SOLID WASTE SEGREGATION AS A STRATEGY FOR IMPROVED WASTE MANAGEMENT IN OKAKA COMMUNITY, BAYELSA STATE.

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Certification

I certify that this study was done by OVOH PREOWEI SOLOMON a postgraduate student in the Department of Environmental Health Science, Faculty of Public Health, University of Ibadan, Ibadan, Nigeria under my supervision.

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Dedication

This work is dedicated to the Lord Jesus Christ Almighty.

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Abstract

Solid wastemanagement is an established environmental health challenge in most societies. The heterogeneousnature of municipal solid wastemakes its management particularly complex. Waste segregation which is key to proper solid waste management has not been adopted in the Nigerian society. Improper waste segregation could result in diarrheal diseases. The study was designed to assess solid waste segregation as a strategy for improved waste management in Okaka Community, Bayelsa State.

A quasi-experimental study was adopted and multistage sampling was used to select (30) households. A semi-structured, self-administered questionnaire comprising respondents' socio-demographic characteristics, 14-point knowledge scale and 14-point practice scale was used. The knowledge and practice scores were rated as poor (≤4), fair (>4-8) and good (>8).Jute sack bags without label or colour code were given to households to collect solid waste for 1 week. Wastes collected were characterised and weighed at pre-intervention. Thereafter, labelledcolour coded jute sack bags (Black for degradable and White for non-degradable waste) were provided and training on its use was conducted for 2 weeks for the households. The questionnaire was re-administered to the selected respondents' after intervention. Waste from the households were collected and weighed for 1 week as post-intervention SW segregation. Non-degradable waste was segregated, characterised and its components were weighed. Data were analysed using descriptive statistics, and t-test at p=0.05.

Respondents' age was 28.6±2.6 years. Educational status of respondents' was non-formal (23.3%), primary (26.7%), secondary (20.0%) and tertiary (30.0%). Pre-intervention knowledge score of respondents' was 2.7±0.2 while the practice score was 2.2±0.1. Respondents' with poor and fair knowledge were 73.3% and 26.7%, while those with poor and fair practice were 70.0% and 30.0%, respectively. Pre-intervention SW segregated among the households were heterogeneous waste (5.0±0.5kg), metals (0.7±0.1kg), plastics (0.6±0.1kg), and glass (0.4±0.1kg). Respondents' score for good knowledge was 9.4±0.2 while the practice score was 10.0±1.4 after intervention. Respondents' knowledge score were good (64.3%) and poor (7.1%) while practice scores were good (93.3%) and poor (2.4%) after intervention. Respondents' scores were fair for knowledge (28.6%) and practice (4.3%) after intervention. Knowledge and practice score were significant at pre and post-

intervention. Waste segregated after intervention was degradables (2.2±0.6kg) and non-degradables (1.7±0.2kg). Components of non-degradable waste were nylon (0.4±0.1kg), metal (0.5±0.1kg), paper(0.4±0.1kg), plastic (0.2±0.1kg), glass (0.4±0.1kg), cloths(0.4±0.1kg), wood(0.5±0.1kg), shoes (0.6±0.1kg), e-waste (0.2±0.1kg), tetra-pack (0.2±0.1kg) and others (0.5±0.1kg).

The knowledge and practice of solid waste segregation were improved after intervention. A lot of advocacy is needed to establish waste segregation practice. Public enlightenment, creation of buy-back recycling centres, community participation and training is highly recommended.

Keywords: Waste segregation; Non-degradable waste; Wastes characterization

Word count: 423

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CHAPTER ONE

BACKGROUND OF STUDY

1.1 INTRODUCTION

Solid waste management as a core environmental health function has persistently cause challenges to many policy makers, professionals and societies in developing countries. Several factors have been attributed to this menace to public health importance and these include factors such as inadequate involvement of trained professionals such as environmental scientists, environmental health officers and environmental engineers in the process,lack of proper planning, urbanization and population growth, negative behaviour and attitudes of humans to solid waste management, poor funding of solid waste management programmes, inadequately trained personnel, lack of political will on the part of policy makers and apathy of trained professionals(Amadi, 2011).

Improperly managed waste from the household and communities is a serious health hazard which causes the spread of infectious diseases. Waste unattended to attracts flies, rodents, and organisms that cause prevalence ofdiseases (Amadi, 2009). Wet waste decomposes and releases bad odour, resulting in unhygienic conditions of immense public health risk e.g. the plague outbreak in Surat(Zamadar, 2010). Excessive Solid waste generated should be handled with utmost care and professionalism so as to ensure its efficient management (MSDU, 2006).

Municipal solid waste is heterogeneous and this makes its management complex but with a well-developed scientific systematic design, adequate public enlightenment, community participation and appropriate legislation put in place for solid waste segregation from the primary point of generation (source), solid waste reduction, re-use, recycling and recovery becomes a very easy task and the "waste to wealth"maxim iseasily achieved with minimal cost.

The large streams of solid waste generated in towns and cities could be re-used to generate substantial financial, environmental and social gains through waste recycling and or energy recovery(ICPE, 2004). But due to improper management plans and conservation, non-

existence recycling practices and absence of deliberate policies, potentially marketable solid waste materials are disposed at insanitary landfills (ICPE, 2004).

1.2 **Statement of the Problem**

The waste around theOkaka Community in Yenagoa Local Government Area of Bayelsa State and its environs, apart from being unsightly, destroys the aesthetic value of the environment and constitutes nuisance such as odour, traffic impediments, creates breeding ground for pests (rodents, vermin, vectors, etc.) and air and water pollution. Therefore, the urgent need for an efficient solid waste management strategy to address this menace that has defied all strategies of policy makers cannot be overemphasized. The issue becomes even more critical because an important step in solid waste management which is waste segregation at the source of generation has been overlooked. Waste segregation at the source of generation is key to efficient solid waste management it is the process that facilitates waste reduction and maximizes material recovery in the community towards achieving zero waste status.

1.3 Justification of the Study

Before the advent of man's technological advancement, waste disposal was not a significant problem since population was small and nature's carrying capacity to assimilate waste was high(Tchobanoglous *et al.*,1993; Ahmed and Ali, 2004). However, with the rapid development of cities around the world came an increase in the quantity of waste produced from human activities; this has caused a major waste disposal challenge to both developed and developing nations (WHO/UNAIDS, 2009). A United Nations Development Programme Survey Report of 151 major cities from around the world showed that inadequate solid waste disposal is the second most challenging problem facing most residents of cities after unemployment (Da Zhu *et al.*, 2008). This situation is further aggravated as the population of many nations continue to increase as cities become rapidly urbanized, making it difficult for most municipal authorities to provide most of the basic sanitation services (Ogbonna *et al.*, 2002; Ayotamuno and Gobo, 2004). The United Nations Statistic Division stated that Nigeria, with a population of about 140 million people and an

annual urban growth of 3.8%, has persistent solid waste management problems coupled with growing population (Walling *et al.*, 2004). An average Nigerian generates about 0.49 kg of solid waste per day with 90% of the total burden of waste being generated by households and commercial centres(Sridhar *et al.*,2010).

Indiscriminate disposal and dumping of waste has become acommon practice in Nigerian cities. Municipal solid waste heaps are found in several parts of major Nigerian cities like Ibadan, Port Harcourt, Yenagoa, Warri, and even Okaka often blocking roads, alleys and pavements (Ayotamuno and Gobo, 2004). Most of the waste dumps are located close to residential areas, markets, farms, roadsides and creeks; with many human activities close to the dump sites, there is an increased threat to public health (Ogbonna *et al.*, 2002). Generally, the uncollected solid wastes are left to decay and this produces foul odour that constitutes a source of environmental nuisance (Ofomata and Eze, 2001). Uncontrolled burning of refuse is another common method of waste disposal in Nigeria which has often led to fire outbreaks. Smoke, arising from such fires can reduce visibility and has been known to cause fatal vehicular accidents (Ofomata and Eze, 2001). The Okaka Community in Yenagoa Local Government Area of Bayelsa State is not left out. Thus, the management of solid waste in our cities, including Okaka, continues to pose serious challenges due to the non-application of the appropriate and environmentally sustainable waste management strategies and technologies as a result of financial and technological constraints (Golit, 2001).

1.4 **Research Questions**

1 What is the knowledge, attitude, and practice of waste segregation at the pre-intervention stage?

1. What is the impact of training on the knowledge, attitude and practice of solid waste segregation?
2. What is the effect of the provision of bags on the practice of solid waste segregation at source?
3. What are the pre-intervention and the post- intervention variations in the nature, amount and management of solid waste?

1.5 Research Hypotheses

In confirming the impact of the different knowledge, attitudes, practices, trainings and provisions of bags and waste segregation practice at pre-intervention and post-intervention on waste segregation at the source of generation, the hypotheses to be tested and analysed using the data collected are;

- there is no significant relationship between the knowledge, attitudes and practices and solid waste segregation at source;
- there is no significant relationship between the training, knowledge, and attitude; and practiceof solid waste segregation at source;
- there is no significant relationship between the provision of bags and solid waste segregation practices at source; and
- there is no significant relationship between the pre-intervention and post-intervention variation of the nature, amount and management of solid waste.

1.6 Limitation of the Study

Most respondents were reluctant to attend training sessions. This resulted in a series of re-scheduled sessions for training that took time and resources.

1.7 Broad Objective of the Study

The main objective of the study is;

to assess solid waste segregation as a strategy for improved waste management in theOkaka Community, of Bayelsa State.

1.8 Specific Objectives

The specific objectives of this work are to;

i. assess the knowledge, attitude and practice of waste segregation at source at pre-intervention;
ii. asses the effects of training on the knowledge, attitude and practice of waste segregation at source;
iii. assess the effect of the provision of labelled colour coded bags on the practice of waste segregation at source; and
iv. evaluate the pre-intervention and post-intervention training variation in the nature, amount and management of solid waste.

CHAPTER TWO

LITERATURE REVIEW

2.1 What is Waste?

The concept of waste is tricky to define(Lardinois and Van de Klundert, 1995). The definition of post-consumption materials as resources in the wrong place at the wrong time incorporate the idea of 'wastes' being resources left over from initial consumption(Lardinois and Van de Klundert, 1995). There is a problem with this definition because not all wastes can properly be regarded as resources. Many hazardous and toxic materials cannot be safely recycled or reused. In any one society, there will always be materials that cannot be used as resources for various reasons. What is a waste is considered from the point of view of the waste generator so*it* is mainly a subjective matter. Waste is what the person responsible for discarding the material regards as waste(Lardinois Van de Klundert, 1995). General waste is any material for which a specific owner ceases to have use for it. It is also any unwanted or discarded material, in solid, liquid or gaseous form. A product, material or container is not considered waste until someone throws it away.

2.2 Solid Waste

Solid waste is non-liquid waste arising from domestic, commercial, industrial, agricultural, mining and construction activities and from public services. Solid waste can also be defined as “unwanted material disposedoff by man which can neither flow into streams nor escapes immediately into the atmosphere(Kulkari, 2008).

2.3 Classification of Solid Waste

Solid waste can be classified in several ways and most classification of solid waste is based on the source from which it is generated(Hoornweg *et al.*, 2008). Major sources of solid waste include;

i. **Residential/Domestic Waste**

This can be single or multifamily dwellings. Types of waste generated here are food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes (e.g., bulky items, consumer electronics, white goods, batteries, oil, tires, and (household hazardous wastes.) (Hoornweg*et al.*, 2008).

ii. **Industrial Waste**

These are light and heavy waste from manufacturing, fabrication, construction sites, power and chemical plants, manufacturing processes such as (refineries, mineral extraction and processing. etc.). The types of waste generated here are housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes, industrial process wastes, scrap materials, off-specification products, slay, tailings etc. The manufacturing industry has a central role to play in the prevention and reduction of waste as the products they manufacture today become the wastes of tomorrow. Manufacturers can achieve this by:

- considering the impact of their products throughout its life at the design stage of the product.
- using manufacturing processes that minimize material and energy usage.
- eliminating or reducing where possible the use of substances or materials hazardous to health or the environment and
- manufacturing products in such a way that they last longer and may be recycled or reused at the end-of-life stage.

The European Union and government policy across Europe is increasingly driven by the need to influence manufacturing practices in an effort to decrease the environmental impact of products during their manufacture, use and end-of-life (Hoornweg*et al.,* 2008).

iii. **Commercial Waste**

These are wastes from stores, hotels, restaurants, markets, office buildings etc. The type and nature of waste generated from these premises are paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes and hazardous wastes(Hoornweg*et al.,* 2008).

iv. **Institutional Waste**

These are waste from schools, hospitals, prisons, government centres and other public services. The types of waste generated is similar to those from commercial source. These include paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes and hazardous wastes(Hoornweg*et al.,* 2008).

v. **Construction and Demolition Waste**

These wastes are from new construction sites, road repairs, renovation sites, demolition of buildings etc. The types of waste associated with these activities are wood, steel, concrete, dirt, glass, bags, polythene, plastic etc. Construction activity is seen as a key indicator of growth and prosperity in western countries. However, construction and demolition waste; instead of being a burden on society and environment, can become a resource to be recycled and reused within the construction industry. Construction and demolition waste have been identified as a priority waste stream by the European Union. This means that particular attention will be paid to policies and measures to ensure increased recycling of construction and demolition waste. Due to the very large volume of construction and demolition waste produced, it can use up valuable space in landfills. In addition, if not separated at source, it can contain small amounts of hazardous waste. However, it also has a high resource value and the technology for the separation and recovery of construction and demolition waste is well established, readily accessible and in general inexpensive. Most importantly, there is a reuse market for aggregates derived from construction and demolition waste in roads, drainage and other construction projects(Hoornweg*et al.,* 2008).

vi. **Municipal Waste**

Municipal waste source includeshousehold waste, construction and demolition debris, sanitation residue, and waste from streets. This garbage is generated mainly from residential and commercial complexes Street cleaning, landscaping, parks, beaches, other recreational areas, water and wastewater treatment plants, tree trimmings; sludge, paupers, disuse vehicles and heavy construction equipment's, abandoned building material and boats. Management ofmunicipal waste has traditionally been landfilled and this remains the predominant management option in most countries. However, some countries have taken significant steps away from landfill. Alternatives offered include incineration (increasingly with recovery of energy), composting and recycling of glass, paper, metal, plastics and other materials etc.Environmental relevance includes the potential impact associated with the landfilling of waste such as the production of leachate and landfill gas, odours, flies, vermin and the use of land (Patriti, 2006).

vii. **Agricultural Waste**

Agricultural Waste mostly comes from farm produce. Sources of Agricultural Waste are crops, orchards, vineyards, dairies, feedlots and farms. Waste types are spoiled food wastes, agricultural wastes, hazardous wastes (e.g. pesticides). There are a number of potential environmental impacts associated with agricultural waste if it is not properly managed not least of which is the run-off of nutrients to surface waters which can cause over-enrichment of the water bodies. Leaking and improper storage of agricultural waste can also pose a serious threat to the environment should the waste reach surface waters. In addition, farming activities can give rise to emissions of ammonia and methane which can cause acidification and contribute to greenhouse gas emissions. There are a number of methods used to treat agricultural waste. These include spreading the waste on land under strict conditions, anaerobic digestion and composting(Hoornweg*et al.*, 2008).

viii. **Hazardous Waste**

Wastes are classified as hazardous if they are reactive, toxic, corrosive or otherwise dangerous to living things the environment. Hazardous waste sources including households, industrial, hospitals, and most commercial areas. The main disposal route for hazardous

waste is landfill, incineration and physical or chemical treatment. On the recovery side, a significant proportion of hazardous waste is recycled or burnt as fuel. Although hazardous waste generated is sometimes very small, it can present a potential risk to both human health and the environment. Hazardous waste is typically the subject of special legislation and requires special management arrangements to ensure that they are kept separate from and treated differently to non-hazardous waste (Patriti, 2006).

ix. Mining Waste

Mining waste arises from prospecting, extraction, treatment and storage of minerals. Mining and quarrying activities give rise to the single biggest waste stream at 29% of the total quantity of waste generated in European Economic Area countries. It has been shown that approximately 50% of the material extracted during extraction and mining activities in Europe becomes waste. It is made up of topsoil, overburden, waste rock and waste from the processing of the ore body (tailings) which may also include process water, process chemicals and portions of the remaining materials. The two major concerns in relation to mining waste are the large volumes that are produced as well as the potential for hazardous substances to be present in the waste stream. Large areas of land are used for depositing mining waste and this activity has the potential to cause environmental pollution if not properly controlled. A number of recent cases of uncontrolled releases of mining waste to surface waters (rivers and lakes) have highlighted the risks of poor mining waste management. In response, the European Union has proposed initiatives that are designed to improve mining waste management(EIONET, 2012).

x. Electrical and Electronic Waste

Waste electrical and electronic equipment (commonly called WEEE) has end of life products and comprises a range of electrical and electronic items such as refrigerators, IT and telecommunication equipment, freezers, electrical and electronic tools, washing machines, medical equipment, toasters, monitoring and control instruments, hairdryers, automatic dispensers, televisions, etc. Therefore, sources are all users of electrical and electronic equipment from householders to all kinds of commercial and industrial activities. WEEE is one of the fastest growing waste streams all over the world. Presently large proportion of WEEE is disposedoff into landfills or incineration plants, depending on local or national practices. In some countries and regions, products such as fridges and freezers

are separately collected and sent to recycling plants for dismantling and recycling. WEEE has been identified as a priority waste stream by the European Commission due to its potentially hazardous nature, the consumption of resources in its manufacture and its expected growth rates. In response, the European Commission has prepared legislation in the form of the following two directives;

- A directive on waste electrical and electronic equipment (WEEE); and
- A directive on the restriction of the use of certain hazardous substances in electrical and electronic equipment.
- A directive on the environmental impact of electrical and electronic equipment.

The directives propose that manufacturers will become responsible for taking back and recycling electrical and electronic equipment. This will in turn provide industry with incentives to design electrical and electronic equipment in an environmentally more efficient way, taking waste management issues into consideration(Hoornweg*et al.,* 2008).

xi. **Biodegradable Municipal Waste**

Biodegradable municipal waste (BMW) is waste from households and commercial activities that is capable of undergoing biological decomposition. Food waste such as corn, tubers, plantain peelings and cuttings, left over foods, garden waste, paper and cardboard are all classified as biodegradable municipal waste. Management options used to treat Biodegradable municipal waste, other than sanitary landfill include composting, mechanical-biological pre-treatment recycling and incineration (with and without energy recovery). Potential impacts associated with landfilling of biodegradable municipal waste include the production of leachate and landfill gas, odours, flies and vermin(Coker et al., 2008).

xii. **Packaging Waste**

Packaging is defined as any material which is used to contain, protect, handle, deliver and present goods. Items like glass bottles, plastic containers, aluminium cans, food wrappers, timber pallets and drums are all classified as packaging. Packaging waste can arise from a

wide range of sources including supermarkets, retail outlets, manufacturing industries, households, hotels, hospitals, restaurants and transport companies. A number of different methods are used to manage packaging waste, these included reuse, recycling (mechanical, chemical and feedstock), composting, thermal treatment and landfill.Packaging and packaging waste can have a number of impacts on the environment. Some of these impacts can be associated with the extraction of the raw materials used for manufacturing the packaging itself, impacts associated with the manufacturing processes, the collection of packaging waste and its subsequent treatment or disposal. In addition packaging may contain some critical substances e.g. polyvinyl chloride and heavy metals which may pose a risk to the environment(Hoornweg*et al.,* 2008).

xiii. **End of Life Vehicle and Tyres (ELVs)**

End-of-life vehicles are defined as cars that hold up to a maximum of eight passengers in addition to the driver and trucks and lorries that are used to carry goods up to a maximum mass of 3.5 tonnes. Thus their sources range from households to commercial and industrial uses. Cars are made up of numerous different materials. Approximately 75% of the weight of a car is made up of steel and aluminium, most of which is recycled. Other materials present include lead, mercury, cadmium and hexavalent chromium in addition to other dangerous substances including anti-freeze, brake fluid and oils that, if not properly managed, may cause significant environmental pollution. The remainder is composed of plastic which is recycled, incinerated or landfilled(Hoornweg*et al.,* 2008).

2.4 Health Impacts of Improper Handling of Solid Waste

Modernization and progress has its share of disadvantages and one of the main aspects of concern is pollution of the earth – be it land, air or water. With increase in the global population and rising demand for food and services, there has been a rise in the amount of waste being generated daily by each household. This waste is ultimately thrown into municipal waste collection centres from where it is collected by the area municipalities to be further thrown into landfills and dumps. However, either due to resource crunch or inefficient infrastructure, not all of this waste gets collected and transported to the final dumpsites. If at this stage the management and disposal is improperly done, it can have serious impacts on health the surrounding environment. Waste that is not properly managed, especially excreta and other liquid and solid waste from households and the community, are

a serious health hazard and lead to the spread of infectious diseases. Unattended waste lying around attracts flies, rats and other creatures that in turn spread disease. Normally it is the wet waste that decomposes and releases a bad odour. This leads to unhygienic conditions and thereby a rise in the health problems. The plague outbreak in Surat is a good example. Plastic waste is another cause for ill health. Thus excessive solid waste that is generated should be controlled by taking certain preventive measures. The group at risk from the unscientific disposal of solid waste include the population in areas where there is no proper waste disposal method, especially the pre-school children; waste workers and workers in facilities producing toxic and infectious material. Other high-risk groups include population living close to a waste dump and those whose water supply has become contaminated either due to waste dumping or leakage from landfill sites. Uncollected solid waste also increases risk of injury and infection(Hoornweg*et al.*, 2008).

2.4.1 Organic Domestic Waste

Food residuals in many areas in are left to decompose in the environment,attracting flies, cockroaches, rodents and other vectors of public health importance. Apartfrom being an unsightly, they create foul odour due to their gradual decomposition. Thisposes a serious threat, since they ferment; creating conditions favourable to the survival and growth of microbial pathogens .Direct handling of solid waste can result in various types of infectious and chronic diseases with the waste workers and the rag pickers being the most vulnerable(Yuwono and Lammers, 2004).

2.4.2 Exposure To Hazardous Waste

Thiscan affect human health; children being more vulnerable to these pollutants. In fact, direct exposure can lead to diseases through chemical exposure as the release of chemical waste into the environment leads to chemical poisoning. There'sa connection between health and hazardous waste(Hoornweg*et al.*, 2008).

2.4.3 Waste From Agriculture and Industries

Theycan also cause serious health risks. Otherthan this, co-disposal of industrial hazardous waste with municipal waste canexpose people to chemical and radioactive hazards. Uncollected solid waste can alsoobstruct storm water runoff resulting in the forming of

stagnant water bodies thatbecome the breeding ground for disease. Waste dumped near a water source alsocauses contamination of the water body or the ground water source. The direct dumpingof untreated waste in rivers, seas and lakes results in the accumulation of toxic substances in the food chain through the plants and animals that feed on it directly or indirectly(Hoornweg*et al.*, 2008).

2.4.4 Disposal of Hospital and other Medical Waste

Theserequire special attention since they can create major health hazards. Waste generated from hospitals, health care centres, medical laboratories, and research centres such as discarded syringe needles, bandages, swabs, plasters, and other types of infectious waste are often disposedoff with the regular non-infectious waste(UNEP, 1996).

