WOLKITE UNIVERSITY

COLLEGE OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF CHEMICAL ENGINEERING

THESIS ON PRODUCTION OF SOLID ORGANIC FERTILIZER FROM STUDENT'S CAFETERIA SOLID FOOD WASTES.

A THESIS SUBMITTED TO WOLKITE UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR SCIENCE (BSc) IN CHEMICAL ENGINEERING UNDER PROCESS STREAM.

PREPARED BY: -

NAME	ID NO
1. ASNAKE BELETE	134/09
2. BERKENEH ALEMU	170/09
3. FANTAHUN AWOKE	358/09
4. EJARA DAJENE	292/09
5. SHIFERAW DECHASA	773/09

Submission date; August 23/2021

WKU, Ethiopia

DECLARATION

We declare that this final thesis entitled ‘’ production of organic fertilizer from student cafeteria solid food wastes‘‘ is our own work and has not been submitted previously by any other researcher. Whenever contributions of others are involved, every effort is made to indicate this clearly, with due reference to the literature and discussions. Information was taken from published and unpublished work of others has been acknowledged in the text and a list of references is given. This work was under the guidance of Mr.Abowerk.

Name of students	signature	date
Fentahun Awoke	....…………………..	...............……….
Asnake Belete	....…………………..	................………..
Berkeneh Alemu	....…………………..	................………
Ejara dejene	....	....
Shiferaw Dechasa	....	....

Advisor	signature	date
Mr. Abowork	………………………...	....

APPROVAL PAGE

This is to certify that the, “production of organic fertilizer from solid food waste by using aerobic composting method” and submitted for fulfillment for the award of the Bachelor’s Degree in Chemical Engineering, complies with the regulations of the university and meets the accepted standards with respect to originality, content and quality.

Approved by:

Advisor	**Signatures**	**Date**
Mr Abowork	....	....
Examiners	**Signatures**	**Date**
1.	....	....
2.	....	....
3.	....	....
4.	....	....
Head of the department	**Signatures**	**Date**
Dr. Gebre Egnet	....	....

ACKNOWLEDGMENT

First we would like to express our praise to the Almighty God for giving us strength, patience and hope for doing this project from the beginning up to the end. Next to God, we would like to express our sincere and immense appreciation to our thesis project advisor Mr. Abowork for continuously providing his guidance, comments and encouragements to the best flow of the project. We would like to thanks to food processing engineering and biotechnology departments and laboratory assistants for allowing us to use all laboratory equipment's with full freedom and for their technical advice and moral supports for the preparation of raw material and analysis nutrient content of the product. Finally, we would like to acknowledge all chemical engineering laboratory assistants.

ABSTRACT

In wolkite university student's cafeteria and lounge, there is large amount of food wastes, which is being disposed continuously. Thus, it needs a solution to convert it into valuable products. The main objective of this project is production of organic fertilizer aerobically from these food wastes. To produce the organic fertilizer, the food waste was collected and prepared. The ratios of Bread to Injera to Onion peels was formulated as R1 (1:2:1), R2 (1:1:1), and R3 (2:2:1) and Moisture contents (20%, 50%and 70%). The prepared raw materials were composted by aerobic method of composting for a month and then the products were collected. The experiments were conducted on moisture content, organic matter, carbon content, water holding capacity, pH and macro nutrients (N, P, and K). Finally, among the total results, from the experimentation the maximum product was found at R2 and 50% moisture content. The total product was obtained 76g of fertilizer from 105g of the feed materials with the value of 0.63% nitrogen, 0.711% phosphorus, and 0.972% potassium. And also, Water holding capacity, organic matter, pH and carbon content of organic fertilizer were 41.92%, 50.2%, 5.51, and 27.89% respectively. This showed that the food by-products have the potential of producing organic fertilizers which are environmentally friendly.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ACRONYMS

C: N	Carbon to nitrogen ratio
^{o}C	Degree centigrade
NPK	Nitrogen-phosphorus-potassium
PH	Potential hydrogen
TOC	Total organic carbon
TOM	Total organic matter
R1	Ratio of Bread: 2 Injera: Onion peels
R2	Ratio of Bread; Injera; Onion peel
R3	Ratio of 2 Bread:2 Injera :Onion peels
WHC	Water holding capacity

1. INTRODUCTION

1.1 Background

Fertilizers are organic or inorganic, natural or synthetic substances that are added to soil to enhance plant growth and production. Plants depend on the nutrients in soil to carry out metabolic reactions because soil contains basic chemicals for plant growth (1). However, the supply of basic chemicals in soil to plants is limited. When plants are being harvested, the nutrient content reduces and causes the reduction of quantity and quality of plants. Fertilizers are applied to replace the chemical materials in soil that are utilized by plants during growth and development (2).

Fertilizers are used to enhance the soil's growing potential because fertilizers are able to provide a better growing condition for plants as compared to natural soil. Fertilizers provide large amount of macronutrients such as nitrogen, phosphorous and potassium while natural soil may not contain sufficient amount of this macronutrients (1). Fertilizers also provide trace elements such as magnesium, calcium and copper that are crucial in plant growth (2). Different types of fertilizers are applied to different types of crops to improve crop growth and production. The types of fertilizers are divided according to the amount of nitrogen and other elements. The examples of fertilizer are sodium nitrates, ammonium sulphate and ammonium salts. Sodium nitrates fertilizer enhances the growth of plants such as wheat, barley and root vegetables because it contains nitrogen that is easily release to plants (3).

Ammonium sulphate fertilizer contains sulphur and nitrogen and is usually applied to alkaline soil to maintain pH balance of soil (1). Inorganic fertilizers are synthetic and chemical fertilizers that are made up of various formulations to apply to different types of crops. Inorganic fertilizers come in powder, granular and pellets inboxes or bags and liquid formulation in bottles. They can provide nutrition rapidly to plants and designed for plants to absorb directly macronutrients and micronutrients (2). Organic fertilizers are natural fertilizers that are made up from animals, plants and minerals. They can be made up from compost, manure, wood ash and peat moss. Organic fertilizers are crucial in agricultural sector because they have positive effect on soil without damage ground water and plants (3).

Organic fertilizers improve soil quality and produce crops with better yield and quality. Production of Organic Fertilizer from Food Waste Organic matter in organic fertilizers is decomposed by soil organism which is slower than inorganic fertilizers (2). The slow release of organic matter reduces nutrient leaching thus maintain soil fertility. Organic fertilizers can be produced by recycling food waste into useful soil amendment for farming (4). Organic fertilizers from food waste can reduce the usage of conventional nitrogen based fertilizers that may cause leaching in oceans, rivers and groundwater.

Food waste is food material that is unused, discarded and not safe to be consumed by human for avoidable reasons at production line. Food waste is edible animals and plants that are harvested to be consumed but not evenly consumed by human because it is spoilt and discarded. Most food waste has been land filled together with other wastes, resulting in various problems such as emanating odor, attracting vermin, emitting toxic gases, contaminating groundwater by the leach ate and wasting landfill capacity. Methane (CH_4) and carbon dioxide (CO_2) emitted as a result of microbial activity under uncontrolled anaerobic conditions at dumping sites are released into the atmosphere and contribute to global warming (5).Composting is a good idea to reduce the amount of solid waste in the landfill. Composting is a controlled decomposition where natural breakdown process occurs. It is the transformations of raw organic materials into biologically stable, humid substances suitable for a variety of soils and plant uses.

The by- products from student cafeteria has the potential of affecting the environment and can be the cause of greenhouses gas emission. Therefore, converting these food by-products into valuable organic fertilizer is the major aim of this project. The aim of this study is to evaluate the physiochemical property of compost made from food wastes of Injera, Bread and Onion peels by using aerobic composing system. And the effect of mixing ratio and moisture content on composting was analyzed (3).

1.2 Statement of Problems

There are large amount of Food waste generated from WKU student's cafeteria. This includes leftover bread, Injera, rice, potato peels, onion peelings, meat, and bones. This is not good for human health as well as for the natural environment. They produce an intolerable smell and contribute environmental pollution. However, these organic food wastes have a potential to produce organic fertilizer. Among from these food wastes are considered to reuse and recycle them is important. Therefore, this project intended to produce organic fertilizer from locally available food wastes environmentally friendly.

1.3 Objectives

1.3.1 General Objective

The general objective of this project is to produce solid organic fertilizer from student cafeteria solid food wastes.

1.3.2 Specific Objectives

- To characterize the physicochemical properties of raw materials (food waste).
- To investigate the effects of mixing ratios and moisture contents on organic fertilizer.
- To characterize the physicochemical properties of the product.

1.4 Scope of the Project

The scope of this project is to produce organic fertilizer (compost) from food wastes of Bread, Injera and Onion peels, and to characterize the physiochemical property of the raw material and produced organic fertilizer and also investigate the effect of moisture content and mixing ratio.

1.5 Limitations

In this project different challenges were occurred to perform the complete study of the project. The major limitations are:

- **Lack of materials and equipment**: there was the shortage of supply full equipment in chemical engineering department laboratories.
- **Lack of time**: The process is not complete in a short period of time. Because it tacks time.
- Other departmental laboratories were not open at any time when we want to done the experimental activities.
- **Climate condition:** the season was winter and very cold. The heat and temperature also too low. It affects the rate of decomposition process.

1.6 Significance of the Project

This project area has significance on effective utilization of food wastes into organic fertilizer to improve soil structure, health and fertility to promote healthier plant growth and higher yields of agricultural crops. By using compost, farmers and gardeners spend less money on expensive fertilizers and pesticides, water, and irrigation and can use that hard-earned cash for expanding their production capacities. Compost reduces and in some cases eliminates the need for chemical fertilizers and it can compensate for a lack of fertilizers. It provides an economically feasible option to produce organic fertilizer, which will play a major role of compost which saves foreign currency and create job opportunity for people. Food waste composting plays an important role in food disposal facilities and serves as a source of income by supplying for the compost producers. By composting wasted food, methane emissions are significantly reduced and decrease the environmental pollution.

2. LITERATURE REVIEW

2.1 Food Waste

Food waste refers to all unconsumed food substances that are disposed of or recycled. Food waste is generated from households, markets, hawker centers, supermarkets and food courts or other eating establishments (6). The types of food waste from different sources can be primarily categorized into two types, namely, preconsumption and postconsumption food wastes (7). Preconsumption food waste refers to the food waste generated during food preparation, as well as unused food discarded before human consumption. Some examples of preconsumption food waste are peelings, apple cores, bones, eggshells, and coffee grounds. On the other hand, postconsumption food waste is any leftover food, usually processed or cooked, generated after human consumption. These wastes must be removed to provide a clean and healthy environment. These can be achieved through the use of composting to manage the waste and to produce compost that can be used in field crop production. Food waste has high energy content and it seems ideal to achieve dual benefits of energy production and waste stabilization. More than a third of total waste generated in households is organic or bio-waste. Lost organic matter directly impoverishes land, degrades agricultural land, draws up accumulated carbon deposits (oil, gas), creates social inequality in the countries where these products come from, encourages climate change (8).

