JIMMA UNIVERSITY

DEPARTMENT OF ENVIRONMENTAL HEALTH SCIENCES AND TECHNOLOGY

ASSESSMENT AND CHARACTERIZATION OF FOOD WASTE AND HUMAN WASTES (FEACES AND URINE) GENERATED FROM JIMMA UNIVERSITY CAMPUSES

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Assessment and characterization of food waste and human wastes (feaces and urine) generated from Jimma University Campuses

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Declaration

I, the undersigned declare that this research paper is my original work and has not been presented for a degree in any other university and that all sources of materials for the research paper have been correctly acknowledged.

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Abstract

Food waste and environmental, societal, and economic impacts are attracting increasing attention across the globe.Around 2.4 billion people do not have sanitation facility and about 2 million people die every year due to diarrheal diseases, most of them are children less than 5 years of age. Jimma University Campuses generate large quantity of food wastes and human excreta from sources mainly from cafeterias and lounges as well as toilets.The main objective of the study is toassess and characterizefood waste and human wastes generated from Jimma University Campuses. The study was conducted in three Jimma University campuses at Jimma university main campus ,Jimma University Institute of Technology and Jimma University College of Agriculture and Veterinary Medicine from May 11-25 /2017.A descriptive survey study design was used. Among the five students' cafeteria and nine staffs' lounge, three cafeterias and three lounges were chosenwith purpose. The sample size for student was 12,915 and 465 academic staff was chosen for study from the three Jimma university campuses. The food waste collection was conducted for consecutive seven days. Food waste was weighed in kg by mass balance.

Taking into account and difficultycollection of human waste, investigator considered about 15 individual volunteer students who are willing to participate for the study. The human waste sample was collected consecutive is for three days at 24hrs.Urine was weighed in liters by bottle plastics. Feaces sample weighed in gram by using sensitive balance. Completed forms were checked for errors and data were inserted into Excel's spreadsheet and saved as data file and descriptive statistics was used. It was found from the study that daily food wastes generated was around 1,662kg /day at students' cafeteria and staffs' lounge. The result showed that waste generated daily from students was about 1,485kg/day. Food waste generated daily from staffs' lounge of JUC was about 177kg/day.In this study, human urine generation rate per day was 1.37litres. The finding an average wet weight of human feaces generation rates per day per student was 121 g/cap/day. The nutrient contents of food waste were78,861.9kgN and 7,537.25.25kgP/cap/year of nitrogen and Phosphorous respectively; Whereas, the nutrient contents of human waste were in total 5.8 and 0.5 kg/cap /year respectively. Food waste alone has fertilizers of N/P/K/Ca.

Keywords: Jimma University Campuses, generation, assessment, characterization, food waste, human wastes.

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Abbreviations and acronyms

AOAC: Association of Official Analytical Chemists

BGPs: Biogas plants

FAO: Food and Agriculture Organization of the United Nations

FAITH: Food Always in the home

FAOSTAT: Food and Agriculture Organization of the Statistical Year Book

FUSIONS: Food Use for Social Innovation byOptimizing waste prevention Strategies

IWMPs: Integrated waste management Plants

IRB: Institutional Review Board

JUIT: Jimma University Institute of Technology

JUMC**:** Jimma University Main campus

JUC:Jimma University Campuses

JUCAVM: Jimma University College of Agriculture and Veterinary Medicine

LSMSISA: Living Standards Measurement Study Integrated Survey on Agriculture

NPK: Nitrogen, Phosphorus, Potassium

PHML: Post Harvest Management Laboratory

STPs: Sewage Treatment Plants

UNEP:United Nations Environmental Protection

USEPA: United States Environmental Protection Agency

UNICEF: United Nations International Children’s Fund

USCB: United States Census Bureau

WFD:Waste Framework Directive

WRAP: Waste and Resources Action Programme

Chapter one: Introduction

1.1Background

Food waste and environmental, societal, and economic impacts are attracting increasing attention across the globe. In developed countries, large quantities of preventable food waste are generated further down the food production chain at the post-retail, consumption level.An approximately one-third of global food production is lost or wasted(FAO, 2013, 2014). Globally, it has been estimated that 30–50% of food produced for human consumption is wasted each year .The developed countries, it is more on the consumption side while developing countries, food is wasted more during production side due to lack of technology and storage capacity (Sandesh, 2014). The energy content of food and that involved in producing, processing, transporting, marketing and storing food is lost when the food is discarded. Besides, Food waste is directly related to water waste because water is used in food production (UNEP 2008).

In South Africa, food wastage rates across supply chains are potentially very different from other sub-Saharan African countries. Indeed, in some respects South Africa's waste generation profile might resemble those of other world regions more closely rather than that of sub-Saharan Africa (SSA). Thus the use of sub-Saharan waste percentages to represent South Africa might be less of an issue in terms of predicting the total food waste quantities (FAO, 2005).

In Ethiopia, food waste is the single largest category of municipal solid waste. Biogas plant operators know well the advantages of adding fat residues or food wastes to their biogas plants. Food wastes collected from restaurants are highly desirable substrates for anaerobic digesters. These substrates are reported to yield 80% of the theoretical methane yields in 10 days of digestion time provided the various parameters affecting biogas generation are monitored properly (Neves, *et al.*,2009). Food waste has a potential for methane production depending on the type of food used. Optimization of methane generation from anaerobic systems is dependent on digester design and operation, although it has been stated that the feed stock is as important as the digester technology (Dearman and Bentham, 2007).

The saying 'we are what we eat' is only part of the story. What we eat is what we excrete, and this means plant nutrients. Human excreta contain the same nitrogen, phosphorus and potassium (NPK) as the Fertilisers used to produce the food consumed (Winker *et al.*, 2009).

However, human excreta are considered unwanted waste throughout the world, creating humanitarian and environmental problems (Baum *et al.,* 2013). In order to replace the nutrients removed from the fields during harvesting more fertilisers are manufactured in industrial processes that are contributing to environmental changes at global level (Rockström*et al.,* 2009). Recycling human excreta back to agricultural fields would reduce the current dependence on fossil fuel-derived fertilisers (Ramirez& Worrell, 2006). It would also improve crop yields in e.g. sub-Saharan Africa, where fertilizer application is low (FAO, 2015), and protect marine ecosystems in the Baltic Sea by limiting the flow of excess nutrients to surface waters (Rockström*et al.*, 2009).

Human waste removal is an important part of daily life, and it is an important factor in human health (Esrey*et al,* 2001: 33). The goal of most modern day sanitation systems is to prevent exposure of humans to the harmful pathogens that are found in excrement. Most systems in the developed world seek to carry away waste, remove pathogens and pollutants in an energy-intensive treatment system, and then release the contents back into nature, often in large volumes of diluted waste that can cause eutrophication. In the developing world, latrines are often used in various ways that concentrate the excrement and still pose a health risk.In addition, when sewer systems are used in the developing world, they often focus more on carrying away waste than adequately treating the waste, discharging pathogens that will contaminate the food and water of people downstream (WHO, 2006: 16).

Beyond these very real concerns, there is also a growing awareness of the valuable nutrients being lost in human waste streams. A new paradigm is forming in the water and wastewater management sector to focus on the resources that can be recovered from wastewater rather than the constituents that must be removed (Guest *et al,* 2009: 6127). Current human waste collection systems do much to minimize human contact with the pathogens in excrement, but little to ensure that those nutrients will be returned to natural systems in a way that benefits food production soils (Vaccari, 2009: 55). The composition of human urine fluctuates from one person to another and depends mainly on diet, climate, physical activity, time of the days and body size (Heinomen- Tanski*et al.*, 2007; Pradhan*et al.*, 2010b).A normal adult human typically produces one to two liters of urine by every house hold to the environment. Ninety five percent of urine is water while five percent is chemicals in solute form (Steinfeld, 2004. Here aim was to assess and characterize food waste and human waste generated at Jimma universities.

1.2. Statement of the problem

Around 1.3 billion tons of food is wasted every year in the world (Pleissner& Carol, 2013). The amount of food wasted in the United States having a serious and seemingly over whelming problem. Food waste is a critical issue because uneaten food carries enormous economic, social, and environmental costs. The U.S. spends $218 billion each year to grow, process, transport, and dispose of food that is never eaten (Dana Gunders, 2012).