2.4.5 Waste Treatment and Disposal Sites

These sitescan also create health hazards for the neighbourhood. Improperly operated incineration plants cause air pollution and improperly managed and designed landfills attract all types of insects and rodents that spread disease. Ideally these sites should be located at a safe distance from all human settlement. Landfill sites should be well lined and walled to ensure that there is no leakage into the nearby ground water sources(UNEP, 1996).

2.4.6 Recycling

Waste recyclingtoo carries health risks if proper precautions are not taken. Workers working with waste containing chemical and metals may experience toxic exposure.Disposal of health-care wastes require special attention since it can create major health hazards, such as Hepatitis B and C, through wounds caused by discarded syringes. Rag pickers and others, who are involved in scavenging in the waste dumps for items that can be recycled may sustain injuries and come into direct contact with these infectious items(UNEP, 1996).

2.4.7 Occupational Hazards Associated with Waste Handling

i. Infections

Skin and blood infections resulting from direct contact with waste, and from infected wounds. Eye and respiratory infections resulting from exposure to infected dust, especially

during landfill operations. Several diseases results from the bites of animals feeding on the waste. Intestinal infections are also transmitted by flies feeding on the waste(Patriti, 2006).

ii. Chronic diseases

Incineration operators are at risk of chronic respiratory diseases, including cancers resulting from exposure to dust and hazardous compounds(UNEP, 1996).

iii. Accidents

Bone and muscle disorders resulting as a result of handling of heavy containers infecting wounds resulting from contact with sharp objects Poisoning and chemical burns resulting from contact with small amounts of hazardous chemical waste mixed with general waste. Burns and other injuries resulting from occupational accidents at waste disposal sites or from methane gas explosion at landfill sites(UNEP, 1996). Therefore, from the above public health implication of Solid waste its proper management can never be over emphasized and should be handled with caution and in line with best practices of safety and hygienic standards.

2.5 Solid Waste Management

Waste management is the practice of the gradual removal of waste substances or materials in an environment with the ultimate aim of eliminating those substances or materials that have the potential to cause harm to people and the environment. Solid waste management therefore, is the planned systematic administration of activities that provide for the collection, source separation, storage, transportation, transfer, processing, treatment and disposal of solid waste.

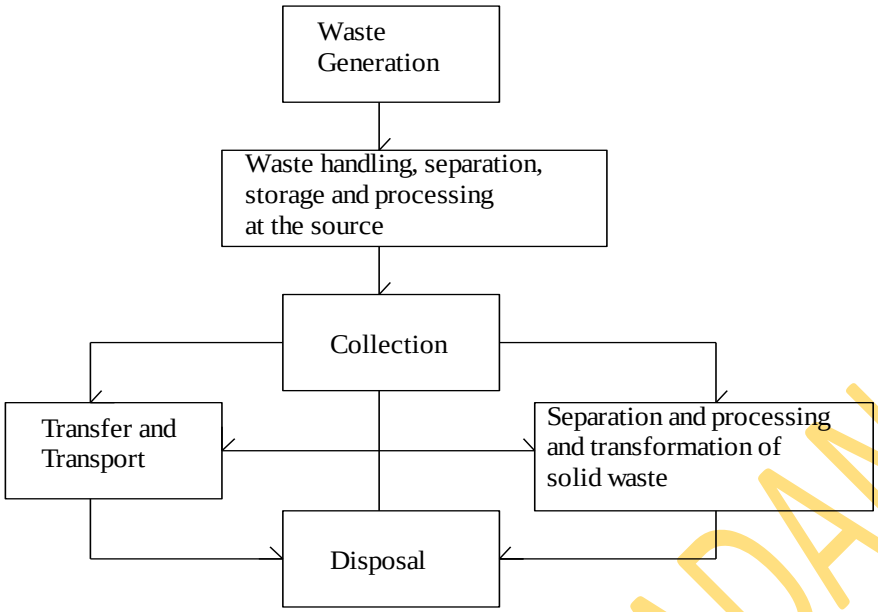


Figure2.1; Schematic diagram of Solid waste management(Sridhar, 2013).

2.6 Objectives of Waste Management

The objectives of waste management are designed to promote aesthetics, land-use, health, prevent pollution of air and water, generate income for economic growth; create awareness for proper solid waste management for municipal, corporate, and individual. Solid waste management is a complex process because it involves many technologies and disciplines. These include technologies associated with the generation (source reduction); on-site handling and storage; collection; transfer and transportation; processing and disposal of solid wastes. All of these processes have to be carried out within existing legal, social and environmental guidelines that protect the public health and the environment in a safe, hygienic and economically acceptable manner. In other to achieve these solid waste management must take an integrated approach (Sridhar, 2013).

2.7 The Waste Management Hierarchy

Waste management activities are often planned and arranged in a hierarchical manner to reflect their desirability:

a) The first priority is waste avoidance, which is, not producing the waste in the first place.

b) If the waste must be produced, then the quantities should be minimized.

c) Once that has been achieved, the next priority is to maximize recovery, reuse and recycling of suitable waste materials.

d) Taken together, these three options are often called waste prevention, although strictly speaking, only the first two are prevention whereas the third is already an end-of pipe solution.

e) Once the possibilities for waste prevention have been exhausted, the next priority is to reduce the volume of residual wastes being passed on for final disposal, extracting resources in the form of products and/or energy in the process.

Most important of the hierarchy, is waste management education, which ensure strict adherence to other options (Sridhar, 2013).

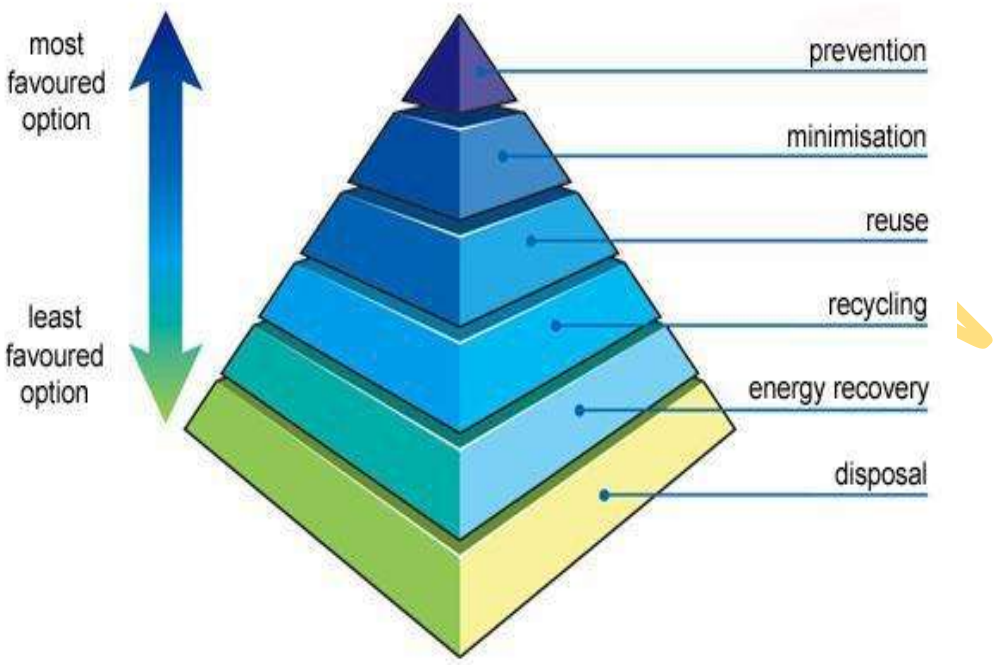


Figure 2.2; Hierarchy of waste segregation (Sridhar, 2013).

2.7.1 Basic Principles of Waste Management

There are five (5) basic principles of waste management and these are;

A. **Waste Inventorization**:- Taking inventory of all waste generated i.e. source of waste, degree of waste generated, form of waste and type /category of waste.

B. **Waste Characterisation**:- Characterization of waste based on physical, chemical and toxicological properties. Characteristics of solid waste include the composition, quantity and specific weight. These may differ due to diverse factors such as time of the year, habits of individuals or groups, education status and economic status of the people; number and type of commercial and industrial operations; whether urban or rural area location. Each community should be studied and actual weighing made to obtain

representative information for design purposes. Various estimates have been made of the quantity of solid waste generated and collected per person per day.

C. **Waste Segregation**: - Selective separation of waste i.e. hand picking/sorting at source.

D. **Waste Minimization**: - This involves the 4Rs. i.e. (1) Reduce (2) Reuse (3)Recycle (4) Recovery(Sridhar, 2013).

i. **Importance of Waste Reduction**

In affluent countries, the main motivation for waste reduction are frequently related to the high cost and scarcity of sites for landfills, and the environmental degradation caused by toxic materials in the deposited wastes. The same considerations apply to large metropolitan areas in developing countries that are surrounded by other populous jurisdictions. The places that currently do not have significant disposal pressures can still benefit from encouraging waste reduction. Their solid waste departments, already overburdened, cannot afford to spend more money and effort on the greater quantities of waste that will inevitably be produced as consumption levels rise and urban wastes change. Solid waste managers in developing countries tend to pay little attention to the topic of reducing non-organic wastes because the wastes they collect are between 50% to 90% organics, dirt and ashes. These municipal wastes however are amenable to composting or digestion, provided they contain very low levels of synthetic materials. Solid waste departments thus have an interest in promoting diversion of synthetic recyclables from the waste stream. Each household generates garbage or waste day in, day out. Items that are no longer needed or do not have any further use fall in the category of waste thrown away. In today's polluted world, learning the correct methods of handling the waste generated has become essential. Segregation is an important method of handling municipal solid waste and it can be clearly understood by schematic representation. Composting is an important waste treatment method to manage wet waste. One common sight in all cities is the rag picker who plays an important role in the segregation of waste. Garbage generated in households can be recycled and reused to prevent creation of waste at source and reduce the amount of waste thrown into the community dustbins (UNEP, 1996).

i. Key Concepts In Municipal Waste Reduction

Waste Reduction: These are measures put in place to reduce the amounts of waste collected and disposed off. This involve legislations and agreements on packaging and product redesign; to local programmes that prevents recyclables and compostable organics from entering the waste streams.

Source Reduction: Any procedure to reduce waste at the point of generation in contrast to sorting out recyclable components after they have been mixed together for collection.

Source Separation: Keeping different categories of recyclables and organics separate at sourcei.e. at the point of generation to facilitate reuse, recycling and composting.

Waste Recovery, Materials Recovery, or Waste Diversion: Obtaining materials/organics (by source separation or sorting out from mixed wastes) that can be reused or recycled.

Reuse: Reusing a product for the same or a different purpose.

Recycling: The process of transforming materials into secondary resources for manufacturing new products is called recycling.

Redemption Centre: Waste trading enterprise that buys recyclable materials and sells to brokers. Sometimes also called "buy-back centre".

Producer Responsibility: Producers of products or services accept a degree of responsibility for the wastes that result from the products/services they market, by reducing materials used in production, making repairable/recyclable goods and/or reducing packaging.

ii. Four Rs(Refuse, Reuse, Recycle, Reduce) to be followed for Waste Management

Refuse - Instead of buying new containers from the market, use the ones that are in the house. Refuse to buy new items though you may think they are prettier than the ones you already have.

Reuse - Do not throw away the soft drink cans or the bottles instead cover them with homemade paper or paint on them and use them as pencil stands or small vases. Alternately, you can store them and sell them to the rag pickerswho take these for recycling. Reuse the plastic bags for shopping again and again. It is better if you use shopping bags made of cloth or jute, which can be used over and over again.

Recycle - Segregate your wastes so that non-perishable wastes are easily collected and taken for recycling. Dig a small pit to compost your organic wastes like kitchen wastes at your home.

Reduce - Reduce the generation of unnecessary waste e.g. carry your own shopping bag when you go to the market and put all your purchases directly into it.

iii. Promoting Waste Reduction and Materials Recovery at the National and Local Levels

Action for waste reduction can take place at both national and local levels. At the national level, the main routes to waste reduction are:

- redesigning of products or packaging,
- promotion of consumer awareness
- promotion of producer responsibility for post-consumer wastes (this applies mostly to industrialized countries). At the local level, the main means of reducing waste are:
- diversion of materials from the waste stream through source separation andtrading.
- recovery of materials from mixed waste.
- pressure on national or regional governments for legislation on redesigning packaging or products;
- support of composting, either centralized or small-scale (UNEP,1996).

E. **Waste Treatment**: - This involves physical, biological and mechanical treatments.

2.8 Integrated Sustainable Solid Waste Management (ISWM)

Integrated sustainable solid waste management or sustainability is any system that is appropriate to the local conditions in which it operates considering its technical, social, economic, financial, Institutional and environmental perspective;

- capable to maintain itself over time without reducing the resources it needs.

An integrated system means any system thatuses a range of inter-related collection and treatment options at different habitat scales (household, neighbourhoods).It involves all stakeholders be they governmental or non-governmental, formal or informal, profit- or non-profit oriented.

- takes into account interactions between the waste management system and other urban systems

The different habitat scales that need to be integrated are the premise, neighbourhood and city level. Table1 below shows the solid waste management activities that can be carried out at each of these levels.

Table 2.1; Habitat scales and activities in an Integrated Sustainable Waste Managementsystem

Habitat scale	Collection and disposal system	Resource Recovery System
Premise level	Storage at source	Prevention
	Separation at source	
	Reuse at source	
Neighbourhood level	Primary collection	Primary collection
	Temporary storage	Sorting and pre-treatment
		Reuse
		Recycling
		Composting
City level	Secondary collection	Sorting and pre-treatment
	Transfer storage	Secondary collection
	Tertiary collection	Reuse
	Final disposal and treatment	Recycling
	Composting	

Source:(Van de Klundert*et al.*, 1999).

Any ISWM system should distinguish between the habitat scales and integrate them as much as possible. Sustainable and integrated are in a sense two sides of the same coin. For example, using different collection and treatment options at different habitat scales can form the basis of a system that is adapted to local (physical, social, economic etc.) conditions. Involvement of stakeholders is one of the pillars of sustainability of a system, leading to a feeling of responsibility for the success of the system, at least if their political and economic interests are served with the system, and a willingness to keep it going on the part of stakeholders. If waste management systems are integrated with other systems, this could enhance sustainability as well. For instance compost made from urban organic waste and applied in urban agriculture, parks etc. can lead to a closed-cycle system within the city, thereby reducing import of raw materials and goods from outside and concurrent burdens on the environment from transportation, manufacturing of chemical fertilisers etc.

ISWM is not supposed to be used as a blueprint. However, it can provide a framework for the selection of appropriate technologies for waste management and for the development of sustainable waste management systems in general, for both liquid (human) and solid waste. It can induce policy and institutional reform to promote sustainability in waste management. In addition, it can provide the basis for analysis of existing waste management systems to assess their sustainability. The concept has already been used as a guideline for the analysis of the solid waste management system in Bangalore, India (van Beukering*et al.,* 1999). Basic principles are as follows;

2.8.1 Principles of ISWM

1. Technical/Operational Principles

Technologies and systems should be:

- adapted to the physical environment, topography and other physical requirements
- preferably locally manufactured and based on indigenous technology
- geared towards efficiency and optimum utilization of equipment
- adapted to the local availability of spare parts that are durable and of good quality; the equipment used should have a long life span (WASTE, 1999).

2. Environmental Principles

Technologies and systems should

- be clean, i.e. minimize the negative impact on soil, air and water at local, regional and global levels
- promote closed cycle systems and avoid loss of raw materials, energy and nutrients

- follow the 'waste management hierarchy' preferring options that promote waste prevention, source separation, re-use and recycling above those merely aimed at collection and disposal
- encourage treatment and resource recovery as close to the source as possible (WASTE, 1999).

3. Financial Principles

Financial management of technologies and systems should

- be based on the 'all beneficiaries contribute principle' i.e. besides the waste generators paying user charges, the resource recovery sector and the local government should also contribute by paying a profit tax and allocating municipal revenues to waste management
- be geared towards the most efficient overall system leading to the lowest cost per ton to operate taking into account the cost of other affected urban systems
- ensure highest productivity of labour and capital in the local situation
- lead to full cost analysis and full cost recovery including all costs and benefits involved.

The 'all beneficiaries contribute' principle is a concept developed by WASTE (Hemelaar and Maksum, 1996; Hemelaar, 1999). It is used here instead of the 'polluter pays' principle because in many cases, cost-based tariff levels are not affordable for low income groups. It is argued instead that all groups that benefit from the waste management system should financially contribute to its operation and maintenance. Citizens are usually the direct users of a waste management service and benefit because their living environment improves. The private sector involved in resource recovery and recycling benefits because it has access to the valuable waste materials and makes profits out of these. The local government benefits because of reduced health care related costs and reduced costs of urban management, especially the cost of potable water supply and treatment and of drainage (Hemelaar, 1999).

4. Socio-economic Principles:

Technologies and systems should

- be provided to all strata of the population regardless of ethnic, cultural, religious or social background
- minimize risks to public health
- be adapted to user demands and priorities
- be adapted to local willingness and ability to pay thereby leading to affordable systems

- incorporate management models which are acceptable to people and institutions involved
- be geared towards improvement of working conditions of system operators
- be geared towards income and employment generation

Note that according to these socio-economic principles, any user charges introduced should be adapted to 'ability to pay' including for example higher charges for industrial and commercial companies thus ensuring cross-subsidization between high- and low-income users. Communities that are not able or willing to pay for expensive servicesshould be given the option of receiving a cheaper yet effective service e.g. block collection instead of door-to-door collection (WASTE,1999).

5. Institutional/Administrative Principles

Technologies and systems should be

-be geared towards capacitybuilding of operators and managers, especially of local authorities

- create room for involvement of all stakeholders in planning and implementation especially as regards weaker and underprivileged groups.
- encourage 'social privatization'
- promoting organizational cultures that foster professionalism, transparency and accountability
- be based on decentralized management giving sufficient regulatory and financial autonomy to local governments to improve waste management sustainably
- ensure competitive bidding for waste service provision by the private sector
- encourage incentives, recruitment and promotion based on merit and performance
- promote inter-sectoral co-operation (with other urban systems) who are stakeholder. Why is stakeholder involvement in planning and implementation important? Stakeholders are all groups and individuals who have a stake and interest in the waste management system in a certain area. The interests and roles stakeholders have in waste management may differsignificantly from each other. A stakeholder analysis defining these roles and interests is therefore a prerequisite for setting up a new solid waste management system or for improving an existing one. Three groups are usually defined as having a stake in waste management: the local community

and its representatives (the community sector), the local government and agencies responsible for cleanliness and public hygiene (the public sector) and the private companies involved in waste management (the private sector). These which can be divided into a formal, usually large-scale and institutionalized group and an informal, usually small-scale and unregistered group. Involvement of stakeholders can take several forms. For example the involvement of local communities in planning and implementation does not mean that residents are used as cheap labour. They can play a range of roles as reported by (Anschutz, 1996; Moreno *et al.*, 1999) such as

- residents - placing waste outside for collection and separating it at source
- community managers - participating in the design of a waste service, recruitment of workers and setting rates for user charges
- citizens - pressuring municipal authorities so that services are offered
- community members - participating in clean-ups
- clients - paying for waste management services
- watchdogs - monitoring and supervising the operation of services

Stakeholder involvement is important, because it can lead to more responsible behaviour, increasedenvironmental awareness and a higher willingness to pay for services of a waste management system. It can also lead to empowerment of groups of stakeholders that have had limited access to decision-making power and resources, for example local residents or informal micro-enterprises involved in collection and recycling of waste. Indeed it needs to be kept in mind that stakeholders do not have an equal starting position. Thus the idea of stakeholder involvement aims at supporting the weaker, underprivileged groups to have a say in planning and implementation of a waste management system. Actors like community-based organisations (CBOs), non-governmental organisations (NGOs), research institutes, universities, etc. should be strengthened for this purpose to enable them to play a role in supporting communities and the informal sector. This can be done through organizing them, providing them with training, promotions (advocacy) or support them with research, technical or financial assistance. Local governments can create room for local communities and the informal sector by changing legislation and recognising them as candidates for service contracts (see Policy/legal aspects below). Internationally, the idea has gained ground that communities, the private sector and the local government can complement each other resulting in a more effective and efficient waste management system. Besides this, the participation of communities and micro- and small-scale enterprises can generate income

and employment in low-income urban areas and thus contribute to the alleviation of urban poverty (Lardinois, 1996). In some countries, especially in Latin America, this has led to the development of the concept of 'social privatization' in which micro- and small-scale enterprises, co-operatives and community-based organisations undertake the management and operation of waste management services in specific, especially in low-income areas. Motivated by social concerns as well as profit motives, they take over the role of the government because public services are absent in these areas or do not function properly. In other cases they undertake activities that are traditionally not pursued by the local government such as recycling (Moreno *et al.*, 1999). Social privatization thus broadens the concept of privatisation from merely selling public enterprises to the private, often large-scale, business sector to a concept where all non-governmental actors, whether small- or large-scale profit- or non-profit-oriented, working in high- or low income areas are considered partners in the city-wide waste management system, worthy of recognition and support.

To involve all these groups and to address the constraints they face requires a change in the attitudes of governments and politicians. The necessary changes are mentioned below under the policy and legal principles. That this is not an impossible task has been proven by many examples from Latin America (Moreno *et al.*, 1999).

6. Policy/Legal Principles

Technologies and systems should be supported by:

A legal framework that

- encourages involvement of non-governmental actors and the private sector
- supports decentralisation of tasks, authority and finance
- contains rules and regulations that are transparent and unambiguous
- enables impartial enforcement of rules and regulations

A policy framework at national and local level that

- encourages decision-making at the lowest level of authority, usually the municipality, regarding financial matters and selection of technologies
- gives waste management high priority both in policies and budgets
- recognizes waste management as an environmental health issue, which necessitates equity in service provision.
- recognizes the role of non-governmental actors and the private sector in waste management

- fosters accountability of decision-makers to ensure efficient use of public funds
- supports the 'waste management hierarchy' giving preference to waste prevention, source separation, re-use and recycling above mere collection and disposal. Policy measures that can be taken to put these principles into practice are listed in section 2.8.3(vi). But first we will elaborate to some extent on the use of these principles of ISWM in analysis and assessment (WASTE, 1999).

2.8.2 Using the Principles of ISWM in Analysis and Assessment

Not all the objectives and principles mentioned above will point in the same direction or go together harmoniously. Some may even be conflicting or contradicting (Lardinois, 1996; Hemelaar, 1999).

Examples are:

- The classical contradiction between the socio-economic principle of 'equity' and the financial principle of 'efficiency'. Can social concerns go together with a commercial and professional approach to waste management? Can CBOs carry out waste management services as efficiently as private enterprises? Experiences are mixed in this respect and appropriate training in financial and technical management could be crucial factors to ensure a good combination of both.
- Recycling could be the environmentally most preferred option but actual recycling takes place under degrading working conditions and it pollutes the air more than the use of raw materials. The solution here would be to take into account all emissions and impacts on the environment of the different options and to upgrade working conditions of the operators involved whenever possible.
- Locally manufactured equipment is not always of the best quality. The solution here would be to build the capacity of the local manufacturing industry.
- The best environmentally friendly solution could turn out to be the most expensive, especially when not all costs are internalized in (market) prices. Here it is of vital importance to use shadow prices and opportunity costs to make sure that all cost and benefits are put into the equation, including the cost and consequences of 'doing nothing'. The optimal solution seems to be the one which considers the highest number of aspects of sustainability. This confirms our earlier statement that a technology that is sustainable only from a technical point of view is less preferred than one that is also socially, environmentally and financially sustainable. The final choice remains a trade-

off between different aspects that can only be dealt with in each specific situation. This trade-off can be a rather complex exercise (van Beukering, 1999). Assessment of the degree of 'integrated sustainability' needs an analysis that uses a range of criteria, both quantitative and qualitative indicators, as well as a mechanism to weigh these different indicators against each other. Some examples of indicators of 'integrated sustainability' are given below (PAHO, 1995).

