CHARACTERIZATION OF SOURCE-SEPARATED SOLID WASTES AND COMMUNITY MOBILIZATION FOR CENTRALIZED RECYCLING AT THE UNIVERSITY OF IBADAN, NIGERIA.

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CERTIFICATION

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ABSTRACT

Improper management of solid wastes is a growing public health problem in Nigeria. Source separation of solid wastes among communities for recycling is a fairly new concept in waste management in Nigeria. Currently, none of the components of solid wastes generated in University of Ibadan (UI) is recycled and the adoption of source separation of waste for recycling depends upon mobilization of the residents. This study characterized the waste and assessed the impact of mobilization on the practices of waste separation for recycling among selected residential areas of the University.

The study was exploratory in design with an interventional component. Three hundred and ten residents of UI were selected by a three-stage sampling procedure from Senior Staff Housing (SSH) 58, Junior Staff Housing (JSH) 182, and Students' hostel (SH) 70. Semi – structured questionnaire was used to assess the practices of waste separation at baseline. An intervention was carried out through establishing Neighbourhood Environmental Action Team (NEAT) among a subset of participants including: 20 households in SSH, 40 households in JSH, and 8 cleaners in the SH. They were mobilized in a week - training to separate their household solid wastes into coded bags provided for biodegradable and non - biodegradable components. The separation was carried out by the participants for a period of three months after which a post-intervention questionnaire was administered to assess the impact of mobilization on their practices. Practice scores were computed based on response to a six - item practice categorical variables on the questionnaire and the 75 percentile cut - off was used to categorize participants into good and poor practices. The non- biodegradable wastes were physically characterized into nylon, plastic, metal, glass while the biodegradable wastes were chemically analyzed for nitrogen, carbon, phosphorus, potassium and heavy metals using standard methods. The components of solid waste generated were weighed and computed for three months and the data generated was analyzed using descriptive statistics and ANOVA.

The mean age of respondents was 27± 10.9 years and 52.0% were females. The proportion of participants with good practice at baseline and after intervention was

33.5%- 67.5% in JSH, 18.2%-85.0% in SSH, 31.3%-41% in SH, ($p<0.05$). The mean monthly recyclable wastes characterized in the three locations revealed that Kitchen waste (biodegradable) were 1019.26 ± 10.39 Kg, nylon 130.41 ± 3.47 Kg, paper 156.26 ± 1.52 Kg, plastics 136.84 ± 1.83 Kg, glass 81.05 ± 3.55 Kg and metal 108.14 ± 1.43 Kg. JSH generated the highest proportion of Nylon (48.0%), Plastic (48.0%), and Metal (57.0%) than SSH and SH ($p<0.05$). The chemical characterization of the kitchen wastes showed the following components pH-6.54 ±0.08, Nitrogen-1.48 ± 0.12%, Carbon-49.21 ± 0.88%, Phosphorus-0.19 ± 0.05%, Potassium-0.21 ± 0.04%, Lead-3.60 ± 0.68 mg/Kg, Cadmium-1.11 ± 0.56 mg/Kg, Nickel-21.36± 3.76 mg/Kg.

When exposed to adequate mobilization, the UI residents engaged in effective source separation of waste. The characterization of solid waste showed a large fraction of recyclables in the waste stream. Adequate structures should be put in place for sustainable waste management on campus.

Key Words: Recycling plant, Solid waste, Source-separation, Community mobilization, Waste-characterization.

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1.0 INTRODUCTION

1.1 Background Information

Municipal solid waste (MSW) is defined as non-air and sewage emissions created within and disposed of by a municipality, including household garbage, commercial refuse, construction and demolition debris, dead animals, and abandoned vehicles (Cointreau 1982). The majority of substances composing municipal solid waste include paper, vegetable matter, plastics, metals, textiles, rubber, and glass (USEPA, 2003).

Municipal solid waste disposal is an enormous concern in developing countries across the world, as poverty, population growth, and high urbanization rates combine with ineffectual and under-funded governments prevent efficient management of wastes (UNEP, 2002; Doan, 1998; Cointreau 1982).

There are several factors that make MSW management in developing countries different from management in industrialized countries. First, the types of materials that compose the majority of the waste are different. In developing countries, there is a much higher proportion of organics, and considerably less plastics (Cointreau, 1982). The large amount of organic material makes the waste denser, with greater moisture and smaller particle size (Cointreau, 1982). A second difference is that technologies used in industrialized countries are often inappropriate for developing countries. Even garbage trucks are less effective because of the much heavier, wetter, and more corrosive quality of their burden (Cointreau, 1982). Other technologies, such as incinerators, are often far too expensive to be applied in poor nations. Thirdly, cities in developing countries are characterized by unplanned, haphazardly constructed, sprawling slums with narrow roads that are inaccessible to collection vehicles (UNESCO, 2003; Daskalopoulos, 1998). Finally, there is often a much smaller stock of environmental and social capital in developing countries. People are unaware or uncaring of cradle-to-grave solid waste management needs, being more concerned with more immediate problems such as disease and hunger.

In Nigeria, waste disposal remains a contentious issue, and with no end in sight, refuse is thrown onto roadways, spread on pedestrian walkways or even dumped into drainage channels. The problem becomes compounded during the rainy season: water, no longer flows freely through the drainage channels and so it remains stagnant, creating effective breeding sites for mosquitoes which cause malaria. There had been outbreak of diseases such as cholera, diarrhea, food poisoning within Ibadan city and other cities in the country (Onibokun, 1989). These health problems stem from poor environmental sanitation, which can be controlled by instituting appropriate preventive measures.

The problem of solid waste disposal has become one of the most serious environmental problems facing many cities in Nigeria. Onibokun (1989) indicated that 35% of Ibadan's households, 33% of Kaduna's and 44% of Enugu's households do not have access to waste collection. When waste is not collected unsanitary conditions develop and pose environmental and human health risks. Stephens and Harpham (1992) attributed prevalence of parasites, tetanus, malaria, hookworm, cholera and Diarrhea in most African cities to the unsanitary conditions in the cities. In recent years, there has been a phenomenal increase in the volume of wastes generated daily in the country. This is due to a number of reasons including the increasing population growth rate, increasing urbanization, industrialization and economic growth. In addition, many urban areas of Nigeria lack effective waste management systems. As a result, most urban households resort to the haphazard dumping, burning and/or burying solid waste. The common arrangement in the few urban communities where a system is in place, is for waste management authorities to collect refuse from households and public containers on a regular basis using collection trucks (Ilemobade and Olanrewaju, 2009).

However, in developed countries wastes are converted to wealth through recycling of the source separated wastes at household level. Waste recycling reduces the demand for natural resources and the amount of waste requiring final disposal. This method of waste management is yet to be fully embraced at household level in Nigeria. Therefore, waste management in the country has defied several options such that a pragmatic approach was adopted requiring residents to spend the morning hours of the last Saturday of every month - cleaning their surroundings; and the refuse are placed on the streets for collection. This exercise was not carried out regularly and so the rubbish piled up. This top-to-bottom approach of community mobilization for waste management has not really changed the peoples' poor attitude to waste management.

There is need for adoption of the bottom-to-top approach of community mobilization that involves the community members in the planning and implementation of an appropriate waste management scheme. This could be achieved through education and mobilization of the populace on the importance of source separation for reuse and recycling in order to reduce the waste burden in the society and encourage waste-to-wealth practice.

1.2 PROBLEM STATEMENT

University of Ibadan (UI) is large and comprises 13 faculties, institutes, centers, student hostels, Senior and Junior staff quarters with enormous population that generate wastes everyday. A lot of solid waste is generated on daily basis by the residents on campus. Hence, a lot of money is being spent by the University administration to manage waste on campus.

The current waste management methods in UI have resulted in both environmental and public health problems due to the fact that the rate of waste generation supersedes the material and manpower resources available. At times the waste bins get overfilled and spill over littering the surroundings, and attracting vectors and animals to the nearby apartments.

In addition, delay in the collection of wastes from the bins leads to air pollution from the odour of degrading organic component of the waste. When the solid wastes are gathered they are transported to Ajibode and other settlements where burning takes place. This continuous burning of both organic and inorganic wastes contributes to the green house gas emissions.

Furthermore, dangerous items such as broken glass, razor blades, hypodermic needles and other healthcare wastes, aerosol cans and potentially explosive containers may pose risks of injury or poisoning, particularly to children and the scavengers. The institutional effort required to correct all these problems will attract huge expenses, if this method is to be continued. However, the problem of improper waste management and extra cost can be reduced if the University authority can involve the residents in the planning and implementation of an appropriate waste management that involves source separation and recycling of waste.

Currently, none of the University's waste stream is recycled. This is seen as a problem because reducing and recycling waste can ultimately save the authority some substantial money, through avoided costs and revenue generation. Creating less waste initially and recycling a larger percentage of the waste produced could decrease the financial resources put in to removing waste from campus.

1.3 Broad Objective

The broad objective of this study was to characterize solid waste and assess the impact of community mobilization on the practices of waste segregation and management by resident groups in the University of Ibadan.

1.4 Specific Objectives

The specific objectives of this study were to:

1) obtain baseline information on the present waste handling and institutional arrangement on waste management on campus;
2) assess the knowledge, attitude and practices of various categories of residents (senior and junior staff, students and the hostel attendants) towards solid waste segregation and recycling in UI;
3) mobilize resident communities to form the Neighborhood Environmental Action Team (NEAT), to facilitate source separation of waste at staff and student residential areas, and

4) physico-chemical characterization of the wastes generated in the selected communities into various recyclable components, in order to identify their recycling potentials.

1.5 Significance of the Study

Household solid waste promotes environmental nuisance if the community members have inadequate knowledge and poor attitude towards the management of their wastes. Making the campus residents responsible for their wastes will encourage good practices of appropriate waste management plan.

The source separation and recycling of solid waste has been embraced long ago in developed countries to a great extent but it is a fairly new concept in Nigeria. The results of this study will help to identify the knowledge gaps among residents so that appropriate interventions can be instituted.

This study will also provide additional baseline information on the community members' attitude and practices towards source separation of household waste and recycling. It will also provide information on characteristics of waste generated and the steps needed to carry out recycling of waste on the campus. The study will provide data for further research on the implementation of recycling programmes in institutions.

a) The study will provide information on: what the University waste stream is composed of, and this will reveal what the University's major solid waste problem is.
b) peoples' view on the current waste management (including recycling) in UI.
c) level of awareness of people about waste recycling program
d) the potential of waste recycling in reducing waste burden in UI

The results of this study will form the basis for introducing a waste recycling scheme in the University of Ibadan. Collaborative efforts among students and staff can ensure that a considerable amount of recyclable materials are diverted from the waste stream. By recycling a high percentage of waste components, the University can also show its commitment to increasing environmental awareness and resource conservation through behaviour change in the selected communities.

The implementation of waste recycling programme on campus will lead to the creation of more jobs, and will ensure the practice of waste to wealth.

Limitations of study

The limitation faced during the course of the project was relocation of some participants at the Junior Staff Housing during the data collection. About five households have relocated from their apartments before the administration of the post intervention questionnaire.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Solid Waste

Waste can be defined as any material lacking direct value to the producer and so must be disposed of. The production of waste material is known as the waste stream and includes the entire variety of refuse generated during domestic, industrial, construction and commercial processes. Solid wastes are 'those wastes that have been rejected for further use and cannot readily escape into the atmosphere' (Oluwande, 1983).

Depending on the industrial base, litter is likely to vary from country to country. In highly developed countries, the major components of industrial wastes are blast furnace and steel slag, and power station ash. Food manufacture and horticulture also contribute to high volumes of industrial waste. The proportion of the different components in refuse of a particular community varies according to the standard of living, customs, food habits, climatic conditions and other factors. In addition, a good knowledge of their make-up helps in the selection of appropriate disposal methods especially when composting is contemplated (Oluwande, 1983).

2.2 Characteristics of Solid Waste

Solid waste consists mainly of four components:

(1) Garbage: This is mainly organic material discarded or remaining as a result of storage, preparation and consumption of food.

(2) Rubbish: This comprises all solid materials not wanted; these vary from tiny pieces of paper to abandoned vehicles. Rubbish makes refuse very bulky and it forms the greatest percentage of refuse.

(3) Ashes and dusts result from sweeping.

(4) Dead animals result from animals that are knocked down by vehicles as they wander about freely on the roads.

2.3 Source of Solid Wastes

2.3.1 Municipal Wastes

Municipal waste is the litter originating from urban areas, houses etc. Although organic waste ranging from garden detritus to food scraps is still the leading component of municipal waste, it accounts for only a relatively small fraction of total waste production and can be personally controlled. Nevertheless, in the absence of appropriate intervention measures, disposal is likely to pose a crisis in many of the world's developing countries in the not too distant future (Melford, 2003).

2.3.2 Domestic Wastes

This category of waste comprises the solid wastes that originate from single and multi-family household units. These wastes are generated as a consequence of household activities such as cooking, cleaning, repairs, hobbies, redecoration, empty containers, packaging, clothing, old books, writing/new paper, and old furnishings. Households also discard bulky wastes such as furniture and large appliances which cannot be repaired and used.

2.3.3 Industrial Wastes

These include: (a) Non-process wastes such as office and cafeteria wastes, packing wastes, etc. which are common to all industries and (b) process wastes which depend upon the type of the products being manufactured, such as tannery wastes, weaving and dying wastes, food-processing wastes, plastic wastes, rubber wastes, metal scraps etc. from the respective industrial establishments. Mineral wastes from mining and mineral processing units also fall under this category.

2.3.4 Agricultural Wastes

These wastes result from farms, feed lots and livestock yards. The agricultural wastes include crop residues, bagasse from sugar cane, tobacco and corn residues, slaughter house wastes, manure etc.

2.3.5 Special Wastes

These include hazardous wastes from different sources e.g.

(a) Radioactive wastes from nuclear power plants, laboratories, hospitals etc.

(b) Toxic substances such as heavy metal sludges, pesticides, pharmaceuticals, etc.

(c) Healthcare wastes, biological products such as enzymes, antibiotics, pathogenic and pathological wastes, etc.

(d) Miscellaneous products such as inflammable substances, corrosive materials, explosives, security wastes etc.

2.4 Composition of Solid Wastes and Physical Properties

The composition of municipal refuse includes food, garden and yard trimmings, paper products, plastics, textiles, rubber, leather, wood, glass, metals, dirt, and ash (Savas, 1977). Waste can be classified into biodegradable and non biodegradable. The former consists of those types e.g agro-based or food based products which can decompose over time as a result of bacterial action. The latter consists of wastes which are not broken down by bacterial process but persist for very long period in the form in which they are discarded e.g glass, metals, plastics, mining, scraps and petroleum products.

A solid waste analysis protocol compiled by the Bhide and Sundaresan (1983) characterized waste into 12 primary classifications, plus further breakdown into secondary classifications. It was reported to also be for general use in categorizing waste (for example, in waste audits). The 12 primary classifications was said to be adopted for all surveys, to facilitate cross-checking with other survey results and to enable the compilation of regional and national statistics. Further breakdown into the secondary classifications should be made as required to meet the objectives of the individual survey. The classification of solid waste are shown in Table 2.1.

2.4.1 Density

A knowledge of the density of a waste i.e. its mass per unit volume (kg/m^3) is essential for the design of all elements of the solid waste management system viz. Community storage, transportation and disposal. For example, in high income countries, considerable benefit is derived through the use of compaction vehicles on collection routes, because

Table 2.1 Classification of Solid Waste

TYPES OF SOLID WASTE	DESCRIPTION	SOURCE
Food waste (garbage)	Wastes from the preparation, cooking, and serving of food. Market refuse, waste from the handling, storage, and sale of produce and meats and vegetable	
Rubbish	Combustible (primary organic) paper, cardboard, cartons wood, boxes, plastics,rags, cloth, bedding, leather, rubber, grass, leaves, yard trimmings **Noncombustible** (primary inorganic) metals, tin cans, metal foils dirt, stones, bricks, ceramics, crockery, glass bottles, other mineral refuse	Households, institutions and commercial such as hotels, stores, restaurants, markets, etc.
Ashes and Residues	Residue from fires used for cooking and for heating buildings, clinkers, thermal power plants	
Bulky waste	Large auto parts, tyres, stoves refrigerators, others large appliances, furniture, large crates, trees, branches, palm fronts, stumps, flotage	
Street waste	Street sweepings, Dirt, leaves, catch basin dirt, animal droppings, contents of litter receptacles dead animals	Streets, sidewalks, alleys, vacant lots, etc.
Dead animals	Small animals: cats, dogs, poultry etc. Large animals: horses, cows etc	

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Construction & demolition waste	Lumber, roofing, and sheathing scraps, crop residues, rubble, broken concrete, plaster, conduit pipe, wire, insulation etc.	Construction and demolition sites, remodeling, repairing sites
Industrial waste & sludges	Solid wastes resulting from industry processes and manufacturing operations, such as food processing wastes, boiler house cylinders, wood, plastic and metal scraps and shaving, etc. Effluent treatment plant sludge of industries and sewage treatment plant sludges, coarse screening, grit & septic tank	Factories, power plants, treatment plants, etc.
Hazardous wastes	Hazardous wastes: pathological waste, explosives, radioactive material, toxic waste etc.	Households, hospitals, institution, stores, industry, etc.
Horticulture Wastes	Tree-trimmings, leaves, waste from parks and gardens, etc.	Parks, gardens, roadside trees, etc.

Source: Bhide and Sunderesan, (1983).

the waste is typically of low density. A reduction of volume of 75% is frequently achieved with normal compaction equipment, so that an initial density of 100 kg/m^3 will readily be increased to 400kg/ m^3. In other words, the vehicle would haul four times the weight of waste in the compacted state than when the waste is uncompacted. The situation in low-income countries is quite different: a high initial density of waste precludes the achievement of high compaction ratio. Consequently, compaction vehicles offer little or no advantage and are not cost-effective. Significant changes in density occur spontaneously as the waste moves from source to disposal, as a result of scavenging, handling, wetting and drying by the weather, vibration in the collection vehicles. Cointreau (1982) reported that the density of waste generated in low income countries is 450-500 Kg/m^3 while medium income countries and industrial countries generate 170-330 Kg/m^3 and 100-170 Kg/m^3 respectively.

2.4.2 Moisture Content

Moisture content of solid wastes is usually expressed as the weight of moisture per unit weight of wet material.

$$\text{Moisture Content (\%)} = \frac{\text{Wet weight} - \text{dry weight}}{\text{Wet weight}} \times 100$$

Techbanoglous et al (1977), stated that a typical range of moisture contents is 20 – 45% representing the extremes of wastes in an arid climate and in the wet season of a region having large precipitation. Values greater than 45% are however not uncommon. On the contrary, Cointreau (1982) stated that moisture level of humid waste generated in low income countries is 40-80% and 40-60%, 20-30% in medium income countries and industrial countries respectively. Moisture increases the weight of solid waste and therefore the cost of collection and transport. Consequently, waste should be insulated from rainfall or other extraneous water.

Moisture content varies with the particle size and physical characteristics of the raw materials, the preferred moisture content for composting is between 50 and 60 per cent. A low moisture content, usually below 40 per cent, will slow the composting process whereas a high moisture content, usually above 65 per cent, will restrict air movement through the pore spaces and result in anaerobic conditions (Lardinois and van der Klundert, 1994).

Moisture content is a critical determinant in the economic feasibility of waste treatment and processing methods by incineration since energy (e.g. heat) must be supplied for evaporation of water and in raising the temperature of the water vapour. Climatic conditions apart, moisture content is generally higher in low income countries because of the higher proportion of food and yard waste.

2.4.3 Size of Waste Constituents

The size distribution of waste constituents in the waste stream is important because of its significance in the design of mechanical separators and shredder and waste treatment process. This varies widely and while designing a system, proper analysis of the waste characteristics should be carried out.

2.5 Chemical Characteristics of solid waste

Knowledge of the classes of chemical compounds and their characteristics is essential for proper understanding of the behaviour of waste as it moves through the waste management system. The products of decomposition and heating values are two examples of the importance of chemical characteristics. Analysis identifies the compounds and the percent dry weights of each class. The rate and products of decomposition are assessed through chemical analysis.

Calorific value indicates the heating value of solid waste. Chemical characteristics are very useful in assessment of potential of methane gas generation. The various chemical components normally found in municipal solid waste are described below.

Knowledge of chemical characteristics of waste is essential in determining the efficacy of any treatment process. Chemical characteristics include (i) chemical; (ii) bio-chemical; and (iii) toxic.

i) Chemical: Chemical characteristics include pH, Nitrogen, Phosphorus and Potassium (N-P-K), total Carbon, C/N ratio, calorific value.

ii) Biochemical: Biochemical characteristics include carbohydrates, proteins, natural fibre, and biodegradable matter.

iii) Toxic: Toxicity characteristics include heavy metals, pesticides, insecticides, Toxicity test for Leachates (TCLP), etc.

2.6 ConventionalSolid Wastes Management Methods

Solid waste management includes all activities that seek to minimize the health, environmental and aesthetic impacts of solid wastes. The principal objectives of solid waste management are to control, collect, treat, utilize and dispose off the solid wastes in an economical manner consistent with the protection of public health.

2.6.1 Collection, Transportation and Storageof Solid Waste

Waste disposal should be regarded as a multi-faceted activity, the different stages of which (collection, storage, transport, treatment and disposal) are highly interdependent, both technically and organizationally. The safe collection and transport of a waste form a critical link in the chain between its point of generation and its place of treatment and disposal.

Solid wastes should be collected at least once a week. However, in high population density areas and for wastes with high putrescible content, particularly during warm weather, more frequent collection of refuse is desired. The modern method of transporting and handling the refuse is by packer trucks or container trucks (with carrying capacity of 4 to 5 tonnes each) provided with compaction facility, which are loaded manually or mechanically. The wastes are then collected at transfer stations equipped with trailer units with higher carrying capacity (about 20 tonnes each). The wastes are then compacted to high density and then transported to the disposal sites (Hagerty et al, 1973).

In the developing countries like Nigeria, different kinds of storage containers are used ranging from galvanized metal containers, plastic, basket, carton. However, some areas with good waste management programmes ensure the use of standard plastic waste bin with cover.

2.6.1.1 Use and Management of Waste Bins

The efficient disposal of Municipal solid waste involves the use of some form of containers/bins or receptacles to collect and carry the waste to a dumping site. Thus, the use and management of waste bins become important issues in waste disposal in private premises. NEST (1991) in a Nigerian urban town revealed that families used non-durable containers, such as empty cartons which disintegrate readily, for waste disposal. Anyakoha and Igboeli (1993) found that 53.3% and 70.3% of their two groups of respondents (homemakers) used empty cartons and local baskets. While, 88.5% and 92.2% indicated that they used plastic and metal bins. This could mean that in many cases the subjects used plastics and metal bins as well as empty cartons and local baskets – which are not durable. This is indication of the absence of the bye-laws or regulations on the types of containers to be used for waste disposal a situation that calls for action.

2.6.2 Pulverization

Solid wastes are pulverized with the help of gratory crutchers or jaw crutchers or other similar equipment prior to transfer, loading, compacting landfills or incineration in order to facilitate these processes. Pulverization helps in getting homogeneous material which helps both in the greater initial settlement of the solids as well as in future reclamation of the land.

2.6.3 Compacting and Bailing

Compaction and bailing of solid wastes using hydraulic or pneumatic presses are carried out at the site or at a central facility. The advantages achieved by this process are:

(1) Reduction in refuse volume
(2) Reduction in collection time
(3) Reduction in transport time and cost
(4) Lesser storage area
(5) Lesser safety hazard
(6) Cleaner storage area.

2.6.4 Solid Wastes Treatment and Disposal Methods

2.6.4.1 Composting

Composting is seen as a method of converting organic waste from landfills while creating a product, at relatively low-costs, that is suitable for agricultural purposes (Kathsen et al., 1999; Wolkowski, 2003). Composting is the aerobic and thermophilic decomposition of organic matter present in the refuse by microorganisms, primarily bacteria and fungi. The organic matter is transformed into a stable humus like substance during this process (Pavoni et al. 1975). The reactions taking place during composting generate heat and hence the compost temperature rises during the process. Depending upon the composition and nature of the waste, the waste volume is reduced by about 30 to 60%. Pavoni et al, 1975 stated that the following conditions are usually adhered to for optimum composting operation

i) Temperature: 40-50°C (if the temperature goes beyond 66°C, biological activity will be reduced)
ii) pH : 4.5 to 9.5 (It is better to maintain pH below 8.5 to minimize the loss of Nitrogen in the form of ammonia as gas)
iii) Moisture: 40 to 70% (The optimum value is about 55%)
iv) Particle size: 0.63 to 2.54cm
v) Air : 0.5 to 0.8m^3/day/Kg of volatile compost solids
vi) Carbon to Nitrogen Ratio: (35 to 50) : 1
vii) Carbon to phosphorus ratio: 100:1

In agreement with this, World Bank (2000) affirmed that composting can occur over a broad pH range due to the variety of microorganisms involved; however, the preferred pH level is between 6 and 8. Fluctuations in pH result from the formation of organic acidic compounds or the production of ammonia. Regardless of the initial pH and fluctuations, the final end product will have a stable pH around 7.

Heavy metal in compost: Presence of heavy metals in composts raise serious concern about the adverse environmental impact as a result of excessive compost application to agricultural lands. High and excessive accumulation of heavy metals in soil may eventually contaminate both human and animal food chain (He et al., 1992; Iwegbue et al., 2006b). Hence some countries of the world have heavy metal limit in compost. Sridhar and Bammeke (1986) revealed the following heavy metals in mg/Kg in Nigeria compost: Cadmium – 3.3, Lead- 7.87, Iron- 11,847.27, Nickel- 12.78, and Chromium- 106.08.

Any composting technique selected should be small-scale, community based, labour intensive, and simple. It should also depend on low-mechanized processes such as windrows, because studies show that small-scale, labour intensive composting projects tend to be viable (Cointreau 1982; Woolveridge 1994; Asomani-Boateng and Haight 1996). Techbanoglous et al (1977) reported that composting may be carried out naturally under controlled condition or in mechanized composting plants. In natural systems, the garbage (which is ground after removing glass and metallic materials) is mixed with a nutrient source (e.g sewage sludge, animal manure or night soil) and filler (e.g wood chips or ground corn cobs) which permits the air to enter into the pile. The mixture is maintained at about 50% moisture content, is kept in windrows having a width of about 2.5m. The mixture is turned over twice a week. Within about 4 to 6 weeks, the temperature falls, the colour darkens and a musty odour develops. This indicates completion of the process. The filler may then be removed and the remaining humus like material is used as soil conditioner.

With mechanical systems, the composting time is reduced to half of that required in natural systems, because of continuous aeration and mixing. The composting process usually consists of the following three steps:

(1) **Waste preparation:** The solid waste is placed on slow moving conveyor belts. Materials like corrugated paper are hand-picked and then the ferrous materials are removed by magnetic separation. The waste is then ground in hammer mills or wet pulpers to the desired size range (0.6 to 2.5cm). Then it is mixed with nutrient source, filler and water (to provide 50% moisture).

(2) **Digestion:** The mixture is placed in the windrows for 4/6 weeks, while turning it once or twice a week. The waste is decomposed by thermophilic micro-organisms during this period. The material is then allowed to stabilize for another 2 to 5 weeks.

(3) **Product upgrading:** In order to ensure quick and better marketing prospects, the product is sometimes upgraded by operations such as curing, grinding, screening, pelletising and bagging.

In Western Europe, Japan, Israel and some Third-World countries which are committed to land reclamation, many successful composting plants have been operating for several years (Techbanoglous et al, (1977). In developing countries like Nigeria, Indore method and Bangalore method are the most adopted.

(A) Indore Method

The Indore method of making compost was systematized by Howard at Indore (India) between 1924 and 1926. This method involves building a heap by putting layers of different materials on top of each other so that the heap is well aerated (ventilated). Because the heap is well aerated, oxygen is available through the entire heap and high temperatures can be reached during the decomposition process, killing weed seeds and diseases. Composting under aerobic conditions is faster and smells less than composting under anaerobic conditions. There are also some disadvantages of the Indore method. It is labour intensive and it requires a lot of water. The composting process usually consists of the following:

a) Coarse materials that are difficult to decompose are used to create a base of 1 m wide and 3 m long. Twigs and cane shoots are good materials for this. This base will ensure that the heap is well aerated.

b) The following layers are piled on top of this base:

   - 10 cm of material which is difficult to decompose, for example maize stalks. This layer should be moistened.

   - 10 cm of material which is easy to decompose, for example fruit and vegetable scraps.

   - 2 cm of animal manure (if available).

