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**ASSESSMENT OF COMPOST POTENTIAL OF DOMESTIC
WASTES FROM SELECTED HOUSEHOLDS IN BDPA,
BENIN CITY**

BY

LEMMY-RUSSEL DANIEL

MAT. NUMBER: ENG1604059

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**DEPARTMENT OF CIVIL ENGINEERING
FACULTY OF ENGINEERING
UNIVERSITY OF BENIN, BENIN CITY
EDO STATE.**

DECEMBER, 2022

CERTIFICATION

This is to certify that this project work titled “ASSESSMENT OF COMPOST POTENTIAL OF DOMESTIC WASTES FROM SELECTED HOUSEHOLDS IN BDPA, BENIN CITY” was carried out by **Lemmy-Russel, Daniel** with matriculation number - ENG1604059 of the Department of Civil Engineering, Faculty of Engineering, University of Benin, Edo State, Nigeria.

PROJECT COORDINATOR:

Name: Engr. E.E Oria-Usifo

Signature and Date.....

PROJECT SUPERVISOR:

Name: Engr. Prince Ogbeifun

Signature and Date.....

HEAD OF DEPARTMENT:

Name: Engr. (Dr) Ngozi Ihimekpen

Signature and Date.....

DEDICATION

This project is dedicated to God almighty for the privilege to embark on the research journey and its successful completion conclude this project work.

ACKNOWLEDGEMENT

My appreciation goes to God for the strength and competence to embark on this project journey.

Appreciation goes to my project supervisor; Engr. Prince Ogbeifun that have contributed to the success of this project.

I want to appreciate the Head of Department, Engr. (Dr.) Solomon Iyeke, the Lecturers and Staff of the Department of Civil Engineering, University of Benin for imparting me academically.

To some of my predecessors – Eucherius, Francis, Precious and Chimezie for their academic support in the accomplishment of this degree (B. Eng in Civil Engineering), may God bless and reward you bountifully and to my friends and well-wishers, thank you all.

I also will not fail to acknowledge my family for their commitment and support during the commencement and completion of my undergraduate program here at the University of Benin. Particular appreciation goes to my mother for all the love and prayers which has guided me throughout my stay at the University of Benin.

ABSTRACT

This research project studied on how organic waste generated domestically can be converted into compost. Organic wastes are wastes which are generated from plants, animals or micro organisms, which can be broken down. The aim of this research project was to produce compost by utilizing domestic wastes collected from selected households in BDPA, Benin City within a duration of 4 weeks by determining the average waste generated from the respective households and how much compost can be generated from the organic wastes, by studying the biology of the composting process and identifying the impacts of composting in the environment.

There are many approaches to studying compost. During this research study, the aerobic composting method was adopted and in so doing, the organic wastes were sorted from the domestic wastes collected from the various households and decomposed using microorganisms that require oxygen. These organic wastes generated consisted of spoiled/perishable foods, bones, vegetables/leaves and woods.

112 The results from this research showed that after four weeks of composting, the total wastes obtained were 30.02kg, 27.56kg, 35.25kg and 31.63kg while the total compost obtained from the respective houses were 8.6kg, 8.8kg, 12.6kg and 8.6kg. These results revealed that the compost generated were about one-third of the total domestic waste collected originally. The percentages of organic waste produced per week were determined to be 63.29%, 68.21%, 72.05% and 69.55%. Domestic wastes could cause problems in the environment if not well managed and utilized for good. 9 Composting is the best low-cost alternative to solve this problem simply because composting can degrade all types of organic wastes, such as fruits, vegetables, herbs, plants, yard wastes and others. The product from the decayed organic waste in the form of compost 9 could be used as nutrients for crops, soil additives and for environmental management. However, factors such as pH of the pile, temperature of the pile, moisture content off the compost pile and concentration of carbon and nitrogen in the organic material and aeration are some of the main parameters which contribute to

the efficiency of the composting process. The study of composting is an important part of the global strategy for the collection, treatment and disposal of domestic waste as it also identifies the benefits of composting and the positive effect it would have in the environment.

TABLE OF CONTENTS

TITLE PAGE	70 i
CERTIFICATION	ii
DEDICATION	iii
ACKNOWLEDGEMENT	iv
ABSTRACT	v
TABLE OF CONTENTS	vii
LIST OF TABLES	ix
LIST OF FIGURES	x
CHAPTER ONE	1
INTRODUCTION	1
1.1 BACKGROUND STUDY	1
1.2 STATEMENT OF PROBLEM	2
1.3 AIM AND OBJECTIVES	3
1.4 SCOPE OF STUDY	4
1.5 JUSTIFICATION OF STUDY	4
CHAPTER TWO	6
LITERATURE REVIEW	5
90 2.1 Introduction	5
2.2 Overview	5
2.3 Methods of Waste Disposal	7
2.4 Classification of Wastes According To Biodegradability	9
2.5 Composting Methods	10
2.6 Major Elements in Compost	12
2.7 Factors Affecting Composting	13

2.8 Environmental Impact of Composting	15
2.9 Review of Works Carried Out On Composting In Nigeria	18
2.10 Formulaes for Calculation	24
2.11 Waste Collection	24
2.11 Waste Sorting	25
2.12 Mixing And Moisture Addition	27
2.13 Aerobic Composting	28
100 CHAPTER THREE	29
METHODOLOGY	29
3.1 Study Area	29
3.2 Description of Composting Procedure	31
CHAPTER FOUR	36
RESULTS AND ANALYSIS	36
4.1 Weight of the Bowls	36
4.2 Results of Composting	38
4.3 Additional Results	48
72 CHAPTER FIVE	50
CONCLUSION AND RECOMMENDATION	50
5.1 Conclusion	50
5.2 Recommendations	51
REFERENCES	52
APPENDICES	56

LIST OF TABLES

Table 4.1: Highlight of Collected Samples for Week 1	36
Table 4.2: Highlight of Collected Samples for Week 2	37
Table 4.3: Highlight of Collected Samples for Week 3	37
Table 4.4: Highlight of Collected Samples for Week 4	38
Table 4.5: Weight before and after Composting (Week 1)	38
61 Table 4.6: Composition of Organic Waste	39
Table 4.7: Table of Compost Formation per Household	40
Table 4.8: Weight before and after Composting (Week 2)	40
61 Table 4.9: Composition of Organic Waste	41
Table 4.10: Table of Compost Formation per Household	41
Table 4.11: Weight before and after Composting (Week 3)	42
63 Table 4.12: Composition of Organic Waste	43
Table 4.13: Rate of Compost Formation per Household	44
Table 4.14: Weight before and after Composting (Week 4)	44
118 Table 4.15: Composition of Organic Waste	45
Table 4.16: Rate of Compost Formation per Household	45
Table 4.17: Weekly Organic Waste produced	48
Table 4.18: Household Weekly Moisture Content	49

LIST OF FIGURES

Figure 2.1 Dumpsite in Asaba (Obasohia, 2022)	19
95 Figure 3.1: Map of Benin City	30
Figure 3.2: Map of BDPA, Benin City showing the study area	31
Figure 3.3: Sample Plastic Litter Bag	32
Figure 3.4: Sample Weighing Machine	32
Figure 3.5: Sample Plastic Bowl	33
Figure 3.6: Sample Nose Mask	33
Figure 4.1 Charts of Organic and Inorganic waste generated for Week 1	46
Figure 4.2 Charts of Organic and Inorganic waste generated for Week 2	46
Figure 4.3 Charts of Organic and Inorganic waste generated for Week 3	47
Figure 4.4 Charts of Organic and Inorganic waste generated for Week 4	47

89 CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND STUDY

In developing countries all over the world, ⁴ solid waste management is the second most important problem after the water quality, Senkoro (2003). Most people don't have access to regular or proper rubbish collection.

According to UNEP, (2002) and Doan, (1998), in less-developed nations, the disposal of solid wastes is a major issue of concern due to population explosion, poverty and high urbanization rates combined with ineffective and under-funding by the government to proffer efficient management of waste. Some factors such as waste composition, technologies and lack of infrastructure have been found to set apart the good management of solid waste in developing nations, Cointreau (1998) and UNESCO (2003).

Waste disposal and collection methods vary from country to country and community to community. Open landfills, which are periodically set on fire, are a common form of disposal in underdeveloped countries like Nigeria. The adverse effect of this action is air pollution as well as leachate production (El-Fadel, 1997).

⁹¹ Composting is the regulated transformation of biodegradable organic wastes and materials into ⁶ useful products with the aid of microbes. Although composting has been around for a while, it still has significant drawbacks that limit how widely it can be used and how effectively it can be utilized. The shortcomings include; pathogen detection, low nutrient status, long duration of composting, long duration of mineralization and odour production (Raymond, 1997).

In agriculture, composting is a vital step that helps with farm waste recycling. The correct management of waste by composting is covered in this review along with various composting techniques, elements that affect composting, long-duration composting, its mechanism, trends in composting now, and predictions for the future. The extraction of mono-fertilizers from

compost, development of strips to test for the availability of heavy metals, pathogens, and odour-trapping techniques can go a long way in enhancing composting procedures (Chang *et al.*, 1996).

Compost's nutritional value may be increased by including activators with the basic materials. The review ¹ recommends that degradable organic material in which composts slowly should be assessed for their ability to mineralize slowly, which could make them beneficial to perennial or biennial crops. Enhancement of composting duration will be useful (Raymond, 1997).

1.2 STATEMENT OF PROBLEM

Domestic wastes are unwanted solid, liquid and gaseous substances which are generated as a result of man's day-to-day activity. The improper management ¹¹⁶ of these domestic wastes are dangerous to human health such as burning of wastes, ocean dumping, open dumping and landfilling. These practices breed insects and pests, emit bad odours, cause disease outbreak, animal and marine death, plant death, ¹⁰³ water pollution, climate change and contribute to global warming.

For this reason, the need for transforming domestic wastes into a useful form using a less harmful method such as compost becomes important, this can either be carried out aerobically or anaerobically. When this transformation is carried out aerobically, compost is produced. This process of transformation is termed composting, it is a safe method of waste management in which the domestic wastes originated from a household are decayed and ¹²⁴ broken down by micro-organisms with the help of oxygen.

