EFFECTS OF TRAINING ON ORGANIC RECYCLING AND THE USE OF COMPOST BIN ON WASTE MANAGEMENT PRACTICES IN TWO SECONDARY SCHOOLS IN IBADAN, NIGERIA.

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CERTIFICATION

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DEDICATION

This piece of work is dedicated to Almighty Allah my incomparable guardian who has made this a reality for me and to my dear parents, Alh. Funsho Okin and late Mrs Sherifat O. Okin.

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ABSTRACT

Management of solid wastes is one of the most crucial environmental problems faced by many schools in developing nations and recycling is an option for averting this problem. Information on segregation and characterization of wastes for recycling in secondary schools is limited in Nigeria. The study was aimed at assessing the effect of training on organic waste recycling and use of compost bin on waste management practices in selected secondary schools in Ibadan.

A quasi-experimental study design was adopted. Two schools were purposively selected with International School Ibadan serving as the Experimental Group (EG) while Walbrook College Ibadan was the Control Group (CG). The EG and CG comprised 196 students each selected from each school using systematic sampling technique. A validated questionnaire with a 14-point knowledge scale and a 16-item observation checklist were used to collect data from participants before and after intervention. Wastes generated over one month in the two schools were characterized and weighed while their physico-chemical characteristics were determined using recommended standard methods. During a month intervention period, a subset of the EG (50 students) were trained on organic waste recycling and provided with a fabricated two-compartment 0.91 by 0.91 metre compost bin for use while the CG continued with the use of the conventional waste bin. At post intervention, the same questionaire used at baseline was used to re-assess the two groups. Data were compared with the Ontario compost guideline limits. Descriptive statistics, t-test and Chi square test were used for data analysis.

The mean age of respondents for EG and CG were 14.8±1.3 and 14.8±1.4 years respectively. The mean knowledge scores before and after intervention among EG were 3.5±1.7 and 5.5± 1.6 ($p<0.05$) while CG had 3.8±1.7 and 4.1±1.8 respectively. Mean organic wastes generated before intervention in EG (156.9±22.6kg) was higher than in CG (56.3±15.9kg) ($p<0.05$). Organic recycling was adopted in EG because of high quantity of organic wastes generated at baseline. Post-intervention organic waste generated in EG and CG were 45.2±7.4kg and 51.2±9.3kg respectively ($p<0.05$). A comparison of the raw organic waste versus compost produced in EG (156.9 ±22.6kg versus 45.2± 7.4kg) showed that both differed significantly while there was no difference in CG (56.3±15.9kg versus 51.2± 9.3kg). The chemical constituents of organic waste before and after intervention in the EG were: Carbon (62.0±0.04% versus 24.0±0.01%), Nitrogen (2.4±0.00% versus 1.9 ± 0.01%), Phosphorus (9.6± 0.3% versus 7.5 ± 0.01%) and Pottasium (3.0 ± 0.04% versus 1.6 ± 0.04%), while that of CG were Carbon (49.0± 0.01% versus 47.2±0.02%), Nitrogen (2.3 ± 0.01% versus 2.2± 0.01%), Phosphorus (10.1± 0.01% versus 9.9± 0.01%) and Pottasium (1.8± 0.01% versus 1.7± 0.01%). Mean NPK concentration in compost (1.9%, 7.5% and 1.6%) were high compared to Ontario compost guideline limits (0.6%, 0.3% and 0.2%). All the 50 participants used the compost bin and reported continued use after intervention.

Training and provision of compost bin resulted in increased knowledge and the practice of organic waste recycling as well as reduction in organic waste generation in the Experimental Group. Training and provision of compost bin should, therefore, be promoted for adoption of organic waste recycling in boarding schools in Nigeria.

Keywords: Solid waste management, Composting, Waste Characterization

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CHAPTER ONE

1.0 INTRODUCTION

Since creation, humankind has been generating waste such as bones and other parts of animals slaughtered for food or wood cut to make carts. No organism, no matter how simple, is 100% efficient. As it consumes resources, there is inevitably a certain amount of wastage. Civilization has always produced waste. However, with the progress of civilization, the waste generated assumed more complex nature. But with evolution in industry and technology and a corresponding growth in world's population, waste management has become an increasingly difficult and complex problem. The increase in population and urbanization has also tremendously contributed to the increase in solid wastes.

Thousands of tons of solid wastes are generated daily in Africa. Most of it ends up in open dumps and wetlands, contaminating surface and ground water and posing major health hazards. Generation rates, available only for selected cities and regions, are approximately 0.5 kilograms per person per day— in some cases reaching as high as 0.8 kilograms per person per day (Sridhar, 2000). While this may seem modest compared to the 1–2 kg per person per day generated in developed countries, most wastes in Africa are not collected by municipal collection systems because of poor management, fiscal irresponsibility, equipment failure, or inadequate waste management budgets.

The waste generated in Nigeria as well as in other countries that do not have proper disposal means create unsanitary living conditions and detrimental health concerns, such as diarrhoea and malnutrition, in addition to a range of sicknesses and diseases (Ksimon, 2008).
Economic Development, urbanization, improved living standards in cities and increase in enrolment of school children due to government policies increase the quantity and complexity of generated solid waste in schools. If accumulated, it leads to degradation of urban environment, stresses natural resources and leads to health problems (CPCB, 2000).

Schools generate a great deal of waste in the United States, especially as a by-product of food service. Many, of course, have some sort of recycling program in place. The challenge to schools is to make waste management a viable and even exciting part of the total learning experience. Often, school districts are unaware of the hard costs of garbage generation and disposal. A large part of this figure is waste generated from school lunch. School meal programs, even when lunch is brought from home, are significant generators of solid waste (Brown, 2004). There are many regional variations that require each community to examine its own waste management needs. Such factors as local and regional availability of suitable landfill space, proximity of markets for recovered materials, population density, commercial and industrial activity and climatic and groundwater variations all may motivate each community to make its own plans (USEPA, 1998).

Waste generation, management, storage, treatment and disposal is an important aspect of sound environmental management. Management of solid wastes is a problem of increasing concern throughout the world. It is one of the greatest challenges facing any urban area in the world. Developing integrated solutions for waste management problems requires public involvement. To economically and efficiently operate a waste management program requires significant cooperation from generators, regardless of the strategies chosen.

Public education stimulates interest on how waste management decisions are made. When citizens become interested in their community's waste management programs, they frequently demand to be involved in the decision-making process (De Young, 1984). Environmental attitude of young people appears to be crucial as they ultimately play a direct role in providing knowledge based-solutions to in-coming environmental problems (Bradley et al, 1999; Eagles and Demare, 1999). Furthermore, school environmental program, although addressed to students, can also influence upon the environmental knowledge, attitude and behaviour of adults (parents, teachers and community members) through the process of intergenerational influence (Evans et al, 1996).

Waste Recycling has been a common practice for most of human history, with recorded advocates as far back as Plato in 400 BC. During periods when resources were scarce, archaeological studies of ancient waste dumps show less household wastes (such as ash, broken tools and pottery) — implying more waste was being recycled in the absence of new material.

Waste Recycling is regarded as one of the key components in the environmental management of solid wastes (Robinson, 1986). It reduces the amounts of solid wastes such that less space is needed for disposal (Kazemi, 1996). Recycling schemes in schools help to improve the environment and can reduce money spent by the school on waste disposal.

1.1 STATEMENT OF THE PROBLEM

The problems associated with the disposal of wastes are many and they include littering of food and other solid wastes in the school compounds. One of the more challenging and negative consequences of the lack of knowledge involving the unsafe and inappropriate disposal of solid waste is the predisposition to health problems and very unpleasant conditions in many schools. This can lead to the breeding of rats and other vectors which are of public health importance (Tchobanoglous et al, 1977). Rats are also destructive and their activities can lead to the destruction of school materials such as paper and other important items.

The problem of waste management has arisen relatively recently in developing countries where there is little history of the implementation of formal or informal community environmental education awareness programmes (Grodzinska-Jurczak et al., 2003).
On a daily basis a great amount of organic waste is produced (more than 30% of municipal solid waste) and can be valued through composting. These organic waste if not well managed could therefore pose hygiene problems and public health hazards. The organic waste component of landfill is broken down by micro-organisms to form 'leachates' which contains bacteria, decaying matter and chemical contaminants from the landfill. This leachate can present a serious hazard if it reaches a watercourse or enters the groundwater. Degrading organic matter in landfills also generates methane, which is a harmful greenhouse gas, in large quantity.

1.2 JUSTIFICATION FOR THE STUDY

With the increase in population, solid waste management remains a major problem for most municipalities. The most common waste management practice, which is mainly dumping of waste and burning by the municipality, should not be allowed from the national, as well as the global point of view considering effect on underground water quality and harmful effects on the ozone layer (Ali, 2001).

For health reasons, waste in tropical regions should actually be collected daily. This makes the challenges and costs of solid waste management in most of Africa even more daunting. It is generally the city center and the wealthier neighborhoods that receive service when it is available. In poorer areas, uncollected wastes accumulate at roadsides, are burned by residents, or are disposed of in illegal dumps which blight neighborhoods and harm public health. Unless more effective urban waste management programs and public water supply systems are put in place, outbreaks of cholera, typhoid and plague may become increasingly common.

Identification of the components of waste stream is also an important step toward addressing the issues associated with the generation and management of municipal solid wastes (MSW). MSW characterizations, which analyze the quantity and composition of the municipal solid waste stream, involve estimating how much MSW is generated, recycled (including composting), combusted, and disposed of in landfills. By determining the makeup of the waste stream, waste characterizations also provide valuable data for setting waste management goals, tracking progress toward those goals, and supporting planning at the national, state and local levels (USEPA, 1998).

Recent concerns about managing wastes and producing food in an environmentally sound manner has led to a renewed interest in small-scale, backyard composting as well as interest in developing large-scale, commercial and municipal composting systems. Taking responsibility for the solid waste stream at school empowers students by giving them a specific action to help their community and the earth. Students develop a sense of school pride by taking steps toward becoming a "green school" (a school that practices wise use of natural resources). Students may spread the compost message and be instrumental in starting composting at home or in their neighborhood.

Composting in schools provides a rich topic for scientific investigation and discovery. Although composting is simple (you just put organic matter in a pile and wait for it to decompose), it also involves some fascinating and as yet incompletely understood interactions between biological, chemical and physical processes and can help students to see the interconnections between various scientific fields.

By addressing the solid waste issue, composting provides a way of instilling in students a sense of environmental stewardship. Many educational programs focus on reducing, reusing, and recycling our solid wastes. Composting fits in with this idea but takes it a step beyond (Cornell Waste Management Institute, 1996).

1.3 BROAD OBJECTIVE OF THE STUDY

The broad objective of the study is to assess the effect of training on organic recycling and the use of compost bin on waste management practices in two secondary schools.

1.4 SPECIFIC OBJECTIVES OF THE STUDY

The specific objectives of the study were to:

i. Assess the knowledge and attitude of students towards organic waste recycling as well as solid waste management practices in selected schools at baseline;
ii. Characterize the waste generated into physical and chemical components in order to explore their recyclable potentials;
iii. Introduce waste segreggation and organic recycling in boarding secondary schools.
iv. Design and fabricate a two-compartment 0.91m by 0.91m compost bin and conduct training on its utilization for organic waste recycling in schools.
v. Assess the effects of training and the designed compost bin on the adoption of organic waste recycling in the selected schools.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 What is waste?

Waste is an unavoidable by-product of human activities and may be regarded as "any unavoidable materials resulting from domestic activity and industrial operations for which there are no economic demand and which must be disposed of" (Central Pollution Control Board, 2000). The term waste can apply to a wide variety of materials, including discarded food, leaves, newspapers, bottles, construction debris, chemicals from a factory, candy wrappers, disposable diapers, and radioactive materials. Waste exists in the three states of matter i.e either solid, liquid or gaseous states.

2.2 Solid Wastes

Solid waste refers to the unwanted or discarded material that requires disposal of some type. It can come in a solid, liquid or gaseous form. This material comes from household, commercial, industrial, agricultural, mining, or municipal activities. Cimino (1975) also defined solid wastes as discarded solids arising from animal or human activities. In general this does not include excreta, although sometimes nappies and the feaces of young children may be mixed with solid wastes. It is also broadly defined as including industrial, commercial and domestic refuse including household organic trash, street sweepings, hospital and institutional garbage and construction waste.

2.3 Classification of Solid Wastes

Solid waste can be classified in several different ways. Most solid wastes can be subdivided into one of three major categories: municipal solid wastes; agricultural, mining and industrial wastes and hazardous wastes. The nature of the material may be important, so classification can be made on the basis of organic, inorganic, combustible, non-combustible, putrescible and non-putrescible fraction.

The classification of solid waste is usually used for choosing treatment, collection, recycling and disposal options (Tchobanoglous et al., 1993). Solid Wastes may also be broadly classified as Hazardous wastes and Non- Hazardous wastes. Non-Hazardous wastes have little or no potential to produce harmful consequence or toxic leachates when stored, while hazardous wastes pose immediate and/or latent hazards to plant, animal and ecological environment. Hazardous wastes produce toxic leachates and harmful fall-out when stored or disposed in the environment (Peavy et al. 1985). The point of origin is important in some cases hence classification into residential, industrial, institutional, commercial, construction may be useful (Table 2.1).

Bhide & Sunderason (1983) also provided a classification based on the source, origin and type of waste. A comprehensive classification is described below:

(i) Domestic/Residential Waste

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

(ii) Commercial Waste

Included in this category are solid wastes that originate in offices, wholesale and retail stores, restaurants, hotels, markets, warehouses and other commercial establishments.

(iii) Institutional Waste

Institutional wastes are those arising from institutions such as schools, universities, hospitals and research institutes. It includes wastes which are classified as garbage and rubbish as well as wastes which are considered to be hazardous to public health and to the environment.

(iv) Garbage

Garbage is the term applied to animal and vegetable wastes resulting from the handling, storage, sale, preparation, cooking and serving of food. Such wastes contain putrescible organic matter, which produces strong odors and therefore attracts rats, flies and other vermin. It requires immediate attention in its storage, handling and disposal.

(v) Rubbish

Rubbish is a general term applied to solid wastes originating in households, commercial establishments and institutions, excluding garbage and ashes.

Table 2.1: Sources and Types of Solid Wastes

Source	Typical waste generators	Types of solid wastes
Residential	Single and multi-family dwellings	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).
Industrial	Light and heavy manufacturing, fabrication, construction sites, power and chemical plants.	Housekeeping wastes, packaging, food wastes, construction and demolition materials, hazardous wastes, ashes, special wastes.
Commercial	Stores, hotels, restaurants, markets, office buildings, etc.	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes.
Institutional	Schools, hospitals, prisons, government centers.	Same as commercial.
Construction and demolition	New construction sites, road repair, renovation sites, demolition of buildings	Wood, steel, concrete, dirt, etc.
Municipal services	Street cleaning, landscaping, parks, beaches, other recreational areas, water and wastewater treatment plants.	Street sweepings; landscape and tree trimmings; general wastes from parks, beaches, and other recreational areas; sludge.
Process (manufacturing, etc.)	Heavy and light manufacturing, refineries, chemical plants, power plants, mineral extraction and processing.	Industrial process wastes, scrap materials, off-specification products, slay, tailings.
Agriculture	Crops, orchards, vineyards, dairies, feedlots, farms.	Spoiled food wastes, agricultural wastes, hazardous wastes (e.g., pesticides).

Source: Hoornweg et al (1999).

(vi) Ashes

Ashes are the residues from the burning of wood, coal, charcoal, coke and other combustible materials, for cooking and heating in houses, institutions and small industrial establishments. When produced in large quantities at power generating plants and factories these wastes are classified as industrial wastes. Ashes consist of a fine powdery residue, cinders and clinker often mixed with small pieces of metal and glass (Cointreau, 1982).

(vii) Bulky Wastes

In this category are bulky household wastes which cannot be accommodated in the normal storage containers of households. For this reason they require special collection. In developed countries bulky wastes are large household appliances such as cookers, refrigerators and washing machines as well as furniture, crates, vehicle parts, tyres, wood, trees and branches. Metallic bulky wastes are sold as scrap metal but some portion is disposed of at sanitary landfills.

(viii) Street Sweepings

This term applies to wastes that are collected from streets, walkways, alleys, parks and vacant lots. In the more affluent countries manual street sweeping has virtually disappeared but it still commonly takes place in developing countries, where littering of public places is a far more widespread and acute problem. Mechanised street sweeping is the dominant practice in the developed countries. Street wastes include paper, cardboard, plastic, dirt, dust, leaves and other vegetable matter.

(ix) Dead Animals

This is a term applied to dead animals that die naturally or accidentally killed. This category does not include carcass and animal parts from slaughter houses which are regarded as industrial wastes. Dead animals are divided into two groups, large and small. Among the large animals are horses, cows, goats, sheep, hogs and the like. Small animals include dogs, cats, rabbits and rats. The reason for this differentiation is that large animals require special equipment for lifting and handling during their wastes (Cointreau, 1982).

2.4 Municipal Solid Waste

Municipal Solid Waste (MSW) is the portion (about 73 percent) of the total solid waste stream that comes from residences, businesses, municipalities and institutions (schools, hospitals, nursing homes etc). MSW does not include solid waste from manufacturing, mining or agricultural operations. Municipal solid wastes (MSW) also called urban wastes is a waste type that includes predominantly household wastes (domestic wastes) with sometimes the addition of commercial wastes collected by a municipality within a given area (Welsh Assembly, 2005). Municipal solid waste is what most people think of as garbage, refuse, or trash. It is generated by households, businesses (other than heavy industry) and institutions such as schools and hospitals. They are in either solid or semisolid form and generally exclude industrial hazardous wastes. The term residual waste relates to waste left from household sources containing materials that have not been separated out or sent for reprocessing. Municipal solid waste as defined by USEPA includes durable goods, non-durable goods, containers and packaging, food wastes and yard trimmings and miscellaneous inorganic wastes.

2.4.1 Categories of Municipal Solid Waste

There are five broad categories of MSW. These include (1) Biodegradable waste: food and kitchen waste, green waste, paper (can also be recycled) (2) Recyclable material: paper, glass, bottles, cans, metals, certain plastics etc (3) Inert waste: construction and demolition waste, dirt, rocks, debris (4) Composite wastes: waste clothing, tetra paks, waste plastics such as toys, (5) Domestic hazardous waste (also called "household hazardous waste") & toxic waste: medication, e-waste, paints, chemicals, light bulbs, fluorescent tubes, spray cans, fertilizer and pesticide containers, batteries, shoe polish. Some examples of the types of MSW that come from each of the broad categories of sources are as shown in table 2.2:

Table 2.2: Sources and Examples of Municipal Solid Wastes

Sources and Examples	Example Products
Residential (single- and multi-family homes)	Newspapers, clothing, disposable tableware, food packaging, cans and bottles, food scraps, yard trimmings
Commercial (office buildings, retail and wholesale establishments, restaurants)	Corrugated boxes, food wastes, office papers, disposable tableware, paper napkins, yard trimmings
Institutional (schools, libraries, hospitals, prisons)	Cafeteria and restroom trash can wastes, office papers, classroom wastes, yard trimmings
Industrial (packaging and administrative; *not* process wastes)	Corrugated boxes, plastic film, wood pallets, lunchroom wastes, office papers.

Source: USEPA 1998.

2.4.2 Functional Elements of Municipal Solid Waste Management System

The functional elements of Municipal solid waste are as follows:

(1) Waste generation: Waste generation encompasses activities in which materials are identified as no longer being of value and are either thrown away or gathered together for disposal.

(2) Waste handling and separation, storage and processing at the source: Waste handling and separation involves the activities associated with management of waste until they are placed in storage container for collection. Handling also encompasses the movement of loaded containers to the point of collection. Separation of waste components is an important step in handling and storage of solid waste at the source (Peavy et al., 1985).

(3) Collection: The functional element of collection includes not only the gathering of solid waste and recyclable materials, but also the transport of these materials, after collection, to the location where the collection vehicle is emptied. This location may be a materials processing facility, a transfer station or a landfill disposal site.

(4) Seperation and processing and transformation of solid wastes: The types of means and facilities that are now used for the recovery of waste materials that have been separated at the source include curbside collection, drop off and buy back centers. The separation and processing of wastes that have been separated at the source and the separation of commingled wastes usually occur at a materials recovery facility, transfer stations. combustion facilities and disposal sites.

(5) Transfer and transport: This element involves two steps:

I. The transfer of wastes from the smaller collection vehicle to the larger transport equipment

II. The subsequent transport of the wastes, usually over long distances, to a processing or disposal site.

(6) Disposal: Today the disposal of wastes by landfilling or landspreading is the ultimate fate of all solid wastes, whether they are residential wastes collected and transported directly to a landfill site, residual materials from materials recovery facilities (MRFs), residue from the combustion of solid waste, compost or other substances from various solid waste processing facilities. A modern sanitary landfill is not a dump; it is an engineered facility used for disposing of solid wastes on land without creating nuisances or hazards to public health or

safety, such as the breeding of rats and insects and the contamination of ground water (Peavy et al., 1985).

2.4.3 Municipal Solid Waste Generation and Management Information

Municipal solid waste data is one that may provide a local, state and nationwide picture of municipal solid waste generation and management (USEPA, 1998). The historical perspective is particularly useful in establishing trends and highlighting the changes that have occurred over the years, both in types of wastes generated and in the ways they are managed. This perspective on MSW and its management is useful in assessing national solid waste management needs and policy. This data however, is of equal or greater value as a solid waste management planning tool for state and local governments and private firms.

At the local or state level, MSW generation and management data can be used to develop approximate (but quick) estimates of MSW generation in a defined area. That is, the data on generation of MSW per person nationally may be used to estimate generation in a city or other local area based on the population in that area. This can be of value when a "ballpark" estimate of MSW generation in an area is needed. This information can help define solid waste management planning areas and the planning needed in those areas. However, for communities making decisions where knowledge of the amount and composition of MSW is crucial e.g. where a solid waste management facility is being sited, local estimates of the waste stream should be made. Another useful feature of MSW data for local planning is MSW trends. Changes over time in total MSW generation and the mix of MSW materials can affect the need for and use of various waste management alternatives. Observing trends in MSW generation can help in planning an integrated waste management system that includes facilities sized and designed for years of service. While the national average data are useful as a checkpoint against local MSW characterization data, any differences between local and national data should be examined carefully.

Possible reasons for differences in MSW generation and management data are:

- Scope of waste streams may differ. That is, a local landfill may be receiving construction and demolition wastes in addition to MSW, but this report addresses MSW only.

- Per capita generation of some products, such as newspapers and telephone directories, varies widely depending upon the average size of the publications. Typically, rural areas will generate less of these products on a per person basis than urban areas.
- The level of commercial activity in a community will influence the generation rate of some products, such as office paper, corrugated boxes, wood pallets and food wastes from restaurants.
- Variations in economic activity can affect waste generation in both the residential and the commercial sectors.
- Variations in climate and local waste management practices will greatly influence generation of yard trimmings. For instance, yard trimmings exhibit strong seasonal variations in most regions of the country. Also, the level of backyard composting in a region will affect generation of yard trimmings.
- Generation and discards of other products will be affected by local and state regulations and practices. Deposit laws, bans on landfilling of specific products, and variable rate pricing for waste collection are examples of practices that can influence a local waste stream (USEPA, 1998).

2.5 Waste Characteristics

There are a number of ways in which wastes produced in developing countries differ from that of industrialized countries. While actual composition is certainly not uniform in all developing regions in either of these categories, there are some general ways in which income influences both waste generation rates and composition. At a macro level, MSW generation increases with an increase in Gross National Product. At a household level, as income rises, the general trend is an increase in paper, metals and glass, a decrease in kitchen waste, accompanied by an increase in total weight and a decrease in density (Wright, 1997). There are number of key waste characteristics.

2.5.1 Physical Characteristics of Solid waste

Peavy et al, (1985) stated that the physical properties of solid waste include: Composition, particle size, moisture content, density and seasonal variability in the quantity and quality of the waste. The physical characteristics aid appropriate bin design and efficient operation of solid waste management.

2.5.1.1 Density

The density data are often needed to assess the total mass and volume of water that must be managed. The density of any solid waste stream will be determined by the composition and by the degree of shape alteration. The densities of solid wastes vary markedly with geographic location, season of the year, and length of time in storage (Tchobanoglous et al., 1993). The physical and chemical properties of solid waste are used to classify wastes and to determine equipment needs. They are essential tools that aid in the design of management plans with respect to source seperation, energy recovery and disposal of solid wastes (Peavy et al, 1985; Waite, 1995). A higher solid waste density also has many implications for the 'traditional' methods of collection and disposal; collection and transfer trucks which are able to achieve compression rates of up to 4:1 in industrialized nations may achieve only 1.5:1 in developing countries, and landfill compression technology which averages volume reduction of up to 6:1 in industrial nations may only achieve 2:1 compaction with these increased waste densities applications; as income level increases and the amount of post-consumer waste such as packaging increases correspondingly, such technologies may be more appropriate. Additionally, the high moisture content and organic composition of wastes in the developing world may lead to problems of increased decomposition rates in areas with high average daily temperatures; high seasonal or year-round rainfall would only compound these problems, presenting additional challenges with insect populations and conditions conducive to disease. To mitigate these problems, much more frequent collection is needed in hot, humid areas to remove organic wastes before they are able to decompose than would be needed in cooler, drier climates. The typical densities and moisture contents of components of municipal solid wastes are as summarized in Table 2.3.

Although daily collection has proven unreliable or unworkable in many cities (Cointreau, 1982), perhaps a twice-weekly collection of organic material possibly in conjunction with a municipal composting operation, would be sufficient to reduce decomposition. Knowledge of the density of a waste is essential for the design of all elements of the solid waste management system viz. Community storage, transportation and disposal. For example, in high income countries, considerable benefit is derived through the use of compaction vehicles on collection routes, because the waste is typically of low density.

Table 2.3: Typical Densities of Municipal Solid Wastes Discarded in Uncompacted Form

MSW Component	Density, Kg/M^3		Moisture Content (%)	
	Range	Typical	Range	Typical
Food Wastes	128.2 – 480.6	288.3	50-80	70
Paper	32.0- 128.2	81.7	4-10	6
Cardboard	32.0 – 80.1	52.4	4-8	5
Plastics	32.0- 128.2	64.1	1-4	2
Textiles	32.0- 96.1	64.1	6-15	10
Rubber	96.1- 192.2	128.2	1-4	2
Leather	96.1- 256.3	160.2	8-12	10
Garden Trimmings	64.1- 224.3	104.1	30-80	60
Wood	128.2- 320.4	240.3	15-40	20
Glass	160.2 – 480.6	193.8	1-4	2
Tin cans	48.1- 160.2	88.1	2-4	3
Nonferrous metals	64.1 – 240.3	160.2	2-4	2
Ferrous metals	128.2 – 1,121.3	320.4	2-6	3
Silt, Ash, Dirt, brick etc.	320.4 – 961.14	480.6	6-12	8

Source: Tchobanoglous et al., (1993)

A reduction of volume of 75% is frequently achieved with normal compaction equipment, so that an initial density of 100 kg/m^3 will readily be increased to 400 kg/m^3. In other words the vehicle would haul four times the weight of waste in the compacted state than when the waste is uncompacted. The situation in low-income countries is quite different: a high initial density of waste precludes the achievement of high compaction ratio. Consequently, compaction vehicles offer little or no advantage and are not cost-effective. Significant changes in density occur spontaneously as the waste moves from source to disposal, as a result of scavenging, handling, wetting and drying by the weather, vibration in the collection vehicles (Bhide and Sunderasan, 1983).

2.5.2 Chemical Characteristics of Solid Waste

Representative data on the ultimate analysis of a typical municipal waste component are presented in Table 2.4. Information on the chemical composition of solid wastes is important in evaluating alternative processing and recovery options. For instance if solid wastes are to be used as fuel, properties to be known are: Proximate analysis, fusing point of ash, Ultimate analysis and Heating Value (Tchobanoglous et al, 1993).

2.6 Solid Waste Characterization

Waste characterization means finding out how much paper, glass, food waste, etc. is discarded in your waste stream. MSW characterizations, which analyze the quantity and composition of the municipal solid waste stream, involve estimating how much MSW is generated, recycled (including composting), combusted and disposed of in landfills.

Solid waste streams are characterized by their sources, by the types of wastes produced, as well as by generation rates and composition. Identifying the components of the waste stream is an important step toward addressing the issues associated with the generation and management of municipal solid wastes. Accurate information in these three areas is necessary in order to monitor and control existing waste management systems and to make regulatory, financial and institutional decisions. The determination of waste quantity and composition is essential to successful solid waste management.

Table 2.1: Typical Data on Ultimate Analysis of the Combustible Components in Municipal Solid Waste

MSW Component	Percentage by dry weight					
	Carbon	Hydrogen	Oxygen	Nitrogen	Sulfur	Ash
Food Wastes	45-75	6-12	20-40	1-2	0.2-0.4	4-5
Paper & Cardboard	30-60	5-10	30-40	0-0.3	0.1-0.2	5-10
Plastics	50-80	8-10	15-20	<0.1	<0.1	6-10
Textiles	40-50	5-8	30-40	1-2	0.1-0.2	3-4
Rubber	60-70	8-10	-	-	1-2	15-20
Leather	50-60	6-8	10-12	8-10	0.2-0.4	8-10
Garden Trimmings	45-50	4-6	30-40	3-4	0.3-0.4	6-8
Wood	45-50	5-6	40-45	0.1-0.2	<0.1	0.5-1.5
Glass	0.5-0.6	0.1-0.2	0.2-0.4	<0.1	-	98-99
Metals	4.5	0.4-0.6	3-4	<0.1	-	90-95
Silt/Ash/Dirt	20-30	3-5	3-4	0.4-0.6	0.1-0.3	60-70

Source: Liu and Liptak (1996)

In low-income countries, waste is usually very high in organics, because other constituents are removed either before set-out or between set-out and collection. High-income countries, by contrast, tend to have a lower proportion of organic waste but more paper, plastic, metal, and glass.

Waste characterization information helps in planning how to reduce waste, set up recycling programs, and conserve money and resources. By determining the makeup of the waste stream, waste characterizations also provide valuable data for setting waste management goals, tracking progress towards those goals, and supporting planning at the national, state, and local levels (USEPA, 1998).

The characterization of municipal solid waste consists of two major parts: **quantity** and **composition**. The first major part of waste characterization, quantity, is the easier of the two to characterize, and it is measured in volume or weight, with greater accuracy coming from weight measurements. Characterizing waste quantity usually involves continuous or periodic weighing of waste delivered to waste management facilities. The second part of waste characterization, waste composition, is not as easily characterized, since it requires taking samples of waste and sorting them into material categories to define the fraction or percentage of the waste from each category. This process is more difficult because:

(1) Defining an easily understood, useful and consistent set of material categories is not straightforward.

(2) Solid waste is a highly heterogeneous material, requiring large numbers of samples to accurately characterize.