   - A thin layer of soil to obtain the microorganisms needed for the composting process. The soil should be from the surface from cropped land or from forest.

c) These layers are repeated until the heap reaches 1m to 1.5 m high. Finally, the heap is covered with grass or leaves to prevent water loss.

d) The heap has to be turned over regularly. This ensures that the heap remains well aerated and that all of the materials are converted into compost. The heap should be turned over after 2 to 3 weeks after it has been built, and this should be repeated every 3 weeks depending on how much the heap has decomposed. The heap should be taken apart for building of a new base of the coarse material. The heap should be rebuilt on top of this new base. Material from the outside of the old heap has probably not decomposed, it's then placed in the middle of the new heap and watered. This core covered with the rest of the material. The original, layered structure will be lost. In 3 months, full decomposition should be reached (HDRA, 2001)

(B) Bangalore Method (Hot Fermentation Process)

It is recommended as a satisfactory method of disposal of town wastes and night soil. Trenches are dug 90 cm (3 ft.) deep, 1.5 to 2.5 m broad and 4.5-5.1m long, depending upon the amount of refuse and night soil to be disposed of. Depths greater than 90 cm are not recommended because of slow decomposition. The pits should be located not less than 800m from city limits. The composting procedure is as follows:

- First a layer of refuse about 15 cm thick is spread at the bottom of the trench. Over this, night-soil is added corresponding to a thickness of 5 cm. Then alternate layers of refuse and night soil are added in the proportion of 15 cm and 5 cm respectively, till the heap rises to 30 cm above the ground level. The top layer of refuse should be at least 25 cm thickness.

- Then the heap is covered with excavated earth. If properly laid, a man's legs will not sink when walking over the compost mass. Within 7 days as a result of bacterial action considerable heat (over 60°C) is generated in the compost mass. This intense heat which persists over 2 or 3 weeks, serves to decompose the refuse and night-soil and to destroy all pathogenic and parasitic organisms. At the end of 4-6 months decomposition is complete and the resulting manure is a well decomposed, odourless, innocuous material of high manurial value ready for application to the land. (http://www.microbiologyprocedure.com)

2.6.4.2 Sanitary Landfill

Landfilling is the most common and economic method of solid waste disposal in many countries. Sanitary landfilling include careful and scientific site selection, controlled deposition, better methods of compaction, reduced cover, leachate collection to avoid water pollution and site monitoring to ensure environmental protection. In sanitary landfill, complex organic wastes are slowly degraded or decomposed by the soil micro-organisms, primarily by aerobic or facultative bacteria and fungi. Decomposition of the organic solid waste results into generation of water-soluble organic acids that enters the water media and diffuses through the landfill soils. The bacteria and fungi present in the soils aerobically metabolize these organic acids into CO_2 and water. Occasionally, anaerobic methane bacteria accumulate in landfill systems and generate appreciable quantities of methane gas. A portion of this gas may be utilized by aerobic bacteria as it diffuses through the landfill.

Cointreau (1982), outlined four features that must be present in order for a landfill to be considered sanitary:

i) *Full or partial hydrogeological isolation* through the use of liners to prevent leachate infiltration into the soil and groundwater; collection and treatment infrastructure should be used where leachate is expected to be generated
ii) *Formal engineering preparations* with an examination of geological and hydrological features and related environmental impact analysis, waste tipping plan and final site restoration plan
iii) *Permanent control*, with trained and equipped staff to supervise construction and use
iv) *Planned waste emplacement and covering*, with waste and soil placed in compacted layers as well as daily and final soil cover to reduce water infiltration and reduce odors and pests

An ideal sanitary landfill site as shown in figure 2.1 should satisfy the following criteria:

1) It should be cheap, accessible and at a reasonable distance

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An ideal sanitary landfill site as shown in figure 2.1 should satisfy the following criteria:

1) It should be cheap, accessible and at a reasonable distance

2) It should be at least 11/2 Km downwind from the commercial and residential neighbouring area.

3) It should be reasonably leveled, clear and well drained, with capacity of use for at least 3 years.

4) Its soil should be of low permeability so that it can be used as satisfactory cover material.

5) It should be well above the ground water table so that the underground water supplies are not polluted.

6) The site selected for landfill should not be deleterious or offensive to the surrounding environment. It should be consistent with the topography, climatic conditions, hydrogeological requirements and economical considerations (Tcchbanoglous et al, 1977).

Landfill site preparation

Preparation of the landfill site involves fencing, grading, stockpiling of the cover material, construction of berms, landscaping and the installation of leachate collection system, gas collection system and monitoring system. Mixed solid wastes with varying degree of compaction are delivered to the landfill site by packed trucks or trailer units. Loose material is placed in the lower part of the pit or trench. It is then spread and compacted by machines in layers of about 0.5m thickness. After the end of each day's operation and when the depth is about 3m, the refuse is covered with 15 to 30cm of earth. This consolidated solid waste enclosed by earth at the end of a day's operation is called a "cell" (Dara, 2005).

It is obvious that a proper, engineered landfill is more expensive to design, tnplement and maintain. This is naturally the main constraint in developing countries, and therefore landfill construction is a focus of development assistance by the World Bank and many other aid organizations. Although the costs may be defrayed and techoical assistance given, in the long term it will be the responsibility of local and national governments to ensure proper waste disposal is a practical and viable option. In an examination of landfills throughout the developing world in 1997-1998, Johannessen (1999) found varying amounts of planning and engineering in MSW dumping; among the various regions visited, African nations (with the exception of South Africa) had the fewest engineered landfills, with most nations practicing open dumping for waste disposal; waste managers in Asian and Latin American nations were more likely to be aware of environmental effects of improper landfill design and were much more likely to design and implement some control measures, however limited in scope.

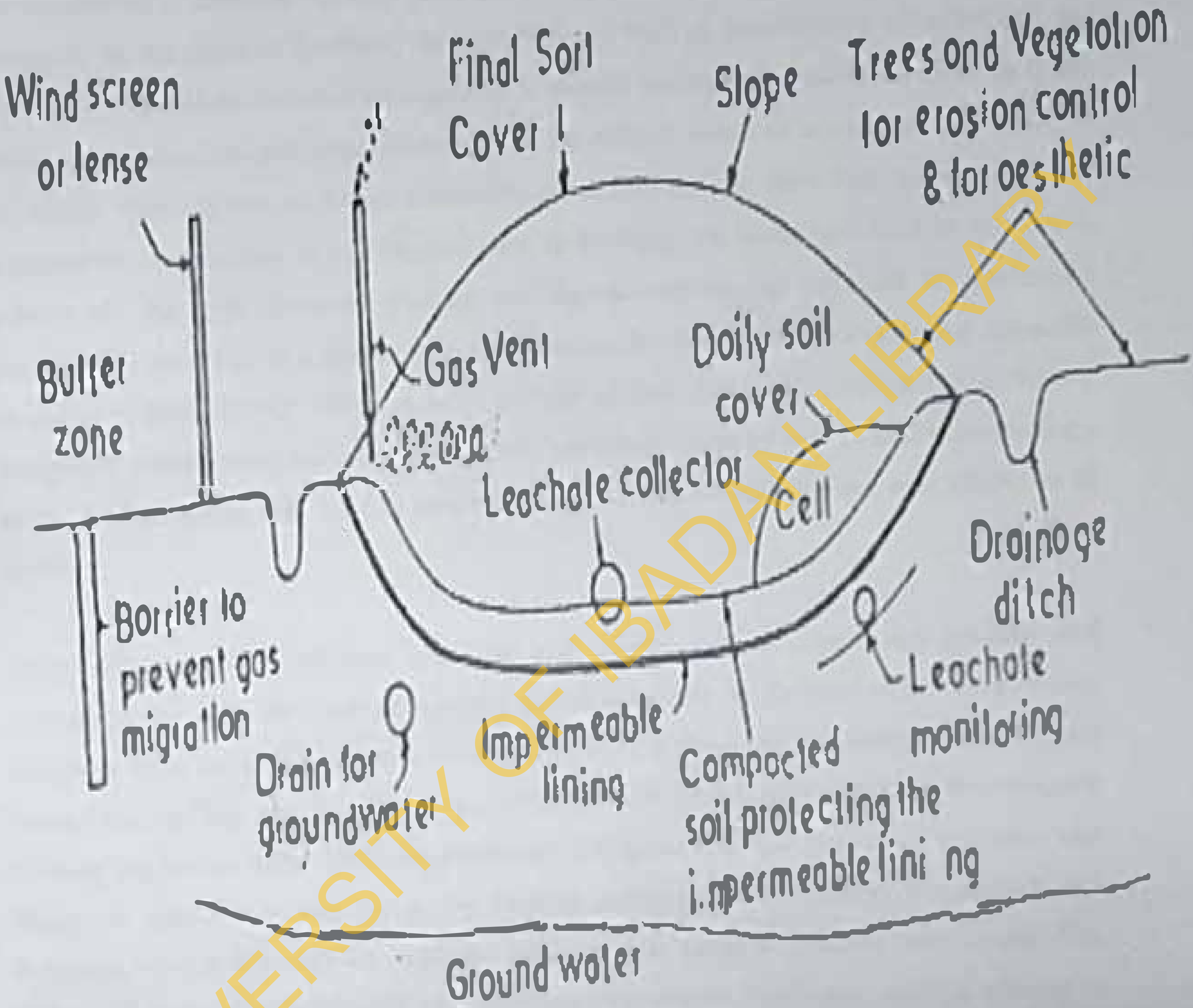

Fig 2.1: Cross-sectional view of a typical sanitary land-fill

Source: Dara, (2005)

2.6.4.3 Incineration

Another option for waste reduction and disposal is incineration. Incineration should not be considered a 'disposal' option, since following incineration there is still some quantity of ash to be disposed of (probably in a landfill), as well as the dispersal of some ash and constituent chemicals into the atmosphere. It should instead be considered more in terms of its waste-reduction potential, which can be 80-95% in terms of waste volume (Rand, et al 2000). This appears to be an extremely attractive option, however, with occasional exceptions, incineration is an inappropriate technology for most low-income countries. Above all, the high financial start-up and operational capital required to implement incineration facilities is a major barrier to successful adoption in developing countries (Rand et al 2000, UNEP 1996). A large portion of that cost is the environmental hazard mitigation components, including emissions "scrubbers"; use of best available technology in the United States can cost as much as 35% of the overall project cost (Rand et al 2000).

Additionally, specific technical expertise and related general repair and maintenance technology are often absent in developing nation scenarios. High costs and environmental problems have led to incinerators being shut down in many cities, among them Buenos Aires, Mexico City, Sao Paolo and New Dehli (UNEP 1996). High costs can be recouped by coupling incinerators with energy-recovery infrastructure. Generation of hot water and steam, to generate electricity or for heating applications in nearby residential and industrial sites is a possibility, and has been used in some developed world sites. The additional level of infrastructure and planning required to implement such a scheme is most likely well beyond the realm of possibility in most developing nations, and arguments for the adoption of incineration projects should not rely on potential energy generation as a primary component of the "sales pitch".

The size of the incinerator is determined on the basis of the weekly quantity of the waste to be incinerated. For unsorted wastes, two types of incinerators are used:

(1) The batch-type incinerator: This is manually stoked and has a relatively small rated capacity. These plants have several disadvantages:

(a) Owing to the intermittent operation, the burning temperature cannot be maintained in a uniform manner. This may result in an inadequate and irregular combustion of the waste

(b) the output of particulate matter is more

(c) the volume reduction of the waste is lesser than the optimal value expected

(d) this may end up with an unstable residue still containing some putrescible matter. Thus, it may still possess some pollution potential.

(e) the intermittent incinerator plants are unsuitable for large urban centers.

(2) **The continuous-type of incinerators:** are equipped with large storage bins, automatic feed hoppers, varied types of moving grates and ash discharging systems. These units are capable of maintaining uniform temperatures for combustion and can be equipped with pollution control devices such as gas scrubbers and electrostatic precipitators. These units are capable of yielding a stable residue which is non-polluting. Although the capital and operating costs are very high, these units, which provide controlled furnace temperatures of 760 to 980°C, can remove odours and also bring about a substantial reduction in waste volume, in an environmentally acceptable form. Since the final residue is stable, the cost of cover material required to ultimately dispose it in the landfill will be substantially minimized or even eliminated in some cases.

High temperature incineration is a recent innovation where temperature of the order of 1,650°C is attained using supplementary fuels. In this process, non-combustible fractions of the refuse (e.g. metal and glass) are melted in a bed of high-temperature coke in the refractory lined incinerator and are drained of as molten slag. This technique can achieve volume reduction of the refuse by 97% (Techbanoglous (1977).

2.6.1.1 Pyrolysis

The chemical constituents and chemical energy of some organic wastes can be recovered by destructive distillation (or pyrolysis) of the solid waste. The combustible constituents of the solid waste are heated in a special retort like chamber known as a pyrolysis reactor at 600 to 1000 °C in a low-oxygen or an oxygen-free environment. This is an endothermic process that involves heating refuse in the absence of air to produce the following components:

(1) Tar or oil phase containing methanol, acetone, acetic acid, etc

(2) Gaseous phase containing H_2, CH_4, CO, CO_2

(3) Solid phase containing pure carbon char and inert materials like glass, rock, metal e.t.c.

The advantage of pyrolysis process include:

(1) Volume reduction by about 90%

(2) Possibility of handling potentially hazardous plastics e.g PVC in a safe way

(3) Absence of pollution problem (Bhide and Sunderasan, 1983)

2.7 Health and Environmental Impacts of Municipal Solid Waste Management

Assessing the impacts of municipal solid waste management involves consideration of a large number of components. Health impacts include exposure to toxic chemicals through air, water and soil media; exposure to infection and biological contaminants, stress related to odor, noise, vermin and visual amenity; risk of fires, explosions, and subsidence; spills, accidents and transport emissions (Dolk, 2002). Environmental impacts can be clustered into six categories: global warming, photochemical oxidant creation, abiotic resource depletion, acidification, eutrophication, and ecotoxicity to water (Seo, 2004)

2.7.1 Health and Environmental Impacts of Landfills

Landfills are associated with a plethora of health and social effects. Health and social impacts include odor nuisance, ozone formation (from reaction of NO_x and nonmethane organic compounds with sunlight) that can cause pulmonary and central nervous system damage; fire and explosion hazards from build-up of methane; an increase in the number of vermin (birds, rodents and insects) which act as disease vectors; and ground and air pollution from leachate and landfill gases (Daskalopoulos 1998, El-Fadel, 1997, USEPA 1995a, Neal and Schubel 1987). Water contamination by leachate can transmit bacteria and diseases. There are also many environmental impacts of landfills. Ozone formation can cause decreases in crop yield and plant growth rate. Methane and carbon dioxide are greenhouse gases that contribute to global warming. Methane is twenty times more effective at trapping heat than carbon dioxide, and more persistent in the environment (USEPA 1995a). Leachate from the landfill can enter ground water systems, leading to increases in nutrient levels that cause eutrophication (El-Fadel, 1997). Finally, bioaccumulation of toxins and heavy metals can occur.

2.7.2 Health and Environmental Impacts of Incineration

Incineration impacts society by production of odors and in the unsightliness of the facility (Garrod and Willis 1998). There is also the potential for surface water pollution from waste waters (used for quenching hot ashes before transport) (USEPA 1995b). The most important health and environmental impact is from air emissions, which include particulates, CO, NO_x, acid gases (chlorides and sulfides), volatile organics and mercury. These compounds contribute to bioaccumulation of toxics and acid rain (Daskalopoulos et al. 1998, USEPA 1995b). Inhalation of particulate matter poses a health danger: smaller particles are more likely to carry heavy metals, which run can be retained in lung tissue and enter the bloodstream (Neal and Schubel 1987).

2.7.3 Health and Environmental Impacts of Composting/Anaerobic Digestion

Health and social impacts include noise, odor, and unsightliness (Garrod and Willis 1998). Additionally, many of the microorganisms found in compost are known respiratory sensitizers that can cause a range of respiratory symptoms including allergic rhinitis, asthma, and chronic bronchitis (Swan, 2002). Both composting and anaerobic digestions produce biogas, though less than landfills. Composting is aerobic and produces primarily carbon dioxide while anaerobic digestion produces methane. Both gases contribute to global warming.

2.7.4 Health and Environmental Impacts of Recycling

Recycling can also pose health and environmental risks. Sorting facilities contain high concentrations of dust, bioaerosols and metals. Workers commonly experience itching eyes, sore throats, and respiratory diseases (Gladding, 2002). Environmentally speaking, recycling uses a large amount of energy resources (Dasknlopoulos, 1998).

Health and social side effects are equally as important as environmental impacts when considering MSW management. For people in developing countries, bodily wellbeing is a far more pressing concern than the fact that open burning of garbage contributes to acid rain or global warming.

2.8 Current Trends in Solid Waste Management.

Waste disposal practices are being altered to include resource recovery and recycling opportunities. This is the result of the common perception that increased recycling offers an environmentally sound alternative to landfill solid waste disposal. In the United States, most states are aggressively pursuing recycling and other solid waste management programmes, such as waste minimization, in order to divert waste from landfills (Thomas-Hope, 1998).

Waste reduction and recycling goals vary from a minimum of 25 percent in most of the southeast US to a mandatory 70 percent in the state of Rhode Island. Higher recycling goals are featured in the northeast US and reflect current limitations in the availability of landfill space. Some states have regulations that ban landfilling of several types of waste that contain heavy metals and mercury. In addition to gains in landfill space, another inherent result of the recycling and waste reduction efforts is that municipal solid waste streams are more amenable to microbial decomposition.

2.9 Source Separation of Solid Wastes For Waste To Wealth Activities

This refers to a solid waste management practice of separating and storing different materials found in solid waste in order to promote recycling and re-use of resources and to reduce the volume of waste for collection and disposal ([illegible] et al, 2002). The segregation of waste prior to collections should therefore be considered. Waste segregation is most effective and is achieved at lowest cost at the place where the individual wastes arise with the provision of containers (Plate 2.1). A decision to segregate wastes should be based on considerations of the type and quantity of the wastes and the hazards they present.

In concordance with this, Asomani-Boateng and Haight (1996) revealed that Source separation, which involves the systematic division of waste into designated categories, is critical to recycling organic solid waste in urban farming. It reduces the incidence of contamination resulting from the co-mingling of different kinds of waste. It is important that any source separation exercise should be undertaken at the household level because once the waste gets to the community bin or collection point, it is likely to be contaminated by hazardous wastes generated by primary health care, dental centres, veterinary clinics, private clinics and laboratories spread throughout African cities.

A system demanding segregation and storage of waste at source would require a very high degree of human behavior change. Separating waste materials at the household level occurs to some extent almost universally, and prevents the most valuable and reusable materials from being discarded. Following in-home retention of valuable material, waste-pickers currently remove most valuable materials either before garbage enters the waste stream or en route, especially in the lower and middle income areas of many municipalities. In these instances, there is little need for additional encouragement of recycling. Even in the more affluent areas of developing cities, often there are found itinerant "buyers" of waste materials such as cardboard and glass. These buyers will help to divert many materials out of the waste stream, and illustrate a key point. If recycling materials is an economically viable undertaking, small enterprises have been and will continue to spring up whenever there is an opportunity. in fact the theft of source-separated recyclable materials has been documented in many pilot schemes in both developed and developing nations (UNEP, 1996). Municipalities should not only recognize the trade in recyclables, it should embrace it. By allowing small enterprise to address the problem, valuable funds are saved (the municipality does not have to create a formal recycling program for most materials), jobs are created, and landfill space is segregation is most effective and is achieved at lowest cost at the place where the individual wastes arise with the provision of containers (Plate 2.1). A decision to segregate wastes should be based on considerations of the type and quantity of the wastes and the hazards they present.

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Adedipe et al (2005), reported that waste to wealth activities as shown in Fig 2.2 must be formalized as policy response in developing countries like Nigeria in order to solve problems of poverty and waste recycling activities. They added that such policies should also include presorting to protect the health of the recycling workers. A number of states in Nigeria like Lagos, Oyo, Niger, and Ondo have been practicing waste to wealth activities.

Ilemobade and Olanrewaju (2009), reported the waste to wealth activities in Ondo State as a successful one. The government of Ondo State established the Ondo State Integrated Waste Recycling and Treatment Project in June 2006 (Sridhar et al 2007). This project was with the aim of minimizing solid wastes in Akure and environs. Since the commencement of the project there has been a huge success in transforming the waste generated in Ondo State to wealth. Profitable products generated are fertilizer, energy, Iron for founding products.

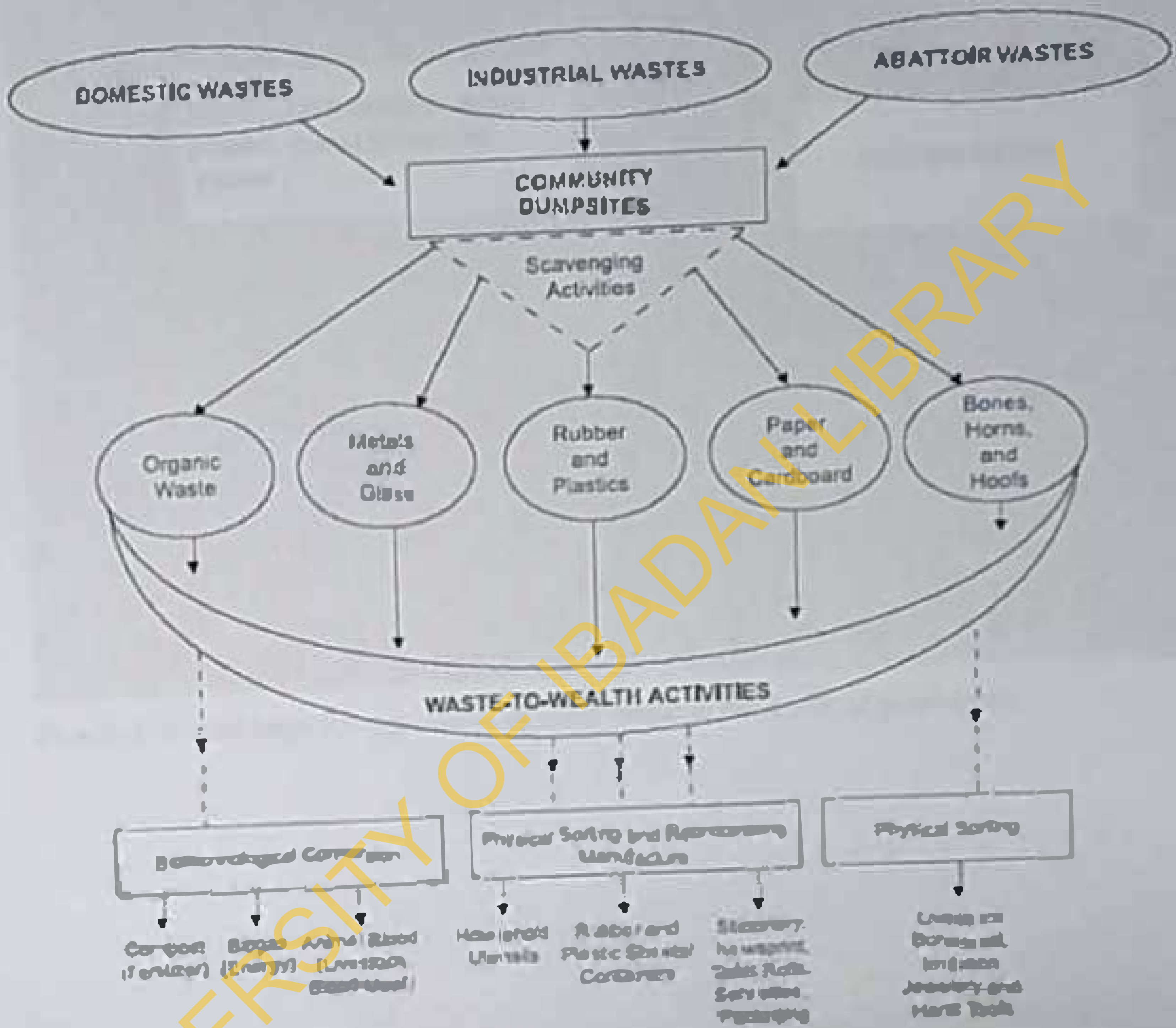

Fig 2.2 Waste-to-Wealth Activity and Processing Profiles in Developing Countries
Source: (Adedipe et al. 2005)

Plate 2.1: Coded bags for separation of solid waste at the point of generation.

2.10 Municipal Solid Waste Recycling

Recycling is the removal of materials from solid waste and the use of those materials as new products for other productive uses. Successful recycling must begin with an examination of the solid waste stream to determine what is recyclable. Up until now, the focus of recycling efforts has been on residential solid waste. But residential solid waste is only one portion of the municipal solid waste stream. Other portions of the waste stream, such as the commercial and industrial sector, have a history of significant recycling and offer the potential for even greater recycling. Table 2.2 shows source and types of recyclable solid waste. And Table 2.3 shows a number of useful products that are obtainable from what is often regarded as waste.

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Table 2.2: Sources and types of recyclable solid waste

Sources	Examples of Recyclable Waste generated
Residential (single- and multi-family homes).	Old newspapers, clothing, packaging, cans and bottles, food scraps, and yard trimmings.
Commercial (office buildings, wholesale and retail business, and restaurants).	Old corrugated containers (OCC), office papers, yard trimmings, wastes from food/drink vendors (food scraps, disposable tableware, paper napkins, cans and bottles).
Institutional (schools, libraries, hospitals and prisons).	Office papers, books, yard trimmings and wastes from cafeteria and other food/drink vendors
Industrial (packaging and administrative, but not process wastes).	OCC, plastic film, wooden pallets, papers and cafeteria wastes (food scraps, disposable tableware, paper napkins, and cans and bottles).

Source: USEPA, (2004)

Table 2.3: **Solid Waste Recyclables and their Uses.**

WASTE	RECYCLABLE VALUE OR USE
Hair, Bristles, Wool, Feather	Brush, Lanol, Fertilizer, Wigs, Blankets, Carpets, Fabrics
Hoofs, Horns	Buttons, Combs, Hair pins, Novelties, Washers, Glue, Gelatin
Bones	Buttons, Cutlery, Handles, Ornaments, Glue, Gelatin, Bone
Hides, Skins, Feet	Horse whips, Seats, Belts, Hand bags, Book binding, Shoes
Intestines	Stock feed, Surgical ligature, Musical (Guiter) strings, Tennis
Blood	Fabrin foam, Purified bovine albumin, Dried blood
Ruminant contents/excreta	Methane gas, Manure
Fats	Soap, Machine oil, Candles, Leather dressings
Glands and special organs	Pharmaceutical products (Insulin, Gall stones corticosteroids)
Aluminium	Soft drink and beer cans, cutlery
Papers	Newspaper, packaging materials, various types of recycled papers
Plastics (various types)	Bottles, thin film packing, battery casing
Glass	Various glass products, decorative pieces
Ferrous metal	Tin cans, metal works
Yard wastes, Organic wastes	Compost
Tires	Road paving, building, shoe soles
Waste oil	Reuse after refining

Source: Sridhar and Onibokun (1997).

2.10.1 Plastic Recycling

Recycling of plastics received considerable attention primarily because of ever increasing use of plastics and also because of their non-biodegradable nature. For a satisfactory recycling of plastics the following two requirements are to be satisfied:

a) The plastic material should be made up of only one type, i.e it should be homogeneous

b) The plastic scrap or waste should be collected from the consumers or intercepted on its way from consumers to the municipal refuse site (Dara, 2005).

Process of plastics recycling may be carried out in any of the following ways:

i. Primary recycling where the same plastic product is manufactured again

ii. Secondary recycling where the material is reprocessed to a new product with different composition and in some cases may be inferior in properties.

iii. Tertiary recycling where the plastic material is completely processed to a new form as in pyrolysis (where some chemicals are recovered). In USA, high density polyethylene bottles used for supplying milk, are collected from consumers and are converted to flake powder by grinding. This can be used for manufacturing plastic drainage pipes or as inert fill material or an aggregate for low weight concrete (Dara, 2005).

2.10.2 Paper Recycling Process

Paper recycling is a specialized process in which waste papers from different institutions are used to produce clean, recycled pulp that can be used to make recycled content paper and paperboards. Wastepaper from office, school and business recycling programs is collected by outside waste-management companies that sort the waste and then sell it in bales to the mill. The wastepaper is mixed with water and chemicals, and reduced to pulp slurry in a giant blender called a pulper. Following pulping, the pulp mix is diluted with water and passes through a system of centrifugal cleaning equipment and screens. This is done to remove large contaminants like wood, plastic, rocks, glass and paper clips, along with small contaminants like string, glue and other sticky materials (plate 2.2).

The pulp is pressed to remove water and dissolved inks, and is then fed into a kneading machine. During kneading, the pulp fibers are rubbed against each other, further loosening the inks, while kneading chemicals are added to begin the brightening process. Brightening the pulp counters any yellowing effect sometimes seen in paper containing wood fibers like those used for newspaper. The fibers soak in chemicals for about three hours in a storage chest. The pulp that went into the brightening process gray and dirty in appearance comes out much whiter and cleaner.

The fibers are then sent through a fine screening process that removes any remaining glue particles and small contaminants. The pulp goes through an ink removal process. Here the pulp is mixed with chemicals, called surfactants, that suds up like washing machine soap. Ink particles, dirt, glues and other very small contaminants adhere to the suds and float to the surface where they are skimmed away leaving the pulp even cleaner. The pulp is then washed, pressed, kneaded and placed in the decolorization chest. A chemical is added to remove any colors that might tint the pulp. The pulp is then washed again to remove any remaining ink particles, fillers or other contaminants. The finished recycled pulp is then either sent to a mill for papermaking or it is formed into sheets of pulp, called "wet lap," for shipment and sale.