⁴ Attaining sustainability in waste management requires an option that uses environmental friendliness. Such a technique must be effective, efficient and less expensive than many alternatives (Sikora, 1998). Due to reasons including poverty, urbanization, and a lack of adequate government financing, ⁴ solid waste management is a huge issue in developing countries all over

the world. Disposal methods such as incinerator, landfill, pyrolysis and gasification are efficient but have negative impacts on the environment as well as threats to public health (Pare, 1998). Composting is a sustainable practice that has a number of advantages, such as the creation of bio-fertilizer, very little air and water pollution, minimal running costs, and revenue-generating.

4 The use of composting for bio-remediation of contaminated soil has gained much ground in many developed countries of the world. If improperly designed, composting could lead to methane production, odour emission and heavy metals build up in the final product (Sikora, 1998).

Therefore, this study examines composting's environmental benefits and various advantages over alternative waste disposal techniques in developing nations. As an organic fertilizer, composting can be a substantial contributor to attaining this objective (Garg, 2012).

By lowering the amount of hazardous substances released into the environment, this change will undoubtedly improve both human and environmental health. There is still a need for a lot more research on the benefits of this technology before farmers can fully embrace it. Concerning the improvement technologies (Williams *et al.*, 1993).

66 1.3 AIM AND OBJECTIVES

The aim of this research is to investigate the amount of waste and compost generated from a home, with a view to determining the possible usage in farm practice.

111 The objectives of the study include:

1. To determine the average waste generated from Nigerian homes over a period of 1 month.
2. To study the biology of the composting process.
3. To study how much manure can be generated from the waste by composting.
4. To study the environmental impact of composting.

1.4 SCOPE OF STUDY

The following are the scope of work for this study:

1. Collection of waste over a period of 4 weeks (1 month).
2. Monitoring and recording the collected waste.
3. Classification of the waste samples according to biodegradability.
4. Determining how much compost can be obtained from the waste.
5. Estimating how much compost could be obtained from every household with the effective application of composting as an effective waste management method.

1.5 JUSTIFICATION OF STUDY

The unsafe practice of improper waste management, which is widespread, can be replaced with improved waste management techniques like composting.

The world tends to improve the environment and human health (Ogwueleka, 2009). As a result of high nutrient content in composts, it is advised that mono nutrients be removed from composts.

When a soil study is done prior to planting, it happens frequently that one nutrient may be deficient. The overapplication of unnecessary nutrients can be avoided by separating mono-fertilizers from compost's compound fertilizer form. In addition, organisms that are capable of degrading complex degradable materials can be made available to farmers as inoculum to speed up composting processes (Sikora, 1998).

Compost's usage in crop production has mostly been driven by its capacity to enhance soil structure and increase nutrient availability by supplementing the nutrients already present. The nutrient focus has usually been on nitrogen, but we have recognized that mineral phosphate available for plant production is a limited resource, and its availability was reported to decline after 2035 (Airan *et al.*, 1980)

In light of this, using the phosphorous in compost and utilising phosphorous more effectively and efficiently ought to be able to, at the very least, greatly prolong the life of our sources of readily available mineral phosphate. Additionally, plant-derived viricides, bactericides, fungicides, and anti-nematode agents can be added to compost to create an effective compost. By avoiding chemical applications, this will support the growth of organic farming. It is advisable to compost slowly degrading materials separately so to shorten the composting period of other materials (Garg, 2012).

LITERATURE REVIEW**2.1 INTRODUCTION**

This chapter reviews on the research works, findings, and recommendations of some researchers as related to the project topic which investigates composting as a sustainable waste management technique. Composting is the microbial degradation of organic solid material by various microorganisms including bacteria, fungi and actinomycetes in the presence of oxygen (Finstain *et al.*, 1975).

Composting is often described as nature's way of recycling (Ladan, 2014). At the simplest level, the process of composting is simply making a heap of wetted organic matter (such as leaves and food waste) and waiting for the material to break into humus after a period of weeks or months (Garg, 2016). Composting is one of the four universally accepted methods of waste disposal and it is a method of converting organic materials into a drier-odoriferous form through bacterial action, primarily to supply humus to the soil (Asomani, 2012).

Composting is now widely used as a waste management method and a way to fertilize the soil for enhanced agricultural production in developing nations because it is a low-tech waste management solution.

2.2 OVERVIEW

Extensive ⁶⁴ research has been carried out globally on the use compost as waste management method ⁸¹ because it is an efficient way to ensure sustainable development and environment preservation.

2.3 METHODS OF WASTE DISPOSAL

Wastes might be composted or disposed of in the usual ways. The garbage disposal options are categorized below and include both traditional and composting approaches.

2.3.1. Refuse Disposal by Open Dump

Wastes are disposed of using this approach in any available location, without regard for where they will end up. Either the street or the highways are suitable places to dump trash. Discouragement should be given to this form of trash disposal. The wastes disposed of by this means are breeding ground for houseflies and rodents, which are vectors of certain diseases (Cholera and Lassa fever). They also cause an offensive odour (Alam *et al.*, 2013).

2.3.2. Refuse Disposal by Animal Feeding

Domesticated animals like goats, dogs, and lambs are fed leftover food as well as garbage like yam peels, cassava peels, leaves, and other organic materials. The food wastes could be infected and lead to infected animals directly feeding on the wastes or humans who feed on them (Zahir, 2005). Human diseases have been traced to the consumption of animals who have been fed with contaminated feeds before (Zahir, 2005).

For instance, trichinosis in humans has been linked to the contamination of raw animal excrement.

2.3.3. Refuse Disposal by River and Ocean Dumping

The water could be toxic to aquatic life and humans (Ogwueleka, 2009). Aquatic life and humans may be poisoned by waste water (Ogwueleka, 2009). Humans may be exposed to toxic waste through ingestion of aquatic animals, which may then be bio-magnified in humans.

Some businesses pour their waste into bodies of water (Zahir, 2005). Regarding garbage disposal, they wish to cut costs. Houses are sometimes constructed on top of bodies of water so that waste

can fall into the water and finally be removed. The water that emanates from this source may include water-borne diseases that could harm people who use the water for various domestic reasons as well as being a source of water that can be used for other purposes in another area. There are water-borne pathogens (Salmonella *et al.*, 2013).

2.3.4. Refuse Dump by Incineration

Combustible wastes are created by burning wastes at high temperatures. The volume of such wastes is reduced by 90 percent by using this technique. From burning materials such as ashes, glass, and metals are disposed of in a sanitary landfill. Using this method, the number of such wastes is reduced by 90 percent (Alam *et al.*, 2013). This method only reduces the size of wastes, but it is not a total method of waste greenhouse disposal. Energy can be produced from incineration (Yang, 2016). This energy is preferable to energy produced from coal. This method could save about 2–2.6 Mt of CO₂ eq per year (Jeswani, 2016).

2.3.5. Refuse Disposal by Deep-Well Injection

Wastes are deposited into the impermeable rock layers under the surface during deep-well injection processes. Applied to hazardous fluid wastes from (Alam *et al.*, 2013). This technique is used to dispose of acidic and caustic chemicals, oil field brine, and radioactive waste from uranium processing plants. The local subsurface geology of the area should be taken into account before garbage may be disposed of using this method to prevent contaminating groundwater. This strategy's drawback is that it might cause groundwater contamination (Modupe, 2020).

2.3.6 Refuse Disposal by Sanitary Landfills

This method of trash disposal uses landfills made of waste. Controlled tipping is another name for this technique (Chan et al., 2017). The technique is carried out by laying debris out in thin layers and utilizing a large bulldozer to add each layer.

The refuse is covered by a thin layer of clean soil when it is 3 m high. The process is repeated until the pit is filled (Alam *et al.*, 2013). Wastes disposed of through this method could host pathogenic microbes or toxic chemicals that are harmful to the soil and soil organisms, as well as humans (through inhalation of polluted air or consumption of contaminated water) (Wang, 2020).

2.3.7. Refuse Disposal by Composting

Composting can rid the environment of degradable organic waste. The term "biodegradable waste" is used to refer to degradable organic waste (Abdel-Shafy, 2018). Composting can be used to transform organic waste into useful products that can be used as biofertilizers. Recalcitrant substances are not composted. Composting is associated with odours and emissions of greenhouse gases (CO₂, SO₂, and NO₂), (Wang *et al.*, 2020).

2.4 Classification of Wastes According to Biodegradability

Wastes can be classified into biodegradable, moderately degradable, and non-biodegradable according to their biodegradability (Bhat, 2018). Aerobic and anaerobic organisms react on biodegradable wastes by accelerating their degradability rate. Biodegradable wastes include a variety of agricultural wastes like cow manure and chicken waste, among others.

Während moderately degradable wastes are gradually degradable, slowly degradable wastes are slowly degradable (Bhat, 2018). They have tough textured components (Alam *et al.*, 2013). Examples of such wastes include cardboard and wood.

2.5 COMPOSTING METHODS

There are numerous ways to compost, and each process has benefits and drawbacks.

Therefore, the composting technique to be used must be determined by the method that best achieves the researcher's objectives and the sort of material to be composted. The following list includes some of the composting techniques:

2.5.1 Vessel Composting

Composting that takes place inside of a vessel, building, or other enclosed space is referred to as in-vessel composting. In-vessel methods depend on a variety of forced aeration and mechanical turning techniques to enhance the composting process (Gonawala, 2018). This process is costly and labour intensive.

2.5.2 Windrow Composting

Raw materials are placed in long, thin piles or windrows that are constantly stirred to create compost. Aeration into the setup is made possible by the mixture of the two materials. A typical windrow composting scheme should begin at 3 feet in height for dense materials such as manures, and 12 feet high for fluffy materials such as leaves (Gonawala, 2018). It is rapid and holds heat, but maintenance is expensive and complicated.

2.5.3 Vermicomposting

The term refers to the use of earthworms for composting degradable organic matters (Arumugam, 2017). Almost every type of organic material can be degraded by earthworms by feeding on it. They can eat up to their body weight each day. Earthworms, for instance, can consume 0.1 kilograms of detritus every day despite only weighing 0.1 kilogram.

Worms' excreta which are termed "castings" are rich in nitrate, as well as available forms of phosphorus, potassium, calcium, and magnesium, which improve soil fertility (Bhat, 2018). The growth of bacteria and actinomycetes is encouraged by earthworms in the soil.