Technical: amount of waste collected by area of the city and per source

- durability of equipment
- existence of a separate hazardous waste management system
- existence of preventive maintenance procedures

Environmental: amount and percentage of waste recycled

- extent of pollution of air, soil and water (emissions, etc.)
- amount of energy and natural resources saved through recycling

Financial: degree of cost recovery

- overall cost of waste management services provided
- labour productivity (amount of waste collected per worker)

Socio-economic: service coverage (percentage of citizens receiving minimum required waste collection service, e.g. twice a week)

- working conditions (number and duration of sick leaves, health complaints)
- user satisfaction with the service by area of the city

Institutional: degree of formalization of informal sector (number of licensed CBOs, co-operatives, micro-and small-scale enterprises)

- existence of feedback mechanisms for citizens (complaint desks, etc.)

Policy/Legal: degree of decentralization of authority and funds

- height of budget earmarked for waste management.

By clustering these indicators, the different options available for the design (or improvement) of a waste management system could be given a rating on each aspect of 'integrated sustainability'. These ratings could be summed up and the total would thus indicate the overall 'degree of integrated sustainability' of the options available.

However, the question remains whether some aspects are more important than others, some might be 'necessary' while others just might be 'sufficient' conditions for 'integrated sustainability'. The question of which criteria are most suitable and which are appropriate needs to be answered (Gerlagh*et al.*, 1999). Besides there is the problem of comparing

quantitative indicators which can be expressed in absolute or relative figures with more qualitative indicators, which can only be given a ranking (e.g. user satisfaction) or a descriptive value. One of the first attempts to design a model to evaluate different waste management alternatives from an ISWM perspective has been carried out by Indian and Dutch economic researchers (Gerlagh*et al.*, 1999).

It uses a combination of linear programming model and multi-criteria analysis. Its goal is to minimize overall system costs and to identify low cost solutions. So their main indicators of sustainability are financial. Nevertheless, social and environmental parameters can be put into the model. There seems still a considerable amount of work to be done in this field. Different tools for analysis exist that should be evaluated for operating ISWM into indicator(Gerlagh*et al.*, 1999).

2.8.3 Measures to take to make Waste Management Systems more Sustainable and Integrated

I. Technical and operational measures

Waste reduction and prevention:

- gather data regarding quantities, types and sources of waste
- disseminate technical guidelines for waste reduction and prevention.
- gather data on waste generation and composition, area characteristics, haul distances, availability of spare parts and service facilities, etc.
- integrate storage, collection and transportation systems
- adapt collection frequency to waste generation and overall efficiency of the system
- improve maintenance capacity and establish a preventive maintenance programme
- establish a record-keeping and monitoring system to support continuous improvement of the system resource recovery:
- encourage waste separation at source through education and economic incentives
- gather data on types and quantities of recyclables generated, collected and recycled
- encourage resource recovery through tax and duty exemptions, land, credit, training, etc.

Disposal and treatment:

- gather data on types and quantities of waste arriving at landfills
- assess life expectancy of landfill

- investigate tipping practices (systematic disposal or not, covering, spraying, waste set on fire,existence of leachate and gases, etc.)
- assess technical performance of treatment facilities (energy recovery, incineration), if any

Handling of special and hazardous wastes:

- gather data on types, quantities and sources of hazardous waste
- explore existing practices regarding hazardous waste
- disseminate technical guidelines for sound hazardous waste handling
- identify possibilities for source reduction and replacement
- identify possibilities for separation at source and for separate treatment and disposal (van Beukering,1999).

II. Environmental measures

Rules and regulations:

- develop and enforce environmental legislation governing collection, disposal andtreatment of all types of waste, especially hazardous wastes.
- make establishment of a sound waste management system a prerequisite for new developments such as industrial estates, residential areas, tourist resorts etc.
- make an EIA obligatory before site selection of a landfill or a waste treatment facility

Environmentally sound practices:

- monitor amount of waste left in streets, empty lots, burnt in the open air, left in water courses, etc.
- monitor coverage of waste collection services and their frequencies
- cover all trucks during transportation
- monitor amounts of recyclables recovered and energy saved through recycling
- monitor amount of energy recovered through treatment plants, if any
- monitor environmental effects of landfills and waste treatment facilities
- control leachate and gases at landfills
- encourage resource recovery through awareness-raising, incentives, training, access to credit, etc.
- introduce waste exchange systems , e.g. for industrial wastes Education and awareness-raising:
- initiate awareness-raising programmes about waste reduction and prevention, resource recovery and hazardous waste handling.

- prepare guidelines for environmentally sound waste collection, disposal and treatment (WASTE,1999).

III. Financial measures

Budgeting and cost accounting:

- assess real costs of waste management systems including the 'costs of doing nothing' (increased cost of water treatment due to waste pollution, drainage problems, increased public health costs)
- increase transparency, accountability and fiscal discipline of local governments through training,incentives, codes of conduct etc.
- earmark local and national revenues for waste management

Revenue generating mechanisms:

- introduce user charges adapted to ability to pay and based on actual costs. These charges could be based on volume and/or type of service
- introduce gate fees for landfills, treatment plants and hazardous waste disposal
- introduce fines and penalties for persistent polluters
- improve revenue collection through simplified billing, better incentives for fee and tax collectorsetc.
- increase revenues from resource recovery (composting, energy recovery)
- increase access of local governments to capital (loans etc.)
- lobby central government
- harness customer willingness to pay cost reduction and control:
- encourage waste minimization at source
- encourage (social) privatization and community participation which is expected result to efficiency, gains and cost savings
- introduce performance related pay-schemes in local governments, preferably linked to efficiency improvements
- close monitoring and evaluation of performance; increasing efficiency whenever possible
- cost savings from improved maintenance, improved financial management and planning from waste exchange systems(PAHO, 1995).

IV. Socio-economic Measures

Monitoring public health

- monitor morbidity and mortality by caused waste-related diseases in different localities

Design of systems:

- prepare a plan to cover unserved areas with waste management services
- identify stakeholders and their interests in waste management (stakeholder analysis)
- prepare a social profile of areas to be served (household size, occupation, income, consumption patterns, attitudes towards waste handling, willingness to separate at source, willingness to pay, etc.) through social surveys, focus group discussions, key informant interviews and other techniques
- assess demands and needs of users (level and quality of services, etc.) through community meetings, social surveys and other social research methods

User participation:

- involve users in monitoring and implementation of waste management services throughneighbourhood committees, citizen panels, local councils, etc.
- establish communication channels between local government and users through complaint desks, information sharing, etc.
- raise awareness and mobilise communities to build a basis for collective participation, using clear and simple messages and popular channels of communication (such as television, radio, theatre, puppet shows, religious leaders, festivals and competitions, etc.)
- build capacities of low income groups to enable them to participate through training of leaders, involving them in neighbourhood committees, involving them as enumerators in social surveys, etc.
- develop linkages and trust among different groups of actors involved in waste management (local government, formal and informal private sector, NGOs, CBOs) through joint management committees, co-ordinating platforms, etc.

Social conditions:

- improve status of waste collectors by providing them with uniforms, ID cards, training, etc.
- improve working conditions of waste collectors by adapting the height of trucks, providing them with protective gear (gloves, boots), give them better tools, etc.
- identify number and type of waste-pickers in streets and at disposal sites and their workingconditions

- introduce measures to improve their working conditions and to raise their awareness of health and hygiene conditions (e.g. introduce special sorting area on landfill, provide them with protective wear, water and sanitary facilities)
- improve income-earning potential of the informal sector through tax exemptions, import duties on raw and waste materials, training, access to credit, help them form co-operativesetc (WASTE,1999).

V. Institutional and administrative measures

Institution building:

- consolidate waste management functions under jurisdiction of one single department
- make a clear division of roles and responsibilities in waste management
- establish transparent procedures for competitive bidding and contracting out of waste management services
- improve organization of the informal sector and increase its integration into the formal wastemanagement system by recognizing it, allowing it to participate in tenders and contracting

Organizational development:

- adjust pay-scales and incentive systems and make them dependent on performance
- develop recruitment and promotion procedures based on merit and performance
- install a transparent system of rewards and penalties

Human resource development:

- assess skills and educational levels of waste management staff within the local government and define training needs
- prepare a training programme to promote the concepts of ISWM (WASTE,1999).

VI. Policy and legal measures

Planning and policy:

- decentralize responsibility for waste management decisions to the local level, including decisions on finances and discretion over earmarking of budgets
- develop a waste management strategic plan for cities and neighbourhoods (including problemanalysis, goals, measures to be taken, organization, private sector involvement, etc.)
- make equity an explicit goal of waste management strategies
- make waste management a high priority in policy and funding decisions

- give policies a long-term orientation and make them predictable and not subject to sudden changes

Regulatory framework:

- establish unambiguous and effective bye laws and ordinances for waste management
- replace legislation that is contrary to ISWM principles (e.g. laws that inhibit private sectorparticipation or that are hostile to the informal sector)
- establish unambiguous and effective regulations and procedures for private sector participation and clear standards for evaluating tenders
- strengthen the legal enforcement and inspection structures
- allow civil society and media to play their role of watchdogs

The measures described above give some ideas on how to make waste management system more sustainable. Their relevance depends largely on the local context. A thorough problem analysis is needed to first determine the main problems inhibiting sustainable waste management systems and the resources available. Then it can be determined what should be done to change these conditions, possibly using some of the measures mentioned above. Generally speaking, decisions about waste management options should also take local resource constraints and concentrate on what is possible in the given context rather than on what should be. These resource constraints can be financial but can also include expertise, authority, political clout, historical character, civic spirit, etc. (IETC, 1996). This section gives an overview of the policies and mechanisms which can be applied to advance the principles of ISWM in practice, based on planning and project experience from all over the world.

The challenge is how to combine them in a consistent manner in a waste management plan so that they have the desired effects on sustainability and integration of waste management. Another challenge is to address the political issues related to waste management. Which stakeholders have an interest in promoting certain policies and measures and themeans does each stakeholder has to influence decision-making and co-operation with other stakeholders? Such issues refer to the ‘politics of waste management’ and to empowerment of local communities and small-scale informal enterprises in the public arena (van Beukering, 1999).

2.9 Waste Segregation

Segregation or Separation at source refers to the practice of setting aside post-consumer materials and household goods so that they do not enter mixed waste streams. The purposes of waste segregation are recycling, reuse, improved waste management suchthat different processes- composting, recycling or incineration can be applied to different kinds of waste, create incentives, improve the aesthetics of the environment, promote public health etc. The concept was coined in affluent societies during the 1980s in contradistinction to the recovery of resources for recycling from mixed post-consumer waste in plants called materials recovery facilities (MRFs). It is an important step in the 'hierarchy' of solid waste management practices.

Goods and materials usually diverted from domestic waste streams by source separation include:

- Reusable items (such as clothes and accessories, utensils and appliances, containers, books and magazines)
- Materials which are usually regarded by the primary consumer as wastes (newspapers, scrap paper, cardboard and boxboard, broken, irreparable plastic items such as buckets and basins, food and drink cans and containers);
- Organic matter (such as food wastes, organic residues and garden wastes);
- Toxic and hazardous wastes that are dangerous in landfills (such as biomedical items and pressurized cans) (Lardinous and Furedy, 2012).

Occupational safety can only be maintained if the risks from the materials are defined, identifiable and the resulting counter measures are taken. By this, the risk of injury and incidents can be minimized in a cost effective way. Recycling can only be carried out if recyclable materials are separated from the hazardous waste (contaminated materials are excluded from any recycling activity and must be treated as mixed hazardous waste). To guarantee a high quality of the recycling materials it must be collected in at source. Mixed waste will decrease the possible income. The separate handling, treatment and disposal of different kinds of hazardous and non-hazardous waste in different ways will drastically reduce costs. Only the different kind of hazardous waste will be treated and disposedoff in a costly way instead of the entire waste stream in a hospital. Segregation is the key to any effective waste management! Without effective segregation system, the complete waste stream must be considered as hazardous (CETH, 2002).

2.10 Definition of a Household

The concept of a "household" differs among countries and even among researchers within a country. In order to maintain consistency the definition created by the United Nations (UN) and documented in their report United Nations: Principles and Recommendations for Population and Housing Censusewas adopted. A household is defined as: "Either a single-person household, wherein one person makes provision for his or her own food or other essentials for living without combining with any other person to form part of multi-person household or a multi-person household, defined as a group of two or more persons living together who make common provision for food or other essentials for living. The persons in the group may pool their incomes and have related or unrelated persons or a combination of persons both related and unrelated (GATS, 2010).

2.11.1 Practiceof Household Waste Segregation

1. Keep separate containers or bags of different colours for dry and wet waste in the kitchen.
2. Keep two bags for wet waste collection and one bag for dry waste collection.
3. Keep plastic from the kitchen clean and dry and drop into the dry waste bin. Keep glass /plastic containers rinsed of food matter.
4. Send wet waste out of the home daily. Store and send dry waste out of the home, once a week.
5. Keep a paper bag for throwing the sanitary waste

2.12 Characterization of Waste for Segregation at the Household

i. **Dry Waste**

- Anything that can be kept for a period of two or three weeks without decomposing. Make sure that plastic sachets of milk, curds, oil are cleaned of all their contents and dried before being put in the dry waste bag to prevent odour. Clean dry waste will not attract any vermin. Store such waste in a bag in the utility area after cleaning and drying till it is picked up. Examples of dry waste include paper, plastics, metal, glass, rubber,styrofoam, fabric, leather, wood etc(Shridhar*et al.*, 1985).

ii. **Wet Waste**

Wet waste consists of kitchen waste which including vegetable and fruit peels and pieces, tea leaves bags, coffee grounds, eggshells, bones and entrails, fish scales as well as cooked food. These could be used for home composting in daily dump spots or in aerated containers. Where this is not feasible, such is collected daily or once in every three days to prevent odour nuisance((Shridhar*et al.,* 2009).

2.13 The Principles of Segregation

- The correct segregation is the clear responsibility of every waste generator, independent of the organizational position of the generator (Duty of care principle).
- In case of doubts regarding the waste group, the precautionary principle must be followed. That means if a classification of the waste is unclear or not recognizable; the waste must be classified in the highest risk group.
- The segregation should be carried out by the producer and close as possible to the place of generation. That means segregation must take place at source e.g. at the ward, at the bedside, operation theatre, laboratory etc. and must be carried out by the person generating the waste e.g. nurse, physician. This is what is called the proximity principle.
- The segregation must be applied from the point of generation, during collection, transport, storage and final disposal.
- Every place of generation should have the necessary equipment for the types of wastes that are generated at that place like bags, bag holders, containers etc.
- Segregation and identification instructions should be placed at each waste collection point. Segregated waste should not be mixed during transport and storage.
- If hazardous and non- hazardous wastes are mixed the entire mixture must be considered and treated as hazardous waste.
- Correct segregation will only be achieved through a rigorous training of all hospital staff and waste generators inside the hospital (this includes patients and visitors).
- The segregation should be carried out first under the "polluter pay" principle and second under the "precautionary" principle. This means the generator must segregate as good as possible and shall only in unclear situation follow the precautionary principle(WASTE, 2005).

2.14 The Planning of Segregation

For the planning of the segregation, some necessary information and facts are needed to ensure a proper waste management in the health care facilities:

- Kinds of waste generated in each department (because departments generate different kinds of waste) so as to be sure of which kinds of bags/containers to be used for the segregation (depending on the waste hazard, treatment and disposal)
- The place where the different kinds of waste are generated. Who generates the different kinds of waste so as to fix the segregation points as near as possible to the point of generation.
- How many of the different kinds of waste and how much are generated. This will help to calculate the needed size and quantity of bags and containers to ensure proper supply of bags/containers.
- If peak times of generation exist so as to ensure the supply of bags and container during the peak times.

The quality of the segregation system will depend on the quality of the segregation concept and quality of the implementation of the concept(WASTE, 2005).

2.15 Colour Coding of the Segregated Waste

Colour coding means the combination of different waste groups with "similar" hazards or characteristics in one main group and to identify that main group in a fast and easy way by a fixed colour. The different waste groups have different colours for the containers and bags for their identification according to the hazards and is applied throughout the complete disposal chain (segregation, collection, storage, transport and disposal):

- Warning colours for hazardous waste (Red, yellow, orange)
- Positive colours for recycling (Blue, green etc.)
- Neutral colours for normal waste (Black etc.)

The colour coding makes the process understandable even for low-skilled workers with language and reading problems(Shridhar*et al.*, 2009).

2.16 The Packaging of the Segregated Waste

Different kinds of waste need different packaging due to the different risks created by the waste. The chemical characteristic of the waste must be obtained. Some chemical solutions can dissolve plastic bags and must be collected in metal containers or glass bottles. The packaging of infectious waste should be done with good quality or other strong materials.

The use of bags with closable bag holder or bins with lid is recommended. The containers for hazardous waste must be puncture proof and sealable. For the identification of the risks, the United Nations packaging symbols should be used(WASTE, 2005).

2.17 The Labelling of the Segregated Waste

The labelling of the waste is absolutely necessary, for the identifying, monitoring, controlling and record keeping of the different waste groups along the entire waste stream. At least all yellow and red waste bags or containers should be labelled with the basic information on their content and on the waste producer. The labels should be clearly, legibly and durably marked with the following information:

- Name of the producer (if applicable) department
- Waste classification, date of production
- Special remarks
- Waste volume-waste destination(WASTE, 2005).

2.18 Planning of Segregation Points

After mapping out the premises into different sections in case of large premises, each section should have its segregation point installed. For example in research laboratories, nearly all kinds of hazardous waste and non-hazardous waste will be generated regularly. For this, segregation points must contain possibilities to collect nearly all waste groups. (Waste streams of a research laboratory) “Segregation point” is the point where waste generators can place the different kinds of separated waste in different waste bags. For each regularly generated waste group, a different receptacle can be found. The choice of the kind of waste that will be collected will depend on the processes carried out in the specific section. Depending on the size of the section, one or more segregation points must be installed. In every section, segregation and identification instructions should be available to the generators to help them decide how the waste must be segregated. Additionally, above the segregation point, an easy to understand short instruction should be put(WASTE, 1999).

2.19 Information Needed for Planning Source Segregation

To achieve the desired goal of waste segregation at the source, proper planning is required.For an efficient segregation the following information will be needed:

- The kind of waste that will be generated at the point
- How the waste is generated (proceedings).
- Volume of waste that will be generated per day.
- The frequency of collection.
- The kind of segregation equipment available.
- Where to place the containers, bins, bags etc.

2.19.1 The Master Plan of the Points Must be Recorded

The results should be recorded in a waste management manual. Based on the results, an analysis can be carried out. The analysis should show the following points:

- Non-hazardous waste: (e.g. domestic waste, paper, plastic)
- Hazardous waste: (e.g. infectious waste, sharps, cytotoxic waste)
- Waste generation according to official proceedings: XX kg/day of Group A, etc. (or: Waste generation is unknown, as there are 5 x 3 = 15 beds about 20 kg are expected (= about 100 litres))
- Collection: Cycle time (e.g. non-hazardous twice, hazardous once per day)
- Equipment: Available equipment for this sector (e.g. black and yellow plastic bags, used disinfection containers, no red bags, no orange bags)
- Segregation point strategy: Where is which kind of waste collected? (e.g.Hazardous waste at the nurses' station, domestic in the patient rooms) Important: Hazardous waste and non-hazardous waste should not be collected together at one segregation point. Hazardous segregation points should be out of reach of patients and visitors. Based on the above information and analysis, the detailed planning can be carried out.
- Each patients room gets a small black bag in a container which will beemptied in a big black bag at the nursing station once a day. Size: Small - 20 litre, Big 2 x 60 litre. Medical disposables will be collected in a cardboard box (with big orange marks by a pen).
- Hazardous waste will be collected at the nursing station: 1 container for infectious waste (20 litre), 1 container (used fixing bath container) for sharps (collected twice a week), Pharmacy will take back pharmaceutical waste once a day.

- Needed equipment per week: 5x7=35 small black waste bags, 2x2x7=28 big black bags, 1x7=7 yellow bags, 2 containers, 2cardboards.

The detail planning should be recorded in the waste management manual. The theoretical calculation must be adjusted on the practical need. For this, an inspection of the segregation points should be regularly carried out. If necessary, the plan must be adjusted(WASTE, 1999).

2.20 Modes of Separation at Source

Customary practices: separation and trading that have persisted over many decades.

Collectively organised interventions (hereafter called 'organized'): interventions of governments or non-governmental organisations promoting or requiring the separation by waste generators of manufactured materials and or organic wastes (Lardinois*et al.*, 2012).

2.20.1 Customary Practices

Gift, barter and sale of post-consumer materials have been known in all societies. They persist on a considerable scale in resource-scarce economies today where attitudes of thrift are significant. This source separation is linked to systems of charity, trading and recycling, whereby re-usable and recyclables reach markets and manufacturers. In free market economies, these activities are largely undertakings of the private sector (both formal and customary).In China, at least until recently, the main trading and recycling undertakings were government-run.Cities that have extensive customary systems of both reuse and recycling (which incorporate both manufactured materials and organics) are generally characterized by:

Scarcity or high cost of primary materials

- Diversity of manufacturing industries, large and small;
- Substantial level of poverty, with social groups associated with waste work and, or numbers of recent migrants seeking work
- Tolerance of itinerant vendors and buyers (often linked to police corruption)
- Domestic animal husbandry and intensive farming in peri-urban areas and the use of artificial fertilizers.

In customary systems, the types of materials separated are determined by needs of charities, trading operations, industries, markets and even by religious observances. For

exampleubiquitous itinerant buyers in Indian cities purchase newspapers and magazines, plastics, pieces of metal, bottles and leather from householders. In Pakistan however, for religio-cultural reasons including Islamic dietary rules, the same buyers also buy stale bread which is traded for cattle feed (Ali, 1997). There are regional differences in how domestic materials are passed on. Clothes are traditionally bartered in exchange for household items such as utensils or kitchenware in South Asia.The buyers are usually organisationally distinct from the itinerant buyers of other post-consumer materials. Itinerant buyers of clean materials, in large Asian cities are almost always men. In Vietnam, the entry of many women into this trade came about during the Vietnamese war when most men were doing military service (Mehta and Satyanarayana, 2011).

Most municipal solid waste departments have little awareness of the customary system of separation and trading and usually do not perceive these practices as reducing the quantities of wastes to be officially collected and disposed of. They do not always regard the customary sector as stakeholders in solid waste management and they are not always aware of the changes taking place in large cities that tend to erode customary systems (such as bylaws restricting waste traders and itinerant buyers) Organized interventions often aim at changing the views of municipal managers.