2.10.3 Metal Recycling Process

Scrap metals are turned into ingots by melting the metal, pouring the liquid metal into moulds, and then removing the moulds when the metal is formed. The most common metal alloys produced from this process are aluminum and cast iron. However, other metals, such as steel, magnesium, copper, tin, and zinc, can also be processed. The melting is performed in a furnace. Furnaces are refractory lined vessels that provide the energy required to melt metals. Modern furnace types include electric arc furnaces (EAF), induction, cupolas, reverberatory, and crucible furnaces. For low temperature melting point alloys, such as zinc or tin, melting furnaces develop to temperature of about 327 degrees Celsius. Electricity, propane, or natural gas is usually used for these temperatures. For high melting point alloys such as steel or nickel based alloys, the furnace must be designed for temperatures over 1360° Celsius. Virgin material, external scrap, internal scrap, and alloying elements are used to charge the furnace. Virgin material refers to commercially pure forms of the primary metal used to form a particular alloy.

Prior to pouring the liquid metals, the foundry produces a mold. The molds are constructed by different processes depending on the type of foundry, the metal to be poured, the quantity of parts to be produced, the size of the casting and the complexity of the casting. The different processes include:

• Sand Casting - Green or Resin bonded sand mold.

• Lost Foam Casting - Polystyrene pattern with a mixture of ceramic and sand mold.

• Investment (Lost Wax) Casting - Wax or similar sacrificial pattern with a ceramic mold

• Plaster Casting - Plaster mold

• V-Process Casting - Vacuum is used in conjunction with thermoformed plastic to form sand molds. No moisture, clay or resin is needed for sand to retain shape.

• Die Casting - Metal mold.

• Billet (Ingot) Casting - Simple mold for producing ingots of metal normally for use in other found (Ilemobade and Olanrewaju, 2009)

Plate 2.2: Paper recycling process
Source: Dara.(2005).

2.10.4 Recycling Studies in Nigeria and around the World.

A study carried out by CASSAD (1998) revealed that through affordable waste recycling technologies, wastes could be turned into wealth. In the developed nations also, a lot of attention is paid to recycling and re-use, while at the community level, people are encouraged to go into small-scale business using recyclable materials. Sridhar and Onibokun (1997) described waste recycling as an organized means of introducing and/or enhancing the utilitarian values of waste arising from different sources. The essential outcome of waste recycling is the benefit of reducing demand for national resources and the amount of waste requiring final disposal.

In Nigeria, recycling activities have been going on in informal sector mostly at the dumpsites. Onibokun and Kumuyi (1999), reported that waste recycling is an aspect that has not been paid the required attention. A significant proportion of wastes of different types should be salvaged, particularly at household level. But a large proportion of waste are not sorted at source, a large proportion of them are lost since they are so contaminated by the time they reach the dumps that, they are difficult to retrieve by scavengers.
However, CASSAD (1998) reported that there are hundreds of small and medium sized recyclers in Nigeria's urban centers, with a survey indicating as many as 200 in Lagos and Ibadan put together.

Sridhar et al (2000) reported that in Nigeria, plastic industries are probably the most active in organized level of recycling. From their survey, some industries in Ibadan, handles up to 150Kg raw material per day. Metal scrap industries are also striving in Nigeria. The most famous are the aluminum pot manufacturers at Shaki in Oyo state, about 300Km north-west of Lagos. After sorting, they manufacture a wide variety of aluminum products including pots, fry pans, spoons, dishes, saucers, cups, motor cycle parts and knives. Most of the urban wastes in African Countries such as Nigeria contain 60 to 80% per cent organic components. These massive waste components are used in organic recycling through composting. Composting has long been in practice and successful in some part of the world, yet in others it has had little or no success (UNEP/IETC, 1996).

Composting in Nigeria

A nation-wide survey by Sridhar (1989) revealed that some composting had been done in Kaduna, Kano, and Maiduguri areas in the past, but that it is no longer practiced on a large scale. Lewcock (1995) revealed that in Kano the practice of using Taki (compost from manure, household waste, street sweepings and ash) as fertilizing material by the city's peri-urban farmers has gone on for centuries. In addition Mortimore (1972) revealed that in 1969 and 1972, 140 and 1,180 tonnes of compost were transported per day to peri-urban farms. It is estimated that 25% of farmers' fertilizer needs were met by waste from Kano. However, this practice shifted in 1960s with the use of artificial fertilizers. Sridhar et al (1993), revealed that other materials are used for composting in other parts of the country and such materials include: stalks of corn, guineacorn, sorghum, rice husk, wheat straw, vegetable peelings, cotton stalks, grasses, cocoa and banana leaves, excreta from poultry, cows, piggery, sheep and goats, ashes and wastes from slaughterhouses, breweries and other industries which process organically rich materials.

Further elaborate studies conducted by "Composting Group" in Ibadan (Sridhar et al. 1985, 1986,1989, 1992; Adeoye et al. 1993) revealed that a variety of crops such as yams, maize, green amaranth, and fruit crops produced better yields with organic manure than those grown on inorganic fertilizers alone. The emphasis of the research was on the use of domestic refuse and animal wastes as basic materials in the production of bio-fertilizer. The aerobic method of composting through surface windrowing was proven to be more efficient in reducing the cost, time of composting and retaining the nutrients to a great extent.

The group constructed a composting plant to treat 20 tons of cow dung and market waste in 1998 in a market in Ibadan. Since then a lot of composting projects have been implemented in many states in Nigeria. A typical example is the Ondo State Integrated

Waste Recycling and Treatment Project. This project started operation in December 2006. The process of composting involves semi-mechanical windrow, curing and milling operations. The project's daily production output averages 5 tonnes of organic/organo-mineral fertilizer (Olanrewaju and Ilemobade, 2009). Also, Ayeye compost plant was established in Ibadan North West in 2002, to produce five tonnes per day of organo-mineral fertilizer (Afritech International, 2010). More studies have been carried out on producing agriculture friendly organic fertilizer. A study by John et al (1996, 1997) showed the possibility of converting organic manure supplemented with other plant nutrients into pellets which can easily be handled by small scale farmers to carry and use on their farms. All these researches show that composting is a feasible way of converting the available wastes into organic manure. A recent study on feasibility of waste recycling in Nigeria revealed that the volume of waste generated will support over 5,000 waste recycling based industries. All that need to make this possible are incentives, seed money in form of micro-credit, policy to facilitate the processes and goodwill of both the public sector and the civil society organizations (Sridhar et al, 2000).

2.11 Solid Wastes Generation Rates

The characterization of solid-waste streams and the estimation of solid waste generation rates are critical data needed to seek alternative solutions to problems created by rising solid-waste-disposal costs, increasing public opposition to new landfills, and growing interest in recycling (Alan et al, 1993). The subject of solid waste generation rates has caused considerable confusion because of the different methods of measurement and the different method of waste classification adopted for reporting data. The reason for measuring generation rate is to obtain data that can be used to determine the total amount of wastes to be managed. Therefore, in any solid waste management study, extreme care must be exercised in allocating fu funding deciding what actually needs to be known (Klee and Carruth, 1970).

2.11.1 Characterization of Wastes by Volume and Weight

Both volume and weight are used for the measurement of solid waste quantities. The use of volume as a measure of quantity can be extremely misleading. For example, a cubic

Waste Recycling and Treatment Project. This project started operation in December 2006. The process of composting involves semi-mechanical windrow, curing and milling operations. The project's daily production output averages 5 tonnes of organic/organo-mineral fertilizer (Olanrewaju and Ilemobade, 2009). Also, Ayeye compost plant was established in Ibadan North West in 2002, to produce five tonnes per day of organo-mineral fertilizer (Afritech International, 2010). More studies have been carried out on producing agriculture friendly organic fertilizer. A study by John et al (1996, 1997) showed the possibility of converting organic manure supplemented with other plant nutrients into pellets which can easily be handled by small scale farmers to carry and use on their farms. All these researches show that composting is a feasible way of converting the available wastes into organic manure. A recent study on feasibility of waste recycling in Nigeria revealed that the volume of waste generated will support over 5,000 waste recycling based industries. All that need to make this possible are incentives, seed money in form of micro-credit, policy to facilitate the processes and goodwill of both the public sector and the civil society organizations (Sridhar et al, 2000).

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2.11.1 Characterization of Wastes by Volume and Weight

Both volume and weight are used for the measurement of solid waste quantities. The use of volume as a measure of quantity can be extremely misleading. For example, a cubic yard of loose wastes represents a different quantity than a cubic yard of wastes that have been compacted in a packer truck, and each of these is different from a cubic yard of wastes that have been compacted further in a landfill. Klee and Carruth (1970) stated that if volume measurements are to be used, the measured volumes must be related to the degree of compaction of the wastes. To avoid confusion, solid waste quantities should be expressed in terms of weight. Weight is the only accurate basis for records because tonnages can be measured directly, regardless of the degree of compaction. The use of weight records is also important in the transport of solid wastes because the quantity that can be hauled usually is restricted by highway weight limits rather than volume.

2.11.2 Issues related to Generation Rates of Wastes

In developing the solid waste management systems, it is often necessary to determine the statistical characteristics of solid waste generation. The container capacity to be provided must be based on a statistical analysis of the generation rates and the characteristics of the collection system. The statistical measures that must be considered include the mean, mode, median, standard deviation, and coefficient of variation. (Muhich et al, 1968)

2.11.3 Methods Used to Determine Generation Rates

Methods commonly used to assess the per capita generation of solid wastes are:

(1) Load – count analysis: In this method, the number of individual loads and the corresponding vehicle characteristics are noted over a specified time period. If scales are available, weight data are also recorded. Unit generation rates are determined by using the field data and where necessary published data. The formula for calculation is

$$\text{Unit rate} = \frac{\text{Total weight of waste/week}}{(\text{Number of households} \times \text{Number of persons per household}) \times (7\ \text{days/week})}$$

(2) Weight-Volume Analysis: Although the use of detailed weight- volume data obtained by weighing and measuring each load will certainly provide better information on the density of various forms of solid wastes at a given location but it might not be the real need in terms of survey results (Muhich et al, 1968)

2.11.4 Factors that Affect Generation Rates

Factors that influence the quantity of wastes generated include:

(1) Geographical Location: The influence of geographical location is related primarily to the different climates that can influence both the amount of certain types of solid wastes generated and the collection operation. For example, in the warmer southern areas where the growing season is considerably longer than in the northern areas, yard wastes are collected not only in considerably greater amounts but also over a longer period of time.

(2) Season of the Year: The quantities of certain types of solid wastes are also affected by the season of the year. For example, the quantities of food wastes are affected by the growing season for vegetables and fruits.

(3) Frequency of Collection: In general, it has been observed that where unlimited collection service is provided, more wastes are collected. This observation should not be used to infer that more wastes are generated. For example, a homeowner may because of limited dustbin capacity, store newspapers or other materials in the garage. Hence, in this situation the quantity of wastes generated may actually be the same, but the quantity collected is different (Muhich et al. 1968).

2.11.5 Solid Wastes Generation Rates in Nigeria

In recent years, there has been a phenomenal increase in the volume of wastes generated daily in the country. This is due to a number of reasons including the increasing population growth rate, increasing urbanization, industrialization and economic growth. Adewumi et al (2005) reported the main source of solid waste generated in south western Nigeria, where domestic waste has the highest percentage of 76.42% followed by commerce 14.37%, Agriculture 5.39%, Industrial 3.76% respectively as shown in Table 2.4. Fantola and Oluwande (1983) estimated that the Dugbe market in Ibadan generates 827,802Kg of organic solid waste per year. Many projects carried out recently described solid waste generation rate in terms of the components of wastes generated. A typical example was reported by Sridhar et al (2004) on the assessment of categories of waste generated in Akure. It was revealed that 80% of the waste is organic in nature, followed by plastic/nylon, 15.72% and about 1% metal.

Furthermore, Adewumi (2001) described components of solid waste generated in some South western cities in Nigeria. The components of waste are Garbage 60.5%, Paper 19.1%, Sand 9.8%, Plastic 7.1%, Glass 1.7%, Metalscraps 1.8% as shown in Table 2.5. Adewumi et al (2005) also reported the biodegradable solid wastes generated from domestic activities in some Nigerian south western cities as shown in Table 2.6. The same study revealed that the per capita per day waste generation rate was 0.58 Kg. Meanwhile, an earlier study conducted in early 80s by the Federal Ministry of Housing and Environment (FMHE, 1982) in 15 cities across Nigeria revealed the per capita per day waste generation rate to be 0.49Kg. In addition Oluwande (1983) estimated the average solid waste generated and its mean production rate per capita for three distinguished areas in Ibadan city to be: 0.42 Kg/day in GRA, 0.377 Kg/day in the outlying area, 0.35 Kg/day in the old city.

Table 2.4: Main Sources of Municipal Solid Wastes (MSW) in South Western Nigerian Cities

City	Sources of Waste %			
	Domestic	Commerce	Agriculture	Industrial
Abeokuta	73.80	17.50	8.20	0.50
Ado-Ekiti	78.90	14.30	4.10	2.70
Akure	70.30	18.60	6.30	4.80
Ibadan	66.10	20.30	2.20	11.40
Igede-Ekiti	75.10	11.00	12.40	1.00
Ijebu-Ode	79.50	14.00	3.50	3.00
IleIfe	67.40	28.40	1.00	1.10
Iyin-Ekiti	79.60	2.20	11.00	6.60
Ode-Omu	91.20	1.80	5.90	1.10
Oshogbo	68.20	23.50	2.10	6.20
Oyo	90.50	6.50	2.00	3.00
Mean	76.42	14.37	5.39	3.76

Source: Adewumi et al (2005)

Table 2.5: Constituents of Municipal Solid Waste Generated in Some South Western Nigerian Cities

City	Constituents of Municipal Solid Waste %					
	Garbage	Paper	Sand	Plastic	Glass	Metal-scraps
Abeokuta	57.8	26.2	3.4	8.7	2.2	1.6
Ado-Ekiti	60.4	21.4	11.5	4.3	2.2	0.2
Akure	59.5	14.5	11.0	1.7	6.3	7.2
Ibadan	64.9	14.2	6.5	9.9	1.7	2.9
Igede-Ekiti	58.1	19.3	17.7	3.6	1.1	0.2
Ijebu-Ode	58.7	19.6	4.7	14.7	1.8	0.5
Ile-Ife	77.9	5.3	7.5	7.3	1.1	0.8
Iyin-Ekiti	60.9	15.3	18.6	14.0	0.8	0.4
Ode-Omu	47.8	37.7	12.3	1.2	0.4	1.4
Oshogbo	58.2	17.8	9.9	12.1	0.6	1.4
Oyo	62.1	18.5	4.3	10.6	1.4	3.1
Mean	60.5	19.1	9.8	7.1	1.7	1.8

Source: Adewumi (2001)

Table 2.6: Biodegradable Solid Wastes Generated from Domestic Activities in Some Cities and States of South Western Nigeria.

City	*Population (year 2003)*	*Biodegradable wastes (Metric tons per week)*
Akure	316.925	46.271
Ibadan	1.650.806	33,050
Ijebu-Ode	330,799	54,773
Oshogbo	253,430	38,852
Oyo	371,355	69,128

Source: Adewumi et al (2005)

2.12 Role of Government in Solid Waste Management

Strong political will in all tiers of government is required to improve solid waste management. It is important for government to take a leading role in increasing public awareness about waste disposal and to provide basic infrastructure such as by providing collection vehicles and storage for recyclable materials.

Adequate mobilization by the government can facilitate establishment of user charges on solid waste disposal as in the case of the study carried out in Nonthaburi, Thailand (Kietham, 2002).

2.12.1 Role of State/Regional/Provincial Government

It is generally agreed, worldwide, that the local government level of governance (city council, municipal council, metropolitan council, town council) is best charged with the responsibility for solid waste management. In the Africa context, however, higher levels, especially those next in upper rank to the local governments, would need to give support to local governments in areas relating to capital infrastructure development. Sridhar et al (2007) suggested that State/Regional/Provincial government should:

1) Issue policy guidelines and establish environmental management standards to guide local governments,
2) Establish standard laboratory for monitoring environmental standards with a view to pollution abatement,
3) Maintain environmental data bank to aid broad environmental planning,
4) Offer technical assistance to local governments through training and manpower development programmes for capacity building and institutional strengthening,
5) Provide environmental education to the public through public enlightenment campaigns,
6) Fund research in solid waste management.

2.12.2 Role of Local Governments

Given that local governments have primary responsibility for solid waste management, their roles were described by Sridhar et al (2000) as to:

i) Establish and strengthen a waste management unit, under the Public Health Department,
ii) Enlist the services of the private sector in waste collection and disposal and provide an enabling environment and guarantee of security for their operation
iii) Prepare and implement a waste management plan suited to its specific needs, drawing experiences from the national and the state/regional/provincial masterplans,
iv) Establish a consultation forum with members of the public where issues of public interest are to be discussed,
v) Budget adequately for the solid waste management sub-sector of public health,
vi) Provide environmental education and public enlightenment.

2.13 Problems of Solid Waste Management in Nigeria

Solid Waste Management (SWM) refers to all activities pertaining to the control, collection, transportation, processing and disposal of those in accordance with the best principles of public health, economics, engineering, conservation, aesthetics and other environment considerations. Its scope includes all attendant administrative, financial, legal, planning and engineering functions. The contemporary municipal solid waste management practices in Nigeria is still ineffective as it culminates in a number of health and environmental problems.

Waste dumped into storm drainage channels, creeks, lagoons and other water impoundment points create serious environmental problems which can escalate into disastrous situations. The devastation of lives and property which occurred due to the 1982 floods in Ibadan, Lagos, Port Harcourt and Aba in Nigeria (Kinako 1979, Filani and Abumere 1992) were attributed partly to an accumulation of refuse which blocked these cities' drainage channels. The urban environment steadily degrades due to waste which is not managed efficiently. For example, Adedibu and Okekunle (1989) characterized Lagos as the "dirtiest capital in the World: in most part of the city, open spaces, market places are littered with solid waste. Furthermore, Onibokun (1989) indicates that 35% of

Ibadan's households, 33% of Kaduna's and 44% of Enugu's do not have access to waste collection.

Urban solid waste management in Nigeria is constitutionally the responsibility of the third tiers of government; that is, the local government (Federal Republic of Nigeria, 1999). Financial, material and human resources that have been committed to waste management by this tier of government have not matched this responsibility. This is evident by the reasons indicated earlier, the poor management of many landfill sites and soil and groundwater pollution due to often mixing of household, industrial and toxic waste (UNEP, 2000). In view of the environmental situation described above in many urban areas, many Nigerian cities have been described as dirty, unsanitary, and aesthetically displeasing in the world (Mabogunje, 2000). As a result of the failures recorded by local governments in solid waste management, many state governments have put in place bodies that are regional in outlook (that is, covering more than one local government). For example, in Oyo state, the Ibadan Waste Management Authority was established in 1996 to oversee all the local government areas within the Ibadan region (Oyo State of Nigeria, 1996). Lagos State established the Lagos State Waste Disposal Board (Adefemi, 1980). Similarly, Ondo State Waste Management Authority (OSWMA) was established in 1999 (Ondo State of Nigeria, 1999).

2.13.1 Problem of Population Density

Nigeria is a nation that exemplifies chronic solid waste management problems in conjunction with population growth. It is the most populous country in Africa, with over 120 million residents (World Bank, 1996), and over the past 50 years, has had the third largest urban growth rate in the world at 5.51% annually (UNWUP, 1997). It is estimated that nearly ten percent of the population (21 million people) live below the national poverty line (World Bank, 1996). Rapid population growth overwhelms the capacity of most developing cities to provide even the most basic of MSWM services. As a result, it is typical to find one to two thirds of solid waste generated going uncollected, leading to waste being dumped indiscriminately in the streets and drains, contributing to flooding, breeding of vermin, and the spread of diseases (Zurbagg, 2003). The waste which is collected often ends up dumped in uncontrolled sites or burned without the most basic of environmental controls.

2.13.2 Obsolete Legislation and Lack of Enforcement

Since gaining independence from Great Britain in 1960, Nigeria's government has been controlled by a succession of military dictators. The election in 1999 of Olusegun Obasanjo was the beginning of the first true democracy in Nigeria (The Economist, 2002), however the country is still known to be extremely corrupt. The federal government has very little control over environmental regulation as a whole. The Federal Environment Protection Agency (FEPA) was established in 1988 to control the growing problems of waste management and pollution in Nigeria (Onibokun and Kumuyi 2003).

Vision 2010 was FEPA's attempt to address environmental problems in the nation. The report proposed goals to be accomplished by the year 2010 that would lead toward sustainable development. In regard to solid waste management, the report says the goal is to "achieve not less than 80 percent effective management of the volume of municipal solid waste generated at all levels and ensure environmentally sound management" (Vision 2010, 2003). Strategies to achieve this goal include education and awareness programs, developing collaborative approaches to integrative management of MSW, strengthening existing laws and ensuring compliance, and encouraging local and private sector participation. Although this represents a positive, though somewhat undefined, approach to solid waste management, the reality of poverty and government corruption has prevented effective implementation of these plans. There is little to hold the government or the public accountable to the regulations developed by FEPA and Vision 2010 (Bankole, 2003).

2.13.3 Poor Logistics

In Nigeria, it seems as though no organization is willing to take responsibility for regulation of waste management. For example, in Ibadan, in the western part of the country, jurisdiction over waste management has changed hands several times since the late 1980s (Onibokun and Kumuyi 2003). Although local governments are intended to fund solid waste disposal, less than a quarter of the necessary money was collected in 1994 (Onibokun and Kumuyi 2003). Since state resources are often extremely limited, private companies will often be contracted for waste disposal. However, these companies are frequently no more effective than the state-in Ibadan in 1991, there were twenty three registered private waste collectors, but only ten were found to be operational (Onibokun 1999).

Lagos has a population of between twelve and eighteen million people, the sixth largest city in the world. Between twenty and twenty-five percent of Lagos' budget is allocated to waste management (UNESCO, 2003). However, even with proper garbage-collecting trucks, the incredibly dense streets of Lagos make it impossible for the trucks to maneuver through to collect the excessive amounts of trash that are produced in a day. In the five other mega-cities of the world (cities with over ten million people), over forty trips are made per day from the city to the dump site. In Lagos, only two trips are possible each day (UNESCO, 2003).

2.13.4 Poor Waste Disposal Practices

Most of the municipal solid waste (MSW) in developing countries is dumped on land in a more or less uncontrolled manner. These dumps make very uneconomical use of the available space, allow free access to waste pickers, animals and flies and often produce unpleasant and hazardous smoke from slow burning fires.

Financial and institutional constraints are the main reasons for inadequate disposal of waste especially where local governments are weak or underfinanced and rapid population growth continues. Financing of safe disposal of solid waste poses a difficult problem as most people are willing to pay for the removal of the refuse from their immediate environment but then "out of sight – out of mind" are generally not concerned with its ultimate disposal. The present disposal situation is expected to deteriorate even more as with rapid urbanization settlements and housing estates now increasingly encircle the existing dumps and the environmental degradation associated with these dumps directly affect the population. Waste disposal sites are therefore also subject to growing opposition and it is becoming increasingly difficult to find new sites which find public approval and which are located at a reasonable distance from the collection area. Siting landfills at greater distances to the central collection areas implies higher transfer costs as well as additional investments in the infrastructure of roads hence intensifying the financial problems of the responsible authorities. In addition to all this, an increase in service coverage will even aggravate the disposal problem if the amount of waste cannot be reduced by waste recovery.

Other reasons for inadequate disposal are the mostly inappropriate guidelines for siting, design and operation of new landfills as well as missing recommendations for possible upgrading options of existing open dumps. Many of the municipal officials think that uncontrolled waste disposal is the best that is possible. Often the only guide-lines for landfills available are those from high-income countries. These are based on techno-logical standards and practices suited to the conditions and regulations of high-income countries and do not take into account for the different technical, economical, social and institutional aspects of developing countries.

The safe alternative, a sanitary landfill, is a site where solid wastes are disposed at a carefully selected location constructed and maintained by means of engineering techniques that minimize pollution of air, water and soil, and other risks to man and animals. Loans or grants to construct sanitary landfills do not necessarily result in sanitary landfill disposal. Equally important as site location and construction is well trained personnel and the provision of sufficient financial and physical resources to allow a reasonable standard of operation. If this is not given good sites, it can quickly degenerate into open dumps.

2.13.5 Poor Waste Collection Practices

Municipal solid waste collection schemes of cities in the developing world generally serve only a limited part of the urban population. The people remaining without waste collection services are usually the low-income population living in peri-urban areas. One of the main reasons is the lack of financial resources to cope with the increasing amount of generated waste produced by the rapid growing cities. Often inadequate fees charged and insufficient funds from a central municipal budget can not finance adequate levels of service. However, not only financial problems affect the availability or sustainability of a waste collection service. Operational inefficiencies of SW services operated by municipalities can be due to inefficient institutional structures, inefficient organizational procedures, or deficient management capacity of the institutions involved as well as the use of inappropriate technologies.

With regard to the technical system, often the "conventional" collection approach, as developed and used in the industrialized countries, is applied in developing countries. The used vehicles are sophisticated, expensive and difficult to operate and maintain, thereby often inadequate for the conditions in developing countries. After a short time of operation usually only a small part of the vehicle fleet remains in operation.

In many countries there is currently great interest in involving private companies in solid waste management. Sometimes this is driven by the failures of municipal systems to provide adequate services, and sometimes by pressure from national governments and international agencies. Arrangements with private companies have not all been successful, and as a result some opposition to private sector involvement is now in evidence. An important factor in the success of private sector participation is the ability of the client or grantor - usually a municipal administration - to write and enforce an effective contract. Many municipalities do not know what it has been costing them to provide a service, so they cannot judge if bids from the private sector are reasonable. The contract document must be well written to describe in quantitative terms what services are required and to specify penalties and other sanctions that will be applied in case of shortcomings. Monitoring and enforcement should be effective. It is also important that the rights of both parties are upheld by the courts. Three key components of successful arrangements are competition, transparency and accountability.

As an alternative to large (often international) companies that can provide most or all of the solid waste services in a city, microenterprises or small enterprises (MSEs) or Community-based Organisations (CBO) can be involved for services at the community level (neighborhoods or the small city administrative zones). They often use simple equipment and labour-intensive methods, and therefore can collect waste in places where the conventional trucks of large companies cannot enter. The MSEs may be started as a business, to create income and employment, or they may be initiated by community members who wish to improve the immediate environment of their homes. A recurring problem with collection schemes that operate at the community level is that these systems generally collect and transport the waste to a relatively short distance up to a transfer point, from where the waste should be collected by another organization - often a municipality. Problems of co-ordination and payment often result in the waste being left at transfer points for a long time creating a hygienic unsatisfactory condition. Another approach is to recycle as much of the waste locally (decentralized) so that there is very little need for on-going transport of collected waste.

2.14 Solid Waste and Health in Nigeria

The following diseases were reported from Nigeria possibly from poor sanitation and environmental degradation:

Fly born diseases	Typhoid, dysentery, diarrhea, salmonellosis, cholera, myiasis, yawns, sandfly fever, rickettsial pox.
Rodents	borne zoonoses histoplasmosis, plague, rat bite,, virus infections, leprospirosis, relapsing fever, rickettsial pox
Mosquito	borne diseases – dengue, encephalitis, malaria, yellow fever

Source: Sridhar 1999, Sridhar and Oloruntoba 2005

2.15 Community Mobilization for Waste Management

Public awareness and attitudes to waste can affect the whole solid waste management system. All steps in solid waste management starting from household waste storage, to waste segregation, recycling, collection frequency, the amount of littering, the willingness to pay for waste management services, the opposition to the siting of waste treatment and disposal facilities, all depend on public awareness and participation. And community participation is the process by which individuals and family assume responsibility for their own needs and for those of the community and develop the capacity to contribute to their and the community's development.

Sridhar et al (2000), described community participation as an important method of promoting waste separation and effective collection. And participation can be achieved through workshops and neighborhood communication sessions. It was added that financial incentives may also encourage better participation. Furthermore, in promoting community participation, it is important to obtain support from formal waste management authority, the community members should be involved right from the beginning stage of the project.

Community participation is able to find solutions to problems and needs identified by the community members themselves either independently or as a result of effective health education. It thus leads to social acceptability and sustainability of such health programmes, when it is truly achieved. According to Olascha, (1997), community participation does the following:

1) Develops citizen sense of belonging and feelings of importance
2) Local resources utilization and development
3) Maximize programme service utilization
4) Encourages service maintenance and sustenance
5) Promotes consumer health knowledge and technical know how
6) Helps to pull the people together for self help projects and makes community more self reliant.

Thus, community mobilization is also a crucial issue which determines the success or failure of a solid waste management system. A system demanding segregation and storage of waste at source would require a very high degree of human behavior change.

Moningka, (2000) stated the following as the factors that are thought to favour the sustainability of community participation and hence of services, like waste collection and separation, set up by the project:

1. Communication strategies are essential to generate a broad-based understanding of solid waste issues among community members on the one hand and responsiveness of the stakeholders to the demands of the community on the other.
2. Representative local leaders and CBOs can stimulate community participation and ensure that community needs are taken into account.
3. Women play a determining role in waste management and they form important channels of communication.
4. Community initiatives and CBOs are less durable if they are not, at some point, recognized and supported by the local authority.
5. Intermediary and consultation organization to support CBOs in continuing their activities in waste management.
6. Cooperation between the CBO and the local authority to maintain and operate the service system according to formal agreements with stakeholders.
7. Financial and operational viability to make community services less dependent on external support.
8. Follow-up support after project implementation to reinforce awareness and new practices and assist when required with operation and management of new organizations. Further research must be conducted on the relevance and importance of these factors and to investigate which other factors are essential for the sustainability of community participation after project completion.