2.5.4 Static Composting

It is a conventional method of composting where wastes are decomposed aerobically by passive aeration (no and rare turnings or static aerations such perforated poles or pipes). When compared to vermicomposting, windrow, vessel, and Indian Bangalore composting, this approach is labor-intensive but it is a straightforward method of composting with low operational and capital requirements. This method uses little work and equipment and entails assembling a large quantity of basic components. The primary method of aeration is the passive passage of air through the pile, which gradually breaks down the organic material (Gonawala, 2018)

2.5.5 Sheet Composting

By using sheet composting, decomposed organic matter is removed from the environment without having to build a compost mound.

This technique involves applying organic material directly to the soil as a mulch, such as leaves, garden waste, grass clippings, weeds, and vegetative food. In place of a heap or container, the organic components are then pounded into the ground with a hoe, spade, or garden fork. One or two layers of organic material(s) are put over the growing area and watered properly before allowing to degrade until planting time. Decomposition is complete at the bottom layers (Misra, 2018). It's a simple and affordable process.

2.5.6 Berkley Rapid Composting

The composting process used here is quick. If the size is between 0.5 and 1.5 inches, the materials will decompose more quickly here. Because they degrade quickly, soft, succulent tissues do not

require cutting into extremely small pieces. The tissues must be divided into smaller pieces the harder they are, in order to speed up decomposition.

Once a pile is started, nothing should be added because it takes a certain length of time for the initial materials to break down, and anything added has to start from the initial breakdown stage thus lengthening the decomposition time for the whole pile (Misra, 2018).

2.6 MAJOR ELEMENTS IN COMPOST

For compost to be useful, it must have some elements in an optimum quantity which will supply adequate nutrients to plants. However, if the compost is intended for landfills, these components might not be required.

(i) **Nitrogen:** Nitrogen is one of the most essential elements for plant growth and development.

Nitrogen is a key component of chlorophyll and is responsible for plants green colour.

According to reports, compost has the highest Nitrogen content required for plant growth (Khater, 2014). Since nutrients in compost fertilizer are progressively released as a result of mineralization, compost fertilizer with high nitrogen content is not typical. Nitrogen in plants due to fertilizer over-application can result in rapid growth, brilliant green colour, and a deteriorating root system (Hafeez, 2014).

In severe circumstances, too much nitrogen might result in the plant's death by burning its leaf tissue. A lack of nitrogen results in stunted development, low protein content, yellow coloration, and a reduction in the amount of green in the leaves.

(ii) **Phosphorus:** Phosphorus is a component of plants' complex nucleic acid structure, which regulates protein synthesis (Razaq, 2017). The creation of new tissue, cell division, and intricate energy transformations in plants all depend on phosphorus. Increased root development, improved winter hardiness, accelerated plant maturity, and promoted tillage are all benefits of adding

phosphorus to low-phosphorus soil. Phosphorus deficiency can cause ¹stunted growth, poor seed and fruit development, delayed maturity, and a change in the colour of mature leaves to a distinctive ¹dark blue to blue-green pigmentation in plants. Compost has been found to have the correct phosphorus content that is required for plant growth (Razaq, 2017).

(iii) Potassium: Potassium is a mineral that is required ¹for proper plant development. ¹Increases plant growth, carotene, and chlorophyll content. Boosts the vigour and plant color.

Potassium is required for the plant to produce sugars to (Kammoun, 2017). Additionally, it is crucial to the health of the plant ⁵since it aids in disease resistance and helps ³the plant endure harsh climatic conditions like cold and drought. Older leaves can be scorched and browning, ¹which progresses to the total leaves with time due to a deficiency of potassium in plants. Weak stalks may also be related to potassium deficiency. According to Kammoun (2017), composts are excellent sources of the essential phosphorus needed for plant growth.

³2.7 FACTORS AFFECTING COMPOSTING

The texture of the input materials, temperature during composting, moisture content, pH, oxygen concentration, and C/N ratio are all variables that affect composting.

2.7.1. Temperature and Carbon to Nitrogen (C:N) Ratio

Temperature is an essential element in composting because it helps to accelerate the composting process and eliminate pathogenic organisms that are harmful to soil organisms, plants, animals, and humans (Hafeez, 2018). The temperature at which they exist is used to categorize them during the composting process. That grow at 20–40°C are classified as mesophilic organisms, while those that grow above 40–70°C are thermophilic bacteria (Chennaou, 2018). Composting is started by mesophilic organisms, which start by dissolving the waste's quickly biodegradable substances; their metabolism results in ¹a rapid rise in the compost temperature.

Depending on the volume of the wastes treated, the temperature (heat production) can be affected by the volume of the wastes treated; if the volume of waste is small, the high temperature will not be achieved. When nutrients in the composting materials are depleted and a competing organism releases enzymes that can kill the pathogens, the temperature during composting does not increase beyond 45°C, but pathogens may perish. For a composting process, an optimal C:N of 30 is recommended (Arumugam, 2017). Due to the low C:N ratio of composting wastes, oxygen cannot reach the pile, causing anaerobic conditions that cause odor creation as well as nitrogen loss in the form of ammonia gas. Moreover, if the C/N ratio is too high, microorganisms' activities will be reduced, and the rate of decomposition will be slow (Modupe, 2020).

2.7.2. Oxygen and pH

During the composting process, the presence of oxygen is crucial. When organisms oxidize carbon to produce energy, the oxygen that is already there is depleted, and gases are created. Without enough oxygen, the composting process will turn anaerobic and release gases (methane, carbon dioxide, and ammonia), which will lead to the development of unpleasant odors. The pH of the decomposed material determines the rate of composting. The ideal pH for composting has been discovered to be alkaline. Due to the destruction of the microorganisms when the pH is acidic, composting proceeds very slowly.

2.7.3. Moisture Content, Particle Size, and Raw Material Texture

Moisture supports the metabolic activities of microorganisms. It's best to keep the moisture content of composting materials between 40% and 60%. Compost contains either the initial water added or the water created by the microorganisms during their metabolic processes.

An organism's metabolic functions are slowed down by too much water because oxygen diffusion is reduced. The majority of the water consumed by microbial cells comes from water.

Because of this, organic molecules can only be removed by bacteria after they have been dissolved in water. Moisture levels fall as composting continues (Tuomela *et al.*, 2000).

2.8 ENVIRONMENTAL IMPACT OF COMPOSTING

- i. By reducing the threats to the environment posed by synthetic fertilizer, composting improves soil biodiversity. ³ Instead of being a natural, unmanaged process, composting is initiated and managed in a controlled environmental setting. Composting and decomposition are separated by the regulating process (Bernal *et al.*, 2017).

- ii. Although composting has ³ many of the reported advantages listed above, there are also a number of drawbacks to this waste management strategy, ⁶⁵ including its effects on climate change, the release of carbon dioxide into the atmosphere, the reduction of oxygen, ³ and the production of unpleasant odours due to the release of hydrogen sulphide produced by anaerobic activity. Various laws regarding the usage of the procedure have been put in place by various agencies in various nations as a result of these health effects. These drawbacks highlight the need for further development of this approach to solve the numerous issues raised (Ayilara *et al.*, 2020).

- iii. It is difficult to compost for such a long time because there are materials that do so more slowly, especially when co-composting. This overview covers proper waste management through composting, various composting techniques, factors impacting ¹ composting, long-duration composting, the mechanism underlying it, current developments in composting, and future prospects. Composting processes can be greatly improved by removing mono-fertilizers from compost, creating test strips to check for the presence of pathogens and heavy metals, and using odour-trapping techniques (Ayilara *et al.*, 2020).

- iv.** The health of people is harmed by improper garbage management. In addition to being unattractive, it contributes to climate change through air pollution, water body damage from spills, and ozone layer destruction from burning. Waste is burned and discarded contribute to global warming (Iguh *et al.*, 2021).
- v.** ⁴³ Compared to the landfilling technique of waste disposal, which could endanger subsurface water, the composting process helps prevent the polluting of groundwater. ⁶⁸ This is due to the fact that microorganisms and chemical contaminants are reduced during composting. These are the pathogenic bacteria that are dangerous to people that are found in waste (Ashraf *et al.*, 2021).
- vi.** Due to the adequate nutrient content of ⁵² the composted materials and the presence of organisms that promote plant growth, composting has been shown to boost agricultural production and soil organic matter content. ⁴³ This goes a long way toward ensuring food security. Compost can be used for more than just fertilizing; it can also be used for bioremediation, weed and disease control, pollution abatement, erosion control, landscaping, and wetland restoration (Ayilara *et al.*, 2020).
- vii.** By holding the soil's granules together and preventing erosion, composting aids in ensuring environmental sustainability. It aids in keeping wastes under control and reprocessed into useful goods. The bioremediation of contaminated soil is aided by them. By luring various pests, bacterial strains, and fungi that are advantageous to the crop, they help boost soil biodiversity (Babla *et al.*,)
- viii.** They also improve the soil and assist to prevent plant diseases.

- ix.** By limiting the generation of gases like methane, they contribute to reducing greenhouse effects. Even while composting releases less CO₂ than other (combustion) waste treatment methods, it nevertheless produces some CO₂.

- x.** As the biodegradable waste component is mostly to blame for the polluted leachate and the methane problems, this dramatically reduces the volume of wastes and lessens the environmental impact of disposal sites (Ahmed *et al.*, 2023)

2.9 REVIEW OF WORKS CARRIED OUT ON COMPOSTING IN NIGERIA

1. Obasiohia (2022) studied the "Waste Management Progress in Delta State, Nigeria", where he identified the waste sources, the major problems affecting the disposal of wastes in Delta State, Asaba and how these wastes can be managed. He stated that Delta State had a serious waste problem which started at the societal level where people dumped their solid waste on the streets and left the government with the sole responsibility of dealing with it.

The Delta State Integrated Waste Management Facility in Asaba, situated at Delta State was responsible for the management and control of waste. Obasiohia also identified that the Integrated Waste Management facility included departments for recycling, composting and burning of non-WTE waste. When these wastes were collected and transported to the facility, they were weighed and then sent along with surgical waste for sorting where the recyclables and compostable wastes were separated from one another. The compostable wastes were then used for producing compost using aerated static pile while, the leftover wastes were delivered to the moving grate, rotary kiln, and fixed end incinerators, where they were burned and combined with cement and grit sand, shaping it into interlocking tiles. Composting accounts for 30% of the garbage, recycling accounts for 15% and incineration accounts for the remaining 45%.