2.6.1 The objective of waste characterization

With more states moving toward establishing waste reduction goals and as regulations and disposal costs have become more of a burden on local governments, the public perception toward solid waste has undergone significant shifts. Solid waste is no longer just "garbage" that goes away when the truck comes. Rather, it is something that must be managed properly to avoid future problems. From this change in emphasis on solid waste emerges the need to "characterize," as precisely as possible with available resources, what it is that must be managed and processed (Roy, Hazen and Sawyer, 1992).

The purpose of waste caracterization however is to gather useful accurate and appropriate data on the amount of the waste stream as needed to assist in planning of solid waste management programmes and facilities. In many instances, some components of the waste stream are managed with one option, while other components are directed to other options. Thus, waste quantity and composition data are necessary to ensure that needs are met and that management options available match these needs.

2.6.2 Planning uses of solid waste characterization

There are a variety of planning uses that waste characterization data can provide. Among these are:

- Sizing of facilities designed to process waste;
- Projecting landfill life expectancy using incoming tonnage and potential waste diversion estimates;
- Identifying materials to target for recycling programs and facilities;
- Identifying materials to target for source reduction initiatives;
- Identifying who (i.e., residents, businesses) generates portions of the waste stream;
- Monitoring impact of source reduction and recycling programs, changes in waste generation habits, and changes in composition brought about by changing community demographics;
- Informing the public about what goes into the waste stream;
- Determining Btu values for waste destined for wastetoenergy facilities.

2.7 Solid Waste Composition

General waste (MSW: Municipal solid waste) is generated every day at various places such as households, shops, restaurants, offices and schools (WACS, 2004). A frequent error in the set-up of collection and transfer systems is to assume that all waste streams are alike. Waste generation and waste components can vary significantly from day to day, season to season and year to year. The composition of the waste stream varies not only seasonally, but within ethnic and social divisions in the same country. Between countries, hemispheres and continents, there is rather large variation.

According to Diaz and Golucke (1985), Urban wastes can be subdivided into two major components; organic and inorganic. In general, the organic components of urban solid waste can be classified into three broad categories: putrescible, fermentable, and non-fermentable. Putrescible wastes tend to decompose rapidly and unless carefully controlled, decompose with the production of objectionable odours and visual unpleasantness. Fermentable wastes tend to decompose rapidly, but without the unpleasant accompaniments of putrefaction. Non-fermentable wastes tend to resist decomposition and, therefore, break down very slowly. A major source of putrescible waste is food preparation and consumption. As such, its nature varies with lifestyle, standard of living and seasonality of foods. Fermentable wastes are typified by crop and market debris.

African cities tend to have waste streams in which the organic content is very high, as exemplified in Table 2.5. The high organic content is due to the fact that reusable materials such as glass, metal, and hard plastics, are retrieved and reused or recycled, resulting in a final waste stream which has limited potential commercial value in the recovery of recyclable materials. However, there still may be sufficient quantities in the MSW of high density cities to warrant implementing recovery programs (Palczynski, 2002). The high organic content, if left alone, constitutes a major health and environmental hazard. Calorific values are reported as being low, making the waste streams typically unsuitable for energy recovery via incineration. However, it has the potential to be used as an organic fertilizer (Asomani-Boateng and Haight, 1999).

Table 2.5: Waste Composition in Selected African Cities

Composition (% by Weight)	*Cities* Kumasi, Ghana	Accra, Ghana	Ibadan, Nigeria	Kampala, Uganda	Kigali, Rwanda
Organic	84.0	85.1	55.8	75.0	94.0
Plastic	-	3.4	6.3	-	-
Glass	-	1.9	1.8	-	-
Metal	-	2.6	-	-	-
Paper	-	4.9	12.9	-	-
Inert	-	-	-	-	-
Cloth	-	3.0	-	-	-

Source: Asomani-Boateng and Haight, 1999

2.7.1 Organic Waste

Organic waste is produced wherever there is human habitation. The main forms of organic wastes are household food waste, agricultural waste, human and animal waste. In industrialised countries, the amount of organic waste produced is increasing dramatically each year. Commercially produced organic waste is generated at institutional buildings such as schools, hotels and restaurants. Organics make up 30-80 percent (~70 percent on average) of the waste stream in Africa, although this varies with the incomes of the neighborhood, region or country. If this part of the waste stream could be used for compost or methane production, many adverse impacts of open dumps and landfills would be reduced. Landfills would require less space, last longer, and produce less leachate.

Waste materials that are organic in nature, such as plant material, food scraps, and paper products, can be recycled using biological composting and digestion processes to decompose the organic matter. The resulting organic material is then recycled as mulch or compost for agricultural or landscaping purposes. The biodegradable fraction in wastes that cannot be recycled or converted into new products, increasingly is treated through composting. It is the lowest cost alternative to landfilling for many wastes.

2.7.2 Putrescible wastes

Putrescible waste is the animal and vegetable waste resulting from the handling, preparation, cooking and serving of food. It is composed largely of degradable organic matter and moisture. It also includes small amounts of free liquids. Putrscible waste originates primarily in homes, kitchens, stores, markets, restaurants and other places where food is prepared, stored or served. This type of waste decompose rapidly particularly in warm weather and may easily produce undesirable odour.

2.7.3 Food wastes

Food leftovers are the single-largest component of the waste stream by weight in the United States. Americans throw away more than 25 percent of the food prepared, about 96 billion pounds of food waste each year. Food waste includes uneaten food and food preparation

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2.7.3.1 Characteristics of Food Wastes

Organic materials generated by commercial facilities, such as supermarkets, food processors, and restaurants, have the potential for diverting large amounts of food, soiled and waxed cardboard, and paper (Ligon & Garland, 1998). In a supermarket for example organic residuals compose 75 to 90 percent of the total waste stream (Ligon & Garland, 1998). Food waste represents approximately 50 to 65 percent of the weight and volume, respectively, of the solid waste generated in commercial and noncommercial food service operations (Byers et al., 1999). If other organics were included, the quantity of waste that could be composted would be even higher.

2.7.3.2 Generators of Food Wastes

Food waste is generated from many sources: food manufacturing and processing facilities; supermarkets; institutions such as schools, prisons, and hospitals; restaurants and food courts; and households. Food waste is categorized as either pre-consumer (i.e. preparatory food scraps) or post-consumer waste (e.g. leftover food or plate scrappings. Large-Scale Generators of Food wastes are food service providers (e.g supermarkets, institutions, restaurants) that produce a significant quantity of food waste each day. However, homeowners and Small-Scale Generators of Food wastes are residents and other small scale generators of food waste that can compost at home or on their own property. By composting food waste onsite, homeowners and small business can significantly reduce the amount of waste for disposal and save money from avoided disposal costs (USEPA, 2006).

2.8 Waste Generation Rates

Generation refers to the amount (weight or volume) of materials and products that enter the waste stream before recycling (including composting), landfilling or combustion takes place (USEPA, 1998) i.e the term generation refers to the weight of materials and products as they enter the waste management system from residential, commercial, institutional and industrial sources and before materials recovery or combustion takes place. Waste generation means the rate of waste produced, no matter how this waste is managed. In many instances, one generation rate is estimated for the entire waste stream to be managed. However, as recycling and waste reduction activities have increased, there has been an increasing need to understand and manage the waste stream based on source. Thus, with increasing frequency, waste generation rates are being broken into two or more categories. At a minimum, most communities will find it necessary to separate the generation rate from residential sources from that of commercial and industrial sources. One reason for categorizing the waste stream by section is that residential waste generation and composition typically vary less from location to location than does commercial and industrial waste. Thus for residential waste, it is more common to utilize existing information than it may be for other segments of the waste stream. Waste generation rates are most often used to project waste management needs. This requires that consideration also be given to projected changes in the waste generation rates. Typically, this requires analysis of the local economic conditions as well as assumptions regarding future waste reduction activities. Generation rates, available only for selected cities and regions, are approximately 0.5 kilograms per person per day - in some cases reaching as high as 0.8 kilograms per person per day. While this may seem modest compared to the 1–2 kg per person per day generated in developed countries, most waste in Africa is not collected by municipal collection systems because of poor management, fiscal irresponsibility, equipment failure, or inadequate waste management budgets (EGSSA, 2009).

Throughout most of sub-Saharan Africa solid waste generation exceeds collection capacity. This is in part due to rapid urban population growth: while only 35 percent of the sub-Saharan population lives in urban areas, the urban population grew by 150 percent between 1970 and 1990. But the problem of growing demand is compounded by broken-down collection trucks and poor program management and design. The Characterization of Municipal Solid Waste in the United States: 1990 update, prepared for the EPA, has projected an increase in waste generation rates over the next twenty years. This is consistent with the trend nationally over the last twenty years. However, it is virtually impossible to generalize in this area. One approach would be to assume that generation rates remain the same and that disposal rates are only decreased by parallel increases in recycling and composting activities. Many generation projections also will give a range of estimates (Roy, Hazen and Sawyer, 1992). Category and the unit of waste generation rate is illustrated in Table 2.6.

Table 2.6: Category and the Unit of Waste Generation Rate.

Category		Waste Generation Rate
Household		g/person/day
Commercial	Restaurants	g/chair/day
	Other shops	g/shop/day
Institution (offices)		g/employee/day
Markets		g/store/day
Hotels		g/room/day
Schools		g/student/day
Road clearing		g/m^2/day

Source: Waste Amount and Composition Survey, 2004.

2.9 Impacts of Solid Wastes

2.9.1 Impacts on the Environment:

- The blockage of roads by refuse leads to traffic chaos and increase in the risk of human and vehicular accidents.
- The blockage of drains and streams by solid wastes results in flooding, which occassionally reaches proportions that cause loss of life and property, breeding of mosquitoes, the causative agent for malaria when they bite exposed humans.
- Indiscriminate burning of refuse leads to production of green house gases which can contribute to global warming (excessive heating of the earth), drought and flooding. It also leads to acid rain which would affect agriculture and pollute the soil and water.
- Loss of prime land for housing and other land use activities.

2.9.2 Impacts on Health:

- The health hazards caused by indiscriminate disposal of solid wastes include fires, injuries from bottles, cans, nails etc.when people tread when dumping more refuse. The resultant wounds can lead to serious diseases such as tetanus.
- Insanitary disposal of solid wastes promotes diseases that can be transmitted from hand to mouth, food to water. These diseases include cholera, typhoid fever, dysentery, polio, hepatitis and worm infections.
- Solid wastes dumps provide breeding grounds for flies, mosquitoes, rats and other vermin which are responsible for the transmission of diseases such as malaria, lassa fever and trachoma.
- Stray animals such as dogs are also attracted to refuse bins and this can lead to dog bites which could result in rabies.

2.10 Solid Waste Management

Solid Waste Management may be defined as that discipline associated with the control of generation, storage, collection, transfer and transport, processing, and disposal of solid wastes in a manner that is in accord with the best principles of public health, economics, engineering, conservation, aesthetics, and other environmental considerations, and that is also responsive to public attitudes. A primary objective of waste management today is to protect the public and the environment from potential harmful effects of waste. Some waste materials are normally safe but can be hazardous if not managed properly. One gallon (3.75 liters) of used motor oil, for example, can contaminate one million gallons (3,750,000 liters) of water.

Who manages waste? Every individual, business, and industry must make decisions and take some responsibility regarding its own waste. On a larger scale, government agencies at the local, state, and federal levels enact and enforce waste management regulations. These agencies also educate the public about proper waste management.

According to Tchobanoglous et al., 1993), management of municipal solid waste involves (a) development of an insight into the impact of waste generation, collection, transportation and disposal methods adopted by a society on the environment and (b) adoption of new methods to reduce this impact. Waste that is not properly managed, especially excreta and other liquid and solid waste from households and the community are a serious health hazard as they attract flies, rats and other creatures and lead to the spread of infectious diseases.

2.10.1 Elements of a Waste Management System

Waste management system include some or all of the following activities:

- Evolving policies
- Planning and evaluating MSWM activites by system designers, users and other stakeholders
- Using waste characterization studies to adjust systems to the types of wastes generated.
- Physically handling waste and recoverable materials including seperation, collection, composting, incineration and landfilling.
- Marketing recovered materials to be taken to end-users for industrial, commercial or small-scale manufacturing purposes.
- Establishing training programs for MSWM workers.
- Carrying out public information and education programmes.
- Identifying financial mechanisms and cost-recovery systems.
- Establishing prices for services and creating incentives.
- Managing public sector administrative and operations units

- Incorporating private sector businesses including informal sector collectors, processors and entrepreneurs (UNEP-IETC, 1998). A growing emphasis has been placed on the Four R's: Reduce, Reuse, Recycle and Resource Recovery.

2.10.2 Worldwide agenda for solid waste management

Environmentally sound management of increasing amounts of difficult-to-treat or organic wastes is among the topics of major concern today in most cities. The logical starting point for solid waste management is to reduce the amounts of waste that must be managed, that is, collected and disposed of as nuisances and hazards. Agenda 21, the agreement reached among participating nations at the United Nations Conference on Environment and Development in Rio de Janeiro in 1992, that reducing wastes and maximizing environmentally sound waste reuse and recycling should be the first steps in waste management. The environmental, social and economic benefits of integrating practices of waste reduction into MSWM are the bases for an emerging worldwide agenda for solid waste management (UNEP-IETC, 1998).

2.10.3 WHO Guideline Principles on Waste Management

WHO collaborated with national government agencies, local organizations and industries to provide principles aimed at ensuring preventive waste management worldwide to combat the enormous problems associated with waste management (Wyes, 1997).

These principles include:

- Segregation of non-hazardous wastes from hazardous waste producing processes to avoid innocuous fractions from being contaminated by hazardous components
- Auditing existing operations and production methods to reduce the volume of waste produced

2.10.4 Solid Waste Management in Nigeria

World Bank in 1996 stated that Nigeria is a nation that exemplifies chronic solid waste management problems in conjunction with population growth. It is the most populous country in Africa, with over 120 million residents and over the past 50 years, has had the third largest urban growth rate in the world at 5.51% annually (UNWUP, 1999). It is estimated that nearly ten percent of the population live below the national poverty line. The Federal Government has very little control over environmental regulation as a whole. The Federal Environmental Protection Agency (FEPA) was established in 1988 to control the growing problems of waste management and pollution in Nigeria (Onibokun and Kumuyi, 2003).

Vision 2010 (2003) report says in regard to solid waste management, the goal is to "achieve not less than 80 percent effective management of the volume of municipal solid waste generated at all levels and ensure environmentally sound management" Strategies to achieve this goal include education and awareness programs, developing colloborotive approaches to integrative management of MSW, strengthening existing laws and ensuring compliance, and encouraging local and private sector participation. Although this represents a positive, though somewhat undefined, approach to solid waste management, the reality of poverty and government corruption has prevented effective implementation of these plans. However, Bankole (2004) stated that there is little to hold the government or the public accountable to the regulations developed by FEPA and Vision 2010.

2.10.5 Institutional Waste Management in Developing Countries

According to Jerie (2006), the analysis of Institutional Waste Management carried out in Gweru, Zimbabwe revealed that Institutional Solid Waste Management has been the slowest to develop either direction or regulatory mechanisms of all environmental problems that have come into focus in Gweru. In Ibadan, Nigeria, Africa's largest indigenous settlement, the spectacular failure of many programs and machineries for waste disposal in this city has led to a continuous shift in responsibilities between agencies and the various tiers of government, as well as prompting some degree of privatization (Onibokun and Kumuyi, 2004). The general picture is that significant quantities of waste are generated in the institutional sector, but there are no sound practices for managing the waste (Jerie, 2006)

2.10.6 Solid Waste Management in Schools

The physical environment of a school adds a lot of value to the school (Ohong, 2007). Egim (2003) observed in her study on School Environment and Administrator's Role Performance in Cross River State Secondary Schools that the physical environment contributes either negatively or positively to the administrator's role performance in the school.

One of the greatest challenges facing developing countries is the unhealthy disposal of solid waste which resulted from human activities of development and survival (Onibokun, 1999; Osinowo, 2001; Joseph, 2006; Longe & William, 2006; Kofoworola, 2007). However, managing school environment has posed great challenges over the years to the government, principals and administrators (Obong et al., 2010). The challenges range from location, beautification, waste materials, landscaping, sanitation, greening, and so forth. These issues have occupied some studies by researchers such as Sanitation Connection (2001/2002) and Egim (2003); Obong (2007). School environment are often strewn with litters of papers, dusty classrooms, poor ventilation, and landscaping for sit-outs during break periods (Obong et al., 2010).

Public Schools in the world are facing a high level of pollution; the situation in developing countries is more acute, this is partly caused by inadequate provision of basic services like water supply, sanitation facilities, transport infrastructure and waste collection (UNCHS (Habitat), 2001). Ehrampoush and Moghadam in 2005, stated that the problem of waste management has arisen recently in developing countries where there is little history of the implementation of formal and informal community environmental education awareness program. It is therefore common to see school environments poorly maintained.

2.10.7 Potential Environmental Impacts from Solid Waste Management Activities

The typical municipal solid waste stream will contain general wastes (organics and recyclables), special wastes (household, hazardous, medical and industrial waste) and construction and demolition debris. Most adverse environmental impacts from solid waste management are rooted in inadequate or incomplete collection and recovery of recyclable or reusable wastes, as well as codisposal of hazardous wastes. These impacts are also due to inappropriate siting, design, operation, or maintenance of dumps and landfills. Improper waste management activities can:

- Increase disease transmission or otherwise threat to public health: Rotting organic materials pose great public health risks, including, as mentioned above, serving as breeding grounds for disease vectors. Waste handlers and waste pickers are especially vulnerable and may also become vectors, contracting and transmitting diseases when human or animal excreta or medical wastes are in the waste stream. Risks of poisoning, cancer, birth defects, and other ailments are also high.

- **Contaminate ground and surface water:** Municipal solid waste streams can bleed toxic materials and pathogenic organisms into the leachate of dumps and landfills. (Leachate is the liquid discharge of dumps and landfills; it is composed of decayed organic waste, liquid wastes, infiltrated rainwater and extracts of soluble material.) If the landfill is unlined, this runoff can contaminate ground or surface water, depending on the drainage system and the composition of the underlying soils. Many toxic materials, once placed in the general solid waste stream, can be treated or removed only with expensive advanced technologies. Currently, these are generally not feasible in Africa. Even after organic and biological elements are treated, the final product remains harmful.
- **Create greenhouse gas emissions and other air pollutants:** When organic wastes are disposed of in deep dumps or landfills, they undergo anaerobic degradation and become significant sources of methane, a gas with 21 times the effect of carbon dioxide in trapping heat in the atmosphere. Garbage is often burned in residential areas and in landfills to reduce volume and uncover metals. Burning creates thick smoke that contains carbon monoxide, soot and nitrogen oxide, all of which are hazardous to human health and degrade urban air quality. Combustion of polyvinyl chlorides (PVCs) generates highly carcinogenic dioxins (Environmental Guidelines for Small Scale Activities, 2009).
- **Damage ecosystems:** When solid waste is dumped into rivers or streams it can alter aquatic habitats and harm native plants and animals. The high nutrient content in organic wastes can deplete dissolved oxygen in water bodies, denying oxygen to fish and other aquatic life forms. Solids can cause sedimentation and change stream flow and bottom habitat. Siting dumps or landfills in sensitive ecosystems may destroy or significantly damage these valuable natural resources and the services they provide.
- **Injure people and property:** In locations where shanty towns or slums exist near open dumps or near badly designed or operated landfills, landslides or fires can destroy homes and injure or kill residents. The accumulation of waste along streets may present physical hazards, clog drains and cause localized flooding.
- **Discourages tourism and other business:** The unpleasant odor and unattractive appearance of piles of uncollected solid waste along streets and in fields, forests and other natural areas,

can discourage tourism and the establishment and/or maintenance of businesses (EGSSA, 2009).

2.11 Integrated Solid Waste Management

Integrated Solid Waste Management (ISWM) refers to the complementary use of a variety of activities, including waste prevention, recycling, composting, incineration and disposal, to safely and effectively handle MSW. A successful ISWM system requires the consideration of "how to prevent, recycle, and manage solid waste in ways that most effectively protect human health and the environment. ISWM involves evaluating local needs and conditions, and then selecting and combining the most appropriate waste management activities for those conditions," (USEPA, 2002).

Integrated waste management is also a frame of reference for designing and implementing new waste management system and for analysing and optimizing existing systems. Integrated waste management is based on the ideas that all aspects of the waste management system should be analysed together, since they are in fact inter-related and development in one area frequently affect practices or activities in another area. The activities have a range of desirability, which are demonstrated in the hierarchy of integrated solid waste management in Fig 2.1

Figure 2.1: Hierarchy of integrated solid waste management

Source: Heimlich et al., 2006

2.11.1 Waste Reduction

Source reduction or waste reduction at source is gaining more attention as an important solid waste management option. Source reduction, often called "waste prevention," is defined by USEPA (2000b) as "any change in the design, manufacturing, purchase, or use of materials or products (including packaging) to reduce the amount or toxicity before they become municipal solid waste. Prevention also refers to the reuse of products or materials." Thus, source reduction activities affect the waste stream before the point of generation. MSW is considered to have been generated if it is placed at curbside or in a receptacle such as a dumpster for pickup or if it is taken by the generator to another site for recycling (including composting) or disposal.

Source reduction activities resulted in more than 23 million tons of municipal solid wastes not having to be discarded in 1996. Approximately 17% of the materials involved in source reduction efforts were containers and packaging. Non-durable goods such as newspapers and clothing and durable goods including appliances, furniture and tires represented 16% and 6%, respectively of source reduction efforts. During this same time period 58% of other municipal solid waste (e.g yard trimmings, food scraps) were diverted for composting. Between 2-5% of the waste stream is potentially reusable. Most communities have some type of collection centers, such as thrift stores and charitable organizations that encourage consumers to donate items for reuse.

Source reduction measures encompass a very broad range of activities by private citizens, communities, commercial establishments, institutional agencies and manufacturers and distributors. Example of source reduction activities include:

- Redesigning products or packages so as to reduce the quantity of materials or the toxicity of the materials used, by substituting lighter materials for heavier ones and lengthening the life of products to postpone disposal.
- Using packaging that reduces the amount of damage or spoilage to the product.
- Reducing amounts of products or packages used through modification of current practices by processors and consumers.

- Reusing products or packages already manufactured.
- Managing non-product organic wastes (food wastes, yard trimmings) through backyard composting or other on-site alternatives to disposal.

2.11.2 Waste Reuse

Reuse and repair are the earliest forms of waste prevention. Waste reuse means reusing a product for the same or a different purpose. The reuse of materials results in water and energy savings and the reduction of pollution and consumption of natural resources. Reuse of products can prevent pollution, reduce waste and improve industrial and economic competitiveness (Medina, 2002).

2.11.2.1 Benefits of Source Reduction and Reuse

Benefits resulting from source reduction and reuse activities include: conservation of natural resources, reduced amount of waste, decreased air pollution and the production of greenhouse gases, reduced toxicity of waste and reduced costs. Reusing decreases the demand on natural resources for manufacturing new products. Reprocessing materials decreases the amount of waste to be recycled or transported to landfills or waste combustion facilities. Toxicity is reduced when manufacturers select less hazardous disposal methods for materials, use the least amount of raw materials, follow label directions on cleaning materials, and recycle hazardous chemicals. Purchasing materials in bulk can also decrease the quantity of waste generated. Communities, businesses, schools, and individual consumers also can experience economic savings from source reduction efforts (Reuse Development Organization, 2000; USEPA, 2000b).

2.11.3 Source Seperation of Solid Wastes

This is the seperation of solid wastes into different components as they are generated in the office, shop or in the homes. It can also be defined as the practice of setting aside post-consumer materials and household goods so that they do not enter mixed waste streams (Lardinois and Furedy, 2007). 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). The process of source seperation is aimed mainly at simplifying the process of recycling i.e the various components of wastes of the same type are collected together for onward transportation to the recycling plants.

2.11.3.1 Benefits of Source Seperation

- Source seperation promotes the removal of all designated recyclable materials from the waste stream and therefore, helps in achieving high reduction rates.
- Source seperation promotes clean, marketable materials by limiting levels of contamination. Contamination undermines long term marketability of recyclable materials.
- Source seperation allows the recycler at the source to receive the economic benefit of cost avoidance by not disposing of recyclable materials as solid waste as well as enabling the recycler to receive revenue by the sale of the recyclable material.
- Source seperation fosters a free market, independent of the solid waste collection and disposal system. This reduces the need for burdensome regulators and costly enforcement.
- Proper documentation is difficult, if not impossible, when recyclables are mixed with solid wastes.
- Source seperation fosters competition among recycling companies, thereby keeping costs low and quality of services high.
- Source seperation encourages a thought process among each individual recycler that solid waste disposal is every person's responsibility. This can foster further source reduction and recycling activities at work, home and school.

2.11.4 Incineration

Incineration is the combustion of waste at high temperatures. It uses a wide variety of combustion systems developed from boiler plant technology and also more novel techniques such as molten salt and fluidised bed incinerators (DETR, 2000). Incineration has a long history in municipal solid waste management. Some American cities began to burn their garbage in the late nineteenth century in devices called cremators. These devices were not very efficient, however, and cities eventually went back to dumping or other methods. In the 1930s and 1940s, many cities built new types of garbage burners known as incinerators. Incineration recaptures value in waste through controlled burning, resulting in the production of steam and water as a by-product that can be used to generate energy (USEPA, 2002). Waste burning enjoyed yet another revival in the 1970s and 1980s. The new incinerators, many of which are still in operation, are called resource recovery or waste-to-energy plants. In addition to burning garbage, they produce heat or electricity that is used in nearby buildings or residences or sold to a utility. By the mid-1980s, it had become difficult to find locations to build these facilities, once again mainly because of air quality issues. Another problem with incineration is that it generates ash, which must be landfilled. Incinerators usually reduce the volume of garbage by 70 to 90 percent. The rest comes out as ash that often contains high concentrations of toxic substances.

2.11.5 Landfilling

Landfilling is considered the least preferable option for the handling of MSW. Landfills are disposal sites for non-hazardous wastes where the waste is spread into layers, compacted and covered by materials such as soil or clay (USEPA, 2002). Landfilling is the technical term used to describe filling large holes in the ground with waste. These holes may be specially excavated for the purpose, or may be old quarries, mine shafts and even railway cuttings. More recently, the term has been expanded to cover the creation of waste mountains even though there is no "filling" as such. This process is also known as land-raising (Friends of the earth, 1997). Landfill sites produce landfill gas (55% methane and 45% carbondioxide) which can be partly captured for energy production.

2.11.6 Recycling

Recycling can be considered a solid waste management strategy. Recycling is a key component of modern waste management and is the third component of the "Reduce, Reuse, Recycle" waste hierarchy. One approach to the management and disposal of municipal solid waste has been recycling. It is as useful as landfill, dumping or incineration (Duston, 1993). Municipal solid waste will probably always be landfilled or burned to some extent. Recycling has been a common practice for most of human history, with recorded advocates as far back as Plato in 400 BC.

During periods when resources were scarce, archaeological studies of ancient waste dumps show less household waste (such as ash, broken tools and pottery) - implying more waste was being recycled in the absence of new material. Resource shortages caused by the world wars, and other such world-changing occurrences greatly encouraged recycling.In order to divert some of the municipal refuse away from landfills, several cities established recycling centers in the early 1970s where people could bring cans, bottles, and newspaper rather than throw them in the trash. Since the mid-1970s, however, non disposal methods such as waste prevention and recycling have become more popular. Since the late 1980s, recycling has been promoted as a viable means of addressing the problems associated with municipal waste disposal. In an age of high technology and scientific innovation, it is ironic that one of man's oldest problems is becoming increasingly acute. The collection and disposal of modern municipal waste products is a monumental task.

Recycling however, is the process of collecting, reprocessing and/or recovering waste materials such as glass, metal, plastics and paper, to make new materials or products (USEPA, 2002). In otherwords, recycling is the process of breaking down of solid wastes into its constituents so that it can be used again. It also reffers to the seperation and collection of solid wastes and their subsequent transformation or remanufacture into reusable or remarketable products or materials.

Recycling involves the collection of used and discarded materials processing these materials and making them into new products (Pelloumail, 2001). Recyclable materials include many kinds of glass, garden wastes, food leftovers, paper, plastic, metals, textiles, and electronics. Aluminum (e.g cell phones and computers). It therefore involves processing of used materials into new products in order to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, reduce air pollution (from incineration) and water pollution (from landfilling) by reducing the need for "conventional" waste disposal, and lower greenhouse gas emissions as compared to virgin production (League of women voters, 1993).

Even the earliest civilizations recycled some items before they became garbage. Broken pottery was often ground up and used to make new pottery, for example. Recycling occurs for three basic reasons: altruistic reasons, economic imperatives, and legal considerations. In the first instance, protecting the environment and conserving resources have become self-evident as being in everyone's general interest. Second, the avoided costs of environmentally acceptable landfill dumping and incineration have risen to a level where it now makes economic sense to recycle many waste materials. Finally, in responding to both public demand and a growing lack of alternative waste disposal methods, government is requiring recycling and providing a wide variety of economic and civil penalties and incentives to encourage recycling (Ferry, 2002). As the amount of municipal solid waste (MSW) to be disposed of increases and the number of available landfills decreases, communities all over the country are grappling with problems related to the management and disposal of garbage. Many communities have undertaken a variety of activities to dispose of municipal solid waste in economically responsible and environmentally viable manners.

2.11.6.1 Benefits of recycling

The US Environmental Protection Agency (1998b; 2000e) has identified the following as the benefits of recycling:

- It preserves raw materials and natural resources.
- It reduces the amount of wastes that requires disposal.
- It reduces energy use and associated pollution.
- It provides jobs and business opportunities.
- It boosts economic activities.
- It reduces greenhouse gas emissions.
- It reduces pollution associated with the use of virgin materials.

Recycling turns materials that would otherwise become waste into valuable resources. Collection of used bottles, cans and newspapers and taking them to the curb or to a collection facility is just the first in a series of steps that generates a host of financial, environmental and social returns. Some of these benefits accrue locally as well as globally.

2.12 Organic Recycling through Composting

Composting is often used synonymously with "biological decomposition". However, for purposes here, it may be more appropriate to define composting as: a method of solid waste management; whereby, the organic component of the waste stream is biologically decomposed under controlled conditions to a state in which the compost can be safely handled, stored and/or applied to the land without adversely affecting the environment (Simpson and Engel, 1991). Composting is in the second level of the EPA's hierarchy for managing solid waste since it is a type of recycling that is particularly applicable to organic wastes (USEPA, 2000f). The biodegradable fraction in wastes that cannot be recycled or converted into new products, increasingly is treated through composting. Composting is associated with concepts of reclamation, recycling, treatment and disposal. Reclamation and recycling are parts of the stewardship of saving and reusing natural resources. Treatment and disposal have been a more typical way to cope with wastes for many decades, particularly as a part of the "industrial revolution." Because of concerns for our environment, "disposal" has become a less desirable option. It is the lowest cost alternative to landfilling for many wastes. It has the potential to manage most of the organic material in the waste stream including restaurant waste, leaves and yard wastes, farm waste, animal manure, animal carcasses, paper products, sewage sludge, wood etc. and can be easily incorporated into any waste management plan.