2.16 Effective Community Partnership in Solid Waste Management.

Bulle (1999) revealed that an intensive process of consultation with the stakeholders concerned is likely to result in sustainable, widely supported activities. Partnerships with community stakeholders have a number of specific benefits, some of which are listed below:

a) A combination of different types of waste services is more likely to meet the (variation in) demands of the residents.

b) Resources of households and the community are mobilized, through taking responsibility for environmental cleanliness and payment of waste collection fees.

c) Jobs and income opportunities in the small-scale economy of waste collection and recycling are promoted.

d) Residents increase their appreciation for the local authority that responds adequately to their demands for waste services

e) Residents acquire more understanding of the issues and capacity to organize waste services for themselves.

Creating partnerships is a process that gradually draws in more residents and more organizations in promoting the various aspects of waste management and urban sanitation on the local level. The partnership process makes the urban waste system both more effective - meeting the needs of the residents more directly - and more sustainable.

2.17.1 Role of Community-Based Organizations (CBOs) in Solid Waste Management

One way of contacting the residents is through a second set of stakeholders: Community-Based Organizations (CBOs). These organizations are usually motivated by values or ideas that involve improving the community and cleaning up the neighbourhood.

Their motivation for engaging in waste management may include:

- A desire for a clean environment for themselves and the community
- The wish to conserve natural resources in the urban environment
- A perceived need for work and income for poor people in their community, such as single women with children, old people, unemployed youth, waste pickers.

A community-based organization can be a critical partner in local waste management when:

i) Its activities deal with subjects concerning the environment, health, education or community service

ii) It has a clear internal communication structure and allocation of responsibilities

iii) It has legitimate leaders who are recognized and respected in the community

Examples of potential partners of community-based organizations

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Examples of potential partners of community-based organizations

1) A community-wide development committee with specialized sub-committees for health, education or urban sanitation
2) A coordinating committee of micro- and small enterprises, active in waste services
3) An association of marketers
4) Women's organizations
5) Youth organizations
6) A locally-based religious organization
7) A home-owners association (Gopal, 1995).

2.17.2 Role of Households in Solid Waste Management

Households form the largest category of stakeholders in waste management. They have a multi-faceted relationship to waste management activities: as waste generators, waste service clients; receivers of information and participants in mobilization for waste management and urban sanitation.

Households prepare their garbage in such a way that it can be collected by micro- and small enterprises, the local authority or a private company, or by waste pickers, or bought by itinerant buyers.

Important roles of households in waste management are:

1) Store garbage properly in the house or compound
2) Engage in separation at source when appropriate
3) Set out the garbage at the agreed time and place
4) Use official disposal sites when there is no door-to-door collection
5) Encourage more re-use of waste materials within the household
6) Maintain private waste facilities
7) Participate with neighbours in activities to keep the environment clean

To support households in playing their expected roles, it is important to recognize that within a neighbourhood community, households may belong to a variety of social or religious groups, and so may vary in their:

- Cultural/religious beliefs and practices
- Major occupations

- o Income and expenditure patterns
- o Access to community and infrastructure services
- o Gender and age

Such distinctions have practical consequences. For example:

• The garbage from vegetarian households has a different composition than that from meat-eating households. This is relevant for the re-use of organic waste in peri-urban agriculture.

• Households headed by women alone have less ability to mobilize resources for construction or repair of soak away pits and the like.

• Households practicing farming or holding animals in their compounds generate different garbage than high-income households generating waste from packaged foods. This is relevant for organizing separation at source.

• Poorer households have a lower ability to pay for services than middle-income households. This affects the level of waste collection service and the type of waste facilities to be provided.

• Households living on steep slopes or far from conventional roads and sanitation facilities, require specially designed waste collection services operated in a way that suits their circumstances and demands (Gopal, 1995).

2.18 Role of Women in Waste Management

Women play a determining role in waste management and they form important channels of communication. In many projects, the important role of women is overlooked and often they are not listened to or their needs and circumstances are not sufficiently taken into consideration. This usually leads to the abortion of expected results in respects of long term sustainability and dependability of most of the solid waste management schemes put in place. Sridhar et al (2001) affirmed in a research titled "Gender involvement in community waste management in urban Nigeria" that women's active involvement in solid waste management in urban Nigeria is limited to a great extent to household storage, because of factors such as: culture, religion, political systems and economics.

In most situations women are the managers of households and thereby they are responsible for cleanliness within and around the home and for taking care of waste. In some societies, this task also involves paying for waste collection and therefore it is vital to include women in determining the fees for waste services. Apart from domestic tasks, women can be active members of CBOs, can stimulate participation of other women or community members and may be the key interlocutor that projects have among the community (Bulle, 1999; Imperato and Ruster, 1999; Scheinberg *et al.*, 1999).

In Karachi, two female shopkeepers proved to be important for stimulating community participation, as they enjoyed a good reputation, had good contacts with the community and were enthusiastic supporters of the project (Zurbrugg and Ahmed, 1999). For women to fulfill a key role, projects should address the particular needs of women, the difficulties faced by women to overcome obstacles against their participation, and the problem for women to reconcile project activities with their normal daily activities (Bulle, 1999; Imperato and Ruster, 1999).

2.19 Private Sector Involvement in Solid Waste Management

The trend of solid waste management is shifting towards resource recovery and recycling. The private sector has a major role to play in the purchase of the recyclable solid waste and the recycled materials. This will encourage the process of source separation and the recycling process as income will be generated.

The role of the private sector is to provide differentiated services that the public sector fails to provide, because of limited resources, priority obligations or political pressure. They comprise all those individuals and micro and small enterprises and cooperatives that see profit in collecting, selling, buying and using waste materials. They are, for example, waste pickers, itinerant buyers, middle men (junk shop owners), micro/small enterprises who collect garbage for a fee, enterprises that recycle materials (plastic, paper, metal) and manufacture new products for sale. The distinguished three types of micro- and small enterprises are: Commodities-Based, Services-Based and Values-Based MSEs.

i) Commodities-Based MSEs are part of the recycling business, they earn income by selling materials and products, which they have salvaged, produced or bought from someone else.

ii) Services-Based MSEs earn their income from removing waste, cleaning or renovating, that is, providing a service.

iii) Values-Based MSEs are formed with the primary goal to promote some form of social, cultural change or environmental protection. Their involvement in urban waste management is either to earn profit for their promotion activity or serves as a means to raise environmental awareness. (Imperato and Ruster, 1999).

2.20 Current Status of Available Literature

A general overview of the present literature survey reveals that although a lot of researches have been done on solid waste management in Nigerian cities. However, there is need to carry out more research on the use of community mobilization in implementation of source separation of solid waste for recycling among residential communities in institutions of higher learning in Nigeria.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of Study Area

This study was carried out on the campus of University of Ibadan, which is located in Ibadan the capital of Oyo State. Ibadan city is in southwest Nigeria, 120km inland from Lagos, a transit point between the coastal region and the areas to the North. Ibadan was created in 1829 as a war camp for warriors coming from Oyo, Ife and Ijebu. It is located at an altitude ranging from 152 – 213m with isolated ridges and peaks rising to 247m (Sridhar and Ojediran 1983) and located near the forest grassland boundary of south-western Nigeria on longitude $3^0 5^1$ East of Greenwich Meridian and Latitude $7^0 23^1$ North of the equator at a distance of about 145km north east of Lagos (Ayeni, 1982). Oyelese (1970) estimated the total area of the city to cover approximately 103.8sq.km. Ibadan is the second-largest indigenous city in the country, and is a major commercial, industrial, and administrative centre. It is a marketplace for cocoa and other local agricultural produce. Industries include chemicals, electronics, plastics, and motor vehicle assembly; many small businesses, including flour-milling, leather-working, and furniture-making also flourish, while craft industries include weaving, dyeing, and pottery.

University of Ibadan is located in Ibadan North Local Government Area (LGA). Ibadan North Local Government is one of the five local government areas within Ibadan metropolis. The LGA is made up of people from different social, religious and cultural backgrounds; professionals, artisans, employed and unemployed. A majority of the dwellers are predominantly Yoruba people while there are Hausa, Igbo, Edo, Urhobo, Itsekiri, Ijaw and Fulani people as well as foreigners.

University of Ibadan is the first citadel of higher education established in the country in 1948 as a college of the University of London. It became a full-fledged independent University in 1962, two years after the country's independence from Britain in 1960. It took off with degree programmes in medicine, basic sciences, arts, social sciences and education. It is now a comprehensive university with additional programmes in agriculture and forestry, veterinary medicine, pharmacy, technology and law. From students enrolment of 144 in 1948 the population of students increased steadily to approximately 18,843. The university has a total population of 23,303; out of which 18843 are students with 35% post graduate and 65% undergraduate, 1197 are academic staff and 3263 are non-academic staff based on the 2007/2008 statistics (Planning Unit, UI).

University of Ibadan is made up of 13 Faculties in which both undergraduate and postgraduate studies are conducted. The faculties are: Arts, Social Science, Science, Education, Agric and Forestry, Technology, Pre-clinical sciences, Vet Medicine, Clinicals, Public Health, Pharmacy, Law. The central administration comprises the registry and bursary. Other sections are Health service called Jaja clinic, works, maintenance, University Press, Cafeteria, Staff union building, Staff common room (Senior staff club, Abadina Community Center), trenchard hall, shops, staff schools private and public. The residential areas in University of Ibadan are classified into students' Halls of Residence located at the South East part, Senior Staff Housing located at South East and North West part and Junior Staff Housing located at the North East part of the University. The students' hostels are 12 in number with the following accommodations (Table 3.1):

Table 3.1: STUDENTS' ACCOMMODATION

S/N	*NAME*	*NUMBER OF BED SPACES*
1	Queen Elizabeth II Hall	611
2	Alexander Brown Hall	601
3	Queen Idia Hall	960
4	Obafemi Awolowo Hall	1,375
5	Tafawa Balewa Hall	207
6	Sultan Bello Hall	428
7	Tedder Hall	506
8	Kuti Hall	541
9	New P.G Hall	634
10	Independence Hall	727
11	Nnamdi Azikwe Hall	717
12	Mellamby Hall	503
	TOTAL	7,768

Source: UI Estate Unit (2005)

The University campus has areas demarcated for the Senior staff housing (about 519 housing units). These are made up of flats, duplex, chalets (Table 3.2). There is an average of five people in each apartment resulting in estimated total population of 2,959.

TABLE 3.2: SENIOR STAFF QUARTERS

S/N	*NAME*	*NUMBER OF HOUSEHOLDS*
1	Alzayath Cresent	24
2	Amina Way	108
3	Barth Road	36
4	Batuta Road	1
5	Benue Road	34
6	Bini Road	7
7	Carr Road	4
8	Chapel Road	1
9	Crowther Lane	6
10	Danfodio Road	8
11	Ebrohime Road	9
12	Elkanemi Road	7
13	Ekwuno Road	2
14	Eliot Close	8
15	Eyo Road	4
16	Gongola Street	6
17	Ijoma Place	8
18	Ijoma Road	20
19	Imo Street	26
20	Jaja Avenue	5
21	Kurunmi Road	21
22	Laird Place	10
23	Laird Road	4
25	Lander Road	4

TABLE 3.2: SENIOR STAFF QUARTERS

26	Lisabi Crescent	9
27	Massaba Road	6
28	Niger Road	4
29	Obong Road	2
30	Oduduwa Road	3
31	Parry Road	21
32	Pepple Road	8
33	Phillipson Road	37
34	Sankore Avenue	21
35	Saunders Road	22
36	Sokoto Crescent	6
38	Wadei Martins	13
	TOTAL	**519**

Source: UI Estate Unit (2005)

Also the University campus has an area demarcated for Junior Staff housing and there are about 389 apartments comprising mostly bungalows and blocks of flats (Table 3.3). There is an average of eight people in each apartment resulting in estimated total population of 3,112.

TABLE 3.3: JUNIOR STAFF QUARTERS ABADINA

S/N	*NAME*	*UNITS*
1	C – Type	31
2	C – Special	2
3	D (New) Type	40
4	D (Old)	126
5	E- Converted	56
6	Flatlets (2- storey blocks)	24
	TOTAL	389

Source: UI Estate Unit (2005)

Plate 3.1 Map of the University of Ibadan (UI Works, 2009)

3.2 Sampling Area/Sites

University of Ibadan is a large community accommodating students, academic and non academic staff with their family members. Hence, a lot of activities are carried out which result in massive waste generation in the residential areas. In this study, the focus was on residential areas.

The residents in University of Ibadan can be classified into Senior Staff residents, Junior Staff residents and Students. For the purpose of this study University of Ibadan residential areas was stratified into three based on the socio-economic and career status. A representative of the Senior Staff residents selected was Amina way. It is located at the South -Eastern part of the University after the main gate. It was purposively selected because it has the highest number of housing units, one hundred and eight in number and they are well laid out. This part of the University is allocated to Senior staff members including both teaching and non teaching staff.

Abadina is the residential area for Junior staff members, New Postgraduate hall was purposively selected to represent the student hall since it has both male and female residents. it's more centralized and currently consists of postgraduate students (both Masters and Ph.D).

3.3 Target Population

The target population for this study especially in the staff residential areas is the most senior woman in each housing units. However a representative was selected in the absence of such a person and in the hostel, cleaners who are in charge of the waste management were selected.

3.4 Study Design

The study has both laboratory and survey components. It serves to determine the knowledge, attitudes and practices of the residents before and after training them on waste segregation for recycling. The study also determined the nature and quantity of recyclable waste generated

3.5 Study Population

The study population comprised 310 residents which is made up of

- 58 participants residing in Amina way,
- 70 participants residing in New Hall and
- 182 participants residing in Abadina community. A participant is from a household.

3.6 Sample Size Determination

The sample size was calculated in line with the following conditions:

1) Proportion with good knowledge, attitude and practice of source separation of waste = 0.5
2) Precision limit = 5%
3) 95% level of significance

$$n = \frac{[Z_{1-\alpha/2}\sqrt{2P_c(1-P_c)} + Z_\beta\sqrt{P_t(1-P_t) + P_c(1-P_c)}]^2}{(P_t-P_c)}$$

(Bamgboye, 2005)

Where

n = Sample size

$Z_{1-\alpha/2}$ = 1.96

β = 1.28 when power is 90%

Pc = Proportion in general population reported that sort waste paper before disposal in a thesis "paper waste management in University of Ibadan (0.318)

Pt = Proportion in the sample estimate (0.5)

P_t = 0.5, Pc = 0.318

Substituting in the formula

$$n = \frac{[1.96\sqrt{2 \times 0.318 \times 0.682} + 1.28\sqrt{(0.5 \times 0.5) + 0.318 \times 0.682}]^2}{(0.5-0.318)}$$

= 141

This is the minimum population that can be studied.

10% of the sample size calculated was added to the sample size to take care of attrition (or no response)

10% of 141= 14.1
n = 141 + 14.1 = 155.1
n = 155

Since the design involves pre and post intervention questionnaire, the sample size was doubled to 310 to minimize error and attrition problem.

3.7 Survey Methods

3.7.1 Questionnaire Administration

A 61- item, semi-structured, interviewer administered questionnaire was administered on participants to elicit information on their perception of separating wastes at household level and solid waste recycling. This was carried out before and after the intervention in order to assess the impact of the intervention on their perception. The baseline information was obtained from a sample of 310 participants selected by multistage sampling technique; they were proportionally allocated into the locations 58, 182, 70 from Amina way, Abadina, New Hall respectively. The questionnaire provided information on respondents' demographic and sociological data, knowledge, attitudes, practices on source separation of waste and recycling and health assessment.

The questionnaire was divided into 5 sections for effective administration

Section 1: assessed the socio-demographic features of the respondents such as age, educational level, religion, occupation, ethnic group and number of occupants per apartment.

Section 2: this section assessed the level of knowledge of the respondent on source separation of waste and recycling.

Section 3: this focused on the attitude of the respondents towards source separation of waste and recycling.

Section 4: this documented the different household solid waste management practices involving separation of waste at source and recycling.

Section 5: the last phase documented the health impact resulting from the current waste management practices.

This phase lasted for two months and questionnaire was administered from house to house. However, out of the 310 questionnaires administered 298 were retrieved. Others were lost to those who requested for self administration.

3.7.2 Focus Group Discussion

Focus Group Discussion (FGD) was conducted among 20 residents of Amina way, 40 residents of Abadina and the cleaners in New hall. Two FGD sessions were conducted at Amina way, four sessions at Abadina and a session was conducted at the student hostel. There were ten participants per session in each of the locations.

3.7.3 Observation Checklist

Observation checklist was also used to authenticate the response given by the respondents. Areas observed were the neighborhood dustbins. the environment, household waste collection and disposal method, the building, categories of recyclable waste generated.

3.8 Questionnaire Pretest

The methods and procedure of the study were pretested under similar conditions at Ibadan Polytechnic, staff residential areas. Pretest was carried out for over a period of one week. Twenty women were interviewed. After the pretest, necessary amendments were made to the questionnaires. Some questions were reframed, while the others were rearranged.

3.9 Entry Procedure

Prior to the conduct of the study, approval was obtained from the Abadina council during one of their meetings; approval was also obtained from the Supervisors of students halls of residence. Approval was obtained from each head of house at the Amina way.

3.10 Sampling Technique

The sample size was selected from the University using three stages sampling procedure. Amina way was purposively selected for SSH. Abadina was purposively selected for JSH and New PG hall was purposively selected for Student hostel. The 310 participants were proportionally allocated to Student hall, Senior and Junior staff residences. 58 were randomly selected from Senior Staff housing (Amina way), 182 from Junior Staff housing (Abadina), 70 from post graduate New Hall. The number for each location was selected based on people sharing the same neighborhood bin.

The concept of the study was carefully explained to the participants at the beginning of each interview. Consent was obtained from each participant when it was ascertained that they thoroughly understood the study.

3.11 Method of Administration of Instruments

FGD was conducted among 20 residents of Amina way who were divided into two groups of ten people in the same neighborhood, 40 residents of Abadina were divided into 4 groups of ten people in the same neighborhood and the cleaners in New Hall. FGD guide was used as shown in Appendix 2. Each focus group discussion consisted of a group of 10 female participants in the age group of 15-50 years and open ended questions were asked. The participants were left to explore themselves, each discussion lasted for 30 minutes. The information obtained from FGD was recorded on a tape and used to develop the questionnaire.

Pre-intervention questionnaire administration

The baseline information was obtained from a sample of 310 participants. The questionnaire was administered with the help of 5 Research Assistants in Abadina, 3 in Amina way, 2 in student hostel

Post-intervention questionnaire administration

The same questionnaire was administered to the same households and effort was made to ensure the same people interviewed at the Pre-intervention stage were used. The same research assistants used for the pre-intervention questionnaire administration were used.

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3.12 Intervention

3.12.1 Training of participants on source separation of wastes

A Neighborhood Environmental Action Team (NEAT) was established among a subset of the interviewed: 20 households in Amina way, 40 households in Abadina, and 8 cleaners in the New P.G hall. A day training was conducted for each group on source separation of solid wastes into biodegradable and non biodegradable wastes. A Bagco bag of 25Kg capacity and a black nylon bag of 10kg capacity were provided for the separation of non biodegradable and biodegradable waste respectively (plate 2.2).

3.12.2 Collection of Source Separated Wastes

The non-biodegradable wastes were gathered once in a week for characterization while the biodegradable was gathered on Wednesdays and Saturdays to avoid decomposition before characterization. The data was obtained for three months in each location.

3.12.3 Characterization of Source Separated Wastes into Physical Components

The non-biodegradable wastes collected from each household weekly were characterized into paper, nylon, plastics, metal and glass by the researcher. Each component was quantified with measuring scale.

3.12.4 Assessment of Chemical Composition of the kitchen waste

The kitchen waste separated into the 10Kg bag was collected from each household and weighed. 3Kg composite sample of fresh kitchen wastes generated were collected per location for each month. They were sun dried to constant weight.

- **Sample collection procedure:**

The fresh kitchen wastes gathered from households in each location were mixed thoroughly and divided into four quadrants. Two were mixed together and a composite sample of 3kg was collected. This was carried out for three months.

- **Sample processing:**

The composite samples were sun dried for weeks, the samples were packed into brown envelopes and were dried further in oven at 65°C until constant weight was attained.

The samples were milled into powdery form to pass a 1.0 mm test in a clean milling machine at Agronomy dept U.I.

3.13 Evaluation of the Intervention

The intervention programme was evaluated by administration of the same questionnaire used at the pre intervention stage. The pre- intervention questionnaire mean score and post intervention questionnaire mean score administered to same households were statisticolly analyzed with ANOVA.

3.14 Laboratory Procedures

Sample pretreatment: The samples were digested for the analysis of heavy metals

3.14.1 Digestion Method for Heavy Metals

Determination of Lead (Pb), Chromium (Cr), Nickel (Ni), Zinc (Zn), and Cadmium (Cd) in the raw organic sample was done by weighing 1 g of grounded sample into a conical flask. 5 ml of digestion reagent (2:1 conc HNO_3 and conc H_2SO_4) were added and heated until brown peroxide evaporated. The resulting residue was totally dried. The procedure was repeated until a white precipitate remained in the flask. This was then filtered through a Whatman filter paper (number 1) into a 100 ml volumetric flask. The filtrate was diluted with 0.1N HNO_3 to 100 ml. The digested samples were then analyzed for the heavy metals with a Bulk Scientific 210/211 VCp Atomic Absorption Spectrophotometer using the American Public Health Association (APHA, 1998) standard methods at the International Institute for Tropical Agriculture (IITA) Ibadan.

3.14.2 Total Carbon Determination

a. Procedure

A dry empty porcelain crucible was weighed W_1. 10g of well mixed oven dried organic waste sample of known moisture content was weighed in a dry porcelain crucible W_2. The sample was heated slowly in a furnace raising the temperatures in steps (100, 200 and 550 ^{0}C). The final temperature setting of 550 ^{0}C was maintained for 8 hours. The crucible containing a greyish white ash was removed cooled in a desiccator and weighed W_3.

b. Calculations

The % Ash, % Organic matter and % Carbon are calculated as follows:

$$\% \text{ ash in sample} = \frac{W_3 - W_1}{W_2 - W_1} X\, 100$$

Where W_1 = Weight of the empty dry crucible

W_2 - Weight of the dry crucible containing organic waste sample

W_3 - Weight of the dry crucible containing organic waste following ignition

% Organic Matter in sample = 100- % ash

$$\% \text{ Carbon in sample} = \frac{\% \text{ Organic Matter in sample}}{1.729}$$

Sample pretreatment for the determination of Nitrogen, potassium and phosphorus

a. Reagents

Selenium powder, Se, Lithium Sulphate, $Li_2SO_4.H_2O$, Hydrogen Peroxide, 30%, H_2O_2 and concentrated Sulphuric acid H_2SO_4.

b. Digestion Mixture Preparation

About 0.42 g of selenium powder and 14 g lithium sulphate were added to 350 ml 30% hydrogen peroxide and mixed well. About 420 ml concentrated H_2SO_4 was slowly added while cooling in an ice bath.

c. Sample Digestion

About 0.3 g of oven dried (65°C) ground wastes sample was measured and placed in a labelled, dry and clean digestion tube. About 4.4 ml digestion mixture was added to each tube and also to 2 reagents blanks for each batch of samples. The solution was digested for 2 hours for 360°C in a furnace until the solution became colourless. The contents were then allowed to cool. About 25 ml distilled water was added and mixed until no more sample dissolved. The contents were then allowed to cool. The solution was then made up to 50 ml with water and mixed well. The solution was then allowed to settle so that a clear solution could be taken from the supernatant for analysis.

3.14.3 % Nitrogen Determination

a. Apparatus

-Macro- Kjeldahl digestion- distillation apparatus

-Macro- Kjeldahl flasks of 500 ml and 750 ml capacity.

b. Reagents

-Boric acid 4% solution (dissolve 40 g of boric acid crystals in 1 litre of distilled water)

-40% hydroxide solution (dissolve 400 g of NaOH pellets in water, cool and make up to 1 litre with distilled water.)

-0.2N HCl (standardized)

-Sodium sulphate (anhydrous)

-Sulphuric acid (H_2SO_4)

- Mixed Indicator: 0.099g bromocresol green; 0.066g methyl red; 0.011 g thymol blue. The solution was dissolved in 100ml ethanol.

c. Procedure

A Markham steam distillation apparatus was set up using NH_3 free distilled water. Steam was passed through the apparatus for 30 min. The steam bank was checked by collecting 50 ml distillate and titrating with N/70 HCl. 5 ml of digestion mixture was transferred to the reaction chamber and 10 ml of 40% NaOH was added. The solution was steamed distilled immediately into 5 ml of 1% boric acid containing 4 drops of the mixed indicator. The distillation was continued for 2 minutes from the time the indicator turned green. The distillate was removed and titrated with N/70 HCl until when the indicator turned from green to a definite pink. The volume of standard HCl required was recorded. A blank determination was run by digesting reagent blanks in place of sample and distilled as before and titrated with N/70 HCl. The ml of N/70 HCl required for the blank was subtracted from the micro-burette reading to give a corrected volume of N/70 HCl

d. **Calculation**

$$\% \text{ N in waste sample} = \frac{\text{corrected ml of N/70 HCl} \times 0.2}{\text{Weight of sample}}$$

3.14.4 Potassium Determination

Procedure

Two ml of the wet digested-sample solution was pipetted into a 50 ml volumetric flask. The solution was made to mark with distilled water and mixed well. Sample solutions starting with standard and blank solutions were sprayed directly into the flame of the Genway flame photometer Model PSP7 (wavelength at 7665Å, slit 0.07 mm). The amount of potassium present in the solution (c) from the calibration curve was read by plotting absorbance readings against potassium concentrations.

Calculation

For a 2.0 ml digest aliquot

$$\% \text{ K in sample} = \frac{\text{concentration} \times 0.125}{\text{Weight of Sample}}$$

3.14.5 Phosphorus Determination (Vanado-molybdate Method)

Procedure

Ten ml of the wet-digested sample was pipetted into a 50 ml volumetric flask and about 0.2 ml of 0.5% Paranitrophenol indicator solution was added. Alkaline solution was made with 6 N NH_3 solutions by drop-wise addition with gentle shaking. About 1 N dilute HNO_3 was added drop-wise with shaking until the solution became colourless. About 5 ml of Ammonium Molybdate/ Ammonium Vanadate mixed reagent was then added. The solution was made to 50ml with distilled water stoppered and mixed well. The flask was kept for 30 minutes and the absorption of the solution was measured at 400nm wavelength setting using a colorimeter. The phosphorus present in the solution was read off from a calibration curve prepared by pipetting 0, 5, 10, 15, 20 and 25 ml of the standard 10 ppm (mg/l) P solution into 50 ml volumetric flasks, representing 0, 1, 2, 3, 4, and 5 ppm (mg/l) P respectively. The vanado-molybdate yellow colour was developed in the standard P solution by the addition of the p-nitrophenol indicator, NH_3 solution and HNO_3. The standards were prepared for each batch of samples.

Calculation

A graph of absorbance was plotted against concentration of standard solutions. The solution concentrations for each of the 2 blanks were determined. The mean blank value was subtracted from the unknowns to give a value for the corrected concentrations.

Taking a 10ml digest aliquot

For a 50 ml final solution used for colour intensity (absorbance) measurement:

$$\% P \text{ in sample} = \frac{\text{concentration} \times 0.025}{\text{Weight of Sample}}$$

3.14.6 pH Determination

Ten ml distilled water was added to 10 g of sample. The mixture was stirred and allowed to stand for 30 minutes; the mixture was stirred again for 2 minutes. The Dwyer Model WPH1 Water Proof pH Meter was calibrated with standard buffers 7.0 and 4.0. The pH of the waste suspension was then measured using the Electronic pH determinations method (Bates, 1954).

Plate 3.2: Training of women on segregation of household solid wastes at the Student Hostel.

Plate 3.2: Training of women on segregation of household solid wastes at the Student Hostel.

Plate 3.3: The weighing of various components of household solid wastes

CHAPTER FOUR

RESULTS

4.0

This chapter presents the description of the demographic characteristics of the population under study, the level of knowledge on source separation of solid waste and recycling, practices in relation to source separation of solid waste and recycling among respondents in the selected communities in the University of Ibadan. This is shown by the results of Focus Group Discussion, administered questionnaire, observation and characterization of wastes generated, and the quantity of recyclable wastes generated.

4.1 Socio-Demographic Characteristics of Respondents

A total of 310 questionnaire were administered to selected residents of University of Ibadan, but 298 were eventually retrieved. The age ranged from 14 – 65 years. In the three communities many of the participants 51 (79.7%), 31(56.4%) and 126 (70.4%) in student hostel, senior staff and junior staff housing respectively were single and most of the participants were Yoruba: 39 (60.9%) in student hostel, 39 (70.9%) in senior staff and 97 (54.2%) in junior staff housing. Majority of the participants in the senior staff housing had tertiary education, all participants in student hostel had tertiary education while quite a number of Junior staff participants have high education and some do not have formal education. Junior staff housing recorded the highest number of traders and artisans. Majority of the participants are Christians 60 (93.8%), 50 (90.9%), 160 (89.4%) in student hostel, senior staff and junior staff housing respectively. Majority of the participants in Junior staff housing had more than 7 people per household, while majority in Senior staff housing had an average of 5 people per household (Table 4.1).