Fruits and vegetables that include tubers and roots showed the highest amount of wastage of any food. Food wastes are normally sent to the landfill for disposal but it may break down and produce large amount of methane gas (Barrows, 2011). Food waste that is not handling properly can cause contamination of groundwater, emission of toxic gas (Okareh*et al.,* 2012).Food waste such as fruits, vegetables, grain, bread and eggshells can be composed and converted into organic fertilizers (Risse&Faucette, 2014).Food waste is generated throughout the University, in retail outlets from small cafés to the larger restaurants.Because the majority of campus food waste is sent to landfill in mixed residual waste bins, it would be difficult to assess how much food waste the University generates (Schmieder T, 2012).

Around 2.4 billion people do not have sanitation facility and about 2 million people die every year due to diarrheal diseases, most of them are children less than 5 years of age (WHO, 2006). In developing countries, human feaces related disease are very common; hence waste contains high concentrations of excreted pathogens such as viruses ,bacteria ,protozoa cysts and helminthes eggs that may cause infectious in human due to poor waste management system. Retreating and recovering of energy from the waste at the source is not practiced yet (Keddy*etal.,* 2004).In Ethiopia, 60 to 80million tons of biomass fuels are consumed annually this leads accelerated deforestation, soil degradation, and emission of greenhouse gases (lakew*etal.,* 2011).In developing countries for instance, an Ethiopia, many people lack their own toilet, thus a mix of urine and feces released openly into the environment will become source of contamination of food and water leaving more than 50% of the people out of sanitation (UNICEF, 2008).

Jimma University Campuses generated large quantityof food wastes and human excreta from cafeterias and lounges as well as toilets.No reliable data on food waste and human excreta characteristics and generation rate within Jimma university campuses. Information on the characteristics, composition, volume and weight of waste generated and collected in Jimma University is limited. Moreover, the food waste generated from university campuses simply disposed for temporary within Campuses on the stationary containers. The main activities of food waste being done are collection and dumping of wastes at dumping site called Kofe which is far 8 km from the Jimma town. The lack of characterization studies suggests the need to research and to document waste composition in order to have the necessary data to propose better handling and management alternatives for waste.The main objective of the study is to assess and characterize food waste and human wastes generated from Jimma University Campuses. In this sense, the study is to reduce the gap between the need for the study.

1.3 Significance of the study

The application of waste technology has economic, environmental benefits (fertilizers substitution, less greenhouse gas emission), health and social benefits.Transformation of organic waste into high quality fertilizers and reduces fertilizer requirements. Recycling the food waste can provide benefits for Jimma University and community in terms of financial, environmental and technical aspects.It benefits for both academic requirement and societal problem. It will be cooperative to decide appropriate Technology for the Waste conversion.It will be a base line for the further study of waste management.It gives values for the control of university campuses waste management.

1.4 Conceptual frame work

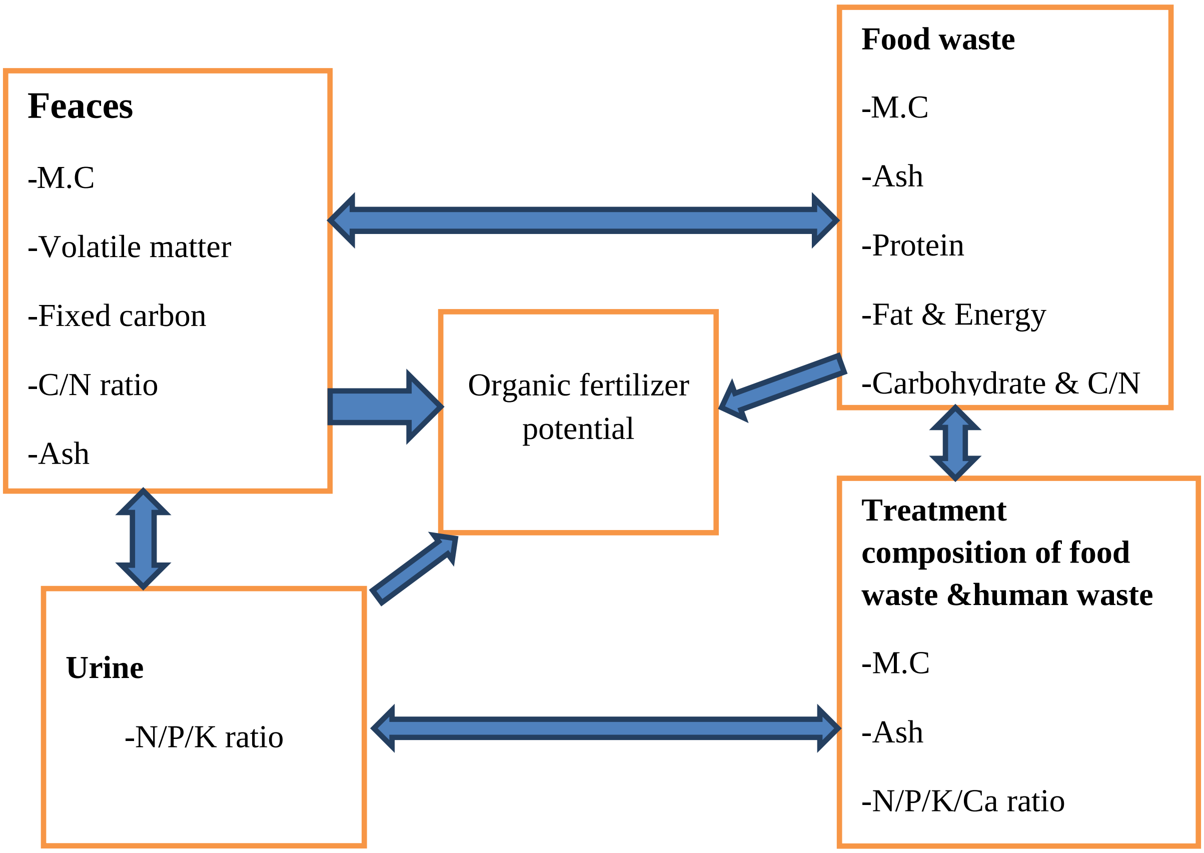

Figure 1: Conceptual frame work relation tovariables

ChapterTwo:Literature Review

2.0Food waste

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’ behavior. “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 (Parfitt*et al.*, 2010).

The Food and Agriculture Organization of the United Nations distinguishes between the so-called “wastage” produced mainly in the beginning of the supply chain called food loss. The wastage generated principally at the end of the supply chain once the food has been processed, known as food waste. The disadvantages of this definition are the difficulty to measure and report these parameters separately; in addition the concepts “food loss” and “food waste” can cover different stages of the supply chain for different food products or geographical areas (e.g. biscuits produced in a factory or directly in the point of sale). By contrast, the project funded by the European Commission Framework Programme 7 named Food Use for Social Innovation by Optimizing Waste Prevention Strategies (FUSIONS) (Östergren, K,.2014)and the UK Waste & Resources Action Programme (WRAP) refers to both of these concepts as food waste(Quested ,T and Johnson,H. 2009).

2.1 A global issue of food waste

Physical mass of food produced for human consumption and of food lost and wasted throughout the food supply chain have been quantified, using available data, results from the literature on global food waste. Developed countries generate more waste than developing countries: in North America and Europe edible food waste reach 280-300kg/capita per year while in sub-Saharan Africa, South and Southeast Asia it is only between 120 and 170kg/capita per year (EU, 2008).

Food loss and food waste has become a worldwide concern in recent years due to its negative impacts on resource use, the environment, and social development (Cuellar & Webber, 2010). Although food loss and food waste occurs throughout the whole food supply chain, food waste at the consumer stage attracts particular attention, because the relatively large amount of consumer food waste means that all resources input at production, processing, storage, and distribution stages and a significant amount of greenhouse gas (GHG) emissions occurring at these stages and at waste management is added (Vittuari, de Menna, &Pagani, 2016).

The school canteen is one important segment of food consumption outside the home. School-aged children are experiencing rapid body growth and maturation, therefore a nutritious and balanced diet benefits their health, well-being, and academic achievement in the long term .In recent years, a few studies have focused on school food waste using case studies in different countries. For example, according to an assessment of the American National School Lunch Program (NSLP) during 1991-1992, approximately 12% of calories from food served to students were lost as plate waste, causing a cost of over 600 million US dollars (Buzby& Guthrie, 2002).