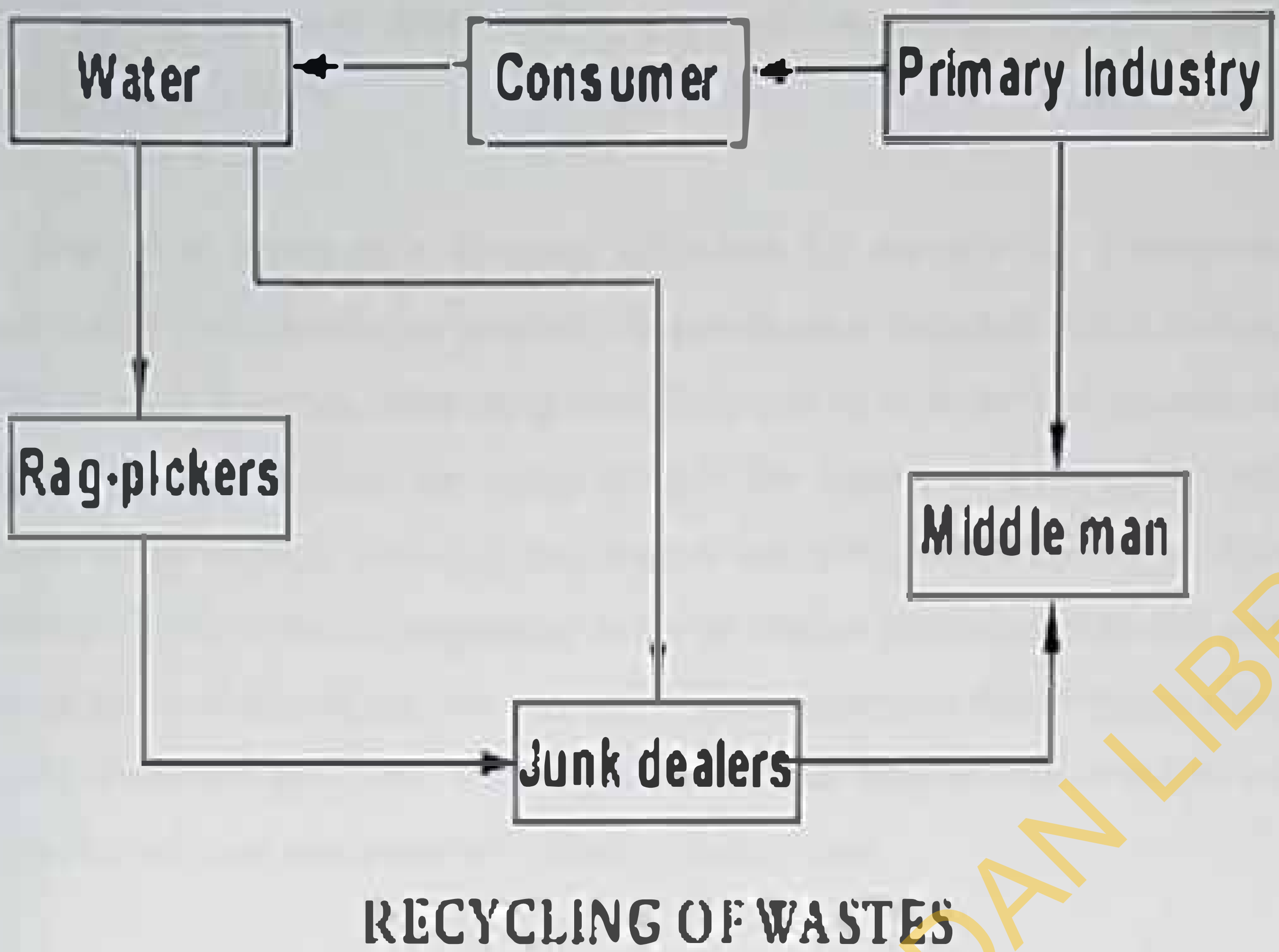

Fig 2.2: Schematic diagram of waste recycling
Source: CPCB, 2000.

Composting can be used to recycle most organic waste generated from food processing and food service facilities, including fruit and vegetable trim and leftover food, waxed corrugated boxes, napkins and other soiled paper (Composting Council Research and Education Foundation, 1997).

There is no universally accepted definition for composting. Composting is the biological process by which microorganisms convert organic materials into a humus-like material called compost. It has been commonly used for centuries to dispose of organic residuals. Most of the definitions emphasize that composting is the natural and biological decomposition process converting organic materials into humuslike product referred to as compost (Haug, 1993). Haug (1993) defined composting as the biological decomposition and stabilization of organic substrates, under conditions that allow development of thermophilic temperatures as a result of biologically produced heat, to produce a final product that is stable, free of pathogens and plant seeds, and can be beneficially applied to land.

Natural composting, or biological decomposition, began with the first plants on earth and has been going on ever since. As vegetation falls to the ground, it slowly decays, providing minerals and nutrients needed for plants, animals, and microorganisms. Modern composting differs from that occurring naturally only in the intentional creation of conditions through the application of scientific knowledge and technology to promote rapid decomposition of organic material and to better control the quality of the final product in an environmentally sensitive manner (Eberle, 1997). Mature compost, however, includes the production of high temperatures to destroy pathogens and weed seeds that natural decomposition does not destroy.

The expression "older than dirt" certainly applies to compost. Nature has been producing compost for millions of years as part of the cycle of life and death on Earth. The first human use of animal manure, a raw form of compost, was in about 3,000B.C. in Egypt when it was spread directly on the fields as a fertilizer. Later, manure was mixed with dirty stable straw and other refuse and allowed to sit in piles until it was needed. Compost is organic material that can be used as a soil amendment or as a medium to grow plants. Mature compost is a stable material with a content called humus that is dark brown or black and has a soil-like, earthy smell. It is created by: combining organic wastes (e.g., yard trimmings, food wastes, manures) in proper ratios into piles, rows, or vessels; adding bulking agents (e.g wood chips) as necessary to accelerate the breakdown of organic materials; and allowing the finished material to fully stabilize and mature through a curing process (Cavelle, 1999).

Composting is relatively simple to manage and can be carried out on a wide range of scales in almost any indoor or outdoor environment and in almost any geographic location. It provides a means of accomplishing all four R's. Through composting, the amount of garbage sent to the landfill is reduced, the organic matter is reused rather than dumped and it is recycled into a useful soil conditioner. It is a way of harnessing the natural process of decomposition to speed up the decay of waste. The U.S Composting Council (2000) emphasizes the importance of composting as a way of diverting a substantial amount of waste from landfills and incinerators. Composting can be an economical alternative to the disposal of organic wastes, and it is also beneficial to agriculture and the environment.

The number of composting plants operated in the U.S. by industries and municipalities has tripled since 1990. Over 3000 sites are registered today. The number of commercial compost operations processing food waste increased from 58 to 214 between 1995 and 1997, and the number of food composting projects is expected to rise. Because of discouraging economic conditions and the complications associated with obtaining a permit, food waste composting is primarily being done by large corporations (USEPA, 1998a). Backyard composting also is starting to play an important role in the U.S. Industries use composting as a process for the destruction of toxic by-products through a process known as "bioremediation". Finally, the composting process is beginning to replace more costly treatment procedures for the destruction and control of human, animal and plant pathogens. Composting, therefore, is becoming a commonly used process. In the United states, growth has exceeded 7% per year for the past five years (from 2003 to 2008 in part due to rising waste volumes and increasing commodity prices as well as support from the government and business communities, and increased consumer awareness. In 2006, 32.5% of MSW generated in the U.S. was recovered for recycling or composting, diverting 82 million tons of material from landfills and incinerators - more than double the value from 15 years earlier. At the same time, tough new environmental laws mandated that industries could no longer simply dump their waste products onto the surrounding land or discharge them into nearby rivers. To meet these laws, many industries began their own recycling and composting programs. Environmental concerns also affected farmers, who were being blamed for the negative health effects that chemical fertilizers and pesticides had on humans and wildlife. As a result, many farmers decided to cut back or eliminate chemicals in favor of using compost.

Today, most compost is processed in large facilities designed to handle a specific type of raw material. Agricultural compost is usually produced and used on the same farm that generated the raw materials. Industrial compost may be bagged and sold to individual buyers, or the raw materials may be sold in bulk to other composting facilities. Municipal yard waste compost is usually produced in facilities operated by the city or the refuse collection company and is sold to local landscaping companies and garden centers (Cavette, 1999).

Composting is a dynamic process which will occur quickly or slowly, depending on the process used and the skill with which it is executed. A neglected pile of organic waste will inevitably decompose, but slowly. This has been referred to as "passive composting," because little maintenance is performed. Fast or "active" composting can be completed in two to six weeks. This method requires three key activities; 1) "aeration," by turning the compost pile, 2) moisture, and 3) the proper carbon to nitrogen (C:N) ratio. Attention to these elements will raise the temperature to around 130-140°c and ensure rapid decomposition.

2.12.1 Compostable and Non Compostable Materials

Any material initiating from the ground that is vegetative or animal in nature can be composted if it has not been contaminated (Haug, 1993). A variety of wastes from foodservice and food processing are suitable for composting. If the feedstock that is contaminated with non compostable materials is added to compost piles, the decomposition time will be longer and the quality of the finished product will be affected. Contamination of feedstock can be problematic in food processing and foodservice operations with high employee turnover rates and limited training. Table 2.7 shows the types of food residue that can be composted and some that should not be composted. Some composting facilities prohibit meat, grease, oils and non-vegetative organics because they break down slowly and require more monitoring (Composting Council Research and Education Foundation, 1997).

2.12.2 Types and Location of Composting Operations

Polprasert (1989) described a composting system based on location as either on-site or off-site composting. On-site composting is an operation that composts organic wastes at the place of generation. Off-site composting involves the collection and transportation of organic wastes to a composting facility. Goldstein, Block, and Oshins (2000) classified composting projects into three broad categories: Centralized Institutional, Commercial, and Industrial (ICI); Centralized Food Processing; and On-site Composting. Centralized ICIs are "private or public composting facilities that accept food residuals from all or some combination of institutional, commercial and industrial generators" and Centralized Food Processing consists of "private or public composting facilities that primarily service food processors in the industrial sector."

2.12.2.1 On-site composting: Goldstein et al. (2000) defined on-site composting as "composting projects located at the generator's site, designed to process residuals produced at that site (or sometimes from a neighboring facility of the same type). Ligon et al. (1998) indicated that institutions such as universities, schools, hospitals and military installations are well suited for on-site composting because they typically generate large quantities of organic materials and have land available for composting. On-site composting can benefit businesses and institutions that are in remote locations or long distances from either disposal or composting sites by avoiding hauling charges. However, composting on-site requires available capital, land, labour and equipment (CCREF, 1997).

2.12.2.2 Off-site composting: Not every organic waste generator can compost its wastes on-site. These operations must rely on programs to collect and compost their wastes at a centralized facility. These large-scale facilities can handle more material and produce a more consistent product (CIWMB, 2000).

Table 2.7: Compostable and Non Compostable Materials

Compostables	Non Compostables
Fruits	
Vegetables	
Dairy Products	Plastics
Grains	Grease
Bread	Glass
Unbleached Paper Napkins	Metals
Coffee Filters	Foil
Newspaper	Polystyrene
Meats	Chemicals

Source: Risse and Faucette, (2000).

Table 2.8: Composting Methods

1	**Hot Composting** Hot composting is the most efficient method for producing quality compost in a relatively short time. In addition, it favours the destruction of weed seeds, fly larvae and pathogens. While hot composting, using the windrow or bin method, requires a high degree of management, hot composting, using the in-vessel method, requires a lesser degree of management
2	**Cold Composting** This method is ideal for adding organic matter around trees, in garden plots, in eroded areas etc. The time required to decompose organic matter using this method is governed, to a large extent, by environmental conditions and could take two years or more.
3	**Sheet Composting** Sheet composting is carried out by spreading organic material on the surface of the soil or untilled ground and allowing it to decompose naturally. Over time, the material will decompose and filter into the soil. This method is ideally suited for forage land, no-till applications, erosion control, roadside landscaping etc. The process does not favour the destruction of weed seeds, fly larvae, pathogens etc. and composting materials should be limited to plant residue and manure. Again, decomposition time is governed by environmental conditions and can be quite lengthy.
4	**Trench Composting** Trench composting is relatively simple. Simply dig a trench 6 - 8 inches deep, fill with 3 - 4 inches of organic material and cover with soil. Wait a few weeks and plant directly above the trench. This method does not favour the destruction of weed seeds, fly larvae and pathogens and the composting process can be relatively slow

(Source: ECOCHEM, 2008)

2.12.3 Community Participation in Composting Schemes

Community participation is the sociological process by which residents organise themselves and become involved at the level of a living area or a neighbourhood, to improve the conditions of daily life (water, sanitation, health, education, etc). It comprises various degrees of individual or collective involvement (financial and/or physical contributions, social and/or political commitment) at different stages of a project. Singh et al., (2007) also defined community participation as the process by which individuals and families understand responsibility for their own health and welfare of societies. This enables them to become agents of their own development instead of positive beneficiaries of development aid.

Community participation is essential to keep any solid waste management systems running. For instance, at a minimum participation of the community is required in putting the garbage at the street in a proper way at the right time. At the individual level, residents are responsible as users. This involves actions like storing waste in a proper way in a bag or bin, separate recyclable or organic materials from other waste, offering waste at the right place at the proper time for collection, and cleaning the area around the house. Apart from individual responsibility, people can be collectively responsible in more or less organised activities, like meetings, clean-up campaigns, and awareness-raising activities. Furthermore, community participation may involve making material, financial or physical contributions to activities of solid waste management, for instance working as cart operator or sweeper, and paying fees for waste collection.

Waste is either treated at home, community or centralised composting schemes. In home composting scheme, biodegradable waste generated by householders is used to produce compost for use by the individual. Although this may involve the purchase of a composter, this may not be essential as many householders may compost using composters made at home. In home composting schemes, it is essential that the householder understands the functioning of the composter and which materials they can dispose of in it. In community composting scheme, biodegradable waste is collected from householders and processed centrally in a centralised scheme. However, community composting schemes are typically smaller than centralised schemes and situated within the local community. The end product is used by the householders participating in the scheme, thereby closing the loop of waste generation and use. Considering both community and centralised schemes, an organised separate collection system seems to be more effective (European Commission, 2000).

A survey conducted amongst 135 elderly farmers at predominantly agricultural areas in the Northern, Southern and Eastern parts of the country revealed that they were aware that composting had been traditionally practiced in Nigeria in the past but that it is no longer practiced on a large scale. Sridhar et al, (1985), initiated the composting process in Shasha, a small community in Ibadan where about 150 kg of market wastes were composted with abattoir waste and finished product was used to grow vegetable crops on experimental plot of land. In the study, the changes in temperature, volume, nitrogen, phosphorus and other scientific parameters were measured. It was also recognized that community should be involved in such projects (Sridhar et al, 1993).

2.12.4 Composting in Schools

The 2000 Food Residuals Composting survey conducted by BioCycle identified 138 projects that process food residuals from a combination of institutional, commercial, and industrial sources and those handling food processing residuals from only industrial generators. However, this survey excluded the 116 institutional projects, included in the 1998 survey, since they only compost food residue generated on-site (Goldstein et al, 2000).

The 1998 BioCycle Food Residuals Composting survey identified 250 composting facilities (187 full-scale composting operations, 37 pilots and 26 projects in development). Table 2.9 indicates the location of these projects. Among those 250 composting facilities, 116 projects were institutional. The survey reported that 85 of the 91 full-scale projects were on-site at an institution, 5 at businesses (mostly resorts), and one at a school served by a municipal operation (Goldstein, Glen, & Gray, 1998).

Every school generates wastes arising from routine activities. Schools generate a great deal of waste, especially as a by-product of food service. The common types of solid wastes found in various schools in communities of developing countries vary in type and in quantity. They include (a) Paper (b) grass (c) nylon (pure water bags, biscuits, lolly, ice-cream, and sweet wrappers (d) sugar cane (e) maize cobs (f) groundnut shell (Wahab, 2003). In addition to the above, some other wastes are found in school premises, which might not have been generated directly by pupils and teachers, such wastes include animal droppings from chickens, goats, sheep, dogs and lately cows. Elemile (2009) also stated major wastes generated in the non-residential areas of the University of Ibadan to include paper, plastics, food waste and garden trimmings. Municipal corporations of the developing countries are not able to handle the increasing quantity of waste, which leads to uncollected waste on roads and other public places amongst which are schools. The problems associated with the disposal of wastes are many which include littering of food and other solid wastes in the school compounds. One of the more crucial and impacting consequences of the lack of knowledge involving the unsafe and inappropriate disposal of solid waste has created considerable health problems and very unpleasant conditions in many schools. This can lead to the breeding of rats and other vectors which are of public health importance (Tchobanoglous et al., 1977).

The challenge to schools is to make waste management a viable and even exciting part of the total learning experience. Organic materials can easily be dealt with where they are produced in the home or at school by on-site composting. A large amount of a schools' waste stream could be composted in-situ (Scott, 2007). A composting project in a school, either in the classroom or on the school property, can be a terrific opportunity for students to gain direct knowledge and experience with natural processes and a method of reducing and recycling biodegradable wastes.

A composting project presents all kinds of opportunities for the school community. Aside from curriculum connections and interdisciplinary learning, composting helps to instill an environmental ethic, conserve natural resources and build school community. Although composting utilizes natural decay processes, these processes are occurring in a relatively small, concentrated area of a pile or bin. There is a potential for human exposure to the organisms involved and the products they produce.

Table 2.9. Location of Institutional Composting Projects

Location	Full-scale operations	Pilot
Correctional facilities	57	1
Primary/secondary schools	17	2
Universities	7	10
Resorts/hotels	4	1
Campus/conference center	3	0
Hospitals	2	0
Restaurants	1	1
Military	0	1

Source: Goldstein et al., (1998)

2.12.5 Reasons for Composting in Schools

Schools can help the environment and their community when they compost food scraps. A school composting program will:

- Reduce the school's solid waste stream
- Recycle natural resources
- Extend the life of a leaching field and septic tank if a garbage disposal system has been in use (or reduce nitrogen loading to the local sewage treatment facility)
- Educate the school community about benefits of composting
- Create a useful product (finished compost) for landscaping projects

Designing successful composting systems requires an understanding of certain biological, chemical, and physical processes such as the movement of air, uptake of carbon and nitrogen, and heat production and transfer. Students can be a part of the process of obtaining scientific information about composting, whether their results are applied in their own home, school or by industry. At the same time, students engage in hands-on, minds-on composting activities with an opportunity to improve their understanding of many scientific processes and disciplines (Cornell Waste Management Institute, 1996).

The study of waste production and management lends itself to interdisciplinary study and school composting provides an opportunity for real-world problem solving with cooperative learning groups. It therefore can motivate students who feel alienated by traditional "science" experiences. Furthermore, students gain an awareness of individuals' roles in the world today as they learn how waste is produced and how it can be reduced. Finally, through construction of compost systems, students are empowered to make a positive change in their world. For it is afterall our youth to whom this planet belongs (Cornell Waste Management Institute, 1996).

2.12.6 Wastes and Residues from the Food Chain

Foodservice operations, including restaurants, schools, healthcare facilities, prisons, and other types of commercial and institutional facilities, generate significant quantities of food wastes/residues and packaging wastes. Research has identified several factors that influence the quantity and type of wastes/residues discarded by foodservice operations including: type

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2.12.6.1 Food Waste Recovery Hierarchy

Similar to its solid waste management hierarchy (e.g. source reduction and reuse, recycling and composting, disposal). U.S Environmental Protection Agency has suggested a food waste recovery hierarchy to show how productive use can be made of excess food. The food waste recovery hierarchy comprises the following activities, with disposal as the final option:

- Source Reduction – Reduce the volume of food waste generated
- Feed People – Donate extra food to food banks, soup kitchens and shelters
- Feed Animals – Provide food to farmers
- Industrial Uses – Provide fats for rendering and food discards for animal feed production
- Composting – Convert food scraps into a nutrient rich soil amendment

2.12.7 Food Waste Composting

Food waste has "unique" properties. Because it has a high moisture content and low physical structure, it is important to mix fresh food waste with a bulking agent that will absorb some of the excess moisture as well as add structure to the mix. Bulking agents with a high C:N ratio, such as sawdust and yard waste, are good choices.

The decomposition of food and other waste under anaerobic (without oxygen) conditions in landfills produces methane, a greenhouse gas (GHG) 21 times more potent than carbon dioxide. Landfills are the largest human-related source of methane in the United States, accounting for 34 percent of all methane emissions. Recover ((i.e. food donations) and recycling (i.e., composting) diverts organic materials from landfills and incinerators, thereby reducing GHG emissions from landfills and waste combustion (USEPA, 2006).

Composting food scraps results in about a 50 percent reduction of your original material. However, daily processing of food scraps can result in a fast accumulation of material. Food waste is highly susceptible to odour production --mainly ammonia --and large quantities of leachate. The best prevention for odor is a well-aerated pile. Captured leachate can be reapplied to the compost. In 2007, almost 12.5 percent of the total municipal solid waste (MSW) generated in American households was food scraps and less than three percent was recovered. The rest was thrown away and disposed in landfills or combusted in incinerators.

Food residue has unique characteristics that require special consideration when used as a feedstock for composting. Due to its high moisture content and low physical structure, food waste must be mixed with a bulking agent that will absorb some of the excess moisture and provide structure to the mix (Risse & Faucette, 2000). This process is referred to as co-composting. The United States Environmental Protection Agency (1995a) defined co-composting as "the composting of two or more feedstocks with different characteristics, for example, the co-composting of biosolids in liquid/dewatered form with yard trimmings and leaves." The US EPA (1998a) reported that most food waste compost programs mix other organic materials, such as sawdust, wood chips, yard trimmings, or manure, with food wastes to produce high quality compost. Yard trimming is the most frequently used bulking agent added to food waste compost, followed by wood chips and sawdust (USEPA, 1998a).

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Table 2.10 Wastes/Residues Generated by Different Types of Foodservice Operations

Type of Operation	Mean wt. per meal (lb)	Mean vol. per meal (gal)	Weight (%)		Volume (%)	
			Food	Packaging	Food	Packaging
School foodservice Operations	0.58	0.49	60.8	32.6	19.2	71.0
University dining hall A	0.57	0.91	71.9	28.1	22.2	77.8
University dining hall B	0.39	0.66	71.8	28.2	22.7	77.3
University dining hall C	0.50	0.85	66.0	34	16.5	83.5
Military foodservice facilities	0.99	0.94	72.1	27.09	12.3	87.7
Continuing care retirement community	0.93	1.22	69.9	30.1	12.5	87.5
Military healthcare A	1.32	1.46	71.2	28.8	26.0	74.0
Military healthcare B	1.13	1.49	67.3	32.7	21.5	78.5
Family bar & grill restaurant	0.89	0.84	64.6	35.4	24.4	75.6

Source : Shanklin and Ferris, (1995)

2.12.8 **Biological, chemical and physical requirements for efficient decomposition**

Maintaining optimum microbial activity in the compost pile is essential for the decomposition of organic materials. Any factor that slows microbial growth also impedes the rate of the composting process. Factors necessary for optimal microbial activity include proper aeration, sufficient moisture, particle size, and nutrient balance, particularly nitrogen (McLaurin & Wade, 1999). The USEPA (1995a) and Eberle (1997) described the ideal levels of the biological, chemical, and physical needs that should be maintained throughout all stages of composting for peak performance.

- **Biological processes:** Microorganisms are the key to the composting process. The ideal conditions for a given microbial population must be present for the composting process to progress at the proper rate. Under ideal conditions composting occurs rapidly. The focus of the management of the compost process should be the microorganisms and promoting conditions that lead to rapid stabilization of the organic materials (USEPA, 1995a).
- **Physical processes:** The essential physical requirements in the compost process are temperature, particle size, mixing, and pile size (USEPA, 1995a).
- **Temperature:** Temperature management of the compost pile is an important component of a composting process. The mesophilic organisms that exist in temperature ranges from 50°F (10°C) to 113°F (45°C) break down soluble and easily degraded compounds during the initial decomposition. These organisms give off heat, which in turn, increases the temperature of the compost pile. The thermophilic organisms that thrive under temperatures between about 113°F (45°C) to 150°F (65°C) replace the mesophilic organisms. This temperature range, preferred by the thermophilic organisms, promotes the breakdown of proteins, complex carbohydrates, and other organic compounds that provide important nutrients for the microorganisms. Since most thermophilic microorganisms cannot survive above 160°F, and the rapid decomposition of organic materials stops above this temperature, it is essential to control the temperature of the compost pile (Eberle, 1997).
- **Particle size:** The particle size of the material being composted is critical to the speed of composting. Because smaller particles usually provide more surfaces per unit of weight, they provide better conditions for microbial activity on their surface, which greatly

reduces decomposition time. However, if the particles are too fine, they provide less open space for air to circulate (USEPA, 1995a).

- **Chemical processes:** Many factors influence the chemical environment for composting. Some of the most important ones include: (a) the presence of an adequate carbon (food)/energy source, (b) a balanced amount of nutrients, (c) the correct amount of water, (d) adequate oxygen, (e) appropriate pH, and (f) the absence of toxic constituents that could inhibit microbial activity (USEPA, 1995a).

(a) **Carbon/energy source:** The carbon in organic materials provides the composting microorganisms with their source of carbon/energy source, not the carbon dioxide and sunlight that is used by higher plants. "As the more easily degradable forms of carbon are decomposed, a small portion of the carbon is converted to microbial cells and a significant portion of this carbon is converted to carbondioxide and lost to the atmosphere. As the composting progresses, the loss of carbon results in a decrease in weight and volume of the feedstock. The less-easily decomposed forms of carbon will form the matrix for the physical structure of the final product-compost (USEPA, 1995a)."

(b) **Nutrients:** Microorganisms need sufficiently balanced nutrient sources for successful composting. This is often described as the carbon:nitrogen ratio (C:N). Carbon in the composting material provides the microbes with their energy. It is also a basic part of microbes' cell structure. Nitrogen is the most important nutrient because it is necessary for the formation of proteins, nucleic acids, and amino acids that make up the bodies of microbes. It is sometimes necessary to mix several materials together to maintain the optimum C:N ratio (Eberle, 1997). During the initial phase of composting a C:N ratio of 30:1 is generally considered ideal for successful decomposition. Higher ratios of C:N may slow the rate of decomposition. Ratios of below 25:1 may result in undesirable odor problems. Nitrogen-rich materials, such as yard trimmings, animal manures, or biosolids, are often added if the C:N ratio is too high (USEPA, 1995a). The C:N ratio of composting organic materials varies widely. For example, food wastes have a carbon to nitrogen ratio of 15:1 and wood chips and saw dust have a C:N ratio of 300:1 and 700:1, respectively (McLaurin & Wade, 1999). To maintain the optimum C:N ratio for food waste composting, co-composting is often necessary.

(c) Moisture: Like all forms of life, microorganisms living in a compost pile require water to survive. The ideal moisture content for compost piles is 50 to 60 percent of total weight (USEPA, 1995a). If the material is too wet (above 60 percent), the flow of oxygen necessary for living microorganisms will be reduced and the decomposition process will be slowed. This occurs because the pile will not heat and an anaerobic condition will result. In addition, excessive moisture flowing freely from the compost pile may cause dissolved nutrients to leach out, cause potential pollution of ground or surface water, and create odor problems. If moisture levels are too low (below 30 percent moisture), the rate of decomposition will be quite slow resulting in a decrease of the organism populations. As a result, the microbial activity will nearly cease (Eberle, 1997). Because of the high moisture content of food wastes, the addition of dry bulking materials, such as wood chips, sawdust, and leaves, is desired to prevent the development of leachate and to increase air flow (Eberle, 1997).

(d) Oxygen: Composting requires sufficient oxygen since it is an aerobic process. A minimum level of 5 percent oxygen is needed for aerobic organisms to survive; however, a level of 10 percent oxygen is considered near optimum. An anaerobic process that uses organisms that do not require oxygen is also available for composting. This process is usually slower and can produce undesirable odors (Eberle, 1997). To maintain adequate oxygen levels, air may be mechanically blown into or pulled from the piles. Turning the pile frequently to expose the microbes to the atmosphere is another way of aerating the compost pile. This method will create more air spaces by fluffing up the pile; however, excess air will remove heat causing the pile to cool, moisture to evaporate, and the decomposition to slow down (USEPA, 1995a).

(e) Acidity (pH): The pH of the compost pile affects the amount of nutrients available to the microorganisms, the solubility of heavy metals, and the overall metabolic activity of the microorganisms. The addition of lime or sulfur to increase or decrease the pH, respectively, is not usually necessary. The desired pH level is between 6 and 8. The final pH of the compost depends on the types of feedstock used and the operating conditions (USEPA, 1995a).

2.12.9 Microorganisms in a compost pile:

Microorganisms such as bacteria, fungi, and actinomycetes account for most of the decomposition that takes place in a pile. They are considered chemical decomposers, because they change the chemistry of organic wastes. The larger decomposers, or macroorganisms, in a compost pile include mites, centipedes, sow bugs, snails, millipedes, springtails, spiders, slugs, beetles, ants, flies, nematodes, flatworms, rotifers and earthworms. They are considered to be physical decomposers because they grind, bite, suck, tear and chew materials into smaller pieces. Of all these organisms, aerobic bacteria are the most important decomposers. There are different types of aerobic bacteria that work in composting piles. Their populations varies according to the pile temperature.

The process is carried out by three classes of bacteria -

- Psychrophiles – low temperature bacteria
- Mesophiles -medium temperature bacteria
- Thermophiles - high temperature bacteria

Psychrophilic bacteria work in the lowest temperature range. They are most active at 55° F and will work in the pile if the initial pile temperature is less than 70° F. The heat they produce is enough however, to help build the pile temperature to the point where another set of bacteria, mesophilic bacteria, start to take over. Mesophilic bacteria rapidly decompose organic matter, producing acids, carbon dioxide and heat. Their working temperature range is generally between 70° to 100°F. Thermophilic bacteria thrive at temperatures ranging from 113° to 160° F. Thermophilic bacteria continue the decomposition process, raising the pile temperature 130° to 160°F, where it usually stabilizes. In later stages other organisms including Actinomycetes, Centipedes, Millipedes, Fungi, Sowbugs, Spiders and Earthworms assist in the process. Many find that composting is as much of an art as a science. Recent concern about managing wastes and producing food in an environmentally sound manner has led to a renewed interest in small-scale, backyard composting as well as an interest in developing large-scale, commercial and municipal composting systems.

2.12.10 Benefits of Composting

The recent increase in popularity of composting can be attributed to several factors, including increasing landfill tipping fees, decreasing landfill capacity and increasingly restrictive measures imposed by regulatory agencies (USEPA, 1995a). At the same time, composting offers attractive benefits to the food industry, agriculture, and environment. Food service and food processing industries can benefit economically by the lower disposal fee charged by the composting facilities or the lower cost of operating an on-site or off-site composting operation than the fee charged by commercial waste haulers. Composting also can improve operation's public relations by showing the public their concern for the environment.