Food losses take place at production, post-harvest and processing stages in the food supply chain. Food losses occurring at the end of the food chain are rather called food waste which relates to retailers and consumers behaviour. Food waste or loss is measured only for products that are directed to human consumption, excluding feed and parts of products which are not edible. Per definition, food losses or waste are the masses of food lost or wasted in the part of food chains leading to edible products going to human consumption (9).

Kitchen waste mostly generates food scraps for disposal. Throwing these scraps can create odor problems and add to the volume of waste going to landfills. As for the composting of kitchen waste, according to, (10) used bio- composter as a composted and the study was conducted for 4 years, from 2008 to 2011 for 135 days per year. The highest temperature recorded was $64^{o}C$ and decreased to 32.7^{o}C at the ambient temperature; the moisture content was observed at 55.8% and decreased to 21.7% at day 36. The loss of moisture content was due to the high temperature. For the pH, an acid pH was recorded during the early days of composting due to the production of organic acids, the pH rose up to 8.6 but later dropped to 6.3. For compositions of the nutrients N, P, K was between 1.16 to 1.20%, 0.03 to 0.053% and 0.30 to 0.38%

In the other study, in vessel composter was used as a method to compost kitchen wastes. The composting process was conducted for 22 days. The compost was mixed with 2 kg of sludge's as inoculums and 3.5 kg of sawdust. The temperature was recorded at 55^{o}C on day 2 and this temperature maintain at day 7. The initial pH value was 5.5 and moisture contents are between 48 to 53%. The C: N ratio decreased from 35.92 to 19 (8).

2.1.1 Raw Materials or Feedstock's of Compost Characterization

Food waste such as fruits, vegetables, grain, and bread can be composed and converted into organic fertilizers. Food waste is widely recycled into organic fertilizer because food waste has special features as raw compost agent. Food waste contains high energy and is suitable for energy production and waste stabilization. The ratio of carbon to nutrients of organic wastes is crucial during fermenting and composting process (11).

Food waste refers to all unconsumed food substances that are disposed of or recycled. Food waste is generated from households, markets, hawker centers, supermarkets and food courts or other eating establishments (5). These wastes must be removed to provide a clean and healthy environment. These can be achieved through the use of composting to manage the waste and to produce compost that can be used in field crop production. Food waste has high energy content and it seems ideal to achieve dual benefits of energy production and waste stabilization (7). In addition, the compost should not include oily cooked food, meat, or fish as they contain pathogen, which may contaminate the compost. Hard items such as bones or oily and greasy items such as cheese also should not be put into the composting process (10).

2.1.2 Food Waste is Unique as a Compost Agent

Food waste has unique properties as a raw compost agent. 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, is good choices.

Food waste has high moisture content and low physical structure as compared to sewage sludge and Manure. Food waste is mixed with bulking agents such as yard waste and sawdust that contain high C: N ratio to absorb more moisture and add structure to the mix thus enhancing composting of food waste. The ratio of carbon to nutrients of organic wastes is crucial during fermenting and composting process (7).

2.2 Background of Compost

Composting is the natural process of 'rotting' or decomposition of organic matter by microorganisms under controlled conditions. Raw organic materials such as crop residues, animal wastes, food garbage, some municipal wastes and suitable industrial wastes, enhance their suitability for application to the soil as a fertilizing resource, after having undergone composting.

Compost is a rich source of organic matter. Soil organic matter plays an important role in sustaining soil fertility, and hence in sustainable agricultural production. In addition to being a source of plant nutrient, it improves the physio-chemical and biological properties of the soil. As a result of these improvements, the soil becomes more resistant to stresses such as drought, diseases and toxicity, helps the crop in improved uptake of plant nutrients and possesses an active nutrient cycling capacity because of vigorous microbial activity. These advantages manifest themselves in reduced cropping risks, higher yields and lower outlays on inorganic fertilizers for farmers. (12)

Composting involves the conversion of organic residues of plant and animal origin into manure. The main product of composting is the compost which is rich in humus and plant nutrients and the by-products are carbon dioxide, water, and heat. It needs oxygen to carry out the composting process which is called as aerobic composting (13). According to Jovino L. that organic fertilizers are residues of any plant or/and animals in various degrees or stages of composition (4). Aerobic microorganisms use organic matter such as food waste, agriculture waste as a substrate. The microorganisms decompose the substrate, breaking it down from complex to intermediate and lastly to simpler compounds. The mixture contains carbon and nitrogen. During composting they are transformed through successive activities of different microbes to more stable organic matter, which chemically and biologically resembles humid substances. There are a few steps to reduce the composting time. The first one is taking care of the carbon to nitrogen (C/N) ratio properly and the temperatures at desirable levels. Besides, make sure that the particle size of the greens and browns are small and do not add too hard items such as bones, or oily and greasy items such as cheese (9).

2.3 Composting process Methods

Food wastes, plants and Animal manure with bulking agents can be composted in a number of different ways, including aerobic and anaerobic methods such as passive manure piles, passive aerated windrows, aerated static pile, in-vessel, pit, vermin composting and windrows systems (14).

2.3.1 Aerobic Composting

Aerobic composting is the process by which organic wastes are converted into compost or manure in presence of air. In this process, aerobic microorganisms break down organic matter and produce carbon dioxide, ammonia, water, heat and humus, the relatively stable organic end-product. Although aerobic composting may produce intermediate compounds such as organic acids, aerobic microorganisms decompose them further. The resultant compost, with its relatively unstable form of organic matter, has little risk of phytotoxicity. The heat generated accelerates the breakdown of proteins, fats and complex carbohydrates such as cellulose and hemicellulose. Hence, the processing time is shorter. Moreover, this process destroys many micro-organisms that are human or plant pathogens, as well as weed seeds, provided it undergoes sufficiently high temperature. Although more nutrients are lost from the materials by aerobic composting, it is considered more efficient and useful than anaerobic composting for agricultural production. There are a variety of methods for aerobic composting (15).

The most common being the Heap Method, where organic matter needs to be divided into three different types and to be placed in a heap one over the other, covered by a thin layer of soil or dry leaves. This heap needs to be mixed every week, and it takes about three weeks for conversion to take place. The process is same in the Pit Method, but carried out in specially constructed pits. Mixing has to be done every 15 days, and there is no fixed time in which the compost may be ready.

In vessel method, these include bin composting, rectangular agitated bins, and silos. In-vessel composting system was first developed by Becari and modified by Verdier and Bordas, and latter several such systems have been developed. The main advantage of this system is process rapidity, low land requirement, complete process control and consistency of end-product. The main feature of in-vessel composting systems is that the compost materials are mixed and the mass advanced and aerated automatically and mechanically. (16)

Berkley Method uses a labor-intensive technique and has precise requirements of the material to be composted. Easily biodegradable materials, such as grass, vegetable matter, etc., are mixed with animal matter in the ratio of 2:1. Compost is usually ready in 15 days.

2.3.2 Anaerobic composting

Anaerobic composting is decomposition that occur using microorganisms that do not require oxygen to survive. In an anaerobic system the majority of the chemical energy contained within the starting material is released as methane. The process is characterized by very strong odors and only a small amount of heat is generated meaning decomposition takes much longer and doesn't reach sufficient temperatures to safely kill plant pathogens, weed and seeds. To overcome these limitations external (artificial) heat is normally added. As the material is broken down by anaerobic digestion, it creates a sludge-like material that is even more difficult to break down. This material, digest ate, typically requires aerobic composting to complete the stabilization process (5).

2.3.4 Vermicomposting

Vermicomposting is a type of composting in which certain species of earthworms are used to enhance the process of organic waste conversion and produce a better end-product. It is a mesophilic process utilizing microorganisms and earthworms. Earthworms feeds the organic waste materials and passes it through their digestive system and gives out in a granular form (cocoons) which is known as vermicomposting. Earthworms consume organic wastes and reduce the volume by 40–60 percent (8).

The level of nutrients in compost depends upon the source of the raw material and the species of earthworm. Apart from other nutrients, a fine worm cast is rich in NPK which are in readily available form and are released within a month of application. Vermicomposting enhances plant growth, suppresses disease in plants, increases porosity and microbial activity in soil, and improves water retention and aeration.

2.4 Factors Affecting Food Waste Composting Process

In order to produce a good quality of organic fertilizer from organic waste, there are some parameters which will affect the food waste composting process. All the factors have their optimum level to produce good quality compost. The factors are moisture content, temperature, pH, and Carbon to Nitrogen ratio. By controlling all these parameters at optimum level, the rate of composting can be increased and the nutrients in the compost will be better. Different material has different C/N ratio. After referring many previous researches, the optimum C/N ratio for composting is 25-30:1 (8). The C/N ratio is calculated based on the weight percentages of the component wastes in the mixture (9). The compost temperature may vary from 25°C to 70°C. Therefore, the composter has to retain heat by not easily lose heat to the surrounding. The pH value for good composting should be nearly neutral in pH is 6.0 to 7.0 (2).

2.4.1 Oxygen

Aerobic composting requires large amounts of O_2, particularly at the initial stage. Aeration is the source of O_2, and, thus, indispensable for aerobic composting (17). Where the supply of O_2 is not sufficient, the growth of aerobic micro-organisms is limited, resulting in slower decomposition. The recommended oxygen value range of feedstock has been reported to be 10-30% (18). Moreover, aeration removes excessive heat, water vapor and other gases trapped in the pile. Heat removal is particularly important in warm climates as the risk of overheating and fire is higher. Therefore, good aeration is indispensable for efficient composting. It may be achieved by controlling the physical quality of the materials (particle size and moisture content), pile size and ventilation and by ensuring adequate frequency of turning.

2.4.2 Carbon-Nitrogen Ratio

For composting to proceed efficiently, microorganisms require specific nutrients in an available form, adequate concentration, and proper ratio. The essential macronutrients needed by microorganisms in relatively large amounts include carbon (C), nitrogen (N), phosphorus (P), and potassium (K). Microorganisms require carbon as an energy source. They also need carbon and nitrogen to synthesize proteins, build cells, and reproduce. The recommended C: N ratio of feedstock has been reported to be 25:1 to 40:1 (19). The ideal carbon-to-nitrogen ration is 30:1, because it is at that ratio where microbial activity is at its greatest. If the C:N ratio is too low in the compost pile, the microorganisms may lose nitrogen into the air as ammonia. If the C:N ratio is too high in the compost pile, the decomposition process diminishes due to the lack of nitrogen. Several materials with differing C:N ratios can be blended to achieve an ideal C:N ratio.

2.4.3 Moisture Content

Microorganisms require moisture to assimilate nutrients, metabolize new cells, and reproduce. They also produce water as part of the decomposition process. If water is accumulated faster than it is eliminated via either aeration or evaporation then, oxygen flow is impeded and anaerobic conditions result (20). According (14), the acceptable moisture content throughout the composting process is 45-65 percent; however, the optimum range is 50-60 percent. Compost piles require moisture for microbial activity crucial to the decomposition to occur efficiently. Those living in areas with little rainfall will be required to water the compost heap periodically to maintain an efficient decomposition rate. Enough water should be added to moisten the pile, but you should avoid overwatering as doing so can replace the air in the pile with water, suffocating the microorganisms. This will result in anaerobic conditions which will slow down the decomposition process and produce foul odors. Piles that are too wet should be turned frequently to increase air. Piles that are too dry should be turned and sprinkled with water. https://www.fast-growing-trees.com/pages/factors-that-affect-composting.