For early elementary students in the U.S., nearly 45.3% of foods and beverages were wasted in a full school week (Byker*et al.,* 2014). The food waste generated in schools is influenced by multiple factors, such as the quality and efficiency of catering service, the dietary habits of students, and the national diet culture. Children eating with larger bowls wasted significantly more than those with smaller ones (Wansink*et al.,* 2014). The large amount of food waste generated in Sweden was strongly related to children's ignorance of the impact of food waste on the environment and ethical issues associated with it (Casimir, 2014). Lack of attention to dietary habits was the most important factor behind school food waste (Falasconi*et al.*, 2015). Low self-efficacy for completely finishing meals was the main reason for Japanese students' food waste behavior (Abe and Akamatsu, 2014).

Americais comprised of the third largest national population in the world with over 98% of its citizens originating from families native to countries outside of the continent according to United States Census Bureau (USCB, 2014). It has been estimated that as much as 25% of the world's food is lost post-harvest due to microbial spoilage while as much as 40% of America's food is wasted due to inefficient production and careless consumer habits; not accounting for foods lost due to diseased livestock (Nellemann, 2009; Gunders, 2012).

In university settings across the U.S., about 3.6 million tons of food is wasted annually. A food waste study completed at Kansas State University sought to understand the effectiveness of two different kinds of educational messages. Baseline food waste was collected for six weeks before the messages were implemented. First, a prompt style message was posted in the facility for two weeks followed by a feedback-based message that was posted for two weeks. The simple prompt-style messages resulted in a food waste reduction of 15 percent.

The following feedback-based messages did not stimulate further waste reduction. An average of 32 pounds of food was wasted per person per semester (Whitehair *et al.*, 2013).

Food losses and waste in sub-Saharan Africa (SSA)can be measured in quantity and/or quality terms, with important distinctions. Quantity losses occur when the actual amount of food, often measured in either kilograms or calories, reduces over time and space. This is generally the focus on PHL magnitude estimation reduction strategies to date.Quality losses occur via the loss of important nutrients and/or through contamination of food (Barrett and Bevis, 2015).

2.2 Causes of food waste

Food is wasted throughout the FSC, from initial agricultural production down to final household consumption. In medium-and high-income countries food is to a high extent wasted, meaning that it is thrown away, even if it is still suitable for human consumption. Significant food loss and waste do, however, also occur earlier in the food supply chain. In low-income countries food is mostly lost during the production-to-processing stages of the food supply chain. In developed countries food gets lost when production exceeds demand. In order to ensure delivery of agreed quantities while anticipating unpredictable bad weather or pest attacks, farmers sometimes make production plans on the safe side, and end-up producing larger quantities than needed, even if conditions are "average". In the case of having produced more than required, some surplus crops are sold to processors or as animal feed. However, this is often not financially profitable considering lower prices in these sectors compared to those from retailers (Gustavsson*et al.,* 2011).

Food loss occurs because food is perishable; it passes through complex supply chains between harvest and consumption; and it represents a small portion of total expenditures for many Americans. Thus, the convenience of wasting food often outweighs the cost. Food loss and waste have many causes, including:Overplanting of crops to guarantee supply, edible crops left in the field due to diminishing returns on investments in harvesting, damage, contamination, or inefficiencies in harvest, storage, processing, and distribution, high cosmetic standards leading to culling of visually imperfect products, Overstocked product displays at stores, inconsistent date labels that confuse consumers, leading to premature disposal, over-preparation, large portion sizes, and aversion (strong dislike) to eating leftovers and lack of awareness about the occurrence and impacts of food waste (Alexander H. Reich and Jonathan A. Foley, 2014).

2.3Impact of food waste

Food waste has very important environmental ramifications(action), taking into account the treatment of the waste and the production of food that ends up being wasted. Several indicators can be used to measure this environmental impact; nevertheless the most widely used and well known are the carbonfootprint, blue water footprint and land occupation. A carbon footprint is the total amount of greenhouse gas (GHG) emissions caused directly and indirectly by an activity or accumulated over the life stages of a product. This indicator should quantify the most important GHG emissions, including carbon dioxide methane and nitrous oxide which are considered the most important GHG up to farm gate carbon dioxide is the most significant in the rest of the UK food supply chain (Garnett, 2011).

Animal products commonly have a higher water footprint per kg of food product due to the large amounts of water required to grow animal feed crops. Improvements must be fundamentally applied to agricultural activities, since 70% of the total water consumed worldwide corresponds to the agricultural stage; for example, switching from the inefficient flood and overhead spray irrigation systems to drip and trickle irrigation is recommended to reduce water consumption. The environmental cost of food waste is a significant global issue that could be used to encourage consumers to change their behavior. Existing evidence suggests that consumers will need to be educated about the connection between food waste and environmental impact before this driver becomes effective (WRAP, 2007a).

2.4 Benefits of recovering food waste

There are several reasons why food loss in general and food waste in particular are important. **The first reason** is that the world population is growing and we will need more food to feed people. The United Nations predicts that the world population will reach 9.3 billion by 2050 (United Nations, 2011) .This growth will require at least a 70% increase in food production, net of crops used for biofuels (FAO, 2009).And, although most of this population growth will occur in developing countries, the reality is that developed countries also face issues of food insecurity. For example, in 2010, almost 49 million people lived in food-insecure households in the United States out of a total population of 304 million (Coleman-Jensen *et al.*, 2011).

The second reason is that food waste represents significant amounts of money and other resources invested throughout food's entire lifecycle to produce, store, transport, and otherwise handle something that does not ultimately meet its intended purpose of feeding people (Buzby*et al.*, 2011). According to the US Environmental Protection Agency (EPA), food waste accounted for almost 31 million tons (14%) of the roughly 220 million tons of municipal solid waste in the United States in 2008.Less than 3% of food waste was recovered and recycled in 2009, with the remainder going to incinerators (EPA, 2011).

The third reason there are negative externalities that arise throughout the entire lifecycle of food (including food waste) and adversely impact society and the environment.In short, food production can result in the co-production of negative externalities. At the beginning of food's life cycle, negative externalities begin to arise when food is produced and these externalities are produced unnecessarily when food is wasted. A few examples of these externalities include: (1) greenhouse gas emissions from cattle production (Lundqvist*et al.,* 2008), (2) air pollution caused by farm machinery and trucks that transport food, (3) water pollution and damage to marine and freshwater fisheries from agricultural chemical run-off during crop production, and (4) soil erosion, salinization, and nutrient depletion that arise from unsustainable production and irrigation practices (Nellemann*et al.,* 2009).

Composting and recycling food waste is part of the integrated waste management strategy that is being gradually recognized by local authorities. Recycling the food waste can provide benefits for local authorities in terms of financial, environmental and technical aspects (Imperial College, 2012). By producing composts from waste materials, the cost on buying commercial fertilizers that provide nutrients to plant and soil can be reduced. The composts produced can be used as organic fertilizers for soil conditioning and nourishment. The compost produces materials that can be used as slow release fertilizer in plantation .The satisfaction can be gained from the improved growth and development of plants in compost amended soil (Ahmad *et al.*, 2007).

2.5Organic fertilizers

Composting is natural process of recycling and decomposing of organic material into humus rich soil amendment called compost (Risse&Faucette, 2004). Microorganism such as bacteria, fungi and actinomycetes uses nutrients and energy in organic material and convert hydrocarbons into carbon dioxide and water by oxidation.Carbon, hydrogen and oxygen that originally found in solid material are converting into gaseous forms and release to atmosphere (Merfield, 2012). Organic fertilizers from waste product can enhance soil quality and improve the quality and quantity of agriculture production.The production of organic fertilizers can decrease the environmental contamination and increase the quality of sustainable land (Sumardiono&Murwono, 2011).

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 (Risse&Faucette, 2014).The ratio of carbon to nutrients of organic wastes iscrucial during fermenting and composting process. These processes depend on microorganism that use carbon source to provide energy and nitrogen to build cell proteins (Owen, 2003). Nitrogen is most critical nutrient and requires small amount of phosphorus and other elements. The C: N ratio on range of 25-27:1 is considered as optimum. The low C: N ratio (less than 25) can cause the loss of nitrogen from compost via ammonia volatilization. However, the high C: N ratio (greater than 40) can cause immobilization of nitrogen in compost and decrease the rate of decomposition. Vegetable and fruit wastes have C: N ratio of less than or equal to 27:1 is moderately suitable in fermentation and composting (Ahmad *et al.*, 2007).

