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Evaluation of the factors Governing Higher Institution Solid Waste Management: case of Obafemi Awolowo University, Ile-Ife, Nigeria

Lateef Adeleke Adeniyi[1] and Charles Adesola Ajagbe[2]

Abstract

This study examines the factors militating against sustainable solid waste management in the institution of higher learning, using Obafemi Awolowo University, Ile-Ife, Nigeria, as the study area. The study utilised primary and secondary data. Primary data were obtained through personal observation, interviews, and the administration of a structured questionnaire in different activity areas of the university. The information requested is on solid waste sorting, storage, collection, transportation, and disposal, as well as the factors influencing solid waste management in the university. The questionnaire was administered to the stakeholders in the four major activity areas of the study area. These are the hostels, staff quarters, academic area, and the market. A total of 306 respondents selected through systematic random sampling of every 10th occupant were administered a questionnaire on the space users. The author's collaborative efforts with four assistants ensured a comprehensive and robust data collection process. The data collected were analysed through inferential statistical methods such as the relative importance index and factor analysis, a statistical technique used to elucidate and rank the variables that contribute significantly to the solid waste management activity. Factor analysis was specifically harnessed to identify and hierarchically order the salient factors responsible for the management of solid waste. The study concluded that the most important factors militating against effective solid waste management are inadequate human and material resources, ineffective institutional framework, the composition and quantity of solid waste generated, inadequate monitoring and evaluation of waste management practices, and lack of technical know-how of the waste collectors.

Keywords
Waste management, Higher institution, University, Factor analysis

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Contact
Lateef Adeleke Adeniyi

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1. Introduction

Comforts of man in an environment and habitability of a place cannot be divorced from how the environment dictates (McHarg & Steiner, 2014; Fargette *et al*., 2019). It is also important to note that humans contribute a lot to how healthy the environment is through various anthropogenic activities, owing to the development of residential, commercial, agricultural, social, economic, industrial, and institutional, as well as recreational activities. There is no doubt that all of these activities have both negative and positive impacts on the environment. The environment as host to the changes produced also paid back indirectly to man, resulting in various environmental hazards. (Schulze-Makusch et al., 2017). One of the environmental problems that resulted from these activities is the generation of waste. The contending problem is not waste generation itself, but effective management of the wastes produced. Of all the types of waste produced by man, the management of the solid type of waste is particularly important, not only because of the pollution produced but also the negative impact created on the landscape. Unfortunately, it is an unavoidable byproduct of human being that is produced irrespective of location, social class, and activities (Adeniyi & Afon, 2022; Adeniyi et al.,2024). Having been regarded as condemned solid material formally used by its owner before it was discarded, solid waste so condemned may be a new product to someone else who may require such a particular product at a time.

Solid waste can be categorised into household waste, institutional waste, healthcare waste, market waste, kitchen waste, and construction waste, based on sources of generation.

[1]*Department of Urban and Regional Planning, Federal University, Oye-Ekiti, Nigeria*
[2]*Department of Geography and Environmental Education, Emmanuel Alayande University of Education, Oyo, Nigeria*

The quantity of solid waste generation have been established to depend on many factors such as eating habit (Afon, 2007; Gebreeyosus, 2018), standard of living (Afon, 2007), population (Adeniyi et al., 2024), activity in operation and time of generation (Ugwu et al 2020; Adeniyi et al, 2022), income level (Adeniyi, et al., 2020), length of staying in a place (Adeniyi, 2019) and development in science and technology (Abdel-Shafy & Mansour 2018; Govani et al., 2021). A lot of these condemned materials in most cities of developing countries end up in thrown away into the landscape, littering the surroundings due to a poor management system. Common solid waste disposal practices in different activity areas of developing countries, including universities, are dumping in open space, water bodies, drains, uncompleted buildings, vacant plots, and burning, among others. All these practices have adverse effects on the environment and constitute a threat to the health of the public (Odonkor et al, 2020; Olaniyan and Adegbola, 2020; Olatunji et al., 2024). The mountain of solid waste that characterizes most urban areas in developing countries emits foul odour and serves as a breeding ground for pathogenic agents is one of the threats observed. Yoada et al., (2014) in the study of domestic waste disposal practice and insights of private sectors' waste management assert that indiscriminate disposal of solid waste persists in Accra despite the level of public awareness of the life-threatening consequences. Despite government efforts and several studies on this environmentally disturbing by-product of human activities, poor management leads to an eyesore outlook of urban landscapes and other land use areas, including educational institutes, which affects the nature of the landscape. Reasons for the continuous handling of solid waste have not been holistically delved into. Thus, it is imperative to investigate the factors responsible for the persistence and unchanging habit of the people on this life-threatening practice that leads to poor management of solid waste.