2.4.4 PH

Bacteria prefer a pH between 6 and 7.5. Fungi thrive in a wider range of pH levels than bacteria, in general preferring a pH between 5.5 and 8 (21). If the pH drops below 6, microorganisms, especially bacteria, die off and decomposition slows (22). If the pH reaches 9, nitrogen is converted to ammonia and becomes unavailable to organisms. This too slows the decomposition process (23).

2.4.5 Temperature

Temperature is a critical factor in determining the rate of decomposition that takes place in a composting pile. The most effective composting temperatures are between 45 and 59°C (113 and 138°F) (19). If temperature is less than 20°C (68°F), the microbes do not proliferate and decomposition slows. If temperature is greater than 59°C (138°F), some microorganisms are inhibited or killed, and the reduced diversity of organisms results in lower rates of decomposition (24).

2.4.6 Particle size

The particle size of the feedstock affects the composting process (14). The size of feedstock materials entering the composting process can vary significantly. In the large particle size the sample as a bulking agent (air circulation easier) and less available of carbon but in small size it is large surface contact, microbial activity increases. In general, the smaller the shreds of composting feedstock, the higher the composting rate. The best range of the particle size is 10-50mm (17).

2.5 Evaluating Compost Quality in Physical and Chemical Attributes

Compost quality can be described in terms of age, maturity, and nutrient content, and other physical, biological and chemical properties. Parameters, which may have a significant influence on compost quality and taken in to consideration in this study, are discussed below (15).

2.5.1 PH

The pH value of compost is important, since applying compost to soil may alter the soil pH and therefore have an effect on the availability of nutrients to plants (23). The Recommended range of pH from 6.9-8.3. But the acceptable pH values in European countries compost quality standards range from 6.5-8.5 (15). A good mix of varied materials and a well aerated compost bin will naturally produce neutral pH compost. Turning the compost to aerate and improve air circulation will help reduce acidity. This is because in the early stages of decomposition the composting bacteria release organic acids. These are great for breaking down some of the more difficult “brown” feedstocks like branches and twigs and they also encourage fungi growth. Adding wood ashes to compost is also said to help neutralize the mix. Ashes are more alkaline in nature and are also a good source of potassium (one of the essential nutrients for growing plants).

2.5.2 Moisture content

Compost with low moisture content can become too clumpy and difficult to transport. Bio treat (2003) and US Composting recommend a moisture range of 45-65% (15) . Fresh materials such as vegetable peelings and grass clippings have a high water content, which makes them heavy. If too much is added to your compost heap at once it can become compacted, excluding air or filling air spaces with water. If your compost bin is too dry it will stop decomposing as the bacteria and fungi responsible for the composting process won't be able to work effectively. Re-wet the heap by watering it - ideally with rainwater, but if you don't have any stored rainwater ordinary water will do. Apply it evenly using a watering can fitted with a rose, mixing the materials at the same time if you can.

2.5.3 Organic matter

Organic matter is an important ingredient in all soils and has an important role to play in maintaining soil structure, nutrient availability and water holding capacity. It is usually expressed as a percentage of dry weight. There is no absolute value of organic matter, which is ideal for compost. It may range from 30-70% (15).

2.5.4 Water holding Capacity (WHC)

Water holding capacity is the ability of hold water. Increasing the water holding capacity of the soil by adding the compost helped all crops during the summer drought by reducing periods of water stress and amendment the soil (12). A wet sample of known initial moisture content was weighed and placed in a beaker. After soaking in water for 1–2 hours and draining excess water through what man filter paper, the saturated sample was weighed again. The amount of water retained by dry sample was calculated as the WHC. The water holding capacity (g water/g dry material) is calculated as;

$$\text{WHC} = \frac{(mass\ of\ soaked\ sample - mass\ of\ dry\ sample) * 100\%}{mass\ of\ soaked\ sample} \quad (1)$$

2.6 Nutrient Content of Compost

Compost contains macro and micronutrients, which are required for plant growth (24). Nitrogen, phosphorous and potassium are the nutrients, which are utilized, in the greatest quantities by plants (19).

2.6.1 Total Nitrogen

Nitrogen is an essential nutrient for successful plant production. The concentration and availability of nitrogen in compost is a very important factor to be assessed when considering its agronomic value. Role of nitrogen in plants are, essential for Amino acid formation, Necessary for cell division and for plant growth, Necessary part in Photosynthesis formation, Essential for formation and uses of carbohydrates, affects the anabolic and catabolic reactions in plants Total N includes N in all its forms which include ammonium, nitrate and organic N. In a finished compost, the total N will range from 0.5-2.5% dry weight basis (25).

2.6.2 Total Phosphorous

Phosphorous is also an important nutrient for plant growth. Phosphorus is essential for cell reproduction and metabolism. Phosphorous essential for seed formation, Generate early root formation and growth of plant, Enhance the fruit quality, Provide tolerance to plant to survive in harsh winter conditions, Use for formation and transfer of energy to plants, Use in cell division and cell enlargement. According to (23) and (25) the range of total phosphorus is usually between 0.4 - 1.1%, dry wt. for biowaste and green waste compost.

2.6.3 Potassium

Potassium is a very essential nutrient to plants. Plants use potassium to open and close stomata's and to move nitrates from the roots to the leaves. Role of potassium in plants are important in carbohydrates metabolism, Enhance the translocation of starch, Use for water use efficiency, important in enzyme activity and control the reaction rate, Enhance the seed and fruit quality, improve the disease resistance, Essential in protein synthesis. Potassium in its available form in compost exists as K_2O.The typical range of total potassium in biowaste and green waste compost is between 0.6- 1.7% on dry weight basis (23).

3. MATERIALS AND METHODS

3.1 Materials

3.1.1 Equipment and instruments

Both the food waste and matured compost will be characterized in the laboratory to determine the physiochemical properties. The characterization of both food waste and matured compost are the same so that, the materials used in the laboratory are similar.

Table 1, Equipment with function

No	Equipment	Function
1	Plastic bins	used for dump food waste sample
2	plastic bucket	used for put samples
3	Plastic cups	used for collecting soil solution
4	beaker and conical flask	used for hold the solution
5	Furnace	Serve us for burning the sample.
6	Oven	Drying the sample
7	Whiteman filter paper	used to filter the solution
8	Digital PH meter (PH016)	used for measuring the PH of the organic fertilizer solution
9	Palintest Photometer7100	Used for measure the macronutrient content (nitrogen, phosphorous, and potassium) of the compost.
10	Electronic balance	Used for measuring the mass of sample.

3.1.2 Chemicals and Reagents

The chemical needed for this project includes;

Table 2, chemicals used

No	Chemical	Purpose
1	tap water	used for moisturizing the compost
2	Ammonium hydroxide (NH_4OH, 98%) and acetic acid (CH_3COOH, 96%)	used for prepare soil solution

3	Distilled water	used for prepare compost solution for measuring the PH of solution
4	phosphate Palintest	serves as analysis phosphorous
5	Nitrocol Palintest	Used for analysis nitrogen content of compost
6	Potassium Palintest	used for analysis potassium content the compost

3.2 Method

3.2.1 Process flow Diagram for Production of Organic Fertilizer

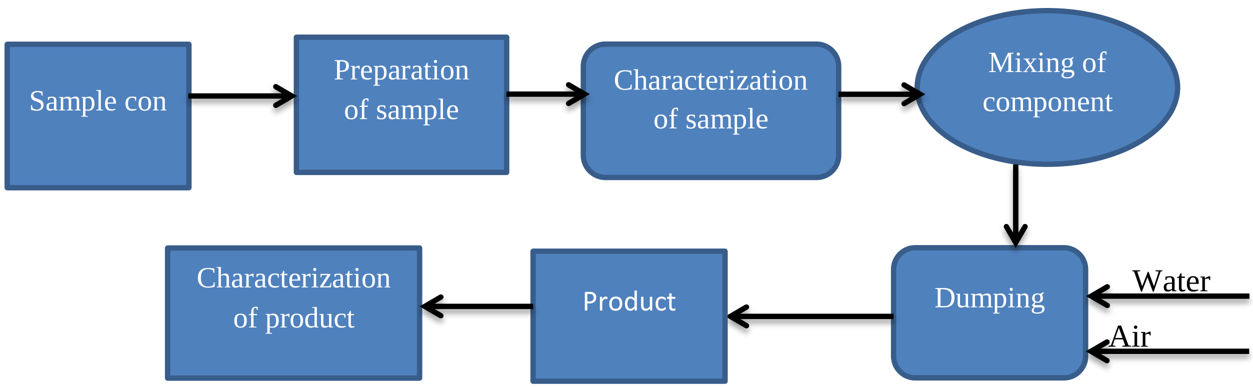


Figure 1, Process Flow diagram of Organic Fertilizer Production

The sample was prepared in the correct proportion and characterization of organic matter; carbon content and moisture content of the sample were determined. Then the sample was sent to the prepared bin for composting process. After the composting process was performed for four weeks, it sent to laboratory to characterize the product.

3.2.2 Sample Collection and Preparation

Samples of food wastes were collected from wolkite university student's cafeteria such as Bread, Injera, and Onion peels. After the samples were collected unwanted materials were removed from the sample, Such as Oily cooked food, meat materials and other bones in order to facilitate the composting process.

Figure 2, Raw materials (bread, injera, onion peel)

3.2.3 Drying

The prepared sample was dried in the oven at the temperature of 105^{o}C and reduced their sizes to increase the surface area and also increase the decomposition process. These food waste samples were taken as ratio of Bread to Injera to Onion peels as 1:2:1, 1:1:1 and 2:2:1 (R1, R2, and R3) respectively. Then, 500 grams of the sample was measured using electric balance and put into nine plastic bins in the appropriate ratio.

Figure 3, drying

3.2.3 Size Reduction

The particle size of the raw material has a major factor on composting process. The size of feedstock materials entering the composting process was reduced to increase the processing rate.

Figure 4, size reduction

3.3 Experimental Design

In this project two factors which are mixing ratio and moisture content are considered to conduct experiment with three levels in replication of k =1 Total run = $\text{levels}^{\text{factors}} * k$

Total run = $3^2 * 1 = 9$

The numbers of experimental runs that are performing in this study are nine.

Table 3, Experimental design

Moisture Content (%)	Mixing Ratio		
	R1	R2	R3
20	1:2:1	1:1:1	2:2:1
50	1:2:1	1:1:1	2:2:1
70	1:2:1	1:1:1	2:2:1

Where Ri : Food Wastes: Bread: Injera: Onion Peels

3.4 Experimental Setup

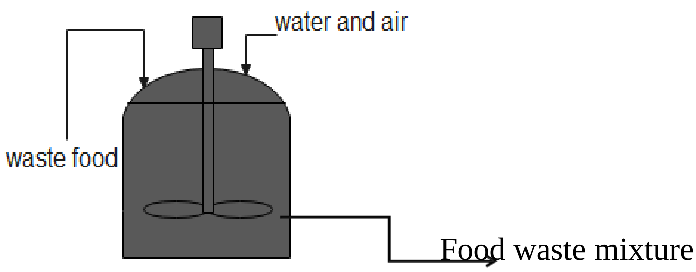


Figure 5, Mixer of Experimental set up

The food wastes were formulated with appropriate ratios and then dumped underground with bins to decompose aerobically. Water is supply with the set proportion and air circulates through tubes to formulate the mixture of the sample. Microorganisms decompose the food wastes aerobically and changed into organic compost.