2.6 Humanexcreta

Our kidneys are our main excretion organ. Each year, one person produces 500 kg of urine as compared to 50 kg of faeces. These faeces contain some 10 kg of dry matter. Thus one person produces approximately 5.7 kg of nitrogen, 0.6 kg of phosphorus and 1.2 kg of potassium per year. Of the human excreta, urine contains some 90% of the nitrogen, 50-65% of the phosphorus and 50-80% of the potassium. The higher figures have been published (Wolgast, 1993). They are based on the human physiology and are often cited in the literature.

From the total amounts of nutrients that are taken up by cereals, 60 % of the N and P, and 15 % of the K can be found in the harvested (consumable) parts (Van der Pol, 1992). Relatively much of the N and P and practically all of the K are excreted by the human body (Cooke, 1988). In India, the amount of human excreta is only 15 % of the total amount of animal (cattle, sheep, goats, and pigs, chicken) and human excreta. However, the nutrients in human excreta account for 50 % of the total nitrogen, 39 % of the total phosphorus and 27% of the total potassium. The percentages for cattle were respectively 32% for N, 40% for P and 50% for K. Average nutrient contents in human excreta are ten times higher than those in cattle excreta (Gaur *et al,* 1984). The total amount of nutrients in annually produced human excreta in sub-Sahara Africa is estimated to be 2.2 million tons of N, 0.5 million ton of P_2O_5, and 0.4 million ton of K_2O. These amounts are comparable to the amount of mineral fertilizers used in 1983/1984 (Cooke, 1988).

2.7A global over view of human excreta

Composition of human excreta consists of feaces and urine, which are the waste products of body metabolism. Therefore, the excreta generated by healthy people eating a similar diet are quite similar in both physical and chemical composition. In a study on the composition of human excreta, it was reported that age, sex, occupation or religion did not affect the chemical composition of the different fractions .However, a significant variation was that older people excreted larger amounts of total wet matter than younger, which was linked to a larger water intake intended to reduce the risk of constipation (Schouw*et al.,* 2002).

Faeces consist of material that passes through the intestines undigested, mixed with material extracted from the blood stream or shed from glands and the intestines (Guyton, 1992). Faeces are malodorous and consist, in addition to the undigested material, of mucus and cells shed from the intestines as well as bile, which give them their characteristic brown color (http://en.wikipedia.org). Faeces contain mainly water, bacteria, nutrients and food residues (Lentner*et al.,* 1983) .They can also contain large concentrations of pathogenic viruses, cysts of protozoa and eggs of helminthes (Faechem*et al.,* 1983).Feaces can contain large concentrations of pathogenic viruses, bacteria, cysts of protozoa and eggs of helminthes (Faechem*et al.*, 1983; WHO, 2006).

The amount of feaces produced by a person depends on the composition of the food consumed. Foods low in fibres, such as meat, result in smaller amounts (mass and volume) of feces than foods high in fibre (Guyton, 1992). The feacal production in the developed countries is approximately 80-140 g/p,d (wet weight) of feces, corresponding to about 25-40 g/p,d of dry matter (Lentner*et al.,* 1981; Feachem*et al.,* 1983; Jönsson*et al*, 2005).Fecal excretion rate in the developing countries is on average 350 g/p,d in rural areas and 250 g/p,d in urban areas (Feachem*etal.,* 1983). In Chinameasured 315 g/p, d while Pieper (1987) measured 520 g/p, d in Kenya (Gao*et al.,* 2002). Fecal measured generation of 15 individuals in three different areas in Southern Thailand and obtained wet fecal generation rates of 120-400 g/p,d (Schouw*et al.,*2002). Fecal excretion rate is on average one stool per person per day, but it may vary from one stool per week up to five stools per day (Lentner*et al.,* 1981; Feachem*et al.,* 1983).

The quantity of urine excreted depends on how much a person drinks and sweats, and also on other factors such as diet, physical activity and climate (Lentner*etal.,* 1981; Feachem*et al.,* 1983).The studied in Sweden suggested that a design value for urine generation to be 1500 g/p, dor 1.5kg/p/d based on measurements(Vinnerås*et al.,*2006) while in Southern Thailand between 600-1200 g/p ,d of urine were produced (Schouw*et al.,*2002). In Switzerland based on measurements reported a urine generation rate of 637 g/p, d on working days (Rossi *et al.,*2009) and in Sweden based on measurements reported 922 g/p, d on weekends, which is in agreement with 610-1090 g/p, dor 0.6-1.2 L/p, d (Jönsson*et al.,*1999).

Urine has been used in Europe in the olden times for household cleaning, softening wool, hardening steel, tanning leather and dyeing clothes. The Greeks and Romans used it to color their hair (Esrey&Andersson, 2001). Sweden is probably the country with the most advanced system of collection and reuse of human urine, where it is practiced by farmers on a large, mechanized scale. In a number of settlements or apartment blocks in the country the residents have ecological sanitation systems with urine diversion toilets. The urine from them houses or apartments is collected in large underground tanks, and what the residents do not use themselves is collected by farmers in road tankers and used for fertilizing their crops. The usual practice is to spray it onto the lands while they are being prepared for planting, and then harrow it into the soil before sowing the seed (Austin &Duncker, 2002).

In the Danish countryside urine was stored and used as a fertilizer experiment on the growth of barley, using urine in parallel with manure. The plant growth experiment showed that the urine had the expected fertilization value (Jansen &Koldby, 2003). In a field trial in Sweden in 2002, different application strategies for urine as a fertilizer on leeks were tested (Båth, 2003). Fertilizing with urine gave a three-fold yield increase. The study also concluded that it is not a problem to apply human urine in agriculture, even in a large city in Sweden (Stintzing, 2005).

In Botswana, Pilot trials for the agricultural use of urine demonstrated the fertilizer potential of household toilet to produce food. Trials were conducted whereby three plots were prepared in each of 16 locations. One was fertilized with urine, the second one with urine and compost, and the third one without any kind of fertilization for comparison purposes. The best results were achieved with the use of compost and urine together. This resulted in participants starting to use urine after the demonstration and even those without toilets started to collect urine for further use (Hanke, 2003).

In Ethiopia a popular practice here is FAITH gardening (Food Always in the Home). The concept is based on a vegetable garden divided into sections that are planted in rotation, at intervals of a few weeks. Thus, while some patches are producing food, others have seed still germinating. In this way there is a constant supply of available food. The vegetable patches are well composted with "human manure" and any other suitable organic material, such as garden refuse. Urine is also used as a liquid fertilizer. Excellent results are obtained (Austin, A. and Duncker, L. 2002).

2.8 Impact of human excreta

In developing countries, excreta-related diseases are very common, and faecalsludges contain correspondingly high concentrations of excreted pathogens - the bacteria, viruses, protozoa, and the helminthes (worms) that cause gastro-intestinal infections (GI) in man. The actual risks to public health that occur through waste use can be divided into three broad categories - those affecting consumers of the crops grownwith the waste (consumer risk), those affecting the agricultural workers who are exposed to the waste (workers', farmers' risk), and those affecting populations living near to a waste reuse scheme (nearby population risk).

The agricultural use of excreta or excreta-derived products such as stored or dewatered faecal sludge or co-compost can only result in an actual risk to public health if all of the following occur (WHO ,1989): That either an infective dose of an excreted pathogen reaches the field or pond, or the pathogen (as in the case of schistosomiasis) multiplies in the field or pond to form an infective dose; this infective dose reaches a human host; this host becomes infected; so that these constitutes the potential risk and this infection causes disease or further transmission is the actual risk to public health. If does not occur, the risks to public health remain potential only.

The epidemiological evidence on the agricultural use of excreta can bestated as follows (Blum and Feachem, 1985): Crop fertilisation with untreated excreta causes' significant excess infection with intestinal nematodes in both consumers and field workers. Excreta treatment, e.g. through thermophilic composting, extended storage and/or drying, significantly reduces or eliminates the risk of transmission of gastro-intestinal infections.Pathogens and parasites found in human excreta are widely responsible for a variety of diseases in developing countries (Pru¨ss*et al.*, 2002). The majority of pathogens can be found in the human faeces (Feachem*et al.*, 1983). Therefore, the main risk lies in the contamination of the environment by faeces spread next to places where people and animals live and especially next to drinking water sources (Esrey*et al.,* 1998). The risk of transmission of infectious diseases via the abundance of pathogens can be reduced essentially by keeping the magnitude of the problem as small as possible by preventing mixing of the critical fraction faeceswith urine or water (Esrey*et al.*, 2001).

