
Shredding	AKCOA	20	14	16	2	3	119	2.16	1.13
	AKCOE	13	19	14	4	5	134	2.44	1.20
	AKPOLY	17	13	20	3	2	125	2.27	1.08
	HEPOLY	16	12	18	2	7	137	2.49	1.30
	OBUNI	17	13	16	3	6	133	2.42	1.29
	UNIUYO	19	13	16	1	6	127	2.31	1.27
Composting	AKCOA	16	19	4	11	5	135	2.45	1.34
	AKCOE	13	20	4	11	7	144	2.62	1.38
	AKPOLY	18	24	0	5	8	126	2.29	1.40
	HEPOLY	18	23	0	6	8	128	2.33	1.41
	OBUNI	18	23	0	6	8	128	2.33	1.41
	UNIUYO	18	23	0	6	8	128	2.33	1.41

Methods of Waste Mgt	Institution	1	2	3	4	5	Sum	Mean	Std. Dev.
Resource Recovery	AKCOA	18	23	8	6	0	112	2.04	0.96
	AKCOE	12	22	10	10	1	131	2.38	1.08
	AKPOLY	16	21	9	9	0	121	2.20	1.04
	HEPOLY	14	24	5	11	1	126	2.29	1.12
	OBUNI	14	21	11	8	1	126	2.29	1.07
	UNIUYO	11	16	13	11	4	146	2.65	1.22
Manufacturing	AKCOA	20	27	8	0	0	98	1.78	0.69
	AKCOE	20	26	9	0	0	99	1.80	0.70
	AKPOLY	20	30	5	0	0	95	1.73	0.62
	HEPOLY	20	28	7	0	0	97	1.76	0.67
	OBUNI	21	26	8	0	0	97	1.76	0.69
	UNIUYO	22	24	9	0	0	97	1.76	0.72

N = 330; 1 = Never; 2 = Rarely; 3 = Sometimes; 4 = Often; 5= Always; AKCOA = Akwa Ibom State College of Art; AKCOE = Akwa Ibom State College of Education; AKPOLY = Akwa Ibom State Polytechnic; HEPOLY = Heritage Polytechnic; OBUNI = Obong University; UNIUYO = University of Uyo

Onsite sorting waste management method at the Akwa Ibom State College of Arts (AKCOA) has the highest mean score of 2.55. The waste management practices varied, with none of the selected institutions demonstrating exceptional scores, suggesting room for improvement across institutions. Akwa Ibom State College of Education (AKCOE) scored the highest in the recycling of waste, with a mean score of 3.27. Crushing and recycling were predominant methods, indicating a preference for methods that manage the waste's physical structure and resource recovery. Crushing waste management method scores ranged narrowly, with AKCOA and AKPOLY showing the highest mean of 3.02 and 3.04 respectively, reflecting their focus on crushing and onsite sorting. Melting waste management practices appeared generally weak across the surveyed institutions. Melting waste management scores were uniformly low across institutions, with the highest mean score of 1.65 at University of Uyo (UNIUYO). The highest score might have been influenced by the practices at the University of Uyo Teaching Hospital (UUTH). Recycling and crushing were the most employed methods but not effectively utilized.

Heritage Polytechnic (HEPOLY) led in the management of waste using shredding with a mean score of 2.49, reflecting better engagement in recycling and shredding. Other institutions lagged, indicating limited attention to shredding as a waste management method. Composting waste scores were similar, with AKCOE scoring highest (2.62). Methods like onsite sorting and recycling were moderately used, but advanced methods were lacking. Resource recovery waste management scoring was led by UNIUYO (2.65) in this category, indicating a slightly higher emphasis on recycling. Other institutions scored similarly, suggesting a consistent but modest approach to managing waste by resource recovery. Manufacturing waste management method scores were uniformly low, with AKCOE scoring marginally better (1.80). Onsite sorting and basic recycling dominated but with limited efficiency.

Institutions like AKCOE and HEPOLY demonstrated relatively better performance in specific waste categories (industrial and e-waste, respectively). Uniformly low scores in biomedical and wastewater management suggest systemic inefficiencies. Onsite sorting, recycling, and crushing were the dominant methods, reflecting cost-effectiveness and ease of implementation. Advanced methods like manufacturing and melting were rarely employed, indicating technological and financial barriers. The limited use of advanced methods may be due to resource constraints, including funding, equipment, and training.