3.5 Ultimate and proximate analysis

Before the sample was dumped, the moisture content of the sample was determined in the following way: firstly, the samples were weighed and then dried at the temperature of 105^{o}C for 2 hours. Finally, the dried samples were weighted.

$$\% \text{ moisture} = \frac{(\text{wet mass} - \text{dry massof sample}) * 100\%}{\text{wet mass of sample}} \quad \text{...} (2)$$

3.5.1 Organic Matter and Organic Carbon

Determination of organic matter and organic carbon content of the sample is performed by the formula of loss ignition method. In order to determine the organic matter of the sample of food waste firstly, it is dry in oven at temperature of 105℃ for 1 hour and then, burn with furnace at temperature of 550 ℃ for 1 hour.

$$\text{TOM } (\%) = \frac{(\text{sample weight } @105℃ - \text{sample weight } @\ 550℃)*100\%}{\text{sample weight } @\ 105℃} \quad \text{...............................} (3)$$

$$\text{TOC } (\%) = \frac{TOM}{1.8} \text{...} (4)$$

Where: TOM = Total organic matter

TOC = total organic carbon.

3.5.2 Ash Content

Ash is inorganic content of the sample like Ca, K, Fe, etc… calcites dry sample are place in a crucible at 550^{o}C for 1hour in furnace. To determine the ash content the following formula is used.

The ash content (Ac) is given in % by:

$$\text{Ac} = \frac{\text{Ma}}{\text{Ms}} * 100\% \text{...} (5)$$

Where: - Ma = mass of ash, Ms = mass of sample

3.5.3 Fixed Carbon Content

To know the fixed carbon content percentage, moisture content, ash and volatile matter from the initial sample was subtracted.

$$\% Fc = 100 - Mc - Vd - Ac \quad (6)$$

Where: Mc= moisture content

Vd= volatility matter

Ac= ash content

In the ultimate analysis percentage of C, H, O, and N, of the food wastes were determined.

Total Carbon was determined from the formula:

$$TOC\ (\%) = \frac{TOM}{1.8} \quad (7)$$

Total Nitrogen is carry out using the standard of hydrogen and oxygen are analyzed from water content of the sample (26)

$$\%\ Hydrogen = \frac{\%\ Moisture}{Molecular\ weight\ of\ water} * molecularweight\ of\ Hydrogen \quad (8)$$

$$\%\ Oxygen = \frac{\%moisture}{molecular\ weight\ of\ water} * molecular\ weight\ of\ oxygen \quad (9)$$

3.6 Composting Process

Composting process is greatly affected by temperature. So in order to prevent temperature variation, covered the bucket by straw instead of digging the ground. Nine bins were prepared to fill with ingredients with different mixing ratio. The prepared samples were inserted to the prepared bins with different ratio of ingredients. Then, nine bins were dump in to ground. Water was supply with its proportion (20%, 50% and 70%) as well mixing of ingredients was performed twice in a week with stirrer. Air also circulates through tubes and the composting process will continue until it becomes brown color for four weeks.

3.6.1 Aerobic Composting

Composting can occur under aerobic or anaerobic conditions, but aerobic composting is much faster (10 to 20 times faster) than anaerobic composting (17). Anaerobic composting tends to generate more odorous because gases such as hydrogen sulfide and amines are produced.

Methane is produced in absence of oxygen. Microorganisms important to composting process require oxygen to break down the organic compounds in the composting feedstock. Without sufficient oxygen, these microorganisms will diminish, and anaerobic microorganisms will take their place (27).

3.6.1.1 In-vessel System

In vessel syetem, These include bin composting, rectangular agitated bins, and silos. In-vessel composting system was first developed by Becari and modified by Verdier and Bordas, and latter several such systems have been developed (16). The main advantage of this system is process rapidity, low land requirement, complete process control and consistency of end-product. The main feature of in-vessel composting systems is that the compost materials are mixed and the mass advanced and aerated automatically and mechanically. In-vessel methods confine the compost mixture to buildings, containers or vessels, and tend to rely on numerous forced aeration and mechanical turning methods which accelerates the composting process (15).

Figure 6, composting process

3.7 Characterization of product

3.7.1 PH Measurement

A 5 g of compost sample add to the beaker and then, 30 ml of distilled water is add to the beaker and shack for 1 hour. Solution will filter with Whitman No.1 filter paper using a Buchner funnel. Finally, PH of the filtrate (solution) will measure by using PH meter.

Figure 7, pH Measurement

3.7.2 Water holding Capacity Determination

5 gram of sample will be measure and add to beaker and 50ml of tap water will be adding then, the solution will shack for 2 hour. Then, the solution will be filter and the volume of the filtrate will measure. Finally, water holding capacity will be determine by the following formula.

$$WHC = \frac{\text{water used for soaking the sample} - \text{amount of filtrate}}{\text{water used for soaking the sample}} * 100\% \ldots\ldots\ldots\ldots\ldots\ldots (10)$$

Figure 8, Water Holding Capacity of Compost

3.7.3 Organic Matter and Carbon Content Determination

Organic matter is an important ingredient in all soils and has an important role to pay in maintaining soil structure, nutrient availability and water holding capacity. It is usually expressed as a percentage of dry weight. There is no absolute value of organic matter, which is ideal for compost. It may range from 30- 70% (15).

20gm of sample will be measure and dry in oven at 105^oC for 2 hrs, then, the dried sample will measure in pre weighted crucible and ignited in to a furnace at 550^oC for 6 hrs. , and then, cool to room temperature. The total organic matters are calculated by the following formula.

TOM (%) = $\frac{\text{sample weight@105oc} - \text{sample weight@550oc}}{\text{sample weight@105oc}} * 100\%$ …………………. (11)

TOC (%) = $\frac{TOM}{1.8}$ .... (12)

Where: TOM = Total organic matter and TOC = total organic carbon

Figure 9, Measurement of organic Matter and Carbon Content

3.8 Analysis of Macro Nutrients in the compost

When the compost is mature, it has a nice soil-like smell and dark brown in color. Since the compost is the organic fertilizer for plants, it must contain the nutrients that a plant requires. The nutrients that plants require in large amount are called macronutrients such as Nitrogen, Phosphorus and potassium (28). The compost will be send to the laboratory to test the nutrients. Macro nutrient of the produced compost will analyze using Palin test photometer 7100 to determine nitrogen, phosphorus, and potassium content. Palin test photometer 7100 determines the amount of nitrogen, phosphorus and potassium by using Nitrocol tablet, phosphate tablet and potassium tablet respectively. Palin test photometers are ideal for providing critical information required for drinking water, wastewater, environmental and process applications. Suitable for a wide range of parameters, photometric analysis is a simple and effective mechanism for determining water quality parameters. The ranges that Palin test can measure are Potassium 0 –

12 mg/L, Nitrite (Nitrocol) 0 – 0.5 mg/L, Phosphate LR 0 – 4 mg/L (26). In order to determine macro nutrients using Palin test photometer 7100; First, ammonium acetate solution will prepare in the following way. In Ammonium Acetate Solution preparation, 700 ml of distilled water (in a 1L-glass beaker), 57 ml of acetic acid and 68 ml of ammonium hydroxide will be add and mix together. The solution in the beaker will stir using magnetic stirrer. The pH of the solution will be adjusted to pH 7.0 by adding using droplet acetic acid or ammonium hydroxide. The solution will be then transfer to a 1.0 L volumetric flask and top up to the mark with distilled water. 4 g of air-dried compost sample will be accurately weighed using electronic balance. 33 ml of ammonium acetate solution will be add and shack for 30 minute. Then, the solution will be filter using filter funnel and clear supernatant will be decant into 100ml volumetric flask and top-up to the mark with distilled water. Finally, the macro-nutrient values will be determined through Photometer (7100 Palin test).

3.8.1 Nitrogen Content Determination

10 ml of clear supernatant solution will add into sample holder tube and Nitrocol Palintest tablet will be add into the solution. Then it will crush, shack and keep for 10 minutes until it becomes cloudy. The Palintest photometer will adjust by blank solution (blank solution will be inserting in Palintest photometer until it says ready). Finally, the sample (sample holder tube) will insert into the Palintest photometer and then, it reads the amount of nitrogen content in the sample.

3.8.2 Potassium Content Determination

10 ml of clear supernatant solution will add into sample holder tube and potassium Palintest tablet will add into the solution. Then it will crush and shack. The Palintest photometer will adjust by blank solution (blank solution will insert in Palintest photometer until it says ready). Finally, the sample (sample holder tube) will insert into the Palintest photometer and then, it reads the amount of potassium content in the sample.

3.8.3 Phosphorus Content Determination

10 ml of clear supernatant solution will add into sample holder tube and phosphate Palintest tablet will add into the solution. Then it will crush, shack and keep for 10 minutes until it becomes cloudy. The Palintest photometer will adjust by blank solution (blank solution will insert in Palintest photometer until it says ready). Finally, the sample (sample holder tube) will

insert into the Palintest photometer and then, it reads the amount of phosphorus content in the sample.

3.9 Statistical Data Analysis

Repeated laboratory measures of each parameter were analyzed using Microsoft office excel 2007 and SPSS with one way of ANOVA.

4. RESULTS AND DISCUSSION

4.1 Introduction

This chapter was focused on effects of operating parameters such as moisture content and mixing ratio on the quality and processing rate of compost. Composted by aerobic means of decomposition were studied using food solid wastes as the raw material. The aspects of the results studies here include quantitative analyses of product components obtained by laboratory analysis and photometer (7100 palin test). To thoroughly investigate the effect of operating parameters on the quality of compost, the focus area in the analysis of the results was directed towards the following points:

- The physiochemical characterization of food solid waste
- Product characterization

4.2 The Physicochemical Characteristics of Raw Material.

Composting of food wastes (Bread, Injera and Onion peels) in different proportion using in vessel composting system was performed. The organic matter, moisture content and organic carbon, proximate and ultimate analysis of each component was determined and shown in the following table.

Table 4, Proximate and Ultimate Analysis

Sample	Mc%	Fc %	Ash %	C %	O %	H %	VM %
Bread	29.9	57.3	1.5	54.7	1.88	1.6	11
Enjera	71.8	18.6	5.7	52.4	2.83	3.9	4
Onion peel	86.3	3.5	8.2	51	42.3	4.7	2

As shown in table 4. 1, Bread has high organic matter and organic carbon than Onion peels and Injera. Generally, these food wastes contain high content of carbohydrate and protein content that is essential for microorganisms to get energy source. The moisture content and fixed carbon were found within the standard values (6). Thus, these food wastes have the potential to produce organic fertilizer.