2.20.2 Collectively Organized Systems

In the North, organized systems are predominantly concerned with obtaining materials for recycling and composting. The exceptions are government-mandated buy-back of certain items such as some soft drink bottles and lead batteries, and the collection for reuse sponsored by non-profit organisations. Separation and collection of materials is usually municipally financed and sometimes nationally mandated. The two main modes of collection are drop-off and curbside, i.e. collection at the side of the household, shop or institution. The three main variations in these collections are: 1) recyclables and residual wastes; 2) organics and recyclables; and 3) organics, recyclables and residual wastes. Voluntary organisations may play a role. The number of categories into which waste generators are asked to separate differs. Some Japanese cities ask householders to keep nine different categories for separate collection (Le, 1995). Cities that collect mixed recyclables rely on materials recovery facilities (MRFs) to sort out different components. These plants are also used to process materials from separate collection. There are about 1,200 MRFs operating in the USA (Newell, 2005). In the South, organized systems have more often started with voluntary projects by NGOs, individuals or educational institutions.

These interventions are linked to the encouragement of recycling or improvements of the status and conditions for waste workers. China, from the 1950s to the late 1980s, represented a government-organized system of the South: waste-buying centres accepted almost every type of recyclable including broken glass, rags and toothpaste tubes (Furedy, 1990).

2.20.2.1 Reasonsfor Interventions under Organized Systems

The reasons for carrying out an intervention to improve source separation among others are basically economic, environmental and social. Others includes

- Improvement of MSW collection and disposal (reduction of amount to be disposed of, environmental safety);
- Improved quality and reduced costs of materials for reuse or recycling (including organics for composting);
- Better working conditions at all stages;
- Improved access to resources by those earning a living from waste recover, (mainly, better earnings and upward mobility of waste pickers);
- Efficient treatment and reuse of organic wastes.
- High-income cities of the North have been more interested in reducing quantities for disposal and curbing environmental pollution(Lardinois and Furedy, 2012).

There have also been pressures from environmental groups for a commitment to recycling (Oskamp, *et al.* 1991),(Newell, 2005). In Latin America, one finds a mixture of institutional motives. In Argentina, landfill space has not been seen as a problem as much as environmental quality. In Brazil, waste reduction and recycling have been encouraged in some cities because of environmental reasons. In Colombia, programs to allow waste pickers to become collectors of source separated materials were set up when picker access to some large dumps was forbidden (Benavides, 1996).In Asia, social motivations (improving the status of waste pickers) were prominent in the early 1990s (Huysman, 1994). But concerns about landfill space are increasing. Almost every large city including Colombo, Manila, Bangkok, Bombay and Guangzhou is short of dumping land. An interest in better access to recyclables on the part of waste traders has been important in Manila (Lapid, 1997.). Reducing the contamination of the organics in municipal solid waste so that they can be more easily composted has been mentioned for Bangkok (Sambaraju*et al*, 1997). The only Southern country to launch a national programme for waste recovery is Malaysia where lack of land for dumping has generated official interest in waste minimization and diversion. The programme, announced in

1993, has however been vigorously pursued in only one municipality of Kuala Lumpur - Petaling Jaya - since 1996 (Noor, 1997). National mandating is being discussed in Argentina. It is only in Southern countries with high levels of general education that environmental values have been of great importance in the initiation of numerous source separation schemes (for instance in Argentina and Colombia). Other factors that have influenced collectively organized schemes in Southern countries include:

- Top-level management or prominent citizens aware of international thinking about waste management (e.g. Bangkok, Madras, Manila, Kuala Lumpur, Cairo, Rio de Janeiro, Buenos Aires, Bogota);
- Social organizations or local governments that wish to link source separation to employment generation or the improvement of status of waste workers (Bangalore, Chiang Mai, Kathmandu, Belo Horizonte, Porto Alegre) (UNEP/IETC, 1996).
- NGO experiments in primary collection systems with door-to-door collectors responding to internationally-aired environmental values (Rajkumar, 1997). Places which have had success in launching organized schemes are of considerable interest for understanding the motives of waste generators and possible institutional incentives which could be relevant for other cities.

2.20.3 Motivations at the Household Level

To sustain separation practices and support separate collection protocols, high-income cities operating source separation systems rely upon a combination of civic commitment, environmental consciousness, convenience of deposit, public education, mandation and enforcement (Oskamp*et al.*, 1991). In Southern cities, the capacity to draw upon such motivations and to provide suitable incentives is weak. Consequently, there is now an interest in understanding why people participate in customary practices, how far they would be prepared to adopt or extend separation and whether altruistic motives (associated with civic concern and environmental awareness) are on the increase.

Empirical research on factors that influence the propensity to source separate is minimalbut pilot studies and discussions among experts suggest the following factors influence the propensity to separate at source:

- **Habit:** there is some evidence that householders in customary systems separate and sell materials "because it has always been done" and without further reflection upon the practices (Furedy, 1995).
- **Frugality or thrift:** this reinforces economic incentives for separation (Ali, 1997).

- **Religio-cultural factors:** for instance, Islamic injunction not to waste bread (Ali, 1997)
- **Charitable motives:** middle and upper income households in cities having a large number of poor residents usually make donations of clothes and household goods to charities (Furedy, 1995);
- **Socio-economic status:** there is some evidence for Karachi and Bangalore that low-income households sell relatively more of their post-consumer household materials than affluent households (Furedy, 1992)
- **Status and wages of household servants:** where servants demonstrate an interest in these resources, separation is enhanced (Ali, 1997)
- **Space in the household:** householders in crowded dwellings find space a constraint on separation if storage is necessary, but if sale of materials to itinerant buyers is convenient and frequent, lack of space can be an incentive for separation (Le, 1995).
- **Convenience of disposing of separated materials:** a survey in Hanoi found that daily collection of separated organics was considered more important than incentives such as free bins or even payments (Le, 1995); as economic incentives decline convenience of deposit becomes more salient (Furedy, 1988)
- **Environmental education:** if education does not specifically address solid waste there isunlikely to be any effect on waste behaviours; specific school education can affecthousehold habits (De Luna Era, 1996)
- **Gender:** studies in Pakistan, Bangladesh and Ho Chi Minh City found women weremore involved in source separation than men of the household (Du, 1995, Beall, 1997).

2.20.4 Issues and Dilemmas

Intervention in a society's long-standing waste practices is difficult. The generation and use of wastes are related closely to consumption patterns, industrial demand, agricultural markets, socio-economic status, the availability and cost of labour, local government capacity and even international markets in primary and secondary materials. Cities thinking of introducing source separation have to consider the cost of publicly-organized collection and sale, the local capacities for recycling, and other economic and managerial factors. Collectively organized systems, whether public or privateneed to develop incentives and educate waste generators. Some of the issues and problems in source separation now being discussed are briefly noted here.

2.20.5 Cost Concerns of Municipally-Organised Separate Collection

Municipal managers and the general public are interested in how much the introduction of a new management system will cost especially in comparison with their current system. Understanding the cost of source separation programs is complicated by the general difficulties of knowing the costs of all the components of municipal waste management (Levine, 1996) including avoided costs associated with the reduced need for disposal in landfills or dumps. If avoided costs are not factored in, source separation systems cost more than conventional collection and disposal because the revenue gained from sale of materials or compost is not sufficient to offset the added expenses. Whether or not separation at source systems are very costly to run depends in the first place on how the separated materials are collected. Centralized drop-off and buy-back systems are usually cheaper than door-to-door (or curbside) collection.
Drop-off systems however have several disadvantages:

- Fewer materials are obtained because residents find dropping off inconvenient;
- Drop-off containers are usually not suitable for organic waste;

  There is difficulty finding locations for drop-off points as residences and shops may object to these being beside their buildings;
- The drop-off points may become unsightly or attract rodents, dogs etc.
- People may deposit non-eligible items in the drop-off containers;
- In some cities the drop-off points are raided to supply waste traders.

Most cities have not been able to obtain significant amounts of materials via drop-off pointsand have added door-to-door collection to the system. If this collection is in addition to the collection of residual waste, it may nearly double (in the case of two extra collections, one for recyclables and the other for organics) collection costs. Other costs include those of educating the waste generators on effective separation, training staff, and, possibly, supplying special vehicles as well as building and running sorting and marketing centres.

Against the extra costs of collection must be set the savings in avoided costs: e.g. disposal land costs, the construction and management of sites and environmental damage. It is increasingly recognized in Northern countries that avoided costs can be a significant portion of the net cost equation. In Toronto for instance, landfill disposal costs CA$50 per tonne but if the cost of constructing new landfills is factored in, the disposal costs about CA$85 per tonne (Maclaren, 1997).In Southern countries, there may be no sound way to currently estimate avoided costs. On the other hand, avoided costs may be undervalued, failing to capture the significant envi-

ronmental costs of open dumps and inadequately constructed landfills.Cities with little prospect of obtaining further land, or where strong environmental awareness supports the avoidance of pollution from solid wastes, however, often are willing to meet the costs of organized separation systems. The materials collected and the degree of municipal involvement in processing also affect costs. The prices obtained for some materials such as paper and cardboard vary with international markets while compost made from urban organic waste may have little or *no*market value but may be usable in city parks.In developing countries where customary systems of separation and trading are extensive, the recyclables gained in separation programs will be of much less value than the post-consumer materials that householders trade privately, consisting largely of thin plastic bags, broken glass, broken hard plastic items, etc.(Lardinois and Furedy, 2012).

There is much emphasis now in Northern countries on reducing the cost of source separation systems, since many cities that introduced these systems have had to cut back on them due to the unacceptably high cost. There are some examples of smaller cities and towns that have managed to set up separate collections systems at little extra running cost compared with conventional mixed collection. This is the case for Guelph, Canada (population: 100,000) where collection costs have been reduced (although they remain higher than forthe previous system) by supplying special vehicles with compartments for recyclables, organic waste and residual waste, having one pass only to pick up the separated wastes and reducing the size of collection crews to one person (Barton, 1997). There are ways to enhance drop-off collection such as involving neighbourhood committees at street level management as is done in many Japanese cities. Buy-back requirements (e.g. deposit-for-return bottles) are another way of diverting recyclables from collection.In deciding about a separation program, cities have to bear in mind that the costs of small pilot experiments may not be indicative of the costs of going to a full-scale, city-wide separate collection system(Lardinois and Furedy, 2012).

To the extent that municipalities have established source separation systems in developing countries, small- and medium-sized cities appear to have been more successful in setting up and maintaining them than large cities. Buenos Aires abandoned its collection ofmaterials because of the high cost (Benavides, 1996). Bangkok's first attempt to introduce separate collection failed although another initiative is now being planned (Maclaren, 1997). A number of municipalities in Malaysia that initiated source separation under the national recycling programme in 1993 have had to give it up (Noor, 1997).

2.20.6 Municipally-Organised Collection vs. Existing Customary Operations

If governments or NGOs institute systems of source separation without reference to the existing trade in post-consumer materials, there may be effects upon prices, wages, resource availability and jobs for private traders and recyclers. The largest intervention in market prices occurred in China from the 1950s to late 1980s. Prices for recovered materials of all kinds were set by a central government ministry and strict control was also exercised over the regional trade in materials (e.g. waste paper). The pricing system was unresponsive to fluctuations in supply and demand. An informal and illegal, parallel trading system emerged (Furedy, 1990; Tay, 1996).

The socio-economic implications of interventions may also be problematic. If materials are diverted from waste pickers or poor itinerant buyers to government departments or voluntary organizations, how is the loss of work and income by these workers to be dealt with? This issue is being debated by NGOs involved with the welfare of waste pickers especially in South Asia (Shah and Lardinois, 1998; Furedy, 1998).

Other factors to be considered are the capacity of solid waste departments to train staff, educate the public and adequately monitor the costs and effectiveness of the new system. The role played by committed and efficient NGOs or even institutions such as universities may be significant in supporting municipalities in undertaking a new waste management system. Lack of such support should be a cautionary signal to municipal waste departments.It is rare for city governments in the South to consider the option of, in the first place, strengthening and extending customary separation and trading practices. At the least, the customary system should be well understood before municipal systems are undertaken(Lardinois and Furedy, 2012).

2.20.7 Special Problems of Organic Wastes

If substantial quantities of municipal organic wastes could be diverted from disposal in the developing countries, this would bring greater gains for municipal management in many cases than further source separation of dry materials. This is because compostable materials constitute a significant proportion of municipal solid waste in most cities of developing countries (UNEP/1ETC, 1996).Further separation of the common household post-consumer manufactured materials however, does not provide a solution to the organic waste problem because it does not result in organic wastes that are pure enough for good composting. To achieve the desirable qual-

ity of organic wastes, very meticulous separation of organics is required through wet/dry separation protocols. This entails education of waste generators, special containers and often expensive collection vehicles.

Although composting of various kinds can readily be carried out in many cities, the production of safe compost is more expensive than simple dumping (Lardinois, 1998; Furedy *et al.*, 1999). There are numerous problems of marketing the products (Lardinois, 1994). Absorbing urban organic wastes on a significant scale requires multi-sectoral planning and solid waste management departments usually are unable to prompt such broad policy recommendations (Furedy, 1990). Small-scale decentralized composting is being tried on a pilot scale in cities such as Nairobi, Bangalore, Jakarta and Quito (Karanja, 1998). The impact of such interventions on solid wastes for final disposal is yet to be determined. Decentralized composting projects (including vermicomposting) may be more useful for their educational value than for their contribution to reducing quantities of solid wastes for disposal.

2.20.8 Incentives and Education

In customary systems, householders sell or barter common materials, and economic motives are significant even for middle-income families (Beall, 1997). Religious and cultural values reinforce economic incentives.Under organized systems, source-separation may be required by law with penalties for non-cooperation such as fines or suspension of collection service. But whether source separation is mandatory or voluntary, waste generators have to be educated on procedures and incentives/disincentives have to be built into the schemes. Some of the incentives offered under organized systems in developing countries have been: appeal to global environmental values; improvement of neighbourhood environs; door-to-door collection of all wastes; exchange of wastes for transit tickets/food and gifts of compost from composting projects.Providing incentives for sustained, careful separation of organics is not easy. How many bags of compost can the average household absorb for instance? Gifts of transit tickets may undermine the profits of transit companies. The cost of public education and of monitoring are usually high, as initial training of educators and functionaries is necessary(Lardinois and Furedy, 2012).

2.20.9 Overview of Separation at Source Case Studies

The following diagram shows the relations of source separation to other forms of resource recovery under customary and collectively organised systems.

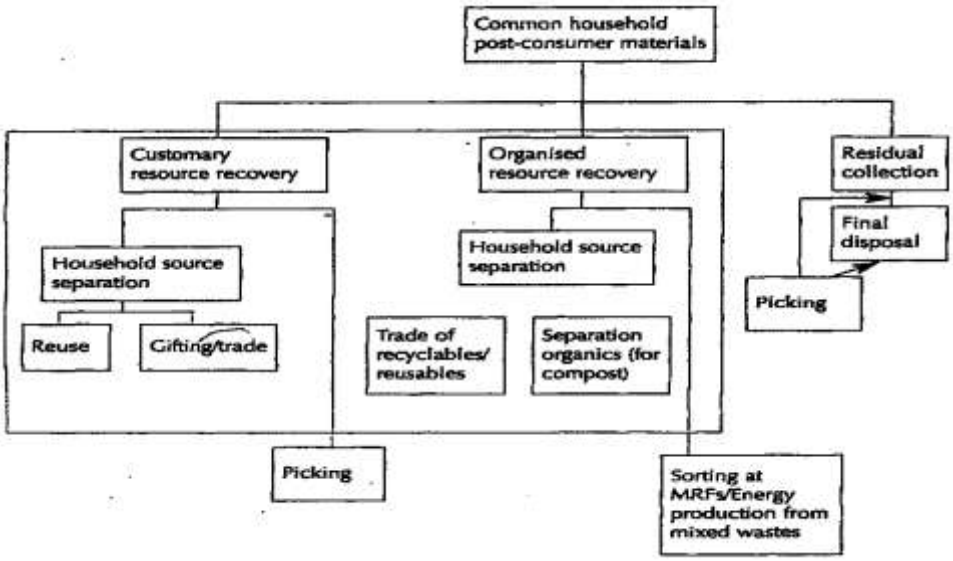


Figure 2.3; Resource recovery of common household post-consumer materials(Lardinois and Furedy, 2012).

Although conventional waste management approaches still dominate in low- and middle-income countries, national waste management policies are increasingly promoting environmentally sound approaches for example in the Philippines and in Colombia. Because many municipal waste management systems were inefficient in the past, NGOs and CBOs have been implementing various forms of primary collection and recycling schemes including source separation. Examples of such initiatives can be found in India, Indonesia, the Philippines, Thailand, Pakistan, Egypt, Mali, Senegal, Kenya, Tanzania, Brazil, Peru, Colombia and Costa Rica to name some of the main countries.

Besides emphasizing environmental goals, more attention is being paid to social aspects. In low- and middle-income countries, the magnitude and impact of existing customaryresource recovery systems is more and more acknowledged. In particular, strategies are being developed mainly by NGOs and church organizations to allow roles for waste pickers and recyclers in municipal waste management systems. Sometimes, waste pickers have been incorporated in separation at source systems for example in Calcutta and Bangalore, India, and Porto Alegre and

Belo Horizonte in Brazil (Furedy, 1 998). The aim may be to transform pickers into collectors or to reduce the time they spend in picking by providing alternative work.

In low- and middle-income countries separation at source systems are rarely implemented by government authorities. The Brazilian and Argentinian cities case studies provide interesting exceptions. In Brazil, around 80 municipalities have implemented separation at source systems. In Argentina, the system particularly involves small municipalities with fewer than 50,000 inhabitants. The striking difference between the Brazilian and Argentinian cases is that, in Brazil, separation is directed towards the recovery of recyclable materials while in Argentina, the prime focus is on organic materials for composting. In other Southern countries, one finds NGOs involved in separation at source projects that combine social and environmental goals although large differences exist in the approaches followed (Furedy, 1998).

The customary system is found in Pakistani cities like Karachi and Faisalabad and various forms of collectively organized projects and systems ranging in scale from city neighbourhoods to national systems. The following table summarizes the scale, initiators, main implementers and actors in the case studies. It does not only include the stakeholders involved in financing of the scheme. Households have not been included either since their role is evident and basically the same in all systems (Furedy, 1998).Table 2.3 gives an overview of the types of waste materials that are separated in each case. As can be seen, while all cases include common dry items and materials from households, organic wastes are collected only in Pakistan (stale bread only), the Netherlands and the projects and municipalities discussed in India and Argentina. Naturally, residual waste is generated in all cases.

Table 2.2; Stakeholder involvement in separation at source cases studied

Country (No. of cities studied)	Mode	Scale	Initiator	Main Implementers	Other main Stakeholders (excluding funding)
Pakistan (2)	customary	city wide	self	itinerant buyers, Traders	
India (1)	organized	neighbour-hood	NGOs	CBOs,	Itinerant Buyers
Philippines (1)	organized	city wide	NGOs	itinerant buyers, traders	Government Authorities
Argentina (5)	organized	city wide	universities, NGOs	municipalities	Eco-clubs, Schools
Brazil (16)	organized	city wide, neighbour-hood and 'closed[7]	universities, NGOs	municipalities, CBOs or other organised	Cooperatives
Netherlands	organzsed	national	government	municipalities	Recovery centres, NGOs

Table 2.3; Type of post-consumer materials separated in the cases studied

Country	Recyclables (for reuse and Recycling	Organic waste	Hazardous waste	Other
Pakistan	X	X (stale bread only)		
India	X	X		
Philippines	X			
Argentina	X	X	X	yard waste
Brazil	X			
Netherlands	X	X	X	Bulky waste

(Furedy, 1998.)

While it may seem obvious that source separation should be promoted, it is by no means clear what interventions are advisable. How far should governments or NGOs introduce source separation? How far should customary practices be left alone? City solid waste departments usually lack the resources and expertise to intervene effectively. The voluntary organisations interested in promoting source separation may have little connection to or credibility with municipal government. The most rational policies may conflict with social concerns, as for the welfare of waste pickers. There is therefore a need to understand the local economy and political environment before committing large resources to source separation programme.

Several studies have shown the Environmental hazard and public health risk associated with poor and inappropriate solid waste management such as water contamination and pollution, air pollution, soil pollution, climate change, eutrophication, proliferation of disease etc. (Adedibu, 1983; Egunjobi, 1986, 1992; Akintola, 1987; Ogu, 1987; Ipadeola, 1988; Olokesusi, 1991 Nwude, 2006 Ukpong, 2006 and Osse, 2006). The high rate of waste generation tells us how source reduction as a waste management method is essential.(Gourlay, 1992) argued that by focusing on the production process itself, examining where wastes are generated and exploring how they can be reduced, even simple measures such as separating wastes so that they can be reused more easily, using different raw materials or replacing non-biodegradable products with biodegradable ones, can help achieve large waste reduction results. He also claimed that the greater part of present waste arises not because the producer does not want it but he fails to use it, or at least use it in such quantities that waste is inevitable. This argument places emphasis on recycling and conversion of waste as important solid waste management practices.

Waste segregation is achieved when waste or materials are separated or separately kept together based on their similarity in properties whether physically, chemically or biologically to fast tract waste handling, treatment and ultimate disposal. Segregation of waste of varying categories e.g. non-infectious ,sharps, pathological waste(most importantly those potentially capable of transmitting infection), regular waste, hazardous waste and low level Radioactive materials from where they are generated may be essential to prevent the heterogeneous mixing of incompatible waste. Segregation facilitates the disposal of waste to specialist outlets. The generator of the waste should be responsible for its segregation. To achieve a successful implementation of waste segregation, personnel of several institutions need to be properly educated on what health care waste is and its classification. Staff of the institution must also know the purpose of segregation and the type of waste the different

colours of containers or bags ought to contain, their location and the use of each segregated waste (WHO, 1999;Cookey,2005).

There should be laid down plans and policies for waste segregation. Institutionalizing waste segregation within health care facilities to separate biological and chemical hazardous waste will generate a clean solid waste stream for easy recycling. Where adequate segregation is attained with proper training, clear standards and strict enforcement, available resources could be channelled to the management of the proportion of waste that requires special treatment (Sridhar, *et al*, 2009).

In most section of India, a lot of people ultimately salvage re-usable or marketable material from waste and exchange them for a price, e.g. newspaper, glass bottles, empty tins, plastic bags, old clothes etc., and as such , these reusable / recyclable waste materials are not discarded for disposal. Nevertheless, much of recyclable dry solid waste material such as waste paper, plastic, broken glass, metal, packaging material etc., are not segregated but discarded on streets waste bins alongside domestic / trade / institutional waste. These wastes are by and large picked up by poor rag pickers for their livelihood. Most times Rag pickers empty dustbins and spread the contents around for effective sorting and collection. When recyclable material are discarded on the streets or into a common dustbin, the quality of recyclable material deteriorates as it gets soiled by wet waste, which most time consists of contaminated and hazardous waste.