Practical implications point towards ineffective management of hazardous and biomedical waste management which poses risks of contamination and disease. Scaling up recycling and onsite sorting methods could mitigate environmental risks and reduce waste volumes. There is the need for policy and investment towards targeted investments in advanced waste management technologies and stricter regulatory enforcement. Waste management practices in tertiary institutions are fragmented and vary widely by institution and waste category. Basic methods like sorting and crushing dominate, but advanced waste processing is underutilized.

It is recommended that educational institutions should develop targeted waste management policies tailored to institutional needs and waste profiles, invest in recycling infrastructure and advanced processing methods as canvased by Gueboudji *et al.* (2024) and Samreen *et al.* (2024). Moreso, the conduct of regular training for waste management personnel and raising awareness among students and staff should be prioritized. Enforcement of penalties for non-compliance and providing incentives for adopting sustainable waste practices may be needed.

Hypothesis one postulates that there is no significant variation in the methods of waste management adopted among the tertiary educational institutions in the study area. To analyse the hypothesis, Kruskal-Wallis H test, which is the non-parametric equivalence of ANOVA test, was used. The result of the test of the hypothesis is presented in Table 4.

Table 4: Kruskal Wallis Test for Variation in Waste Management Methods

Category of Wastes	Test Parameter	Onsite sorting	Recycling	Crushing	Melting	Shredding	Compos-ting	Resource Recovery	Manufac-turing
Municipal Wastes	Chi-Square	4.773	2.558	2.717	5.973	11.282	4.658	12.224	1.069
	df	5	5	5	5	5	5	5	5
	Asymp. Sig.	0.444	0.768	0.744	0.309	0.046	0.459	0.032	0.957
Industrial wastes	Chi-Square	3.317	5.03	4.802	2.371	5.375	2.436	7.864	0.191
	df	5	5	5	5	5	5	5	5
	Asymp. Sig.	0.651	0.412	0.44	0.796	0.372	0.786	0.164	0.999
Hazardous Wastes	Chi-Square	3.685	5.332	4.593	3.983	7.626	4.652	3.4	0.635
	df	5	5	5	5	5	5	5	5
	Asymp. Sig.	0.596	0.377	0.467	0.552	0.178	0.46	0.639	0.986
Biomedical wastes	Chi-Square	3.929	1.762	10.664	4.531	2.689	0.557	6.108	3.145
	df	5	5	5	5	5	5	5	5
	Asymp. Sig.	0.56	0.881	0.058	0.476	0.748	0.99	0.296	0.678
E-wastes	Chi-Square	10.675	8.331	2.869	3.595	1.145	1.713	9.899	3.046
	df	5	5	5	5	5	5	5	5
	Asymp. Sig.	0.058	0.139	0.72	0.609	0.95	0.887	0.078	0.693
Construction and Demolition Wastes	Chi-Square	16.502	11.517	3.346	4.435	9.12	12.273	11.565	1.154
	df	5	5	5	5	5	5	5	5
	Asymp. Sig.	0.006	0.042	0.647	0.489	0.104	0.031	0.041	0.949
Agricultural Wastes	Chi-Square	3.909	10.816	15.508	5.2	6.274	0.442	3.736	4.426
	df	5	5	5	5	5	5	5	5
	Asymp. Sig.	0.563	0.055	0.008	0.392	0.28	0.994	0.588	0.49
Waste water	Chi-Square	6.017	13.26	9.147	0.324	1.927	0.117	5.285	2.344
	df	5	5	5	5	5	5	5	5
	Asymp. Sig.	0.305	0.021	0.103	0.997	0.859	1	0.382	0.8

[a] Kruskal Wallis Test; b Grouping Variable: Institution

Significant variation was found in managing municipal waste using shredding and resource recovery methods with p-values of 0.000 and 0.030 respectively. Other methods like onsite sorting, recycling, and crushing did not show significant variation across institutions. This finding is similar to the phenomenon in the study of three tertiary institutions in Tanzania by Mbuligwe (2002). No significant differences nor variation were observed for any waste management method in the management of industrial waste, indicating uniformity in practices across institutions.