Salinity of human urine a potential problem associated with the use of urine based fertilizer is salinity. The perceived risk of urine-fertilized soils becoming saline is related to the content of soluble salts especially Na+ and Cl- inherently in urine. Soil salinity is a worldwide threat to crop production, as it (André Läuchli, 2002)affects plants through osmotic stress, ion toxicity and nutritional imbalances (Michael,Y, 2013).

Human urine contains pharmaceuticals filtrates even after protracted storage of urine as a treatment step (Gulyas, 2008). Thereby, the reuse of human urine is associated with a risk of transfer of pharmaceutical filtrates to the agricultures fields. About 70 % of pharmaceuticals taken in are excreted in urine and is accounting for 50 % of the eco-toxicological risk. Slight is known in the fate of pharmaceuticals (anti-malarial drug, antibiotics and so fourth) presentin urine regarding their accumulations in soil, transfer in ground water and uptake in plants (SeneMoustapha,2013).

2.9 Benefits of recovering human excreta

The nutrient value in human waste for food production has been well-documented; both in terms of the benefits to crop productivityand cost benefit analysis (Richert*et al.*, 2010). Human waste is utilized for food production in various forms around the world, with guidelines for ensuring its safe use (WHO, 2006).

The potential energy value of human waste has been given less attention to date and its benefits are less likely to be appreciated. There are two potential sources of energy from human waste. “Biogas” is generated through anaerobic (oxygen free) digestion resulting from bacteria breakdown of faecal matter and any other organic material. Biogas is approximately 60% methane by volume and has an average thermal value of 25MJ per m^3 (Cao and Powlowski, 2012). Dried and charred faecal sludge has been found to have similar energy content to coal and charcoal, with a heating value of approximately 25 MJ/kg, depending on the temperature at which charring occurs (Ward *et al.*, 2014). This is an extremely important observation.

While biogas has been harnessed in many large municipal wastewater treatment plants, and some countries have undertaken concerted (and successful) efforts to develop household biogas systems using either animal or human faeces, there has been little uptake of processed faecal sludge as an alternative to coal and charcoal. Given that the global production of fuel wood reached 1.9 billion cubic metres in 2013 (World Bioenergy Association, 2015) and that deforestation is contributing to soil and land degradation, as well as declining water quality, the use of dried sludge as an alternative energy source is a significant social, environmental, and economic opportunity.

Waste to Wealth makes a case for using modern bioenergy technologies to convert human and other organic wastes into resources that provide economic benefits, as well as protecting the environment and human health. It is founded in the application of anaerobic digestion technologies linked to sanitation systems. By identifying the value in waste forenergy and/or fertilizer, Waste to Wealth provides an incentive to use toilets and a mechanism to finance the capital costs as well as operation, maintenance, and expansion of sanitation infrastructure. In addition to the economic opportunities, sanitation interventions have known benefits to individual, household, and community health and wellbeing (Hutton, 2015).

There are many reasons that urine works so well as a fertilizer. Human urine contains very few, if any, pathogens but contains the majority of plant fertilizing nutrients .This high nutrient, low pathogen combination means that urine can be used very easily and safely to increase the yields of food crops. Add to this the ease and low cost of separating urine in most developing world sanitation systems and it is easy to see why the use of urine fertilizer could mean very real benefits for farmers and families with small gardens (Esrey*et al,* 2001:44).

Waste recycling is promoted for both economic and environmental reasons, but the use of fresh excreta carries considerable health hazards. On the other hand it rich sources of nitrogen and other nutrients necessary for plant growth. The Chinese rely over percent of excreta for agriculture (WHO/UNICEF, 1997).The heating value of mixed municipality waste range from<6 to >14MJ/kg (Bogner, 2007)

All over the world waste generation rate is highly fittest to population, wealth and urbanization, is still a key challenge for municipality to collect, recycle, treat and dispose of waste. Recycling of the waste in safe environment and many public healths' affordable way is the corner stone of the sustainable development and successful waste management carry out which parallel decrease GHG emissions and improve the quality of life, promote public health, prevent water and soil contamination, conserve natural resources and provide renewable energy benefits (Bogner, 2007).

2.10 Recovering Technologies

Anaerobic digestion is considered to be a sustainable bio-conversion technology as it produces biogas a renewable gaseous fuel and it also stabilizes and reduces the volume of waste. As a part of an integrated waste management system anaerobic digestion reduces the emission of greenhouse gases into the atmosphere. The degradation process or digestion of solids in an anaerobic digester takes place in three stages. The first stage is the hydrolysis of particulate and colloidal wastes to solubilize the waste in the form of organic acids and alcohols. The second stage is the conversion of the organic acids and alcohols to acetate, carbon dioxide, and hydrogen. The third stage is the production of gases mostly methane and new bacterial cells or sludge from acetate and hydrogen. In an anaerobic digester a great diversity of bacteria are required to perform phases of hydrolysis, acidogenesis and methanogens of the input substrate feed that contains diversified wastes in term of carbohydrates, fats and proteins (Geraradi, M.H, 2003).

Anaerobic digestion in biogas plants (BGPs) is an alternative way to handle biowaste, which includes animal and human waste. In Europe, increasing numbers of BGPs use food waste and manure as energy sources. In Denmark there are 19 BGPs, in Germany 11, and in Sweden there are 10 large scale BGPs operating today (Albihn*et al.*, 1999; Ortenblad, 2000). Anaerobic digestion produces methane (biogas), reduces odour, and the digested residues may be used as fertiliser in agriculture. The main suppliers of biowaste are slaughterhouses, households, restaurants, food and beverage industries as well as sewage treatment plants (STPs) and animal farms.

In the Swedish BGPs, animal wastes from slaughterhouses are used with other biowaste, mainly manure and food industrial waste. In some countries, BGPs use sewage sludge with other biowaste, but in Sweden sewage sludge is treated separately in STPs. Because bio waste is known to contain pathogens, the digested residues must be proven hygienically safe for both people and animals in order to be recycled. Otherwise, new ways of transmission of pathogens between people and animals could be established. There are no EU regulations concerning the hygienic standard of the BGP residue.

Composting is the microbiological degradation of organic material to a humus-like stable product under aerobic, moist and self-heating conditions. Composting is often performed in order to convert potentially degradable waste into a beneficial product, to disinfect material that might be contaminated with pathogens and also for bioremediation of hazardous waste (Haug, 1993). The product from a well-functioning and managed thermophilic compost process is usually free of pathogens and plant seeds and can be beneficially applied to land, supplying nutrients for plant growth, humus and organic matter for soil improvement (Epstein, 1997; Arvanitoyannis &Kassaveti, 2007).

When a well-conditioned substrate (sufficient energy, nutrients, moisture, structure etc.) is composted, aerobic degradation of its organics occurs. The process is exothermic, i.e. heat is generated, resulting in increased temperature. The heat produced either remains in the compostmass or escapes by conduction, convection and radiation, or is lost with the outgoing gas. To keep the material undergoing composting hot enough for sanitation, sufficient amounts of the heat generated should remain in the compost matrix. This requires, at least on the small and medium scale, that the compost be well insulated. The outer parts of large compost piles act as insulators to the inner parts of the pile, resulting in a temperature gradient within the pile, with the highest temperature in the interior (Finger *et al.*, 1976).

Chapter Three: Objective of the study

3.1General objective

To assess and characterize food waste and human wastes generated from Jimma university campuses.

3.2 Specific objectives

1 To quantity the food waste and human wastes generated rate from three Jimma university campuses.

2 To determine the characteristics of each waste streams using single and mixed waste approach.

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ChapterFour: Methods and Materials

4.1 Study area and period

The study was conducted in three Jimma University Campuses: at Jimma University main campus (JUMC), Jimma University Institute of Technology (JUIT) and Jimma University College of Agriculture and Veterinary Medicine (JUCAVM) from May 11-25 /2017. Jimma town located at 355 km southwest Ethiopia. Its geographical coordinates are: 07°39' Latitude and 36°50' Longitude, at an altitude of 1,700-1,750 m above sea level.

Jimma University is organized into eight colleges, out of which five of them are located in Jimma university main campus. Jimma University is one of the largest and comprehensive public research universities in Africa. The university graduates innovative professionals through its community oriented educational philosophy in the fields of agriculture and veterinary medicine, environment, health and medical sciences, natural and social sciences, technology and information sciences, business and economics, educationand behavioral science and law. It has twelve research facilities, a modern hospital, a community school, and a community radio station (FM 102.0), an ICT center, libraries and revenue generating enterprises. The university is operating on four campuses and it is on the phase of establishing its fifth campus at Agaro(Jimma University-Wikipedia).