Sharma & Jain (2020) attribute poor solid waste management in most cities to inadequate funding, wrong selection of technology, ineffective waste policies, inadequate infrastructure facilities, and lack of trained personnel. The nature of activities and the socio-economic background of the stakeholders in the university are important factors that may bring variations. Lema et al (2019) opined that indiscriminate solid waste management is a result of a lack of technical know-how on the part of waste managers as well as the inaccessibility of some houses in most urban areas. In the same vein, Gebreeyorous (2018) and Rugatiri et al. (2021) considered the educational status of waste generators as one of the factors driving solid waste management. In similar studies, Ssemugabo et al (2020) and Sankoh et al (2013) attribute poor waste management to the attitude of people. Similarly, Sarfo-Menzah et al (2019) link poor solid waste management in Ghana to factors such as violation of sanctions by waste generators, bad attitudes, and inadequate budgetary allocation. Similarly, Adeniyi et al (2022) on the implications of changing urban land use on solid waste management attribute indiscriminate solid waste management among categories of socio-economic status to a lack of enforcement of regulation on the violators. Upadhway et al. (2012) attribute indiscriminate waste management in developing countries to non-recognition of informal sectors, lack of funds, inadequate infrastructure, and inappropriate technology, as well as inadequately trained people. Such claims have not been established in an institution of higher learning. It could be established from the foregoing that factors influencing solid waste management are numerous. There is a need to harmonize the factors raised by different researchers with consideration of different land use areas to proffer a holistic solution to solid waste management in developing countries. However, peculiarities of different land uses within urban areas with different socio-cultural attributes have not been incorporated into the previous studies. One of such land uses with peculiarities is an educational institute like Obafemi Awolowo University.

A typical university is like a mini-city comprising different land uses of the types that can be seen in cities. The land uses range from student and staff residences, academic, commercial, health centre, and market land use, as well as recreational, among others. The expectation that such institutes with multiple activity areas and unique social classes should be free of poor solid waste management problems is not always as assumed. Thus, this community with various activities in operation needs to be investigated for its environmental consequences and management of solid waste in particular. The task before the current study is to investigate solid waste management activities in Obafemi Awolowo University and determine the factors influencing the management practices.

2. Materials and Methods

2.1 Study Area

Obafemi Awolowo University is located in Ile-Ife, Osun State, Nigeria. Ile-Ife lies between latitude 7° 28′ 43.5″ and 7°34′ 51.41″ North of the Equator and longitude 4° 27′ 22.5′′ and 4° 35′ 40.61″ East of Greenwich. (Fig.1). It has a high relative humidity with a rainfall of between 1800 and 2000 mm annually (Sogbesan 2015). The rainy period is between April and October, while the dry period lasts from November to March. The estimated population of Ile-Ife town, which includes the university, according to World Population Review (2021), was 384,863. The University lies to the North of the town. The campus has an attractive landscape built on about 5000 acres (20 km^2) of a total of 13,850 acres (53 km^2) of land acquired for its use. The climatic situation is as found in the rain forest zone, but modified by the topography of the land to a limited extent. The University Campus has eight main activity areas of students' residential, staff residential, the academic, market, banking, health centre, the University farm, and sports complex. The students' residential area consists of nine halls of residence. Four each were meant exclusively for male and female students' occupations. Staff residential area provides accommodation for both senior and junior staff members of the University in different quarters, a bookshop, library, faculties, and departments. There are staff offices, lecture rooms/studios, laboratories, board rooms, libraries, seminar rooms, workshops, stores, and modelling rooms at the faculty and departmental levels. Others are banks, the market, health centre, primary and secondary schools, and other affiliated activity areas.

The population estimation of the University as contained in the master plan prepared in 2013 used to project was 59,282 people. It should be noted that the daily population figure does not include increases that may occur as a result of special occasions such as convocation, matriculation, and inaugural lectures (Adeniyi, 2019). Using a compound interest calculator and 3% recommended by the National Population Commission of 2006, the estimated population for 2023 was 79. 992. This figure accounts for about 20% of the total number of people in the university. A glance at the University environment shows that solid waste management is not given adequate attention. Overflowing of waste receptacles located in strategic locations, waiting for the attention of collectors, is evidence of partial neglect. It could also be noted that all categories of solid waste were given uniform storage, showing that no reasonable consideration was attached to the solid waste sorting of different components. Similarly, open burning, which was observed as the most popular waste management practice in the university, attracted the attention of the researchers. These, among others, prompted the interest of this research in the study area.