2.12.10.1 Benefits to the food industry. Risse and Faucette (2000) identified the following benefits of composting for the food industry:

- reduces solid waste disposal fees.
- eliminates wasting large quantities of recyclable raw ingredients.
- educates consumers on the benefits of food waste composting.
- markets an establishment as environmentally conscious.
- reduces the need for more landfill space.

2.12.10.2 Benefits to agriculture. The following have been identified as benefits of composting to agriculture: (Risse & Faucette, 2000):

- suppresses certain plant diseases and parasites and kills weed seeds
- increases yield and size of some crops.
- reduces fertilizer requirements.
- reduces water requirements and irrigation.
- increases profits because of the higher prices paid for organically grown crops.

2.12.10.3 Benefits to the environment. Risse and Faucette (2000) described the following benefits of composting for the environment:

- conserves the water and soil,
- protects groundwater quality.
- avoids methane production and leachate formation in landfills.
- drastically reduces the need for pesticides and fertilizers.
- buffers soil pH levels.

2.12.10.4 Economic benefits. Revenue can be generated for composting operations through the sale of the finished product. For example, Upper Valley Recycling sold the finished product for $22 to $25/ton to vineyard growers, local residents, and nurseries (Block & Glen, 2000).

2.12.11 Benefits of School Composting

Below are some reasons why a school might take on a composting program:

1. Take responsibility for school's waste
2. Recycle natural resources
3. Educate the community about the benefits of composting
4. Change cultural attitudes about garbage in a way that will benefit society
5. Affect the life style decisions made by future citizens of the community
6. Reduce the school solid waste stream
7. Enhance teaching of science concepts
8. Teach social responsibility
9. Empower students (gives them a specific action they can take to help the earth)
10. Inform parents as well as students about composting
11. Provide a soil amendment for school gardening projects or for sale as a fund raiser
12. Help the school work toward becoming a "green school"
13. Foster a sense of school pride

Source: Connecticut State Department of Education, (2002).

2.13 Environmental Education

Environmental Education is a process of recognising values and clarifying concepts in order to develop skills and added tools necessary to understand and appreciate the inter-relationship among man, his culture and his bio-physical surrounding (Ahove, 2000). Environmental education refers to organized efforts to teach about how natural environments function and, particularly, how human beings can manage their behaviour and ecosystems in order to live sustainably. The term is often used to imply education within the school system, from primary to post-secondary (Gruenewald et al, 2004). It creates an overall perspective, which acknowledges the fact that natural environment and man-made environment are interdependent.

Environmental education is a learning process that increases people's knowledge and awareness about the environment and associated challenges, develops the necessary skills and expertise to address the challenges, and fosters attitudes, motivations, and commitments to make informed decisions and take responsible action (UNESCO, 1978).

It should consider the environment in its totality and should be a continuous lifelong process beginning at the pre-school level and continuing through all stages. It should be inter-disciplinary and examine major environmental issues from local, national and international points of view. It should utilise various educational approaches to teach and learn about and from the environment with stress on practical activities and first-hand experience. It is through this process of education that people can be sensitized about the environmental issues.

Learning how to live within the limits of the planet's resources is the biggest challenge facing the world's population today. Waste generation and management is at the very heart of that challenge. Students need to begin to make connections between human patterns of living and the need to conserve natural resources. Waste represents enormous stores of energy that can be reclaimed and recycled. Good programs of waste management at schools are powerful and accessible learning tools that begin to make these vital connections for students. Though high- and low-value recyclables are typically recovered and reused, these make up only a small proportion of the total waste stream. The great majority of the waste (~70 percent) is organic. In theory, this waste could be converted to compost or used to generate biogas, but in situations where rudimentary solid waste management systems barely function, it is difficult to promote innovation, even when it is potentially cost-effective to do so. In addition, hazardous and infectious materials are discarded along with general waste throughout the continent. This is an especially dangerous condition that complicates the waste management problem. Today's students are hungry for work that is real, for learning that is meaningful. Project-based learning is a teaching strategy that allows students to take more responsibility for their learning as they make decisions and create solutions to problems that interest them. All subjects can be integrated as students apply their academic, social and life skills to their work. As schools change, so will our impact on the future. Project-based learning is a teaching strategy that honors students as capable people, readying themselves to be future leaders by giving them chances to be leaders as children. Today, population growth and changes in society have led to more people and fewer natural resources. It now becomes important to heed new educational imperatives (Payne, 1999). Composting, therefore, is becoming a commonly used process (Hansen et al, 1995).

Various studies have examined the effect of environmental education on knowledge. The few studies conducted on the environmental education program, regarding children and young people show that the level of environmental awareness is relatively low (Grodzinska-Jurczak, 2003). However, Manzanal, Barreiro and Jimenez (1999) pointed out that an understanding of the concepts and issues would help make the desired change in behaviour and attitude towards the environment. Hence this creates the opportunity to train people to contribute to the care of the environment. Some researchers have reported that junior high and high school students exposed to environmental courses demonstrated an increase in responsible environmental behaviour and an increased awareness of environmental issues (Jaus, 1984; Jordan et al., 1986; J. M. Ramsey, et al., 1992; C. E. Ramsey & Rickson, 1976). Similarly, numerous studies conducted on knowledge and attitudes have found a significant relationship between the two variables. In a study of the effectiveness of a visitor education strategy in raising levels of knowledge and attitudes toward nature conservation, Olson, Bowman and Roth (1984) found a positive relationship between scores on the knowledge test and scores on the attitude test for all concepts measured. Similarly, Armstrong & Impara (1991) found that positive attitudes followed exposure to a K-7 environmental education publication on knowledge and attitudes about the environment. In a study of environmental education and its effect on the knowledge and attitudes of preparatory school students in Egypt by Abd El Salam, El-Naggar and Hussein (2009), attitude was found to be positively correlated to their level of knowledge prior to and following the Environmental education session.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the Study Area

The study was carried out in Ibadan North L.G.A of Oyo state. Ibadan is the capital city of Oyo state and the largest city in West Africa. It is located in the south-western region of Nigeria. It is 78km inland from Lagos and is a prominent transit point between the coastal region and the areas to the north. It lies between latitude 7° and 9°30' east of prime meridian. Ibadan covers a land area of 12 kilometers radius. It has an altitude generally ranging from 152 to 213m with isolated ridges and peaks rising to 274m. Its population is estimated to be about 3.8million according to the National Population Commission's 2006 census estimates. The principal inhabitants of the city are the Yorubas (Brown, 2009). Ibadan has over 300 schools made up of both Public and Private Nursery, Primary and Secondary Schools, one Polytechnic and two Universities

3.1.1 Brief Description of Ibadan North Local Government Area

The Ibadan North Local Government was founded by the Federal Military Government of Nigeria on 27th of September 1991. The Local Government was carved out of the defunct Ibadan Municipal Government along with others. The components of the Local Government covers areas between Beere roundabout through Oke-Are to Mokola, Oke-itunu and Ijokodo. The other components are areas from Beere roundabout to Gate, Idi-ape to Bashorun and up to Lagos/Ibadan Express way, Secretariat, Bodija, University of Ibadan and Agbowo Areas. The headquarters of the Local Government is Bodija. The Local Government headquarters is temporarily accomodated at Quarter 87 at Government Reserved Area in Agodi where the Secretariat is located. Ibadan North Local Government is bounded by other L.G.As including Akinyele, Ido, Ibadan South West, Ibadan South East and Lagelu L.G.As. The Ibadan North Local Government has a population of about 308,119 people, comprising 152,608 males and 155,511 females (2006 Population Census). Using a growth rate of 3.2% from 2006 census, the 2010 estimated population for the Local Government area is put at 347,998 people (OYSG, 2010)

Table 3.1: Ibadan North Local Government Wards

S/No	WARDS
1	Beere, Keninke, Agbadagbudu, Oke Are, Odo Oye
2	Ode Oolc, Inalende, Oniyanrin and Oke Oloro
3	Adeoyo, Yemetu, Oke Aremo and Isale Alfa
4	Itutaba, Idi omo, Oje Igodun, Kube, Oke apon, Abenla, Aliwo/Total garden and NTA Area
5	Bashorun, Oluwo, Ashi, Akingbolu, Ikolaba and Gate
6	Sabo Area
7	Oke Itunu, Cocacola and Oremeji Areas
8	Sango, Ijokodo
9	Mokola, Ago Tapa and Premier Hotel Areas
10	Bodija, Secretariat, Awolowo, Obasa, Sanusi
11	Samonda, Polytechnic, University of Ibadan
12	Agbowo, Bodija Market, Oju Irin, Barika, Iso Patako, Lagos/Ibadan Express Road

Source: Brown, 2009

The Local Government comprises multi-ethnic nationalities that is predominantly dominated by the Yorubas. Others include the Igbos, Edos, Urhobos, Itsekiris, Ijaws, Hausas, Fulanis and Foreigners who are from Europe, America, Asia and other parts of the World.

Majority of the population of Ibadan North Local Government are in the private sector. They are mainly traders, and Artisans. A good number of their workers are civil servants who live predominantly around Bodija Estate, Agbowo, Sango, Mokola, the University of Ibadan and the Polytechnic Ibadan (Brown, 2009)

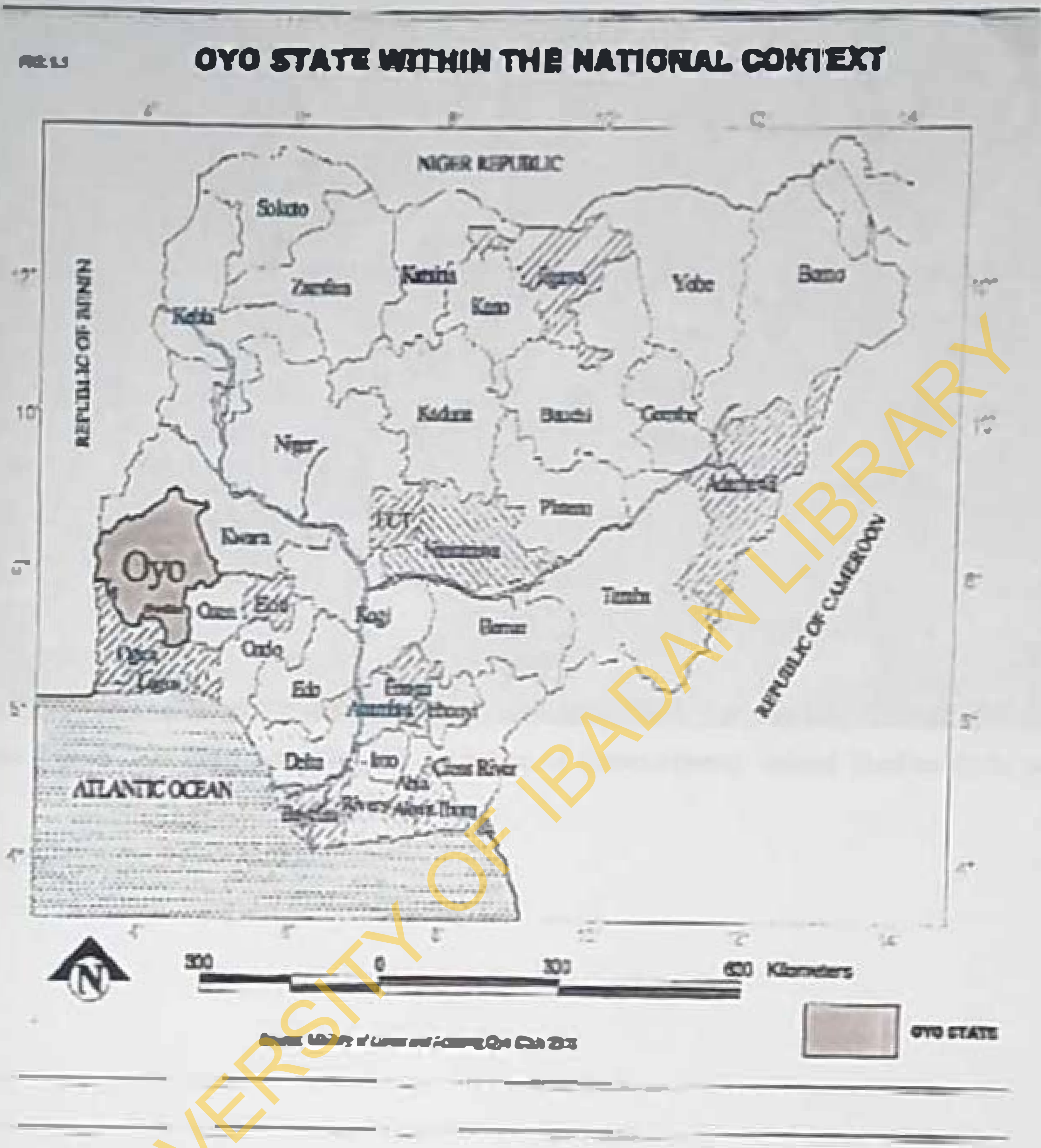

Fig. 3.1: Map of Oyo State in the Context of Nigeria

Source : Ministry of Lands and Housing Oyo State, 2010

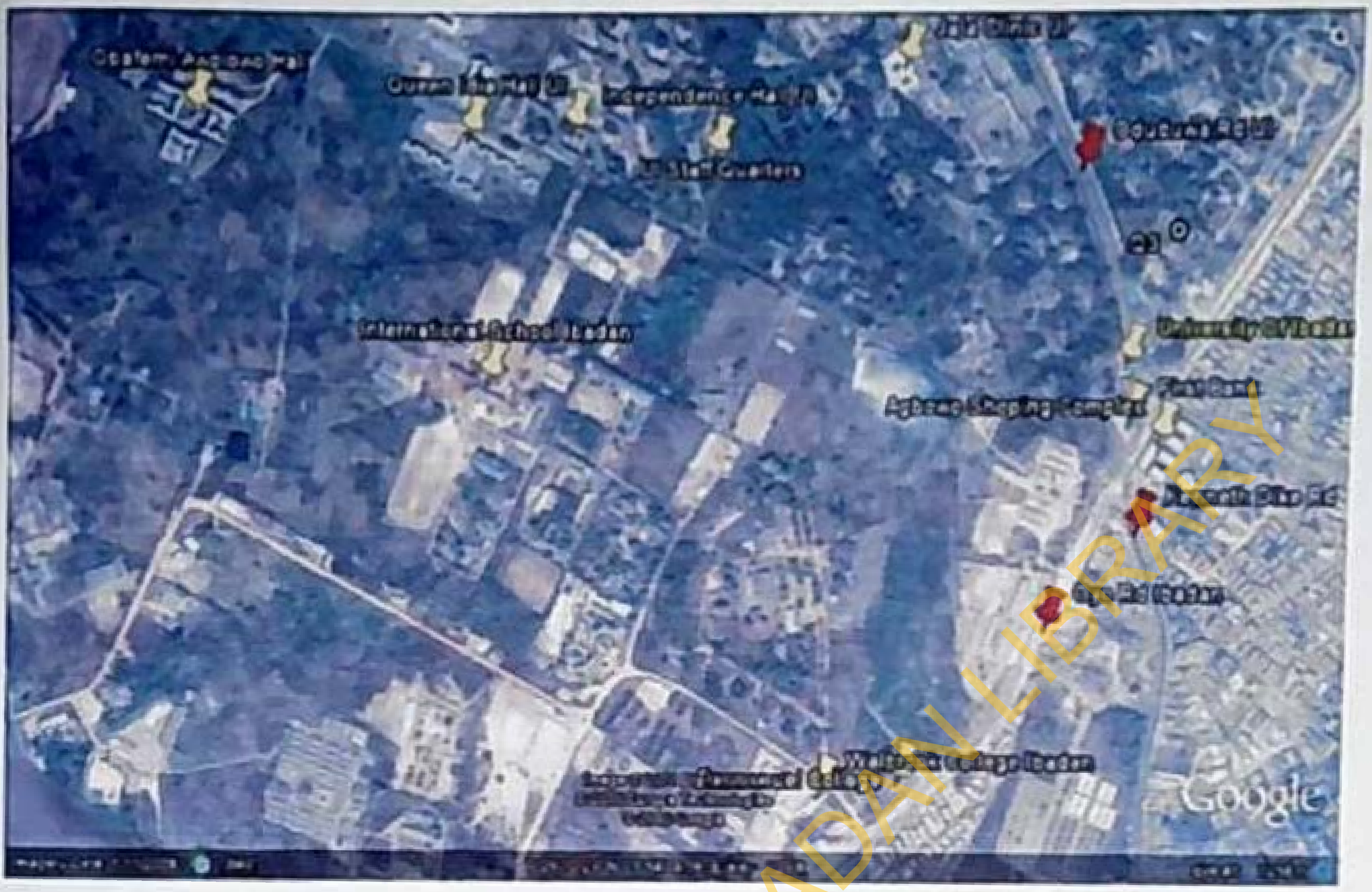

Plate 3.1: A 3-D Map Showing the Location of International School Ibadan (ISI) and Walbrook College Ibadan

Source: Google Earth, 2011

3.2 Study Design

The study was quasi-experimental in design with students of The International School Ibadan (ISI) as the experimental group and those of Walbrook College Ibadan (WCI) as the control group. It also involved a field survey, laboratory analysis of organic waste, compost produced from organic waste recycling as well as training of students of the experimental group on utilization of the fabricated compost bin (windrow method) for organic waste recycling at ISI.

3.3 Study Population

This comprised students of the schools of interest selected for the study.

3.4 Criteria for School Selection

The schools considered for the study were selected based on the following criteria:

1. The school must be a boarding school.
2. The school must be a private secondary school.
3. The school must be a heterogenous (mixed) school.
4. The school selected for the study must be within the L.G.A selected for the study.

3.5 Sample size determination

This was calculated as follows:

1. At 5% level of significance
2. Proportion of students with good knowledge, attitude and practice of waste recycling = 50% (0.5)

Using the formula

$$N = \frac{[Z_{1-\alpha/2}\ 2P(1-P) + Z_{1-\beta}\ P_1(1-P_1)+P_2(1-P_2)]^2}{(P_1-P_2)^2}$$

Where

$$P = \frac{P_1 + P_2}{2}$$

P_1 = Proportion of students with good knowledge of recycling before the intervention (composting) = 50% = 0.5.

P_2 = Proportion of students with good knowledge of waste recycling after the intervention(composting) = 60% =0.6.

$Z_{1-\alpha/2}$ = 1.96 [std normal deviate at 95% confidence level]

$Z_{1-\beta}$ = 0.84 [power of 80%]

N =Sample size

P = Proportion with good knowledge of waste recycling

Substituting in the formula

$$N = \frac{[1.96\sqrt{2 \times 0.55(1-0.55)} + 0.84\sqrt{0.5(1-0.5)+0.6(1-0.6)}]^2}{(0.5-0.6)^2}$$

N= 392

The calculated sample size was approximated to 400 to accommodate the loss due to attrition

3.6 Sampling Technique

3.6.1 Sampling Procedure

The International School and Walbrook College used for the study were purposively selected.

3.6.2 Sample Frame:

The sampling frame for selection of students in both schools was the classroom register. In all 392 students were selected from both schools with 196 students each from ISI and WCI respectively this however spread across SSS1-SSS3 in each school.

3.7 Pretesting of Questionnaire

In order to ensure validity and reliability of questionnaire, it was pre-tested among 50 secondary school students of a school different from the target population. However, this was analysed and corrections were made accordingly.

3.8 Questionnaire Administration

A 53-item semi-structured self administered questionnaire was used to elicit information from the participants with the assistance of some teachers in the schools. The questionnaire was based on a 14-point and 11-point knowledge and attitude scale respectively. It consisted of five sections namely, socio-demographic characteristics with 5 questions, knowledge on waste recycling with 14 questions, information regarding attitude with 11 questions using a 3-point Likert scale of 'agree', 'indifferent' and 'disagree', 15 questions on solid waste management practices in the school and 8 questions on problems associated with current solid waste management practices in the schools. The best score for knowledge was 10 and was scaled as; more than 7 = good, 7-5 = moderate and 4 and below as low.

3.9 Observation Checklist

An observation checklist was developed to validate the responses obtained from the participants. The features included in this instrument consisted of the types of solid waste receptacles, adequacy of receptacles, sanitary conditions of receptacles, distance of units from the classrooms, location of receptacles, solid waste disposal methods, frequency of collection of wastes, environmental problems caused by wastes and state of school surroundings.

3.10 Training of Participants on Organic Waste Recycling

A sub-set of 50 students (25% of the study participants) were randomly selected from the study population in both schools. A day training workshop on segreggation and recycling of wastes with emphasis on organic waste recycling (composting) was conducted and they were provided with two different coloured bags for separation of waste into organic/biodegradable and non biodegradable/inorganic fractions respectively. A pre and post evaluation was conducted before and after the training in ISI. This was done in order to assess the impact of the training on knowledge, attitude and practice of students on organic waste recycling. A sub set of 50 students were also selected from the study participants in WCI. they were however not trained but allowed to continue with their usual method of disposal (use of the conventional dustbin) and were also evaluated after the intervention.

Plate 3.2: Training of Students on Organic Waste Recycling in ISI during the Intervention

3.11 Physical and Chemical Characterization of Wastes

3.11.1 Physical Characterization of Solid Wastes

1. **Waste Sorting**

Waste generated in both schools were sorted on daily basis. This characterisation was carried out in order to classify the various fractions of the waste stream such as paper, nylon and plastics, glass, metals and organic wastes. The output method which entails sorting and weighing of each fraction of the waste stream was adopted (Tchobanoglous et al, 1993). Protective clothings were worn before sorting. These include thick rubber gloves, heavy duty rubber boots and nose (facial) mask. Several labelled bags were available to hold sorted wastes. The categories include paper, nylon and plastics, glass, metals and compostable organics. Waste generated were then sorted into their respective labelled bags.

2. **Determination of weight**

Weight of physical components of wastes generated in both schools were determined over a period of four weeks i.e weight of wastes generated everyday from Monday to Friday for academic environment while that of hostel premises was from Monday to Sunday in both Schools (since they were both boarding schools). Waste materials were also collected from the school kitchens sorted and weighed accordingly using a 20kg camry kitchen scale. This was done for four weeks in both schools.

3. **Density of waste generated**

Using the Archimedes'principle, density was determined by collecting grab samples each for the different fractions of wastes generated across the schools namely paper, Nylon and plastics, organic waste, metals and glass once a week for four different weeks. These were then weighed using a 20kg kitchen scale and kept in an air tight polyethene bag which was immersed in water.

The volume of water displaced was recorded as the volume of wastes. Density was then obtained using the formula:

$$\text{Density} = \frac{\text{Weight}}{\text{Volume}}$$

Plate 3.3: Sorting and Segregation of Wastes in WCI

4 Unit Generation Rate

Waste generation means the rate of waste production, no matter how this waste is managed According to Khan and Ahsan, (2003)

$$\text{Unit Generation Rate} = \frac{\text{Total Quantity of Wastes}}{\text{No. of Houses} \times \text{Residents per House} \times \text{Days}}$$

3.11.2 Chemical Characterization of Solid Wastes

Laboratory procedures used for chemical analysis in this study were:

I. Grab Sample collection

Two grab samples of raw organic waste and compost were collected from the heap of sorted organic waste and compost from different points: sides, depth and centre of the heaps respectively thrice a week in both schools. These samples were then mixed together to form composite samples and a spadeful of waste were then taken, labelled and kept. At the end of the assessment period, compost produced from ISI as well as raw organic waste from WCI were also collected. All the composite samples were mixed together thoroughly and dried. From each school, a total of nine samples of organic waste and two samples of compost were collected using a polyethene bag, labelled and taken to the laboratory for analysis.

II. Sample Preparation

Raw organic waste and compost were oven dried at 65°C for a period of 72 hours and grinded to pass a 1.0mm mesh using a stainless steel grinder. A representative sample of approximately 25g was retained by coning and quartering. This same standard method was used for the compost sample prior to its analysis.

III. pH Determination

Ten ml distilled water was added to 10 g of sample. The mixture was stirred and allowed to stand for 30 minutes, the mixture was stirred again for 2 minutes. The Dwyer Model WPH1 Water Proof pH Meter was calibrated with standard buffer 7.0 and 4.0. The pH of the waste suspension was then measured using the Electronic pH determinations method (Bates, 1954). This same standard method was used to determine pH of the organic waste from the onset of the composting process all through to the production of compost.

IV. Moisture Content Determination

Using Gartner (1991) method, an empty moisture can was weighed W_0. About 2g of the grab sample was added to the moisture can and weighed W_1. The moisture can and sample were then dried in the oven for 24 hours, and thereafter cooled in a desiccator. The can with the dry sample was finally weighed until a constant weight was obtained W_2

Calculation:

Moisture Content = $[(W_1 - W_2)/(W1 - W_0)] \times 100$ (expressed in %).

3.11.3 Determination of Nitrogen, Phosphorus, Potassium and Carbon in Organic Waste and Compost

All the parameters were analyzed using standard methods recommended by the modified standard method 2540-B American Public Health Association (APHA, 1998).

Pre-treatment of Sample

a. Reagents

Selenium powder (Se), Lithium Sulphate ($Li_2SO_4.H_20$), Hydrogen Peroxide 30% (H_20_2) and concentrated Sulphuric acid (H_2SO_4).

b. Digestion Mixture Preparation

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

c. Sample Digestion

About 0.3g of oven dried (65^{0}C) ground wastes sample was measured and placed in a labelled, dry and clean digestion tube. About 4.4 ml digestion mixture was added to each tube and also to 2 reagents blanks for each batch of samples. The solution was digested for 2 hours for 360^{0}C in a furnace until the solution became colourless. The contents were then allowed to cool. About 25ml distilled water was added and mixed until no more sediment dissolved. The contents were then allowed to cool. The solution was finally made up to 50ml with distilled water, mixed well and allowed to settle so that a clear solution could be taken from the supernatant for analysis.

3.11.3.1 Total Nitrogen Determination

Total nitrogen in organic waste and compost were determined using the regular Macro-kjeldahl method (Jackson, 1963).

Apparatus

Macro-kjeldahl digestion distillation apparatus

Macro-kjeldahl flask of 500ml and 750ml capacity

Reagents

Boric acid 4% solution (dissolve 400g of Boric acid crystals in 1 litre of distilled water)

Zinc granules

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

0.2 NHCl9 (standardized)

Sodium sulphate (anhydrous)

Sulphuric acid (H_2SO_4)

Cupric sulphate

Procedure

After the sample had been grinded to pass through 0.5mm sieve, 0.5g (W) was weighed into a 500ml kjeldahl flask and washed with distilled water. Then 0.65g of Cupric sulphate, 15g of anhydrous sodium sulphate and 25ml of Sulphuric acid (conc. H_2SO_4) was added to the solution and the content of the flask placed in kjeldahl digestion unit for more than 1 hour until water had been removed and frothing seized. The heat was later increased until the digest cleared. The samples were then allowed to cool, transferred into a 500ml volumetric flask and made up to mark..

About 100ml of the samples were then pipette into another flask and 50ml of 40% NaOH was added. Also a few drops of boiling zinc granules plus 100ml of distilled water was added to reduce the risk of boiling off and cracking of the flask. Then, 100ml of 4% boric acid, 3 drops of methyl red indicator and 3 drops of bromocresol green indicator were sequencially added into 250ml Erlenmeyer flask. The kjeldahl flask was connected to the distillation unit and distilled into the boric acid. Distillation continued until 100ml of the distillate was collected. The solution in the kjeldahl flask turned black while that in the receiving flask turned dark-red and the volume of acid (VAHCl) used recorded. The concentration of total nitrogen in the samples was calculated as follows.

$$\%Nitrogen = \frac{VAHCl * NHCl * VT * 100 * 14}{VS * 1000 * W}$$

Where

VAHCl = Volume of acid used

NHCl = Normality of HCl (0.2N)

VT = Total volume made up after digestion

VS = Volume of sample used

W = Weight of sample used

3.11.3.2 Phosphorus Determination (Expressed as P_2O_5)

Determination of total phosphorus in the organic waste and compost was done spectrophotometrically using the Mo (molybdovanadate) blue colour method of Murphy and Riley (1962)

Reagents

Ammonium molybdate; antimony potassium tartrate; 2.5MH_2SO_4 (148ml conc. H_2SO_4 diluted to 1 litre); potassium hydrogen phosphate (KH_2PO_4); ascorbic acid. P- Nitrophenol (0.25% wt/vol); 5MNaOH and 5MHCl.

Procedure

From ammonium molybdate, 12g was taken and dissolved in 250ml of distilled water. Also, 0.2908g of antimony potassium tartrate was dissolved in 100ml of distilled water

The two dissolved reagents were added to 1000ml of 2.5M H_2SO_4 and mixed thoroughly before being made up to 2 litres. Then, the mixture was labelled as A and stored in pyrex glass vessel in dark cool temperature.

At the time of analysis, 1.056g of ascorbic acid was dissolved in 200ml of the reagent A above. It was mixed thoroughly and labelled as B. From the digested sample, 5ml was pipetted into 50ml volumetric flask and then made up to 40ml with distilled water. To this solution was added 8ml of reagent B and the mixture was thoroughly mixed.

The absorbance of the coloured solution was matched against a reagent blank at 882nm, after staying for 30mins.

Preparation of Standard Curve (Fig 3.3)

From dry KH_2PO_4, 0.2194kg was taken, dissolved in distilled water in 500ml flask and then made up to mark. This standard P stock solution contained 100µgP/ml. From the stock solution above, 5ml was taken and diluted to 100ml volumetric flask. This solution contained 5µgP/ml. Then from the diluted solution above, 2ml, 4ml, 6ml, 8ml and 10ml was pipetted seperately into 50ml flask each and the volume was made up to 35ml with distilled water. To each of these diluted samples, 8ml of reagent B was added and mixed thoroughly before the volume was nade up to the mark (50ml) with distilled water. These solution contained 0.2, 0.4, 0.6, 0.8 and 1.0 µgP/ml respectively.