No significant variation was observed for any method in the management of hazardous waste, reflecting consistency in hazardous waste management practices. A marginal difference was found in crushing method for managing biomedical waste revealing a p-value of 0.058, though it was not statistically significant. No significant variation was observed for any method in the management of e-waste waste, reflecting consistency in hazardous waste management practices.

Significant variations were observed in the management of construction and demolition waste with methods such as onsite sorting ($p = 0.006$), recycling ($p = 0.042$), composting ($p = 0.031$), and resource recovery ($p = 0.041$), suggesting different approaches by institutions. In the management of agricultural waste, significant variation was found in crushing ($p = 0.008$**)**, while other methods were consistent across institutions. Significant differences were found in recycling methods for managing wastewater with a p-value of 0.021, but no variation was observed in advanced methods like melting or manufacturing.

Generally, the significant differences in managing municipal, construction and demolition, and agricultural wastes reflect diverse institutional priorities, available resources, and waste profiles. In contrast, the uniformity in managing hazardous, industrial, and biomedical waste indicates shared challenges or similar resource constraints. Summarily, shredding, recycling, and resource recovery were more likely to show institutional variations, as they require specific infrastructure and expertise. Advanced waste management methods like melting and manufacturing were consistently underutilized, suggesting technological and financial barriers.

The practical implication of the result is constituted in the variations in managing municipal and construction waste which highlight the need for standardized practices to minimize health and environmental risks. Investment in recycling infrastructure and training is essential to improve uniformity and efficiency in waste management. Consistent but low adoption of advanced hazardous waste management methods poses significant health risks, warranting immediate attention. It is recommended that institutions should be encouraged to adopt the best practices observed in high-performing institutions, especially for shredding and resource recovery. Investment in recycling infrastructure and training is essential to improve uniformity and efficiency in waste management.

4.3 Efficiency of Wastes Management

The analysis in Table 5 shows the result of the efficiency of wastes management methods adopted in the study area by the different surveyed tertiary educational institutions. About eight different approaches were assessed to understand the effectiveness and sustainability of the approaches as practiced by the various surveyed institutions.

Table 5 presents an analysis of the efficiency of various waste management methods adopted by tertiary institutions in the study area. Eight different waste management strategies were evaluated, including onsite sorting, recycling, prohibition of littering, daily waste collection, waste treatment plants, revenue generation from recycling, waste reduction, and landfill disposal.

The key findings show that onsite sorting and recycling strategies are moderate to high mean scores across institutions, indicating their widespread acceptance. Daily collection of waste strategy received consistently high ratings, reflecting its effectiveness in maintaining cleanliness and environmental aesthetics, while waste treatment plants strategy was among the least preferred, suggesting infrastructural and financial constraints in adopting advanced waste treatment facilities.

Revenue generation from recycling shows relatively low mean scores and suggest that institutions are not fully leveraging recycling as a revenue-generating initiative. Waste reduction as a management strategy was rated favourably, emphasizing its importance in minimizing waste generation at the source, while landfill disposal, despite its limitations, remains a common waste disposal strategy across institutions.

Table 5: Efficiency Waste Management among the Selected Tertiary Educational Institutions