Segregation of recyclable waste at source is invariably not seriously practiced by households and establishments, who rather dispose waste on the streets or in the municipal bins unsegregated. At least 15% of the total waste can be conveniently segregated at point of generation for recycling, rather than outright disposal into the municipal waste receptacle on the streets, where waste segregation at the source is not practiced. Most of this discarded recyclable waste is picked up by rag-pickers in a soiled condition and sold to middle men at a low price, who in turn sells the material to the recycling industry at a higher price after cleaning or segregation while a large chunk of waste which remains uncollected finds their way to the dumping grounds or insanitary landfills (ICPE, 2011).

Hammed, (2011) reported that the question that frequently comes to his mind is to what extent can a newly established solid waste recycling facility be sustained in Nigeria. This is predicated on the fact that the success of solid wastes management strategy with respect to recycling into useful products depends on the way and manner the mixed solid wastes are

separated into different components. In Nigeria and in other developing countries, waste separation at the household or source of generation is looked at as a filthy exercise. Most individuals want to move waste from their sight as fast and as cheap immediately after generation. The storage of wastes together makes recycling operations a very tedious exercise, reduces productivity and increases cost of management at the waste recycling plant. This also affects the quality of recyclables, for example when organic matter and other factions of waste are disposed off together, the organic fraction of the mixed wastes decomposes with foul odour that makes the waste looks absurd.This attracts flies and pests of economic importance, thus making the waste objectionable.

Hammed, (2011), further stressed that the separation of solid waste at the recycling site or from the dumps by rag pickers takes skill, time, intensive labour with attendant cost implication. Probably, poor separation of recyclable materials alters the quality of recyclables and reduces their marketability. Successful recycling entails that recycled products can compete well with virgin materials in quality as well as price. The cost of refined or recycled materials depends on the cost of collection activities. The quality is influenced by the way collection activities including sorting are performed. However, wastes are not normally collected in cost-effective and environmentally sound manner in this country. Research has shown that waste collection and segregation accounts for the total cost of solid waste recycling. The current practice is that the municipal waste management Authority collects heterogeneous waste and dispose offinto insanitary landfills without proper leachate control, which is not a sustainable or environment friendly practice. This negates resource conservation through waste recycling and promotes waste of resources. Thus, it is the poor and jobless people from low socio-economic class that scavenges such dumpsite to salvage recyclable materials like plastics, bottles and metal scraps, at the expense of their health and well-being.

Ogboi and Okosun,(2003) observed that waste collectors (scavengers) play a significant role in minimizing solid waste in many Nigerian cities through the collection of metals, bottles, glass-wares and plastic materials from refuse dumps for recycling and reuse. They observed that as urban population increases with technological advancement the composition of waste tends to be more of non-biodegradable materials with high recycling and re-use values, the place of waste scavengers become more necessary in urban solid waste management. This is because the activities of waste scavengers open up a wide range of economic opportunities.

They called on the policy makers to harness the potentials of waste scavengers to maintain a clean and healthy urban environment in Nigeria.

The Solid Waste Management Department of the Athmallik N.A.C., India headed byZamadar has undertaken a programme to encourage the citizens by organizing awareness programme for segregation of wastes and promote recycling or reuse of segregated materials. The N.A.C Authority have undertaken phased programme to ensure community participation in waste segregation. For this purpose, regular meetings at quarterly intervals have been arranged with representatives of local residents, welfare associations and non-governmental organizations (Zamadar, 2010).

The management of waste must be consistent from the point of generation (cradle) to the point of final disposal (grave). The proper segregation of waste at the point of generation hinges on a clear identification of the different categories of waste and the appropriate disposal of the waste in accordance with the categorization chosen.

Segregation must be done at the point of generation of the waste. To promote segregation at source, reusable containers or baskets with liners of the correct size and thickness are placed as close to the point of generation as possible. They should be properly labelled (colour-coded e.g. yellow or red for infectious waste) and have the international infectious waste symbol clearly marked. When they are 3/4 full, the liners are closed with plastic cable ties or strings and placed into larger containers or liners at the intermediate storage areas. Suitable latex gloves must always be worn when handling infectious waste (WHO, 2001 & 2011).

Moritz, (1995) in his paper stressed that effective segregation at source is a key factor in waste management strategy and it will enable hospital authorities to make economic savings in waste disposal costs. The paper considers the Duty of Care under the Environmental Protection Act 1990 and stresses the obligation on each person in the waste disposal chain to discharge their duty.

Goal 7 of the United Nations 8 Millennium Development Goals is to ‘ensure environmental sustainability’ (UNESCO, 2011). An important step that is crucial to realizing this goal is the need to develop and adopt effective strategies for solid waste management (SWM) and most especially in densely populated urban areas. The main purpose of SWM is to provide hygienic, efficient and economic collection, transportation, treatment and/or disposal of solid wastes without polluting the atmosphere, soil or water resources. The environmental and

public health issues associated with inadequate waste disposal have been well documented: surface and groundwater are contaminated by leachate: the soil by direct waste contact or leachate; the air by burning of waste; the spread of diseases by different vectors such as birds, insects and rodents and the uncontrolled release of methane from anaerobic waste decomposition (Schertenleib and Meyer, 1992).

Mixed waste collection directly from communities by the Nigerian government appears to be very easy and cheap but results in separation complexity at the sorting centre and recycling facilities. Though the transportation of sorted wastes from households makes collection and transportation complex but it ensure that the labour is reduced, exposure of workers to hazard is controlled and ensures easy operation at reduced costs at the recycling facilities. The cost of managing a sorting centre is removed. It is expedient that we adopt the appropriate strategy of waste segregation and transportation that is suitable for the country. The methods that favour waste recycling and material recovery should be adopted as the permanent solution to persistent waste management problems in the country. The strategy of waste segregation at the point of generation, be it at the residential, commercial, institutional, or industrial level, where waste is bagged and transported in a single compartment vehicle needs to be encouraged (Hammed, 2011).

CHAPTER THREE

METHODOLOGY

3.1 Study Design and Scope

This study was a quasi-experimental design. It was aimed at documenting a field survey of the knowledge, attitude and practices of solid waste segregation, characterization and weighing of solid waste segregated as well as training and provision of labelled colour coded waste collection bags. A stratified random sampling technique was employed in selecting 30 households drawn from Okaka Community.

3.2 Description of Study Area

The study was carried out in Okaka Community in Yenagoa Local Government Area, Bayelsa State, Nigeria. Yenagoa is the capital city of Bayelsastate, it is located in the South-South region of Nigeria which is commonly called the Niger Delta. This community was chosen because it has two unique settlements i.e. the Government owned housing estate; a well-planned low density area and the main heart of the community, a high density settlement. Okaka community lies within longitude 6^0 17' 55.93"E and latitude 4^0 55' 44.80"N the equator, with a population of about 35,000, covering a land area of 13245sqkm is situated at the northern part of Yenagoa Local Government Area, sharing boundaries with Ekeki community to its north west, Yenezue-epie to its south, Azikoro community in the East. The people of Okaka belong to the Epie-Atisa kingdom. The people are believed to have migrated from the Ijaw and Egene speaking people as such their cultural practices are similar to those of these tribes. They are predominantly epie speaking people. The community hosts the state government owned housing estate. The community is administered by a traditional ruler with his council of chiefs. However, due to its current status as co-host to theBayelsa state capital, it is fast losing its initial traditional status.

3.3 Study Population

The study population comprised of 574 households from Okaka community. Participants were selected based on mutual consent.

3.4 Criteria for Selection

The Community considered for the study was selected based on the following criteria;

1. It's a semi-urban setting.
2. It has a population variation of high and low density areas.
3. It's within Yenagoa, the state capital.

3.5 Sample Size Estimation

The sample size was calculated using the formula below.

$$n= [Z_\alpha (2P(1-P))^{1/2} + Z_\beta (p_1 (1-p_1) + p_2 (1-p_2))^{1/2}]^2/(p_1-p_2)^2$$

An approximate formula is given below

$$n= (Z_\alpha + Z_\beta)^2 \{p_1 (1-p_1) + p_2 (1-p_2)\}/ (p_1- p_2)^2$$

p_1 = proportion with event in group 1=0.5

p_2 = proportion with event in group 2=0.5

p = average of p_1 and p_2

Z_α is standard normal deviate corresponding to level of significance (usually 5%)

Z_β is standard deviate corresponding to power of 1-β

Using 90 power= 1.28

$$N = \frac{(1.9+1.28)^2 \; x \; 0.5 \; (1-0.5)+0.5 \; (1-0.5)}{(0.5-0.5)^2} \therefore N \rightarrow \alpha \; 5.25$$

nr =An attrition or non-response rate (nr) of 10% for household survey as suggested by WHO/UNAIDS (2009) was further considered.

(Nx1/1-nr) 5.25 x 1/1-0.1 = **5.83**

For higher precision the sample size was raised to 15 which means 15 x 2 = 30 in both locations.

3.6 Sampling Procedure

The sampling approach as suggested by (GATS, 2010) was used for the study. Okaka Community was stratified into two; the housing estate (low density area- LD) with 40 households and the actual communal settlement (high density area-HD) with 534 households. A total of 30 households were selected for the study.

Stage 1; Following the stratification into LD and HD areas. They were mapped and listed to ascertain the total number of households, with exclusion of business premises and residential premises used as business premises (See Appendix v-xi).

Stage2;The proportion of participants for each stratum was proportionally allotted by dividing the total number of each stratum with the sum of both multiplied by the sample size 30.

PP= proportion of participants

M_a= sum of LD and HD

M_1=no of households in LD

M_2= no of households in HD

$PP = \frac{M_1}{M_a}\ x\ \frac{30}{1} = \frac{40}{574} x \frac{30}{1}\ x$ 2.09i.e. 2 household for LD.

$PP = \frac{M_2}{M_a}\ x\ \frac{30}{1} = \frac{534}{574} x \frac{30}{1}\ x$ 27.9i.e. 28 household for HD.

Stage 3; A systematic random sampling was used to select the participating households from each stratum. Sampling interval was determined by dividing the sampling frames of each stratum by the proportion of participants. Hence a sampling interval of 20 and 19 was used for LD and HD respectively. A central point in each selected stratum was determined as a marker. Markers were school, superstores or a strategic point assumed to be the center of the strata. A direction from the central point was randomly chosen by "spinning-a-pen". The number of houses from the central point to the edge of the stratum was then accounted for (Lemeshow and Robinson, 1985). Every 19th and 20th household was systematically

selected for sampling. Any person of 15 years and above who resides in the selected household was used as the respondent.

3.7 Sampling Frame

The sampling frame for the selection of households in both strata of the Community was the 534 households for Okaka Community and the 40 households for Okaka Housing Estate. They were established after an extensive mapping of the community (see mappings appendix v-xi). In all a total of 30 households were selected.

3.8 Selection Criteria

3.8.1 Inclusion Criteria

These include households within the Community and housing estate who gave their consent, and where no form of commercial, institutional, manufacturing etc. activity is taking place.

3.8.2 Exclusion Criteria

These include Commercial premises, Canteens, Restaurants, houses where some form of commercial, institutional, manufacturing etc. activity is taking place.

3.8.3 Method(s) and Instrument(s) for Data Collection

A quantitative method for data collection was used for the study. Instruments used consisted of: waste segregation materials and a validated self-administered semi-structured questionnaire.

3.8.4 Waste Segregation Materials

Materials employed for sampling includes a 2003A digital glass platform weighing scale, max 150kg d=0.1kg, max330lb d=0.2lb, a 50kg weighing scale, surgical hand gloves, face mask, insulated rubber gloves, waste basket, bags, labelled colour coded bags, an improvised weighing cuboid and a 30cm meter rule.

3.8.5 The Semi-structured Questionnaire

The questionnaire was divided into five sections – Labelled section A, B, C, D. Section A consisted of questions for documenting the socio-demographic characteristics of the respondents while section B contained questions used to determine the level of knowledge about solid waste segregation at source. Section C contained questions documenting respondent's attitude regarding segregation at source. The respondent's practice of solid waste segregation at source was determined using the questions contained in section D of the semi-structured questionnaire. The questionnaire was used to assess baseline and post-intervention knowledge, attitude and practice of waste segregation. The questionnaire was designed after reviewing related literatures and extracting the pertinent variables relating to solid waste segregation at source. The self-administered questionnaire was preferred to avoid interviewers' bias and to save cost.

Knowledge, Attitude and practices were assessed on 14-, 10- and 14-points scales respectively. Knowledge and Practice scores of 0≤4, ≥4-8 and ≥8 were rated poor, fair and good respectively. Attitude scores 0≤4, ≥4-7 and ≥7 were rated poor, fair and good.Experts from the fields of Environmental Health, Epidemiology, Health Promotion and Education were consulted during the design of the instruments.

3.9 Validity and Reliability of Instruments

Several measures were taken to ensure the validity and reliability of the instrument.

They are outlined below:

3.9.1 Validity

To enhance the face and content validity of the instrument, it was giving to experts in the Field of Environmental Health, Epidemiology and Health Promotion and Education in the faculty of public Health for appraisal. Necessary amendments were made following appraisal by these experts and reviewed by my Research supervisor. The questionnaire was translated into Izon language and later translated back into English. This was done to make sure that the instrument maintains its originality.

3.9.2 Reliability

In order to determine its reliability, the instrument was pre-tested among 15 households in Azikoro town in Yenagoa local government area, Bayelsa State. A community different but has similar characteristics with the study population. The pretested questionnaires were cleaned, coded and entered into Statistical Package for Social Sciences, SPSS (version16). Cronbach's alpha coefficient analysis was used to determine its reliability. This is a model technique for measuring internal consistency based on the average inter-item correlation. The reliability co-efficient was 0.92 implying that the instrument was very reliable.

3.10 Training of Field Assistants

Five field assistants vast in Pidgin, English and Izon language from Okaka community were hired and trained for two days to administer questionnaires to respondents. This was to ensure that they had adequate understanding of the instrument prior to commencement of data collection. The training focused on the objectives and importance of the study, sampling process, how to secure respondents informed consent, basic practical skills for waste collection and how to review questionnaires to ensure completeness. The field assistants were also involved in the pre-testing of the questionnaires in order to create opportunity for them to acquire practical skills. Resource person for the training of participants were trained on what the study entails and how to guide the respondents to avoid bias.

3.11 Data Collection Process

The study was carried out within a space of nine (9) weeks (June 3rd to August 10th, 2013). The paramount ruler of the community and his cabinet members as well as other sectional leaders such Okaka estate dwellers chairman was first visited prior to the commencement of the study to formally inform them of the purpose of being there. The objectives and importance of the study to the community were clearly explained to them. Solid waste segregation was done and data was collected using the semi-structured self-administered questionnaire (see appendix i) with the help of five trained field assistants. Consent of the participant was sought after explaining to them the purpose of the research, time that would be spent and benefits of the research.

3.11.1 Administration of Semi-structured Questionnaire

Questionnaire was administered on the research participants (household head or adult designated by the household).The questionnaire was self- administered. A total of 30 questionnaires were administered, and retrieved. The questionnaires were administered at the selected households visited in the morning and evening between; 8:30am and 10:30pm, and 3:00pm and 6:00pm. Every household selected for data collection was visited and participants were properly greeted upon reception.

3.11.2 Pre-interventionSurvey

After the selection of participating household jute sac bags were provided for them to collect waste generated in the selected households for 1week. These bags were retrieved, characterized and weighed to ascertain pre-intervention waste segregation practice, nature and amount of waste generated.

3.11.3 Intervention

In this section detail of the entire study and the segregation exercise to be undertaken in the various households was communicated to the participants. The participants were thought on waste reduction, generation, segregation, storage, collection, transportation, reuse, recovery, recycle, treatment and final disposal, they were told what solid waste is, and how it is not completely useless and should be discarded as was generally conceived, I recall this incident where a participant insisted that there was nothing useful about waste but as the session progressed she exclaimed in elation that truly waste is not completely useless. This was carried out as an intervention for the training of the selected households on the concept and practice of waste segregation at the source among others. Training was done for a period of two (2) weeks at the Okaka Health Centre, it commenced with a pretest to ascertain their level of awareness on the subject matter, participants were thought on the concept of waste segregation, its benefits and probable demerits and practical sessions were held to show to the respondents the use of the two different colour of bags. At the end of the two weeks of training, a post test was done to ascertain whether the participants perfectly understood the concept of waste segregation at the source of generation, being satisfied with their level of

understanding well labelled, colour coded(black and white) bags for waste collection was given to them as part of the intervention for the waste segregation exercise, the black bag was for the collection of wet waste (organic degradable waste) while the white bag was for the collection of dry waste (non-degradable). The section was presided over by an experience Environmental health professional, with the principal investigator as moderator, a recorder and a guide as interpreter where necessary.

Plate3.1; Training of Participants on Solid Waste Segregation at source in Okaka Community.

3.11.4 Post Intervention Evaluation

The semi structured questionnaire was re-administered to the respondents after the training to evaluate the effect of training on the respondents' knowledge, attitude and practice of waste segregation at source.

3.11.5 Waste Segregation (Assessment)

This was done after the Training, here waste generated for one (1wk) in the household units of enquiry were segregated and assessed. The nature and amount of waste generated was observed. Two (2) Big black bagco jute sac bags (1000kg capacity) was used for collecting wet organic biodegradable waste (food remains, plant material, peelings of banana, yam,plantain etc. and leaves) at interval of 3 and 4 days in the week while white bagco jute sac bags (1000kg capacity) was used to collect dry non-degradable waste (metals, glass, nylon plastic, paper, shoes, clothes, etc.), the bags were labelled with codes indicating the household. For the purpose of convenience and saving cost the dry waste was collected at the expiration of the 7days while the wet waste was collected twice in the week i.e. Sunday, Monday, Tuesday waste was collected on Wednesday morning, while Wednesday, Thursday, Friday and Saturday waste was collected on Saturday evening , this was done to minimize odour nuisance. The waste collected were characterized and weighed using a sensitive balance and recorded on a data sheet, while the dry non-biodegradable wastes were separated into different components; metal, nylon, glass, plastics etc., weighed and recorded. The mean weight and nature of waste generated between the high and low density areas was obtained. Adequate personal protective equipment such as gloves, nose mask, and boots were used. After the training and waste segregation interventional exercise the same questionnaire administered to the respondents at baseline was re-administered as a post intervention evaluation test.

3.12 Field Supervision

I ensured that proper field supervision was done by making sure that all forms and questionnaires were filled in correctly and that there were no missing data, I also ensure that all sampling bags were labelled correctly, data collection was done thoroughly and all

equipment were in perfect working order to obtain accurate, reliable and quality data, to reduce the possibility of information bias.

Plate 3.2: Mapping the community with my guide.

Plate 3.3; Collection of source segregation bags

3.13 Data Management and Analysis

The questionnaires were collated and edited by the researcher with the help of the field assistants. The questionnaires were checked for completeness and serially numbered for easy identification. Responses in each questionnaire were hand coded, facilitated by the use of a coding guide developed by the researcher after a careful review of the responses in all the questionnaires. A template on SPSS (version 16) was then designed for entering the coded data. Each questionnaire was entered into SPSS 16 software. The data were analysed using descriptive statistics, t-test at p=0.05. Results were presented using Tables, pie chart and bar graphs in chapter four.

3.14 Ethical Consideration

Ethical principles guiding the use of human participants in research were taken into consideration in the design and conduct of the study.

Ethical approval: Since there was no ethical approval office in Bayelsa State, I obtained a letter of introduction from the Environmental Health sciences Department in the University of Ibadan.

3.14.1 Informed Consent

The purpose of the study was well explained to respondents. Oral and written consent were obtained from them before administering the questionnaires.

3.14.2 Voluntariness

Participation in the study was made voluntary. Respondents were given the right to withdraw at any stage of the study without suffering any form of discrimination or untoward consequences.

3.14.3 Confidentiality

Confidentiality was assured to participants by serially allocating numbers in lieu of respondents' names.

3.14.4 Beneficence

The study would benefit respondents and the general public by providing information for developing future intervention programmes related to the prevention and control of Lassa fever.

3.14.5 Non-maleficence

No harm was done to respondents since the research was neither invasive nor harmful.

CHAPTER FOUR

4 RESULTS

This chapter highlights the demographic characteristic of the study population, their knowledge, attitude and practice towards solid waste segregation at the source of generation, (household) at pre-intervention as well as at post-intervention and assessment of the nature and amount (weight) of solid waste generated by the respondents. The questionnaire was validated by the findings of the waste segregation exercise. Results were analysed by grouping the questionnaire into three main sections these are; knowledge, attitude (perception) and practice which majorly assessed the effect of the intervention on the respondents and the nature and amount of waste generated within the community.

4.1 Questionnaire Survey

4.1.1 Socio-Demographic Characteristics of Respondents

A total of 30 respondents were interviewed from the community with age ranging between 15 to 45 years. Mean age of respondents in the community is 28.6±2.6 years. Table 4.1 shows the socio-demographic characteristics of respondents from the community.

4.1.2 Knowledge of Respondentson Solid Waste Segregation

The mean knowledge score of the 30 respondents' interviewed at pre-intervention was 2.7±0.2 of number 73.3% has poor knowledge, while 26.7% has fair knowledge. Tables 4.2 4.5 and figure 4.1 shows the knowledge level of respondents' on solid waste segregation.

4.1.3 Attitude of Respondents to Solid Waste Segregation

Among the 30 respondents interviewed from the community 86.7% had bad attitude only 13.3% had fair attitude. Tables 4.3, 4.6 and figure 4.1 show the attitude level of respondents to solid waste segregation at source.

4.1.4 Practice of Solid Waste Segregation

The mean practice score of solid waste segregation of the 30 respondents' interviewed was 2.2±0.1 of this number , 70.0% of respondents' had poor practice, while 30.0% had fair practice as shown in tables 4.4, 4.7 and figures 4.1 respectively.

4.2 Comparison of Knowledge Attitude and Practice of Waste Segregation at Pre-Intervention

The pre-intervention knowledge attitude and practice of respondents was not significant using the Fishers' exact test as shown in Table 4.8- 4.9, whereas comparisons of the knowledge of waste segregation with some demographic characteristics was significant using the Fishers' exact test as shown in Table 4.10.

4.3 Comparison of Knowledge, Attitude and Practice at Pre-Intervention and Post-Intervention

The difference in knowledge attitude and practice of the respondents at pre-intervention and post-intervention varied remarkably. The mean score of respondents knowledge and practice at pre-intervention was 2.7±0.4 and 2.9±0.3, while that at post-intervention was 9.4±1.4 and 10±2.4 respectively. Tables 4.12- 4.18 and figure 4.1, show these differences.

4.4 Waste Segregation

4.4.1 Nature and Amount of Waste Segregated at Pre-intervention

Solid waste segregated at pre-intervention were heterogeneous waste (degradables and non-degradables) 5.0±0.5, metals 0.7±0.1, plastics 0.6±0.1, as shown in Table 4.16 and figure 4.3.

4.4.2 Comparison of the Nature and Amount of Waste Segregated at Pre and Post-Intervention

Solid waste components segregated after intervention was more than those at pre-intervention. After intervention heterogeneous waste was separated at source into degradables and non-degradables. Table 4.20 and figure 4.4 shows these variations.