Total Phosphorus in the sample was calculated as follows:

$$\text{Total P} = \frac{12.7 * 50 * AB * 10}{\text{Weight of sample}}$$

Where AB is the absorbance at 882nm

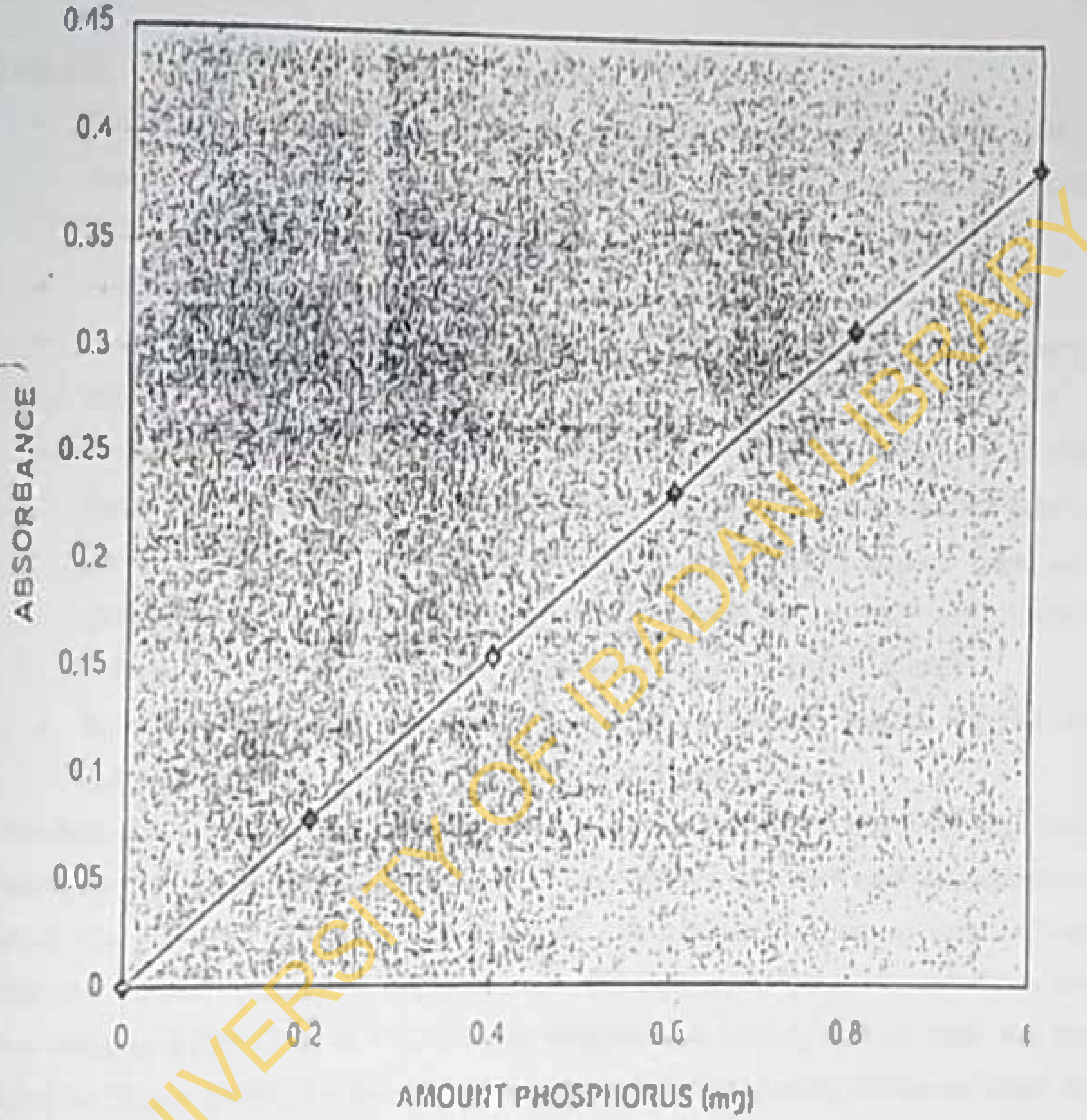

Figure 3.2: Calibration Curve for Phosphorus (Expressed as P_2O_5)

3.11.3.3 Potassium Determination (Expressed as K_2O)

Potassium content of Organic waste and compost was determined using sodium tetraphenylboron volumetric method as described by APHA methods of analysis (1992).

Reagents

- Ammonium oxalate (4%) to prepared this, 40g of ammonium oxalate $(NH_4)_2C_2O_4$) was dissolved in water with slight heating. The resulting solution was then made up to 100ml and stored in plastics container.
- Formaldenhyde solution (37- 40%)
- Clayton yellow (0.04%): This was prepared by dissolving 40mg of indicator (Titan yellow) in water and diluting to 10ml
- Sodiumtetraphenylboron (STBP): STBP crystals (0.1g) was dissolved in 800ml of water. 20.25g of aluminium hydroxide (Al $(OH)_3$) was added and the solution was stirred for 10 mins and then left for 2 days. It as filtered through paper pulp pad vaccum: 4ml of 20% NaOH was added followed by distilled water to make the volume to 21ml and the mixture twas then stored in a plastic container.
- Standard Zephiran (Quaternary Ammonium Chloride). Diluted 12.5ml of 50% Zephiran chloride and made up to mark with distilled water.

Standardization of Zephiran and STBP were done as follows : STBP solution (10ml) was pipette into of 250ml of Erlemeyer flask and 2mls of 20% of NaOH and formaldenhyde were added plus 10 drops of titan yellow indicator. The mixture was titrated with Zephiran to a pink end – point. Volume of Zephiran used which represent the blank value was noted. In standardizing STBP, 2.5g of KH_2PO_4 was weighed into 25ml Erlemeyer flask that had been dried for 2hrs at 105°C. To this was added 50ml of 4% ammonium oxalate solution and then boiled for 30mins. It was allowed to cool before it was transferred to a 50ml volumetric flask and made up to mark with distilled water. From this, 5ml of aliquot was taken into a 100ml volumetric flaskand 2ml of 20% NaOH. 5ml of formaldenhyde were added. The solution was swirled, refrigerated for 15min and then filtered through 0.5μ fibre glass filter paper. To the filterate was added 10 drops of titan yellow indicator and titrated against Zephiran to a pink end point with volume of Zephiran used (V) recorded K_2O factor (F) was calculated as follows:

$$F = \frac{W * 94 * 5}{500 * 272 \text{ (blank - V)}}$$

Where W = Weight of KH_2PO_4

94 = Mol. Wt. of K_2O

5 = Vol of KH_2PO_4 aliquot used

272 = KH_2PO_4 equivalent

500 = Vol. made up of KH_2PO_4

F = K_2O Factor

Analysis was carried out by weighing about 0.5% of prepared sample and washing it into a 250ml beaker. To this was added 50ml of 4% Aluminium oxalate and distilled water to make up to 150mls from this solution, 10ml aliquot was pipetted intom a 100ml volumetric flask and refrigderated for 15mins and filtered through a 0.45 fibre glass filter paper. To the filterate was added 10 drops of titan yellow and titrated against Zephiran to a pink end point with volume of Zephiran (V_2) used recorded. The concentration of potassium (as K_2O) used was calculated as follows:

$$\% K_2O = \frac{(\text{Blank} - V_2) * F * 250 * 100}{10 * W} = Z$$

Where

V2 = Volume of Zephiran used

F = K_2O factor

B = Blank value obtained in the standardization of Zephiran

W = Wt of sample used

$$\% K = \frac{\text{Mol. Wt. K}}{\text{Mol. Wt. } K_2O} * Z$$

$$F = \frac{W * 94 * 5}{500 * 272\ (blank - V)}$$

Where W = Weight of KH_2PO_4

94 = Mol. Wt. of K_2O

5 = Vol of KH_2PO_4 aliquot used

272 = KH_2PO_4 equivalent

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Where

V2 = Volume of Zephiran used

F = K_2O factor

B = Blank value obtained in the standardization of Zephiran

W = Wt of sample used

$$\%K = \frac{Mol.\ Wt.\ K}{Mol.\ Wt. K_2O} * Z$$

3.11.3.4 Carbon Determination

Carbon content was determined using Walkey Black wet oxidation method (Walkey Black, 1934).

Apparatus

Burettes- 50ml capacity, Erlemeyer flask, pipette-10ml capacity and automatic pipette

Reagents

1N $K_2Cr_2O_7$, Conc H_2SO_4 and indicator: O- phenanthroline-ferrous complex. The indicator was prepared by dissolving 14.85g of O- phenanthroline monohydrate and 6.95g of $FeSO_4.7H_2O$ in water and diluting up to 1 litre. Ferrous ammonium sulphate $Fe(NH)_2(SO_4)_3.6H_2O$ in 800ml of water containing 20ml of conc H_2SO_4 and diluting to1 litre.

Procedure

Organic waste and compost were dried and grinded seperately to pass through 0.5mm sieve. One gram of the sample was weighed in duplicate and these were transferred into 250ml Erlemeyer flask. 10ml of 1N K_2Cr_2O7 solution was pipette accurately into each flask and swirled gently to disperse the sample. Then, 20ml conc H_2SO_4 was rapidly added into the suspension and this was swirled gently and vigorously for one minute. After 30 mins, 100ml of the distilled water was added before 3 drops of indicator. The solution was then titrated against 0.5N ferrous sulphate solution. The solution changed from greenish to dark green colour and finally maroon colour at the end point.

The blank titration was made in the same manner but without the sample solution to standardize the dichromate. The result was calculated as thus:

$$\% \text{ Organic Carbon} = \frac{(NY\ FeSO_4 \text{ for Blank} - NY\ FeSO_4 \text{ for sample}) * 0.390}{\text{Weight of air-dried sample}}$$

Where

N = Normality of solution

V = ml of solution used

0.390 = constant

3.11.3.4 Carbon Determination

Carbon content was determined using Walkey Black wet oxidation method (Walkey Black, 1934).

Apparatus

Burettes- 50ml capacity, Erlemeyer flask, pipette-10ml capacity and automatic pipette

Reagents

1N $K_2Cr_2O_7$, Conc H_2SO_4 and indicator: O- phenanthroline-ferrous complex. The indicator was prepared by dissolving 14.85g of O- pheanathroline monohydrate and 6.95g of $FeSO_4.7H_2O$ in water and diluting up to 1 litre. Ferrous ammonium sulphate $Fe(NH)_2(SO_4)_3.6H_2O$ in 800ml of water containing 20ml of conc H_2SO_4 and diluting to 1 litre.

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Where

N = Normality of solution

V = ml of solution used

0.390 = constant

3.12 Determination of Heavy Metals in Organic Waste and Compost

The determination of lead, chromium, nickel, arsenic, cadmium, zinc and copper in the organic waste as well as the compost produced were all done by weighing 1g of the ground sample into a conical flask. About 5 ml of the digestion reagent (2:1 Conc. HNO_3 and Conc. H_2SO_4) were added and heated until brown peroxide and white perchloric acid evaporated. The resulting residue was totally dried. The procedure was repeated until a white precipitate remained in the flask. This was then filtered through a Whatman filter paper into a 100ml volumetric flask. The Filtrate was diluted with 0.1N HNO_3 to 100 ml. The digested samples were then analysed for the heavy metals with a Bulk Scientific 210/211 VCP Atomic Absorption Spectrophotometer (AAS) using methods described by the American Public Health Association (APHA, 1998).

The physical parameters of the organic waste measured were moisture content, density and the pH while the chemical parameters of the organic waste expressed in % were nitrogen, phosphorus, potassium, carbon and organic matter while zinc, copper, chromium, cadmium, lead, arsenic and nickel were expressed in mg/kg.

3.13 Compost Bin Design and Construction

Hot composting using windrow or bin method was adopted for the study. The dimensions of the compost bin was 0.91m by 0.91m by 0.91m (i.e length, breadth and width) and made up of compartments with common removable walls and fronts which allows compost to be turned from one bin to the adjacent bin conveniently. This was fabricated to accomodate the organic fraction of the waste generated in ISI. This type of bins are modelled specifically for schools and business centers interested in composting (organic waste recycling). The bins have the following unique features:

- Lockable lids that keep out garbage and unwanted visitors
- One removable side for easy access
- Hinges to ensure lids don't slam down on users
- Sleek and natural look

Source: Connecticut Department of Environmental Protection, (2002)

Plate 3.4: Front view of Compost Bin Designed and Constructed for Use in ISI

Plate 3.4: Side view of Compost Bin Designed and Constructed for Use in ISI

3.14 Composting Procedure at ISI

Following a waste characterisation and audit carried out at ISI, a two compartment compost bin system was constructed. Hot composting method was adopted. This is the most efficient method for producing quality compost in a relatively short time. Compost curriculum and testing was developed for the selected participants in ISI. Organic waste generated from different parts of the school mainly yard wastes from the cafeteria and kitchen and other parts of the school such as classrooms, hostels, school lawn etc were utilised for the exercise. These include – food wastes such as rice, yam, spaghetti, garri, yam peels, plantain and banana peels, wrapping leaves, vegetables such as peas, cabbage, spinach, spinach stems, fruits such as oranges, banana, pepper stalks and seeds and yard clippings. Grab samples of the organic wastes were taken to the laboratory and the C:N ratio, moisture content and pH were determined prior to the onset of the process. Organic wastes were however collected and transffered to the compost shed. Same volume of water was added throughout the process. Turning of the compost heap as well as monitoring of the environmental conditions such as temperature, pH and moisture content of the compost pile were however carried out on a 3-day basis from the onset to completion of the process.

3.15 Data Analysis and Management

All completed questionnaires were collected and screened for completeness manually while the frequency of all variables were computed. The data was analyzed using SPSS computer software version 17. The results were presented in frequency tables, charts and figures.

Data on current waste management programmes, source-separation of solid waste and waste recycling in the schools as well as waste management practices obtained from the questionnaires were analyzed using descriptive statistics. The effect of the training and the provision of the two compartment compost bin on the adoption of composting as a waste management strategy among the students was tested with the computation of pre and post intervention mean knowledge scores which were tested for significance using the students' t-test. Proportion of students with good and poor knowledge and attitude level was obtained by crosstabulation using the Chi square method. All analysis were done at 5% level of significance.

CHAPTER FOUR

4.0 RESULTS

This chapter highlights the demographic characteristics of the study population, their knowledge, attitude and practice towards organic waste recycling at baseline and after intervention as well as effect of environmental education, components of wastes generated, waste management practices, environmental and health effect of current waste management practice across the schools. The questionaire results were validated by the findings of the observation checklist. Also presented are the quantity of wastes generated, physico-chemical components of wastes such as density of wastes, unit of generation of wastes, moisture content, pH, temperature of compost, chemical analysis of organic waste as well as that of compost produced from organic waste recycling. Of all the 800 questionnaires administered, 784 were retrieved. Results were analysed by grouping the questionnaire into three main sections namely: knowledge, perception and practice section which mainly assessed the effect of the intervention on the respondents, the nature of wastes generated and various ways in which solid waste have been managed and the current problems of solid waste management with its associated effects on the school environment and health of the students across the schools.

4.1 Questionnaire Survey

4.1.1 Socio-Demographic Characteristics of Respondents

A total of 392 students were interviewed in both schools with age ranging between 11 and 17 years. Mean age of the respondents in both schools was 14.8 ± 1.4 years. Of all the students in ISI, 96 were males (49.0%), while 100 were females (51.0%). In WCI, there were 110 males (56.1%) and 86 females (43.9%) respectively. Majority of the respondents were Yorubas 81.0% (ISI) and 68.9% (WCI). Other characteristics are as shown in Table 4.1.

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Table 4.1: Socio-demographic Characteristics of Students in Study Schools

Age Group	ISI (%)	WCI (%)	Total
11-13years	41(20.9)	40(20.4)	81(20.7)
14-16years	144(73.5)	132(67.3)	276(70.4)
17years and above	11(5.6)	24(12.2)	35(8.9)
Mean ± SD years	14.8 ± 1.3	14.8 ± 1.4	14.8±1.4
Sex			
Male	96(49.0)	110(56.1)	206(52.6)
Female	100(51.0)	86(43.9)	186(47.4)
Religion			
Christainity	162(82.7)	144(73.5)	306(78.1)
Islam	34(17.3)	52(26.5)	86(21.9)
Ethnicity			
Yoruba	159(81.1)	135(68.9)	294(75.0)
Igbo	22(11.2)	32(16.3)	54(13.8)
Hausa	0(0.00)	10(5.1)	10(2.6)
Others	15(7.7)	19(9.7)	34(8.7)
Class of Respondent			
SSS1	74(37.8)	70(35.7)	144(36.7)
SSS2	48(24.5)	57(29.1)	105(26.8)
SSS3	74(37.8)	69(35.2)	143(36.5)

4.1.2 Knowledge of Respondents on Organic Waste Recycling at Baseline

Table 4.2 shows the knowledge of respondents on organic waste recycling. At baseline, 34.1% of the respondents had no prior knowledge on any form of waste management in ISI, while in WCI, 26.7%, also had no knowledge on any form of waste management. Again, only 12 % of the respondents at ISI did not know that waste can be converted into useful materials while exactly half (i.e 50%) of the respondents at WCI did not know that waste could be converted into useful materials. About 41.5% and 38.7% of the respondents knew that waste can be recycled in ISI and WCI respectively. However, some of the respondents (41.5%) at ISI and (38.7%) at WCI reported that waste could be recycled at baseline. More than half 55.7% (ISI) and 55.2% (WCI) of the respondents reported compost is highly beneficial to plants.

4.1.3 Knowledge Level of Respondents on Organic Waste Recycling at Baseline

Table 4.3 shows the knowledge level of respondents at baseline. This shows that more than half of the respondents (57.1%) had poor knowledge of waste recycling in ISI while almost half (46.9%) had poor knowledge in WCI. Knowledge score of respondents in ISI was 3.48 ± 1.69 while that of WCI was 3.84 ± 1.68.

Table 4.2: Knowledge of Respondents on Organic Waste Recycling In Study Schools at Baseline

Characteristics	Variable	Baseline		
		ISI (%)	WCI (%)	Total (%)
Do you know any form of waste management practice	Yes	102(53.1)	114(58.5)	216(55.8)
	No	66(34.4)	52(26.7)	118(30.5)
	Don't Know	24(12.5)	29(14.9)	53(13.7)
Do you think waste can be converted into useful materials	Yes	71(37.2)	63(32.5)	134(34.8)
	No	23(12.0)	97(50.0)	120(31.2)
	Don't Know	97(50.8)	34(17.5)	131(34.0)
Do know waste can be recycled	Yes	80(41.5)	75(38.7)	155(40.1)
	No	62(32.1)	79(40.7)	141(364)
	Don't Know	51(26.4)	40(20.6)	91(23.5)
Do you think recyling can help manage waste properly	Yes	77(42.1)	95(49.2)	172(45.7)
	No	56(30.6)	10(5.2)	66(17.6)
	Don't Know	50(27.3)	88(45.6)	138(36.7)
Do you know if solid waste can be seperated at source	Yes	66(35.7)	73(37.4)	139(36.6)
	No	59(31.9)	87(44.6)	146(38.4)
	Don't Know	60(32.4)	35(17.9)	95(25.0)
Do you know about composting	Yes	75(39.3)	84(43.5)	159(41.4)
	No	82(42.9)	56(29.0)	138(35.9)
	Don't Know	34(17.8)	53(27.5)	87(22.7)
Do you think compost is highly beneficial to plants	Yes	103(55.7)	107(55.2)	210(55.4)
	No	7(3.8)	22(11.3)	29(7.7)
	Don't Know	75(40.5)	65(33.5)	140(36.9)
Do you think proper solid waste management can affect health	Yes	108(57.4)	104(54.5)	212(55.9)
	No	42(22.3)	54(28.3)	96(24.3)
	Don't Know	38(20.2)	33(17.3)	71(18.7)

Table 4.3: Knowledge Level of Respondents on Organic Waste Recycling at Baseline.

	Baseline		
Category	ISI (%)	WCI (%)	Total (%)
Poor	112(57.1)	92(46.9)	204(52.0)
Good	54(27.6)	75(38.3)	129(32.9)
Excellent	30(15.3)	29(14.8)	59(15.1)
Mean±S.D Knowledge Score	3.48±1.69	3.84±1.68	3.56±1.68
Chi-square test	X^2 =5.396, df= 2, p= 0.067		

4.1.4 Attitude Towards Organic Waste Recycling at Baseline

Results of the survey (Table 4.4) showed the attitude of students towards organic waste recycling in schools. This revealed the attitude of ISI students towards organic waste recycling as compared with WCI students. In ISI, only 25.3% of the students agreed that solid waste recycling is necessary in schools. 10.8% agreed that training of students on how to recycle wastes is necessary in schools, 20.3% agreed that the school authorities alone should be held responsible for managing wastes generated in the school environment while 43.8% agreed that every student should be involved in the recycling of waste generated in the school. In WCI, 29.2% of the students agreed that waste recycling was necessary in the schools, another 17.1% agreed that training of students on organic waste recycling is necessary in schools, another 24.9% agreed that the school authorities alone should be held responsible for managing wastes generated in the school while 48.2% agreed that every student should be involved in the recycling of waste generated in the school.

4.1.5 Attitude Level of Respondents at Baseline

Table 4.5 shows the attitude level of respondents in ISI and WCI at baseline. In both schools, 31.3% (ISI) and 39.5% (WCI) of the respondents had negative attitude towards organic waste recycling.

4.1.6 Relationship Between Knowledge and Attitude level of Respondents in Study Schools at Baseline

The table 4.6 shows the relationship between knowledge and attitude level of respondents at ISI and WCI at baseline. More than half of the respondents (51.8%) who had poor knowledge also had a negative attitude. However, few students with excellent knowledge on waste recycling (16.7%) also had positive attitude towards waste recycling at baseline in both ISI and WCI.

Table 4.4 : Attitude of Respondents towards Organic Waste Recycling at Baseline in Study Schools

Characteristics	Variable	Baseline		
		ISI (%)	WCI (%)	Total (%)
Solid waste recycling is necessary in the school community.	Agree	48(25.3)	56(29.2)	105(27.2)
	Indifferent	60(30.9)	26(13.5)	86(22.3)
	Disagree	85(43.8)	110(57.3)	195(50.5)
Training of students on how to recycle solid waste is necessary in schools.	Agree	21(10.8)	33(17.1)	54(14.0)
	Indifferent	43(22.2)	68(35.2)	111(28.7)
	Disagree	130(67.0)	92(47.7)	222(57.4)
Waste management enhances good health of the students and beauty of the school environment.	Agree	168(87.0)	139(72.4)	307(79.7)
	Indifferent	16(8.3)	19(9.9)	35(9.1)
	Disagree	9(4.7)	34(17.7)	43(11.2)
The school authorities alone should be held responsible for managing waste generated in the school.	Agree	39(20.3)	48(24.9)	87(22.6)
	Indifferent	50(26.0)	30(15.5)	80(20.8)
	Disagree	103(53.6)	115(59.8)	218(56.6)

Every student should be involved in the recycling of waste in the school.	Agree	84(43.8)	92(48.2)	176(46.0)
	Indifferent	60(31.3)	39(20.4)	49(25.8)
	Disagree	48(25.0)	60(31.4)	108(28.2)
Individual seperation of waste is necessary for proper management of waste.	Agree	92(48.2)	107(56.0)	199(52.1)
	Indifferent	71(37.2)	48(25.1)	119(31.2)
	Disagree	28(14.7)	36(18.8)	64(16.8)
Seperation of waste into various components in the school setting is simply a great disturbance.	Agree	54(28.3)	66(34.6)	120(31.4)
	Indifferent	87(45.5)	53(27.7)	140(36.6)
	Disagree	50(26.2)	72(37.7)	122(31.9)
Composting of organic waste will constitute nuisance to the school.	Agree	67(34.7)	70(36.5)	137(35.6)
	Indifferent	58(30.1)	41(21.4)	99(25.7)
	Disagree	68(35.2)	81(42.2)	149(38.7)

$X^2 = 3.23$, $df = 1$, $p = 0.07$

Table 4.5: Attitude Level of Respondents towards Waste Recycling at Baseline

	Baseline		
Attitude Level	ISI (%)	WCI (%)	Total (%)
Negative	61(31.3)	77(39.5)	139(35.6)
Positive	134(68.7)	118(60.5)	251(64.4)

$X^2 = 0.151$, $df = 2$, $p = 0.927$ $X^2 = 6.432$, $df = 4$, $p = 0.175$

Table 4.6: Relationship between Knowledge Level and Attitude Level at Baseline

Knowledge Level	Attitude Level		Total
	Negative	Positive	
Poor	72 51.8%	130 51.8%	202 51.8%
Good	50 36.0%	79 31.5%	129 33.1%
Excellent	17 12.2%	42 16.7%	59 15.1%
Total	139 100%	251 100%	390 100%

$X^2 = 1.746$, $df = 2$, $p = 0.475$

4.1.7 Organic Waste Recycling in Study Schools at Baseline.

Table 4.7 shows the organic waste recycling practices in both schools at baseline. In ISI, none of the respondents seperated their wastes at source and practiced composting (organic waste recycling) at baseline. At WCI, none reported they seperated their wastes and none practiced organic waste recycling.

Table 4.7 : Organic Waste Recycling Practices in Study schools at Baseline

Responses	ISI N=196(%)	WCI N=196(%)
Yes (Source seperation of solid wastes)	0(0.00)	0(0.00)
Yes (organic waste recycling)	0(0.00)	0(0.00)

4.2 Nature and Quantity of Wastes generated in the Study Schools.

4.2.1 Physical Assessment of Components of Solid Wastes generated in the Study Schools

The questionnaire survey showed that solid wastes in both schools include paper, nylon and plastics, organic wastes, glass and metals (Tin cans). The percentage composition of the wastes generated in a month at each of the schools as shown in Figures 4.1 and 4.2 below showed that, in ISI and WCI, 51.8% and 44.9% of the respondents reported organic waste as the most generated form of waste in both schools. This was followed by paper (28.2% and 21.4%), nylon and plastics (14.9% and 28.1%), glass (2.6% and 2.0%) and metals (0.5% and 1.5%) respectively. Figure 4.3 illustrates the percentage composition of the combined wastes generated in the two Schools. It can be deduced that organic wastes was the most generated (53%) followed by paper (27%), nylon and plastics (15 %), glass (2.0%) and metals (0.8%).

4.2.2 Comparison of the Physico-Chemical Components of Solid Waste Generated in the Study Schools

Mean weekly weight of wastes as illustrated by Table 4.8 was 156.9kg for organic wastes, 45.70kg for papers, 45.36kg for nylon and plastics, 3.50kg for metals (Tin cans) and 1.63kg for glass at ISI. However in WCI, mean weekly weight for various wastes generated include 56.25kg for organic wastes, 54.63kg for nylon and plastics, 37.63kg for paper and 1.25kg for metals (Tin cans) respectively.

Weight of solid waste generated in the two schools daily varied significantly. In ISI, organic wastes and papers were the most dominantly generated wastes daily with mean daily values of 20.85±4.02kg and 6.09±2.14kg respectively. This was followed closely by nylon and plastics with mean daily value of 6.05±1.48kg. Organic waste as well as Nylon and plastics were the most dominantly generated wastes daily at WCI with mean daily values of 7.77± 1.65 kg and 7.30±1.23 kg respectively. Mean weight of papers generated daily was 5.02±0.97kg (Fig 4.4)

Mean densities of components of solid wastes generated in both schools as shown in Figure 4.5 revealed that in ISI, mean density of paper, plastics and organic wastes were 85.02kg/m^3, 78.0kg/m^3 and 132.05 kg/m^3 respectively while in WCI, mean density of paper, nylon and plastics and organic wastes was 80.0kgm^3, 82.0kg/m^3 and 106.82kg/m^3 respectively.

4.2.3 Unit Waste Generation Rate in the Study Schools

The mean generation rate reported in this study were 0.18kg/c/day and 0.12kg/c/day in ISI and WCI respectively. These were however lower than the standard of 0.5kg/c/day.

Figure 4.1: Percentage Composition by Weight of Wastes generated in ISI

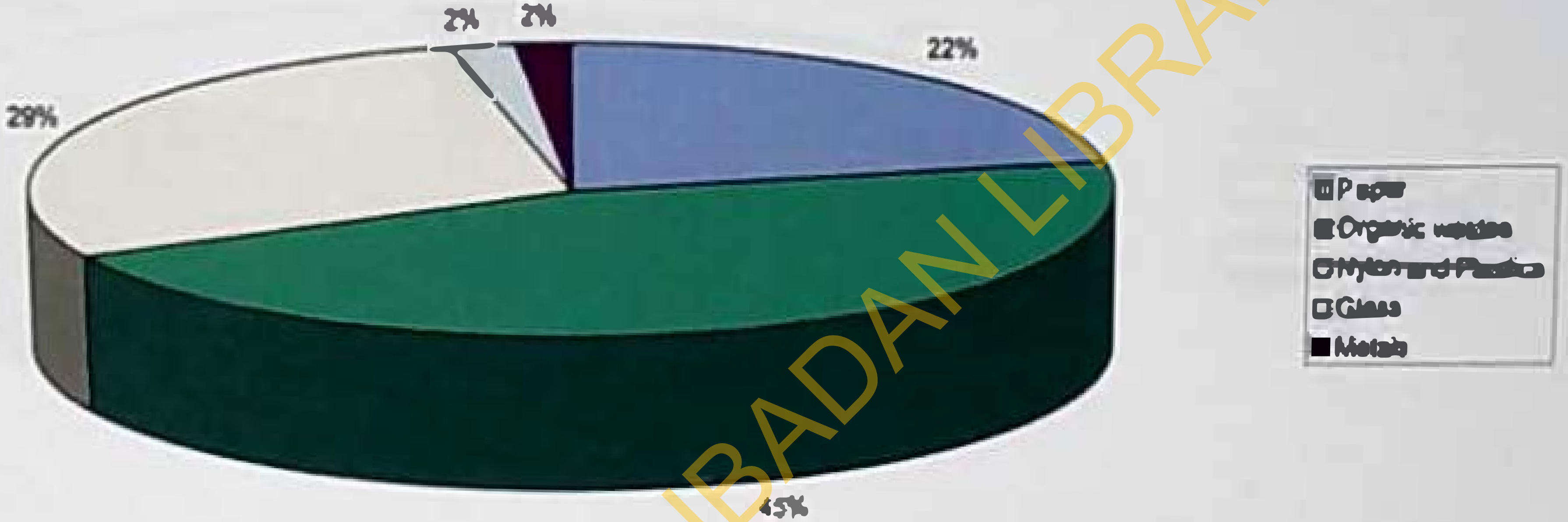

Figure 4.2: Percentage Composition by Weight of Wastes generated in WCI

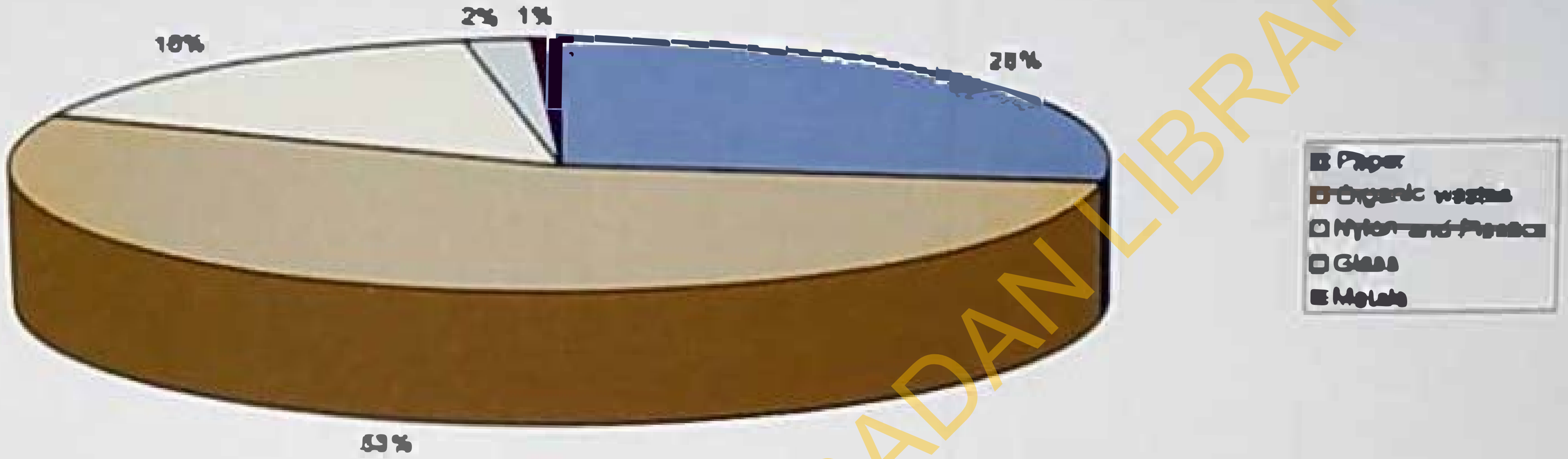

Figure 4.3: Percentage Composition by Weight of Wastes generated in Study Schools

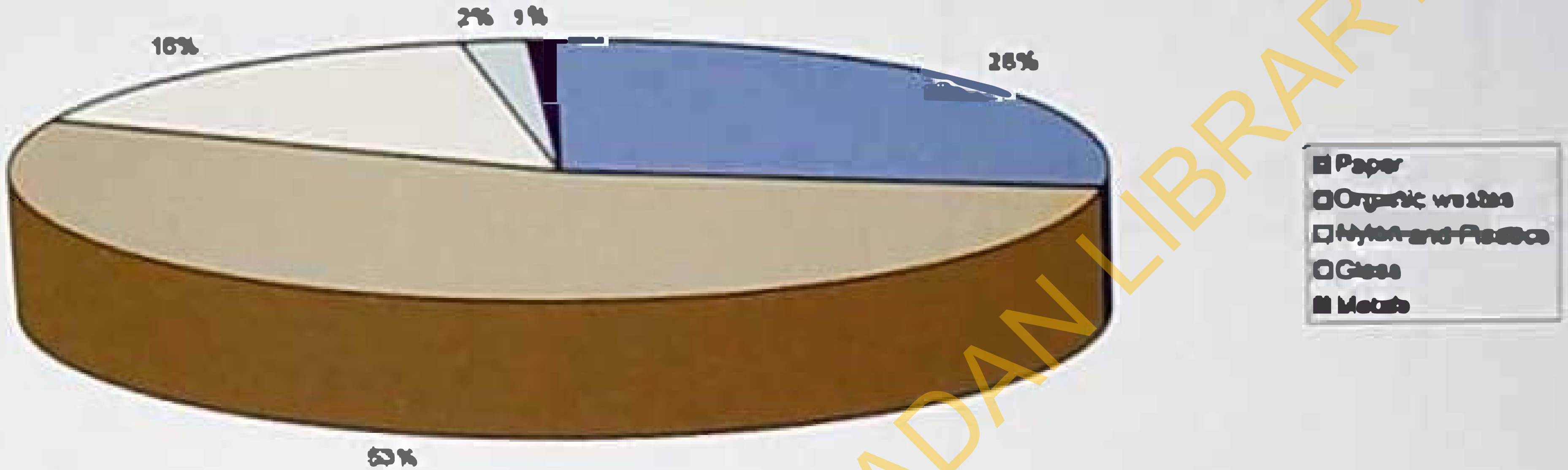

Figure 4.3: Percentage Composition by Weight of Wastes generated in Study Schools

Table 4.8: Mean Weekly Weight of Solid Waste Components generated in Study Schools.