According to Obasohia (2022), before the Asaba waste management facility was constructed, the majority of the rubbish was dumped at a dumpsite close to the Delta State Airport. The smell and sight of people nearby resulted in a visual dis-amenity. The local environmental quality is vastly improving as a result of the work being done at the dumpsite. The Private Sector Participants (PSP) work with the Delta State government to ensure that this problem is avoided at Asaba, where each member of this team received adequate training in collecting residential waste from various parts of the city and delivering it to the treatment facility. For this reason, households pay

for garbage that is collected in the streets, from outside individual homes and from communal areas.



Figure 2.1 Waste Management Progress in Delta State (Obasiohia, 2022)

Obasiohia (2022) also highlighted that this is an improvement, but there is still more to be done. Educating people on sustainable waste management can have a positive effect on lives by reducing their exposure to toxins and improving their surroundings. This is because, so many people are not aware about the importance of proper waste management. There is a lot of cultural adaptation to be done before people stop throwing garbage and litter on the streets and the state's leadership is devoted to implementing an effective waste management strategy. Infrastructure, collections, and cleanup have all had an impact and law enforcement efforts are beginning to alter public perceptions of waste management in Delta State. Plans are currently being finalized to build a facility in Warri, the industrial center of Delta State, that will be twice as large as the one in Asaba with hope that Delta State's accomplishments serve as a model for state governments in other states. The positive shifts that are being brought about by our example of healthier, sanitary,

and more environmentally responsible waste management, as well as the positive outcomes that are being provided, could spur new growth elsewhere in the region, which could match or even surpass Delta State's outcomes. Nigeria's waste management record may leave a lot to be desired, but things could look better in the future.

2. Sridhar *et al* (1993) studied "Waste Recycling Through Composting In Nigeria" and according to Gilles (1946), urban and rural wastes were disposed off or utilized in Nigeria a half century ago. Waste materials like market sweepings, stable manure, and rubbish were burned in incinerators of various designs in Kano, northern Nigeria. Dirt from pit latrines was dumped in otway pits or short trenches. He also emphasized that the province as a whole and the intensively agricultural area around Kano had lost out on the benefit of these wastes as fertilizer. For use as fertilizer on their farms, commercial and domestic sweepings, including cattle, donkey, horse, sheep, and goat manure, were all readily available.

Since Gilles gave this account, Nigeria's efforts to treat organic waste for agricultural use have not improved. According to a survey by Srihar (1989) involving 135 elderly farmers in Nigeria showed that the majority of respondents were male and that composting had been done in Kaduna, Kano, and Maiduguri areas in the past, but that it is no longer done on a large scale.

2 Gilles was the first to provide a thorough description of a Kano composting facility that was in operation from 1936 to 1942. Landfill wastes were mixed with night soil or slaughterhouse wastes in 31 chambers (1 per day) that were specially designed for this purpose. Composting took 31 days, and the material was turned three times. 43,800 tons of high-quality compost were produced in total over the course of five years. No additional research on composting was done until Sridhar *et al.*, (1985) began the procedure at Shasha, a small trading hamlet in Ibadan. About 150 kg of market waste and slaughterhouse waste were composted with the completed product and utilized to produce vegetable crops on experimental plots.

In this investigation, the variations in temperature, volume, nitrogen, phosphorus, and other scientific factors were measured. Communities should be included in such projects, it was agreed.

Using a variety of local waste products, we have carried out a number of composting studies.

A range of waste products from towns, farms, animal operations, and industries can be composted. The following things are some of them: banana leaves, grasses, and cocoa leaves; corn, guinea corn, and sorghum stalks; rice husks, wheat, straw, vegetable peelings, cotton stalks, grasses, cacao, and banana leaves; Ash and waste from breweries, slaughterhouses, and other businesses that work with organic materials, as well as garbage from cities. Due to cultural considerations, night soil is not commonly used for composting. There were no rules for using other wastes, such poultry, pigs, or other animals.

A nationwide survey carried out by Sridhar (1989) revealed that a variety of methods are practiced in making compost. All of these composting methods are labour intensive. According to Sridhar (1989), composting in Anambra and Imo States is practiced by;

(a) Dumping the waste in a pit and stirring it twice a week till planting season.

(b) Wastes are dumped into each of the three pits for two weeks, after which they are turned, moved to the second pit, turned again, and finally moved to the third pit (the first pit's contents are moved to the second pit mostly for aeration). Fresh biomass is poured into the first pit right away. Some folks occasionally employ four pits.

(c) Bamboos and green leaves are maintained in a 2 m-deep trench until they rot.

(d) All of the waste is deposited into a circular pit that is 10 meters in diameter and 5 meters deep, and it is periodically turned with a stick. It takes three months or such. The size of the pits can vary, and in some places they are covered to protect them from the elements. Urine or urea can be put to heaps to speed up decomposition. Northern Nigeria, particularly the states of Borno, Kano, Kaduna, and Niger, recognizes the importance of composting for agricultural usage. Animal or human excrement is combined in a 1:3 ratio with trash or crop residues, watered, and turned

sometimes until it reaches maturity. The compost can be ready in 30 days in some regions after the mixtures have been rotated three times. In certain places, the trash is combined and stored in a pit for three months before being used. In Niger State, some residents mix animal waste and ashes with garbage before piling it up and using it on their farms. If considerable nutrient losses have occurred and the completed composts differ in their fertilizer value, or product quality, for instance, there is no proof that the end product is environmentally acceptable.

The Department of Preventive and Social Medicine started conducting composting experiments in 1985, and later the Agronomy Department collaborated with it to conduct extensive composting and use studies. Prior research involved windrows of sorted market trash and abattoir waste. The community used the compost on demonstration plots where they grew greens, maize, tomatoes, and peppers in 90 days, and good compost was produced during that time. Additional research on composting included waste from breweries, including discarded grains, mixed with garbage from the city, cow manure, and chicken droppings. About two tons of trash were used in each of the three-by-two-by-one-meter composting pits. The pits contained a 3:1 mixture of garbage and refuse. Other qualities and the appropriate age for maturity are specified. Several studies included;

- (a) poultry waste composted for 12 weeks after being blended 2:1 with leaves and sawdust.
- (b) Composting takes place in holes measuring 2 meters by 2 meters by 1 meter for a period of 12 weeks. These composts were used for growing various crops as reported.

When considering compost in conjunction with the second crop, the average grain yield shows that it has a clear positive impact. For the low-fertility soils, it leaves a strong residual effect.

The composts enhanced soil aggregation and had fertilizer value. The compost created from poultry waste was the one that produced stable soil aggregates the fastest among the different composts. Composted manure was also used to cultivate the following key crops: yam, pepper, tomato, greens, and beans. The main purpose of growing these crops was to show the local populations the benefits of compost.

According to Adeoye (1986), while some modest composting was done in Nigeria about 50 years ago, it has since mostly fallen out of use. Because fertilizers are so simple to carry, store, and apply, farmers find it more practical to use them. Farmers who voiced worry about the utilization of organic wastes cited the following reasons:

- (a) They are heavy, making handling them challenging and expensive.
- (b) The majority of wastes have unpleasant odors that deter people from handling them.
- (c) The idea that they contain pathogenic organisms is still prevalent.
- (d) Roads that lead from the production facility to the farms are inaccessible. However, because they cultivate a range of crops that benefit from organic manures, farmers in the northern states support the idea that wastes can be used for good. In the northern states, people transport their garbage and compost to their farms using donkeys, camels, or even bicycles and scooters. Composting in the southern states is significantly impacted by transportation costs. Despite the communities' interest, water is a limiting factor in several places.

Nigeria is mostly an agricultural nation. Many different types of food and other consumer items are imported, and the wastes that are produced accumulate in both urban and rural locations. No urban center has yet developed a systematic mechanism for handling these garbage. Only collection, which is sporadic, is used for disposal. The federal government has issued a number of regulations pertaining to environmental sanitation throughout the past ten years.

The most significant was the one from 1986, which designated the last Saturday of each month as sanitation day and required everyone to clean the property between 7am and 10am.

The make-up of waste has seen a significant change since 1986. People from low socioeconomic backgrounds are increasingly turning to scavenging on the trash dumps to gather paper, metal, glass, and plastics.

As a result, between 60 and 80 percent of the entire amount of trash produced is made up largely of organic materials. Now is the perfect time to start creating compost in various areas.

2.10 FORMULAE FOR CALCULATION

The formulae often utilized for compost generations are ¹²³ percentage of organic waste produced and the percentage moisture content presented in equation 2.1 and 2.2 respectively.

Percentage of organic waste produced (per week)

$$\frac{\text{Organic Weight (Wt. Per Week)}}{\text{Total (Wt. Per Week)}} = \frac{x (\%)}{100 (\%)} \quad (2.1)$$

Percentage of ⁹⁹ moisture content (%)

$$\text{Moisture Content} = \frac{\text{Wet Wt.} - \text{Dry Wt.}}{\text{Wet Wt.}} \times 100 \quad (2.2)$$

2.11 WASTE COLLECTION

In the waste management process, waste collecting takes place. In this regard, solid waste is moved ⁷¹ from the point of use and disposal to the point of treatment or ⁵⁴ landfill. As part of a municipal landfill diversion program, garbage collection also involves the curbside collection of recyclables, which are technically not waste. In economically developed nations, household waste is typically dumped in recycling bins or trash cans before being picked up ¹²⁷ by a waste collector in a waste collection vehicle.

A crucial element of all waste management plans worldwide is the urban garbage collection system. Therefore, the ability of the collection systems to fully adapt to the prevalent cultural and social contexts within which they function is crucial to the effective performance and success of these schemes in urban pollution control, (Fobil *et al.*, 1996).

According to Fobil (1996), waste collection systems embedded in institutions can only fully evolve continuously to reflect evolving social and technical matrices underlying the cultures, organizations, institutions, and social conditions they are designed to address. Conceptually, institutions are the rules guiding the conduct of public service provision and routine social interactions.

In this project, the waste samples will be collected for four houses in (4) four weeks with the use of waste bowls. The various waste will be collected at weekly intervals and weighed using a 20-kg weighing scale. The weights of waste were recorded.

2.11 WASTE SORTING

The process of sorting waste involves separating and classifying the collected rubbish into several categories according to the waste's components. The separation of waste can be done manually at the household and collected through curbside collection programs, or it can be done automatically in materials recovery facilities or mechanical biological treatment systems. Hand sorting was the first method used in the history of waste sorting, (Yen-Nee-Lee, 2019). Planning for sustainable waste management should consider waste collection at the source, its division into component parts, and storage. Waste is often collected by door-to-door pickup, roadside dumpsters, and community collection stations. Local governments like municipalities and local bodies are primarily responsible for waste collection. In certain cities, biodegradable and non-biodegradable wastes are collected in separate roadside containers.