4.3 Compost Product Characterization

The compost samples analysis results for total nitrogen, total phosphorus, potassium, organic matter and organic carbon, pH and water holding capacity with respect to mixing ratio and moisture content are represented in the tables and located from the appendix.

4.3.1 PH Values

As demonstrated in the figure 4. 1, the pH value is low when moisture content is very low (20%) and high when moisture content is increased to 40%, However, as moisture content is increased to 60 % the pH value becomes decreased. This indicates that at moisture content of 20% and 70%, the pH is low (the compost is acidic). At the moisture content of 40%, the mixing ratio R1 and R2 has the pH value of 5.72 and 5.51 respectively. Thus, the value is found in the range of pH 5.5-8 (22). Therefore, the organic fertilizer at the mixing ratio of R1 with the pH value 5.72 and R2 with the pH value 5.51 have the potential for soil amendment.

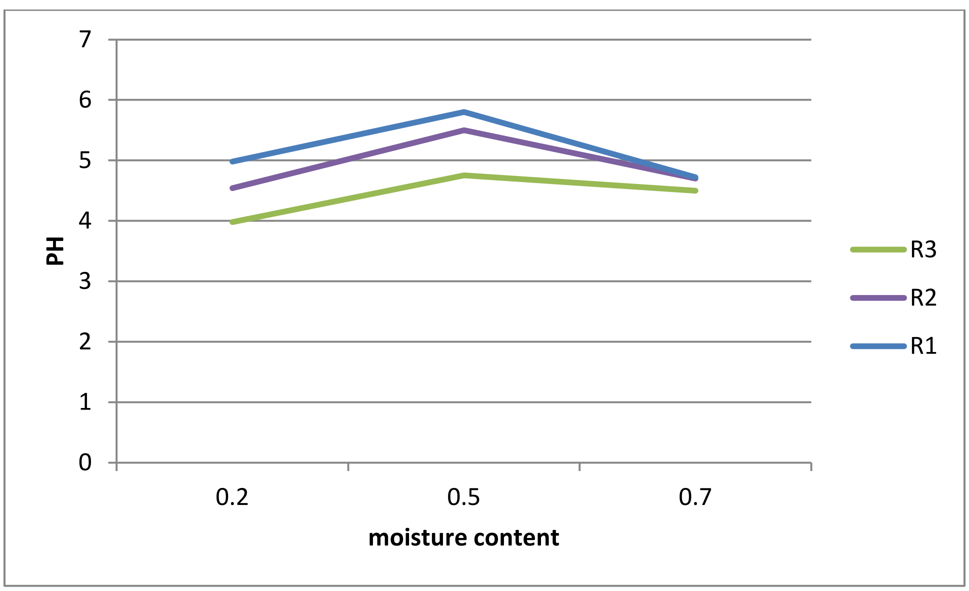


Figure 10, pH Change with Moisture Content and Mixing Ratio

4.3.2 Water holding Capacity

As it can be seen in figure 4.2, the Water holding capacity was increased when the moisture content increased from 20% to 40%. However, when the moisture content increased to 60 %, the water holding capacity decreased due to the diluted solution of the sample created and this condition hinders microorganisms in the composting process. The maximum water holding capacity,41.92%,was obtained at moisture content of 40% and mixing ratio of R2 (1:1:1). The previous researchers had found similar amount of water holding capacity and they recommended that product to be used as water retaining for a longer time (10). Thus, this result can enhance the soil to retain water and resist the dry period.

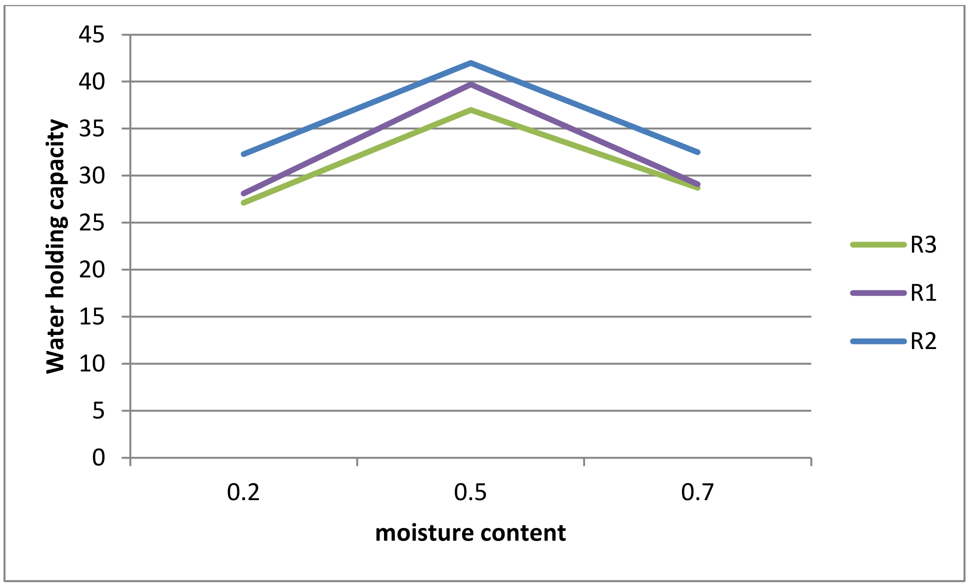


Figure 11, Water Holding Capacity with Mixing Ratio and Moisture Content

4.4 Organic Matter and Organic Carbon

4.4.1 Organic Matter

As it can be seen in figure 4.3, the organic matter was increased when the moisture content increased from 20% to 50%; however when the moisture content increased to 70 %, the organic matter decreased due to the creation of diluted solution and this condition hinders the microorganisms from composting. The maximum organic matter content, 50.2, was obtained at moisture content of 50% and mixing ratio of R2 (1:1:1). The previous researchers had found similar amount of organic matter content and they recommended that organic fertilizer with this value can amend the soil (15). Thus, this result can provide to maintain soil structure and nutrient availability.

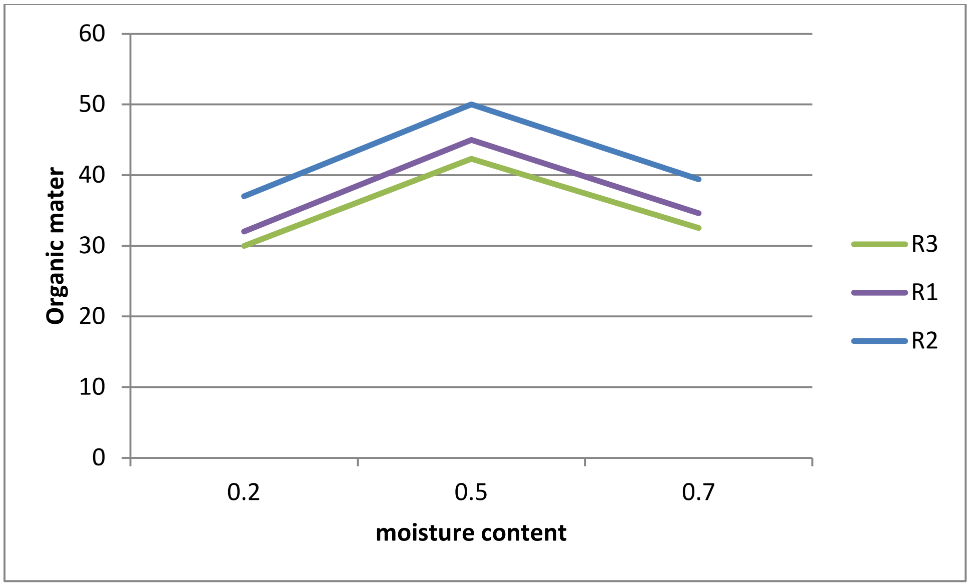


Figure 12, Organic Matter Vs Mixing Ratio and Moisture Content

4.4.2 Organic Carbon

As it can be illustrated in figure 4.4, mixing ratio of R1 and R3 has smaller values of carbon content whereas mixing ratio R2 contained higher organic carbon. Moisture content of 20 % and 60 % has lower value of organic carbon than moisture content of 40%. Therefore, mixing ratio R2 and 40% moisture content with the value of 27.89% organic carbon is maximum value. Thus, the value is found in the range of standards (15). This shows that the produced organic compost has enough amount of organic carbon and can be used as a fertilizer.

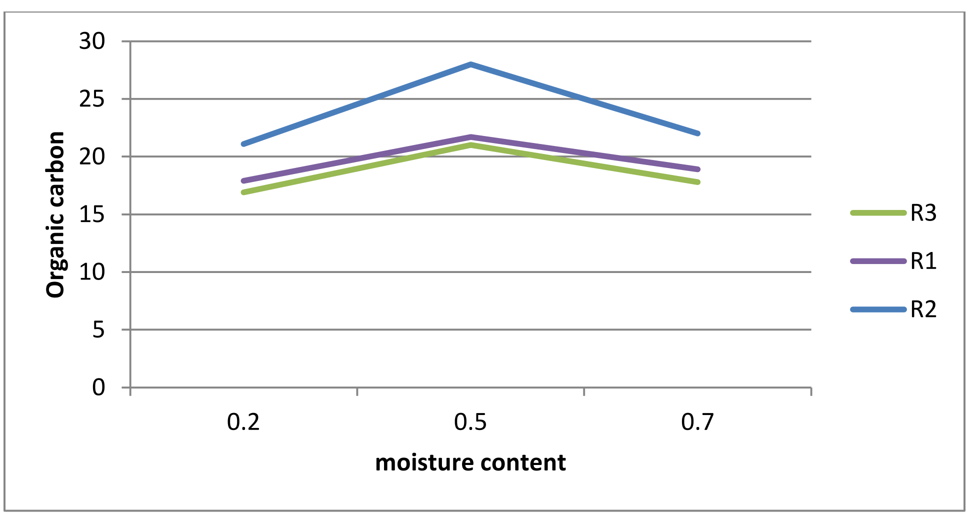


Figure 13, Organic Carbon vs Mixing Ratio and Moisture Content

4.4.3 Nitrogen Content

As it shown in figure 4.5,the general trend of the nitrogen content was increased while the moisture content was increased from 20% to 50%, nevertheless, it decreased when the moisture content was added up to 70% due unfavorable condition to microorganisms like food depletion condition existence. The maximum nitrogen content (0.63%) was found at mixing ratio R2 and moisture content 50%. Thus, the experimental result value (0.63%) is found in the range of 0.5-2.5% (15). Therefore, the produced organic fertilizer can give nitrogen part for the plant.