Parameter	Location	Mean ± S.D (kg)
Paper	ISI	45.70 ± 8.32
	WCI	37.63 ± 9.23
Nylon and Plastics	ISI	45.36 ± 9.82
	WCI	54.63 ± 18.89
Organic Wastes	ISI	156.89 ± 22.61
	WCI	56.25 ± 15.93
Metals	ISI	3.50 ± 2.96
	WCI	1.25 ± 2.92
Glass	ISI	1.63 ± 1.88
	WCI	0.00 ± 0.00

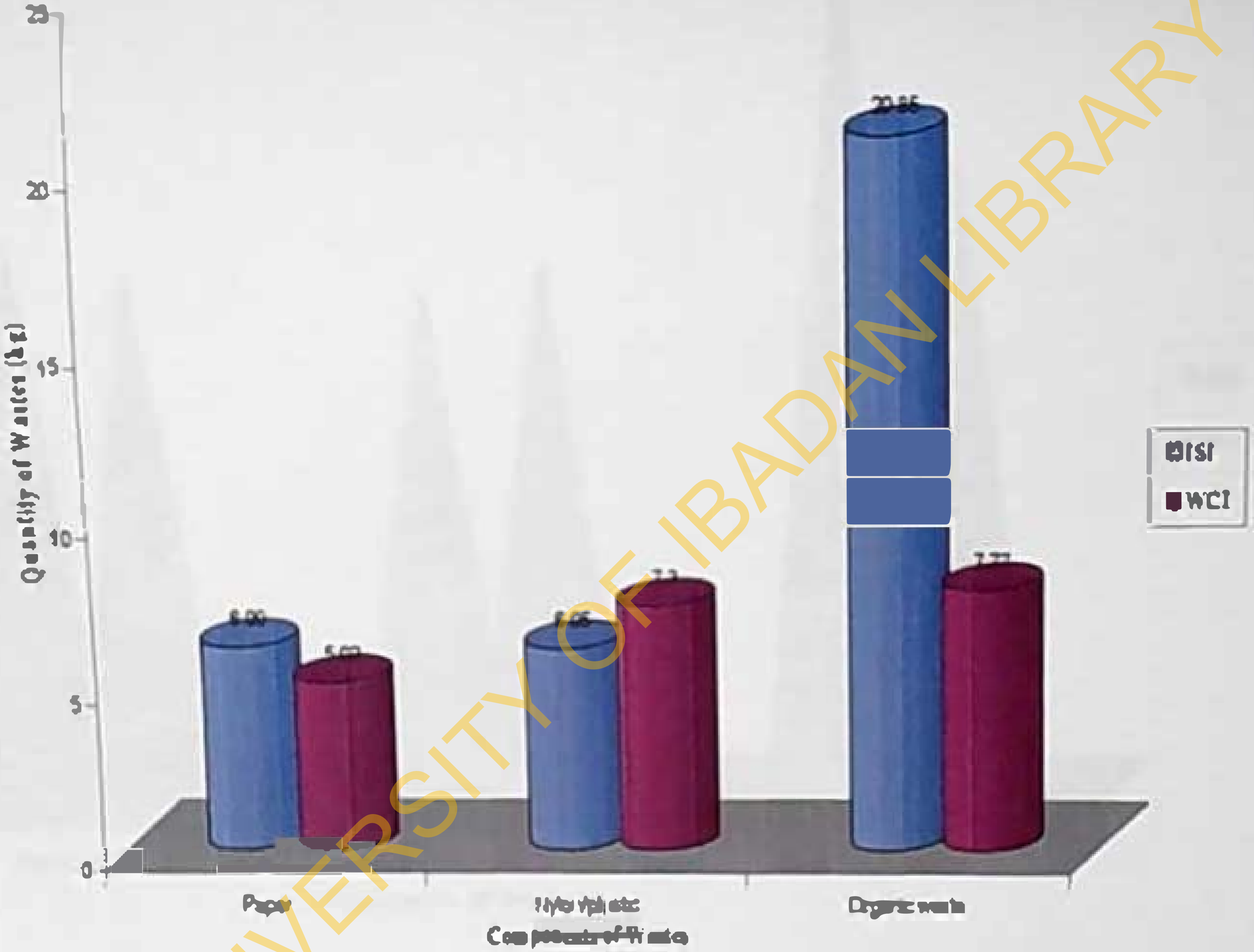

Figure 4.4: Mean Weight of Wastes generated Daily in Study Schools

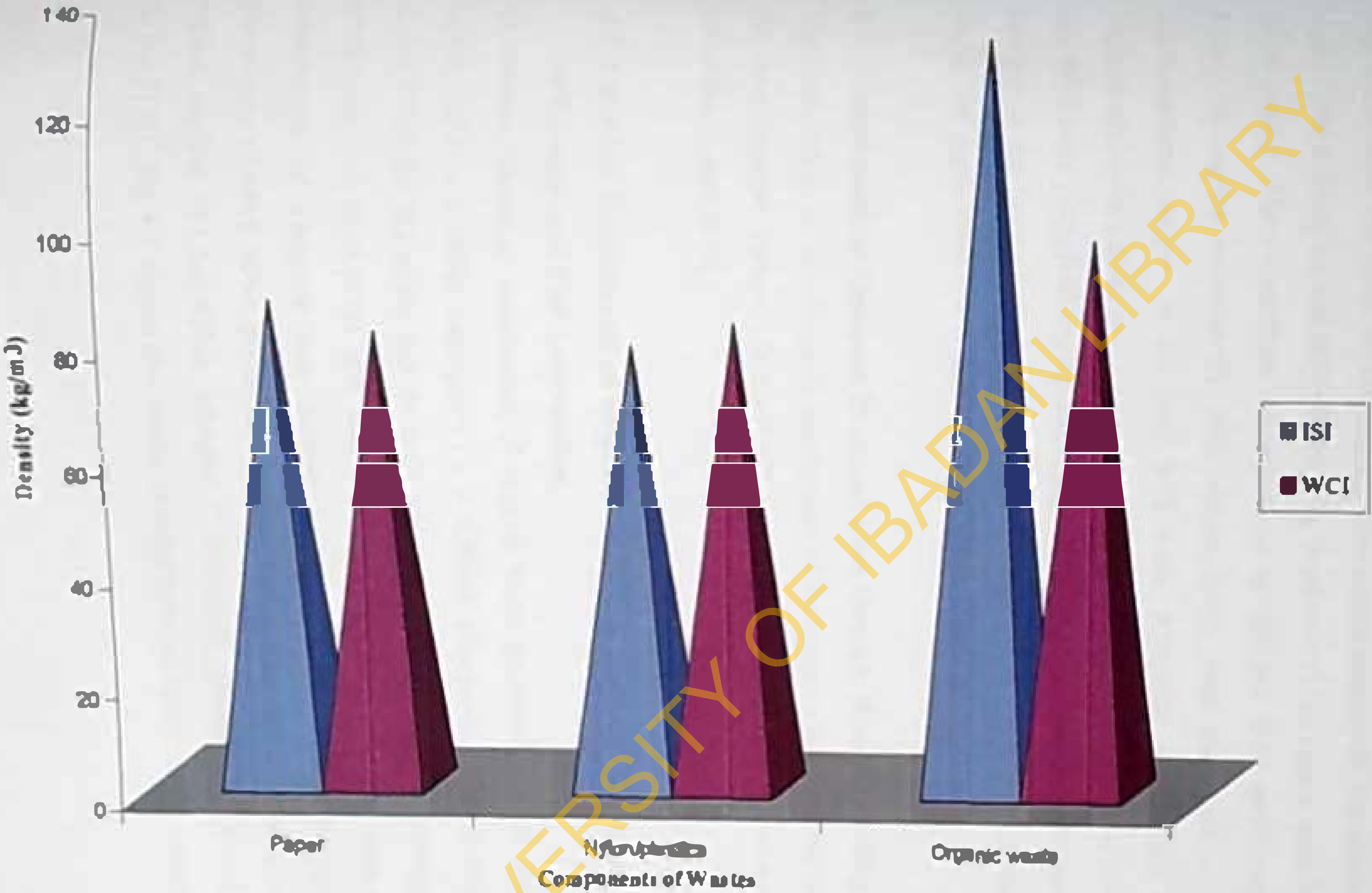

Figure 4.5: Mean Densities of Wastes generated in Study Schools

4.3 Heavy Metal Components of Organic Wastes Generated in the Study Schools.

Figure 4.6 shows the mean values of heavy metals concentrations in the organic waste generated in the two schools studied as compared with the Ontario composting guideline limits. The concentrations of zinc in ISI and WCI were 1.52±0.10mg/kg and .21±0.00 mg/kg respectively, and these were lower than the limit of 500 mg/kg. The concentrations of lead at ISI and WCI were 0.23±0.00 mg/kg and 0.10±0.00mg/kg respectively, and these were also lower than the limit of 150 mg/kg. The concentrations of Chromium in ISI and WCI were 0.06±0.00mg/kg and 0.01±0.00mg/kg respectively, the values were lower than the limit of 50 mg/kg. Also, Cadmium concentrations in ISI and WCI were 0.03±0.00 mg/kg and 0.01±0.00 mg/kg respectively with values lower than the limit of 3.0 mg/kg. The concentrations copper in ISI and WCI were: 0.50±0.00 mg/kg and 0.15±0.01 mg/kg respectively, with values also lower than the limit of 60 mg/kg. Arsenic concentrations in ISI and WCI were 0.02±0.00 mg/kg and 0.01±0.00 mg/kg respectively and these values were also lower than the limit of 10mg/kg. Nickel concentration in ISI and WCI were and 0.01+0.00 mg/kg and again were lower than the limit of 60 mg/kg.

4.4 Constituents of Compost Produced from Organic Waste Recycling

The mean values of the chemical constituents of the compost from organic wastes recycling in ISI were organic carbon (24.00±0.01%), nitrogen (1.9±0.01%), phosphorus (7.5±0.01%), pottasium (1.6±0.01%).

4.5 Chemical Constituents of Organic Waste and Compost Produced in Study Schools at Baseline and Post Intervention.

At baseline, chemical constituents of organic waste generated in both schools was organic carbon (62.0 ± 0.04%), nitrogen (2.4 ± 0.00%), phosphorus (9.6±0.28%) and pottasium (3.0±0.04%) for ISI while that of WCI was carbon (49.02±0.01%), nitrogen (2.32±0.01%), phosphorus (10.14±0.01%) and pottasium (1.84±0.01%). At post intervention, chemical constituents of compost was organic carbon (24.00±0.00%), nitrogen (1.91±0.00%), phosphorus (7.48±0.00%), pottasium (1.57±0.00%) while that of organic waste at WCI was organic carbon (47.2±0.02%), nitrogen (2.2±0.01%), phosphorus (9.9±0.01%), pottasium (1.7±0.01%). Fig 4.7 shows the mean concentration of heavy metal constituents of organic wastes at baseline versus compost produced at post intervention in ISI. This was as follows 1.52±0.10mg/kg and 0.19±0.00 mg/kg (zinc), 0.23±0.00 mg/kg and 0.10±0.00mg/kg (lead), 0.06±0.00mg/kg and 0.00±0.00 mg/kg (chromium), 0.03±0.00 mg/kg and 0.00±0.00mg/kg (cadmium), 0.50±0.00 mg/kg and 0.13±0.00mg/kg (copper), 0.02±0.00 mg/kg and 0.00±0.00mg/kg (arsenic) and 0.01±0.00 mg/kg and 0.00±0.00 mg/kg (nickel).

4.6 Comparison of Physico-Chemical Conditions required for Efficient Recycling of Organic Waste generated in Study Schools

Table 4.9 shows the variation in the physico-chemical parameters in the two schools. The C: N ratio at ISI and WCI were 25.8:1 and 21.1:1 respectively. The Moisture Content for ISI and WCI were 57.80±14.94 and 73.10±1.0 % respectively. The pH values for ISI and WCI were 7.37±0.54 and 6.80±0.20 respectively.

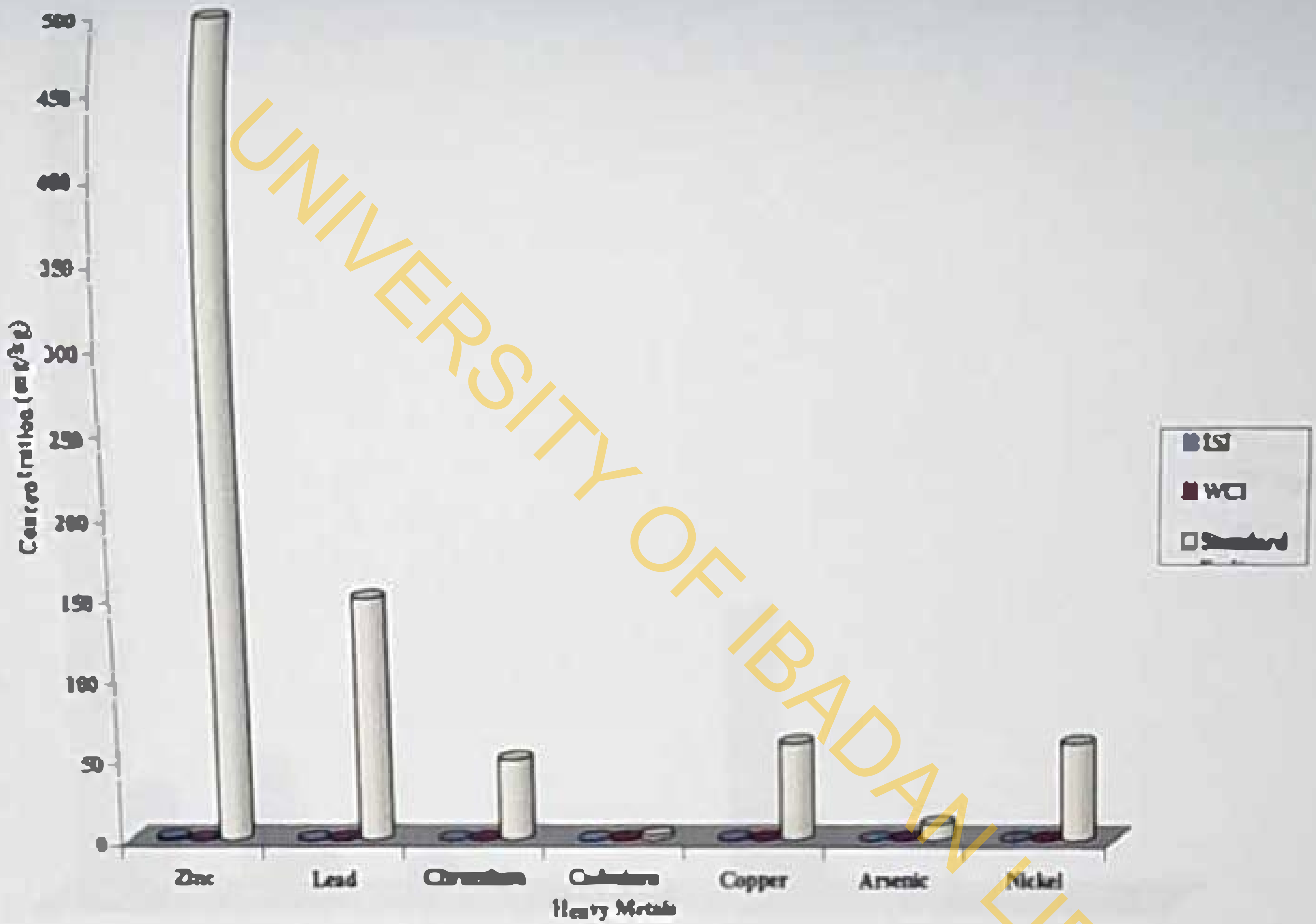

Figure 4.6: Mean Concentration of Heavy Metals in Organic Wastes generated in Study Schools

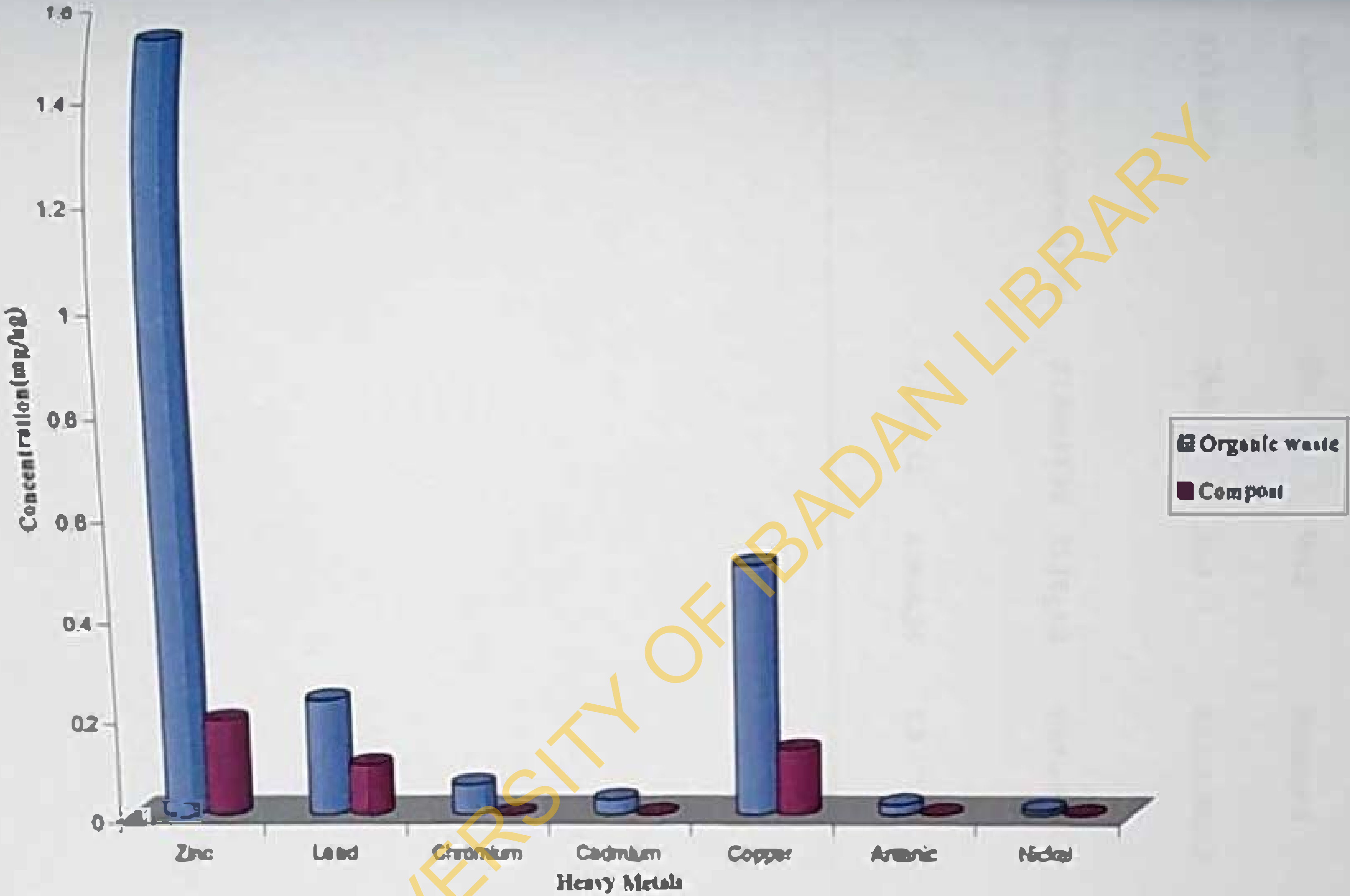

Figure 4.7: Mean Concentration of Heavy Metals in Organic Waste versus Compost in ISI

Table 4.9: Comparison of Physico-Chemical Conditions required for Composting of Organic Waste generated in Study Schools

Parameter	ISI	WCI	Standard
C:N Ratio	25.8 : 1	21.1 : 1	25.1:1-30.1:1
Moisture Content (%)	57.80±14.94	73.10±1.8	50.0 – 60.0
pH	7.37±0.54	6.80±0.20	6.0 – 7.5

4.7 Variations in Physico-chemical Conditions observed during Composting in ISI

The pH of organic wastes from the start of the experiment was 6. This gradually increased to 6.8 as observed on the 6th day of the process and increased to 8.0 on the 12th day. This reduced to 7.1 on completion of the process i.e 30th day. Temperature reading from the onset (i.e first 3days) was 34°C. This increased to 55°C on the 6th day and to 57°C on the 15th day of the process. However, on the 24th day, it reduced to 48°C and gradually to 42°C on the 27th day and finally to 39°C on completion of the process. For moisture content, the organic waste contained 61% moisture on the 3rd day of the process. On the 15th day however, it reduced to 48% and finally to 54% on the 27th day and on completion of the process. Fig 4.8 - 4.10 illustrates the variation in physico-chemical conditions (pH, temperature and moisture content) observed during the composting process. However, the mean values of pH, temperature and moisture content were 7.37±0.54, 49.50±7.46°C and 57.80±14.94% respectively.

4.8 Waste Management Practices in Study Schools at Baseline

Table 4.10 below shows the results of the survey which illustrates the waste management practices across the schools at baseline. Waste management at ISI was basically open dumping with little or no seperation of wastes (10.8%). As reported earlier, 65.6% and 68.1% of respondents in ISI and WCI respectively utilized the school waste bin for waste disposal, while 52.9% and 58.4% at ISI and WCI respectively reported that there were medium sized plastic bins without cover. Partaining to adequacy of bins 53.8% and 85.8% of the students in ISI and WCI respectively reported that each classroom had at least one waste bin each located either within or outside the classroom. However, 65.2% of the respondents at ISI reported that waste was disposed of from the school by an external contractor licensed by the school while 75.2% at WCI reported waste was burnt openly (Open burning).

4.9 Problems Associated with Waste Management Practices across the Schools.

4.9.1 Environmental Problems

The major environmental problems associated with solid waste in the schools were odour, vector breeding, scavengers, unsightliness and leachates. Fig 4.11 shows that in ISI and WCI, (45.2%, 2.7%, 25.2%, 0.9% and 1.7%) and (54.8%, 11.9%, 25.1%, 1.3% and 7.1%) reported odour, vector breeding, scavengers, unsigthliness, leachates and scavengers respectively.

4.9.2 Health Problems

Health problems reported to be associated with solid waste management across the schools were malaria, typhoid fever, diarrhoea, yellow fever and dog bite. Fig 4.12 shows that in ISI and WCI, (76.0%, 53.1%, 42.5%, 51.1%, 19.2% and 4.6%) and (65.7%, 45.0%, 33.3%, 50.3%, 28.2% and 3.9%) reported malaria, typhoid fever, diarrhoea, cholera, yellow fever and dog bite respectively.

Table 4.10 : Waste Management Practices in Study Schools

Variable	Options	ISI N=196(%)	WCI N=196(%)
Waste disposal/collection method employed by Students	Bush dumping	24(12.9)	19(9.9)
	Open dumping	37(19.9)	31(16.2)
	Pit dumping	3(1.6)	11(5.8)
	School waste bin	122(65.6)	130(68.1)
Frequency of Waste disposal from Classrooms and Hostels	Once a day	129(83.9)	137(73.7)
	Twice a day	10(6.5)	40(21.5)
	Every two days	8(5.2)	3(1.6)
	Once a week	3(1.9)	2(1.1)
	Once in two weeks	4(2.6)	4(2.2)
Frequency of Waste Disposal in School.	Daily	111(62.7)	152(80.0)
	Every 2days	13(7.3)	11(5.8)
	Beyond 2days	5(2.8)	1(0.5)
	Weekly	13(7.3)	14(7.4)
	Not sure	35(19.8)	12(6.3)
Method of Collection/ Disposal of Waste in School(School licensedContractors)	Yes	116(65.2)	45(24.7)
	No	62(34.8)	137(75.3)
Open burning	Yes	24(12.2)	103(75.2)
	No	172(87.8)	34(24.8)