2.2 Data needed, collection, and analysis

Discussion in this subsection includes data needed, collection method, as well as the analysis used for the data collected. The data used for this study were primary and secondary. Primary data were obtained through personal observation, interviews, and the administration of a structured questionnaire in different activity areas of the university. The information requested is on solid waste sorting, storage, collection, transportation, and disposal. Other information sought was on the factors driving solid waste management in the university. The factors included in the questionnaire were sourced from the literature of similar studies. The questionnaire was administered to the stakeholders in the four major activity areas of the study area. These are the hostels, staff quarters, academic area, and the market. A total of 306 respondents selected in the four activity areas through systematic random sampling of every 10th were used for this study. The administration of the questionnaire was a collaborative effort involving the authors and four assistants, ensuring a comprehensive and robust data collection process. The data collected were analysed through inferential statistical methods. Inferential statistics, such as the relative importance index and factor analysis, were used to make predictions from the sample size. This involved the use of the Relative Importance Index (RII) and factor analysis to examine residents' perceptions of the constraints of solid waste management. The constraints of waste management were measured by 17 variables that were established in the literature. The variables were structured on a 5-point Likert scale that ranges from 1–strongly disagree, 2–disagree, 3–partially agree, 4—agree, 5–strongly agree. Respondents were asked to rate the variables on how they pose challenges to or affect the management of solid waste in the study area. The relative importance index (RII) was first used to rank these associated factors based on their order of importance (Rooshdi et al., 2018; Oladehinde et al., 2023). To arrive at the RII, weight values of 1, 2, 3, 4, and 5 were attached to a rating of strongly disagree, disagree, partially agree, agree, and strongly agree, respectively. The index for each element was achieved by dividing the Summation of Weight Value (SMV) by the total number of responses. The SWV for each element was obtained through the addition of the product of the number of responses to each aspect and the respective weight value attached to each rating. Thus, the higher the RII, the higher the factors affecting access to land for housing development. The formula of this procedure is expressed below:

SWVn=15nkxiyi (1)

where SWV is referred to as the summation of weight value; Xi is the number of respondents to rating i; and yi is the assigned weight that is assigned to values ranging from 1, 2, 3, 4,

5. SWV was later subdivided by the number of respondents to arrive at each factor variable's RII.

The formula is expressed as:

$$RII = \Sigma WA \times N \quad (2)$$

where W = assigned weight of each statement by the respondents; A = highest weight, and N = total number of respondents.

After establishing the order of importance of the identified variable factors of solid waste management. The rating was further subjected to factor analysis to reduce and classify the number of identified variables into a smaller number of factors.

Factor analysis is used to identify underlying variables, or factors, that explain the pattern of correlations within a set of observed variables. It is also used to classify variables contextually into more meaningful latent variables rather than any individual manifest variables. In this study, factor analysis was employed to reduce a large number of variables into a smaller number of factors by restructuring many variables into a smaller number of components. Factor analysis (FA) is useful for the elimination of variable collinearity and uncovering latent variables (Aiken et al., 2008). It tries to simplify complex and diverse relationships that exist among a set of observed variables by uncovering common dimensions or factors that link together the seemingly unrelated variables and consequently provides insight into the underlying structure of the data (Child, 2006). FA can produce descriptive summaries of data matrices, which aid in detecting the presence of meaningful patterns among a set of variables (Bandalos & Gerstner, 2016; Flora et al., 2012).

The inferential analysis involved the deployment of factor analysis; a statistical technique used to elucidate and rank the variables that contribute significantly to the solid waste management activity. Factor analysis was specifically harnessed to identify and hierarchically order the salient factors responsible for the management of solid waste. A dataset is "factorable" indicated that it can be decomposed or factorized to reveal underlying structures or latent variables that explain patterns within the data. In grouping the identified indicators of variables into a smaller number of factors, the study employed factor analysis to reduce and classify all 17 variables into fewer groups. Respondents' opinions were measured on a five-point Likert scale rating in the order of 1–strongly disagree, 2–disagree, 3–partially agree, 4–agree, and 5–strongly agree. In conducting factor analysis, the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test were the first instance determined. The two tests are both statistical tools commonly employed in the field of factor analysis, a statistical technique used to identify underlying relationships among variables. According to Cleff (2019) and Backhaus et al., (2021), the KMO measure assesses the suitability of data for factor analysis by evaluating the adequacy of the sample size and the correlations among variables. A high KMO value (typically ranging from 0 to 1) indicates that the data is well-suited for factor analysis. On the other hand, Bartlett's test examines whether the observed correlation matrix significantly differs from an identity matrix, which assumes no correlation between variables. A significant result in Bartlett's test suggests that the variables are interrelated, justifying conducting factor analysis. In essence, these tests serve as diagnostic tools to ensure the reliability and validity of the data before delving into the more intricate process of factor analysis, enhancing the robustness of the subsequent findings.

Principal component analysis was conducted on seventeen variables with orthogonal rotation (Varimax). This stage was examined to achieve a meaningful result. Sampling adequacy was conducted on the analysis using Kaiser-Meyer-Olkin. After this, the eigenvalues associated with linear composite factors and after extraction, and after rotation were derived. Values derived represented the variance (%) explained by a particular linear composite. Through this, variable loading and factor scores were generated, classified, and named from the analysis. There was a need to verify the suitability of the data for factor analysis. Kaiser-Meyer-Olkin and Bartlett's test of sphericity value was used. Results are as shown in Table 1.