According to human resource office data in2017, JUC had hired a total of8,198 workers as academic and administrative staffs.According to the data from JU registrar office,the University educates more than 43,000 students: 33,176undergraduate, 1,526 PGDT and 4,208 postgraduate, 206 in PhD programs in regular, summer and distance education with more enrollments in the years to come.The University has many national and international linkages and collaborations in the area of research, education and community service. Its innovative educational philosophy, staff commitment and motivation and availability of better research facility have helped the University in attracting both national and international partners (Dar es Salaam, 2004, p. 37)

Huge of wastes from sources mainly from students' cafeteria kitchen and it is the one, whichrecommendation liquid wastes management. The JUMC waste is discharged into kochi stream without any form of treatment and enter into Aweto stream and ultimately to Gibe river which is the main tributary of the river Gibe, such as wastes discharge. Without any form of treatment not only becomes potential health hazards to the nearby communities, the wastes may also upset the ecological integrity of the River Aweto by reducing the dissolve oxygen downstream.

4.2 Sample collection and preparation of sample

Research ethical committee approval was obtained prior to the study to collect the food waste and human wastes sample and conduct the study. Before collecting the sample; checklist was prepared to conduct the study. Data collectors were selected to gather data from the three Jimma University campuses. Among the five students' cafeteria and nine staffs' lounge, three cafeterias and three lounges were chosen based on the number of student's cafeterias and staff's lounges. The data collectors were properly oriented about the data collection procedures by investigator. Before food waste collection started; materials used for collection were prepared (for e.g. dishes). Food waste samples were collected from three students' cafeteria and three staffs' lounge. The sample sites were JUMC (Jegaye cafeteria), JUIT (graduate student cafeteria) and JUCVM (student's dining hall). For the quality of the data, in first day materials were prepared before collecting the sample. Right after the second day up to the eight day (7days) food waste sample was collected.

The food waste collection was for consecutive seven days (from Monday to Sunday) throughout the study period. The investigation was carried out at working hours at breakfast (1:00am-2:00 am), at lunch (5:30am-7:30pm) and dinner (11:30 pm-2:00 pm). In this study design, food waste collection was categorized into during preparation and leftover (i.e. breakfast, lunch and dinner). Waste during preparation was categorized in to five waste sub-categories (Onions peeling, potatoes peeling, cabbages peeling, avocadoes peeling, and mangoes peeling). Food waste collecting was measured or quantified by using mass balance and after working hours. For laboratory analysis, 10 different samples of food wastes were selected randomly from three campuses to representative sampling sites. An approximately 5 kg of food waste samples were taken by plastics bags for laboratory analysis.

Human waste collection: human feaces and urine was collected from volunteer students from three JUC. Taking into account and difficulty collection of human waste, investigator considered about 15 individual volunteer students who are willing to participate for the study. Before sample collection, volunteer students were oriented for the period of collection and how to use the collection materials that prepared. Before collecting the sample, the plastic bags and bottle plastics distributed for each anonymous volunteer students one day before.

For feaces and urine was collected in separately. Using the plastic bags and bottle plastics, the aim was to prevent the health risk due to direct handling of feaces and urine and promote closed lope sanitation technology. Feaces sample weighed in gram by using sensitive balance. Then samples material was quickly deposited into a metal container mixed with stick for homogeneous. The preparation of the feaces sample was kept at room temperature for two days for initial moisture content to initiate. Approximately 5,000g of feaces sample was transported to the laboratory for analysis. And the identification number was assigned to each student and corresponding level is given for each and every plastic bags and bottle plastics that distributed for them.

The human waste sample was collected consecutive for three days at 24 hours. Then; all volunteer students were informed when the sample collector comes back during study period. On the next day early in the morning the collection of samples began. Sample collector collected all the distributed plastic bags, and bottle plastics with feaces and urine waste kept in, and brought to the specific place for measuring purpose. Urine was weighed in liters by bottle plastics. After finished the collecting urine sample, mixed into Jeri cans. In this case sample preparation was stored on ice and until transport to the laboratory.

4.2.1Estimation of waste generation rates

It was assumed that the academic year is made up of ten months for regular students and twelve months for staffs when the population of the universities is at a maximum. During this period, the population of the universities is made of academic staffs and students. It is assumed the staffs and students in residential accommodation stay in the university. The waste generation rate was estimated for the one period; the period when the universities are in session.The volume of the waste generated in each of the universities was estimated based on the following assumptions (Arthur, R.,2011).

i. The Volunteer's students in the dorm on an average use the toilet for consecutive three day at 24 hours;
ii. The Staffs and students resident on an average use the lounges and cafeteria for consecutive seven days;
iii. The students are at the cafeterias ten months in a year; (get their meal three times a day);
iv. The number of persons at three staff's lounge in three campuses is 465
v. The number of students in three cafeterias in three campuses is 12,915

vi. Staffs are at lounges during a meal times a day

vii. The staffs stay on the university campuses throughout the year.

For the purpose of this study,the population in university campuses was categorized into; a) Students in residential campuses, b) staffs staying in campus

4.3 Study design

4.3.1 Survey

Adescriptive survey study design was used to quantify on food waste and human waste generation samplesfor the purpose.

The laboratory based experimental study design was characterized of food waste and human excreta (feaces and urine) in to different laboratories to evaluate organic fertilizers potential. The characteristics of food waste and human excreta were done at JUCAVM at Post-Harvest Management (PHM) laboratory and at JIJE Analytical Testing Service Laboratory, Addis Ababa, Ethiopia. Each sample was prepared in triplicate for analysis and triplicate sample was repeatedly carried out to evaluate the precision of measurement according to the tests method (see in annex I).

4.3.2 Characterization of the food waste and human excreta

The physical /Proximate/characteristic of food waste: thisdesign provides the weight percent of moisture content, protein, fat, carbohydrate, ash, and energy.

The moisture (or total solids) content of foods is important to food manufacturers for a variety of reasons. Moisture is an important factor in food quality, preservation, and resistance to deterioration. Determination of moisture content also is necessary to calculate the content of other food constituents on a uniform basis (i.e., dry weight basis). The dry matter that remains after moisture analysis is commonly referred to as total solids. While moisture content is not given on a nutrition label, it must be determined to calculate total carbohydrate content. Moisture content of foods can be determined by a variety of methods, but obtaining accurate and precise data is commonly a challenge.

Moisture was determined by Standard Official Methods of Analysis of the (AOAC, 2000). In this procedure, 5 g of each sample was accurately weighed in petridish (W1). The partially covered dish was placed in a thermostatic oven at the temperature of 105^0C until constant weight was obtained for 4 hours. Then, the petri dish was placed in desiccator for 30 minutes to cool. The sample was reweighed after cooling (W2).

%Moisture = $\frac{(W_1-W_2)}{\text{Wt. of sample}}$ x 100 ----------------------- (Equation 1)

Ash content was determined by standardofficial method of analysis of the (AOAC, 2000). Cleaned empty crucibles were placed in a muffle furnace at 550^{0}C for one hour, cooled in desiccator and then weight of empty crucible was noted (W_1). 3 g of each sample was placed in crucibles (W_2). The crucibles were then placed in a muffle furnace at 550^{0}C for 8 hours. After the complete ignition the furnace was turned off; the crucibles were cooled and weighed (W3). The percentage ash was calculated according to equation:

% Ash = $\frac{(W_3-W_1)}{\text{Wt. of Sample}}$x100 --------------------------(Equation 2)

Fat content was determined by ether extract method using Soxlet apparatus (AOAC, 2000).The bottle and lid in the incubator placed at 105^{0}c overnight to ensure the weight of the bottle is stable. Weighed about 4 g of each moisture free sample was wrapped in filter paper.Sample was placed into extraction thimble and then introduced in the extraction tube or sox let. Weighed, cleaned and dried receiving beakers were filled about 250ml of petroleum ether into the bottle and was taken it on the heating mantle and fitted into the apparatus. Connected the sox let apparatus and turned on the water to cool them and then switched on the heating the mantle. The sample was heated about 8 hours. The solvent was evaporated by using the vacuum condenser. In cubed the bottle at 80-90^{0}c until solvent was completely evaporated and bottle was completely dried. After dried, transferred the bottle with partially covered lid to the desiccators to cool, then reweighed the bottle and it dried content.