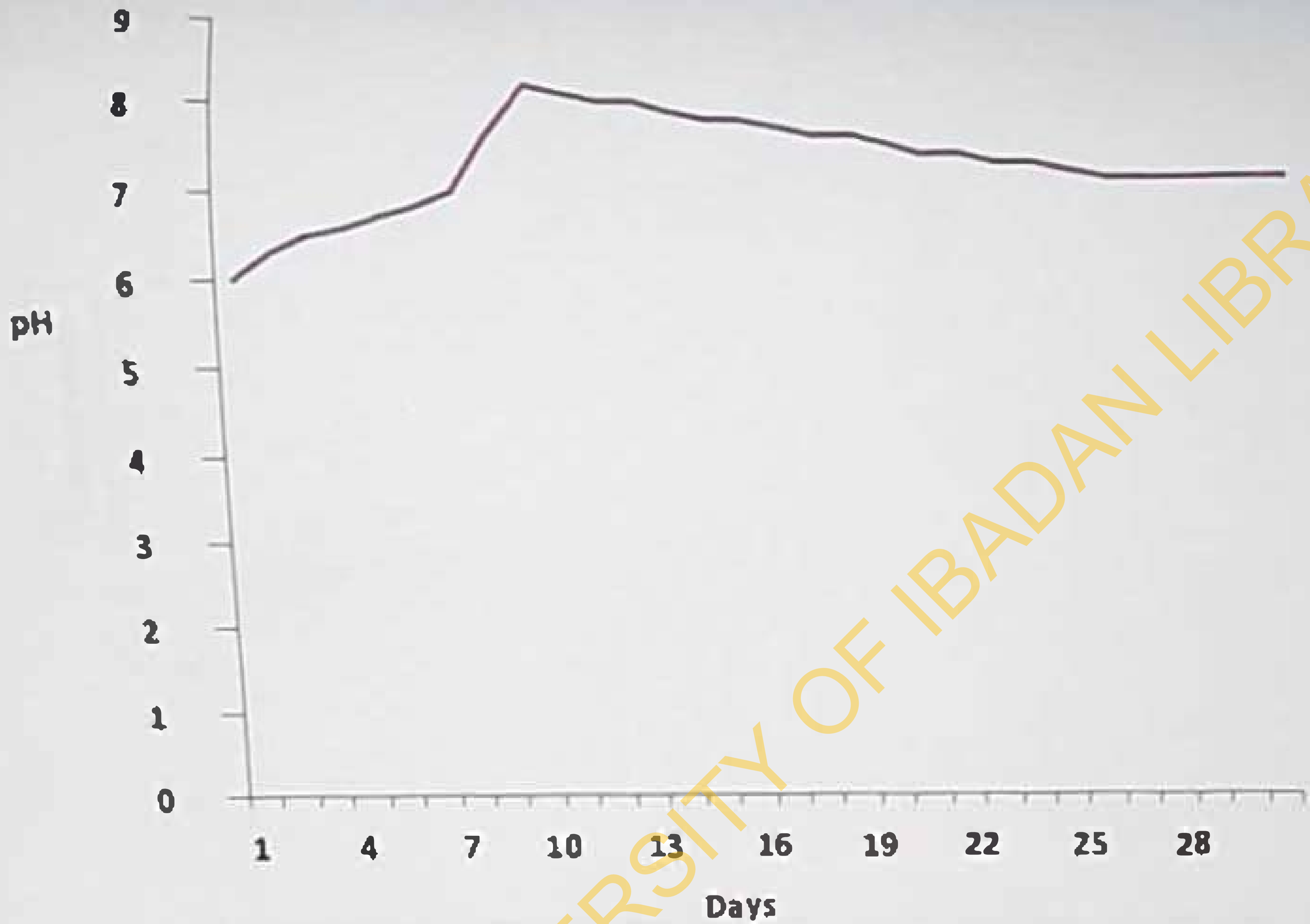

Figure 4.8: Variation in pH observed during Composting in ISI

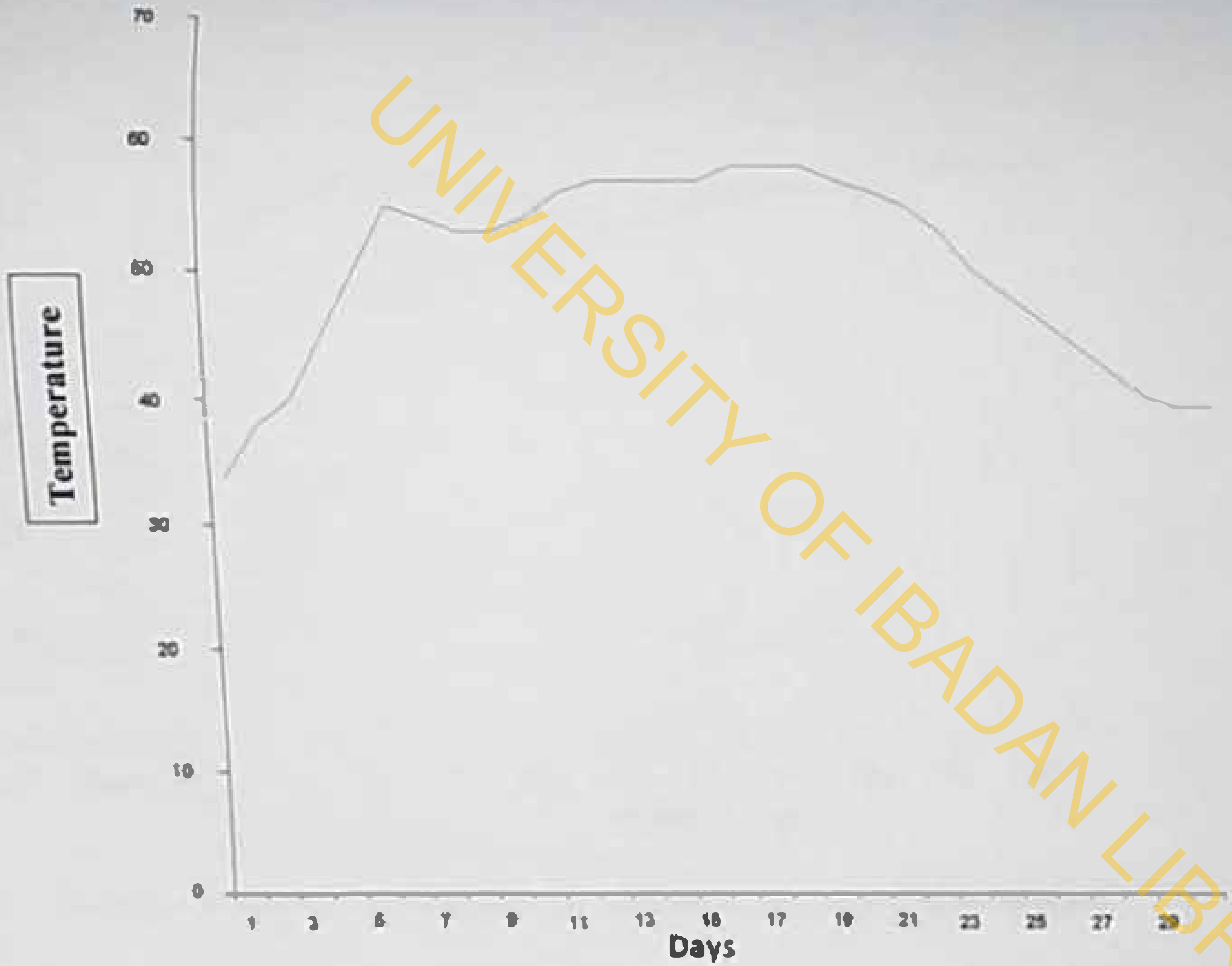

Figure 4.9 : Temperature Variation During Composting of Organic Waste

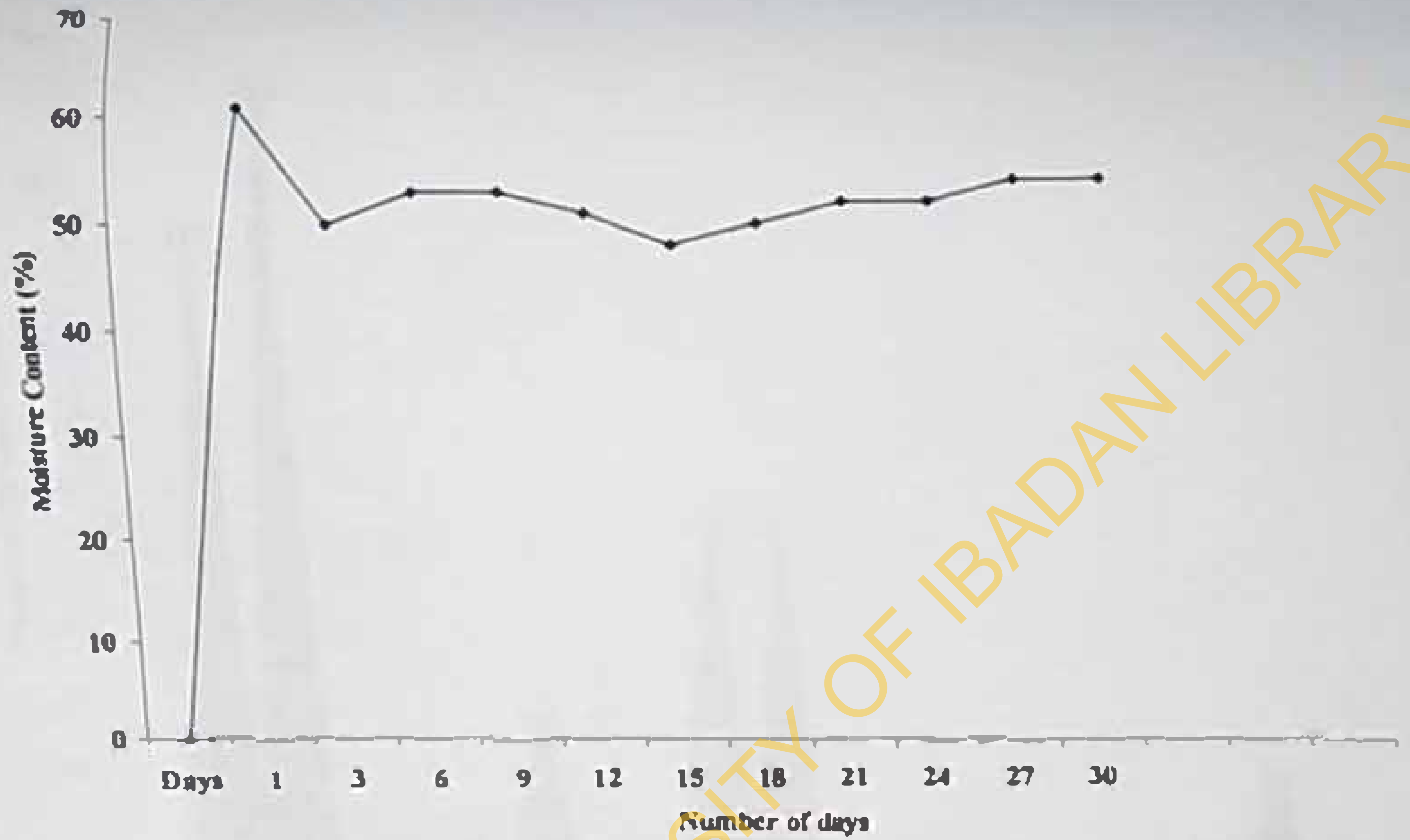

Figure 4.10: Variation in Moisture Content observed during Composting in ISI

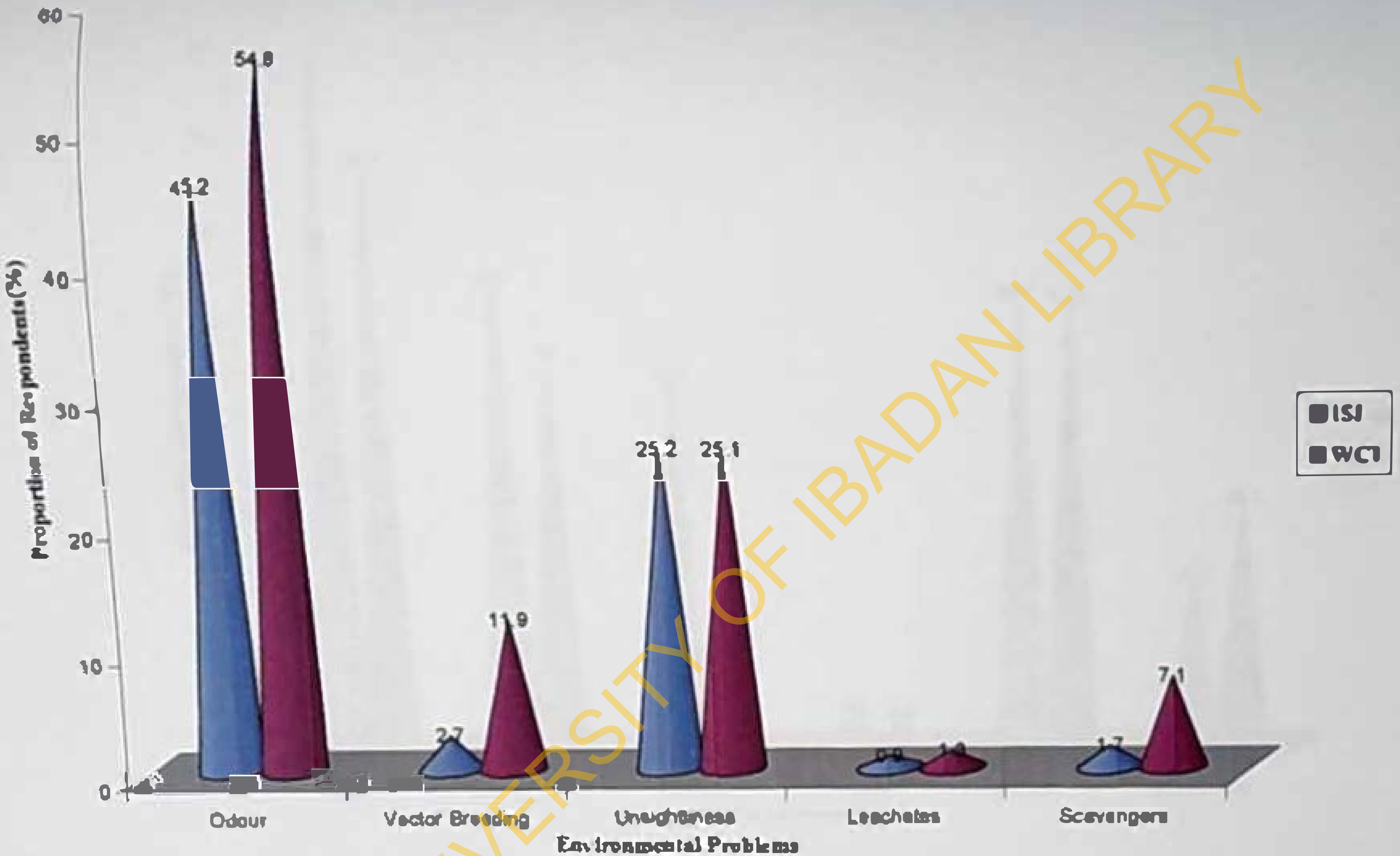

Figure 4.11: Environmental Problems associated with Waste Management across the Study Schools

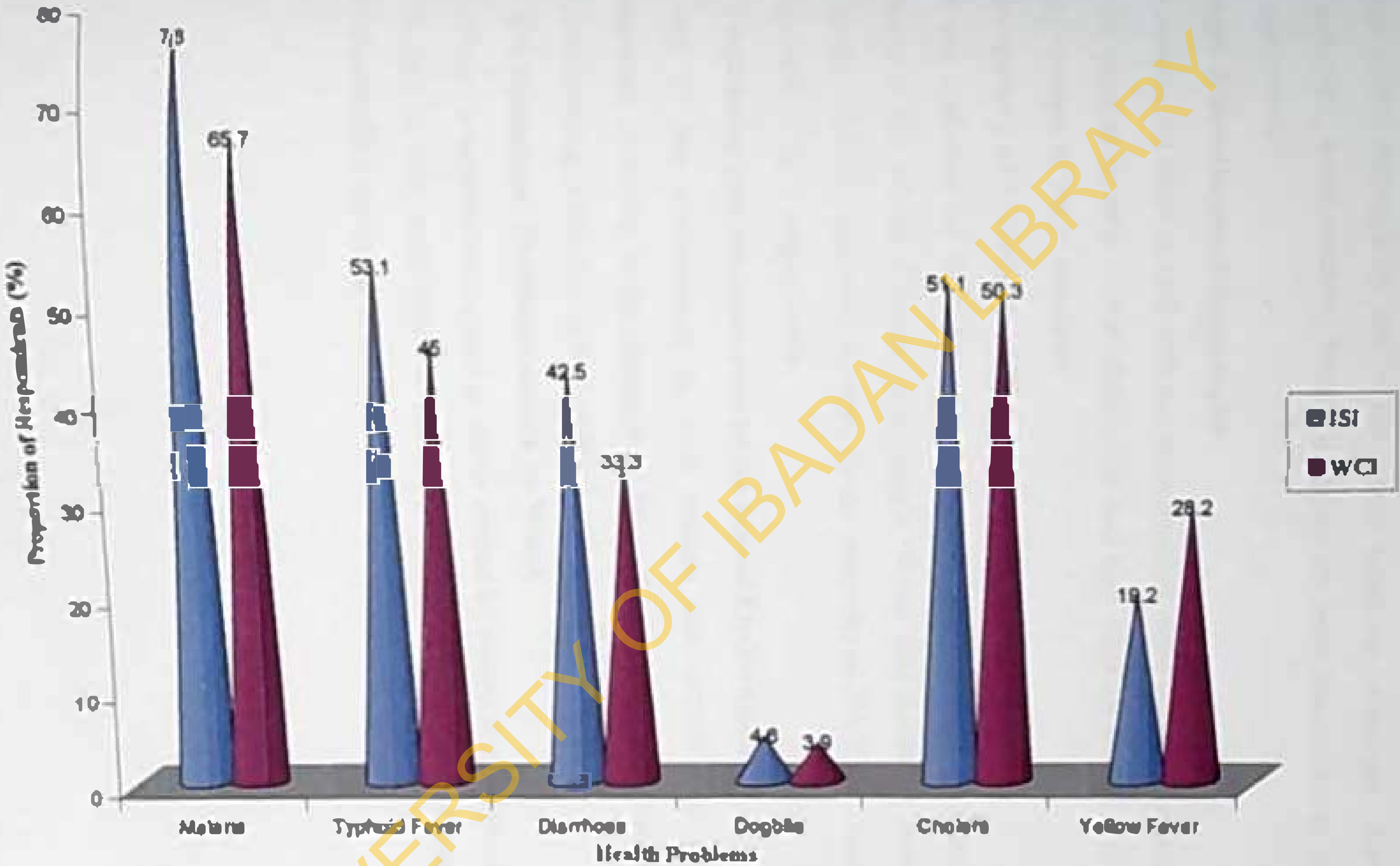

Figure 4.12: Health Problems associated with Waste management Practices across the Study Schools

4.10 On site Observations using Checklist

In order to validate the responses given by students certain areas and practices were observed and these include the physical features of the school environment. These are presented as follows (Table 4.11):

a. Disposal of Solid Wastes by Students

This was mainly through the use of the school waste bin. Although wastes such as papers, sweet wrappers, water satchets, biscuit wrappers etc were found littered on the floor in some of the classrooms.

b. Solid Waste Disposal Receptacles

Waste receptacles used in both schools were medium sized plastic bins without covers. These were also present in each of the classrooms and they were located at a corner within a short walking distance in the classrooms.

c. Frequency of Collection of Wastes

Waste was collected on daily basis by the school cleaners from all areas of the school and transferred to the school dumpsite accordingly. Waste was thereafter collected three times a week by an external contractor licensed by the authority at ISI while waste was burnt openly on daily basis at WCI respectively.

d. Cleanliness and Maintainance of the School Environment

The state of the environment in both schools was orderly and neat except for the indiscriminate dumping in the dumpsite at ISI as the large bin provided was inadequate and found overflowing. Drainage in both schools was also free flowing.

e. Environmental Problems caused by Waste

This includes unsightliness as well as odour caused by wastes at the dumpsite in both schools. Vectors such as flies were found at the dumpsite and occassionally scavengers like dogs due to the uncontrolled dumping of wastes at ISI.

Plate 4.1: State of Dumpsite in ISI

Plate 4.2: State of Dumpsite in WCI

Table 4.11: On site Observation Checklist in the Study Schools

Indicators Observed	ISI	WCI
	Ranking	
Disposal of Solid Wastes by Students	++	++
Adequacy of Solid Waste Disposal Receptacles	++	++
Frequency of Collection of Wastes	++	++
Cleanliness and Maintainance of the Environment	++	++
State of Dumpsite	+	++
Presence of Scavengers at School Dumpsite	++	-
Presence of Vectors at School Dumpsite	++	+
Types of Solid Waste Receptacles		
Drums	+	-
Bins	++	++
Metal Containers	-	-
Sanitary Condition of Receptacles		
Covered	-	-
Exposed	++	++
Overflowing	-	-
Waste Disposal Practices		
Use of Bin	++	++
Recycling	-	-
Open Dumping	+	++
Open Burning	+	+++

Frequency of Waste Collection		
Daily	++	+++
Once a Week	-	-
Twice a Week	-	-
State of Surroundings	+++	+++
Location of Receptacles	++	++
Location Capable of causing Hazard to Students	-	-
Use of External/Licensed Waste Collection Services	+	-

Key +++ Good ++ Fair + Poor - Absent

Frequency of Waste Collection		
Daily	++	+++
Once a Week	-	-
Twice a Week	-	-
State of Surroundings	+++	+++
Location of Receptacles	++	++
Location Capable of causing Hazard to Students	-	-
Use of External/Licensed Waste Collection Services	+	-

Key +++ Good ++ Fair + Poor - Absent

4.11 Training and Provision of Compost Bin for Organic Waste Recycling

After the physical assessment of the wastes in the two Schools, it was observed that organic wastes was the most dominant waste generated followed by paper and plastics at appreciable quantities. Therefore a two compartment compost bin following windrows method was designed and fabricated for the recycling of the organic wastes component in ISI. The intervention also included training on source seggregation and the effective use of the fabricated bin for recycling of organic wastes in ISI. The bin was left for use in ISI for a period of one month after which a post intervention survey was conducted with the same questionnaire used at baseline.

4.11.1 Training Session on Organic Waste Recycling

Training was conducted as part of the intervention on waste segreggation and composting of organic waste using the windrows method. A two compartment 3ft by 3ft by 3ft compost bin was constructed to this effect in ISI. A total of 50 students were randomly selected from the target population i.e SSS1-3 students and enrolled in the training. A pre-evaluation test comprising 14 questions was conducted. A mean knowledge score of 3.48 was obtained which eventually increased to 5.49 after the same set of questions administered initially were used. This shows the increase in knowledge of the participants.

4.11.2 Effect of Training and Provision of Compost Bin on knowledge

Table 4.12 shows the proportion of respondents with good knowledge after the training. The increase in knowledge shows the effect of the training on the knowledge of students on organic waste recycling in ISI as compared to that of WCI students where there was no training.

Table 4.13 shows the mean knowledge score of ISI students at baseline as 3.5±1.7 while that of WCI at baseline was 3.8±1.7 with no significant difference observed. Mean baseline knowledge score and its corresponding score after intervention for ISI was 3.5±1.7 and 5.5±1.6, while that of WCI was 3.8±1.7 and its corresponding post inervention score was 4.1±1.8. The difference between the two post intervention knowledge scores for the two schools was significant ($p<0.05$).

4.11.3 Effect of Training and Provision of Compost Bin on Attitude

The result of the survey as shown in Table 4.14 shows the differences in the attitude of students towards organic waste recycling at baseline and after intervention. In ISI, 25.3% and 76.4% reported that organic waste recycling was necessary in schools. 10.8% and 69.8% admitted that training of students on organic waste recycling was necessary in schools, 20.3% and 11.0% stated that the school authorities alone should manage wastes generated in the school. 43.8% and 64.2% of the respondents agreed that every student should be involved in the recycling of wastes; 48.2% and 52.0% agreed that component sorting of wastes was necessary for proper management of waste at baseline and after intervention respectively. In WCI, 29.2% and 54.7% disagreed that organic waste recycling was necessary in schools. 17.1% and 39.0% agreed that training of students on how to recycle organic waste was necessary in schools; 24.9% and 30.7% agreed that the school authority alone should be responsible for management of waste generated in the school; 48.2% and 52.6% agreed that every student should be involved in the recycling of waste in the school at baseline and post intervention respectively. This is a reflection that the training programme had a positive effect on the attitude of students towards organic waste recycling.

4.11.4 Effect of Training and Utilization of Bin for Composting

Table 4.15 shows the effect of intervention on utilization of the compost bin for composting in both schools. In ISI, 0.00% and 18.7% seperated their waste while 0.00% and 26.0% practiced composting before and after the provision of compost bin respectively. In WCI, none of the respondents separated their waste and practiced composting before and after the intervention.

Table 4.12 : Differences in Knowledge at Baseline and after Intervention in Study Schools.

Characteristics	Variable	Baseline			Post-intervention		
		ISI (%)	WCI(%)	Total (%)	ISI (%)	WCI(%)	Total (%)
Do you know any form of waste management	Yes	102(53.1)	114(58.5)	216(55.8)	129(66.5)	122(62.9)	251(64.7)
	No	66(34.4)	52(26.7)	118(30.5)	46(23.7)	55(28.4)	101(26.0)
	Don't Know	24(12.5)	29(14.9)	53(13.7)	19(9.8)	17(8.8)	36(9.3)
Do you think waste can be converted into useful materials	Yes	71(37.2)	63(32.5)	134(34.8)	118(60.8)	91(46.9)	209(53.9)
	No	23(12.0)	97(50.0)	120(31.2)	5(2.6)	87(44.8)	92(23.7)
	Don't Know	97(50.8)	34(17.5)	131(34.0)	71(36.6)	16(8.2)	87(22.4)

Do know waste can be recycled	Yes	80(41.5)	75(38.7)	155(40.1)	157(80.9)	80(41.2)	237(61.1)
	No	62(32.1)	79(40.7)	141(36.4)	23(11.9)	59(30.4)	82(21.1)
	Don't Know	51(26.4)	40(20.6)	91(23.5)	14(7.2)	55(28.4)	69(17.8)
Do you think recyling can help manage waste properly	Yes	77(42.1)	95(49.2)	172(45.7)	151(82.1)	116(60.4)	267(71.0)
	No	56(30.6)	10(5.2)	66(17.6)	18(9.8)	22(11.5)	40(10.6)
	Don't Know	50(27.3)	88(45.6)	138(36.7)	15(8.2)	54(28.1)	69(18.4)
Do you know if solid waste can be separated at source	Yes	66(35.7)	73(37.4)	139(36.6)	99(53.5)	102(53.1)	201(53.3)
	No	59(31.9)	87(44.6)	146(38.4)	58(31.4)	33(17.2)	91(24.1)
	Don't Know	60(32.4)	35(17.9)	95(25.0)	28(15.1)	57(29.7)	85(22.5)
Do you know about	Yes	75(39.3)	84(43.5)	159(41.4)	152(79.6)	80(41.5)	232(60.4))

Do know waste can be recycled	Yes	80(41.5)	75(38.7)	155(40.1)	157(80.9)	80(41.2)	237(61.1)
	No	62(32.1)	79(40.7)	141(36.4)	23(11.9)	59(30.4)	82(21.1)
	Don't Know	51(26.4)	40(20.6)	91(23.5)	14(7.2)	55(28.4)	69(17.8)
Do you think recyling can help manage waste properly	Yes	77(42.1)	95(49.2)	172(45.7)	151(82.1)	116(60.4)	267(71.0)
	No	56(30.6)	10(5.2)	66(17.6)	18(9.8)	22(11.5)	40(10.6)
	Don't Know	50(27.3)	88(45.6)	138(36.7)	15(8.2)	54(28.1)	69(18.4)
Do you know if solid waste can be separated at source	Yes	66(35.7)	73(37.4)	139(36.6)	99(53.5)	102(53.1)	201(53.3)
	No	59(31.9)	87(44.6)	146(38.4)	58(31.4)	33(17.2)	91(24.1)
	Don't Know	60(32.4)	35(17.9)	95(25.0)	28(15.1)	57(29.7)	85(22.5)
Do you know about	Yes	75(39.3)	84(43.5)	159(41.4)	152(79.6)	80(41.5)	232(60.4))

composting							
	No	82(42.9)	56(29.0)	138(35.9)	24(12.6)	48(24.9)	72(18.8)
	Don't Know	34(17.8)	53(27.5)	87(22.7)	15(7.9)	65(33.7)	80(20.8)
Do you think compost is highly beneficial to plants	Yes	103(55.7)	107(55.2)	210(55.4)	132(71.4)	106(55.2)	238(63.1)
	No	7(3.8)	22(11.3)	29(7.7)	47(25.4)	46(24.0)	93(24.7)
	Don't Know	75(40.5)	65(33.5)	140(36.9)	6(3.2)	40(20.8)	46(12.2)
Do you think proper solid waste management can affect health	Yes	108(57.4)	104(54.5)	212(55.9)	139(77.2)	111(58.1)	220(75.6)
	No	42(22.3)	54(28.3)	96(24.3)	27(15.0)	60(31.4)	51((17.5)
	Don't Know	38(20.2)	33(17.3)	71(18.7)	14(7.8)	20(10.5)	20(6.9)

Table 4.13: Mean Knowledge Scores of Respondents in Study Schools

Parameter	Options	ISI N=196	WCI N=196
Knowledge	Pre-Intervention mean Score	3.48±1.69	3.84±1.68
	Post-Intervention Mean Score	5.49±1.63	4.12±1.84
	P value	<0.05	>0.05

Table 4.14: Attitude of Respondents towards Organic Waste Recycling after Intervention in Study Schools

Characteristics	Variable	Baseline			Post-intervention		
		ISI (%)	WCI (%)	Total(%)	ISI (%)	WCI(%)	Total(%)
Solid waste recycling is necessary in the school community.	Agree	48(25.3)	56(29.2)	105(27.2)	149(76.4)	105(54.7)	254(65.6)
	Indifferent	60(30.9)	26(13.5)	86(22.3)	22(11.3)	27(14.1)	49(12.7)
	Disagree	85(43.8)	110(57.3)	195(50.5)	24(12.2)	60(31.3)	84(21.7)
Training of students on how to recycle solid waste is necessary in schools.	Agree	21(10.8)	33(17.1)	54(14.0)	134(69.8)	76(39.0)	210(54.3)
	Indifferent	43(22.2)	68(35.2)	111(28.7)	23(11.8)	30(15.6)	53(13.7)
	Disagree	130(67.0)	92(47.7)	222(57.4)	96(49.2)	28(14.6)	124(32.0)
Waste management enhances good health of the students and beauty of the school environment.	Agree	168(87.0)	139(72.4)	307(79.7)	160(82.5)	147(76.6)	307(79.5)
	Indifferent	16(8.3)	19(9.9)	35(9.1)	19(9.8)	20(10.4)	39(10.1)
	Disagree	9(4.7)	34(17.7)	43(11.2)	15(7.7)	25(13.0)	40(10.4)
The school authorities alone should be held responsible for managing waste generated in the school.	Agree	39(20.3)	48(24.9)	87(22.6)	21(11.0)	59(30.7)	80(20.9)
	Indifferent	50(26.0)	30(15.5)	80(20.8)	30(15.7)	41(21.4)	71(18.5)
	Disagree	103(53.6)	115(59.8)	218(56.6)	140(73.3)	92(47.9)	232(60.6)

Every students should be involved in the recycling of waste in the school	Agree	84(43.8)	92(48.2)	176(46.0)	124(64.2)	100(52.6)	224(58.5)
	Indifferent	60(31.3)	39(20.4)	49(25.8)	35(18.1)	40(21.1)	75(19.6)
	Disagree	48(25.0)	60(31.4)	108(28.2)	34(17.8)	50(26.3)	84(21.9)
Individual seperation of waste is necessary for proper management of waste.	Agree	92(48.2)	107(56.0)	199(52.1)	94(48.7)	109(57.4)	203(53.0)
	Indifferent	71(37.2)	48(25.1)	119(31.2)	72(37.3)	46(24.2)	118(30.8)
	Disagree	28(14.7)	36(18.8)	64(16.8)	27(14.0)	35(18.4)	62(16.2)
Seperation of waste into various components in the school setting is simply a great disturbance.	Agree	54(28.3)	66(34.6)	120(31.4)	26(13.4)	67(35.1)	93(24.2)
	Indifferent	87(45.5)	53(27.7)	140(36.6)	44(22.7)	66(34.6)	110(28.6)
	Disagree	50(26.2)	72(37.7)	122(31.9)	124(63.9)	58(30.4)	182(47.3)
Composting of organic waste will constitute nuisance to the school.	Agree	67(34.7)	70(36.5)	137(35.6)	40(20.7)	71(37.2)	111(28.9)
	Indifferent	58(30.1)	41(21.4)	99(25.7)	52(26.9)	36(18.8)	88(22.9)
	Disagree	68(35.2)	81(42.2)	149(38.7)	101(52.3)	84(44.0)	185(48.2)

Table 4.15: Effect of Environmental Training and Utilization of Bin for Composting in Study Schools

Variable	Options	ISI (N=196)%	WCI (N=196)%
Do you separate your waste before disposal	Pre-intervention (Yes)	0(0.00)	0(0.00)
	Post-interventon (Yes)	36(18.7)	0(0.00)
Do you practice composting	Pre-intercention(Yes)	0(0.00)	0 (0.00)
	Post-intervention(Yes)	50(26.0)	0(0.00)

4.11.5 Comparison of Knowledge Level of Respondents at Baseline and after the Training and Provision of Compost Bin.

Table 4.16 shows a comparison of knowledge level of students in both schools before and after the training and provison of compost bin. Proportion of students in ISI with poor knowledge on waste recycling and composting reduced from 57.1% to 12.2% while there was little or no decrease in respondents poor knowledge in WCI (42.3% and 46.9%) before and after the intervention.

4.11.6 Comparison of Attitude Level of Respondents at Baseline and after Intervention

Table 4.17 shows a comparison of the attitude level of students in ISI and WCI before and after the intervention. This shows that respondents in ISI with negative attitude reduced from 31.3% to 11.7% after the intervention while those with positive attitude increased from 68.7% to 88.7%. In WCI, there was a slight decrease in number of students with negative attitude (39.5 to 24.9%).