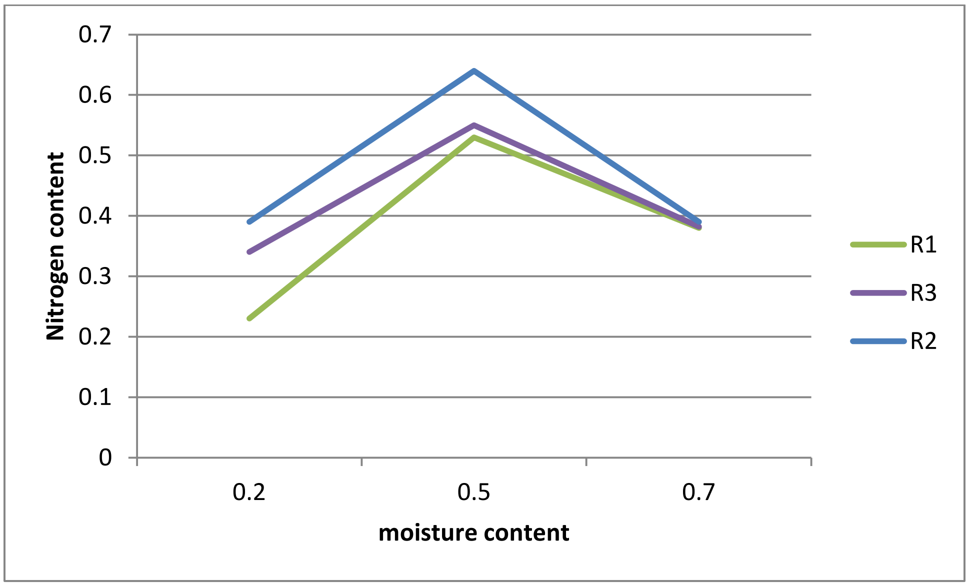


Figure 14, Nitrogen Content of the Compost

4.4.4 Phosphorous Content

The analysis results as shown in figure 4.6, the percentage of total phosphorus content of the mixing ratio of R1, R2 and R3 was found in the range of 0.3% to 0.90%. When the moisture content was increased from 20% to 50% the total phosphorus content was increased however, as it increases to 70% moisture content phosphorous content decreases. The maximum result was found at mixing ratio R2 and at the moisture content of 50% and this maximum experimental phosphorus content value (0.711%) found in the range of 0.4-1.1% (23) (25). Thus, the produced organic fertilizer has a potential for cell reproduction and metabolism of plants.

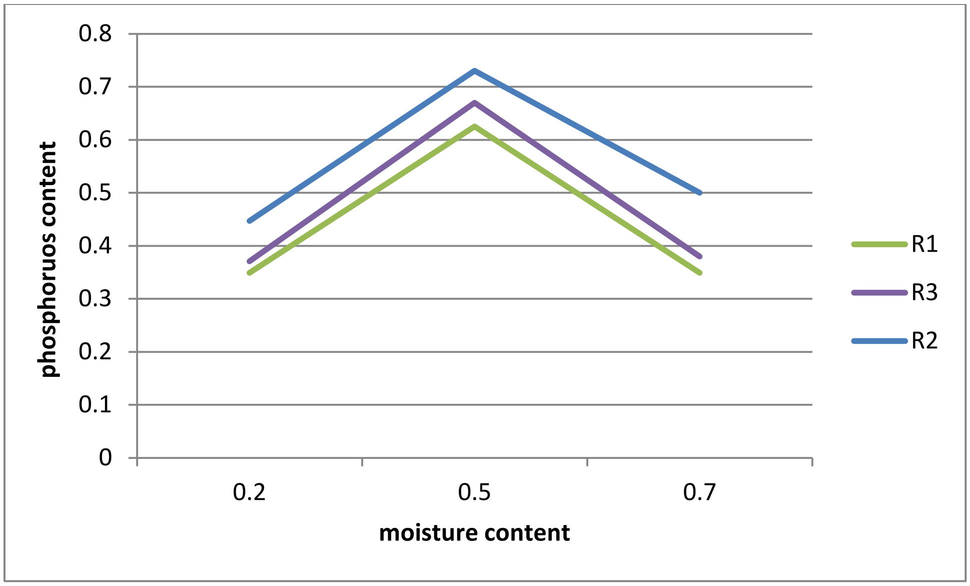


Figure 15, Phosphorus Content

4.4.5 Potassium Content

As shown in figure 4.7 when the moisture content was increased from 20 % to 50%, total potassium content increased. However, when moisture content increases to 70%, potassium content decreased due to the creation of unfavorable conditions to microorganisms since they simply hinders at higher moisture content. Mixing ratio R2 at 50% moisture content has higher potassium content value of 0.972% and this experimental result value is found in the range of 0.6-`1.7% (23). Therefore, the produced organic fertilizer with 0.972% of potassium content can be used as a fertilizer.

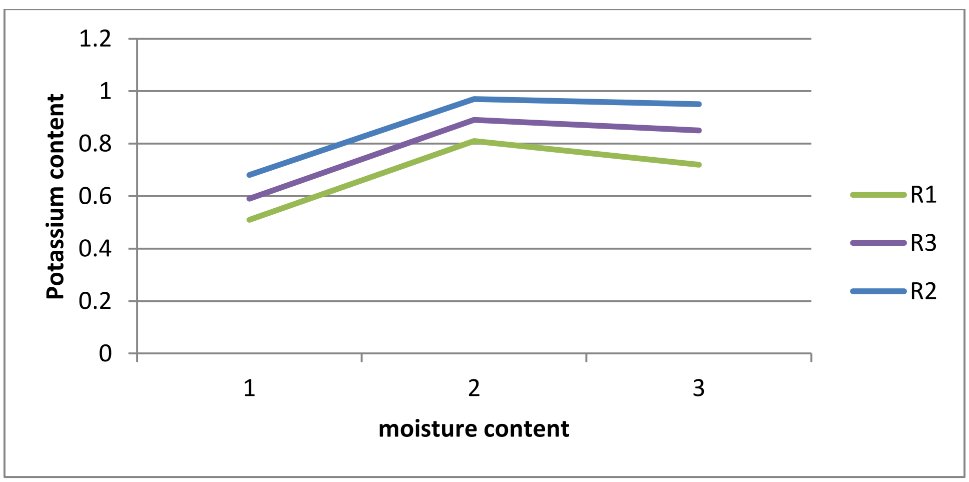


Figure 16, Potassium Content

5 MATERIAL AND ENERGY BALANCE

5.1 introduction

The amount of Materials that pass through processing operations can be described by material balances. Such balances are statements on the conservation of mass. Similarly, energy quantities can be described by energy balances, which are statements on the conservation of energy. Material and energy balances are very important in an industry. Material balances are fundamental to the control of processing, particularly in the control of yields of the products. Energy balance used to determine the amount of energy required for plant.

Assumptions: Food wastes were collected from wolkite University student's cafeteria.

Generation, consumption and accumulation are negligible.

The system is steady state and there is no chemical reaction.

Basis:

Moisture content of Bread = 29.9%, Enjera = 71.8%, and Onion peel = 86%.

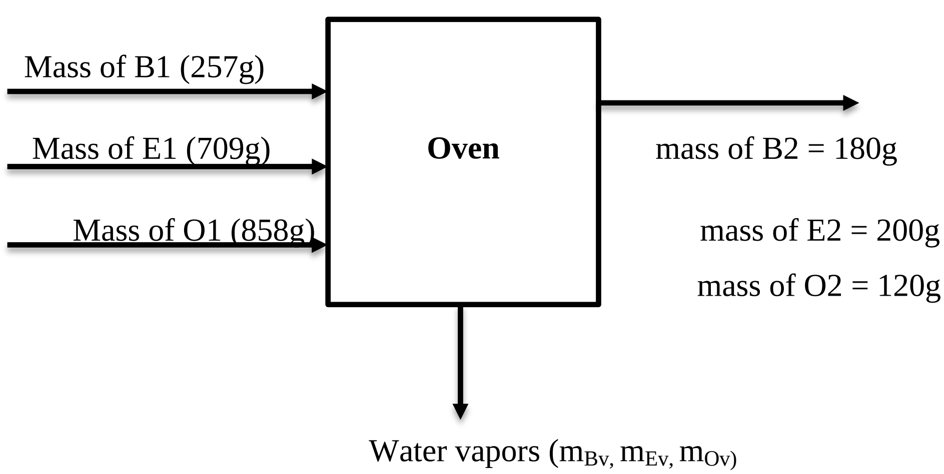
Mass of samples before drying: Bread = 257g, Enjera = 709 and Onion peel = 858g

Mass of samples after drying: Bread = 180g, Enjera = 200g and Onion peel = 120g

Total mass of the sample = 500g.

5.2 Material balance

Material balance on oven



Where: B = Bred m_{Bv} = mass of bread vapor

E = Enjera m_{Ev} = mass of Enjera vapor

O = Onion peel m_{Ov} = mass of Onion

Mass in + generation=mass out + consumption+ accumulation

Mass in = mass out

Mass balances of B: $m_{B1} = m_{Bv} + m_{B2}$

$257g = 180g + m_{Bv}$

$m_{Bv} = 77g$

Mass balances of O: $m_{O1} = m_{O2} + m_{Ov}$

$858g = 120g + m_{Ov}$

$m_{Ov} = 738g$

Mass balances of E: $m_{E1} = m_{E2} + m_{Ev}$

$709g = 200g + m_{Ev}$

$m_{Ev} = 509g$

5.3 Energy balance

From conservation of energy principle law: $\Delta H+\Delta KE+\Delta PE=Q-W$

Where ΔH is enthalpy (change of enthalpy) Q is heat

ΔKE is change of Kinetic Energy W is work

ΔPE is change of potential energy

Assumption: - The systems not accelerating and falling or rising: $\Delta KE+PE=0$

- There is no moving parts at system boundary W=0

Therefore $\Delta H+\Delta KE+\Delta PE = Q - W$

The general energy balance reduce to $\Delta H = Q$

The amount of heat energy gained or lost by a substance can also be calculated for mass of substance:

$Q = MCP\Delta T$ then $H = Mcp\Delta T$

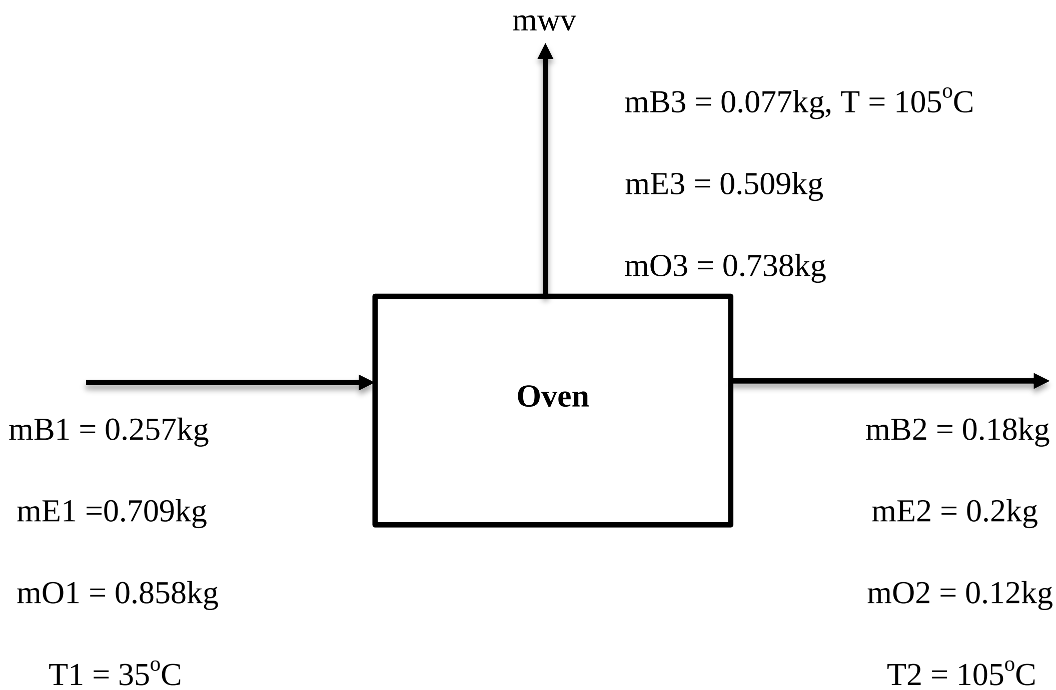
Where: Q = amount of heat energy gained or lost by substance

M = mass of substance

Cp = specific heat capacity (kJ/kg .k)

ΔT = change of temperature

Energy balance on oven



Ti = 25°C, (temperature of raw material), i.e room temperature.