Table 1: KMO and Bartlett's test of Sphericity

Institution		**Value**
OAU, Ile-Ife	Kaiser-Meyer-Olkin Measure of Sampling Adequacy	.566
	Bartlett's Test of Sphericity Approx Chi-Square	1004.283
	Df	136
	Sig	.000

3. Results and Discussion

3.1 Solid waste management activities

The current situation of solid waste management activities was discussed in this section. These activities include solid waste sorting, storage, collection, treatment, and disposal practices in the study area. Optimizing the entire operation of solid waste management needs a systematic approach. Sorting of solid waste is expected to lead to a reduction in the quantity of solid waste for final disposal. Information obtained established that priority was not given to sorting of solid waste in all the activity areas, as no different storage bin was used for categories of solid waste. The only sorting practice observed was the activity of scavengers who came to pick reusable materials from either metal (see plate 1). Similarly, waste storage receptacles used in the different activity areas were of different types that were not environmentally sustainable (see plate 2). These include bucket, polythene and nylon bags, carton, traditional basket, perforated dustbin, and sacks. Others are small lid bin, big lid bin, and wheel lid bin. This study corroborates Ababakar et., (2022), which established that a common storage receptacle was used for both household and hazardous waste in a related study. The collection of solid waste is one of the important activities affecting solid waste management. These include the gathering of solid waste and hauling of waste to a location where it is recycled or deposited. Waste collection service, as observed and expressed by the residents, was irregular. The frequency of collection is twice a week. The survey also established that Saturday and Sunday were left out of the collection days. This could be considered as one of the reasons for the overflowing of most of the big metal bins, especially on Monday morning of every week.

Plate 1: A Scavenger sorting reusable materials out of a metal waste bin with mixed solid waste

Plate 2: Typical condition of the Metal waste receptacle on Monday of every week and holiday periods.

In the same vein, transportation of waste was the sole responsibility of the environmental unit of the University. Only two of the three available waste collection vehicles were in use. The available vehicles were moribund as they were in their old age, having been purchased more than thirty years ago (see plate 3). It was also observed that the vehicles used had a partially opened top. Solid waste is supposed to be transported in a closed truck to prevent air pollution. This is one of the major obstacles to effective solid waste management that characterises the study area. An earlier study by Imam et al. (2008) also reported ineffective collection and transportation systems as a problem militating against environment-friendly waste management. It could be concluded that waste transportation practice in OAU was not in line with the world's conventional practices.

Plate 3: A typical waste collection vehicle on collection and disposal duty

The disposal and treatment of solid waste collected is the responsibility of the environmental unit of the university. The dumpsite used was *Asunle,* which is the central dumpsite in OAU. *Asunle* was known and popular for the pollution that emanated from solid waste burning. It serves as a dumpsite for all the categories of solid waste emanating from different activity areas of the study area. Also observed at the site were sorted plastics, which, according to the waste treatment personnel, were sorted by scavengers. Further study established that the life of the personnel employed for waste treatment was not insured by their employer, as they are prone to environmental threats. The incinerator available was small, old, and no longer in use because it could no longer treat the volume of the waste generated in the different activity areas of the University. Further study showed that an incinerator was also procured for the treatment of medical waste generated from the health centre. However, the incinerator had not been put into use since the day it was acquired, as no personnel were trained on how to put the machine into use since the time it was acquired. It can be established from the foregoing that there were challenges in the waste management system, as it was characterized by irregularity. This was not in compliance with the global standard practices. It is therefore submitted that the system requires investigation of the factors leading to poor management of solid waste in the institution.

Plate: Available but not used incinerators at the Asunle waste treatment site

3.2 Factors driving solid waste management as identified by factor analysis

The variable discovered to have the highest communalities value is inadequate equipment. It accounts for 77.8% of the variable after extraction. In the same vein, the variable with the lowest communalities is regulation on solid waste management, with 56.6% variance. Seven (7) variables are retained for further analysis in the study, based on the communality value. Ten (10) variables with low communality are removed from the analysis. Similarly, seven variables have a communality value above 0.669. Other variables with the highest communality apart from lack of equipment are: mixture of waste components (0.712), lack of technical know-how (0.757), number of staff members (0.734), composition of waste (0.712), lack of sanitary landfill, and poor remuneration for waste collectors (0.677). On the other hand, the four variables with the least value are training for waste handlers (0.621), quantity of waste generated (0.583), location from home to disposal facilities (0.575), and regulation on waste management (0.566). See Table 2.

Examined in the study is the variance explained by determinants of waste management practices. Eigenvalues associated with linear composite (factor) before and after extraction, and after rotation, are very important in factor analysis. This, according to Field (2009), is because values associated with each particular factor composite represent the variance explained by such a composite and the percentage of variance explained. Seventeen linear composites were recognized before extraction. These were the same as the initial/available variables. The variables were reduced to seven (7) before and after extraction, and rotation for the data of the study area. As presented in Table 3, variables explained by factors 1, 2, 3,4,5,6, and 7 before extraction included: 15.38%, 12.2%, 10.18%, 9.6%, and 6.9%. Others were 6.5% and 5.95%, respectively. After rotation, factor 1 represented 12.48% of the total variance. Factors 2, 3,4,5,6, and 7 account for 9.88%, 9.2%, 9.1%, 8.9%, 8.7% and 8.4% of the total variance, respectively.