Table 4.1: Socio-demographic characteristics of the respondents

Demographic Characteristics	Student Hostel (64)	Senior staff housing (55)	Junior staff housing (179)	p-value
Age				0.001
<20	0 (0.0%)	19 (16.3%)	64 (36.9%)	
20-29	44 (68.8%)	18 (32.9%)	69 (31.7%)	
30-39	17 (26.5%)	11 (19.9%)	20 (11.3%)	
40-49	3 (4.8%)	9 (16.3%)	15 (8.6%)	
50-59	0 (0.0%)	5 (9.0%)	9 (5.0%)	
60+	0 (0.0%)	3 (5.4%)	0 (0.0%)	
Sex				0.000
Male	42 (65.6%)	29 (52.7%)	71 (39.7%)	
Female	22 (34.4%)	26 (47.3%)	108 (60.30%)	
Marital Status				0.092
Single	51 (79.7%)	31 (56.4%)	126 (70.4%)	
Married	12 (18.8%)	23 (41.8%)	51 (28.5%)	
Others(Separated)	1 (1.6%)	1 (1.8%)	2 (1.1%)	
Religion				0.588
Christianity	60 (93.8%)	50 (90.9%)	160 (89.4%)	
Islam	4 (6.6%)	5 (9.1%)	19 (10.6%)	
Traditional	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Ethnic Group				0.401
Yoruba	39 (60.9%)	39 (70.9%)	97 (54.2%)	
Hausa	4 (6.3%)	4 (7.3%)	16 (8.9%)	
Igbo	21 (32.8%)	9 (16.4%)	65 (36.3%)	
Others	0 (0.0%)	3 (5.5%)	1 (0.6%)	

Table 4.1: Socio-demographic characteristics of the Respondents

Demographic Characteristics	Student Hostel (64)	Senior staff housing (55)	Junior staff housing (179)	p-value
Educational Status				0.000
None	0 (0.0%)	0 (0.0%)	4 (2.2%)	
Primary	0 (0.0%)	0 (0.0%)	10 (5.6%)	
Secondary	0 (0.0%)	9 (16.4%)	73 (40.8%)	
Tertiary	59 (92.2%)	44 (80.0%)	87 (48.6%)	
Others	5 (7.8%)	2 (3.6%)	5 (2.8%)	
Occupation				0.000
Student	54 (84.4%)	4 (7.2%)	18 (10.10%)	
Civil Servant	5 (7.9%)	29 (52.7%)	124 (69.3%)	
Trader	0 (0.0%)	3 (5.5%)	21 (11.70%)	
Artisan	0 (0.0%)	1 (1.8%)	9 (5.0%)	
Professional	5 (7.8%)	18 (32.7%)	4 (3.5%)	
Number of persons per house hold				0.000
1-3		7 (16.7%)	28 (16.8%)	
4-6		27 (64.3%)	68 (40.7%)	
7+		8 (19.0%)	71 (42.5%)	
Number of students per room				
1	1 (1.8%)			
2	50 (89.3%)			
3+	5 (8.0%)			

4.2 Respondents' Knowledge at baseline on Source Separation and Recycling of Household Solid Wastes

This section shows respondents' knowledge on source separation and recycling of household solid waste with respect to knowledge on concept of what constitutes household solid waste, waste recycling, and importance of separation of household waste for recycling, recyclable waste generated, and current waste treatment method.

(A). Respondents' knowledge level at pre-intervention stage End.

Figure 4.1 illustrates that SH had the highest proportion (81.20%) of respondents recording above 75 Percentile. This was followed by SSH (78.20%) and then JSH (45.3%).

(B). Knowledge of Respondents on Recycling of Solid Waste

Table 4.2 indicates respondents' knowledge or awareness on source separation and recycling of household solid waste before the training was carried out. The results show that SH 54 (84.4%) and SSH 42 (76.4%) have higher knowledge of waste recycling when compared to JSH 80 (41.7%).

(C). Respondents' knowledge on the various components of household recyclable solid wastes generated

Figure 4.2 illustrates the knowledge of respondents on the waste they generate that can be turned to useful materials. At SH, Nylon was reported by highest respondents (32.8%), followed by paper which was reported by 21.8%, 17.2% reported plastics, 15.6% reported kitchen waste, 10.9% reported glass while 1.5% reported metals. At SSH, 25.5% reported plastics, 21.8% reported nylon, 18.2% reported papers, 16.4% reported kitchen waste, 12.7% reported metal, 3.6% reported glass and 1.8% reported wood. While at JSH, 26.8% reported nylon, 21.8% reported plastics, 16.3% reported papers, 13.9% reported wood, 8.9% reported kitchen waste, 7.3% reported metals and 5% reported glass.

4.2 Respondents' Knowledge at baseline on Source Separation and Recycling of Household Solid Wastes

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(A). Respondents' knowledge level at pre-intervention stage

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(C). Respondents' knowledge on the various components of household recyclable solid wastes generated

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(D) Respondents' knowledge on the method of final disposal of household solid wastes collected from their neighborhood

The knowledge of the respondents on method of final disposal of waste collected from their neighborhood is illustrated in Figure 4.3. Majority in the three locations reported that the wastes are conveyed to dumpsites. At SH, 54.7% reported that the wastes are transported to dumpsite, 4.7% reported the wastes are converted to fertilizer, 34.4% reported the wastes are burnt, 1.5% reported they are incinerated while 4.7 reported they are recycled. At JSH, 60.9% reported that the wastes are transported to dumpsite, 2.8% reported they are converted to fertilizer, 31.8% reported burning, 3.9% reported recycled while 0.6% reported incinerated. At SSH, 74.5% reported that the wastes are transported to dumpsite, 1.8% reported the wastes are converted to fertilizer, 20.0% reported the wastes are burnt, 3.6% reported they are incinerated while 0% reported they are recycled.

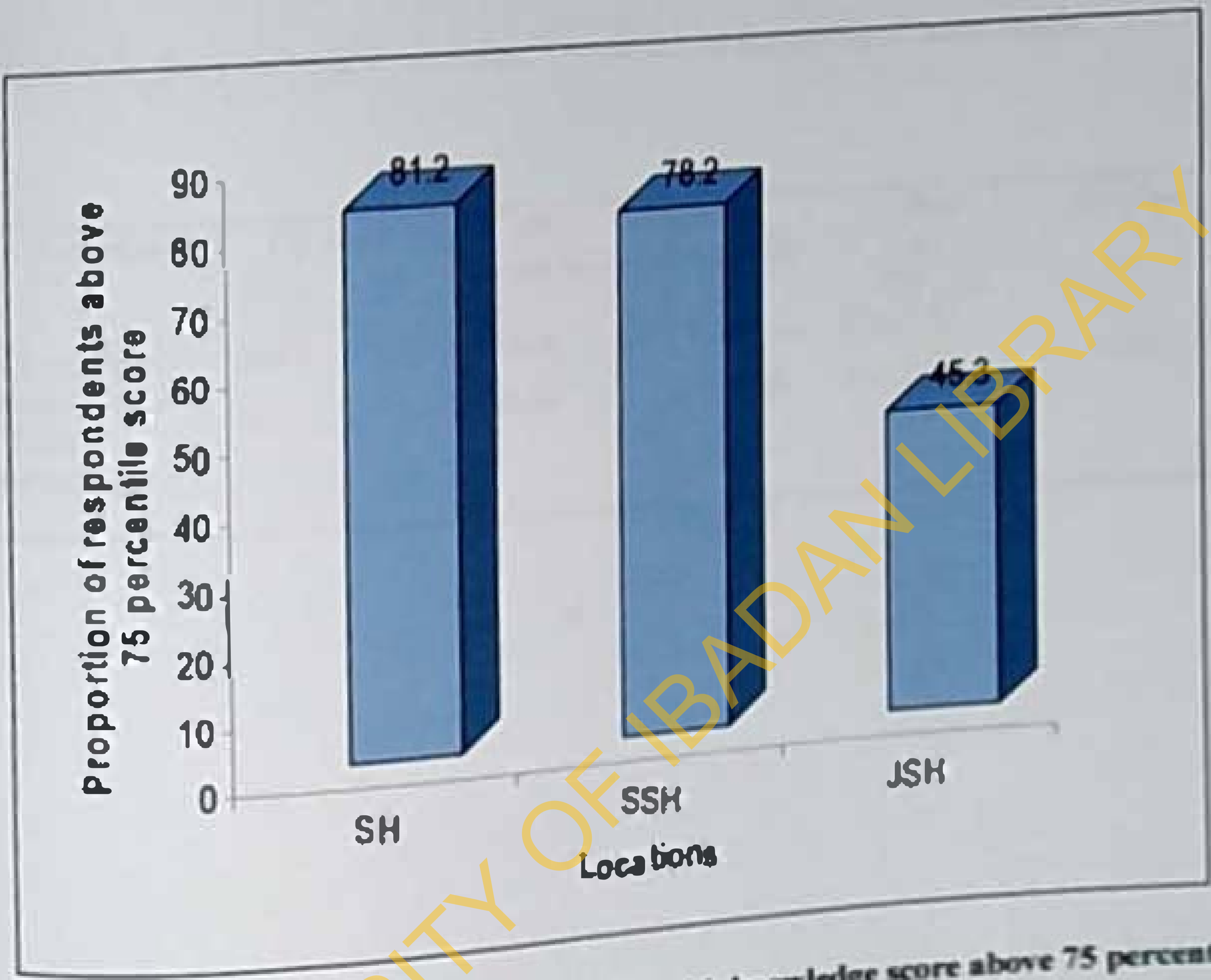

Fig 4.1: Proportion of respondents with knowledge score above 75 percentile

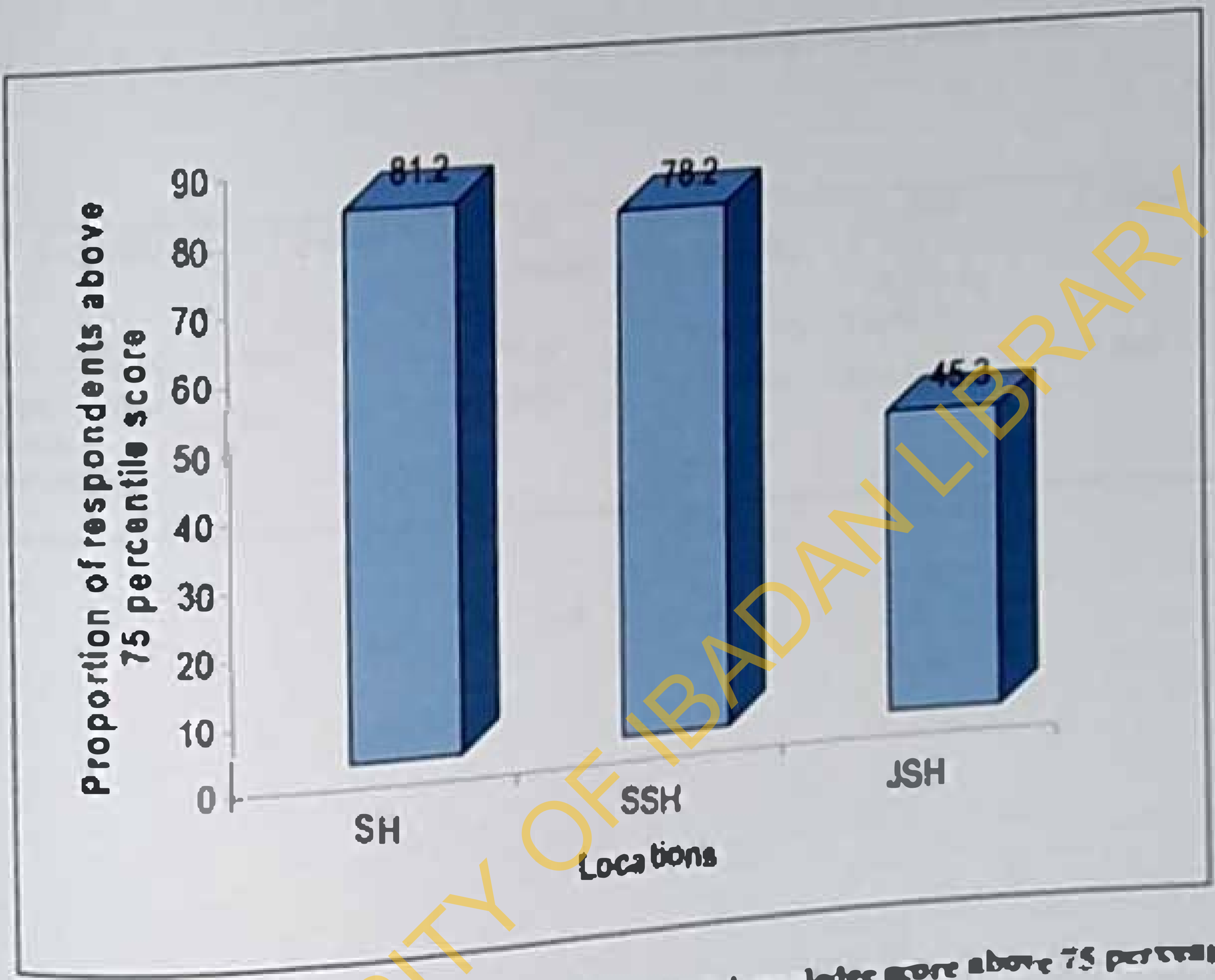

Fig 4.1: Proportion of respondents with knowledge score above 75 percentile

Table 4.2: Respondents' knowledge/ awareness on Recycling of Solid Waste

Variable	Options	SII n = 64(%)	SSII n = 55(%)	JSII n = 179 (%)	P-value
Knowledge/ awareness on Waste Recycling	Yes	54(84.4)	42(76.4)	80(44.7)	0.000
	No	10(15.6)	13(23.6)	99(55.39)	

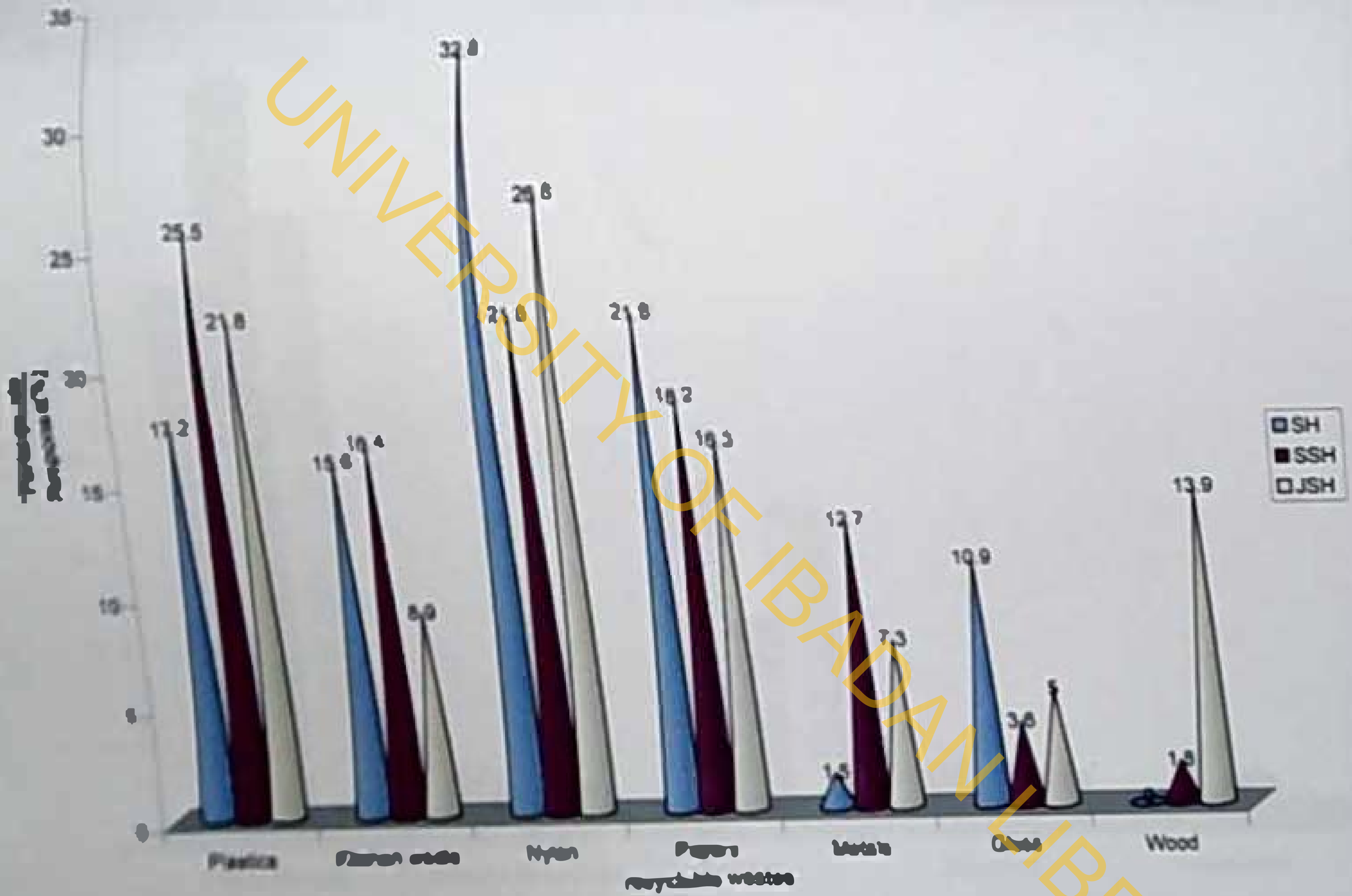

Fig 4.2: Respondents' knowledge on the various components of household recyclable solid wastes generated

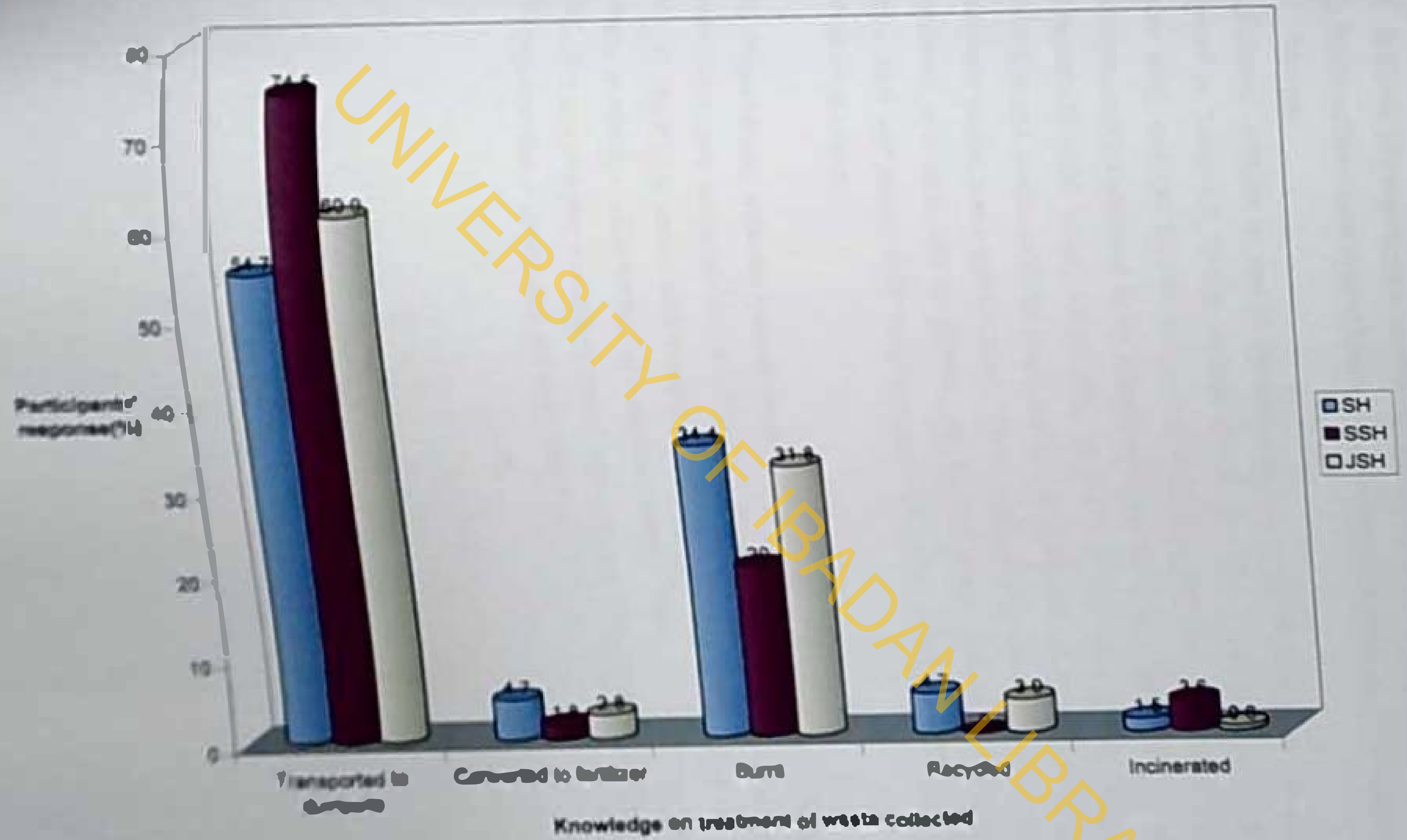

Fig 4.3: Respondents' knowledge on the disposal of household solid wastes collected from their neighborhood

4.3 Attitude of respondents to solid waste recycling before intervention

(A). Respondents' attitudes to Source Separation and Recycling of Household Solid Wastes

Participants' attitude to source separation and recycling of household solid wastes is reported in Table 4.3. It was reported that 58 (90.6%) in students hostel, 48 (87.3%) senior staff, and 117(82.1%) junior staff housing agreed that every household should participate and be involved in the management of solid waste. With respect to separation of household solid waste, 55 (85.9%), 49 (89.1%), 122 (68.2%) participants in the students hostel, senior staff and junior staff housing respectively agreed that separation of household wastes was a good method of solid waste management which was statistically significant ($p<0.005$) and 39 (60.9%), 40 (72.7%) and 94 (52.5%) in students hostel, senior staff and junior staff housing respectively were willing to separate their solid wastes from others.

(B). Respondents' attitude towards implementation of recycling plant on campus

In the three study communities, 35 (68.6%) in students hostel, 37 (74.0%) in senior staff and 115 (80.4%) in junior staff housing agreed that implementing recycling plant on the campus would be a good method of waste management. While, 13.7%, 8%, 0.7 % in SH, SSH, JSH reported that it would be capital intensive, and 7.6%, 14.1%, 9.1% in SH, SSH, JSH reported that it would save resources (Fig 4.4).

Table 4.3: Responses with respect to attitude towards waste recycling and source separation at baseline

Statements	Options	Student Hostel N = 64 (%)	Senior Staff Housing N = 55 (%)	Junior Staff Housing N = 179 (%)	P< 0.05
It is the responsibility of University administration to arrange for waste separation	Agree	47 (73.4)	34 (61.8)	118 (65.9)	0.135
	Disagree	10 (15.6)	14 (25.5)	43 (24.0)	
	Not sure	7 (10.9)	7 (12.7)	18 (10.1)	
Every household should participate and be involved in refuse management	Agree	58 (90.6)	48 (87.3)	147 (82.1)	0.214
	Disagree	2 (3.1)	3 (5.5)	17 (9.5)	
	Not sure	4 (6.3)	4 (7.3)	15 (8.4)	
I am willing to separate my recyclable waste from other wastes	Agree	39 (60.9)	40 (72.7)	94 (52.5)	0.098
	Disagree	17 (26.6)	9 (16.4)	60 (33.5)	
	Not sure	8 (12.5)	6(10.9)	25 (14.0)	
Separation of recyclable waste from others is a good method of waste management	Agree	55 (85.9)	49 (89.1)	122 (68.2)	0.001
	Disagree	2 (3.1)	2 (3.6)	34 (19.0)	
	Not sure	7 (10.9)	4 (7.3)	23 (12.8)	
Wealth is generated from the practice of waste recycling	Agree	60 (93.8)	50 (90.9)	136 (76.0)	0.002
	Disagree	0 (0.0)	0 (0.0)	18 (10.1)	
	Not sure	4 (6.3)	5 (9.1)	25 (14.0)	

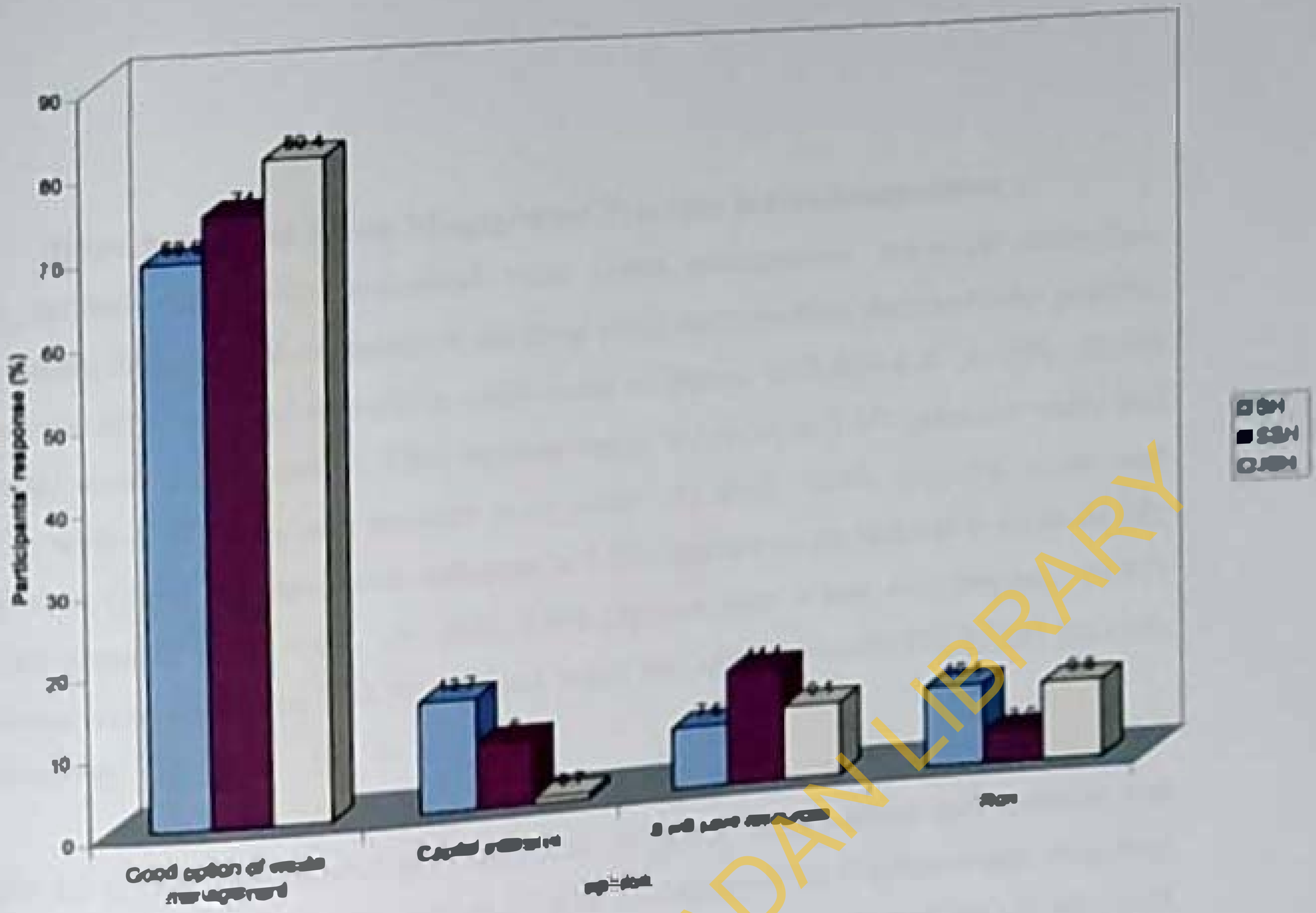

Fig 4.4: Respondents' attitude towards implementation of a recycling plant on campus

4.4 Household Solid Waste Management Practices before intervention

This section deals with household solid waste management practices collection, separation, disposal and treatment in the three study communities. Respondents' practice of source separation of household solid waste is shown in Table 4.4. At SH, 10.9% separate waste and dispose it. 7.8% separate waste and reuse it, 1.6% separate waste and sell it while 79.7% do not separate their waste. At SSH, 16.4% separate waste and dispose it, 14.5% separate waste and reuse it, 5.5% separate waste and sell it while 63.6% do not separate their waste. At JSH, 8.9% separate their waste and dispose, 24.6% separate waste and reuse it, 2.2% separate waste and sell it while 64.2% do not separate their waste.