4.11.7 Effect of Intervention on Knowledge and Attitude Level after Intervention

Table 4.18 shows the relationship between knowledge and attitude level of all the respondents in both schools after intervention. The results show that few students (26) with poor knowledge also had negative attitude towards waste recycling while the least number of students (22) had excellent knowledge on waste recycling and negative attitude towards waste recycling. Interestingly, majority of the students (138) who had excellent knowledge on organic waste recycling (composting) also had positive attitude towards it.

4.12 Effect of Organic Waste Recycling on Quantity of Organic Waste

Table 4.19 shows the quantity of organic wastes generated at baseline and after the intervention in both schools. In ISI, 156.9kg of organic waste was generated at baseline. However, after the intervention period 45.2kg of organic manure (compost) was produced from the recycling of the organic waste. In WCI, 56.3 kg of organic waste was generated at baseline while 51.2kg was realised after the intervention. There was significant reduction in quantity of organic waste in ISI (from 156.9kg to 45.2kg) before and after the intervention following the recycling process (composting) while there was little or no reduction in the quantity of organic waste in WCI (from 56.3 kg to 51.2kg) before and after intervention since no composting was adopted or practiced.

Table 4.16: Knowledge Level of Respondents after Intervention in Study Schools

	Baseline			Post intervention		
Category	ISI (%)	WCI (%)	Total (%)	ISI (%)	WCI (%)	Total (%)
Poor	112(57.1)	92(46.9)	204(52.0)	24(12.2)	83(42.3)	107(27.3)
Good	54(27.6)	75(38.3)	129(32.9)	61(31.1)	64(32.7)	125(31.9)
Excellent	30(15.3)	29(14.8)	59(15.1)	111(56.6)	49(25.0)	160(40.8)
Mean ± S.D Knowledge Score	3.48±1.69	3.84±1.68	3.56±1.68	5.49±1.63	4.12±1.84	4.81±1.87
Chi-square test	X^2 =5.396, df= 2, p= 0.067			X^2 = 56.630, df= 2, p<0.001		

Table 4.17: Attitude Level of Respondents at Baseline and Post Intervention in Study Schools.

	Baseline			Post intervention		
Attitude Level	ISI (%)	WCI (%)	Total (%)	ISI (%)	WCI (%)	Total (%)
Negative	61(31.3)	77(39.5)	139(35.6)	23(11.7)	48(24.9)	71(18.3)
Positive	134(68.7)	118(60.5)	251(64.4)	173(88.3)	145(75.1)	318(81.7)

$X^2 = 0.996$, df = 2, p = 0.608 $X^2 = 17.529$, df = 2, p<0.001

Table 4.18: Relationship between Knowledge and Attitude Level of Respondents after Intervention.

Knowledge level	Attitude level		Total
	Negative	Positive	
Poor	26	78	104
Good	23	102	125
Excellent	22	138	160
Total	71	318	389

X^2= 6.036, df= 2, p= 0.04

Table 4.19: Effect of Composting on the Quantity of Organic Waste in Study Schools after Intervention

	Quantity of Organic Waste (kg)		
School	Baseline	Post Intervention	P - Value
ISI	156.90	45.20	> 0.05
WCI	56.30	51.20	< 0.05

CHAPTER FIVE

5.0 DISCUSSION

In this section, the implications of the socio-demographic characteristics of the population under study, quantity and composition of solid wastes generated in the two schools as well as the physico-chemical characteristics of the solid wastes generated and the compost produced from the recycling of organic waste are presented. In addition, baseline data on solid waste composition and generation in the study schools, solid waste management practices and the problems associated with such practices in the study schools and the effect of training and provision of a two compartment compost bin for recycling of organic waste generated in ISI is also discussed.

5.1 Socio-Demographic Characteristics of Students in the Study Schools.

The result of the survey had shown that in both schools, majority of the students were within 14 and 16 years of age. This could be due to the fact that students selected for the study were mostly in the senior secondary section and most of them are within 14 and 16 age bracket.

5.2 Waste Management Practices across the Study Schools

Majority of the students utilized the school waste bin for waste disposal in both schools. However, direct observations using the checklist indicated that although plastic waste bins were provided for disposal, wastes such as paper, nylon, left over snacks, sweet wrappers etc were found littering the floor of classrooms. This conforms with the observations of the Central Pollution Control Board (CPCB) (2000) that problems associated with solid waste disposal are numerous and included littering of food and other solid wastes in the school compound. Generally, wastes generated across the two schools were dumped in an open dumpsite which had a central bin that was inadequate and overflowing with waste littered indiscriminately on the floor. The bins were however evacuated by external contractors licensed by the school while waste in WCI was burnt openly. This is in conformity with the findings of Akpovi and Sridhar (1985), UNICEF/FOS (1997) which stated that ineffective solid waste collection results in open dumping as seen in ISI.

5.3 Problems associated with Solid Waste Management Practices

5.3.1 Environmental Problems

The environmental problems associated with solid waste management practices across the two schools which included odour, vector breeding, scavengers and unsightliness conformed with the findings of Cambell (1993) which listed odour, vector breeding, littering and vermin as problems associated with decomposing refuse. This is also in agreement with the report of Medecins Sans Frontieres (1994) which indicated that decomposing organic wastes attracts animals, vermin and flies and that flies played a major role in the transmission of faeco-oral diseases particularly where wastes contains faeces. Mwanthi, Nyabola and Tenambergen in 1997 also stated that from the public and environmental health points of view, improper solid waste management can pollute the environment (water courses, air, and land) and provide niches for disease vectors such as mosquitoes, rodents, houseflies, and cockroaches.

5.3.2 Health Problems

The major health problems associated with solid waste management practices across the two schools were malaria, typhoid fever, diarrohea, yellow fever etc with malaria being the most prevalent of all the health problems. This finding is in agreement with the studies of Medecins Sans Frontieres (1994) which indicated that solid wastes provide breeding sites for mosquitoes such as the Aedes genus which lay eggs in water stored in discarded items such as tins and containers which are responsible for the spread of dengue and yellow fever. He however, further stated that such conditions may also attract mosquitoes of the Anopheles genus which transmitts malaria. Yhdego and Majura (1998) also reported that poor sanitation and improper waste disposal practices resulted in the spread of infectious diseases, which are the most frequent causes of morbidity and mortality. Stephens and Harpham in 1992 also attributed the prevalence of parasites, tetanus, malaria, hookworm, cholera and diarrohea in most African cities to the unsanitary conditions in these cities. Songsore and McGranahan (1993) thereafter stated malaria, diarrohea, intestinal worms and upper respiratory tract infections as the most common health problems reported in out-patient facilities in the Greater Accra Region of Ghana. In 2008, Ksunon stated that the waste generated in Nigeria as well as in other countries that do not have proper disposal means create unsanitary living conditions and detrimental health concerns, such as diarrhoea and malnutrition, in addition to a range of sicknesses and diseases

5.4 Physical Characteristics of Solid Wastes

5.4.1 Solid Waste Composition

In order to develop an effective waste management strategy for a given region, it is important to know the amount of waste generated and the composition of the waste stream. Past research has shown that the amount of waste generated is proportional to the population and the average mean living standards or the average income of the people. In addition, other factors may affect the amount and composition of waste. These are climate, living habits, level of education, religious and cultural beliefs and social and public attitudes (Bandara et al, 2007).

Components of solid waste generated across the two schools were; paper, nylon /plastics, organic wastes, glass and metals which were in agreement with the findings of Wahab (2003) which also found the composition of wastes found in schools to include the following Paper, grass, nylon (pure water bags), biscuits, lolly, ice-cream and sweet wrappers, sugar cane, maize cobs and groundnut shell. These components also varied in quantity which is in agreement with the findings of Wahab (2003) which stated that common types of solid wastes found in various schools in developing countries vary in type and in quantity. However, organic waste was the most generated of all the solid waste components in the two schools. This may be due to the fact that both schools were boarding schools where a lot of food wastes are generated in the school cafeteria. The composition of wastes in the schools conformed with the findings of Ifegbesan (2010) in which composition of wastes generated in schools recorded an unexpectedly large percentage (62%) of biodegradeables consisting of food remains, fruits, vegetables etc. with less paper waste. This composition makes recycling; composting and sanitary landfills to be viable waste management options in the school community.

5.4.2 Solid Waste Generation

There was a significant difference in the various components of solid waste generated except that glass was not generated at all in WCI during the survey period while a negligible quantity was generated in ISI. The higher quantity of food waste generated in ISI as compared to WCI was due to the hogging activities that take place in WCI as compared to ISI. As such. less quantity of food waste is been disposed of in WCI. However, in ISI, paper was found to be the most generated after food waste while in WCI nylon/plastics though closely followed by paper was most generated after food waste. This may be attributed to higher disposal of nylon/plastic products such as biscuit wrappers, sweet wrappers, pure water nylon, drink containers etc as compared with paper during the period of the survey in WCI. In ISI, the high volume of metals/cans found as compared to WCI could be attributed to the high consumption of canned products such as drink cans, bottle covers, body spray cans, cutleries such as spoons, air freshner containers, mathematical instruments etc.

The generation rates obtained from the study revealed that there was a significant difference across the two schools. The estimated mean daily solid waste generation rate was low in the two schools although it was higher in ISI. This could be attributed to the higher volume of organic waste and paper generated in ISI.

5.5 Chemical Characteristics of Solid Waste

Information on the chemical composition of solid wastes is important in evaluating alternative processing and recovery options (Tchobanoglous et al, 1993). Barnmeke and Sridhar in 1998 also stated that chemical characteristics of solid waste include organic and inorganic components which is essential for predicting their application for composting or conversion into methane and ethanol. Tchobanoglous et al, (1993) also stated the primary nutrients required by microorganism for growth as carbon (C), nitrogen (N), phosphorus (P) and pottasium (K) where C and N play a vital role in the composting process. The ultimate analysis of waste typically involves the determination of the percent C (carbon), H (hydrogen), O (oxygen), N (nitrogen), S (sulphur) and P (pottasium) (Pecsok et al 1976). The results of the ultimate analysis are used to characterise the chemical composition of the organic matter in MSW. They are also used to define the proper mix of waste materials to achieve suitable C/N ratios for biological conversion processes.

Chemical analysis of wastes conducted in this study shows that the organic waste generated in ISI was suitable for composting because of the high content of organic carbon and nitrogen with a C:N ratio of 25.8:1 respectively which conforms with the acceptable standards of 25.5:1-30.1:1 which is the ideal C:N ratio for starting material on dry weight basis. Therefore, no animal waste was required for the composting process. This is because, nitrogen given off at lower ratio (i.e high value of nitrogen) impedes biological activity. However, the C:N ratio obtained from the analysis of organic waste generated in WCI was lower than the acceptable standard.

The result of the chemical analysis of compost produced in ISI revealed that the chemical constituents of the compost were within the guideline limits. The C:N ratio of the finished compost (12.6:1) conforms with the guideline limits of <17:1 for C:N ratio of finished compost given by the California Department of Resources Recycling and Recovery (2004). Total organic matter present in the finished compost was also within standard limits of finished compost.

5.5.1 Heavy Metal Constituents of Organic Waste Generated in Study Schools and Finished Compost after Intervention.

Heavy metal constituents of organic waste generated in both schools are discussed in this section. The data from the laboratory analysis showed that organic wastes generated in ISI and WCI contained; zinc, lead, chromium, cadmium, copper, arsenic and nickel which were all lower than the guideline limits given by the Ontario Ministry of Environment (1989). Barker and Bryson (2002) reported that, hazardous organic and metallic residues or by-products can enter into plants, soils and sediments from processes associated with domestic, municipal, agricultural, industrial and military activities. Handling, ingestion, application on land or other distributions of the contaminated materials in the environment might cause harm to humans, livestock, wildlife, crops, or native plants. The concentrations of the heavy metals which are of public health importance such as lead, cadmium, nickel and chromium in the organic wastes generated in the two schools were all within guideline limits as such they do not seem to pose any threats to human health.

Heavy metal constituents of compost produced in ISI were all within the Ontario guideline limits. A comparison of the heavy metal constituents of the parent organic waste and that of the compost produced after the intervention showed that there was a reduction in the heavy metal content after the composting process. Ogunbanwo (2001), stated that lower values of heavy metals obtained could be further reduced by composting. He further emphasized that, other studies have shown reduction in heavy metal levels during composting. Peter (1992) indicated that, although the exact mechanisms of these reductions are not known, it has been attributed to binding of the metal ions to the organic molecules thereby reducing their solubility and their pollution potentials. However, the low content of heavy metal in the compost could be attributed to the fact that the parent organic material was source seperated prior to composting. This conforms with the findings of the study conducted by Kraus and Grammel (1992) in which composts from several regions were paired into either non-source seperated solid waste based compost and source-seperated compost and found out that source-seperated compost contained a quarter of heavy metals contained in non-source seperated solid waste compost.

5.6 The Composting Process and Conditions in ISI

Variations in environmental conditions such as pH, temperature and moisture content observed during the composting process in ISI are presented in this section. The pH of organic waste from the onset of the composting process was 6 which tallies with the pH range of 6 - 8 at the onset of composting process indicated by USEPA (1995a). On the 15th day, the pH increased to 7.8 while the finished compost was 7.1. At the initial stage of decompostion, the temperature of the organic waste was 34°C which corresponded with the findings of Eberle in 1997 which states that the mesophilic organisms (bacteria) that survive temperature ranges from 50°F (10°C) to 113° (45°C) break down soluble and easily degraded compounds during the initial decomposition of organic waste. This however increased gradually to 57°C on the 15th day of the composting process and the final temperature on the 30th day of the process was 39°C. The decrease in the temperature as the day progresses was due to the gradual decrease in the metabolic activities of the microbes in the compost pile. The composting guide for Michigan communities by Michigan DNR (1988) stated that as the temperature of compost pile approaches 140°F, the rate of decomposition begins to decline rapidly as organisms begin to die off or assume dormant forms. Moisture content at the onset of the process was 61% and this gradually reduced to 48% on the 15th day of the process and finally to 54% on the 30th day. This could be due to the reduction in the metabolic activities in the compost heap as a result of the death of most of the microbes.

5.7 Effects of Environmental Training and Provision of Compost Bin on Knowledge

The results of the baseline survey showed that, the proportion of students with good knowledge of organic waste recycling (composting) was low. This conforms with the findings of Grodzinska-Jurczak et-al (2003) which indicated the level of knowledge among people regarding municipal waste and waste management appeared to be low and incomplete. However, Manzanal et al., (1999) pointed out that an understanding of the concepts and issues would help make the desired change in behaviour and attitude towards the environment. Hence this creates the opportunity to train people to contribute to the care of the environment. Pooley and O'Connor (2000) also stated that a proper knowledge base is important because citizens are given factual information and resources to be used to make responsible decisions with regard to the environment. Some environmental educators however believe that environmental literacy has to go beyond a knowledge base (Weber et al, 2000). Sia (1984) stated that the more skillful and knowledgeable of action strategies an individual is, the more likely he or she will behave in an environmentally responsible manner. After the intervention, there was significant increase in the knowledge of students in ISI as compared with those of students in WCI. This implies that the training was effective and it facilitated an increase in knowledge on organic waste recycling as well as the proper use of the compost bin provided for organic recycling in ISI. This outcome is supported by that of Grodzinska-Jurczak et-al (2003) which substantiated that environmental education had a positive and significant impact on environmental knowledge.

5.8 Effect of Environmental Training and Provision of Compost Bin on Attitude

The result of the survey shows that there was significant difference between the attitude of students towards organic waste recycling at baseline and after the intervention in ISI while there was no such difference in the attitude of students at baseline and after intervention in WCI. This is in agreement with the findings of Weber et al, (2000) which indicated that the development of knowledge includes the development of an individual's values and attitude-helping an individual realize his or her personal values and attitude toward environmental issues. Furthermore, the study of Ehrampoush & Moghadam in 2005 along with others indicated that programs to improve students environmental awareness can increase their knowledge of them, which in turn results in improvement of students and parents' attitudes and behaviour. Similarly, Armstrong & Impara (1991) found that positive attitudes followed exposure to a K-7 environmental education publication on knowledge and attitudes about the environment.

5.9 Relationship between Knowledge Level and Attitude Level of Students in the Study Schools

Crosstabulation of the knowledge level and attitude level of students before and after intervention in the two schools showed that there was a significant increase in knowledge and attitude level of students in ISI after the training while there was no such increase in WCI. It is assumed that increased knowledge about the environment promotes positive attitudes. This corresponds with the results of the findings of a study on the effectiveness of a visitor education strategy in raising levels of knowledge and attitudes toward nature conservation by Olson et al., 1984. They found a positive relationship between scores on the knowledge test and scores on the attitude test for all concepts measured. This was successful in raising both the levels of knowledge and improving attitudes towards environmental management. The increased knowledge and attitude in ISI confirms the relationship between knowledge and attitude as corroborated by Kallegren and Wood (1986). In their study, knowledge was seen as a key variable affecting levels of environmental action including attitude. Abd El Salam et al., 2009 in their study conducted on environmental education and its effect on the knowledge and attitudes of preparatory school students in Egypt, attitude was found to be positively correlated to their level of knowledge prior to and following the Environmental education sessions.

5.10 Effect of Environmental Training and Provision of Compost Bin on Practice

The results of the survey revealed that the effect of the training on the practice of organic waste recycling was significant in ISI. At baseline, none of the students practiced organic waste recycling as shown in the result section. At post-intervention, the proportion increased as all the participants involved in the study reported continued use of the compost bin after the intervention while in WCI, none of the students practiced organic waste recycling.

5.11 Effect of Organic Waste Recycling on Quantity of Organic Waste in ISI

The result of the physical characteristics of the waste generated in both schools showing the quantity of organic waste at baseline and after the intervention indicated that the quantity of organic waste in ISI reduced remarkably in contrast to the level of reduction recorded at WCI. This was due to recycling (composting) of the organic fraction of the waste generated in ISI. Composting has thus been established as a method of waste reduction in the school.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The following conclusions were made from the findings on the nature and characteristics of wastes generated in the study schools, current solid waste management practices, knowledge, attitude and practice of students towards organic waste recycling and finally the effect of the intervention i.e training and the provision of compost bin for recycling of organic wastes on wastes generated.

- A substantial amount of organic waste was generated in the schools hence justifying the need for introducing recycling of organic wastes in schools.
- The organic wastes generated in the two schools had good recycling potentials and are thus a viable source of raw material for composting.
- The current waste management practices in the schools were not effective especially in terms of adequacy of receptacles for collection.
- Although knowledge of students on organic waste recycling was low in both schools, their attitude was moderate at baseline.
- There was a significant reduction in the quantity of organic wastes generated due to the recycling of the organic wastes.
- The compost produced from the recycling of organic waste was rich in nutrients (NPK) in quantities that exceeded the Ontario compost guideline limits hence serving as a good source of organic manure/fertilizer for soil conditioning, potting mixture for school gardening or for soil amendment in school farms.
- The concentrations of heavy metals in the organic wastes and compost were low and within the guideline limits.
- The training and provision of the compost bin was effective as it increased the knowledge and practice of students towards organic waste recycling. it also reduced the quantity of organic waste remarkably.

6.2 Recommendations

In furtherance to the above conclusions made, the following recommendations are proffered:

- An organic waste recycling scheme (composting) should be established in schools.
- Provision of two or more types of plastic storage bins to seperate storage of solid wastes in order to facilitate recycling process is required.
- Integration of environmental education into the secondary school curricula should be promoted.
- Establish sustainable waste management schemes and assess their effectiveness in reducing debilitating effects of poor waste management practices in schools.
- Measures aimed at reducing health risks associated with poor environmental sanitation such as malaria, typhoid fever etc by regular clearing of bushes and regular disposal of wastes in schools should be encouraged.
- Define and implement measures to reduce indiscriminate dumping of refuse in schools (e.g through provision of collection bins in classrooms and strategic areas within the school such as playgrounds, cafeteria, library, hostels etc).
- Strengthen compliance with the environmental rules and regulations (e.g concerning sanitary disposal of wastes) through increased inspection and enforcement in schools.
- Workshops should be organized by school authorities for students and staffs on organic waste recycling in schools.
- Revenue can be generated for schools through the sale of the finished product (compost).

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APPENDIX I

QUESTIONNAIRE ON EFFECT OF TRAINING ON WASTE RECYCLING AND USE OF COMPOST BIN ON WASTE MANAGEMENT PRACTICES IN TWO SECONDARY SCHOOLS IN IBADAN, NIGERIA.

Dear Respondent,

I am a Postgraduate student of the Department of Epidemiology, Medical Statistics and Environmental Health (EMSEH), College of Medicine, University of Ibadan presently carrying out a research which focuses on effect of training on solid waste recycling practices among selected boarding secondary schools . I wish to kindly request your voluntary participation by providing appropriate responses to the following questions as this would increase the quality of the findings. Please, be rest assured that the information provided by you would be used for research purposes only and strict confidentiality would be ensured.

Thanks for your anticipated cooperation.

Okin, A.O

Location................................ Serial No ....

INSTRUCTION: PLEASE TICK OR PROVIDE THE CORRECT RESPONSES ACCORDINGLY

Section A: SOCIO-DEMOGRAPHIC CHARACTERISTICS

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

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

(3) **Religion** : (1) Christianity (2) Islam (3) Traditional (4) others

(4) **Ethnic group:**

(1)Yoruba (2) Igbo (3) Hausa (4) Others

(5) Class: (1) SSS1 (2) SSS2 (3) SSS3

SECTION B: KNOWLEDGE ABOUT SOLID WASTE MANAGEMENT AND RECYCLING IN SCHOOL

(6) Which of these wastes do you generate/handle most often in your school?

(1) Food waste (2) Papers (3) Nylon and Plastics (4) Glass

(5) Metals (6) Old furniture/wood

(7) Do you know any form of solid waste managment? (1) Yes (2) No (3) Not sure

(8) If "Yes" What form of solid waste management method do you know?

(1) Recycling (2)Reuse (3) Landfilling (4) Incineratioo (5) Open burning

(6) Composting

(9) Do you know how the solid waste in your school is being managed?

(1) Yes (2) No (3) Not sure

(10) If "Yes",what solid waste management method does your school employ?

(1) Recycling (2) Reuse (3) Landfilling (4) Incineration

(5) Open burning (6) Composting

(11) Do you think waste can be converted into useful materials?

(1) Yes (2) No (3) Not sure

(12) Do you know waste can be recycled (1) Yes (2) No (3) Not sure

(13) If "Yes", what form of waste recycling do you know?

(1) Plastic recycling (2) Paper recycling (3) Organic waste recycling

(4)All of the above

(14) Do you think recycling can help manage solid waste Properly?(1)Yes (2) No (3) Not sure

(15) Do you know if solid waste can be separated at source (1) Yes (2) No (3) Not sure

(16) Do you know about composting? (1) Yes (2)No (3)Not sure

(17) If "Yes" what form of composting do you know ?

(1) Pit method (2)Windrows method (3) Bin method (4) In vessel method

(18) Do you think compost is highly beneficial to plants? (1) Yes (2) No (3)Not sure

(19) Do you think proper solid waste management can affect health?

(1) Yes (2) No (3) Not sure

SECTION C: ATTITUDE TOWARDS SOLID WASTE MANAGEMENT IN SCHOOL

Instruction: Please Tick the word that best suites your option for each statement.

A-Agree (1) I- Indifferent (2) D- Disagree (3)

S/No	Question	A	I	D
20	Solid waste recycling is necessary in the School Community.			
21	Training of students on how to recycle solid waste is necessary in Schools.			
22	Waste management enhances good health of the students and beauty of the School environment.			
23	The School Authorities alone should be held responsible for managing waste generated in the School.			
24	Every student should be involved in the recycling of organic waste in the school.			
25	Individual seperation of waste is necessary for proper management of waste.			
26	Seperation of waste into various components in the school setting is simply a great disturbance.			
27	Composting of organic waste will constitute nuisance to the school.			
28	Composting is a good method of resource recovery.			
29	Compost is generated from practice of organic waste recycling.			
30	Composting will reduce the bulk of waste being disposed from the school.			

SECTION D: SOLID WASTE MANAGEMENT PRACTICE IN THE SCHOOL.

(31) What waste disposal methods do you employ in your school?

(1) Bush dumping (2) Open dumping (3) Pit dumping (4) School waste bin

(32) Do you separate your solid waste into biodgradable and non biodegradable fractions?

(1) Yes (2) No

(33) If "yes" what do you do with the biodegradable fractions of waste obtained?

(1) Dispose (2) Recycle (3) process (4) Nothing

(34) what do you do with the non-biodegradable fraction?

(1) Sell (2) Reuse (3) Nothing (4)None of the above

Does anyone come around to collect waste generated in your school?

(1) Yes (2) No

(36) Is waste recycling practiced in your school?

(1) Yes (2) No (3) Not sure

(37) Is composting practiced in your school?

(1) Yes (2) No (3) Not sure

(38) Would recycling of organic waste enhance proper management of solid waste in your school (1)Yes (2) No (3) Not sure

(39) Does each classroom have a dustbin in your school? (1)Yes (2) No

(40) If "No" how many classrooms share one dustbin?

(1) One (2) More than one (3) Not sure

(41) How often do you empty the waste bin in your cl ssroom?

(1) Once a day (2) Twice a day (3) Every two days (4) Once a week (5) Once in two weeks

(42) What do you use to collect your waste in the classroom?

(1) Basket (2) Nylon (3) Carton (4) Metal with lid (5) Plastic Bin

(43) What is the size of your bin? (1) Small (2) Medium (3) Large

(44) When does the school bin get filled up? (1) Dail (2) Every 2 days (3) More than 2 days (4) Weekly

(45) How often is the school bin emptied?

(1) Daily (2) Every 2 days (3) Beyond 2 days (4) Weekly (5) Not sure

SECTION E: PROBLEMS OF CURRENT SOLID WASTE MANAGEMENT OPTIONS

(46) Does the waste generated in your school constitute a nuisance to you?

(1) Yes (2) No

(47) In what way does it constitute a nuisance?

(1) Odour (2) Flies (3) Scavangers (4)Unsightliness (5) Leachate

(48) Does the waste generated in your school block the drainage in your environment?

(1) Yes (2) No

(49) Does the waste generated in your school attract vectors ?

(1) Yes (2) No

(50) If 'Yes' which of the following vectors does it attract?

(1) Rats (5) All of the above

(2) Mosquito

(3) Flies

(4) Cockroach

(51) Is the present waste disposal practice in your school effective?

(1) Yes (2) No (3) Not sure

(52) What are the commonest environmental problems caused by the waste generated in your school?

	Yes	No
Prevent Free Flow of Surface Water In Drains		
Odour		
Flies Breeding		
Filthy Land		

(53) Which of the following health problems do you think is associated with the present waste management, please tick all that apply

	TRUE	FALSE
MALARIA		
CHOLERA		
TYPHOID		
YELLOW FEVER		
DIARRHOEA		
DOG BITE		

APPENDIX II

OBSERVATION CHECKLIST

Indicators Observed	ISI	WCI
	Ranking	
Disposal of Solid Wastes by Students		
Adequacy of Solid Waste Disposal Receptacles		
Frequency of Collection of Wastes		
Cleanliness and Maintainance of the Environment		
State of Dumpsite		
Presence of Scavengers at School Dumpsite		
Presence of Vectors at School Dumpsite		
Types of Solid Waste Receptacles Drums Bins Metal Containers		
Sanitary Condition of Receptacles Covered Exposed Overflowing		
Waste Disposal Practices Use of Bin Recycling Open Dumping Open Burning		

Frequency of Waste Collection Daily Once a Week Twice a Week		
State of Surroundings		
Location of Receptacles		
Location Capable of causing Hazard to Students		
Use of External/Licensed Waste Collection Services		

APPENDIX III

Evaluation Questions

Answer all questions, choose only one option

1. Solid waste could be defined as..............

   (a)Anything that has weight

   (b)Anything that occupies space

   (c)Anything order than liquid and gas that is no longer needed for use and thrown away

   (d)Anything that can be used to build houses

2. Solid waste can be classified into the following except..............

   (a)Biodegradable and non-biodegradable

   (b)Renewable and non-renewable

   (c)Reusable and non-reusable

   (d)Retriveable and non- retriveable

3. Which of the following is not a source of solid waste?

   (a)Industrial waste

   (b)Domestic waste

   (c)Airborne waste

   (d)Municipal waste

4. Which of the following is the reason for disposing solid waste?

   (a)So as to make money

   (b)So as to have enough land to cultivate

   (c)In order to prevent adverse effects on the health of man

   (d)So as to breed enough vectors

4. Wate sorting promotes ....

   (a) Introduction of indigenous materials in waste recycling

   (b) Removal of retrivable meterials

   (c) Removal of all designated recyclable materials from the waste stream

   (d) Unclean marketable materials and encourages high levels of contamination

5. Which of the following is an effect of improper disposal of solid wastes?

(a)Cholera

(b)Diabetes

(c)Pneumonia

(d)Albinism

6. Waste recycling could be defined as..............

(a)Turning waste into cycles

(b)Turning waste into liquid

(c)Using waste to construct roads

(d)Separation,collection and transformation or remanufacture into usable or marketable products

7. Which of the following is a method of waste recycling?

(a)Open burning

(b)Incineration

(c)Composting

(d)Land filling

8. The following types of solid waste can be recycled except?

(a)Grass trimmings

(b)Paper

(c)Metals

(d)Stone

9. Composting is defined as ....

(a) Composting is a natural biological process, carried out under controlled aerobic conditions to produce a dark, brown, and crumbly material with an earthy odor

(b) Composting is a chemical process of replicating waste for planting

(c) Composting is a process of seperating waste

(d) Composting is a biological process of activating solid waste

10. The following organisms are involved in the process of composting except?

(a) Millipedes

(b) Earthworm

(c) Bacteria

(d)Mosquito

12. .... and .... are approaches to composting?

(a)Active and passive

(b)Turning and stirring

(c)Cultivation and motivation

(d)Mulching and tilling

13. All of these materials are compostable except?

(a) Bones

(b) Tea bags

(c) Grass

(d) Fruits

14. .... is a method of composting?

(a)Shelf composting

(b)Wood/plank composting

(c)Windrow/Bin composting

(d)Farm composting

15. Compost can be used for...............

(a)Disinfection

(b) Gardening

(c)Harvesting

(d)Crumbling

16. Unpleasant odour in composting can be due to...............

(a) Inadequate air due to overwatering

(b) Inadequate water

(c) Insects activity

(d) Metabolism of humus

17. .... can be added when compost pile heats exceeds 160°F

(a) Carbon materials

(b) More organic materials

(c) Water

(d) Lime

18. The following are macro organisms found in a compost pile except ....

(a) Centipedes

(b) Racoons

(c) Ants

(d) Spiders

19.Microbes in a compost pile use carbon for............ and nitrogen for ....

(a) Protein synthesis and Energy

(b) Energy and Protein synthesis

(c) Mineralisation and Protein synthesis

(d) Protein synthesis and Mineralisation

20. Charcoal should be avoided in a compost pile because ....

(a) It is hard

(b) It contains sulphur oxides

(c) It attracts pests

(d) It is calcerous