Institution	WMECODE	1	2	3	4	5	Sum	Mean	Std. Dev.	Var.
Akwa Ibom State College of Arts	WME1	27	13	5	10	0	108	1.96	1.15	1.33
	WME2	9	5	10	18	13	186	3.38	1.38	1.91
	WME3	13	5	17	11	9	163	2.96	1.39	1.93
	WME4	9	6	6	17	17	192	3.49	1.45	2.11
	WME5	19	17	12	7	0	117	2.13	1.04	1.08
	WME6	18	10	13	8	6	139	2.53	1.37	1.88
	WME7	6	6	16	12	15	189	3.44	1.30	1.70
	WME8	10	5	10	13	17	187	3.40	1.47	2.17
Akwa Ibom State College of Education	WME1	26	13	2	11	3	117	2.13	1.35	1.82
	WME2	15	5	12	12	11	164	2.98	1.50	2.24
	WME3	6	9	11	14	15	188	3.42	1.34	1.80
	WME4	8	4	6	19	18	200	3.64	1.39	1.94
	WME5	22	12	11	5	5	124	2.25	1.32	1.75
	WME6	14	14	14	8	5	141	2.56	1.27	1.62
	WME7	11	5	10	14	15	182	3.31	1.48	2.18
	WME8	8	4	13	14	16	191	3.47	1.37	1.88
Akwa Ibom State Polytechnic	WME1	23	14	7	8	3	119	2.16	1.27	1.62
	WME2	2	7	13	17	16	203	3.69	1.14	1.29
	WME3	11	7	11	12	14	176	3.20	1.47	2.16
	WME4	8	5	10	17	15	191	3.47	1.37	1.88
	WME5	22	15	7	7	4	121	2.20	1.30	1.68
	WME6	21	11	12	7	4	127	2.31	1.30	1.70
	WME7	5	5	15	13	17	197	3.58	1.27	1.62
	WME8	10	4	14	11	16	184	3.35	1.44	2.08
Heritage Polytechnic	WME1	16	19	6	12	2	130	2.36	1.22	1.50
	WME2	11	8	10	13	13	174	3.16	1.46	2.14
	WME3	7	7	14	8	19	190	3.45	1.41	1.99
	WME4	7	5	12	14	17	194	3.53	1.36	1.85
	WME5	19	16	12	7	1	120	2.18	1.11	1.23
	WME6	15	11	11	14	4	146	2.65	1.32	1.75
	WME7	6	6	14	13	16	192	3.49	1.32	1.74
	WME8	8	5	11	11	20	195	3.55	1.44	2.07
Obong University	WME1	23	11	7	8	6	128	2.33	1.43	2.04
	WME2	4	7	15	14	15	194	3.53	1.23	1.51
	WME3	8	6	11	15	15	188	3.42	1.38	1.91
	WME4	5	5	11	16	18	202	3.67	1.28	1.63
	WME5	23	13	12	5	2	115	2.09	1.16	1.34
	WME6	23	13	7	7	5	123	2.24	1.36	1.85
	WME7	7	4	11	12	21	201	3.65	1.39	1.93
	WME8	7	5	10	16	17	196	3.56	1.36	1.84

Institution	WMECODE	1	2	3	4	5	Sum	Mean	Std. Dev.	Var.
University of Uyo	WME1	19	16	6	11	3	128	2.33	1.29	1.67
	WME2	12	7	10	16	10	170	3.09	1.43	2.05
	WME3	7	8	10	18	12	185	3.36	1.32	1.75
	WME4	14	3	8	13	17	181	3.29	1.58	2.51
	WME5	22	16	8	7	2	116	2.11	1.18	1.40
	WME6	22	14	9	8	2	119	2.16	1.21	1.47
	WME7	10	4	14	10	17	185	3.36	1.46	2.13
	WME8	8	4	12	11	20	196	3.56	1.42	2.03

WME1 = The nature of the environment affects proper waste management in my school.

WME2 = Functional environmental legislation ensures proper wastes management in my school/workplace.

WME3 = Prohibition of indiscriminate dropping of litter on the ground.

WME4 = Daily collection of waste from the disposal point retains beauty of the environment.

WME5 = Installation of a waste treatment plant in the school is preferred.

WME6 = Recycled waste generates revenue for my school.

WME7 = Reduction in quantity of wastes generated is the best approach to wastes management.

WME8 = Disposal of Wastes in well-constructed landfills.

Practical implications of the results suggest that institutions prioritize simpler and cost-effective waste management strategies such as daily collection and waste reduction, rather than more complex strategies like waste treatment plants. The low emphasis on recycling for revenue generation implies missed economic opportunities.

To enhance efficiency, institutions should invest in recycling infrastructure because encouraging recycling not only promotes sustainability but also provides an alternative revenue stream. Institutions should explore adopt advanced waste treatment technologies such as the feasibility of establishing waste treatment plants to improve waste processing. Additionally, awareness and training programmes should be enhanced for students and staff can promote better waste management practices. The study reveals that while some waste management strategies are effectively implemented, there is a need for greater institutional investment in recycling, resource recovery, and waste treatment plants to achieve more sustainable waste management.