Table 4.1: Socio-demographic characteristics of respondents

Variable	Total
Age:	
15-19	3 (10.0%)
20-24	11 (36.7%)
25-29	6 (20.0%)
30-45	10 (33.3%)
Mean ± SD	28.6±2.6
Sex:	
Male	12 (40.0%)
female	18 (60.0%)
Marital Status:	
Married	16 (53.3%)
Divorced	5 (16.7%)
Single	4 (13.3%)
Separated	2 (6.7%)
Widow	3 (10.0%)
Educational status:	
No formal education	7 (23.3%)
Primary education	8 (26.7%)
Secondary education	6 (20.0%)
Tertiary education	9 (30.0%)
Occupation:	
Unemployed	3 (10.0%)
Trading	2 (6.7%)
Civil servant	17 (56.7%)
Corporate body	5 (16.7%)
Fisherman	3 (10.0%)

Table 4.2: Respondents knowledge on solid waste segregation

Variable	At Pre-intervention		
			Total (%)
Do you know any form of solid waste management:			
good	1 (50%)	6 (21.4%)	7 (23.3%)
poor	1 (50%)	14 (50.0%)	15 (50.0%)
Fair		8 (28.6%)	
Do you think solid waste can be converted into useful material:			
good	2 (100%)	5 (17.9%)	7 (23.3%)
poor		20 (71.4%)	20 (66.7%)
Fair		3 (10.7%)	10 (10.0%)
Do you know that solid waste can be separated at the source of generation:			
good		2 (7.1%)	2 (6.7%)
poor	2 (100%)	19 (69.9%)	21 (70.0%)
Fair		7 (25.0%)	7 (23.0%)
Do you know that waste can be reused, recycled and recovered:			
good	1 (50%)	5 (17.9%)	6 (20.0%
poor	1 (50%)	18 (64.3%)	19 (63.0%)
fair		5 (17.9%)	5 (16.7%)
Do you think waste segregation at source is beneficial to health:			
good		5 (17.9%)	5 (16.7%)
poor	2 (100%)	13 (46.4%)	15 (50.0%)
fair		10 (35.7%)	10 (33.3%)
Do you know if there are useful materials in solid waste:			
good	2 (100%)	8 (28.6%)	10 (33.3%)
poor		17 (60.7%)	17 (56.7%)
Fair		3 (10.7%)	3 (10.0%)
Do you think it's ideal to put all your waste in a single waste bin:			
good	2 (100%)	8 (28.6%)	10 (33.3%)
poor		18 (64.3%)	18 (60.0%)
fair		2 (7.1%)	2 (6.7%)

Note; LD= Low Density and HD= High Density.

Table 4.3: Respondents attitude to waste segregation

Variable	At pre- intervention		
	LD	HD	Total (%)
Solid waste segregation at the source is necessary in Okaka community			
good	0 (0%)	6 (21.4%)	6 (20.0%)
fair	0 (0%)	8 (28.6%)	8 (26.7%)
bad	2 (100%)	14 (50.0%)	16 (53.3%)
Training of households on solid waste segregation is necessary in Okaka community			
good	0 (0%)	2 (7.1%)	2 (6.7%)
fair	1 (50%)	3 (10.7%)	4 (13.3%)
bad	1 (50%)	23 (82.1%)	24 (80.0%)
Solid waste segregation at the source enhances waste minimization and resource maximization			
good	1 (50%)	5 (17.9%)	6 (20.0%)
fair	0 (0%)	10 (35.7%)	10 (33.3%)
bad	1 (50%)	13 (46.4%)	14 (46.4%)
Solid waste management should be left for the waste management authority an government alone			
Good	0 (0%)	11 (39.3%)	11 (36.7%)
fair	0 (0%)	5 (17.9%)	5 (16.7%)
Bad	2 (100%)	12 (42.9%)	14 (46.7%)
Solid waste segregation enhances a clean and healthy environment			
good	0 (0%)	7 (25.0%)	7 (23.3%)
fair	1 (50%)	5 (17.9%)	6 (20.0%)
bad	1 (50%)	16 (42.9%)	17 (56.7%)

Note; LD= Low Density and HD= High Density.

Table 4.4: Respondents practice of waste segregation

Variable	At Pre-intervention		
	LD	HD	Total (%)
Do you separate valuables in waste			
Good	1 (50%)	3 (10.7%)	4 (13.3%)
poor	1 (50%)	25 (89.3%)	26 (86.7%)
Fair	0 (%)	0 (0%)	0 (0%)
Do you use separate containers or bags for the collection/storage of different category of valuables			
good	0 (0%)	5 (17.9%)	5 (16.7%)
poor	2 (100%)	19 (67.9%)	21 (70.0%)
Fair	0 (0%)	4 (14.3%)	4 (13.3%)
Do you separate valuables into different categories			
good	0 (0%)	6 (21.4%)	6 (20.0%)
poor	2 (100%)	16 (57.1%)	18 (60.0%)
Fair	0 (0%)	6 (21.4%)	6 (20.0%)
Do you sell some of your waste items			
good	0 (0%)	6 (21.4%)	6 (20.0%)
poor	2 (100%)	19 (67.9%)	21 (70.0%)
Fair	0 (0%)	3 (10.7%)	3 (10.0%)
Do you keep plastics, bottles, and tin cans in separate place after using their contents			
good	2 (100%)	6 (21.4%)	8 (26.7%)
Poor	0 (0%)	19 (67.9%)	19 (63.3%)
Fair	0 (0%)	3 (10.7%)	3 (10.0%)
Does your neighbour do what is asked in question above			
good	2 (100%)	8 (28.6%)	10 (33.3%)
Poor	0 (0%)	14 (50.0%)	14 (46.7%)
Fair	0 (0%)	6 (21.4%)	6 (20.0%)
Have you exchanged waste materials for any valuable			
good	2 (100%)	8 (28.6%)	10 (33.3%)
poor	0 (0%)	10 (35.7%)	10 (33.3%)
Fair	0 (0%)	10 (35.7%)	10 (33.3%)

Note; LD= Low Density and HD= High Density.

Table 4.5: Respondents level of knowledge of solid waste segregation

	Level of knowledge			χ^2	P-value
	Poor (%)	**Fair (%)**	**Good (%)**		
Location at Pre-intervention	22 (73.3%)	8 (26.7%)	0 (0%)	5.893†	0.064

†FT = Fisher's exact test (4 cells (66.6%) has expected count less than 5)
Relationship was not significant

Table 4.6: Respondents level of attitude to solid waste segregation

	Level of attitude			χ^2	P-value
	Bad (%)	**Fair (%)**	**Good (%)**		
Location at Pre-intervention	26 (86.7%)	4 (13.3%)	0 (0%)	0.333†	1.000

†FT = Fisher's exact test
Relationship was not significant

Table 4.7: Respondents level of practice to solid waste segregation

Variable	Practices			χ^2	P-value
	Poor (%)	**Fair (%)**	**Good (%)**	5.00†	0.083
Location at Pre-intervention	21(70)	9 (30)	0 (0)		

†FT= Fisher's exact test
Relationship was not significant

Table 4.8: Relationship between level of knowledge, attitude and practice at pre-intervention

Variable	Attitude at pre-intervention			χ^2	P-value
	Poor (%)	Fair (%)	Good (%)		
Practice at pre-intervention:					
Poor	19 (90.5)	2(9.5)	0 (0)	0.879†	0.563
Fair	7 (78.8)	2 (22.2)	0 (0)		
Good	0 (0)	0 (0)	0 (0)		
Knowledge at pre-intrvention :					
Poor	18 (81.8)	4 (18.2)	0 (0)	1.678	0.550
Fair	8 (100)	0 (0)	0 (0)		
Good	0 (0)	0 (0)	0 (0)		

†FT= Fisher's exact test
Relationships were not significant

Table 4.9: Relationship between level of knowledge and practices of solid waste segregation at pre-intervention

Variable	Level of knowledge at pre-intervention			χ^2	P-value
	Poor	Fair	Good		
Practice at pre-intervention:					
Poor	15 (71.4)	6 (28.6)	0 (0)	0.130†	1.000
Fair	7 (77.4)	2 (22.2)	0 (0)		
Good	0 (0)	0 (0)	0 (0)		

†FT= Fisher's exact test
Relationship was not significant

Table 4.10: comparison between respondents' mean knowledge score at pre-intervention with selected socio-demographic characteristics

Variable	Number	Mean	SD	T	P-value
Sex:					
Male	12	1.83	2.48	2.155	0.040*
Female	18	3.89	2.61		
Marital status:					
Currently married	12	2.88	2.92	-0.407	0.687
Not currently+ married	18	3.29	2.55		
Age:					
18-25(young adult)	15	2.67	2.69	-0.802	0.429
26-45(adult)	15	3.47	2.77		

*Relationship was statistically significant
+not currently married= divorced, widowed, separated

Table 4.11: Relationship between knowledge and socio demographic characteristics

Variable	Knowledge at pre-intervention			χ^2	P-value
	Poor (%)	Fair (%)	Good (%)		
Age:					
15-25(young adult)	12(80.0)	3(20.0)	0(0)	0.682†	0.682
26-45 (adult)	10(66.7)	5(33.3)	0(0)		
Marital status:					
Currently married	12(75.0)	4(25.0)	0(0)	0.049†	0.574
Not currently married	10(71.4)	4(28.6)	0(0)		
Educational status:					
Non-formal	2(28.6)	5(71.4)	0(0)	10.266	0.016*
Primary	7(87.5)	1(12.5)	0(0)		
Secondary	6(100)	0(0)	0(0)		
Tertiary	7(77.8)	2(22.2)	0(0)		
Occupational status:					
Employed	15(68.2)	7(31.8)	0(0)	1.503	0.472
Self employed	4(80.0)	1(20.0)	0(0)		
Unemployed	3(100)	0(0)	0(0)		

†FT=Fisher's exact test
*Relationship was statistically significant

Table 4.12: Differences in knowledge at pre- and post-intervention among respondents

Variable	At pre-intervention (%)	Post-intervention (%)	Difference
Do you know any form of solid waste management:			
good	6 (21.4)	20 (71.4)	14(50.0)
poor	14 (50.0)	5(17.9)	-9(32.1)
Fair	8 (28.6)	3(10.9)	-5(17.7)
Do you think solid waste can be converted into useful material:			
good	5 (17.9)	20(71.4)	15(53.5)
poor	20 (71.4)	5(17.9)	-15(53.5)
Fair	3 (10.7)	3(10.9)	0(0.2)
Do you know that solid waste can be separated at the source of generation:			
good	2 (7.1)	20(71.4)	18(64.3)
poor	19 (69.9)	5(17.9)	-14(52.0)
Fair	7 (25.0)	3(10.7)	-5(14.3)
Do you know that waste can be reused, recycled and recovered:			
good	5 (17.9)	22(78.6)	17(60.7)
poor	18 (64.3)	4(14.3)	-14(50.0)
fair	5 (17.9)	2(7.1)	-3(10.8)
Do you think waste segregation at source is beneficial to health:			
good	5 (17.9)	20(71.4)	15(53.5)
poor	13 (46.4)	5(17.9)	-8(28.5)
fair	10 (35.7)	3(10.7)	-8(25.0)
Do you know if there are useful materials in solid waste:			
good	8 (28.6)	22(78.6)	14(50.0)
poor	17 (60.7)	3(10.7)	-15(50.0)
Fair	3 (10.7)	3(10.7)	0(0)
Do you think it's ideal to put all your waste in a single waste bin:			
good	8 (28.6)	7(25.0)	-1(3.6)
poor	18 (64.3)	20(71.4)	2(7.1)
fair	2 (7.1)	1(3.6)	-(3.5)

Table 4.13: Differences in attitude at pre-intervention and post-intervention among respondents

Variable	At pre-intervention (%)	Post intervention (%)	Difference (%)
Solid waste segregation at the source is necessary in Okaka community			
good	6 (21.4)	24 (85.7)	18(64.3)
fair	8 (28.6)	1(3.6)	-7(25.0)
bad	14 (50.0)	3(10.7)	-11(39.3)
Training of households on solid waste segregation is necessary in Okaka community			
good	2 (7.1)	22(78.6)	20(71.5)
fair	3 (10.7)	2(7.1)	-1(3.6)
bad	23 (82.1)	4(14.3)	19(67.8)
Solid waste segregation at the source enhances waste minimization and resource maximization			
good	5 (17.9)	23(82.1)	18(64.2)
fair	10 (35.7)	4(14.3)	-6(21.4)
bad	13 (46.4)	1(3.6)	12(42.6)
Solid waste management should be left for the waste management authority an government alone			
good	11 (39.3)	19(67.9)	8(28.6)
Fair	5 (17.9)	1(3.6)	-4(14.3)
bad	12 (42.9)	8(28.6)	-4(14.3)
Solid waste segregation enhances a clean and healthy environment			
Good	7 (25.0)	23(82.1)	16(57.1)
fair	5 (17.9)	1(3.6)	-4(14.3)
bad	16 (42.9)	4(14.3)	-12(28.6)

Table 4.14: Differences in waste segregation practices at pre-intervention and post-intervention among respondents

Variable	At pre-intervention (%)	Post-intervention (%)	Difference (%)
Do you separate valuables in waste			
good	3 (10.7)	21(75.0)	18(64.3)
poor	25 (89.3)	6(21.0)	-19(68.3)
Fair	0 (0)	1(3.6)	1(3.6)
Do you use separate containers or bags for the collection/storage of different category of valuables			
good	5 (17.9)	25(89.3)	20(71.4)
poor	19 (67.9)	1(3.6)	-18(64.3)
Fair	4 (14.3)	2(7.1)	-2(7.2)
Do you separate valuables into different categories			
good	6 (21.4)	24(85.7)	18(64.3)
poor	16 (57.1)	4(14.3)	-12(42.8)
Fair	6 (21.4)	0(0)	-6(21.4)
Do you sell some of your waste items			
good	6 (21.4)	18(64.3)	12(42.9)
poor	19 (67.9)	9(32.1)	-10(35.8)
Fair	3 (10.7)	1(3.6)	-2(7.1)
Do you keep plastics, bottles, and tin cans in separate place after using their contents			
good	6 (21.4)	17(60.7)	11(39.3)
poor	19 (67.9)	10(35.7)	-9(32.2)
Fair	3 (10.7)	1(3.6)	-2(7.1)
Does your neighbour do what is asked in question above			
good	8 (28.6)	21(75.0)	13(46.4)
poor	14 (50.0)	6(21.4)	8(28.6)
Fair	6 (21.4)	1(3.6)	-5(17.8)
Have you exchanged waste materials for any valuable			
Good	8 (28.6)	16(57.1)	8(28.5)
poor	10 (35.7)	7(25.0)	-3(10.7)
Fair	10 (35.7)	5(17.9)	-5(17.8)

Table 4.15: Comparison of knowledge, attitude and practice at pre-intervention and post-intervention

Variable	Number	Mean score	Standard Deviation	Difference	T	P-value
Knowledge at pre-intervention	30	2.7	0.4	6.7	12.192	0.000*
Knowledge post-intervention	30	9.4	1.4			
Respondents attitude:						
Attitude at baseline	30	2.2	0.1	5.7	7.725	0.000*
Attitude post intervention	30	7.9	0.9			
Respondent practices:						
Practice at baseline	30	2.9	0.3	7.1	12.061	0.000*
Practice post intervention	30	10.0	2.4			

*Relationships were statistically significant

Table 4.16: Respondents' level of knowledge of solid waste segregation

	Level of knowledge			χ^2	P-value
	Poor (%)	**Fair (%)**	**Good (%)**		
Post-intervention	2 (7.1%)	8 (28.6%)	20(64.3%)	3.693†	0.034

†FT = Fisher's exact test (4 cells (66.6%) has expected count less than 5)
Relationship was not significant

Table 4.17: respondents' level of attitude to solid waste segregation

	Level of attitude			χ^2	P-value
	Bad (%)	**Fair (%)**	**Good (%)**		
Post-intervention	8 (28.6%)	3 (10.7%)	19(60.7%)	0.033†	0.001

†FT = Fisher's exact test
Relationship was not significant

Table 4.18: Respondents level of practice to solid waste segregation

Variable	Practices			χ^2	P-value
	Poor (%)	**Fair (%)**	**Good (%)**		
Post-intervention	1(2.4%)	2(4.3%)	27(93.3%)	2.00†	0.043

†FT= Fisher's exact test
Relationship was not significant

Table 4.19: means weight of solid waste segregated at pre-intervention.

Solid waste	**Weight(kg)**
Degradable and non-degradable	5.0±0.5
Metal	0.7±0.1
Plastic	0.6±0.1
Nylon	0.0
Clothes	0.0
Shoes	0.0
Glass	0.4±0.1
Paper	0.0
Tetrapack	0.0
E-waste	0.0
Woods	0.0
Hairs	0.0
Others	0.0

*Others; minute pieces of all the items of solid waste.

Table 4.20: mean weight of solid waste segregated at pre and post-intervention

At pre-intervention	**Mean/SD (Kg)**	**Post-intervention**	**Mean/SD (Kg)**
Non-degradable		Non-degradable	1.7±0.6
Degradable		Degradable	2.2±0.6
Degradable and non-degradable	5.0±0.5		
Metal	0.7±0.1	Metal	0.5±0.1
Plastic	0.6±0.1	Plastic	0.2±0.1
Nylon	0.0	Nylon	0.4±0.1
Clothes	0.0	Clothes	0.4±0.1
Shoes	0.0	Shoes	0.6±0.1
Glass	0.4±0.1	Glass	0.4±0.1
Paper	0.0	Paper	0.4±0.1
Tetra-pack	0.0	Tetra-pack	0.2±0.1
E-waste	0.0	E-waste	0.2±0.1
Woods	0.0	Woods	0.5±0.1
Hairs	0.0	Hairs	0.0
Others	0.0	Others*	0.5±0.1

*Others = minute pieces of all the items of solid waste.

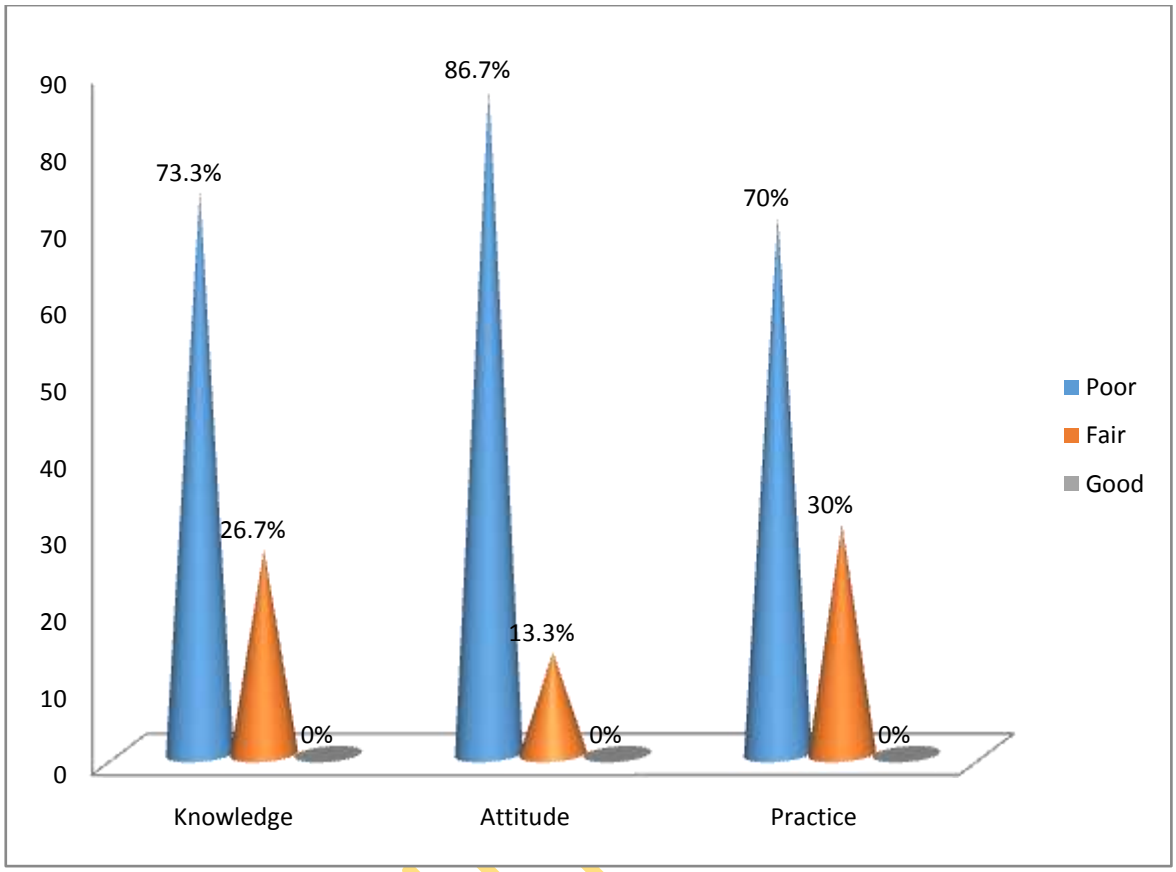


Figure 4.1: Chart showing knowledge, attitude and practice levels at pre-intervention.

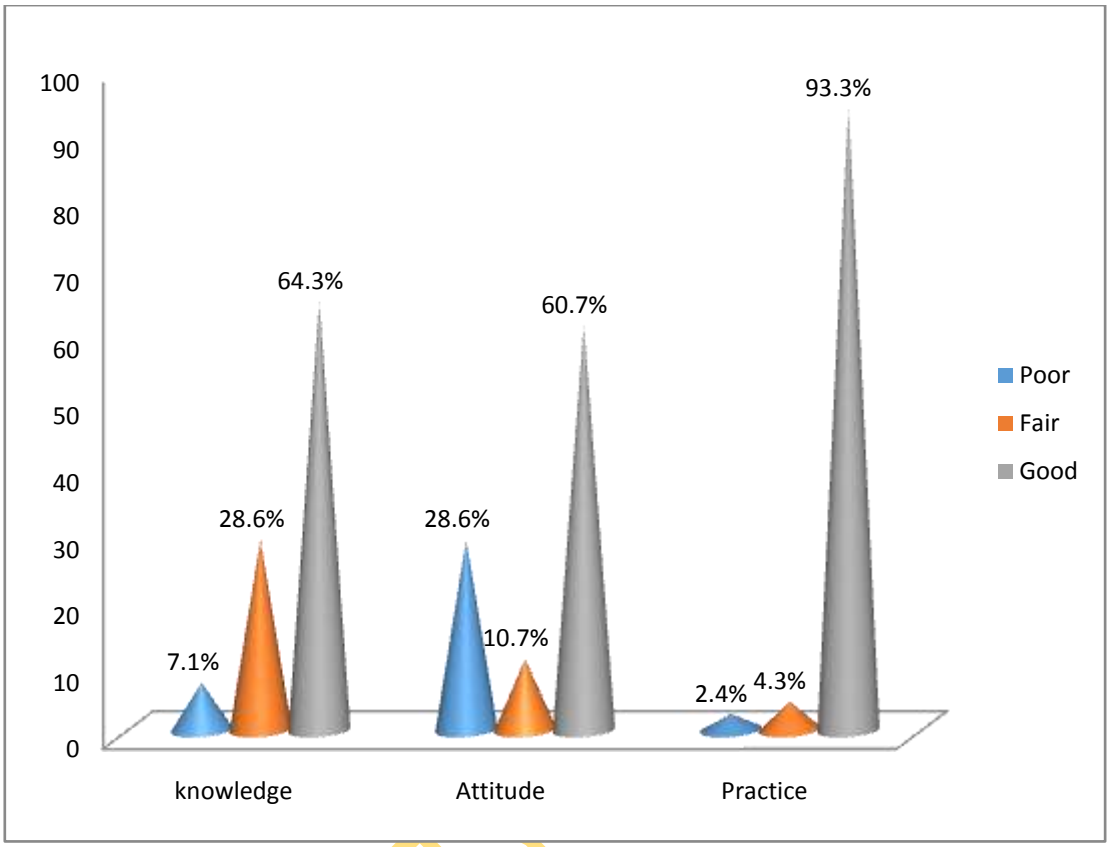


Figure 4.2: Chart showing knowledge, attitude and practice levels at post-intervention.