Table 4.5 revealed that few of the respondents in student hostel, senior staff housing and junior staff housing 7(10.9%), 4(7.3%), 29(16.2%) respectively practice waste recycling on their own. Majority of the households 53(82.8%), 49(89.1%), 133(74.3%) in SH, SSH and JSH respectively dispose their waste into the neighborhood waste bin as revealed in Table 4.6.

Characteristics of the Refuse bins used by the respondents at the three locations are shown in Table 4.7 Many of the respondents 47(73.4%) and 104 (58.1%) at SH and JSH respectively use only one refuse bin while many participants in SSH use more than two refuse bins. Majority of the respondents 61 (95.3%), 25 (45.5), 83 (46.4) at SH, SSH and JSH respectively use the plastic basket for the collection of their waste while, a few people 7 (3.9%) make use of cartons in junior staff housing. In SH 47 (73.4%) of the respondents use small containers, of about 10liters in capacity. In SSH 29 (52.7%) of the respondents use medium sized containers of about 25liters in capacity. However, in Junior staff housing. 59 (33%) of the respondents use small containers and 69 (38.5%) use medium capacity containers. In SH, 49 (76.6%) of the respondents dispose their wastes once a day, 7 (10.9%) dispose their waste every two days. In SSH, 25 (45.5%) of the respondents dispose their wastes once a day while 20 (36.4%) dispose their solid wastes every two days. In JSH, 103 (57.5%) of the respondents dispose their wastes once a day and 30 (20.1%) dispose their waste every two days.

Table 4.4: Respondents' Practices of Source Separated Household Solid Wastes before intervention

Responses	Student Hostel N = 64 (%)	Senior Staff Housing N = 55 (%)	Junior Staff Housing N = 179 (%)
Yes (Sell)	1(1.6)	3(5.5)	4(2.2)
Yes (Reuse)	5(7.8)	8(14.5)	44(24.6)
Yes (Disposed off)	7(10.9)	9(16.4)	16(8.9)
No	51(79.7)	35(63.6)	115(64.2)

Table 4.4: Respondents' Practices of Source Separated Household Solid Wastes before intervention

Responses	Student Hostel N = 64 (%)	Senior Staff Housing N = 55 (%)	Junior Staff Housing N = 179 (%)
Yes (Sell)	1(1.6)	3(5.5)	4(2.2)
Yes (Reuse)	5(7.8)	8(14.5)	44(24.6)
Yes (Disposed off)	7(10.9)	9(16.4)	16(8.9)
No	51(79.7)	35(63.6)	115(64.2)

Table 4.4: Respondents' Practices of Source Separated Household Solid Wastes before intervention

Responses	Student Hostel N = 64 (%)	Senior Staff Housing N = 55 (%)	Junior Staff Housing N = 179 (%)
Yes (Sell)	1(1.6)	3(5.5)	4(2.2)
Yes (Reuse)	5(7.8)	8(14.5)	44(24.6)
Yes (Disposed off)	7(10.9)	9(16.4)	16(8.9)
No	51(79.7)	35(63.6)	115(64.2)

Table 4.5: Practice of Household Solid Waste Recycling before intervention

Responses	*Student Hostel* N = 64 (%)	*Senior Staff Housing* N = 55 (%)	Junior Staff Housing N = 179 (%)
Practiced	7(10.9)	4(7.3)	29(16.2)
Not practiced	57(89.1)	51(92.7)	150(83.8)

Table 4.6: Respondents' Solid Waste Disposal practices at Household Level.

Disposal Method	Student Hostel (64)		Senior staff housing (55)		Junior staff housing (179)	
	Number	%	Number	%	Number	%
Neighborhood waste bin	53	82.8	49	89.1	133	74.3
Burn	8	12.5	4	7.3	37	20.7
Throw into Bush	3	4.7	2	3.6	9	5.0
Total	64	100	55	100	179	100

Table 4.7: Characteristics of the Refuse Bins used by the Respondents at the Three Locations

Variable	Options	Student Hostel (64)	Senior staff housing (55)	Junior staff housing (179)
Number of bins	1	47(73.4)	22(40.0)	104(58.1)
	2+	17(26.6)	33(60.0)	75(41.9)
Capacity of Bin	Small	47(73.4)	17(30.9)	59(33.0)
	Medium	6(9.4)	29(52.7)	69(38.5)
	Large	11(17.2)	9(16.4)	51(28.5)
Type of Container	Basket	61(95.3)	25(45.5)	83(46.4)
	Nylon	3(4.7)	4(7.3)	14(7.8)
	Bucket with cover	0(0.0)	25(45.5)	75(41.9)
	Carton	0(0.0)	1(1.8)	7(3.9)
Frequency of Solid waste Disposal	Once a day	49(76.6)	25(45.5)	103(57.5)
	Twice a day	3(4.7)	5(9.1)	21(11.7)
	Every two days	7(10.9)	20(36.4)	30(20.1)
	Once a week	5(7.8)	5(9.1)	19(10.6)

4.5 Response on Solid Waste Management on Campus

Majority of the respondents 64 (100%) in SH observed that the campus refuse bins get filled up everyday, while at SSH 22 (40%) observed that the campus refuse bins get filled up weekly and 15 (27.3%) observed that the refuse bins get filled up every two days. Majority of the participants 70 (39.1%) in JSH observed that the campus refuse bins get filled up everyday. Daily campus refuse bin collection was reported by 35 (54.7%) respondents in SH, at SSH 29 (52.7%) reported weekly while, at JSH 61 (34.0%) reported the refuse are collected weekly and 44 (24.6%) reported every 2-3 days (Table 4.8).

4.6 Awareness of Solid Waste Recycling Practice on Campus

Table 4.9 shows that majority of the respondents from the three locations were not sure if solid waste recycling was being practiced on campus. While 11 (17.2%) at SH, 2 (3.6%) at SSH and 29 (16.2%) at JSH reported that waste is recycled on campus.

Table 4.8: Response on solid waste management

Variable	Options	Student Hostel (64)	Senior staff housing (55)	Junior staff housing (179)
Observation of When Campus Bin fills Up	Everyday	64 (100)	4 (7.3)	70 (39.1)
	Every 2 Days	0 (0.0)	15 (27.3)	35 (19.6)
	More than 2 days	0(0.0)	14 (25.5)	33(18.4)
	Weekly	0(0.0)	22 (40.0)	41(22.9)
Observation of When Campus Bin is Collected	Everyday	35 (54.7)	4 (7.3)	35(19.6)
	Every 2-3 Days	3(4.7)	11 (20.0)	44 (24.6)
	More than 2 days	6(9.4)	11 (20.0)	39(21.8)
	Weekly	20(31.2)	29 (52.7)	61(34.0)

Table 4.9: Responses about solid wastes recycling awareness on campus.

Solid waste recycling practice on campus	*Student Hostel (64)*		*Senior staff housing (55)*		*Junior staff housing (179)*	
	Number	%	Number	%	Number	%
Practiced	11	17.2	2	3.6	29	16.2
Not practiced	10	15.6	10	18.2	47	26.3
Not sure	43	67.2	43	78.2	103	57.5

4.7 Commonest Environmental Problems Associated with Poor Solid Waste Disposal Experienced and Reported by the Respondents

The commonest environmental problems caused by the present solid waste management practices on campus were promotion of fly breeding, odour, filthy land and drainage blockage. Figure 4.5 shows that promotion of fly breeding ranked highest among the commonest environmental problems reported. Many of the respondents 29 (45.3%), 23 (41.8%) and 69 (38.5%) at SH, SSH and JSH respectively reported flies breeding. It was also revealed that odour was more reported by 20 (36.4%) respondents at the SSH followed by 47 (26.3%) respondents in JSH and 11 (17.1%) in SH. Filthy land was reported by 18 (28.1%), 9 (16.4%), 42 (23.5%) respondents at SH, SSH and JSH respectively. Prevention of free flow of water was reported by 6 (4.5%), 3 (5.4%), 21 (11.7%) respondents at SH, SSH and JSH respectively.

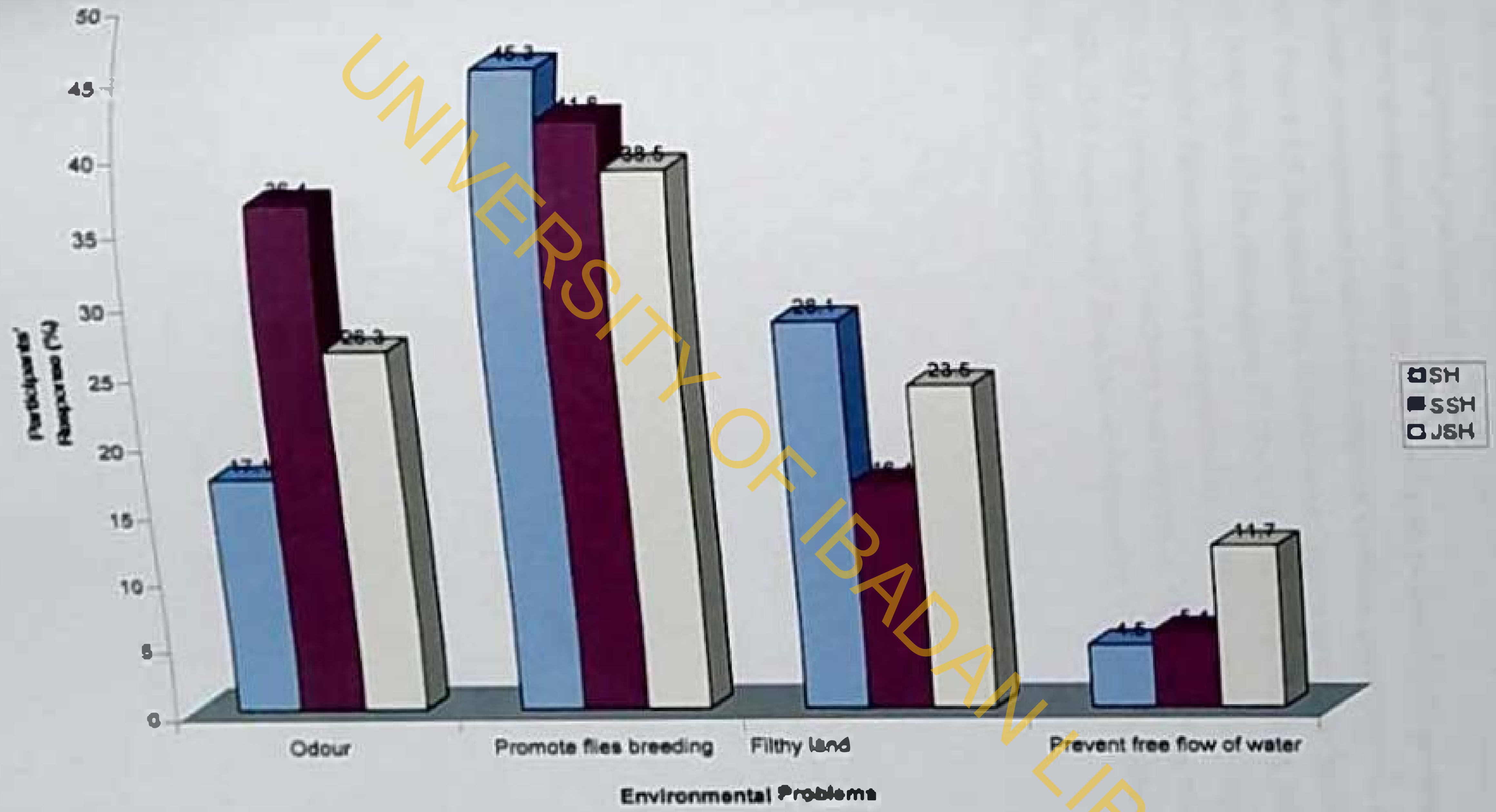

Fig 4.5: Common environmental problems associated with poor refuse disposal as reported by respondents

4.8 Health problems perceived to be associated with the present Waste management practices on campus

The respondents reported the major health problems perceived to be associated with the present waste management practice on campus are malaria, gastroenteritis, diarrhea, and dog bites. Figure 4.6 illustrated that malaria ranked highest among the health problems reported. Majority of the respondents 67.2%, 45.5%, 63.7% at SH, SSH, JSH respectively reported malaria. Gastroenteritis was reported by 17.2%, 25.5%, 22.9% respondents at SH, SSH, JSH respectively. Diarrhoea was reported by 12.5%, 23.6%, 6.1% respondents at SH, SSH, JSH respectively. Dog bite was reported by 3.1%, 3.6%, 7.2% respondents at SH, SSH, JSH respectively.

Fig 4.6: Participants' observation of health problems directly associated with the present waste management practices on campus

4.9 Effect of training on participants' perspective of source separation and recycling of solid waste

4.9.1 Effect of training on participants' knowledge

The mean knowledge score of the participants from SH, SSH, JSH at pre-intervention and post-intervention are shown in Table 4.10. The mean knowledge score at baseline of SH was 4.9 ± 1.5, SSH was 4.1 ± 1.1, JSH was 2.1± 1.1 which when compared was statistically significant ($p<0.05$). The mean knowledge score of participants in SH before and after the training (4.9 ± 1.5 and 5.1 ± 1.2) were compared and there was no significant difference, likewise the mean knowledge score of participants in SSH before and after the training (4.1 ± 1.1 and 4.8 ± 1.4) did not show significant difference ($p>0.05$), while the mean knowledge score of participants in JSH before and after the training (2.1± 1.1 and 4.6± 1.1) when compared was statistically significant ($p<0.05$).

The post intervention mean knowledge scores 5.1 ± 1.2, 4.8 ± 1.4, 4.6± 1.1 of SH, SSH, JSH respectively did not show any significant difference. Table 4.11 shows the proportion of participants with 75 percentile knowledge score on source separation and recycling of solid waste. It reveals that at SH, 81.3% and 95% of the participants recorded a knowledge score within 75 percentile at pre and post intervention respectively, which when compared was not statistically significant. At SSH, 78.2% and 90.1% of the participants recorded a knowledge score within 75 percentile at pre and post intervention respectively, which when compared was not statistically significant. However, at JSH 43.3% and 80.8% of the participants recorded a knowledge score within 75 percentile at pre and post intervention respectively, which when compared was statistically significant confirming the effect of the training.

Table 4.10: Statistical Analysis of the Mean Knowledge of the Participants

Parameter	Options	Student Hostel (64)	Senior staff housing (55)	Junior staff housing (179)	P- value
Knowledge	Pre-Intervention Mean Score	4.9 ± 1.5	4.1 ± 1.1	2.1± 1.1	<0.05
	Post-Intervention Mean Score	5.1 ± 1.2	4.8 ± 1.4	4.6± 1.1	>0.05
	P-Value	> 0.05	> 0.05	< 0.05	

Table 4:11: Proportion of Respondents in the Three Locations with Knowledge level of Source Separation of Solid Waste before and after Intervention (above 75 percentile)

Location	*Before (%)*	*After (%)*	*P-Value*
SII	81.3	95.0	> 0.005
SSII	78.2	90.1	> 0.005
JSII	43.3	80.8	< 0.005

4.9.2 Effect of Training on participants' attitude

Table 4.12 revealed the attitude of participants in the three locations towards source separation and recycling of solid wastes before and after the training. Only JSH showed a statistical significance in the attitude of the participants before and after the training. At SH, 73.4% and 76.6% agreed that it is the responsibility of University administration to arrange for waste separation before and after training respectively. Also 90.6% and 95.3% agreed that every household should participate and be involved in refuse management before and after training respectively. A total of 60.9% and 70.3% agreed that they would be willing to separate recyclable waste from other wastes before and after training respectively. While, 85.9% and 92.2% agreed that separation of recyclable waste from others is a good method of waste management before and after training respectively. Also, 93.8% and 100% agreed that wealth is generated from the practice of waste recycling before and after training respectively.

At SSH, 61.8% and 50.9% agreed that it is the responsibility of University administration to arrange for waste separation before and after training respectively. Also, 87.3% and 94.5% agreed that every household should participate and be involved in refuse management before and after training respectively. A total of 72.7% and 85.5% agreed that they would be willing to separate their recyclable waste from other wastes before and after training respectively. While, 89.1% and 98.2% agreed that separation of recyclable waste from others is a good method of waste management before and after training respectively. Also, 90.9% and 96.4% agreed that wealth is generated from the practice of waste recycling before and after training respectively.

At JSH, 65.9% and 92.7% agreed it is the responsibility of University administration to arrange for waste separation before and after training respectively. Also 82.1% and 98.1% agreed that every household should participate and be involved in refuse management before and after training respectively. A total of 52.5% and 93.8% agreed that they would be willing to separate their recyclable waste from other wastes before and after training respectively. While, 68.2% and 89.9% agreed that separation of recyclable waste from others is a good method of waste management before and after training respectively. Also, 76.0% and 95.5% agreed that wealth is generated from the practice of waste recycling before and after training respectively.

[illegible]

Statements	Response	Students Hostel N = 64 (%)			Senior Staff Housing N = 55 (%)			Junior Staff Housing N = 179 (%)		
		Pre-Intervention	Post - Intervention	P-Value	Pre-Intervention	Post - Intervention	P-value	Pre-Intervention	Post - Intervention	P-Value
It is the responsibility of University administration to arrange for waste separation	Agree	47 (73.4)	49 (76.6)	>0.005	34 (61.8)	28 (50.9)	>0.005	118 (65.9)	165(92.7)	<0.005
	Disagree	10(15.6)	13 (20.3)	>0.005	14 (25.5)	23 (41.8)	>0.005	43 (24.0)	14(7.3)	<0.005
	Not sure	7 (10.9)	2 (3.1)	>0.005	7 (12.7)	4 (7.3)	>0.005	18 (10.1)	0(0.0)	<0.005
Every household should participate and be involved in refuse management	Agree	58 (90.6)	61 (95.3)	>0.005	48 (87.3)	52 (94.5)	>0.005	147 (82.1)	175(98.1)	<0.005
	Disagree	2 (3.1)	2 (3.1)	>0.005	3 (5.5)	3 (5.4)	>0.005	17 (9.5)	4(1.9)	<0.005
	Not sure	4 (6.3)	1 (1.6)	>0.005	4 (7.3)	0 (0.0)	>0.005	15 (8.4)	0(0.0)	<0.005
willing to separate their own recyclable waste from other wastes	Agree	39 (60.9)	45 (70.3)	>0.005	40 (72.7)	47 (85.5)	>0.005	94 (52.5)	168(93.8)	<0.005
	Disagree	17 (26.6)	12(18.7)	>0.005	9 (16.4)	8 (14.5)	>0.005	60 (33.5)	11 (6.2)	<0.005
	Not sure	8 (12.5)	7 (10.9)	>0.005	6 (10.9)	0 (0.0)	>0.005	25 (14.0)	0(0.0)	<0.005
Separation of recyclable waste from others is a good method of waste management	Agree	55 (85.9)	59 (92.2)	>0.005	49 (89.1)	54 (98.2)	>0.005	122 (68.2)	160(89.9)	<0.005
	Disagree	2 (3.1)	4 (6.2)	>0.005	2 (3.6)	1 (1.8)	>0.005	34 (19.0)	19(10.1)	<0.005
	Not sure	7 (10.9)	1 (1.6)	>0.005	4 (7.3)	0 (0.0)	>0.005	23 (12.8)	0(0.0)	<0.005
Wealth is generated from the practice of waste recycling	Agree	60 (93.8)	64 (100)	>0.005	50 (90.9)	53 (96.4)	>0.005	136 (76.0)	171(95.5)	<0.005
	Disagree	0 (0.0)	0 (0.0)	>0.005	0 (0.0)	2 (3.6)	>0.005	18 (10.1)	8(4.5)	<0.005
	Not sure	4 (6.3)	0 (0.0)	>0.005	5 (9.1)	0 (0.0)	>0.005	25 (14.0)	0(0.0)	<0.005

4.9.3 Effect of Training on participants' practice

Effect of the training on the practice of source separation of solid waste is displayed in Table 4.13. The proportion of respondents at the SH, SSH and JSH that separated their waste at baseline were 20.3%, 36.1% and 35.8% respectively with no significant difference. At post-intervention the proportions were 20.3%, 81.8% and 66.5% at the SH, SSH and JSH respectively with a significant difference ($p<0.05$).

Table 4.13: Effect of intervention on participants' Practice of Source separation of solid waste

Variable	Options	Student Hostel N = 64 (%)	Senior Staff Housing N = 55 (%)	Junior Staff Housing N = 179 (%)	P- Value
Do you Separate your waste before disposal	Pre-Intervention Yes	13 (20.3)	20 (36.4)	64 (35.8)	>0.005
	Post-Intervention Yes	13 (20.3)	45 (81.8)	119 (66.5)	<0.005
	P- Value	>0.005	<0.005	<0.005	

4.10 Assessment of the Nature and Quantity of Household Solid Waste Generated.

This section deals with the assessment of the nature and quantity of wastes generated in the Students hostel, senior staff, and junior staff housing within three months interval. The study revealed that the components of solid waste generated in the three locations are: paper, nylon, plastic, metal, glass, and kitchen waste. Figures 4.7 to 4.9 revealed percentage total waste generated in three months in each location. Figure 4.7 revealed that at SH, food waste 57% was the highest waste generated in three months followed by paper 22%, nylon 7%, plastic 6%, glass 4% and metal 4%. Figure 4.8 illustrated that at JSH, food waste 67% was the highest waste generated in three months followed by nylon 8%, plastic 8%, metal 7%, glass 6% and paper 4%. Figure 4.9 illustrated that at SSH, food waste 57% was the highest waste generated in three months followed by plastic 15%, nylon 11%, metal 9%, paper 5%, and glass 6%. Figure 4.10 illustrate the percentage waste generated monthly in the three locations combined. Food waste 62% was the highest waste generated followed by paper 10%, nylon 8%, plastic 8%, metal 7% and glass 5%.

Monthly weight of recyclable solid waste generated in each location was illustrated by Figure 4.11. It revealed that food waste generation was highest at JSH 1.699Kg followed by SH 882.18Kg and then SSH 476.6Kg. Nylon generation was highest at JSH 187.9Kg followed by SH 107.8Kg and then SSH 95.5Kg. Plastic generation was highest at JSH 196.9Kg followed by SSH 121.7Kg and then SH 91.9Kg. Paper generation was highest at SH 340.3Kg followed by JSH 88Kg then SSH 40.5Kg. Glass generation was highest at JSH 146.8Kg followed by SH 70Kg and then SSH 26.3Kg. Metal generation was highest at JSH 148.9Kg followed by SSH 72.5Kg and then SH 67Kg. The mean monthly recyclable wastes characterized in the three locations revealed that kitchen waste was 1019.26± 10.39Kg, nylon 130.41 ± 3.47Kg, paper 156.26 ± 1.52Kg, plastics 136.84± 1.83Kg, glass 81.05 ± 3.55Kg and metal 108.14 ± 1.43Kg (Fig 4.10). Figures 4.12, 4.13, 4.14 revealed that JSH generated highest proportion of nylon 45%, plastic 48% and metal 57%.

4.10.1 Heavy Metal Components of Food Waste Generated

The mean concentrations of heavy metals analyzed in the kitchen waste of the three locations are illustrated in Fig 4.15. The heavy metals concentrations are compared with the compost guideline limit by Sridhar and Bammeke (1986). It was observed that nickel concentrations in kitchen waste from the locations are higher than the guideline limit concentration. The concentration of cadmium was 1.4±0.49mg/Kg at SH, 1.1±0.53mg/Kg at JSH, 0.8±0.29mg/Kg at SSH which are all below the compost guideline limit of 2.0mg/Kg for compost. The concentration of lead was 3.5±0.77mg/Kg at SH, 4.0±0.71mg/Kg at JSH, 3.3±0.56mg/Kg at SSH which are all below the compost guideline limit of 11.6mg/Kg. The concentration of Nickel was 17.3±3.92mg/Kg at SH, 26.2±5.57mg/Kg at JSH and 20.6±1.78mg/Kg at SSH which are all above the compost guideline limit of 14.0mg/Kg.

4.10.2 Comparison of Physicochemical Components of Solid Waste Generated

The mean weekly generation rate of paper, metal, plastic, nylon are significantly different across the three locations ($p<0.05$). The mean weekly generation rate of paper at SSH was 10.15±2.08Kg, at JSH 10.05±2.43Kg, while SH generated the highest 18.88±5.58Kg. For metals, 5.51±1.79Kg was generated at SSH, 6.26±1.89Kg was generated at SH, and JSH generated the highest 15.27±4.15Kg. For plastic, SSH generated 5.01±1.39Kg, SH generated 12.51±4.11Kg and JSH generated the highest 16.69±9.73Kg. For nylon, SSH generated 11.69±2.08Kg, SH generated 20.91±4.38 and JSH generated the highest 30.13±4.62 (Table 4.14).

The chemical components of the kitchen wastes analyzed were subjected to statistical analysis. This revealed that only nitrogen is significantly different among the analytes in the kitchen waste across the three locations (Table 4.15). The moisture content (%) of kitchen waste generated was 41.60, 37.33 at and 40.40 at the SSH, JSH, SH respectively. The values of the C:N ratio at the JSH, SH, and SSH 48:1, 40:2 and 5[illegible]:1 respectively. The pH of the kitchen waste analyzed was 6.9, 6.2, 6.5 for JSH, SH, SSH respectively.

4.10.3 Solid Waste Generation Rate in the Study Locations.

The quantity of solid waste generated in SSH was 0.05 Kg/person/day, while 0.03 Kg/person/day was generated in JSH and 0.08 Kg/person/day in SH.