From the perspective of recycling and for reducing the amount of waste that needs to be disposed of further, proper waste segregation is crucial. Both individual individuals and staff members who are dedicated to waste collection and segregation are responsible for waste segregation. The separation of plastic, metals, woods, papers, and bio-waste not only offers economic benefits owing to recycling but also saves money and labour for their subsequent treatment or disposal.

The key to effective trash segregation is increased public knowledge. The public's behaviour in correctly sorting waste depends on their socioeconomic background. Through various activities that emphasize the economic and environmental benefits of waste sorting, the local government should take care to increase public awareness of the practice. Although waste collection, sorting, and storage are well-served in urban and suburban regions, open waste disposal is more common in rural locations. The collected waste is held at particular locations before being delivered to a landfill or treatment facility. Some wastes, such as electronic waste, require distinct storage facilities, which have not yet been effectively developed.

Environmental concerns, trash management guidance, home ownership, income, the building type, and education are a few characteristics that have an impact on waste sorting. Surface area, waste management guidance, home ownership, income, and education are also elements to consider. Those with low incomes and education levels are more likely to sort their trash than those with higher incomes and education levels.

The collected waste will then be sorted and categorized into;

1. Organic waste: All waste that is biological in nature (was once alive or a component of an organism), such as coffee grounds, food scraps, banana peels, bread crusts, paper, paper towels, cardboard, eggshells, coffee grounds, food waste, food-soiled paper, non-hazardous wood waste, green waste, and pruning and landscape waste, etc.

2. Inorganic waste: All waste that isn't biological (from industrial processes or other non-natural sources), including plastic soda bottles, glass yogurt cups, spoons, cellophane, aluminum cans, plastic bags, glass, metal, dust, and more (Aguilera, 2012).

3. Toxic trash: Batteries, pesticide containers, medicine bottles, motor oil, cell phones, solvent-based paints, pesticides and other garden chemicals, motor oils (from cars or lawnmowers), gasoline and kerosene, cleaning and polishing chemicals, swimming pool or spa bath chemicals, etc. are examples of trash that releases hazardous substances (Senior, 1986).

2.12 MIXING AND MOISTURE ADDITION

All organisms, including bacteria, required for composting require water in order to survive and function. It is necessary for the organic material to be broken down to be moist but not drenched. The compost heap's biological activity will slow down as it starts to dry out, and if it dries out, the majority of the beneficial compost organisms will go dormant or pass away, thereby halting all biological activity (Misra, 2003).

Composting will not function properly if there is too much or too little moisture present. Composting will slow down or halt if there isn't enough. The essential air holes will be filled by too much moisture in the pile, turning it into an anaerobic digester, which is something that most garden composters try to avoid because it is a common composting method with specific criteria (Misra, 2003).

The bacteria and fungi necessary for composting will not be able to flourish if your compost bin is too dry, which will lead it to cease decomposing. Rehydrate the heap by watering it; rainwater is preferable, but regular water can work if you don't have any saved rainfall. Home gardeners and commercial enterprises have been forced to reconsider their watering strategies as a result of the unprecedented drought that has affected many (and we do mean many) regions of the nation.

The amount of moisture in a compost pile is crucial to organic gardeners. It is typically advised to compost at home with a moisture content of between 50 and 60 percent. A thin water coating will cover the composting material's particles within the ideal range, but it won't fill the air gaps (pores) around or between the particles. Bacterial activity is limited if there is inadequate moisture (30 percent), which might be problematic during hot, dry weather. On the other hand, too much moisture (>65%) causes sluggish decomposition, anaerobic pockets to produce odours and nutrient leaching (Holmer, 2002).

15 During the maturation stage, a slightly lower moisture content is preferred since the compost will become lighter and simpler to combine to create seed or potting compost or use in the garden. I

make an effort to maintain the moisture level during the first months of maturation, but I let it dry out for about a month before harvest.

2.13 AEROBIC COMPOSTING

The process by which organic wastes are transformed into compost or manure while being exposed to air is known as aerobic composting. Carbon dioxide, ammonia, water, heat, and humus are the byproducts of the breakdown of organic matter by aerobic bacteria. Aerobic microbes further breakdown them even though aerobic composting may yield organic acids, which act as intermediate components.

The comparatively unstable form of organic matter that results from composting reduces the danger of phytotoxicity. Proteins, lipids, and complex carbohydrates like cellulose and hemicellulose break down more quickly as a result of the heat produced. If this process is exposed to sufficiently high temperatures, it also kills many microorganisms that are human or plant diseases in addition to weed seeds. While anaerobic composting depletes the soil of fewer nutrients, aerobic composting is thought to be more efficient and advantageous for agricultural productivity. The most popular method for aerobic composting is the heap method, which includes separating organic matter into three distinct groups and piling them on top of one another in a heap. It takes around three weeks for the process to complete, and this heap needs to be mixed every week. The technique is the same, but it is carried out in specially made pits as opposed to the Pit Method. When the compost will be ready is not specified. The Berkley Method is labor-intensive and requires particular specifications for the compostable material. vegetation, such as grass. Compost typically takes 15 days to complete.

117 CHAPTER THREE

METHODOLOGY

3.1 STUDY AREA

The largest and capital of Edo State in southern Nigeria is Benin City. After Lagos, Kano, and Ibadan, it is the fourth-largest city in Nigeria, with a population of 1,782,000 as of 2021. It is located 320 miles (480 kilometers) east of Lagos and about 40 kilometers north of the Benin River. Nigeria's oil production is a key business, and Benin City is home to the country's rubber industry.

The population of Edo state is 4 million (census 2006 projection). With a population estimated to be 2.86 million in 2002 (up from 2.1 million in 1991, of which 50.13 percent were males), Edo State is comparable in size to Jamaica (2.74 million), larger than Botswana (1.6 million), and Trinidad and Tobago (1.6 million), according to USAID data (1.1m). One of the states in Nigeria with a very high concentration of young people is Edo State, where 32 percent of the population is made up of adolescents and young adults (10 to 24 years old). Christianity, Islam, and African traditional religion are the three most prevalent religions in the state, which is multireligious and multiethnic.

Benin City, Nigeria, is located between latitude 6° 17'N and 6°24'N and longitude 5°30'E and 5°48'E. Benin City lies in the thick equatorial rainforest zone, prone to heavy rainfall. The city is well drained by two major rivers – Ikpoba River, which drains the Northeast of the city and Ogba River, which drains the southwest of the city. The city was the center of the Beninian Edo Kingdom, which existed from the 13th to the 19th century. Prior to being seized, looted, and burned in 1897 by a British punitive expedition, it had significant trading ties with Portugal in previous centuries. Following their victory, the British began to slowly colonize the area,

eventually incorporating it into Colonial Nigeria. The British took many ⁷⁴ bronze sculptures from Benin City Palace, collectively known as the Benin Bronzes. The Bini language is spoken by the natives ¹⁰ of Benin City, known as the Edo people (also known as the Benin People). The inhabitants of the city have one of the most diverse and elaborate dress traditions ⁴⁵ on the entire African continent. They are renowned for their use of beads, body art, bangles, anklets, and raffia, as well as their subsistence farming of cassava, plantains, and yam.

⁴⁷ One of Nigeria's largest cities, Benin City is situated about 40 miles from the Gulf of Guinea in the southwest of the country. The economy of this ¹⁰⁷ significant industrial and cultural hub is dominated by businesses that produce rubber and other oils. Nearly 1.2 million people call the city home, and the majority of them are of local Edo culture ethnic origin. ¹⁰ Benin City became the capital of the Mid-Western Region when it was divided from the Western Region in June 1963, the year Nigeria earned independence from British domination.

It was still the region's capital ¹⁰ when the area was renamed Bendel State in 1976, and it became the state capital of Edo State when Bendel State was divided into Delta state and Edo state in 1991.

The map of Nigeria is shown in Figure 3.1, and the map of Edo State with the study regions is ¹⁰⁹ shown in Figure 3.2.

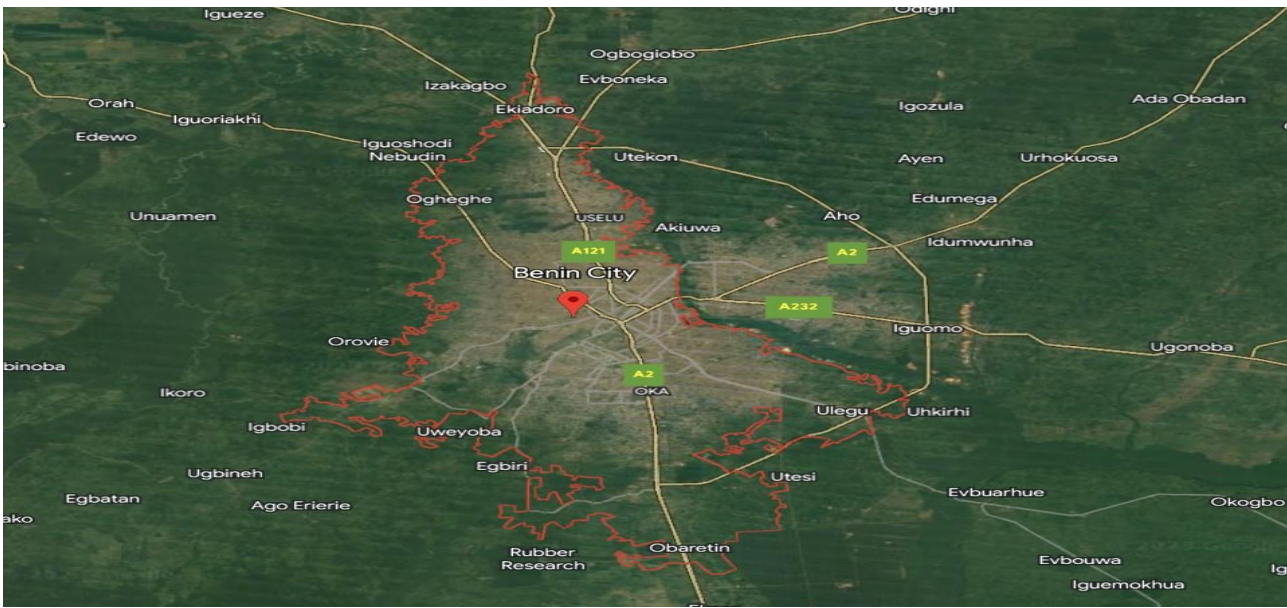


Figure 3.1: Map of Benin City (Google Earth Imagery)

3.2.2 Sample Collection

During this process, all the wastes which were acquired from the respective houses were picked up and stored in litter bags. The process of waste collection was carried out for a period of 4 weeks. After then, the wastes were weighed and placed in plastic bowls which were labelled according to their respective time of collection. This was done so as to determine the respective weights of solid wastes from each household, on a weekly basis.