The Cp (specific heat capacity) of B, E and O are 0.65, 2.96 and 0.78(kJ/kg .k) respectively.

specific heat capacity of water is 4.18kJ/kg.k

$$Q_{net} = Q_{out} - Q_{in}$$

Q_{in} = (mB1*cpB+mE1*cpE+mO1*cpO) ΔT

= (0.257kg *0.65kJ/kg.k + 0.709kg*2.96kJ/kg.k + 0.858kg*0.78kJ/kg.k)*(35-25)k

= 29.35kJ

Q_{out} = (mB2*cpB+mE2*cpE+mO2*cpO) ΔT + (mB3*cpw+mE3*cpw+mO3*cpw) ΔT

= (0.18kg*0.65kJ/kg.k+0.2kg*2.96kJ/kg.k+0.12kg*0.78kJ/kg.k)*(105-25)k

+ (0.077kg+0.509kg+0.738kg)*(4.1878kJ/kg.k) *(105-25)k

= 506.95kJ

Q_{net} = 506.95kJ – 29.35kJ

= 477.9kJ

6. ECONOMIC ANALYSIS OF ORGANIC FERTILIZER PRODUCTION FROM FOOD WASTE.

6.1 Building, equipment and manpower requirement

Plant parameter

Capacity per year = 34,602.82kg/yr

Number of shifts /day = Working days/year = 300 day

Land area/ covered, =1000m2

Machinery and equipment

Table 5, Specification and purchased equipment cost.

purchased equipment	Capacity	Req.no	Material	Total cost (birr)
Belt conveyor	L=7m	3	Carbon steel	382,807.5
Rotary Cutter -	2kg/s	1		267,653.5
Mixing tank	0.38m3	1	Stainless steel	119,626
Water storage tank (H)	L=4.4m	2	Carbon stee	330,734.5
Dryer	3m3	2	Carbon steel	**234,457**
Furnace	2m3	1	Stainless steel	765,739
Pump	0.009m3/s	**1**	Centrifuge Cast steel	119,045.5
Total	2,220,063			
Contingencies on Equipment 10%	2,220,06.3			
Transportation cost = 10% of equipment cost	2,220,06.3			
Grand total	3,875,405.6			

Manpower requirement

Table 6, manpower requirement & cost

No	Manpower.	Req. No	Monthly Salary (Birr)	Annual Salary (Birr)
1	General manager	1	5000	60,000
2	Secretary	2	2000	48,000
3	Accountant	2	2500	60,000
4	Production and Technical Head	1	3000	36,000
5	Mechanic	2	2000	48,000
6	Electrical	2	2000	48,000
7	Store keeper	2	1800	43,200
8	Quality control		2500	60,000
9	Operators	6	2000	144,000
10	Ass. Operators	3	1800	64,800
11	Guards	2	1500	36,000
12	Total	648,000		

6.2 Cost estimation

Cost of raw materials and additives

Table 7, Cost of raw materials

No	Particulars Total	Unit price	Quantity per annum	Total cost(birr)
1	Food waste	5birr/kg	1,015,504.54kg/yr	5,077,522.7
2	Water	0.005Bir/lit	6,407,268.97lit/yr	3,497.2
3	Ammonium sulfates	550birr/L	1032.78lit/yr	568,029
4	Total raw material cost	5,629,048.9		

Fixed capital cost estimation

Table 8, Estimation of Fixed Capital Investment

Component	Factor	Cost (birr)
1.Total direct cost	Purchased equipment cost (PEC)	3,875,405.6
Installation	0.25 PEC	1,106,910.275
Instrumentation	0.1PEC	442,764.11
Electrical installed	0.1PEC	442,764.11
Piping installed	0.2PEC	885,528.22
Building including service	0.1PEC	442,764.11
Yard improvement	0.4PEC	1,771,056.44
Land		
Total direct cost (DC)		9,519,428.365
2.Total indirect cost Engineering and supervision	0.06 DC	571,165.702
Construction expense and contractors fee	0.05DC	475971.418
Total indirect cost (IC)		1,047,137.12
3. Fixed capital investment (FCI)	FCI = DC + IC	10,566,565.485
4.Working capital	0.15TCI	1,864,688.03
5.Total capital investment (TCI)	WC + FCI	12,431,253.512

Estimation of total product cost

Total production cost(x) = Manufacturing cost + General expense

FCI =DC + IC, FCI =10,566,565.485birr

TCI = FCI + WC, since working capital cost = (10-20) % of total capital investment

TCI =FCI + 0.15TCI, TCI = 10,566,565.485 + 0.15TCI

TCI = 10,566,565.485/0.85 =12,431,253.512birr

Manufacturing cost = Direct production cost + Fixed charges + Plant overhead cost.

A. Fixed Charges (FC)

1. Depreciation =10% of equipment cost+2.5% of building

= 442,764.11+442,764.11×0.025 =453,833.212birr,

2. Local taxes = 2.5% of FCI =0.025×10,566,565.485 = 264,164.14 birr

3. Insurance = 0.7% of FCI = 0.007×10,566,565.485= 73,965.9583birr

Thus, Fixed Charges =453,833.212birr +264,164.14 birr +73,965.9583birr =791,963.31birr

B. Direct Production Cost: (about 60% of total product cost)

Let, the total product cost be X

Raw materials raw material cost = 5,554,501.07birr

Operating labor (OL): Operating labor cost = 648,000

Labor cost = 0.14* 648,000birr=90,720birr

Utilities: (10-20% of total product cost) Consider the cost of Utilities = 15% of total product cost

Utilities cost = 0.15 *X

Maintenance and repairs (M & R): (2-10% of fixed capital investment) Consider the Maintenance and repair cost = 5% of fixed capital investment

Maintenance and repair cost = 0.05×10,566,565.485 = 528,328.27birr

Laboratory Charges: (10-20% of OL) Consider the Laboratory charges = 15% of OL Laboratory charges = 0.15*648,000birr =97,200birr

C. Plant overhead Costs:

(50-70% of Operating labor, supervision, and maintenance or 5-15% of total product cost) includes for the following: general plant upkeep and overhead, payroll overhead, packaging, medical services, safety and protection, restaurants, recreation, salvage, laboratories, and storage facilities. Plant overhead cost 10% of total product cost, Plant overhead cost = 0.1* X

Manufacture cost = Direct production cost + Fixed charges + Plant overhead costs.

Manufacture cost = 0.15* X +6,874,721.99 birr +791,963.31birr +0.1* X

D. General expenses

Administration cost (4% of TPC) = $0.04 * X$

Distribution and selling cost (11% of TPC) = 0.11∗X

Research and development cost (5% of TPC) = 0.05∗X

General expense = $0.04*X$+0.11∗X+0.05∗X

Total production cost(x) = Manufacturing cost + General expense

X=0.15* X +6,874,721.99 birr +791,963.31birr +0.1* X +$0.04*X$+0.11∗X+0.05∗X

X=0.45X+7,666,685.3birr, X - 0.45 = 7,666,685.3birr

TPC(X) = 7,666,685.3birr*0.55 = 13,939,427.818birr

Gross earning/ income

Total income from product = unit selling price × Quantity of product manufactured

Annual income = 40 birr/60kg bag × 35,208.046kg/yr×1000kg/bag = 23,472,030.8br

Total income from solid cake = unit selling price × Quantity of by product...

Annually earning of solid cake =2.00birr/kg*(431,510.575kg/yr) = 863,021.15birr

Total Income = Income of product + earning of solid cake =23,472,030.8br +863,021.15birr

Total income =24,335,052birr

Gross income = Total Income – Total Product Cost = 24,335,052birr -13,939,427.818birr

=10,395,624.182 birr

Let the tax rate be 35% (income tax of Ethiopia)

Taxes = 0.35* 10,395,624.182 birr = 3,638,468.46birr

Net profit = gross income - tax =10,395,624.182 birr -3,638,468.46birr = 6,757,155.718birr

Rate of return

Minimum acceptable rate of return (Mar) Minimum acceptable rate of return (mar) for new capacity with established corporate with low levels of risk=12%

ROI = Net profit/Total capital investment × 100% = 6,757,155.718br/12,431,253.512 × 100%

= 54.35%

Since ROI ≥ Mar, 59.98 ≥ 12% the project is feasible

Payback period = FIC/(NP + Depr) = 10,566,565.485/6,757,155.718br+453,833.212br)

= 10,566,565.485/7,210,988.928 = 1.5yrs

Break even analysis

Breakeven point is the point when total annual production cost equals total annual sales. That is the point where profit equals zero. The breakeven point is determined from the relation:

BEP = $TFCSup-Vcup$ = $TPC-DPCSup-Vcup$

Where: BEP = Break-even point (units of production), DPC = direct production

Vcup = variable costs per unit of production

Sup = selling price per unit of production

TPC = total production cost

Vcu=Direct production cost/Amount of solid fertilizer produced

=9,009,663.51birr/yr/35,208,04kgl/yr = 0.256birr/kg.

Sup = 0.667birr/kg

BEP = (13,939,427.818birr−9,009,663.51birr/yr)/(0.667−0.256 birr/kg)

= 4,929,764.310/0.411 = 11,994,560.36 kg/yr

BEP (%) = 11,994,560.36 kg/yr/35,208,046kg/yr ×100% = 34.1%

7. PLANT SITE SELECTION AND LOCATION

The geographical location of the final plant can have a strong influence on the success of an industrial venture. An approximate idea as to the plant location should be obtained before a design project reaches the detailed estimate design. The choice of the final site should first be based on a complete survey of the advantages and disadvantages of various geographical areas and ultimately on the advantages and disadvantages of available real estate. The following factors should be considered in choosing a plant site.

Raw Materials

- Transportation
- Source of raw materials
- Prospective market for products
- Climatic condition
- Pollution requirements (Waste disposal)
- Utilities – water and power supplies
- Amount of site preparation necessary(site conditions)
- Operating labor
- Taxes
- Living conditions
- Corrosion
- Expansion possibilities
- Other factors.