Table 2: Communalities of Variables

Variables	Initial	Extraction	Rank
Lack of Equipment	1.000	.778	1st
Mixture of waste components	1.000	.757	2nd
Lack of technical know-how	1.000	.757	3rd
Number of staff members	1.000	.734	4th
Composition of waste	1.000	.712	5th
Lack of sanitary landfills	1.000	.693	6th
Poor remuneration	1.000	.677	7th
Inadequate personnel	1.000	.669	8th
Financial capacity	1.000	.664	9th
Size of the University	1.000	.662	10th
Season of the year	1.000	.661	11th
Poor road	1.000	.631	12th
Institutional framework	1.000	.622	13th
Training for waste handlers	1.000	.621	14th
Quantity of waste generated	1.000	.583	15th
Location of waste disposal facilities	1.000	.575	16th
Regulation on waste management	1.000	.566	17th

Source: Authors' fieldwork, 2024

It is noted that the percentages of variance at the initial stage were unlike what we have after rotation. It is also apparent that factor 1 accounts for more variance than the remaining six before rotation. This indicated that rotation had effects on the structure of factors. Notwithstanding, these seven factors explained only 67% variance both before extraction and after rotation. This showed that there are other unexplained variations, which can be accounted for by another group of variables/factors not identified in this analysis.

The preceded was the variance explained by determinants of waste management practices, having identified the eigenvalue associated with each of the composite factors. It is equally important to itemize variables that load on each factor. It is also necessary to name and discuss them. Some variables may be loaded on one factor and low on others. Therefore, rotation of the matrix is essential. Varimax rotation was used for this purpose. The rotation composite matrix of respondents, known as determinants of waste management practices, explained the structure of variables that are loaded.

In this aspect, only variables loading above 0.50 were included in the rotated composite matrix. In the same vein, only factors with a minimum of two (2) variables that are loaded 0.50 were named and discussed. Presented in Table 3 are the variables that are loaded on each factor for the study area. It should be noted that the extraction method used was Principal Component Analysis, and the rotation method was Varimax with Kaiser Normalization. Loaded on factor 1 are four factors. These factors are poor remuneration (0.691), location of the University (0.671), lack of sanitary landfill (0.651), and regulation on solid waste management (0.508). The variable that loaded on the factor described issues with human and material resources in the study area. Factor 1, is termed human and material resources. This shows that one of the factors influencing waste management practices in the university was issues relating to human and material resources. The same observation was made by Jyotirmayee et al., (2024) in a study of solid waste management comparing the Covid-19 period and after.

The variables loaded on Factor 2 are lack of technical know-how (0.834) and financial capability (0.715). The variable that accounts for the dimension of Factor 2 is largely associated with the lack of knowledge on solid waste management practices. This can be corrected if the department responsible for waste management is regularized and provided with standard institutional framework. It could be established that the institutional framework for waste management is a major factor to be considered if solid waste management in the university is going to be sustained. The study corroborates other studies, such as Gupta et al., (2023); Sharman & Jain (2020), that the institutional framework plays a significant role in solid waste management sustainability in the university.

Variables related to the composition of waste generated in the University are loaded in factor 3. The two variables considered are a mixture of waste generated (0.811) and the size of the University (0.531). Availability of information on the types of waste generated in institutions of higher education is an essential factor required for effective waste management practices. Factor 3 was termed the composition and quantity of waste generated. It could therefore be established that the composition and quantity of solid waste must be considered to achieve solid waste management that is acceptable. Earlier justified the finding was Kamaruddin et al., (2021), in the study of the types and the quantity of solid waste, submitted that information on the type and volume of solid waste is one of the important drivers of solid waste management. Das et al. (2019) made a similar conclusion in a related study.

Table 3: Rotated composite matrix of data of the study area

	Composite						
	1	2	3	4	5	6	7
Poor remuneration of waste workers	.691						
Location of the University	.671						
Lack of sanitary landfill	.651						
Regulation on waste management	.508						
Lack of technical know-how		.834					
Financial capacity		.715					
Mixture of waste			.811				
Size of the University			.531				
Inadequate personnel				.747			
The quantity of waste generated				.698			
Composition of waste					.804		
Lack of equipment						.805	
Season of the year							.781
Training of waste handlers							.508

Source: Authors' fieldwork, 2024

Variables that described the nature of Factor 4 are inadequate personnel (0.747) and quantity of waste generated (0.678). Variables surrounded the issue of monitoring waste management activities. If the policy of waste management activities is stipulated, the number of personnel required to manage the quantity of waste generated will be understood. Waste management activities include: waste generation, sorting, storage, collection, transportation, treatment, disposal, financial planning, and cost recovery (Adeniyi, 2019). The factor is referred to as the monitoring and evaluation of waste management practices.