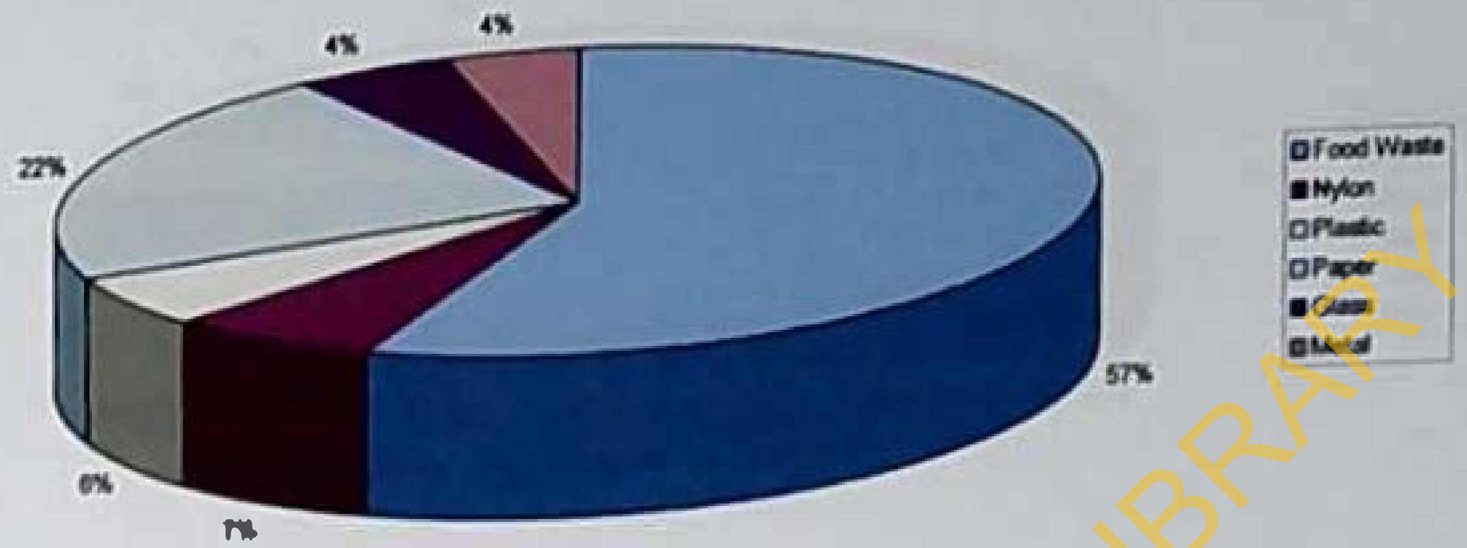

Figure 4.7: Total quantity of wastes generated (%) in Students Hostel

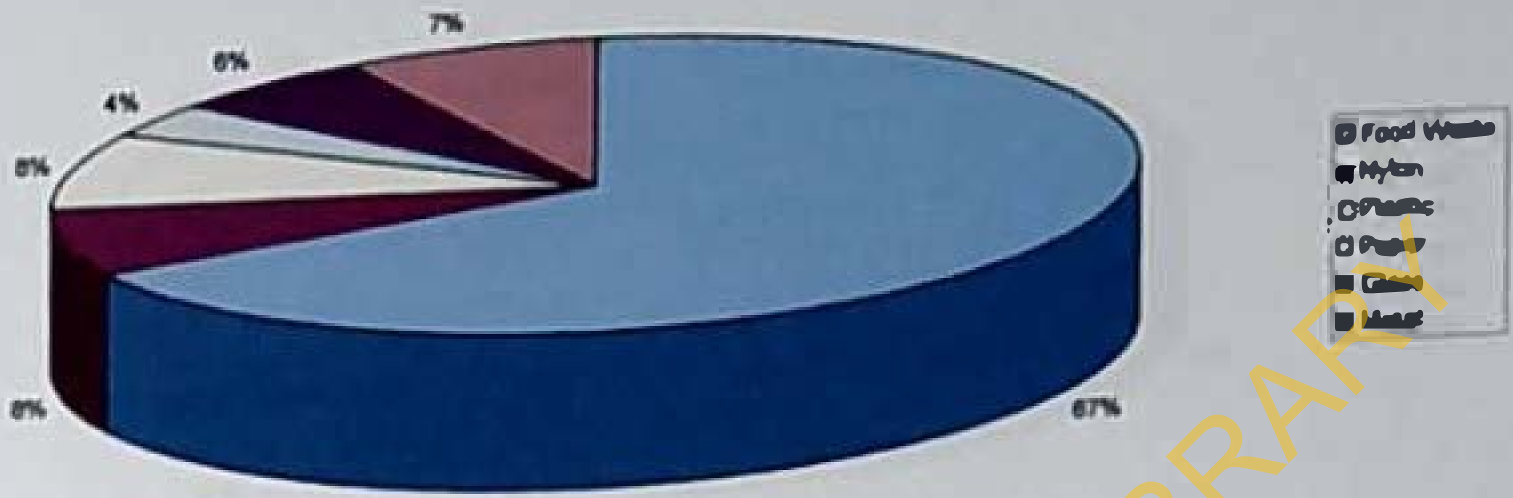

Figure 4.8: Total quantity of wastes generated in Junior Staff Quarters

Figure 4.9: Total quantity of waste generated in Senior Staff Quarters

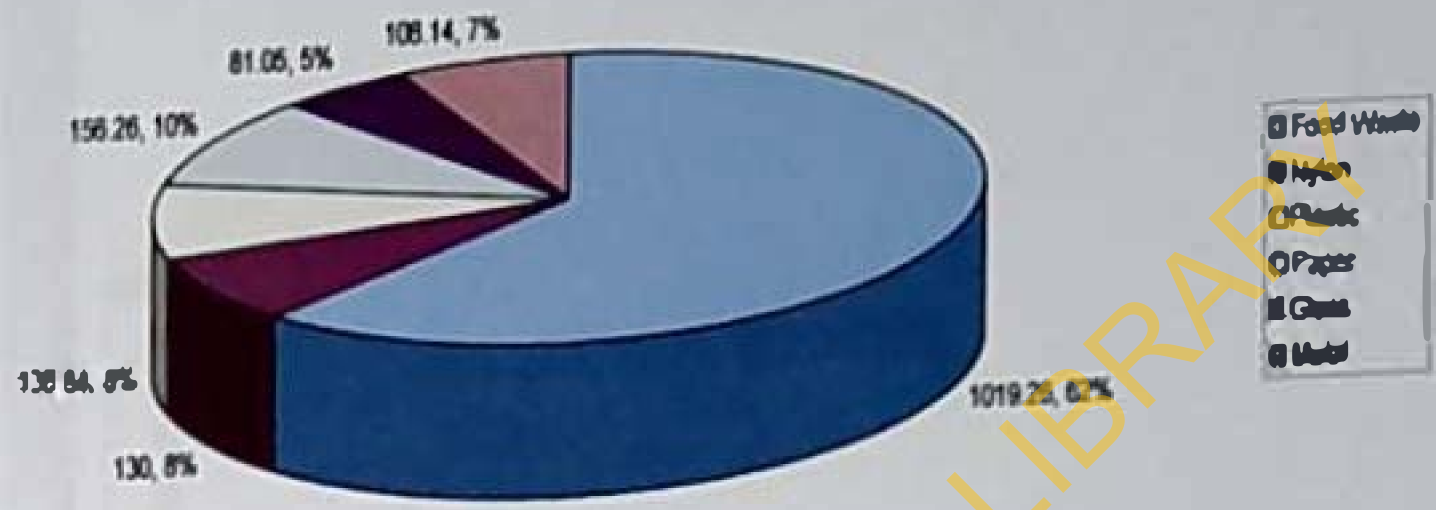

Figure 4.10: Total quantity of waste generated (%) monthly in the three locations combined

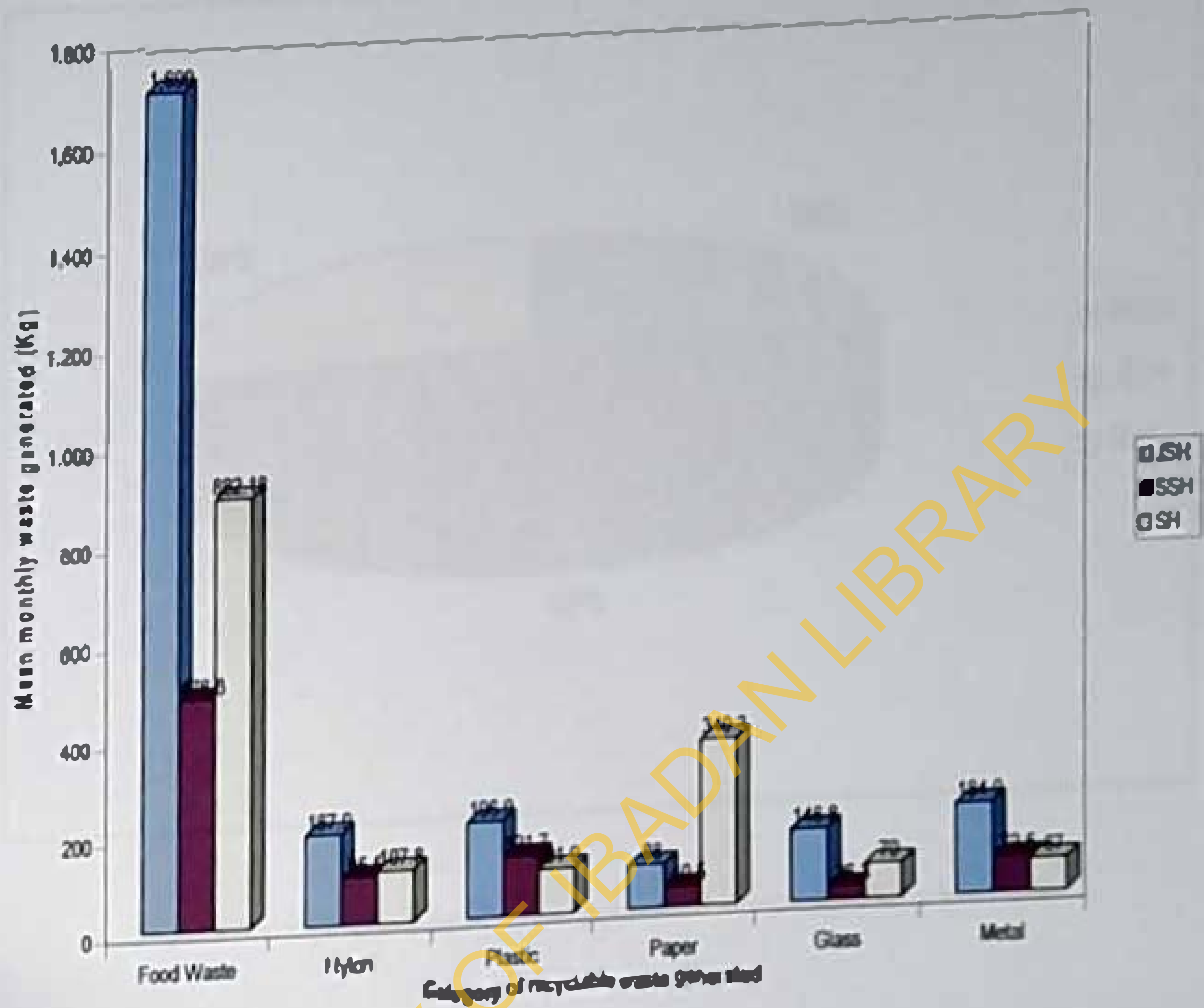

Figure 4.11: Mean monthly waste generated across the three locations

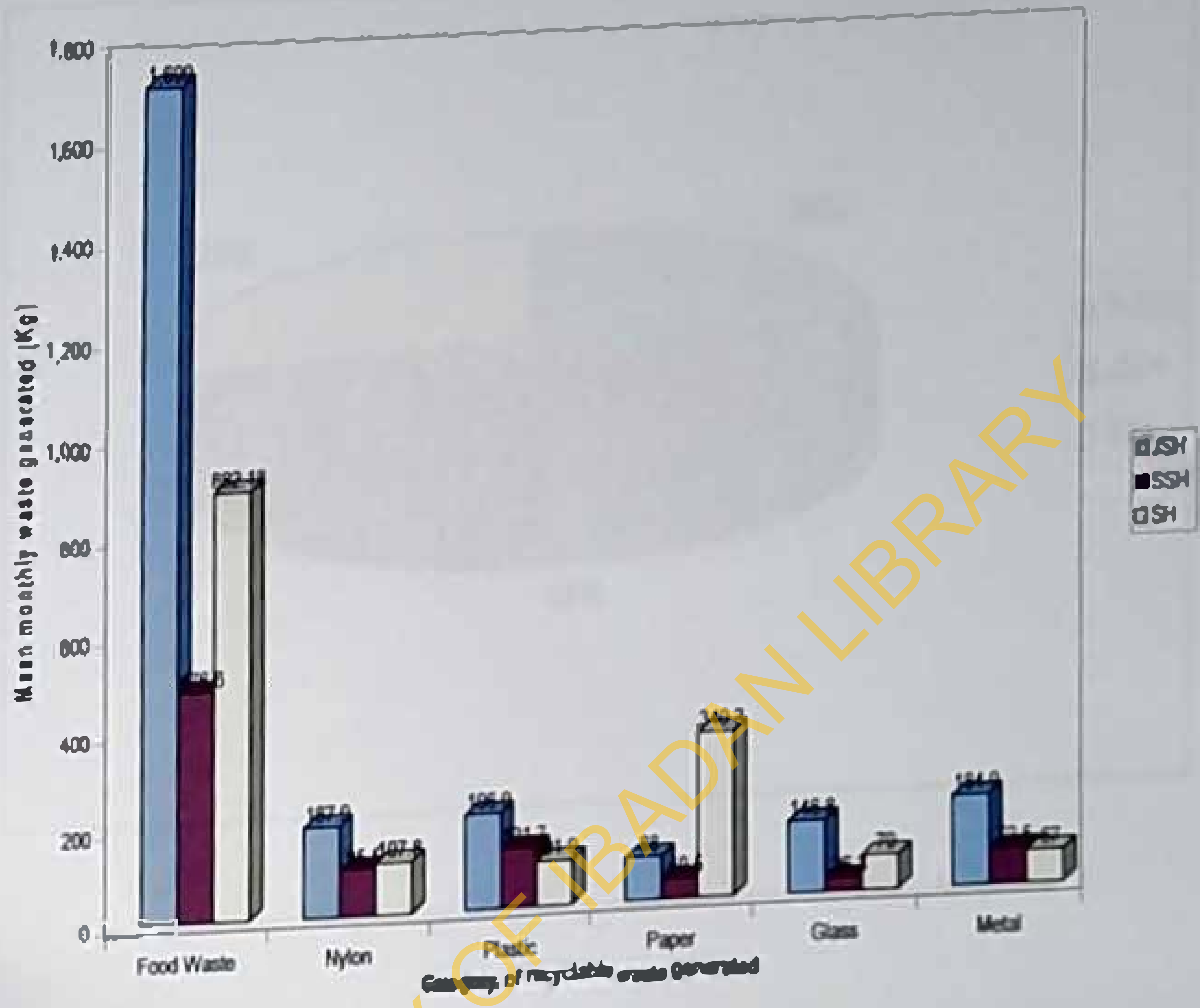

Figure 4.11: Mean monthly waste generated across the three locations

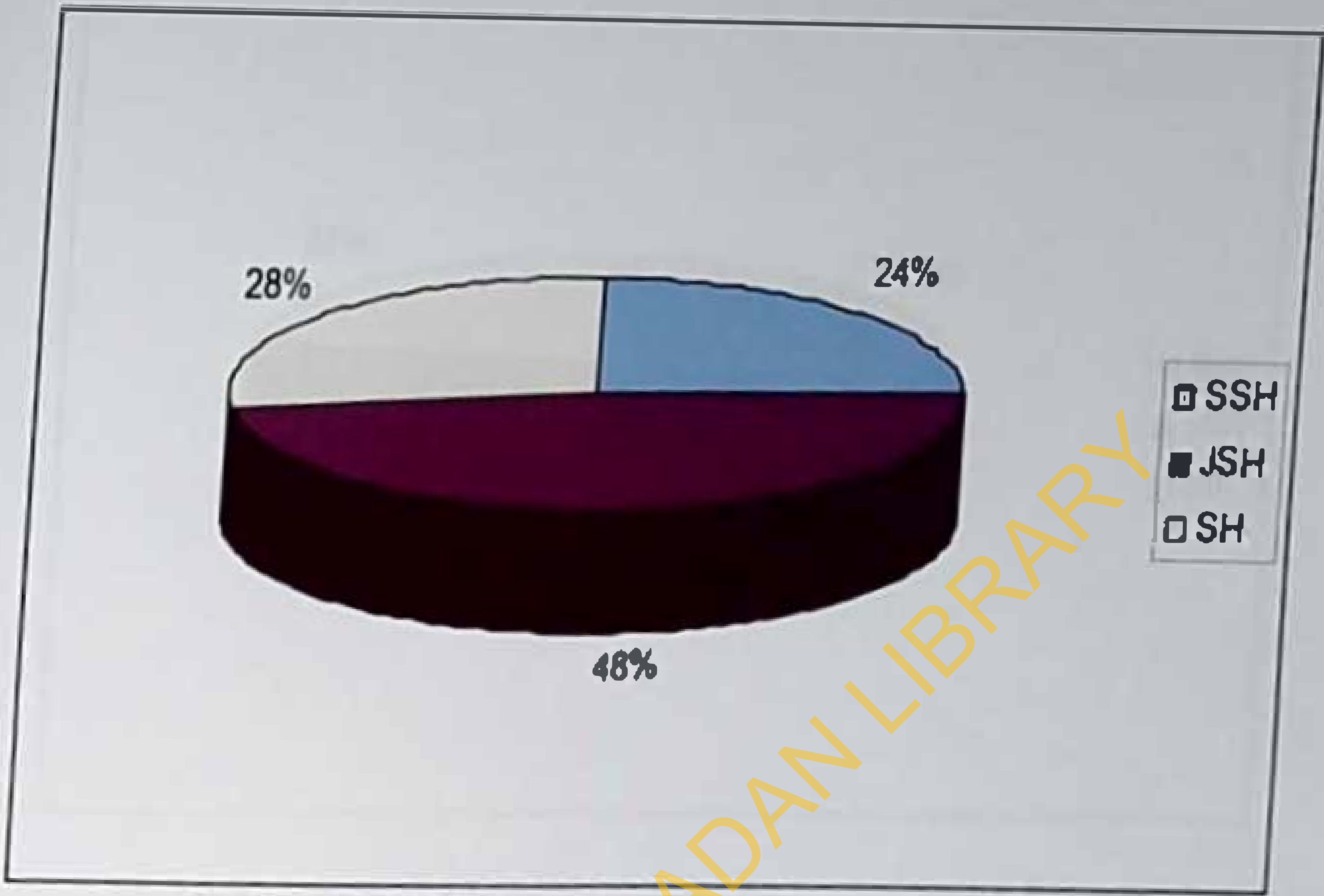

Figure 4.12: Proportion of nylon generated across the three locations

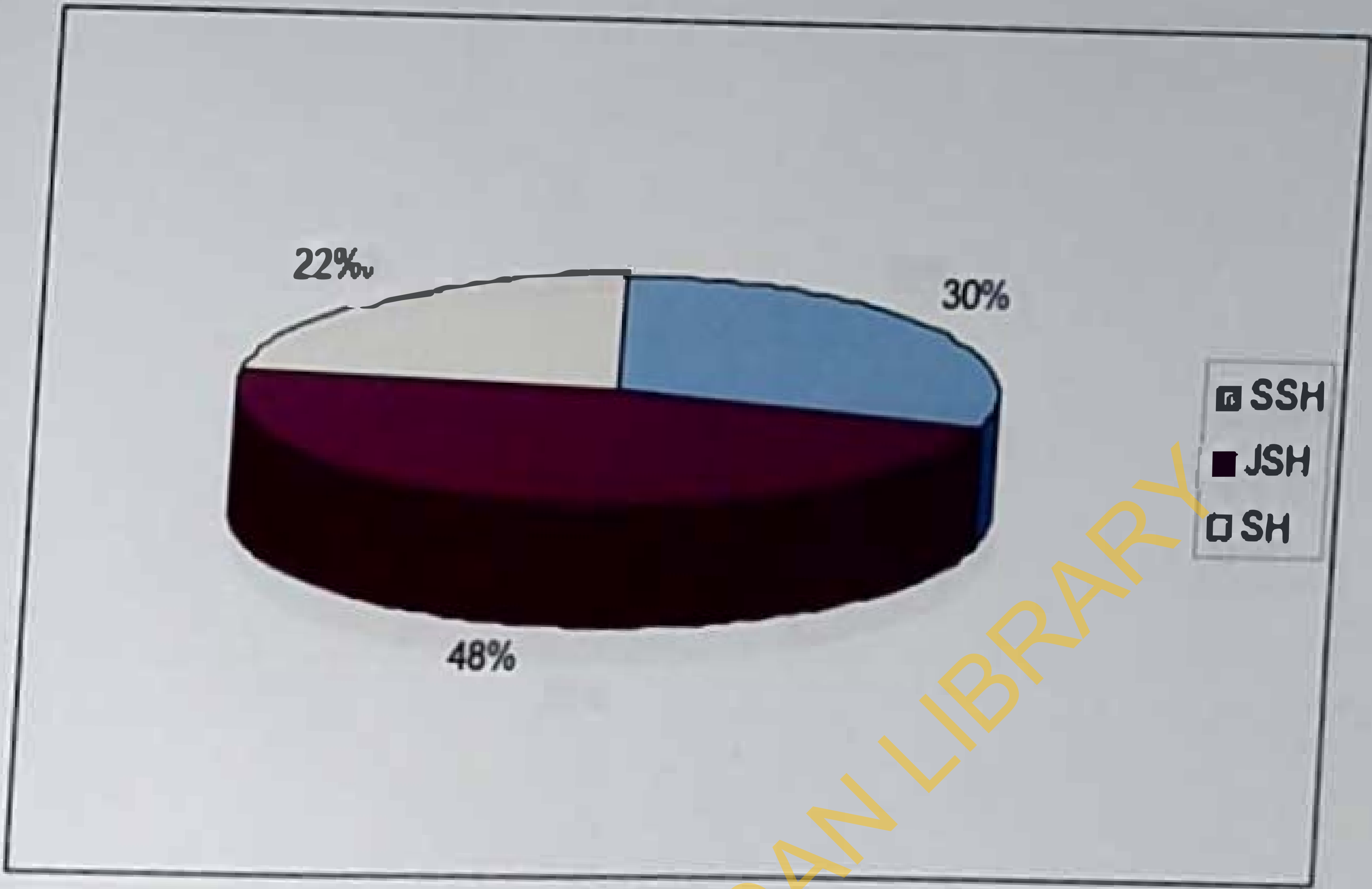

Figure 4.13: Proportion (%) of plastics generated

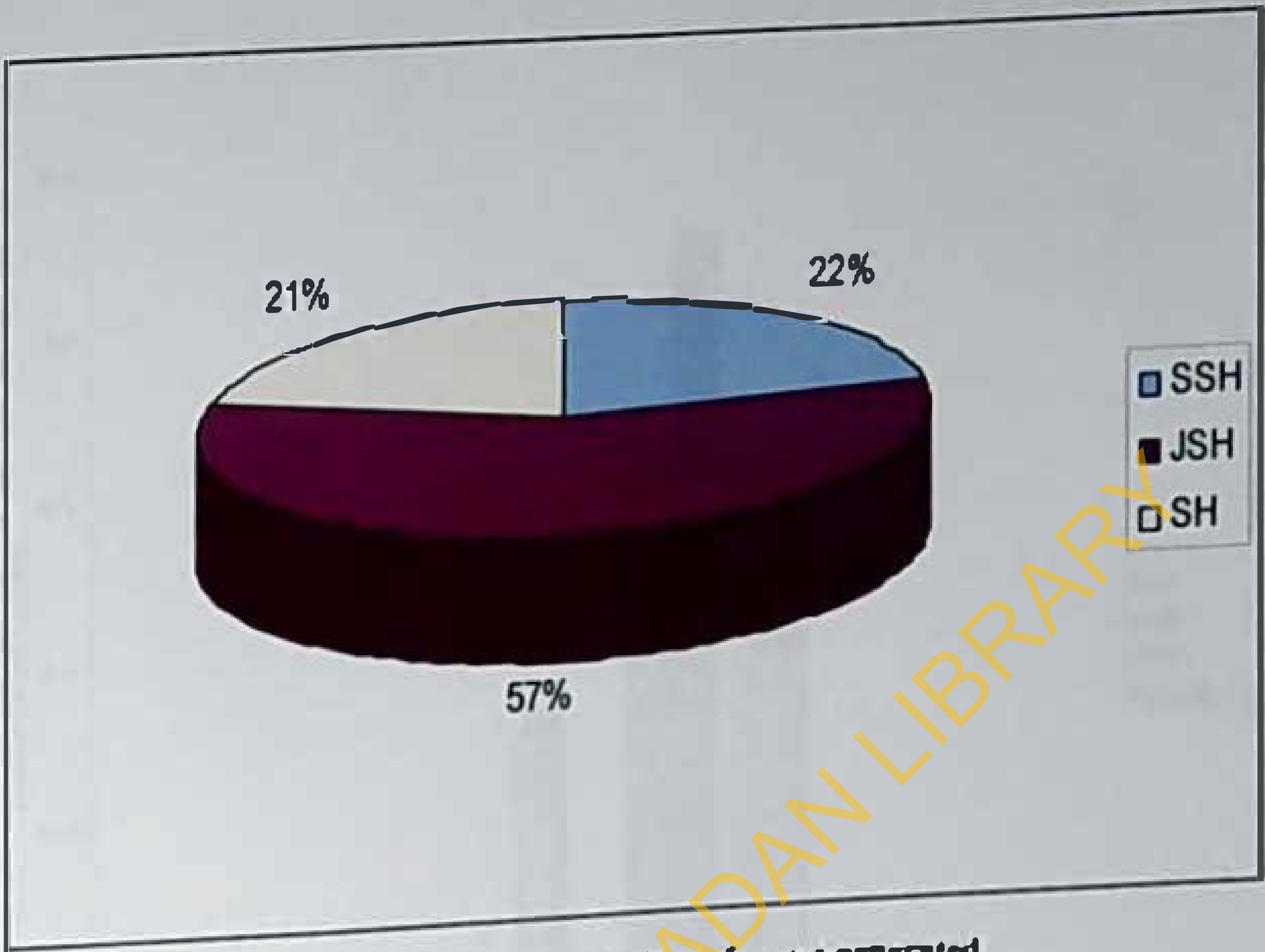

Figure 4.14: Proportion (%) of metal generated

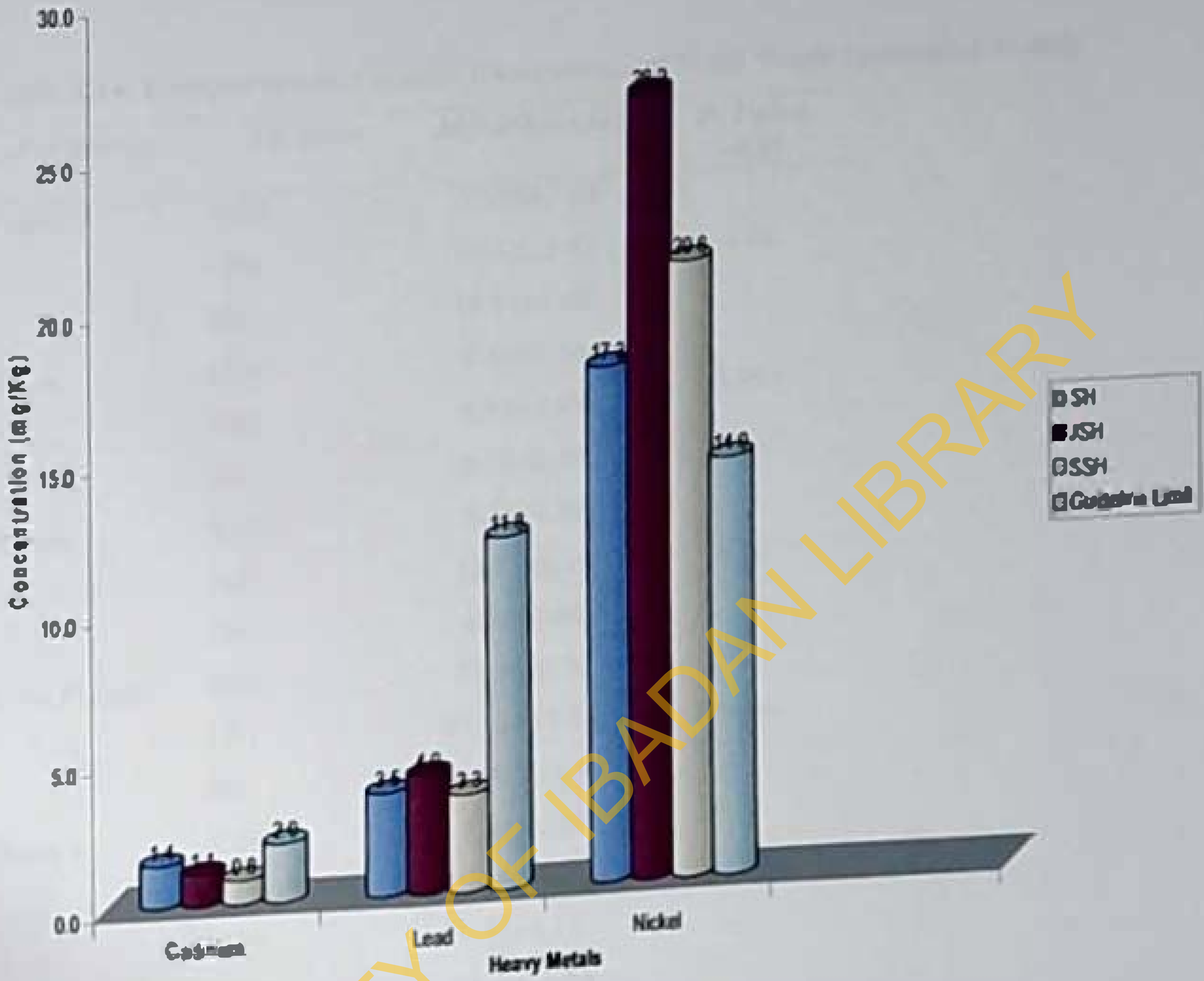

Figure 4.15: Mean Concentrations of Heavy Metals

Table 4.14: Comparison of Physical Components of Solid Waste Generated weekly

Parameter	Location	Mean(Kg)±SD	P- Value <0.05
Paper	SSH	10.15±2.08	0.00
	JSH	10.05±2.43	
	SH	18.88±5.58	
Glass	SSH	6.62±2.44	0.952
	JSH	6.94±2.91	
	SH	6.70±2.54	
Metals	SSH	5.51±1.79	0.00
	JSH	15.27±4.15	
	SH	6.26±1.89	
Food Waste	SSH	73.00±8.92	0.146
	JSH	87.82±34.88	
	SH	91.53±19.98	
Plastics	SSH	5.01±1.39	0.00
	JSH	16.69±9.73	
	SH	12.51±4.11	
Nylon	SSH	11.69±2.80	0.00
	JSH	30.13±4.62	
	SH	20.91±4.38	

Table 4.15: Comparison of Chemical Constituents of Food Waste generated in the Three Locations:

Parameter	*Location*	*Mean±SD*	*P- Value <0.05*
Nitrogen (%)	SSH	1.09±0.106	0.00
	JSH	1.91±0.161	
	SH	1.43±0.082	
Phosphorus (%)	SSH	0.09±0.008	0.020
	JSH	0.31±0.102	
	SH	0.19±0.051	
Carbon (%)	SSH	50.26±1.235	0.564
	JSH	48.47±4.509	
	SH	49.16±2.354	
Potassium (%)	SSH	0.19±0.012	0.513
	JSH	0.20±0.020	
	SH	0.24±0.084	
Lead (mg/Kg)	SSH	3.29±0.56	0.458
	JSH	4.02±0.71	
	SH	3.51±0.77	
Cadmium (mg/Kg)	SSH	0.82±0.29	0.317
	JSH	1.08±0.53	
	SH	1.44±0.49	
Nickel (mg/Kg)	SSH	20.61±1.78	0.089
	JSH	26.23±5.57	
	SH	17.27±3.92	

4.11 Findings From Focus Group Discussion

The results obtained from Focus Group Discussion are presented under three subheadings namely: Perception on types of recyclable wastes generated, Economic importance or reported uses of recyclable wastes and solid waste management practices. The Focus Group Discussants comprised ten residents of same age group and sex in each of the three study communities.

4.11.1 Perception on Types of Solid Wastes Generated

The Focus Group Discussants from the three study communities had a good knowledge of what constitutes solid wastes. They described waste as "anything useless". They stated that the various kinds of wastes generated in their homes included: Kitchen waste, plastics, metal, nylon, papers, and glass.