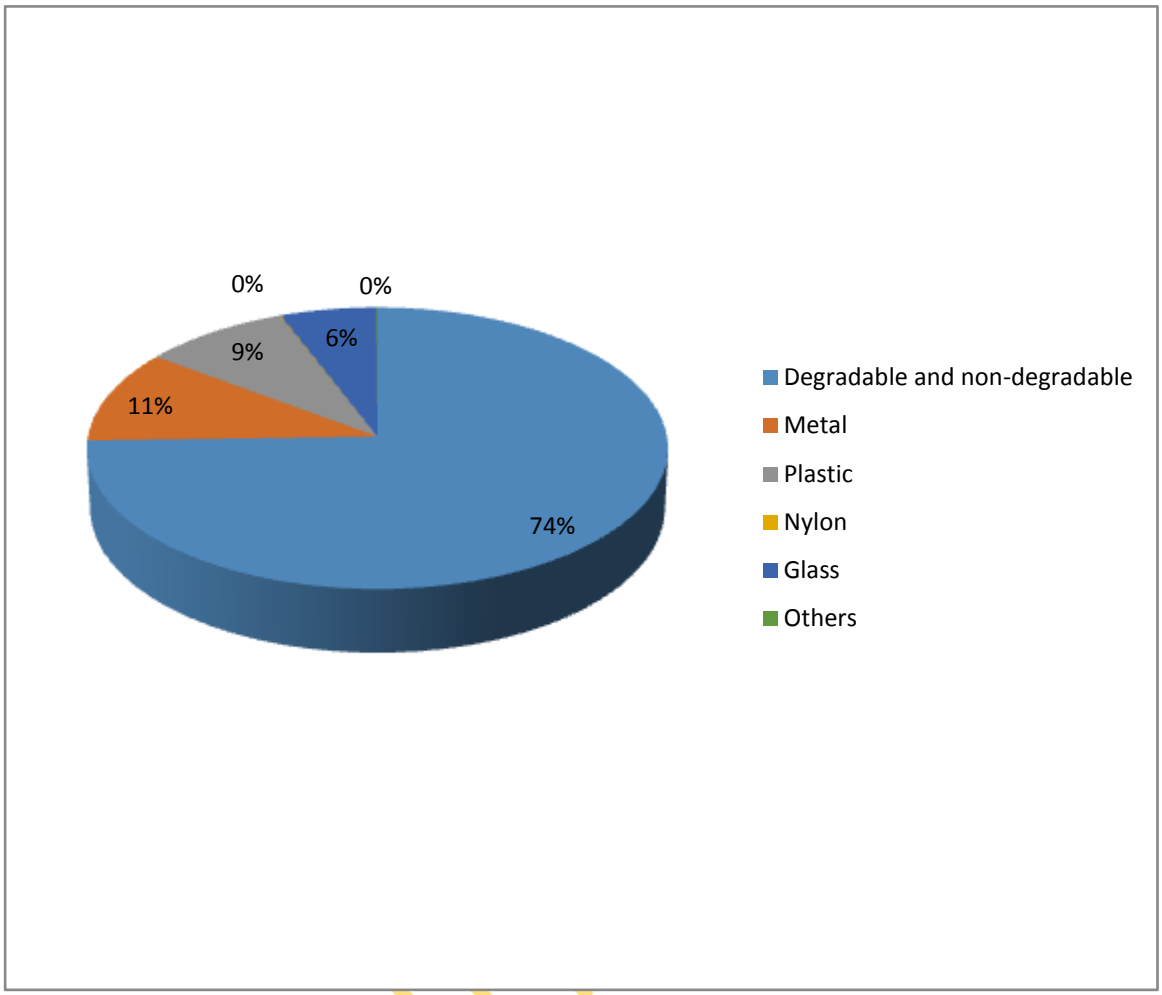


Figure 4.3; Pie chart showing solid waste segregated at pre-intervention.

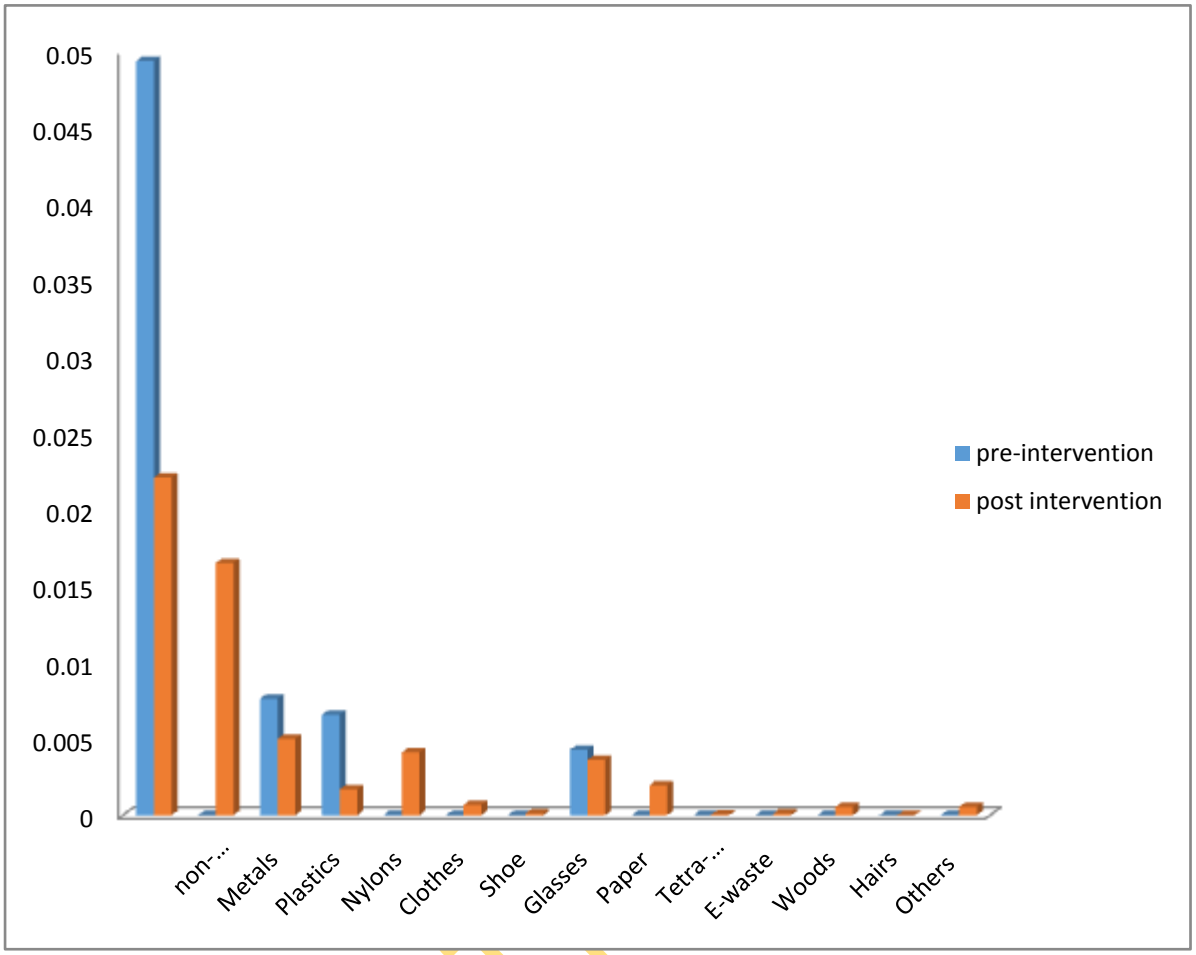


Figure 4.4: Bar chart showing solid waste segregation at pre and post intervention.
NB: Degradable at baseline include non-degradable.

CHAPTER FIVE

DISCUSSION

Majority of respondents from the community were females within the age range of 15 to 45 years with a mean age of 28.6±2.6 years as shown in Table 4.1. This could be due to the fact that women are the chief custodians of the home and even if they are in gainful employment, many of them work as cleaners and return home to prepare for the family needs. Margret, (2011) report that gender is significantly related to solid waste separation; she reports that women are more likely to separate solid waste than men. This behaviour is most probably because within the household, it is women who know and decide what is useful and what constitutes waste. Studies in Pakistan, Bangladesh and Ho Chi Minh City also find out women are more involved in source separation than men in the household (Beall,1997;Du, 1995). Ekere*et al.*,(2009) report similar results when they studied the separation of crop waste in Uganda.

Respondents had poor knowledge on waste segregation at the source of generation at pre-intervention as shown in Table 4.5 where 73.3% and 26.7% has poor and fair knowledge respectively. This would have been attributed to their varying levels of education but that seem not to be the case because respondents with tertiary and secondary education show that they know little or nothing about solid waste segregation at the source. This suggests that one's level of education does not confer awareness on solid waste segregation at the source of generation on one. Sridhar *et al.*,(2009) report that awareness on solid waste segregation can only come through persistent and carefully designed enlightenment programmes by well trained professionals in solid waste management WHO(1999) and Cookey, (2005) report that successful implementation of waste segregation can only be achieved by proper training of personnel of several institutions on what healthcare waste is, its classification, the purpose of segregation, the types of waste, the different colours of containers or bags designated for specific waste, their location and the use of each segregated waste. However, at post- intervention, respondents knowledge increased as shown in Table 4.16, were 64.3% and 7.1% are with good and poor knowledge respectively.

The attitude of respondents toward solid waste segregation at pre-intervention is shown in Table 4.6. The attitude of 86.7% is bad while that of 13.3% is fair attitude res. This could be attributed to the general attitude of people toward waste. Improperly managed waste exudes offensive odour. Thus people regard waste as filth that should never be meddled with. Hammed(2011) submits that In Nigeria and other developing countries, waste separation at

the household or source of generation is looked at as a filthy exercise. Most individuals want to remove waste from their sights as soon and as cheap as possible. However, at post intervention the attitude of respondents improved as shown in Table 4.17. The attitudes of 60.7% to waste became good while 28.6% still exhibited bad attitudes.

As indicated in Table 4.7, 70.0% of the pre-intervention practices is poor while 30.0% is fair. Majority of households disposed degradable and non-degradable waste together, only few households carried out what I referred to as partial waste segregation, because only few valuables such as cans of drink and infant formulas, plastic water bottles and whole bottles were set aside for reuse, and in most cases for sale to scavengers. This could be due to their knowledge and attitude levels. However, it could be due to poor motivation since the common practice in the environment could influence ones action. Hammed(2011) finds out that the current practice is that the municipal waste management Authority collects heterogeneous waste and disposes them into insanitary landfills without proper leachate control, which is not a sustainable or environment-friendly practice. ICPE India (2011) also reports thatSegregation of recyclable wastes at source is invariably not seriously practiced by households and establishments who rather dispose waste on the streets or in the municipal bins unsegregated because that is the normal practice overtime. However,93.3% of the post-intervention practices of waste segregation as shown in Table 4.18 is good and 2.4% is poor.

The nature and the quantity of materials segregated at pre-intervention, as shown in Table 4.19 are 5.0±0.5 for heterogeneous waste (degradables and non-degradables), other materials segregated were tin cans, plastic water bottles and glass bottles. This could be attributed to the lack of adequate knowledge on how and where to market valuables. Gorlay (1992) discovers that present waste arises not because the producer does not want it, but because he fails to use it or use less of it due to poor or lack of the knowledge or technology of recycling and or conversion. However, at post-intervention,the effect of training on the practice of solid waste segregation at the source of waste generation is significant in the community. The nature and the quantity of materials segregated as shown in Table 4.20 are 1.7±0.6 and 2.2±0.2 for dry waste (non-degradables) and wet waste(degradables) respectively.

Components of dry waste (non-degradable) segregated at post-intervention were polythene, metals, papers, plastics, glass (bottles) clothes, woods, shoes, human hair and tetra packs.

Sridhar *et al.*,(2010) reports that in Nigeria, an average citizen produces about 0.43 Kg solid waste per head per day with organic matters, plastics, polythene and scrap metals making up to about 60 to 80 per cent of the total waste stream .

Findings of this study have shown that there is the urgent need to formulate policies and create programmes that will encourage solid waste segregation. This will greatly impact on our present waste management practice. Public enlightenment and community participation should be given priority too. People should be adequately involved in the planning, development, implementation and evaluation of any solid waste management intervention programmes. Household composting should be encouraged. Simple composting techniques that are environmentally friendly should be adopted and practiced within the community to help reduce the load of organic waste from the community and provide manure for gardens. Adequate and proper legal framework should be put in place during the formulation of policies and programmes on solid waste management. Government at all levels should demonstrate the political will to implement solid waste segregation practices at the source of generation.

CHAPTERSIX

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Results of this intervention show that waste segregation at source is a practicable and sustainable approach for a more effective solid waste management in the country. However, there is need for collaboration of all stakeholders involved especially in the area of advocacy, public enlightenment, creation of buy-back recycling centres, community participation and public-private partnership arrangement. The findings of this study will improve the planning, development, implementation and evaluation of solid waste management in the Community, Local government area, state and Nigeria.

6.2 Recommendations

It is therefore recommend in very strong terms that

1. Increased community based public awareness programmes be undertaken.
2. Provision of bags by government as motivational incentive for waste segregation at the source.
3. Government should establish buy-back recycling centres.
4. Before any policy on Solid waste management should be adopted research on baseline information of the present situation of solid waste generation and practice be obtained.
5. Encourage solid waste segregation from the source of generation.
6. Encourage community participation.
7. Encourage house based waste composting.
8. Provide adequate legislation and enforcement.

REFERENCES

Adedibu A.A, 1983. Solid waste Characteristics in Ilorin Journal of the Nigeria Institute of Town Planners. 3 (1):17-21.

Ahmed S.A. and Ali S.M. 2004. Partnership for Solid Waste Management in Developing Countries. Habitat international. 28:467-479.

Akintola F.O. 1987. Prospects of Solid Waste Management in Ibadan City. Seminar paper, Department of Geography, University of Ibadan: 6-8.

Ali S.M. 1997. Separation at Source: A Case Study of Karachi, Pakistan. Amsterdam: UWEP: 52.

Amadi A.N 2011. ABC of Environmental health, Nationwide Printers and Publishers co ltd: 4-6.

Amadi A.N. 2009. Modern Environmental Sanitation, Nationwide Printers and Publishers co ltd: 80-85.

Anschütz J. 1996. Community-Based Solid Waste Management and Water Supply Projects: Problems And Solutions Compared A Survey of the Literature: 14-16.

Ayotamuno M.J. and Gobo E. 2004. Municipal Solid Waste Management in Port Harcourt, Nigeria, Obstacles and Prospects, Management of Environmental Quality; An International journal6 (15): 3-39.

Barton J.R, Darlley D, Patel V.S. 1997. Lifecycle Assessment for Waste Management.35-50.

Beall J. 1997. "Thoughts on Poverty from a South Asian Rubbish Dump: Gender, Inequality and Household Waste." IDS Bulletin 28 (3): 73–90.

Benavide 1996. Comparative analysis of hazardous household waste in two Mexican Cities. An international journal.16(4): 45.

Beukering van P, Sehker M, Gerlagh R, Kumar V. 1999. Analysing urban solid waste in developing countries: a perspective from Bangalore, India. Working Paper "CREED" 24: 5-8

CETH, 2002. Sino German Centre for Environmental Technology Newsletter: 20.

Cookey P., 2005. Fundamentals of Waste Water Treatment and Management: 12-13.

Coker, A. O. , Shridhar M. C. K., Akinyele J. O., 2008. An assessment of food residue and Development of an on-site composting bin for a community in Ibadan, Nigeria. International : CIGR, Journal, cigrjournal.org. accessed 5th febuary, 2013; 1.

Da Zhu M., Asnani R.H., Zuburgg C, Anapvsky S. 2008. Improving Municipal Solid Waste Management in India; A Source Book for Policy Makers and Professionals: 35.

De Luna Era and Marlon 1996.Environmental Awareness and Behaviour Regarding Waste Management Practices among Households in Muntinlupa Municipality, Manila. Master's thesis, Asian Institute of Technology (Bangkok): 85.

Du P.T, 1995. "The Determinants of Solid Waste Generation, Reuse and Recycling by Households in Ho Chi Minh City, Vietnam." Master Thesis. Asian Institute of Technology, Bangkok, Thailand: 100-112.

Egunjobi L, 1986.The Solid Waste Management Problem, Urban Growth and Urban Management in Nigeria with Particular Reference to Public Utilities and Infrastructure, NISER, Ibadan. 2(4): 64-70.

Egunjobi, L. 1992. Perception of Urban Environmental Problems: A pilot study centred on the City of Ibadan, Nigeria. NISER. 4(1) (2): 59-69.

EIONET, 2010. Soil data collection. www.eionet.europa.eu/ October: 1-5.

Ekere T, Mugisha W.J, L. Drake. 2009. "Factors Influencing Waste Separation and Utilization among Households in the Lake Victoria Crescent, Uganda." WasteManagement journal 29(3): 3047-3051.

Furedy C, Maclaren V.W., Whitney J.B.R.,1999. "Reuse of Waste for Food Production in Asian Cities: Health and Economic Prospects". In M. Koc, R. MacRae, L. Muogeot and J. Welsh (eds.) *For Hunger-Proof Cities: Sustainable Urban Food Systems* (Ottawa: International Development Research Centre): 136-144.

Furedy C., 1990. Social Aspects of Solid Waste Recovery in Asian Cities, Environmental Sanitation Review Series, Bangkok: Environmental Sanitation Information Centre. 30(5): 41-46.

Furedy C., 1992.Garbage*:* exploring non-conventional options in Asian cities, Environment and Urbanization,4(2): 42-61.

Furedy C., 1995.One world of waste : should countries like India solve solid wasteproblems through source separation? In: Tepper, E./ Wood, J.R.: Enrichedby South Asia: Social Science. Montreal: Canadian Asian Studies Association. 2(4):.87-107.

FuredyC, Lardinois I, Shah E.,1998. Source Separation in Developing Countries. Fieldnotes, June, Beijing, Gouda: WASTE: 10-30.

Gerlagh R, P. van Beukering, M. Verma, P.P. Yadav, P. Pandey, 1999. Integrated modelling of solidwaste in India. Working Paper "CREEDS". 26: 25-28.

Golit, 2001.Sustainable Cities and Benefits Regional Policy and Development Series. Mitshire Kingsley publishers London. 9(2): 241-256.

Gourlay, 1992.Problems of solid waste management in Nima, Accra: 35-40.

GATS, (Global Adult Tobacco Survey) 2010. Mapping and Listing Manual: 22-23.

Hammed T, 2011.Waste segregation at home-key to sustainable solid waste Recycling. Enzine articles.com: 4-5.

Hemelaar L. andMaksum A., 1996. Economy and finance in integrated sustainable waste management.Proceedings van de International Conference on Urban Engineering in Asian Cities in the 21st century,November 1996, Bangkok, Thailand, Asian Institute of Technology. 1(4):6-10.

Hemelaar L. (1999). Financing waste management in developing countries. Warmer Bulletin, January1999: 12.

Hoornweg D, Thomas L, Otten L (2008).Composting and its Applicability in Developing Countries. Urban and Local Government Working Paper Series, The World Bank, Washington, DC. 7: 24.

Hoornweg, Daniel and Laura Thomas. 1999. What A Waste: Solid Waste Management in Asia. Working Paper Series, Urban Development Sector Unit.East Asia and Pacific Region. 1: 5.

Huysman Marijk, 1994.The position of women waste pickers in Bangalore. In Baud,Isa/ Schenk, Hans (eds.): Solid Waste Management: Modes, assessments,appraisals and Linkages in Bangalore. New Delhi: Manohar Publishers: 105-145.

ICPE, 2004. Power Converters and Control of Renewable Energy.2(5): 150-200.

ICPE, 2011. Plastic Recycling and Waste management. 2(4): 5.

IEARN GEN 1, 2011. A survey of Household Solid waste management in Otukpo; A case study of Residents around Wesley high School Otukpo, Benue state Nigeria: 5-7.

IETC, 1996. International source book on environmentally sound technologies for municipal solid waste management. International Environmental Technology Centre, UNEP, Shiga, Japan: 10-17.

Ipadeola S.F. 1988. Solid waste Generation Management: Towards an Environmental Sanitation Policy Environmental Issues and Management in Nigeria Development, Heineman, Ibadan: 77-87.

Johannessen, Lars M, Dijkman M, Bartone C, Hanrahan D, Boyer, M. Gabriela,Chandra Candace, 1999.Health Care Waste Management Guidance Note. Urban Development Division, Infrastructure Group, Environment Department and Health, Nutrition and Population Team.The World Bank, Washington, D.C: 64.

Karanja, 1998. Improved solid waste incinerators: 64-85.

Klundert van de A andLardinois I., 1995. Community and private (formal and informal) sector involvement in municipal solid waste management in developing countries. Background paper for the UMP workshop in Ittingen: 12.

Kulkari S. 2008. Solid waste management at Garware wall ropes ltd: 4-9.

Lapid and Danilo G. (1997): Computerized information inquiry system for junk shops andrecyclers. In Dungate, D./ Fernandez, A./ Oya, K. (eds.): Recycling in Asia.Nagoya: United nations Centre for Regional Development (UNCRD)4(2): 125-136.

Lardinois I. andFuredy .C, 2012.Analysis of Case Studies from Pakistan, the Philippines, India, BrazilArgentina and the NetherlandsUrban Waste Series. 7: 21-31.

Lardinois.Iand van de Klundert A, 1994. Organic Waste, Urban Solid Waste Series, Amsterdam and Gouda: Tool, Transfer of Technology for Development and WASTE Consultants. 1(3): 8-30.

Lardinois I. and van de Klundert A. 1995. Community and private (formal and informal) sectorinvolvement in municipal solid waste management in developing countries.Background paper for theUMP workshop in Ittingen, Switzerland, 10-12 April 1995. Gouda, WASTE: 4-13.

Lardinois I. 1996. Integrated Sustainable Waste Management: concept and examples from Latin-America. Lecture at the seminar on Sustainable Urban Development in Developing Countries, 12-9-1996,organised by WASTE, IIUE and NUHG: 23-37.

Lardinois I, 1998. Source Separationin Developing Countries. Field notes,June, Beijing, Gouda: WASTE: 10-30.

Le ThiHuong, 1995.Urban Waste Derived Compost in Hanoi, Vietnam: Factorsaffecting Supply and Demand. Bangkok: Asian Institute of Technology: 54-55.

Lemeshow S. and Robinson D. 1985.Surveys to measure programme coverage and impact; a review of the methodology used by the Expanded Programme on Immunization. World health statistic quarterly. 38 (1): 65-75.