The variables that loaded on Factor 5 are season of the year (0,781) and training of waste handlers (0.508). The variables bordered on the issue of understanding the nature of waste generated in different seasons of the year by the waste handlers. This aspect required regular training of the waste collectors. Factor 5 is therefore tagged as training and education of waste handlers. Training of waste handlers and education has been confirmed by Lema et al. (2019) and Adeniyi et al. (2022) as one of the factors that must be intensified if effective solid waste management is to be realized. This was established in a related study conducted in the urban area of Osogbo, Nigeria.

As can be viewed in Table 4, the rotation of the sum of square loading (after rotation) for factors 1, 2, and 3 are 12.48%, 9.88%, and 9.24% respectively.

Others were factors 4 and 5, respectively, which accounted for 9.16% and 8.9%. It was therefore shown that human and material explained 9.88%, and the composition and quantity of waste generated factor explained 9.24%. Others were monitoring of waste management activities accounts for 9.16%, and training and resources explained 12.48% variance, the institutional framework for waste management factor, and education of waste handlers represent 8.9%. The explained variance by these five factors represents 49.67%. It was established that five factors that are significantly influence solid waste management practices in OAU in order of hierarchy are the human and materials resources, the institutional framework for waste management control authority, the composition and quantity of waste generated, monitoring of waste management activities, and training and education of waste handlers. These factors contribute 49.6% to solid waste management adopted at the Obafemi Awolowo University.

Table 4: Variables explained by the determinants of solid waste management practices

Factors	Initial Eigenvalues (Before extraction)			Extraction Sums of Squared Loading (after extraction)			Rotation Sums of Squared Loading (after rotation)		
	Total	% of variance	Cumulative	Total	% of variance	Cumulative	Total	% of variance	Cumulative
1	2.615	15.380	15.380	2.615	15.380	15.380	2.123	12.488	12.488
2	2.081	12.239	27.618	2.081	12.239	27.618	1.680	9.883	22.370
3	1.731	10.183	37.801	1.731	10.183	37.801	1.571	9.240	31.610
4	1.635	9.620	47.421	1.635	9.620	47.421	1.557	9.161	40.771
5	1.176	6.916	54.337	1.176	6.916	54.337	1.513	8.900	49.671
6	1.118	6.575	60.912	1.118	6.575	60.912	1.485	8.737	58.408
7	1.008	5.929	66.841	1.008	5.929	66.841	1.434	8.433	66.841

Extraction Method: Principal Component Analysis

The study concluded that the most important factors militating against effective solid waste management are inadequate human and material resources, ineffective institutional framework, the composition and quantity of solid waste generated, inadequate monitoring and evaluation of waste management practices, and lack of technical know-how of the waste collectors. It is recommended that a separate directorate, headed by a director who possesses academic qualifications and experience in waste management, should be created. The Director is expected to formulate a technical and informative policy on sustainable waste management practices. The office should be equipped to design, implement, and monitor the strategies of the policy formulated. It is suggested that the department should be divided into three units to be headed by deputy directors who must also be experts on solid waste management.

4. Conclusion

The study investigated how solid waste is managed in Obafemi Awolowo University, spanning towards understanding waste management activities such as sorting, storage, collection, transportation, and disposal. This gave the study an insight to investigate the problems militating against the sustainable management of waste in a holistic system. To achieve this, the study relied on data collected through personal observations and a structured questionnaire administered to randomly selected samples in the study area. In sum, solid waste management practice was rated as very poor since the majority of the activities involved in waste management were not in compliance with the global practice and therefore are not result-oriented. Investigation of the factors affecting solid waste management showed that

The study concluded that the most important factors militating against effective solid waste management are inadequate human and material resources, ineffective institutional framework, the composition and quantity of solid waste generated, inadequate monitoring and evaluation of waste management practices, and lack of technical know-how of the waste collectors. As a result, the study recommends engagement of professionals in the management of solid waste, who must be equipped with adequate material resources. This should be backed with regular training of waste managers with modern technology that can sustain an effective institutional framework to address the current waste quantity generated in the study area and other institutions with similar environmental problems.

References

Abdel-Shafy, H. I., & Mansour, M. S. (2018). Solid waste issue: Sources, composition, disposal, recycling, and valorization. *Egyptian journal of petroleum*, *27*(4), 1275-1290.

Abubakar, I. R., Maniruzzaman, K. M., Dano, U. L., AlShihri, F. S., AlShammari, M. S., Ahmed, S. M. S., Al-Gehlani, W. A. G., & Alrawaf, T. I. (2022). Environmental Sustainability Impacts of Solid Waste Management Practices in the Global South. *International journal of environmental research and public health*, *19*(19), 12717. https://doi.org/10.3390/ijerph191912717

Adeniyi, L. A. (2019). Assessment of solid waste management in Obafemi Awolowo University, Ile-Ife, Nigeria. PhD Thesis, Obafemi Awolowo University, Ile-Ife, Nigeria.