4.3.1 Test of Hypothesis Two (H_{02})

The variance in the efficiency of waste management methods observed in the immediate previous section reflecting differences in institutional priorities, resources, and waste profiles necessitates the test of hypothesis two (H_{02}). Hypothesis two postulates that there is no significant variation in the efficiency of waste management strategies adopted by the tertiary educational institutions in the study area. To analyse the hypothesis, Kruskal-Wallis H test, which is the non-parametric equivalence of ANOVA test, was used. The result of the test of the hypothesis is presented in Table 6.

Table 6 presents the results of a Kruskal-Wallis H test, which was conducted to examine variations in the efficiency of waste management strategies across different tertiary institutions. The key findings derived from the result of the test show that there are variations in institutional approaches. The statistical test indicates that certain waste management strategies, particularly those requiring infrastructure and financial investment (for instance, shredding and resource recovery), showed significant variation across institutions. Whereas strategies such as onsite sorting, recycling, and crushing did not exhibit significant differences, implying that these approaches are widely implemented at similar levels across institutions. The variance in advanced waste management methods suggests that some institutions have better infrastructure and financial capacity to implement more sophisticated strategies, while others rely on basic waste management methods.

Table 6: Result of Test of Hypothesis Two

Educ Institutional	N	Mean Rank	Chi-Square	df	Asymp. Sig.
Akwa Ibom State College of Arts	8	21.25			
Akwa Ibom State College of Education	8	23.69			
Akwa Ibom State Polytechnic	8	25.5	2.15	5	0.828
Heritage Polytechnic	8	26.88			
Obong University	8	29			
University of Uyo	8	20.69			

AKCOA = Akwa Ibom State College of Art; AKCOE = Akwa Ibom State College of Education; AKPOLY = Akwa Ibom State Polytechnic; HEPOLY = Heritage Polytechnic; OBUNI = Obong University; UNIUYO = University of Uyo

The result implies that there is a need for a harmonized approach to waste management across institutions to ensure efficiency and environmental sustainability. Institutions with lower efficiency in waste management should be encouraged to adopt best practices from high-performing institutions. Government agencies and institutional policymakers should support tertiary institutions by providing funding and regulatory frameworks to enhance waste management efficiency. The results of the hypothesis two confirm that while certain basic waste management strategies are consistently applied across institutions, advanced waste management methods show significant variation. This highlights the need for increased investment in infrastructure and policy interventions to bridge the gap in waste management efficiency.

5. Conclusions and Recommendations

The findings of this study highlight significant variations in waste management practices across the surveyed tertiary institutions, demonstrating a lack of uniformity in waste handling approaches. Recycling, onsite sorting, and shredding emerged as the most adopted methods, primarily due to their feasibility and ease of implementation. However, more advanced waste management techniques, such as melting and manufacturing, remain largely underutilized. This underutilization is likely due to financial constraints, inadequate infrastructure, and technical limitations. Additionally, the inconsistent adoption of effective waste management strategies for hazardous and biomedical waste poses serious public health and environmental risks. These findings underscore the need for a more standardized and efficient waste management framework to ensure sustainability and mitigate the negative impacts of improper waste disposal.

To address these challenges, institutions should invest in infrastructure that supports recycling and advanced waste management methods. The adoption of manufacturing and waste treatment plants for specific waste categories would significantly improve overall waste management efficiency. Additionally, increasing awareness and providing training programmes for students and staff would encourage better participation and compliance with waste management practices.

Furthermore, financial incentives and penalties should be introduced as part of institutional waste management policies. Institutions that successfully implement sustainable waste disposal and resource recovery strategies should be rewarded, while penalties should be enforced for non-compliance. Waste reduction strategies should also be prioritized by implementing strict policies that minimize waste generation at the source and encourage the reuse of materials wherever possible.

Collaboration between tertiary institutions, government agencies, and the private sector is essential to secure funding and technical support for improved waste management facilities and strategies. By adopting these measures, tertiary institutions can significantly enhance their waste management efficiency, reduce environmental hazards, and create a more sustainable and healthier campus environment.

6. LIMITATION OF THESTUDY

The study focuses on tertiary educational institutions in Akwa Ibom State, which may limit the generalizability of the findings to other regions. Further studies incorporating comparative analyses across different States or Countries could provide broader insights into institutional waste management practices.

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