% Fat = $\frac{\text{Wt. of Ether Extract}}{\text{Wt. of Sample}}$ X100 --------------------------- (Equation 3)

The protein content of food sample was determined using the Micro-Kjeldahl method of (AOAC, 1984). The method for protein analysis is based on nitrogen determination. Both methods are official for the purposes of nutrition labeling of food. Protein was determined by three steps in Kjeldahl methods.

Protein digestion phase:1g of each dried and homogenized sample was weighed and digested in suitable Kjeldahl test tubes/flasks with 12ml of concentration of 98% H_2SO_4 was added. Concentration of H_2SO_4 was used, reagent with reduce nitrogen content(ammonia and nitrate) .To rise the temperature, 7g of K_2SO_4 and 0.2g of $CUSO_4.5H_2O$ (9:1) was used as a catalyst. 30% of H_2O_2 with addition of 20ml concentrated of H_2SO_4 was only used as catalyst for meat and derived product sample .The flasks /test tubes were swirled in order to mix the contents thoroughly. Digestion was carried out by heating for 60minutes at 420^0C the mixture till become clear. After 50-60^0C cooling the digest was then transferred to 100 ml vol. flask and volume was made up to the mark by the addition of distilled water.

Protein distillation: Before use, the Markham distillation apparatus was steamed through for 10 minutes after which a 100ml conical flask containing 20ml of 4%Boric acid (H_3BO_3) solution with few drops of modified or 7 ml of Bromocresol green and 5ml of methyl red indicator was placed under the condenser such that the condenser tip was under the liquid.About10 ml of the digest was pipetted into the body of the apparatus via a small funnel apparatus. The digest was washed down with distilled water followed by addition of 2000 ml of 40 % NaOH solution. The digest in the condenser was steamed through for about 10 minutes after which enough ammonium sulphate was collected as NaOH in conical flask. The receiving flask /receiver solution was removed and the tip of the condenser washed down into the flask after which the condensed water was removed. The solution in the receiving flask was treated with 0.01M hydrochloric acid. Also, a blank was run through along with the sample.

During distillation -titration yellowish color appeared due to NaOH. The distillate was then titrated against the standard 0.2 N HCl solution till the appearance of pink color. A blank value was also run through all the steps as above to check the nitrogen in the system. Protein was determined according the following equations:

$$\%N = \frac{[V(1) - V(Bl)] * F * c * f * M(N) * 100\%}{m.1000} \quad \text{------------------ (Equation 4)}$$

V (1): consumption of titrant, sample [mL]

V (Bl): average consumption of titrant, blank [mL]

F: molar reaction factor (1 = HCl, 2 = H_2SO_4)

C: concentration of titrant [mol /L]

f: factor of titrant

M (N): molecular weight of N (14,007 [g/mol])

m: sample weight [g]

1000: conversion factor (ml in L)

PF: protein factor

% N: % of weight of N

% P: % of weight of protein

Percentage of nitrogen was calculated according the formulae:

% Nitrogen = Vs–VB x Macidx0.01401 x100 W, Where, Vs = Volume (ml) of acid required to titrate sample; VB = Volume (ml) of acid required to titrate the blank; Macid=Molarity of acid; W=Weight of sample (g). Then, percentage protein in the food sample was calculated from the percentage of Nitrogen as: percent of protein is equal to percent of Nitrogen multiplied by conversion factor (F), Where, F (conversion factor) is equivalent to according to the types of food waste in the tests method (see annex I).

The carbohydrate content of samples was obtained in form of difference between 100 and the sum of moisture, protein, fat and ash values (AOAC, 2000).This method involved adding the total values of protein, fat, moisture and ash constituents of the sample and subtracting it from 100. The value obtained is the percentage carbohydrate constituent of the sample. Thus: % carbohydrate=100–(% moisture +% protein+%fat+% ash).The **energy value** of the sample was determined by multiplying the protein content by 4, carbohydrate content by 4 and fat content by 9(AOAC, 1990).

Physical characteristic of human excreta: the proximate /physical /analysis feaces provide weight percent of moisture content, ash, volatile matter and fixed carbon in the sample. Thus 1gram of the sampled feaces was prepared in triplicate after homogenizing. Then determination of the percentage of the moisture and ash content of the feaces was carried out based on standard methods AOAC Official Methods 923.03& 925.10 respectively.Each of the triplicate samples was repeatedly carried out to evaluate the precision of measurement.

Moisture content: The muffle furnace was heated to 750^0c and placed the previously ignited porcelain crucibles covers in the furnace for 10minutes. The crucibles allowed cooling down in desiccators for one hour. After cooling the crucibles, 2 g of feaces have been added to each of them and weighed the nearest 0.1mg of ground sample.

Samples were placed in the oven at 105^0c for 2hours.The samples were placed in desiccators for 1hr and weighed were put in an oven again for 2hours. The percentage loss of weight gives the percentage of moisture in the sample. The percentage of the moisture content is equal to loss in weight multiplied by hundred and divided by weight of sample take the mixing with the same weight of solid waste and reevaluate the result.

Volatile matter: The dried sample after moisture removal were taken in crucible and placed in electrically heated furnace at a temperature of 925^0c for seven minutes and then cooled in dissectors. The percentage of weight loss gave the volatile matter content. Percentage of volatile matter is equal to loss due to removal of volatile matter multiplied by hundred and divided by weight of the sample taken.

Ash content: The remaining sample after evaluation of volatile matter was kept in a furnace at a temperature of one hour and half hour. The percent of ash content is equal to weight of ash left multiplied by hundred divided by weight of sample taken.So that having the percentage of moisture content and ash content fixed carbon can be calculated. The percentage of **fixed carbon** is equal to hundred minus percentage of moisture plus percentage of ash content.

Elementalanalysisof food waste:elemental analysis in this analysis involves the determination of nitrogen and carbon.The determination of total nitrogen was carried out using the standard Kjeldhal method after digestion and titration.The percentage of carbon content of the sample was obtained from volatile solids data using the empirical equation (Yitayal, 2011).

% Carbon = (100 - %Ash)/1.8 ------------------------- (Equation 5)

After obtained the protein determination, finally the ratios of carbon to nitrogen ratio was calculated as: percent of carbon divided by percent of nitrogen.

Elemental analysis of feaces: A matter provide the weight fractions of mineral elementtotal organiccarbon (TOC) and total nitrogen (TN).This can be used to evaluate the extent value and the organic constituents in the sample. Total organic carbon and total nitrogen was conducted by using analyzerMethods AOAC Official Methods 923.03and Modified ESISO1871:2013 respectively.In order to evaluate the precision of measurement; each sample was carried out in triplicate.

Elemental analysis of urine matter: provide the weight fractions of macronutrient elements (NPK)was carried out using analyzer test methods(APHA 4500-Norg C., APHA 4500-P C. & APHA 3111 C.) respectively.