Only very few discussants in the Junior Staff Housing (Abadina) knew that household solid wastes can be recycled. Many said all waste should be thrown away except kitchen waste that can be fed to animals. Conversely, many discussants were aware of waste recycling in the Senior Staff Housing (Amina way) and Cleaners in Students' Hostel.

The group of discussants in the three study communities disclosed that separation of solid wastes at source was beneficial in that some items such as bottles, tins, news papers separated can be sold to generate income. In addition, kitchen waste could be useful for manure which is important in improving soil quality for cultivation.

The willingness to carry out source separation of solid waste was highest among New PG hall cleaners. They indicated willingness to practice if sorting bags were provided and if they were ordered to do so. Abadina residents were less willing because they considered separation of waste as wasting of time and energy. The willingness was least in Amina way because they believed waste recycling cannot be sustained even if implemented on campus, and so it will be a waste of time if they sorted their waste.

Almost all the discussants in the three study communities knew that poor household waste management could cause diseases such as cholera and also promote infestation of vectors like rodents and cockroaches. They added that it could cause environmental pollution such as repulsive odour and unsightliness.

4.11.2 Reported Uses or Economic Importance of Household Solid Waste

Majority of the discussants in the three study communities knew about the uses or economic importance of household solid wastes. According to the discussants, solid wastes were useful in the following ways:

1. Selling of containers like plastic and glass bottles, big tins, jars, metals to the scavengers on campus.
2. Conversion of kitchen wastes into manure for farming.
3. Conversion of used paper into brown papers and toilet rolls.
4. Conversion of used pure water sachet and nylons into poly bags and
5. Conversion of old plastics into new ones.

4.11.3. Current Household Solid Wastes Management Practices on Campus

All the discussants in Senior Staff housing indicated that they use small basket as dustbin to store their wastes at home and then empty them into the big blue neighbourhood bin closest to them. They added that the waste in the neighborhood bin is emptied every two days by the University Waste Management Authority. The Student Hostel cleaners collected wastes from waste baskets in front of each room and emptied them into the waste depot located outside the fence for the waste collectors to pick up everyday. Majority of the discussants in the Junior Staff Housing made use of the neighbourhood bin while others living close to the bush practice open air burning of combustibles and threw others into the bush.

Few discussants at Senior Staff Housing separated bottles, tins, and glass meant for selling to scavengers, even though almost all of them had knowledge about separation of waste for recycling. The Cleaners in the students' hostel usually separated the recyclable solid wastes before selling them to the recyclers outside the campus. They however complained about the ridiculous prices offered for pure water sachets. This constituted a major discouraging factor for separating pure water sachet. Many of the discussants at Junior staff Housing separated their kitchen wastes to feed animals but threw away the leftovers. Some of the discussants whose knowledge level were high regarding separation of waste for recycling indicated their willingness to separate if bags were provided.

Some of the discussants who were knowledgeable about separation of wastes but did not practice it gave reasons such as: "we are very busy to separate waste", " If waste recycling is implemented it won't work because nothing works in Nigeria".

The perception of the discussants in the three locations is summarized in the Table 4.15.

Table 4.16: Comparison of Focus Group Discussion Results in the Three Locations

Options	Student Hostel Cleaners	Senior Staff Housing	Junior Staff Housing
Awareness on Household waste recycling	90% were aware	70% were aware	30% were aware
Willingness to separate waste	All were willing	50% willingness	60% willingness
Effect of poor waste management	Causes unsightliness	Results in environmental pollution	Attracts vectors
Method of waste disposal	Dispose waste at open dump site carried out around the SH	Dispose waste into the neighborhood bin	Many dispose waste into the neighborhood bin while some burn, others throw into the bush
Separation of household recyclable waste for recycling	All cleaners separate recyclable waste for sale	Many do not separate their wastes	Many separate their kitchen waste to feed their livestocks.

4.12 Result of Observation Checklist

The personal observation made by the researcher revealed that massive wastes are generated from the three locations per day. However, the drums are insufficient to contain the waste leading to overflow especially at the JSH (Plate 6). At the SSH some non durable waste bins like raffia basket are also used to collect waste as displayed in (Plate 7). Whereas open dump is being practiced at the SH. Majority of the residents in SSH and JSH dispose their waste into the neighborhood bin, while a few living close to the bush at JSH dispose their wastes into the bush or burn them.

It was also observed that the wastes were collected from the neighborhood every two days. Before the waste is collected the waste would have littered the ground, decaying materials also attract goats, birds, dogs that scatter the waste all over creating unsightliness. The decaying materials also promote the breeding of flies.

Plate 4.1: Filthy environment due to overflowing dustbins that attract vectors at the Junior Staff Housing area

Plate 4.2: Inadequate waste bin and use of different non durable containers for dumping waste at Senior Staff Housing area.

Plate 4.3: A typical open dump site at the New Postgraduate Hall

CHAPTER FIVE

DISCUSSION

This chapter discusses the results obtained from the various instruments used to determine the perspective of University of Ibadan residents on source separation of solid waste and the categories of solid waste generated. The impact of mobilization on the practices of waste separation for recycling is also discussed.

5.1 Demographic Characteristics

The age distribution ranges between 15 years and 65 years. More than half of the study population were females a fact corroborated by Bulle (1999) that women are responsible for domestic activities and especially waste disposal. Hence involving women in waste project would facilitate source separation of solid waste. Majority of the respondents 160 (89.4%) in Junior staff housing, 50 (90.9%) in senior staff housing and 60 (93.8%) in student hostel were Christians. Majority of the respondents 97 (54.2%), 39 (70.9%), 39 (60.9%) in Junior staff housing, Senior staff housing and Student hostel respectively were Yoruba. This is a reflection of the ethnic group that resides in the southwestern part of Nigeria. Nearly all the respondents in the senior staff housing 46 (83.6%) and student hostel 64 (100%) were more educated (tertiary education) than respondents in the junior staff housing 87(48.6%). This is as a result of the fact that more educated people are allocated to the senior staff housing while the Junior staff housing are allocated to people of low educational status. Majority of the respondents in Junior staff housing live with more than seven people compared to Senior staff and student hostel. This is a reflection of the massive waste generated at the Junior staff housing compared to other locations.

5.2 Present Waste Management Practice and Institutional Arrangement on Campus

The University authority has made arrangement with the private waste collector in order to achieve effective waste management programme. This action was supported by Imperato and Ruster (1999), that stated that the private sector provides better services that the public sector fails to provide, because of limited resources and priority obligations.

CHAPTER FIVE

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This chapter discusses the results obtained from the various instruments used to determine the perspective of University of Ibadan residents on source separation of solid waste and the categories of solid waste generated. The impact of mobilization on the practices of waste separation for recycling is also discussed.

5.1 Demographic Characteristics

The age distribution ranges between 15 years and 65 years. More than half of the study population were females a fact corroborated by Bulle (1999) that women are responsible for domestic activities and especially waste disposal. Hence involving women in waste project would facilitate source separation of solid waste. Majority of the respondents 160 (89.4%) in Junior staff housing, 50 (90.9%) in senior staff housing and 60 (93.8%) in student hostel were Christians. Majority of the respondents 97 (54.2%), 39 (70.9%), 39 (60.9%) in Junior staff housing, Senior staff housing and Student hostel respectively were Yoruba. This is a reflection of the ethnic group that resides in the southwestern part of Nigeria. Nearly all the respondents in the senior staff housing 46 (83.6%) and student hostel 64 (100%) were more educated (tertiary education) than respondents in the junior staff housing 87(48.6%). This is as a result of the fact that more educated people are allocated to the senior staff housing while the Junior staff housing are allocated to people of low educational status. Majority of the respondents in Junior staff housing live with more than seven people compared to Senior staff and student hostel. This is a reflection of the massive waste generated at the Junior staff housing compared to other locations.

5.2 Present Waste Management Practice and Institutional Arrangement on Campus

The University authority has made arrangement with the private waste collector in order to achieve effective waste management programme. This action was supported by Imperato and Ruster (1999), that stated that the private sector provides better services that the public sector fails to provide, because of limited resources and priority obligations.

This study showed that waste collection is carried out every two days during which the drums get overfull and litter the ground.

The overflowing neighborhood bins results in environmental problems which the residents reported as unsightliness, odour, housefly infestation and other vectors breeding. The observation checklist confirmed this to be true at the Junior staff and Senior staff housing areas. Some health problems were also discussed to be associated with the current waste management practiced on campus. The major health problems pointed out were malaria and typhoid fever. This agrees with Akpovi and Sridhar (1985) that flies from solid wastes can transmit typhoid fever, cholera while open containers in refuse heaps retain water that provide breeding sites for mosquitoes that cause malaria.

There are cleaners who are responsible for collection of wastes generated in each room everyday at the student hostel. The wastes collected are the taken to open dump site for the private contractor to evacuate. Majority of the households collect their waste in small basket which is emptied into the neighborhood bin provided by the University authority. This is at variance with findings of Anyakoha and Igboeli (1993) that 53.3% and 70.3% of their two groups of respondents use empty cartons and baskets. The University authority allocated an average of two bins without cover to each neighborhood. These two bins are inadequate to contain the massive wastes generated per day in most of the neighborhoods.

Currently, none of the solid waste stream is being recycled and majority of the residents do not separate their waste before disposal due to lack of knowledge coupled with the fact that there is yet to be an arrangement for recycling on campus. The Focus Group Discussion however revealed that few households in the Junior staff housing separate their kitchen wastes to feed their livestock. While scavengers also go around to pick the recyclable from the dustbins.

5.3 Effect of Training on Knowledge of Source Separation of Household Solid Waste For Recycling.

This study at the pre-intervention stage revealed that respondents from student hostel 52 (81.3%) had more knowledge on source separation and recycling of household solid waste compared with senior staff and junior staff housing 43 (78.2%) and 81 (45.3%) respectively. Many of the respondents in junior staff housing 99 (55.3%) did not know much about waste recycling which may be due to their low educational status compared to the senior staff housing and student hostel. This was confirmed by the result of focus group discussion. Knowledge of source separation and recycling of waste was found to be significantly associated with the educational status of the respondents.

The study showed that many of the respondents perceived that the nylon, paper and plastics they generated could be recycled. The study also showed that source separation of waste was beneficial since it encourages recycling. Also a study carried out by Okpala et al (1994), revealed that segregation of wastes keeps the environment clean and generates income. Hence, there is need to create awareness on the problems created by improper waste management and the benefits of source separation of these wastes in order to get cooperation of all the residents in the three locations.

At the post intervention stage, there was a significant difference in the knowledge of the Junior staff housing residents towards solid waste recycling practice. It was therefore concluded that adequate training of residents is essential for awareness creation among them. Then it would be easier to implement source separation of solid waste on campus.

5.4 Effect of Training on Attitude to Source Separation of Household Solid Waste for Recycling.

This study revealed that there was an improvement in the attitude of respondents in senior staff and junior staff housing after the intervention. The change in attitude was a result of the training received hence corroborating studies reported by Kallegren and Wood (1986) that personal experience of receiving training is a factor that may influence attitude and behaviour.

Most of the respondents had positive attitude toward household solid wastes recycling. The study revealed that most of the respondents in the three locations indicated that they would be willing to separate their recyclable solid wastes if the facilities were provided. The willingness exhibited by the hostel cleaners could be associated with additional income they realized when they separated the recyclable wastes for sale. An earlier study carried out by Fatmahal (1995) on resource recovery revealed that most respondents said that they would be willing to separate their household solid waste.

It has been proven that adequate mobilization of community plays a significant role in changing people's attitude to waste disposal and implementation of source separation of solid waste. Adewumi et al (2005) revealed that after adequate mobilization, users were willing to pay for collection and separate garbage from trash to enhance further processing of wastes.

5.5 Effect of Training on practice of Source Separation of Household Solid Waste For Recycling.

This research revealed the importance of training on the practice of source separation of solid waste since there was a significant increase in the number of people that practice source separation of waste at Junior staff housing and senior staff housing. This corroborates the finding of Sridhar et al (2000) that community participation is an important method of promoting waste separation and effective collection.

5.6 Practices on Household Solid Waste Source Separation and Recycling

The use of refuse bins is important in waste disposal in households for efficient disposal of household wastes; this deserves more emphasis in all households. This study revealed that most of the respondents had refuse bins in their homes. In a previous study carried out by Jenpar (1998), it was revealed that 53% of households in Ibadan had refuse bins. The presence of refuse bins was found to be related to the number of people in the house. The more the people in the house the more the waste generated and hence the need for dustbin.

A study carried out by Anyakoha and Eluwa (1991), showed that effective disposal of waste requires waste to be segregated into different components and disposed accordingly. This method requires the use of more than one refuse bin. However, this study showed that majority of the respondents do not consider it necessary to keep different containers for different types of waste and hence they do not segregate before disposal. As majority of the respondents only have one refuse bin, 104 (58.1%), 22 (40%), 47 (73.4%), in junior staff, senior staff housing and student hostel respectively. This is in agreement with the findings of Anyakoha and Igboeli (1993) in which a high percentage of the respondents 60.4% to 68.1% did not keep more than one refuse bin. Large families usually generate large quantities of waste, hence the more the number of people in the house, the more the number of refuse bins.

A study carried out by Nwana (1991) in Ibadan showed that families used non durable containers for waste disposal. Also, NEST (1991) reported that many households used various inappropriate containers as dustbins. The findings from this study however showed that majority of the respondents use the small plastic basket, few people use refuse bins with cover. This is because more standard and durable refuse bins were found to be very expensive and so people tend to buy the cheap ones since there are no regulations or bye-laws on the types of containers to be used for waste disposal. Wastes should be removed from household premises as soon as they are generated. The study showed that this is not the practice by most of the respondents in senior and junior staff housing because they dispose their waste once in a week. The respondents followed different disposal schedules.

Waste collection and disposal has been an intractable problem in Nigeria and Ibadan city in particular, and this has caused serious adverse environmental and health consequences. NEST, (1991), Nwana, (1991), and Nwokoh, (1993) reported that arrangements for waste disposal have been ineffective and or insufficient in many urban and rural centres throughout the country, hence wastes are often disposed indiscriminately along streets, open spaces, and along drainage channels etc. This study revealed that the neighborhood waste bins where most residents dispose their waste were not emptied every day as reported by majority of the respondents in senior staff and junior staff housing. This could be responsible for the unsightliness around the waste bins, breeding of houseflies and odour generation observed.

5.7 Nature and Quantity of Wastes Generated in Households

Assessment of the nature of wastes in the three study locations revealed that biodegradable (vegetables and left over foods) wastes were commonly disposed in the households, 53% at junior staff housing, 66% senior staff housing, and 59% in student hostels. Therefore, these materials should serve as manure/fertilizer, where the consumers are educated on waste management. This agrees with the study of Sridhar (1999b) and Filani's (1999), where biodegradable wastes seem to be the major component of solid wastes in Ibadan. The non biodegradable wastes that are commonly generated in households are various forms of recyclables (paper, plastic, nylon, glass and metal), these are in various forms, sizes and shapes. There is significant difference in Nylon, metal and plastic generated, with Junior staff housing generating the highest quantity. This is due to the fact that many households are petty traders of pure water, zobo, provisions, they produce more nylon, and plastics. Artisans like vulcanizer and electronic repairer generate metal. However, Student hostels have the highest percentage of paper 12%.

The waste per capital per day generated was low at the three locations although Junior Staff housing has the highest. The high value at this location could be as a result of enormous waste generated from various commercial activities carried out at the locations. These low values at the three locations contradict the value of 0.4Kg/person/day to 0.6 Kg/person/day given by Cointreau (1982) for developing countries.

The optimum recommended composting condition of the biodegradable waste in terms of C:N ratio is 35-50:1. This condition was met by the kitchen waste generated in the three locations. Student hostels had significantly higher Nitrogen content due to disposal of much left over foods by the students. The recommended moisture content for composting is 40-70% however the optimum is 55%, the biodegradable wastes from the Senior staff housing and Student hostel met the condition except from that of Junior staff housing that is lower than standard. There was no significant difference in the pH values obtained at the three locations. The values were within the acceptable range of 4.5-9.5 (Dara, 2005).

In respect of the heavy metals examined in the food wastes cadmium and lead contents in all the locations were within the acceptable limit, while the Nickel content of food wastes at the locations was higher than the acceptable limit for Nickel as reported by Sridhar and Bammeke (1986). Although there was no significant difference in the concentrations of the heavy metal component of food waste generated at the three locations.
Nickel is one of the heavy metals of public health importance to be treated in the food waste before using it for compost. Agunwamba (1998) revealed the fact that animals can consume heavy metals in plants hence posing threat to human health.

This implies that the waste stream in UI has high recyclable wastes most especially the biodegradable wastes. This is similar to findings by Okpala et al (1994) that 90% (average of 35.8Kg out of 37Kg) per day of wastes generated by 12 families were biodegradable. The implication of this is that if biodegradable wastes are segregated from other wastes and disposed separately, the final quantity of waste that get to dump will be reduced drastically. This will also enhance agriculture, by using the biodegradable for compost. Also, the recyclables separated will generate income for households and or the institution.

Majority of the respondents did not separate their waste before disposal. There is a gap between awareness of source separation for recycling and the practice. Only very few that had knowledge about recycling before the intervention separated bottles and tins for the scavengers, and kitchen waste to feed animals. The intervention helped to improve the participants' attitude towards source separation such that they were interested in the practice.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The outcome of investigations indicated the nature and quantity of household solid wastes and their management in residential areas of the University of Ibadan. It also showed the level of knowledge, attitude and practices of residents in the University towards household source separation of solid waste for recycling.

The study showed that residents in the junior staff housing had little knowledge, attitude and practice of source separation of solid waste and recycling before the intervention, these were however improved upon after the intervention.

Before the intervention, more than half of the participants in senior staff housing had good knowledge but poor attitude to and practice of source separation of solid waste and recycling. Post intervention result showed an increase in their knowledge, attitude and practice. The students did not practice any source separation of waste but their cleaners did remove recyclable materials from the waste stream. The cleaners showed increased willingness to practice source separation of solid wastes due to the benefit of income generated from the separated recyclable wastes. Most of the residents dumped all the wastes together in the neighborhood bin provided by the University authority, while some removed the valuable materials which could be reused or resold.

The characteristic nature of the wastes in the households showed that the wastes stream in UI was full of recyclable wastes most especially the biodegradable wastes that are compostable into organic manure. Hence, separation of recyclable waste from one another will facilitate reuse, composting, income generation and waste minimization.

Finally, the problem of household solid waste management in University of Ibadan and Nigeria as a whole should be tackled by bridging the gap between the knowledge and practice in managing these wastes. Hence, there is need for adequate sensitization and mobilization of residents on campus on the concept of source separation for recycling of solid waste.

6.2 Recommendations

Effective household solid waste generation and management (in households and Hostels) in the University calls for enhanced commitment on the part of all residents and the University authority.

The University of Ibadan authority should have a policy for the management of household solid waste on campus. The specific recommendations are as follows:

(1) The University of Ibadan should set up a committee to be specifically in charge of the waste management on campus.

(2) All the residents and especially women, need to be educated on importance of source separation and recycling of solid waste. This is necessary through environmental education to enhance environmental awareness of the residents through appropriate mass media like erection of bill board, publication of environmental issues in the University bulletin, use of fliers and discussion at the neighborhood groups.

(3) The students should also be involved in the source separation of solid waste in hostel since they generate the wastes. This could be achieved by establishing rules that all hostel occupants should separate waste before disposal. The authorities in charge of hostels should see to the law enforcement.

(4) Households should be encouraged to separate their recyclable wastes from one another by providing waste bags, and identified drums for each component, so that the biodegradable waste could be used for organic manure and funds can be generated from the sales of other non biodegradables.

(5) The University authority should enact laws and ensure the enforcement with the aid of the security officers.

(6) The University authority should create collection centre for each component of recyclable waste where local recyclers can purchase such materials.

(7) There should be extension of this project to other residential and non residential areas in the University community.

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APPENDIX I

QESTIONNAIRE ON SOURCE SEPARATION AND CHARATERIZATION OF SOLID WASTE FOR RECYCLING SCHEME IN POLYTECHNIQUE OF IBADAN.

Dear Respondent,

I am a MPh student of Environmental Health, EMSEH Department College Of Medicine, U.I. Please your assistance is needed in completing this questionnaire. It is designed to seek your opinion on waste management and recycling practices on campus. All information provided will be kept confidential. Please, kindly answer the questions correctly. Thank you for taking your time to fill this questionnaire.

Agbaje B.O

Serial No ....

INSTRUCTION: PLEASE WRITE YOUR CHOICE OPTION IN THE BOX

Section A: SOCIO-DEMOGRAPHIC CHARACTERISTICS

Address ....

1) Age: (last Birthday) ....

2) Sex: (1) Male .... (2) Female ....

3) Occupation ....

4) Level of Education:

1) No Formal Education 2) Quranic Education 3) Primary Education

4) Secondary Education 5) Tertiary

6) Others Specify...

5) Marital Status:

(1) Single (2) Married (3) Separated (4) Divorced (5) Widowed (6) Cohabiting

6) Ethnic group:

1) Yoruba 2) Igbo 3) Hausa

Others ....

7) How many people are in your apartment? ....

8) Religion: 1. Christianity 2. Islam 3. Traditional

SECTION B: KNOWLEDGE ON RECYCLING OF HOUSEHOLD WASTE

9) What is the major waste you generate in your home?
1) Kitchen waste 2) Papers 3) Nylon and Plastics 4) Glass
5) Metals 6) Old furniture/wood

10) Do you know about waste recycling? 1. Yes 2. No

11) Do you practice it? 1. Yes 2. No

12) Do you think the wastes you generate can be turned to any useful material?
1. Yes 2. No

13) If yes explain..

14) If no explain..

15) How many households use the same neighborhood waste bin with you?
1) 1-3 2) 4-6 3) 7-10 4) > 10

16) How is the neighborhood bin cleared?
1) Neighbors contribution 2) Individual volunteer 3) Institution's arrangement

17) The current waste management system on campus is efficient
1. Strongly agree 2. Agree 3. Disagree 4. Strongly Disagree

18) Does anyone come to pick wastes from your neighborhood bin?
1. Yes 2. No

19) Do you think it is important to separate waste at home for recycling?
1. Yes 2. No 3. Not sure

20) Which of the solid wastes can be recycled?..

21) Which of the wastes can be reused?..

22) Which area of waste management do you have problem

	Yes	No	If yes state the problem	Suggest solution
Collection				
Separation				
Transportation				
Processing/treatment				

Disposal					

SECTION C:

ATTITUDE TO RECYCLING OF HOUSEHOLD WASTE

23) Does the neighborhood bin constitute a nuisance to the environment? [ ]

1. Yes 2. No 3. Not sure

24) What is the nature of the nuisance? [ ]

1. Smell 2. animals 3. Flies

25) What is your opinion about implementing waste recycling on campus?

....

26) Who do you think should be responsible for separation of waste at source? [ ]

1. Private agent 2. The institution 3. Household

27) It is the responsibility of the Polytechnique administration to make arrangement for waste separation 1. Agree 2. Disagree 3. Not sure [ ]

28) Every household should participate and be involved in the management of refuse 1. Agree 2. Disagree 3. Not sure [ ]

29) I am willing to separate my recyclable wastes from other wastes [ ]

1. Agree 2. Disagree 3. Not sure

30) Bothering about separation of recyclable waste is unnecessary trouble [ ]

1. Agree 2. Disagree 3. Not sure

31) Separation of recyclable waste from others is a good method of waste management 1. Agree 2. Disagree 3. Not sure [ ]

32) Wealth is generated from the practice of waste recycling? [ ]

1. Agree 2. Disagree 3. Not sure

SECTION D:

PRACTICES IN RELATION TO RECYCLING OF SOLID WASTE

33) Do you practice waste recycling?
 1. Yes 2. No

34) Do you separate your waste before disposal?
 1. Yes 2. No

35) If yes which waste do you separate?..

36) Why do you separate the wastes?..

37) If you separate your waste what do you do with the different types of materials you obtain? 1) Sell 2) Reuse 3) Nothing 4) Others Specify..........................

38) How often do you empty the waste bin in your home?
 1) Once a day 2) Twice a day 3) Every two days 4) Once a week?

39) Which container do you use to collect your wastes at home?
 1) Basket 2) Nylon 3) Carton 4) Bucket with cover

40) What is the size of the waste bin?..

41) How many waste bins do you have?..

42) How do you dispose off the content of your waste bin?
 1) Bush 2) Burn 3) Pit 4) Neighborhood waste bin

43) When does the Neighborhood bin get filled up?
 1) Daily 2) Every 2 days 3) More than 2 days 4) Weekly

44) Is waste recycling practiced on campus?
 1) Yes 2) No 3) Not sure

45) How often is the neighborhood bin emptied?
 1) Daily 2) Every 2 days 3) More than 2 days 4) Weekly 5) Not sure

SECTION E

HEALTH ASSESSMENT

46) What are the pests you see around the neighborhood bin?.......................................

47) What are the commonest environmental problems caused by the present waste management system in your area?

	TRUE	FALSE
PREVENT FREE FLOW OF SURFACE WATER		
ODOUR		
FLIES BREEDING		
FILTHY LAND		

OTHERS SPECIFY ....

47) Which of the following are health problems directly associated with the present waste management, please tick all that apply

	TRUE	FALSE
MALARIA		
CHOLERA		
TYPHOID		
YELLOW FEVER		
DIARRHOEA		
DOG BITE		

OTHERS SPECIFY ....

APPENDIX 2

FOCUSED GROUP DISCUSSION GUIDE FOR HOUSEHOLD REPRESENTATIVES IN THE UNIVERSITY OF IBADAN.

TOPIC: SOURCE SEPARATION AND CHARACTERISATION OF SOLID WASTE FOR WASTE RECYCLING SCHEME IN UNIVERSITY OF IBADAN.

INTRODUCTION

I thank you all for agreeing to participate in this discussion. My name is Agbaje Bukola and I will be moderating our discussion today. This discussion is a research work that intends to find out some vital information on the waste management system on campus. During this discussion, no views expressed by any participant will be judged right or wrong and everybody is free to express his view on any issue pertinent to the discussion. This discussion will remain completely confidential and will only be used for the purpose of the research project to improve the environment.

Thanks for your anticipated cooperation.

INTERVIEW

1. What is solid waste?
2. What are the wastes you generate at home?
3. What are the problems of current waste management practice on campus
4. What is recycling?
5. What are recyclable wastes?
6. What are the processes involved in recycling?
7. What are the benefits of waste recycling?
8. Do you practice it?
9. How can recycling be practiced effectively on University of Ibadan campus?

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APPENDIX 3

OBSERVATION CHECKLIST ON SOLID WASTE MANAGEMENT IN UNIVERSITY OF IBADAN.

House code...

Study area..

No of houses in the neighborhood........................

A. WASTE COLLECTION METHOD

METHOD	PRESENT & FUNCTIONING	PRESENT BUT NOT FUNCTIONING	ABSENT
ON THE FLOOR			
CARTON			
METAL DUSTBIN			
PLASTIC DUSTBIN			

B. WASTE DISPOSAL METHOD

METHOD	PRESENT & FUNCTIONING	PRESENT BUT NOT FUNCTIONING	ABSENT
BUSH			
NEIGHBORHOOD BIN			
BURYING			
BURNING			

C. TYPE OF WASTE GENERATED

WASTE TYPE	HIGH	MEDIUM	LOW
PAPERS			
KITCHEN/ASH			
GLASS			
METALS			
PLASTICS/NYLON			
WOOD			
TIN			

D. WASTE COLLECTION FREQUENCY

COLLECTION	YES	NO
ONCE A WEEK		
TWICE A WEEK		
THRICE A WEEK		
FOUR TIMES		

E. TYPES OF WASTE SCAVENGERS PICK

WASTE TYPE	YES	NO
PAPER		
KITCHEN		
GLASS		
METAL		
PLASTIC/NYLON		
WOOD		
TIN		

C. TYPE OF WASTE GENERATED

WASTE TYPE	HIGH	MEDIUM	LOW
PAPERS			
KITCHEN/ASH			
GLASS			
METALS			
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KITCHEN		
GLASS		
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PLASTIC/NYLON		
WOOD		
TIN		

APPENDIX 4

INFORMATION EDUCATION AND COMMUNICATION (IEC) MATERIAL FOR NEIGHBORHOOD ENVIRONMENTAL ACTION TEAM (NEAT)

Solid Waste Management is an activity in which public participation is the key to success. It is not the technology alone, but public attitude and behavior and the efficiency and effectiveness of the systems and practices that determine the success of a solid waste management system. A system demanding segregation and storage of waste at source would require a very high degree of human behavior change. Hence IEC material to guide the conduct of NEAT focused on:

1. Reduce, Reuse Recycle and Recover – 4R
2. No waste on ground
3. Segregation and storage at source
4. Waste recycling at local level.
5. Willingness to pay for services.
6. Reaching out to the other community members for mobilization and participation.
7. Making community aware of the health risks emanating from poor management of solid wastes
8. Zero waste concept
9. Participation of community in deciding options.
10. Collective Monitoring
11. Establish administrative structure within each team, schedule regular meeting for decision making at selected locations.

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