Adeniyi, L.A., Olutola, E.A. and Adesoye,P.O. (2020). Residents' socio-economic attributes as drivers of sustainable solid waste disposal practices in Ede, Osun State, Nigeria. In Ibrahim and Muili (eds) Planning and management of sustainable infrastructure development in Nigeria. Ladoke Akintola University Press, Ogbomoso, Nigeria.

Adeniyi, L. A., Adebara, T. M. and Oladehinde, G. J. (2022) Evaluation of implications of changing land-use pattern on solid waste disposal practices in traditional city in Nigeria. Int. J. Environ. Sci. Technol. https://doi.org/10.1007/s13762-022-03947-w.

Adeniyi, L. A., & Afon, A. O. (2022). Seasonal quantification and characterization of solid waste generation in tertiary institution: a case study. *Journal of Material Cycles and Waste Management*, *24*(3), 1172-1181.

Adeniyi, L. A., Olayiwola, A. M., & Sakariyau, S. A. (2024). Residents' satisfaction with urban solid waste collection amidst covid-19 pandemic period in Ede, Nigeria. International Journal of Environment and Waste Management, 34(1), 39–56

Afon, A. O. (2007). An analysis of solid waste generation in a traditional African city: The example of Ogbomoso, Nigeria. *Environment and Urbanization, 19*(2), 527–537.

Aiken, L. S., West, S. G., & Millsap, R. E. (2008). Doctoral training in statistics, measurement, and methodology in psychology. American Psychologist, 63, 32–50. https://doi.org/10.1037/0003-066X.63.1.32

Backhaus, K., Erichson, B., Gensler, S., Weiber, R., Weiber, T. (2021). Factor analysis. In: Multivariance Analysis. Springer Gabler, Wiesbaden. https://doi.org/10.1007/978-3- 658- 32589-3_7

Bandalos, D. L., & Gerstner, J. J. (2016). Using factor analy sis in test construction. In K. Schweizer & C. DiStefano (Eds.), Principles and methods of test construction: Standards and recent advances (pp. 26–51). Hogrefe.

Cleff, T. (2019). Factor Analysis. In: Applied Statistics and Multivariance Data Analysis for Business and Economics. Springer, Cham. https://doi.org/10.1007/978-3-030-17767- 6_13

Dass, S., Lee, S.H., Kumar, P., Kim, K.H., Lee, S.S. and Bhattacharya, S.S. (2019). Solid waste management: Scope and the challenge of sustainability. Journal of Cleaner Production, 228, 658-678

Fargette, M., Loireau, M., Libourel, T. (2019). The Relationship Between Man and His Environment: A Systemic Approach of the Viability of "System Earth". In: Barrière, O., *et al.* Coviability of Social and Ecological Systems: Reconnecting Mankind to the Biosphere in an Era of Global Change. Springer, Cham. https://doi.org/10.1007/978-3- 319-78497-7_5

Field, A. (2009). Discovering statistics using SPSS. Third Edition, London: Sage Publication Ltd.

Flora, D. B., LaBrish, C., & Chalmers, R. P. (2012). Old and new ideas for data screening and assumption testing for exploratory and confirmatory factor analysis. Frontiers in Psychology, 3(55), 1–21. https://doi.org/10.3389/fpsyg. 2012.00055

Gebreeyosus M. A. | (2018) Urban dwellers and solid waste management plans: A case study of selected towns in Afar regional state, Ethiopia, Cogent Environmental Science, 4:1, 1524052, https://doi.org/10.1080/23311843.2018.1524052.

Govani, J., Singh, E., Kumar, A., Zacharia, M., & Kumar, S. (2021). New generation technologies for solid waste management. In *Current developments in biotechnology and bioengineering* (pp. 77-106). Elsevier.

Gupta, p., Sharma, A., Bhardwaj, L.K. (2023). Solid waste management (SWM) and its effect on environment and human health. Preprint.

Jyotirmayee, B., Samal, I.P., Jena, S., Mahalik, G. (2024). Solid waste management during and after COVID-19 outbreak: Possibilities, difficulties and approaches. In: Das, A.P., Mishra, S. (eds) Impact of COVID-19 waste on environmental pollution and its sustainable management. Environmental Science and Engineering. Springer, Cham. https://doi.org/10.1007/978-3-031-50840-0_16.

Imam, A., Mohammed, B., Wilson, D. C., & Cheeseman, C. R. (2008). Solid waste management in Abuja, Nigeria. *Waste management*, *28*(2), 468-472.

Kamaruddin, M. A., Norashiddin, F. A., Hanif, M. H. M., Shadi, A. M. H., Yusoff, M. S., Wang, L. K., & Wang, M. H. S. (2021). Characterization and Measurement of Solid Waste. *Solid Waste Engineering and Management: Volume 1*, 209-295.