Levine S. 1997. Project Preparation: Solid Waste Management, Section IV. In: Urban Waste Management, Guidelines, Tools and Practices in Sub-Saharan Africa, World Bank, Washington DC: 36.

Levine S. 1994. Private sector participation in municipal solid waste services in developing countries. Urban Management and the Environment, UNDP/UNCHS (United Nations Centre for Human Settlements), World Bank, Washington DC. 1(13): 52.

Maclaren V.W. and Yu, C.C. 1997. "Solid Waste Recycling Behaviour of Industrial-Commercial-Institutional (ICI) Establishments", Growth and Change quarterly. 28(1): 93-109.

Margret B., 2011. Household Knowledge, Attitudes and Practices in Solid Waste Segregation andRecycling: The Case of Urban Kampala: 10.

Mehta Meera and Satyanarayana V., 2011.Pricing and Cost Recovery For Urban Services: A CityPerspective - Case of Pune Municipal Corporation.Paper presented at the Seminar on 'Pricing andCost Recovery of Urban Infrastructure and Services' organised by National Institute of Urban Affairs,National Institute of Public Finance and Policy, and Community Consulting international in Novemberat New Delhi: .35.

Moreno J.A, Rios F.R., Lardinois I., 1999. Solid waste management in Latin America: the role of micro- and small enterprises and co-operatives. IPES/ACEPESA/WASTE.Urban Waste Series.5: 10.

Morenzo C., 1996.Guidelines for solid waste management for developing countries.A manual prepared for UNCHS, Nairobi, Kenya: 10-15.

Moritz J.M. 1995. Current legislature governing clinical waste disposal; journal of Hospital infections.30(2): 521-530.

MSDU, 2006. Infectious Waste Management.8(2): 6-12. www.msdu.org, 12th October, 2012.

Newell C.J. and Adamson, D.T., 2005. Planning-Level Source Decay Models to Evaluate Impact of Source Depletion on Remediation Time Frame, Remediation.15 (4):25-36.

Noor K. M. 1997.Lessons learned from a recycling project in Malaysia. In Dungate, D. / Fernandez, A. / Oya, K. (eds.): Recycling in Asia.Nagoya: United Nations Centre for RegionalDevelopment(UNCRD): 59-82.

Nwude M.O 2006. A Sustainable Option for Solid Waste Management in Kaduna Metropolis Unpublished MSc thesis: 36.

Ofomata A, and Eze O. 2001. Geographical Perspective on Environmental Problems and Management in Nigeria, Jamoc Publishers: 40.

Ogboi K.C. and Okosun A.E. 2003. The role of scavengers in solid waste management in Nigeria, in Environmental studies and Research journal.3(2): 85-92.

Ogbonna D.N, Amangabara G.T, EkereT. 2002. Urban Solid Waste Generation in Port Harcourt Metropolis and its Implications for Waste Management: 12-14.

Ogu B.C., 1987. Solid waste Management in Imo State Urban Centres: The Case Study of Aba. Unpublished MURP Dissertation, Centre for Urban and Regional Planning, University of Ibadan: 18.

Olokesusi, G., 1991. Impact of the Ring Solid Waste Disposal Facility in Ibadan: 6.

Oskamp, Harrington S.M.J, Edwards T.C, Sherwood D.L, Okuda S.M and Swanson D.C. 1991. "Factors Influencing Household Recycling Behaviour." Environment and Behaviour. 23: 494-519.

Osse F.O 2006. Characterization of Abuja Federal Capital city Solid Waste for Appropriate Management Strategy. Unpublished MSc thesis: 10.

PAHO, 1995.Methodological guidelines for sectoral analysis in solid waste. Technical Report Seriesno. 4. Regional Plan for the Investment in the Environment and Public Health.USAID/BID/PAHO/World Bank. March 1995: 5-34.

Prakriti., 2006 – 07. Centre for Management Studies, Dibrugarh University National Environment Awareness Campaign. (http://cmsdu.org); 2-3. Accessed 10th oct., 2012.

Rajkumar T. K. 1997. Posting to internet conference on source separation in developing countries.http://www.mailbase.ac.uk/lists/solid-wastemanagementrecycle/archive.html: 10.

Sambaraju K and Shah E. 1997. Financial and marketing analysis of composting enterprises in Bangalore. Draft report prepared for WASTE: 12-14.

Schertenleib R and Meyer, N. 1992. Municipal solid waste management in DC's; problems and issues; needs for future research, IRCWD. 2: 25

Shah E. and Lardinois I.,1998. SourceSeparation in Developing Countries.Field notes,June, Beijing, Gouda: WASTE: 10-30.

Sridhar, M.K.C., Bammeke, A.O. and Omishakin, M.A. 1985. A Study on the Characteristics of refuse in Ibadan, Nigeria, Waste Management and Research, 3: 191-201.

Shridhar, M. C. K., Coker, A. O. 2009. Treatment and Disposal of Healthcare Waste; Health Care Waste Management- A Handbook for developing countries. Ibadan University Press, Ibadan, Nigeria: 18-25.

Sridhar M.C.K., Wahab B, Ayorinde D, Asamu S.O and Tairu T A, 2010.Report on Characterization of Solid Wastes in Ibadan: A Rapid Appraisal Survey in Four Residential Communities: 8.

Sridhar M.C.K., 2013. Integrated Waste Management Strategy. Lecture notes (unpublished): 4.

Tay, 1996. Solid waste management in humanitarian Response: 5217-5222.

Tchobanoglous G., Theisen H., Vigil S.A., 1993. Integrated Solid Waste Management Engineering principles and Management. 2(13): 978.

UkpongB., 2006. Strategy for sustainable solid waste management in the federal capital territory (garki, wuse, and karu). Unpublished MSc thesis: 9.

UNEP-IETC, 1996. International Source Book on Environmentally Sound Technologies for Municipal Solid Waste Management.Technical Publication Series, Osaka/Shiga: UNEP International Environmental Technology Centre. 6: 421-427.

UNESCO, 2011. UNESCO and Education "Everyone has the right to Education"pais United Nations Educational, Scientific and Cultural organization: 14.

Van Beukering, Verma M, Yadav P.P, Pandey P, 1999. Integrated modelling of solid waste in India. Working Paper "CREEDS" 26: 25-28.

Van de Klundert A. and Anschütz J. 1999, 2001. Integrated Sustainable Waste Management- the Concept. Tools for Decision-makers. Experiences from the Urban Waste Expertise Programme (1995-2001). WASTE: 5-25.

Van de Klundert A.,1999. Integrated Sustainable Waste Management- the Concept. Tools for Decision-makers. Experiences from the Urban Waste Expertise Programme (1995-2001). WASTE: 21-42.

Walling E, Walson A, Warren E, Warshay B, Wilhelm E, 2004. Municipal Solid Waste Management in Developing Countries, Nigeria, a Case Study: 6.

WASTE, 2005.www.Edugreen.teri.res.in/explore/solwaste/seg.,http://www.waste.nl (Accessed May 10th, 2013: 3-16.

WHO, 1999. Improving Health through Schools; National and International strategies. School health components of WHO mega county network for Health promotion: 25.

WHO, 2001-2011. Health care Waste management; the eight (8) steps along the waste stream: 15.

WHO/UNAIDS, 2009. Global Health Risk, Selected Major Risks; Mortality and Burden of Diseases Attributable: 96.

Yuwono, A.S. and Lammers, P.S. 2004 Odor Pollution in the Environment and the Detection Instrumentation. Agricultural Engineering International: the CIGR Journal of Scientific Research and Development.7:6.

Zamadar, 2010. Management of municipal solid waste of N.A.C India: 2-3

APPENDIX A

Questionnaires

I am a post graduate student of the University of Ibadan, faculty of Public Health, Environmental Health department. I am carrying out this work on solid waste segregation at the source of generation as a means of effective and efficient solid waste management using Okaka Community in Bayelsa State as a case study, for purely academic purposes all information obtained will be treated confidentially. I therefore solicit for your co-operation.

Thanks

1. Respondent's Number_____
2. Sex
   a. Male ☐
   b. Female ☐
3. How old are you?
   a. 18—25 ☐
   b. 25—35 ☐
   c. 35—45 ☐
   d. 45—above ☐
4. Occupation:
   a. Trading ☐
   b. Civil service ☐
   c. Corporate body ☐
   d. None ☐
   e. Others specify_____
5. Marital Status
   a. Married ☐
   b. Divorced ☐
   c. Single ☐
   d. Unmarried ☐
   e. Widow ☐
6. Education?
   a. Non-formal ☐
   b. Primary ☐

c. Secondary e. Tertiary

d. training workshop ☐

☐

7. Do you know any form of solid waste management?
   a. Yes ☐
   b. No ☐
   c. I can't tell ☐
8. Do you think solid waste can be converted into useful material?
   a. Yes ☐
   b. No ☐
   c. I can't tell ☐
9. Do you know if solid waste can be separated at source?
   a. Yes ☐
   b. No ☐
   c. I can't tell ☐
10. Do you know waste can be reused and recycled?
   a. Yes ☐
   b. No ☐
   c. I can't tell ☐
11. Do you think waste segregation at the source is beneficial to health?
   a. Yes ☐
   b. No ☐
   c. I can't tell ☐
12. Do you know if there is any useful material in solid waste?
   a. Yes ☐
   b. No ☐
   c. I can't tell ☐
13. Do you think it is ideal to put all your waste in a single bag?
   a. Yes ☐
   b. No ☐
   c. I can't tell ☐

14. Solid waste segregation at the source is necessary in Okaka Community
    a. Agree ☐
    b. Indifferent ☐
    c. Disagree ☐
15. Training of household on solid waste segregation is necessary in Okaka Community
    a. Agree ☐
    b. Indifferent ☐
    c. Disagree ☐
16. Do you know that people buy waste items
    a. Yes ☐
    b. No ☐
    c. I can't tell ☐
17. Solid waste segregation at the source enhances waste minimization and resource maximization
    a. Agree ☐
    b. Indifferent ☐
    c. Disagree ☐
18. The waste management authority and Government should be held responsible for the management of solid waste generated
    a. Agree ☐
    b. Indifferent ☐
    c. Disagree ☐
19. Solid waste segregation enhances a clean and healthy environment
    a. Agree ☐
    b. Indifferent ☐
    c. Disagree ☐

20. Do you use separate containers or bags for the collection/ storage of different category of valuables in waste
    a. Yes ☐
    b. No ☐
    c. I can't tell ☐
21. Do you separate valuables in waste before disposal
    a. Yes ☐
    b. No ☐
    c. I can't tell ☐
22. Do you separate valuables into different categories
    a. Yes ☐
    b. No ☐
    c. I can't tell ☐
23. Do you sell some of your waste items
    a. Yes ☐
    b. No ☐
    c. I can't tell ☐
24. Do you know about composting
    a. Yes ☐
    b. No ☐
    c. I can't tell ☐
25. Have you heard of waste segregation at source before?
    a. Yes ☐
    b. No ☐
    c. I can't tell ☐
26. Do you carry out solid waste segregation at the point of generation (in your household)?
    a. Yes ☐
    b. No ☐
    c. I can't tell ☐

27. Does your neighbour practice it?
    a. Yes ☐
    b. No ☐
    c. I can't tell ☐
28. Would you contribution to solid waste segregation at the source of generation (household)?
    a. Yes ☐
    b. No ☐
    c. I can't tell ☐
29. Do you know your organic waste can be a source of manure?
    a. Yes ☐
    b. No ☐
    c. I can't tell ☐

APPENDIX B

TRAINING MANUAL FOR SOLID WASTE SEGREGATION

- What is solid waste?
- **What is Dry Waste?**
- Paper, plastics, metal, glass, rubber, thermocool, Styrofoam, fabric, leather, rexine, wood – anything that can be kept for an extended period without decomposing
- **Will dry waste smell if I store it for a week?**
- Not if it is clean and dry. Make sure that plastic sachets of milk, curds, oil, idli batter, any food item, are cleaned of all their contents and dried before being put in the dry waste bag. Then they will not stink.
- **Will I have cockroach, rats and flies problems?**
- Only if any food residue or organic matter is present in the dry waste. Clean dry waste will not attract any vermin.
- **What is wet waste?**
- Wet waste consists of kitchen waste - including vegetable and fruit peels and pieces, tea leaves, coffee grounds, eggshells, bones and entrails, fish scales, as well as cooked food (both veg and non-veg).
- **Can I compost at home?**
- Of course. Home composting can be easily done in Daily Dump's pot system, or in any aerated container.
- **I don't have time to compost at home, what are my alternatives?**
- If you live in a large apartment building, a community composting system like tank composting or an improvised drum for composting could be set up for all the wet waste from the residents. If not, the wet waste can be given out every day.
- **If I don't use a plastic liner, how do I dispose my food waste in the bin?**
- Before the advent of the bin liner, we would all put our garbage directly in the bin, and wash it every day. That is what we will have to do now. The bin can

be lined with a newspaper liner or a layer of sawdust if you don't want to put the wet waste directly into it.

- Where does solid waste come from?
- Concerns about solid waste management
- How do we manage solid waste?
- How do we minimize solid waste?
- How do we maximize resource recovery from solid waste?
- What is solid waste segregation?

Waste segregation basically means keeping wet and dry wastes separately, so that dry can be recycled and wet waste can be composted.

Why should I do it?

1. So that it will reduces waste that gets landfilled and reduces pollution(air, water), improve aesthetics, pest infestation (rodents, vermins, vectors)

2. So that different processes- composting, recycling, incineration can be applied to different kinds of waste.

- How is it done (practical session)

1. Keep separate containers or bags for dry and wet waste in the kitchen

2. Keep plastic from the kitchen clean and dry and drop into the dry waste bin. Keep glass /plastic containers rinsed of food matter

3. Send wet waste out of the home daily. Store and send dry waste out of the home, once a week.

- How do we dispose solid waste materials finally

APPENDIX C

ABBREVIATIONS/ KEYWORDS USED

Waste segregation; the process of differentiating solid waste materials or products with the aim of recovery, reducing, reusing and recycling waste material.

Non-degradable waste; is waste that cannot be broken down to its base compounds by micro-organisms, air, moisture or soil in a reasonable time

Waste characterisation; the process of analysing the composition of different waste stream.

APPENDIX D

Principal researcher during mapping exercise

Principal researcher collecting segregated solid waste in bags.

APPENDIX E

A cross sectional of trainees

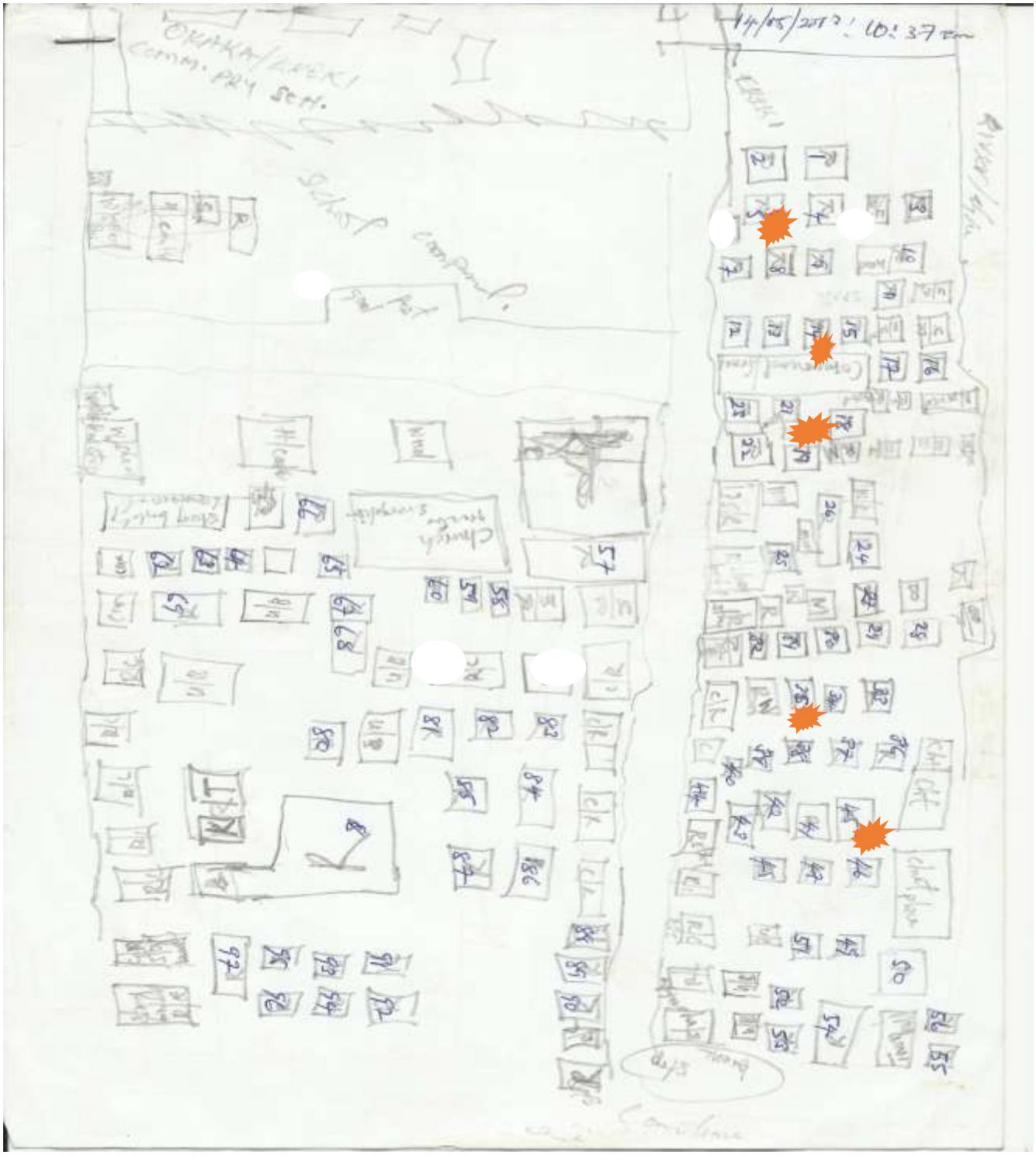
Principal researcher segregating the components of the dry non-degradable solid waste

APPENDIX F

Principal researcher with the materials used.

APPENDIX G

BASE MAP OF OKAKA COMMUNITY



APPENDIX H


21/05/2013 08:46 am
old settlement
Total 148 residential premises
END OF BKSAKI

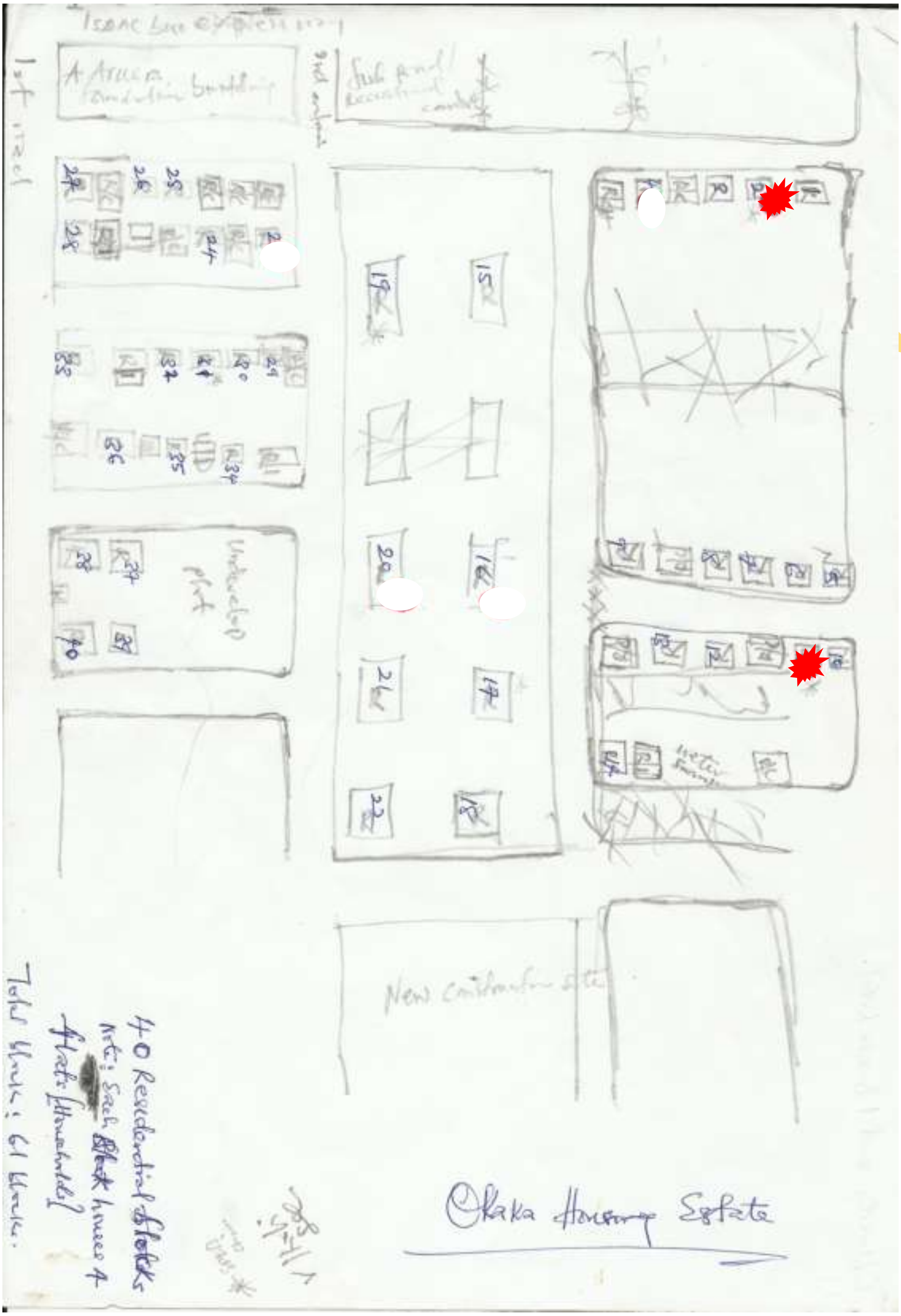
APPENDIX I

APPENDIX J

APPENDIX K

APPENDIX L

APPENDIX M



APPENDIX N

DEPARTMENT OF ENVIRONMENTAL HEALTH SCIENCES
FACULTY OF PUBLIC HEALTH, COLLEGE OF MEDICINE
UNIVERSITY OF IBADAN, IBADAN, NIGERIA.

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Email: ehsnov2011@gmail.com

*Our Ref:*_____ *Your Ref:*_____ *Date:*_____

11th June 2013

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Sir,

LETTER OF INTRODUCTION – OVOH, PREOWEI SOLOMON

I write with respect to the above introducing the bearer (Mr. **OVOH Preowei Solomon**) who is undergoing his postgraduate programme in the Department of Environmental Health Sciences. His particulars are as follows:-

Name	OVOH PREOWEI SOLOMON
Matric No.	166536
Sex:	Male
Programme	MPH, Environmental Health
Department	Environmental Health Sciences
Faculty	Faculty of Public Health

It shall therefore be appreciated if he is duly accorded necessary assistance.

Thank you.

Warmest Regards.

Dr. G.R.E.E. Ana
Coordinator