A. Raw Materials

Availability The source of raw materials is one of the most important factors influencing the selection of a plant site. This is particularly true for the fertilizer production plant because a large volume of raw material is consumed in the process, which will result in the reduction of the transportation and storage charges. The raw material for the production of the fertilizer this case is food waste thus the availability is directly related to the location.

B. Transport

The transport of materials and products to and from plant will be an overriding consideration in site selection. If practicable, a site should be selected so that it is close to at least two major forms of transport: road, rail, waterway or a seaport. Road transport is being increasingly used, and is suitable for local distribution from a central warehouse. The cheapest and most available mode of transport is trucks.

C. Availability of Suitable Land

The characteristics of the land at the proposed plant site should be examined carefully. The topography of the tract of land structure must be considered. The land should be ideally flat, well drained and have load -bearing characteristics. A full site evaluation should be made to determine the need for piling or other special foundations.

D. Availability of Labors

Labors will be needed for construction of the plant and its operation. Skilled construction workers will usually be brought in from outside the site, but there should be an adequate pool of unskilled labors available locally; and labors suitable for training to operate the plant.

E. Availability of Utilities

The word “utilities” is generally used for the ancillary services needed in the operation of any production process. These services will normally be supplied from a central facility and includes Water, Fuel and Electricity.

F. Local Community Considerations

The proposed plant must fit in with and be acceptable to the local community. Full consideration must be given to the safe location of the plant so that it does not impose a significant additional risk to the community.

G. Climate

Adverse climatic conditions at site will increase costs. Extremes of low temperatures will require the provision of additional insulation and special heating for equipment and piping. Similarly, excessive humidity and hot temperatures pose serious problems and must be considered for selecting a site for the plant. Stronger structures will be needed at locations subject to high wind loads or earthquakes. Finally, due to the above criteria's our plant location will be implemented in the place of fulfill the above criteria's.

8. CONCLUSION AND RECOMMENDATION

8.1 Conclusion

Food wastes (Bread Injera and Onion peels) contain high fraction of organic wastes which can be transformed to valuable organic fertilizer (compost) through in vessel composting which is technically simple, economically viable and easily adaptable to construct.

The composting process was conducted for four weeks with different mixing ratio and moisture content. The composting process of food waste is best in mixing ratio of 1:1:1 of Bread, Injera, and Onion peels (R2) and at the moisture content of 50%.

The maximum results was obtained 76g of fertilizer from 105g of input at R2 and 50% moisture content were pH value of 5.551, Water holding capacity of 41.92%, organic matter of 50.2%, organic carbon of 27.89%as well as nitrogen content of 0.5%, phosphorous content of 0.91%, and potassium content of 0.722%. Therefore, the organic fertilizer of this project can be used for agricultural application.

8.2 Recommendation

Through this project, physicochemical characteristics such as, moisture content, pH, water holding capacity and nitrogen, phosphorus and potassium contents of the product composts and proximate and ultimate analysis of raw materials were investigated. However, the remaining parameters to be studied like:

- Investigation of time effect on composting process.
- Investigation of temperature effect on composting process.
- Investigation of composting process other than in vessel method.
- Investigation of particle size effect on composting process.

REFERENCES

1. **Toor, R.K, Savage,G.P andheep, A.** the influence of different types of fertilizer on the major antioxidant component of tomato. s.l. : journal of food composition and analysis , 2006. 19(1),20-27.

2. **.a, hazen.** ,development of organic fertilizer from food waste by composting. maliyzia : lim pei qi,journal of applied chemistry and natural resource, 2019. volume 1,p 1-6.

3. **al., AmraBratovcic et.** Investigation of Compost Quality of Meadow Grass. s.l. : International Journal of Advances in Agricultural Science and Technology, October-2017. Vol.4 Issue.10, , pg. 18-27(15)..

4. **Morash, Kumar, S., & Kumar, S.** Composting of municipal solid waste. 2015. 8551(December), 20–29..

5. **Paraiba, W.** Anaerobic Treatment of Agricultural Residues and Wastewater Application of High-Rate Reactors. s.l. : Department of Biotechnology, Lund University, 2004 .

6. **Min, T. L.** "Production of Fertilizer using Food Wastes of Vegetables and Fruits". 2015.

7. **Lebersorger, S., and F. Schneider.** Discussion on the methodology for determining food waste in household waste composition studies. s.l. : Waste Manag, 2011. 31 (9–10):1924–1933. doi:10.1016/j.wasman.2011.05.023..

8. **R. P. Singh, P. Singh, A. S. F. Araujo, M. Hakimi Ibrahim, and O. Sulaiman.** “Management of urban solid waste: Vermicomposting a sustainable option". s.l. : Resour. Conserv. Recycl., 2011. vol. 55, no. 7, pp. 719–729.

9. **H. H. Khoo, T. Z. Lim, and R. B. H. Tan.** “Food waste conversion options in Singapore: Environment alp. 1-66 ,” Sci. . s.l. : Published by FAZ Publishing http://www.fazpublishing.com/jacnar impacts based on an LCA perspective, 2010. Total Environ., vol. 408, no. 6, pp. 1367-1373.

10. **Council), (US Composting.** 2003.

11. **Al, (Ahmad Et.** seed Dispersal And SoiSeed Bank Of SeriphidiumQuettense(Asteraceae) In Highland Balochistan. Pakistan : s.n., 2007 .

12. **Bekele, SahilemedihinSertsu and Taye.** Procedures for Soil and Plant Analysis.Technical Paper. . s.l. : National Fertilizer Sector Project. Addis Ababa, Ethiopia., 2000.

13. **Cooperband, P. Leslie R.** "Composting: Art and Science of Organic Waste Conversion to a Valuable Soil Resource,". 2000. Lab. Med., vol. 31, no. JUNE, pp. 283–290..

14. **Christian, H. A., Evanylo, K.G. and Pease, W.J.** On-Farm Composting: A Guide to Principles, Planning and Operations. s.l. : Virginia State University, 1997. p. 1-17.

15. **Rynk, R.** On-Farm Composting Handbook. s.l. : Ithaca, NY: Cooperative Extension,Northeast Regional Agricultural Engineering Service-54, 1992. p.160-186..

16. **Gotass, H.B.** Composting Sanitary Disposal and Reclamation of Organic Wastes. Geneva : World health organizattion, Monograph series, 1956. No 31,.

17. **EPA.** Composting of Yard Trimmings and Municipal Solid Waste. U.S. : EPA, Office of Solid Waste and Emergency, 1994. EPA530-R-94-003. p. 17-21, 139.

18. **Wilson, M.** Igneous Petrogenesis: A Global Tectonic Approach. London : Unwin Hyman, 1989. 466p.https://doi.org/10.1007/978-1-4020-6788-4.

19. **Richard, T.L.** Municipal solid waste composting Physical and biological processing. Biomass & Bioenergy. Tarrytown : NY: Pergamon Press, 1992. 3(3-4):163-18.

20. **Gray K.R., Sherman, K. and Biddlestone, A.J.** A review of composting Part 1- Process Biochemistry. 1971a. 6(6):32-36. .

21. **Boyd, RF.** General microbiology. s.l. : Wirtz, VA: Time Mirror/Mosby College Publishing, 1984.

22. **Wiley, J.S.** Proceedings of the 1lth industrial waste conference. s.l. : Purdue University, 1956. series 91, p. 334. .

23. **Mona, Bordna.** Compost Testing and Analysis Service . s.l. : Interpretation of Results, New bridge, Co. Kildare., 2003.

24. **Zethner, G., B Götz and Amlinger.F.** Quality of Austrian Compost from Derived Waste Collection of Summary. s.l. : availableat;http://www.ubavie.gv.at/publikationen/Mono/M133s.HTM. accessed on 15/9/2007, 2000.

25. **Travis, W., Halbrendt, N., Hed, B., Rytter, J., Anderson, E.Jarjour, B. and Griggs, J.** A Practical Guide to the Application of Compost in Vineyards. s.l. : Penn State University: In Cooperation with Cornell University Terry Bates and Grape Growers. Sid Butler,Joane Leven good,philRoth, 2003. pg.3-15.

26. Water-Testing-Catalogue. -P-PPCAT_01E_v3.4-August-2019-lores-1.

27. **Lorrine, H.** A study of the Quality of Waste Derived Compost In Ireland. . s.l. : Composting Association of Ireland, 2003. p 59.-60.

28. **B. K. Adhikari, S. Barrington, J. Martinez, and S. King.** "Effectiveness of three bulking agents for food waste composting" . s.l. : Waste Manag. vol. 29, no. 1, pp. 197– 203, Jan. 2009..

APPENDICES

Appendix 1

Appendix 1.1

The data recorded for water holding capacity. The amount of water added ineachbeaker is 50ml (volume of water added).

Moisture content (%)	Ratio	Volume of filtrate (ml)
20	R1	36.0
	R2	33.9
	R3	32.9
50	R1	30.2
	R2	29.1
	R3	18.6
70	R1	35.4
	R2	33.9
	R3	34.8

Appendix 1.2

Data Recorded for Organic Matter and Organic Carbon

Moisture content (%)	Ratio	Initial mass at 105℃ (gram)	Final mass at 550℃ (gram)
20	R1	15	10.26
	R2	15	9.285
	R3	15	10
50	R1	15	8.655
	R2	15	7.5
	R3	15	8.73
	R1	15	9.885

70	R2	15	9.09
	R3	15	9.735

Appendix 2

Table 4.2 pH and Water holding Capacity

Mixing ratio	Moisture content					
	20%		50%		70%	
	PH	WHC%	PH	WHC%	PH	WHC%
R1	4.86	28.08	5.72	39.53	5.33	29.12
R2	4.71	32.21	5.51	41.92	5.31	32.22
R3	3.95	27.5	4.85	37.11	5.01	28.91

Table 4. 3 Organic Matter and Organic Carbon

Mixing ratio	Moisture content					
	20		50		70	
	Organic matter (%)	Organic carbon (%)	Organic matter (%)	Organic carbon (%)	Organic matter (%)	Organic carbon (%)
R1	31.6	17.56	42.3	32.5	34.1	28.94
R2	38.1	21.17	50.2	27.89	39.4	21.89
R3	30.5	16.94	41.5	23.05	32.2	17.8
Standard [13]	Organic matter (%)		30-70%			
	Organic carbon (%)					

Table 4. 4 major nutrient content of compost

Moisture content (%)		Mixing ratio			Standards [13]
20	Nutrient				

	Content (%)	R1	R2	R3	N=0.5-2.5%
	N	0.220	0.385	0.331	
	K	0.512	0.672	0.588	K=0.6-1.7%
	P	0.351	0.435	0.382	
50	N	0.520	0.630	0.54	P=0.4-1.1%
	K	0.812	0.972	0.898	
	P	0.621	0.972	0.683	
70	N	0.481	0.499	0.488	
	K	0.712	0.967	0.854	
	P	0.344	0.500	0.389	

The data recorded for Macronutrient in mg/l Conversion of mg/l to percent.

1mg/10ml=1mg/l*100

1mg/ml=%

Appendix 3

Food waste

Formulation of sample with appropriate mixing ratio

Compost products

Furnace and crucibles