Tools and equipment utilized include:

- i. **Plastic litter bag** (For collecting the waste samples from respective homes).

A sample plastic litter bag is shown in Figure 3.3



Figure 3.3 Plastic Litter Bag

- ii. **Weighing Machine** (For measuring the collected waste samples).

A sample plastic litter bag is shown in Figure 3.4



Figure 3.4 Weighing Machine

iii. **Plastic bowl** (For storing the waste samples during composting process).

A sample plastic litter bag is shown in Figure 3.5



Figure 3.5 Plastic Bowl

iv. **Gloves** (For handling and mixing of the waste).

v. **Nose Masks** (for protection against respiratory infections and foul smell).

A sample plastic litter bag is shown in Figure 3.6



Figure 3.6 Nose Mask

3.2.3 Sample Sorting

The waste sorting process involved the separation of the organic wastes which can be composted from the inorganic (categorised into papers, cellophane and sachets, plastic, textile, metal and glass) and toxic wastes (batteries, pesticides, electronic devices e.t.c) depending on the nature of the source material and biodegradability. During experimental work, hand sorting method was used to sort the waste collected.

The chosen method of sorting depended on many factors such as the nature of the waste, the ease of segregation, the cost-efficiency and the yield and quality of the resultant recyclates.

3.2.4 Moisture Addition and Mixing

This process was carried out after the waste sorting of the organic waste from the inorganic; for the purpose of controlling the water content of the organic waste and the turning (mixing) the compost pile daily so the oxygen level of the waste is maintained. Rapid decomposition requires optimum water content.

- i. If too dry, bacterial activity will slow or cease.
- ii. If too wet, loss of air in the pile will lead to anaerobic conditions.
- iii. Pile water content should be at 40-70% and as wet as a squeezed-out sponge.
- iv. When pile no longer heat up after mixing, it was allowed to cure (stand without mixing).

3.2.5 Aerobic composting

Aerobic composting was then carried out with the aim of decomposing the organic wastes using microorganisms in the presence of oxygen. Oxygen from the air diffuses in to the moisture and is taken up by the microbes. These microbes responsible for composting process are naturally occurring and live in the moisture surrounding the organic matter.

Composting with decomposers requiring oxygen⁹² is the fastest way to make high quality compost. These aerobic decomposers produce heat.

When the compost reached maturation, the colour turned dark brown. It was crumbly, loose and humus-like. It had an earthy smell. The pile (head of the organic waste which should decompose to manure) had shrunk to about 1/3 - 2/3 of its original weight.

- i. Decomposers – The decomposers served as the composting work crew. These are the microbes (mainly bacteria and fungi) that did most of the job.
- ii. They are made up of soil leaves, food scraps, saw dust, fowl dung⁸² and finished compost. Each of these will add microorganisms to the compost pile.
- iii. Food for the decomposers - The organic wastes to be composted.
- iv. The right amount of air, water and warm to keep the decomposers alive.

3.2.6 Analysis of family and Source of Waste:

- **HOUSE A:** 2 Persons (All adults – both male).
- **HOUSE B:** 3 Persons (All adults – 2 females and a male).
- **HOUSE C:** 2 Persons (All adults – both male).
- **HOUSE D:** 2 Persons (All adults – both male).

Source of waste: Municipal (Household) Waste from spoiled food, banana peels, bread crusts, paper, cardboard, eggshells, coffee grounds,³⁷ food waste, food-spoiled paper, non-hazardous wood waste, green waste, pruning waste e.t.c

CHAPTER FOUR

RESULTS AND ANALYSIS

4.1 Weight of the Bowls

Table 4.1 shows the weight and volume of the respective bowls used in collecting wastes from houses A, B, C and D for week 1. It is evident that bowl 1 from House A had a volume of 10 litres and weighed 0.5kg, while the other bowls from Houses B, C and D had a volume of 25 litres and weighed 1kg. It can therefore be stated that House A produced the least volume and weight for this study.

Table 4.1: Highlight of Collected Samples for Week 1

House(s)	Bowl Number	Weight of Bowls (kg)	Volume of Bowls (Litres)
A	1	0.5	10
B	2	1.0	25
C	3	1.0	25
D	4	1.0	25

Table 4.2 shows the weight and volume of the respective bowls used in collecting wastes from houses A, B, C and D for week 2. It is evident that bowl 4 from House D had a volume of 10 litres and weighed 0.5kg, while the other bowls from Houses B, C and D had a volume of 25 litres and weighed 0.9kg. It can therefore be stated that House D produced the least volume and weight for this study.

Table 4.2: Highlight of Collected Samples for Week 2

Houses	Bowl Number	Weight of Bowls (kg)	Volume of Bowls (Litres)
<i>A</i>	1	0.9kg	25
<i>B</i>	2	0.9kg	25
<i>C</i>	3	0.9kg	25
<i>D</i>	4	0.5kg	10

Table 4.3 shows the weight and volume of the respective bowls used in collecting wastes from houses A, B, C and D for week 3. It is evident that bowls ⁸³1, 2, 3 and 4 from Houses A, B, C and D all had a volume of 10 litres and weighed 0.5kg. It can therefore be stated that all the houses produced the same volume and weight for this study.

Table 4.3: Highlight of Collected Samples for Week 3

Houses	Bowl Number	Weight of Bowls (kg)	Volume of Bowls (Litres)
<i>A</i>	1	0.5kg	10
<i>B</i>	2	0.5kg	10
<i>C</i>	3	0.5kg	10
<i>D</i>	4	0.5kg	10

Table 4.4 shows the weight and volume of the respective bowls used in collecting wastes from houses A, B, C and D for week 4. It is evident that all bowls from Houses A, B, C and D had a volume of 10 litres but weighed 0.5kg, 0.8kg, 0.8kg and 1.0kg respectively. It can therefore be stated that house A produced the least weight for this study.

Table 4.4: Highlight of Collected Samples for Week 4

Houses	Bowl Number	Weight of Bowls (kg)	Volume of Bowls (Litres)
A	1	0.5	10
B	2	0.8	10
C	3	0.8	10
D	4	1.0	10

4.2 Results of Composting

The results obtained from the tests carried out on the various aggregates percentage for this study are tabulated and recorded in the tables below:

4.2.1 Results of Week 1 Composting

Table 4.5, 4.6 and 4.7 shows the weight of the items collected before and after composting, the composition of the organic waste and the rate of compost formation per house respectively.

Table 4.5: Weight before and after Composting (Week 1)

S/N	House Address	Family Size	Values in kg									
			Organic Wastes	Papers	Cellophane And Sachets	Plastics	Textile	Metal	Glass	Others	Total Waste	Wt. After Composting
1.	House A	2	4.2	0.2	0.15	0.25	1.2	0.34	-	0.2	6.54	2.3
2.	House B	3	8.2	0.4	0.16	0.2	2	-	0.1	0.3	11.36	3.9
3.	House C	2	3.8	0.25	0.1	0.32	1.3	0.25	-	0.3	6.32	1.4
4.	House D	2	2.8	0.16	0.09	-	2.5	0.1	-	0.15	5.8	1.0
Total			19	1.01	0.5	0.77	7	0.69	0.1	0.95	30.02	8.6

From Table 4.5, the total collected waste was obtained as 30.02kg while the total compost obtained from Houses A, B, C and D was 8.6kg. Houses A, B, C and D generated 6.54kg, 11.36kg, 6.32kg and 5.8kg respectively.

Table 4.6: Composition of Organic Waste

S/N	Spoiled/ Perishable Food(s)	Bones	Vegetables/ Leaves	Wood(s)
1.	3.92kg	0.25kg	0.03kg	-
2.	8.15kg	0.05kg	-	-
3.	3.8kg	-	-	-
4.	2.7kg	-	-	0.1kg
Percentage Composition	97.74%	1.57%	0.158%	0.526%

From Table 4.6, the total compostable waste generated from House A, House B, House C and House D was 19kg) while the percentage composition of organic waste was 97.74% (for spoiled/perishable foods), 1.57% (for bones), 0.158% (vegetables/leaves) and 0.526% (woods) respectively. The weights of the spoiled/perishable foods obtained from the respective houses were 3.92kg, 8.15kg, 3.8kg and 2.7kg. The weights of the bones obtained from houses A and B were 0.25kg, 0.05kg while houses C and D had no weight. The weights of the vegetables/leaves obtained from house A was 0.03kg while houses B, C and D had no weight. The weight of the woods obtained from house D was 0.1kg from houses A, B and C had no weight.

Table 4.7 shows the description of the compost generated after week 1.

Table 4.7: Rate of Compost Formation per House

Number Of Houses	Organic Waste Generated (kg)	Rate Of Compost Formation Per House (kg)
4	19	4.75

18 From the analysis of the results obtained in Table 4.7; House A generated 2.3kg, House B generated 3.9kg, House C generated 1.4kg and House D generated 3.9kg. From Table 4.7; the total compostable was generated was 19kg and an average of 4.75kg of compostable waste was generated (per house) and 2.15kg (per person) on the first week.

4.2.2 Results of Week 2 Composting

Table 4.8, 4.9 and 4.10 shows the weight of the items collected before and after composting, 24 the composition of the organic waste and the rate of compost formation per house.