Lema, G., Mesfun, M. G., Eshete, A and Abdeta, G. (2019). Assessment of status of solid waste management in Asella town, Ethiopia. BMC Public Health 19:1261, https://doi.org/10.1186/s12889-019-7551-1.

McHarg, I., Steiner, F. (2014). Man and the Environment. In: Ndubisi, F.O. (eds) The Ecological Design and Planning Reader. Island Press, Washington, DC. https://doi.org/10.5822/978- 1-61091-491-8_11.

Odonkor, S. T., Kwasi Frimpong, K. and Napoleon Kurantin, N. (2020). An assessment of household solid waste management in a large Ghanaian district, Heliyon, 6 (1), https://doi.org/10.1016/j.heliyon.2019.e03040.

Oladehinde, G.J., Dada, O.T., Olowoporoku,A.O. and Adeniyi, L.A. (2023). Land accessibility and housing development in Nigerian border communities. GeoJournal, 88(1), 359- 382, doi: 10.1007/s10708-022-10610-x.

Olaniyan, O. S and Adegbola, A. A. (2020). Sustainable solid waste management in Omi Adio, Ibadan. In Ibrahim and Muili (eds) Planning and management of sustainable infrastructure development in Nigeria. Ladoke Akintola University Press, Ogbomoso, Nigeria.

Olatunji, S.A., John, E.A., Adedeji. A.A., & Mukaila, M.L. (2024). Assessment of parking facilities in public areas: the case of Keffi Town. CSID Journal of Infrastructure Development, 7(3). https://doi.org/10.7454/jid.v7i3.1152

Rooshdi, R. R. R. M., Majid, M. Z. A., Sahamir, S. R., & Ismail, N. A. A. (2018). Relative importance index of sustainable design and construction activities criteria for green highway. Chemical Engineering Transactions, 63, 151–156. https://doi.org/10.3303/CET1863026

Rugatiri, J., Abidin, Z., & Ismail, A. (2021). Assessing solid waste management strategy in higher education institutions of Indonesia: A case study of IPB University. In *IOP Conference Series: Earth and Environmental Science* (Vol. 771, No. 1, p. 012023). IOP Publishing.

Sankoh, F. P., Yan, X. and Tran, Q. (2013). Environmental and health impact of solid waste disposal in developing cities: a case study of Granville Brook dumpsite, Freetown, Sierra Leone. Journal of Environmental Protection, 4, 665-670, http://www.scirp.org/journal/PaperInformation.aspx?PaperID=34526

Sarfo-Mensah, P., Obeng-Okrah k., Arhin, A. A., Amaning, T. K and Oblitei, R. T. (2019). Solid waste management in urban communities in Ghana: A case study of the Kumasi metropolis. African Journal of Environmental Science and Technology. 13(9), 342-353, https://doi.org/10.5897/AJEST2019.2713

Schulze-Makuch D, Airo A and Schirmack J (2017) The Adaptability of Life on Earth and the Diversity of Planetary Habitats. Front. Microbiol. 8:2011. doi: 10.3389/fmicb.2017.02011

Sharma, K. D and Jain, S. (2020). Municipal solid waste generation, composition, and management: the global scenario. Social Responsibility Journal. 16 (6), 917-948, https://doi.org/10.1108/SRJ-06-2019-0210.

Sogbesan OZ (2015) The potential of digital representation: The changing meaning of Ife colonial digital British Museum. PhD Thesis submitted to the Department of Culture and creative, University of London. Retrieved from http;//openaccess.cityac.uk/1721.

Ssemugabo, C Solomon Tsebeni Wafula, S. T., Lubega, G. B., Ndejjo, R., Osuret, J., Halage, A. A and Musok, D. (2020). Status of household solid waste management and associated factors in a slum community in Kampala, Uganda. Journal of *Environmental and Public Health, 6807630, https://doi.org/10.1155/2020/6807630*

Ugwu, C.O., Ozoegwu, C.G. and Ozor, P.A. (2020), "Solid waste quantification and characterization in university of Nigeria, Nsukka campus, and recommendations for sustainable management", Heliyon, Vol. 6 No. 6, e04255, doi: 10.1016/j.heliyon.2020.e04255.

Upadhyay, V., Jethoo A.S, and Poonia M. P. (2012). Solid waste collection and segregation: a case study of MNIT campus, Jaipur. International Journal of Engineering and Innovative Technology, 1(3),144-149.

World Population Review (2021). Ife Population: demography, map, graph. Retrieved Jan. 20, 2022 from https:// world popul ation review. com/ world- cities/ ife-popul ation

Yoada, R. M., Chirawurah, D., & Adongo, P. B. (2014). Domestic waste disposal practice and perceptions of private sector waste management in urban Accra. *BMC public health*, *14*, 697. https://doi.org/10.1186/1471-2458-14-697