Table 4.8: Weight before and after Composting (Week 2)

S/N	House Address	Family Size	Values in kg									Total Waste	Wt. After Composting
			Organic Wastes	Papers	Cellophane And Sachets	Plastics	Textile	Metal	Glass	Others			
1.	House A	2	5.0	0.6	0.2	0.35	0.6	-	-	0.4	7.15	2.5	
2.	House B	3	6.9	0.5	0.3	0.4	0.8	0.2	0.5	0.37	9.97	3.4	
3.	House C	2	4.4	0.3	0.14	0.2	-	0.3	-	0.2	5.54	2.0	
4.	House D	2	2.5	0	0.4	0.6	0.95	-	0.2	0.25	4.9	0.9	
Total			18.8	1.4	1.04	1.55	2.35	0.69	0.7	1.22	27.56	8.8	

From Table 4.8, the total waste was obtained as 27.56kg while the total compost obtained from Houses A, B, C and D was 8.8kg. Houses A, B, C and D generated 7.15kg, 9.97kg, 5.54kg and 4.9kg respectively.

Table 4.9: Composition of Organic Waste

S/N	Spoiled/ Perishable Food(s)	Bones	Vegetables/ Leaves	Wood(s)
1.	5.0kg	-	-	-
2.	6.9kg	-	-	-
3.	4.4kg	-	-	-
4.	2.2kg	-	0.3kg	-
Percentage Composition	98.40%	0%	1.6%	0%

From Table 4.9, the total compostable waste generated from House A, House B, House C and House D was 19kg) while the percentage composition of organic waste was 98.40% (for spoiled/perishable foods), 0% (for bones), 1.6% (for vegetables/leaves) and 0% (for woods) respectively. The weights of the spoiled/perishable foods obtained from the respective houses were 5.0kg, 6.9kg, 4.4kg and 2.2kg. The weight of the vegetables/leaves obtained from house D was 0.3kg while houses A, B and C had no weight.

Table 4.10 shows the description of the compost generated after week 2.

Table 4.10: Rate of Compost Formation per House

Number Of Houses	Organic Waste Generated (kg)	Rate Of Compost Formation Per House (kg)
4	18.8	4.70

18 From the analysis of the results obtained in Table 4.10; House A generated 2.5kg, House B generated 3.4kg, House C generated 2.0kg and House D generated 0.9kg. From Table 4.10; the total compostable waste generated was 18.8kg and an average of 4.70kg of compostable waste was generated (per house) and 2.11kg (per person) on the second week.

4.2.3 Results of Week 3 Composting

Table 4.11, 4.12 and 4.13 shows the weight of the items collected before and after composting, the composition of the organic waste and the rate of compost formation per house.

Table 4.11: Weight before and after Composting (Week 3)

S/N	House Address	Family Size	Values in kg									
			Organic Wastes	Papers	Cellophane And Sachets	Plastics	Textile	Metal	Glass	Others	Total Waste	Wt. After Composting
1.	House A	2	6.7	0.4	0.3	0.4	1.2	-	0.1	0.2	9.3	3.4
2.	House B	3	7.5	0.45	0.25	0.2	0.3	1.5	-	0.35	10.55	3.7
3.	House C	2	5.4	0.3	0.3	0.25	0.8	-	0.5	0.4	7.95	2.8
4.	House D	2	5.8	0.2	0.2	-	0.45	0.6	0.2	0.3	7.75	2.7
Total			25.4	1.35	1.05	0.85	2.75	2.1	0.8	1.25	35.25	12.6

From Table 4.11, the total waste was obtained as 35.25kg while the total compost obtained from Houses A, B, C and D was 12.6kg. Houses A, B, C and D generated 6.54kg, 11.36kg, 6.32kg and 5.8kg respectively.

Table 4.12: Composition of Organic Waste

S/N	Spoiled/ Perishable Food(s)	Bones	Vegetables/ Leaves	Wood(s)
1.	6.65kg	0.05kg	-	-
2.	6.95kg	-	0.25kg	0.3kg
3.	5.40kg	-	-	-
4.	5.70kg	0.10kg	-	-
Percentage Composition	97.24%	0.59%	0.98%	1.18%

From Table 4.6, the total compostable waste generated from House A, House B, House C and House D was 19kg) while the percentage composition of organic waste was 97.24% (for spoiled/perishable foods), 0.59% (for bones), 0.98% (for vegetables/leaves) and 1.18% (for woods). The weights of the spoiled/perishable foods obtained from the respective houses were 6.65kg, 6.95kg, 5.40kg and 5.70kg. The weights of the bones obtained from the respective houses A and D houses were 0.05kg, 0.10kg while houses B and C had no weights. The weights of the vegetables/leaves obtained from house B was 0.25kg while houses A, C, D had no weights. The weights of the woods obtained from house B was 0.3kg while houses A, C, D had no weights.

Table 4.13 shows the description of the compost generated after week 3.

Table 4.13: Rate of Compost Formation per House

Number Of Houses	Organic Waste Generated (kg)	Rate Of Compost Formation Per House (kg)
4	25.4	6.35

18 From the analysis of the results obtained in Table 4.13; House A generated 3.4kg, House B generated 3.7kg, House C generated 2.8kg and House D generated 2.7kg. From Table 4.13; the total compostable waste generated was 25.4kg and an average of 6.35kg of compostable waste was generated (per house) and 2.82kg (per person) on the third week.

4.2.4 Results of Week 4 Composting

Table 4.14, 4.15 and 4.16 shows the weight of the items collected before and after composting, 24 the composition of the organic waste and the rate of compost formation per house.

Table 4.14: Weight before and after Composting (Week 4)

S/N	House Address	Family Size	Values in kg									
			Organic Wastes	Papers	Cellophane And Sachets	Plastics	Textile	Metal	Glass	Others	Total Waste	Wt. After Composting
1.	House A	2	5.2	0.32	0.2	0.3	3	1	-	0.5	10.52	1.9
2.	House B	3	6	0.1	0.05	-	0.2	-	0.8	0.4	7.55	2.8
3.	House C	2	6.3	-	0.26	1.1	-	-	0.2	0.1	7.96	2.4
4.	House D	2	4.5	0.4	-	-	0.3	0.2	-	0.2	5.6	1.5
Total			22	0.82	0.51	1.4	3.5	1.2	1.0	1.2	31.63	8.6

From Table 4.5, the total waste was obtained as 31.63kg while the total compost obtained from Houses A, B, C and D was 8.6kg. Houses A, B, C and D generated 6.54kg, 11.36kg, 6.32kg and 5.8kg respectively.

Table 4.15: Composition of Organic Waste

S/N	Spoiled/ Perishable Food(s)	Bones	Vegetables/ Leaves	Wood(s)
1.	5.18kg	0.02kg	-	-
2.	6kg	-	-	-
3.	6.2kg	-	-	0.1kg
4.	4.45kg	0.05kg	-	-
Percentage Composition	99.32%	0.091%	0%	0.0455%

From Table 4.6, the total compostable waste generated from House A, House B, House C and House D was 19kg) while the percentage composition of organic waste was 99.32% (for spoiled/perishable foods), 0.091% (for bones), 0% (for vegetables/leaves) and 0.0455% (for woods) respectively. The weights of the spoiled/perishable foods obtained from the respective houses were 5.18kg, 6.00kg, 6.2kg and 4.45kg. The weights of the bones obtained from houses A and D were 0.02kg and 0.05kg while houses B and C had no weights. The weights of the woods obtained from the respective house C was 0.1kg while houses A, B and D had no weights.

Table 4.16 shows the description of the compost generated after week 4.

Table 4.16: Rate of Compost Formation per House

Number Of Houses	Organic Waste Generated (kg)	Rate Of Compost Formation Per House (kg)
4	22	6.35

18 From the analysis of the results obtained in Table 4.16; House A generated 1.9kg, House B generated 2.8kg, House C generated 2.4kg and House D generated 1.5kg. From Table 4.16; the total compostable waste generated was 22kg and an average of 6.35kg of compostable waste was generated (per house) and 2.44kg (per person) on the fourth week.

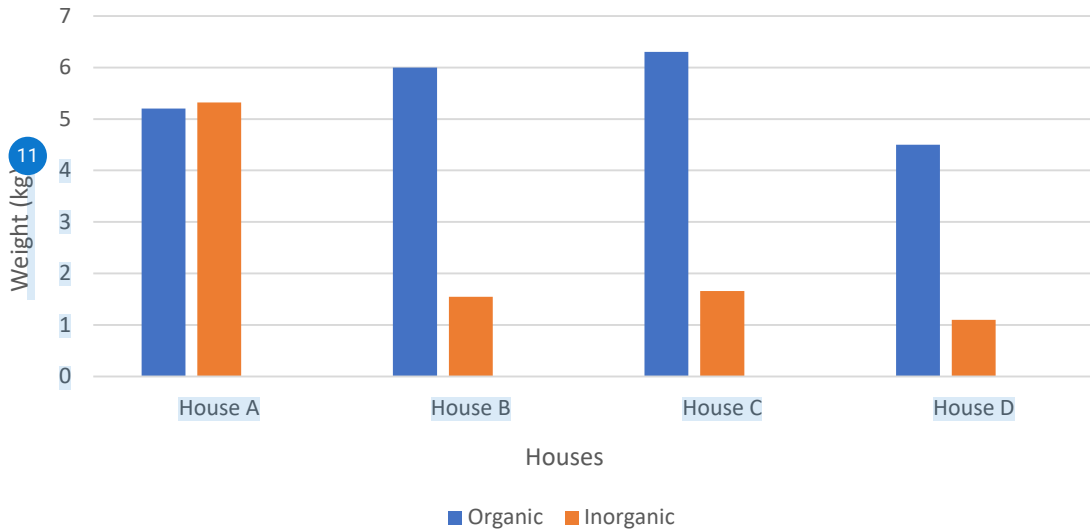


Figure 4.1 Charts of Organic and Inorganic waste generated for Week 1

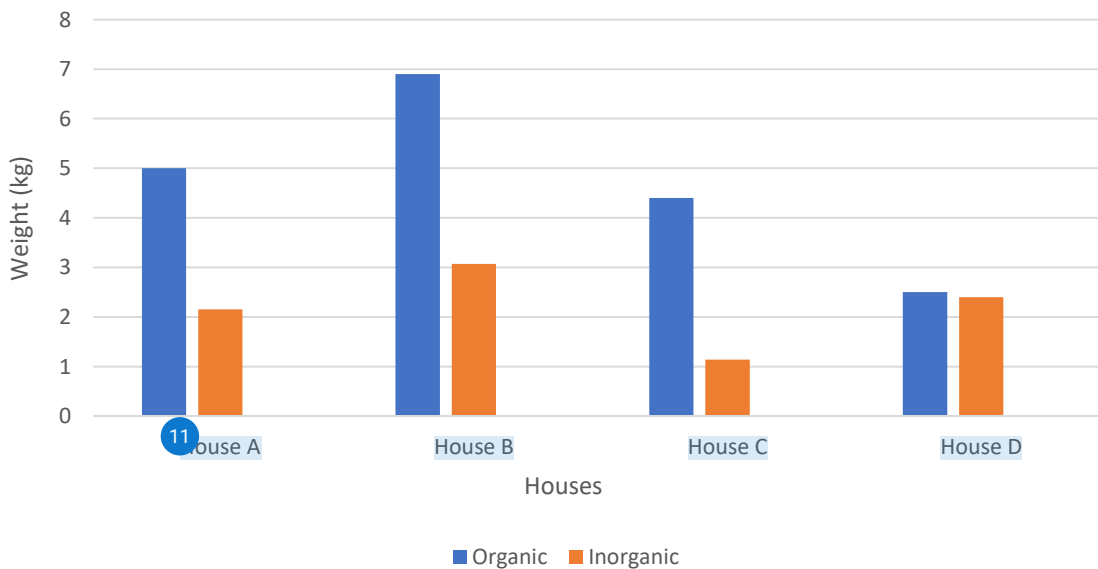


Figure 4.2 Charts of Organic and Inorganic waste generated for Week 2

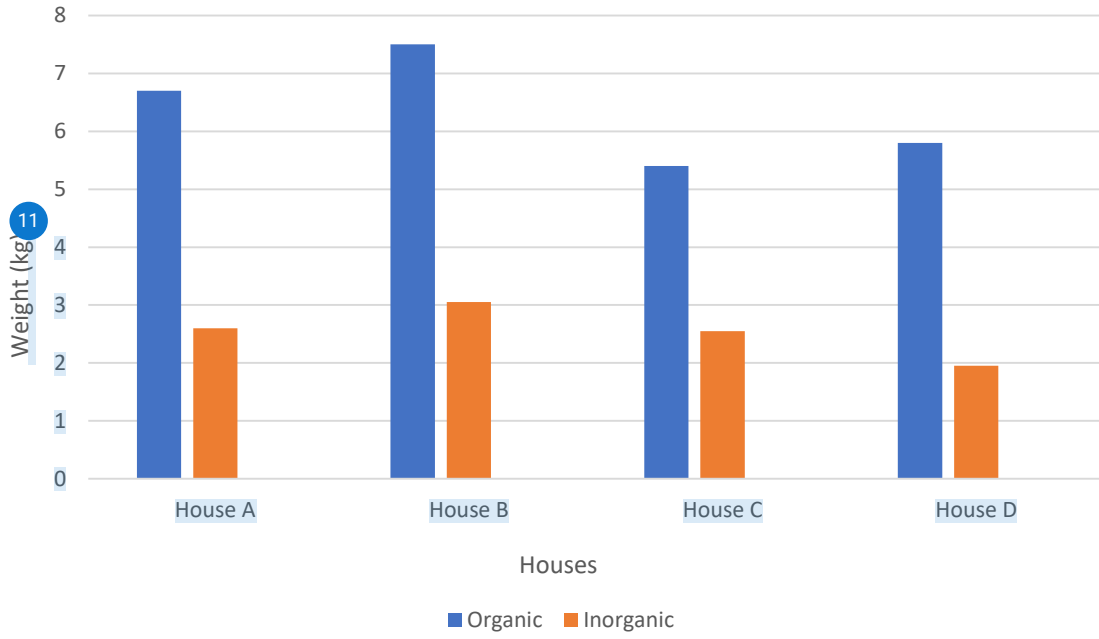


Figure 4.3 Charts of Organic and Inorganic waste generated for Week 3

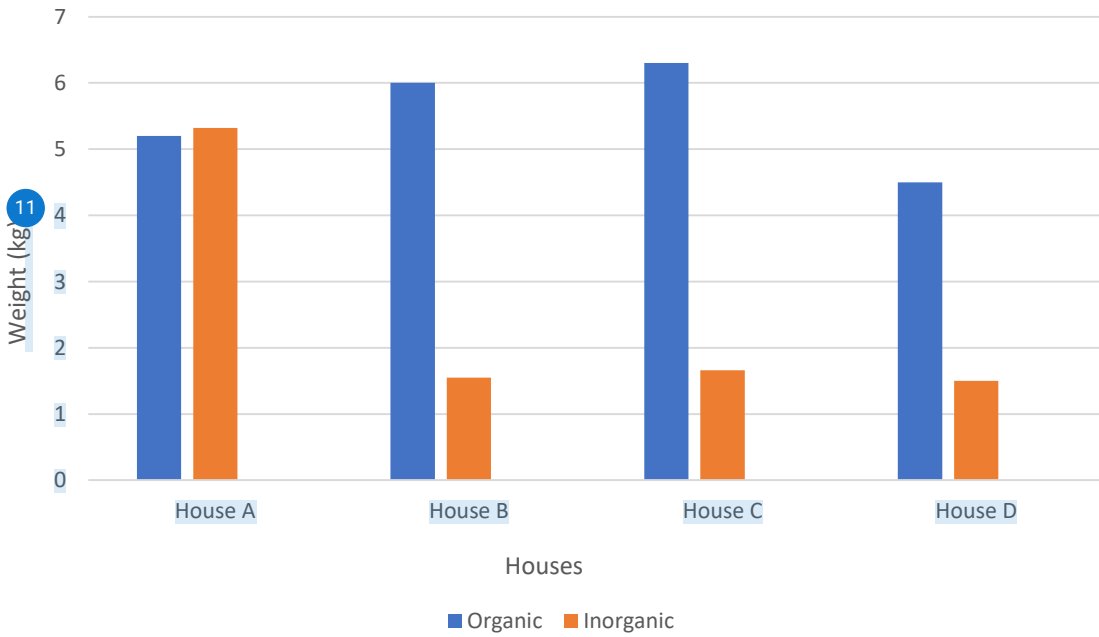


Figure 4.4 Charts of Organic and Inorganic waste generated for Week 4

4.3 ADDITIONAL RESULTS

The following are some of the additional results obtained in this study:

4.3.1 Weekly Organic Waste

Table 4.17 shows a breakdown of the percentage organic waste produced in Week 1, Week 2, Week 3 and Week 4 respectively which had a percentage of 63.29%, 68.21%, 72.05% and 69.55%. From these results, it is evident that the Week 1 produced the least percentage of organic waste while Week 3 produced the largest percentage of organic waste. In addition, an average percentage of 68.28% was generated during this study within a period of four weeks.

Table 4.17: Weekly organic waste produced (%)

WEEK	ORGANIC WASTE PRODUCED PER WEEK (%)
1	63.29
2	68.21
3	72.05
4	69.55

Table 4.18 shows the percentage moisture content of the organic waste produced in Week 1, Week 2, Week 3 and Week 4 per household. From these results, it can be deduced that on the first week, house A produced the least moisture content with a value of 63.29% while house D produced the highest moisture content; in the second week, house A also produced the least moisture content while house D produced the highest moisture content; in the third week, house C produced the least moisture content while house D produced the highest moisture content and on the fourth week, house B produced the least moisture content while house D produced the highest moisture content.

Table 4.18: Household weekly moisture content (%)

MOISTURE CONTENT (%)				
HOUSES	WEEK 1	WEEK 2	WEEK 3	WEEK 4
A	45	50	49.25	63.46
B	52	50.72	50.67	53.33
C	63	54.52	48.14	61.90
D	64	64	53.44	66.66

79 CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

This study assesses the compost potential of domestic wastes with the benefits of lowering the amount of hazardous substances released into the environment and transforms domestic wastes into useful form, through a less harmful method which can be carried out aerobically using the method of composting. Due to the 63 improper management of domestic waste which result in environmental pollution, new cost-efficient methods for better waste management are been implemented.

From this study, the domestic waste generated from weeks 1, 2, 3 and 4 weighed 30.02kg, 27.56kg, 35.25kg and 31.63kg respectively. This implied that a total domestic waste of 124.46kg was generated. An average domestic waste was generated after four weeks of composting from the respective houses was 31.11kg, which produced an average compost of 9.65kg which was determined to be about one-third of the average domestic waste collected during this study.

Composting 119 as a sustainable waste management technique has been studied to be economical and eco-friendly. Composting contributes greatly to the use of solid waste and should be considered as an integral part of a global strategy 64 for the collection, treatment and disposal of biodegradable waste.

3.2 RECOMMENDATIONS

The following are some of the recommendations in this study:

- i. The collection of waste from houses, landfills and waste disposal sites are encouraged for compost generation as this offers a veritable avenue to obtain large quantity of waste.
- ii. Composting in large-scale may require more work, a larger land area for the storage of compost pits and more skilled hands. For this reason, proper planning is encouraged.
- iii. ¹⁰⁵ The use of decomposers as a means of decomposing solid waste is encouraged.
- iv. The proper storage of compost bins so as to prevent pollution such as the smell or dust from compost is recommended.

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APPENDICES



Plate 1.1 Compost obtained from HOUSE A generated from the waste of WEEK 1.



Plate 1.2 Compost obtained from HOUSE B generated from the waste of WEEK 1.



Plate 1.3 Compost obtained from HOUSE C generated from the waste of WEEK 1.



Plate 1.4 Compost obtained from HOUSE D generated from the waste of WEEK 1.



Plate 1.5 Compost obtained from HOUSE A generated from the waste of WEEK 2.



Plate 1.6 Compost obtained from HOUSE B generated from the waste of WEEK 2.



Plate 1.7 Compost obtained from HOUSE C generated from the waste of WEEK 2.



Plate 1.7 Compost obtained from HOUSE D generated from the waste of WEEK 2.



Plate 1.8 Compost obtained from HOUSE A generated from the waste of WEEK 3.



Plate 1.9 Compost obtained from HOUSE B generated from the waste of WEEK 3.



Plate 2.0 Compost obtained from HOUSE C generated from the waste of WEEK 3.



Plate 2.1 Compost obtained from HOUSE D generated from the waste of WEEK 3.



Plate 2.2 Compost obtained from HOUSE A generated from the waste of WEEK 4.



Plate 2.3 Compost obtained from HOUSE B generated from the waste of WEEK 4.



Plate 2.4 Compost obtained from HOUSE C generated from the waste of WEEK 4.



Plate 2.5 Compost obtained from HOUSE D generated from the waste of WEEK 4.

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