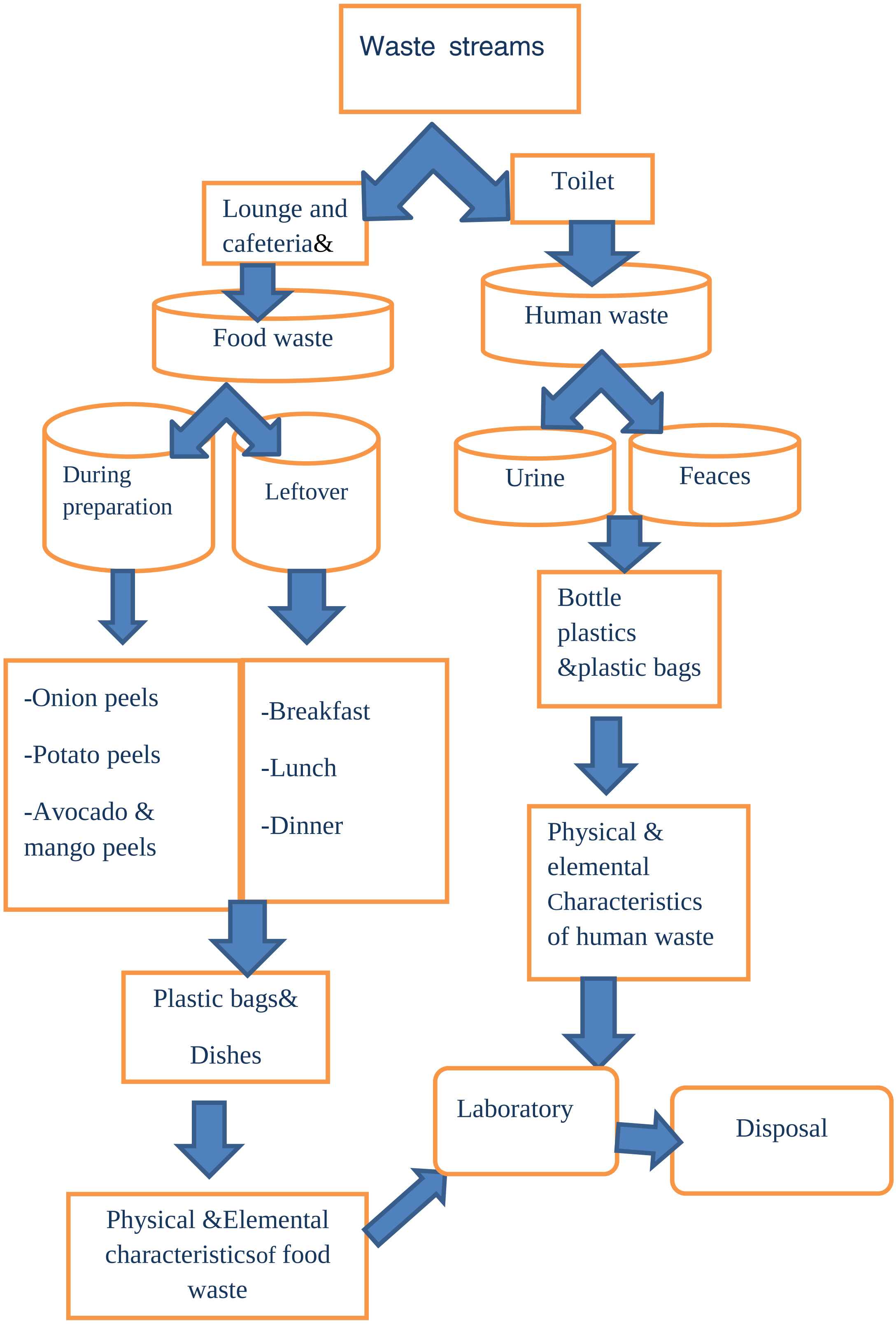

Figure 2:Diagrammatic representatives of food waste and human waste

4.4Materials and Instruments

The waste materials used for the study were: food waste fromJimma University Main Campus, Institute of Technology and College of Agriculture and Veterinary Medicine students' cafeteria and staffs' lounge. Human feaces and urine was fromstudent residence in dormitory at Jimma University Campuses. During the study time the following listed materials and equipment's were used:

- **Hand protective plastic gloves**: to protect hand from direct contact with samples
- **Mouth & Nose Mask**: to protect one from bad smell,
- **Plastic bags**: for the collection food waste and feaces,
- **Dishes:** for holding of leftover food,
- **weighing balance and sensitive balance**: to determine the weight (kg) of food waste sample and human feaces in (g),
- **Bottle plastics and Jericane** : for collection urine and mixing urine,
- **Micro-Kjeldahl method:** for determination of total protein and nitrogen
- **Non-digital oven:** for proximate analysis (including moisture content, and ash content
- **Open crucibles:** Used during the determination of ash
- **Metal plastics**: For collection of feaces and transport.
- **Graduated cylinder**: for urine volume measurement for accurate of urine in the bottle plastics.

4.5Data analysis

In order to achieve the objective, three approaches were used: first approach, survey. Data sampledsurvey wasanalyzed to obtain their characteristics in the following manner.

Generation rate: generation rate (GR; weight of waste produced by person per unit time) was determined based on a weight volume analysis.

GR=weight of sample waste-------------------- (Equation 6)

Total samplex days (duration)

Data for the campuses were calculated as a weighted average per capita generation rate, contributions of students in different cafeteriasand lounges.

Food waste characterization: the collected food wastes were characterized into wastes category and sub categories then analyzed for each campus. The weight of food waste components was determined in percentage before and after food processed in subcategories.

During preparation such as onions peeling,potatoes, peeling, cabbagesare peeling, avocadoes peeling,mangoes peeling. Whereas after food processed are leftover food (breakfast, lunch and dinner).
The percentage for each category was calculated using the following equation:

$$PS=\frac{PL}{PT}x100 \quad \text{-- (Equation 7)}$$

Where: PS - is the sub-category percentage, PL - is the amount of sub-category present in kg, and PT - is the total weight of sample in kg (Armijo *et al.,* 2008). An average weight percentage of each representative food waste generator beforeand after food processed was analyzedin each campus. Weight percentage of food wastes each subcategory at cafeteriasand lounges were analyzed.Completed forms were checked for errors and data were inserted into Excel's spreadsheet and saved as data file and descriptive statistics in graphs and tables and standard error was used.

The second approach: collected food waste and human waste were characterized with key properties (physical /proximate and elemental analysis).Both proximate and elemental analysis was made as a single waste approach. Where each waste streams was analyzed separately. Characterization of food waste and human waste approach was required mixing the each waste streams with different proportions.A feed stock in the digester was considering the digester capacity, for the purpose of the research. The processes of anaerobic digestion for generation of biogas and nutrients potential of different wastes were conducted in five treatments (T) with different ratios wastes in the laboratory (Ogunwande*et al.,* 2012).

In this thesis, the mixed wastes approach was food waste (leftovers) and human waste (feaces and urine) with different treatments composition ratios in five treatments. The parameters analyses were under taken to determine the physical characteristics of both food and human excreta on ash contents and moisture contents. The chemical characteristics were to analyses on macronutrients such as total nitrogen (TN), Calcium (Ca), Potassium (K) and Phosphorous (P).

Table1: Treatment and composition of feed stocks

Treatments	Composition
T1	FW 100%
T2	FW 70%+ HW 30%(15% F+15%U)
T3	FW 50%+HW 50%(25%F+25%U)
T4	FW 30%+HW 70%(35%F+35%U)
T5	HW 100% (50% F+50% U)

FW-is Food waste, HW- is human waste (F- is feaces, U- is urine).

In this approach, nutrient contents in food waste and human excreta were calculated. The calculation was met the (FAO, 1999) standard provides per capita protein consumption data on assumption basis. Data was calculated to predict the nitrogen and phosphorus outputs with the following equations (Jonsson*et al.*, 2004: 5):

Nitrogen = 0.13 x Total Food Protein ---------------------------------- (Equation 8)

Phosphorus = 0.011 x (Total Food Protein + Plant Food Protein) ------- (Equation 9)

Where the flow of proteins come from the FAO statistics on food supply (FAO, 2003).

Analysis of physical and elemental of food and human waste was calculated using different approaches of heating value fordifferent scenarios.

Table 2: List of equations for the calculation of heating value of using different approaches

FC fixed carbon, VM =volatile matter, C =carbon, all in percent.

Equations correlation of HHV*10^3(MJ/kg)	**References**
Proximate analysis	
1 HHV=19.91-0.232 Ash	Sheng ,C.(2005)
2 HHV=0.196FC+14.12	Dermirbas, A .(1997)
3 HHV=0.312FC+0.153VM	Dermirbas ,A.(1997)
4 HHV=0.354FC+0.171VM	Cordero ,T.(2001)
Elemental analysis	
5 HHV=0.32C+3.46	Sheng ,C.(2005)

Third approach: developing different scenarios and analysis using the results from first and second**:**In this approach, a theoretical model was used and compared with the literature reports. Three scenarios were developed: waste-to-energy conversion, waste-to-fertilizer conversion and combined conversion to energy and fertilizer. Therefore, organized the methodology based on the above approaches, since each section has its specific approached or procedures. However, this was accommodated important elements of the methodology.

4.6 Operational definitions

Food waste: Any solid or liquid food substance, raw or cooked, which is discarded, or intended to be discarded.

Food losses: refer to the decrease in edible food mass throughout the part of the supply chain that specifically leads to edible food for humanconsumption.

Human excreta: waste discharged from the body, especially feaces and urine.

Human urine: a liquid that is secreted by the kidneys, collected within the bladder and excreted through the urethra.

SoxhletMethods:an apparatus used for determination the fat content.

Kjeldahl method: an apparatus of determining the nitrogen content of organic and inorganic substances.

Digestion: the decomposition of nitrogen in organic samples utilizing a concentrated sulfuric acid solution and the end result is an ammonium sulfate solution

Distillation: adding excess base to the acid digestion mixture to convert NH_4+ to NH_3, followed by boiling and condensation of the NH_3 gas in a receiving solution.

Titration: quantifying the amount of ammonia in the receiving solution.

Desiccator: an apparatus holding a drying agent for removing or keeping moisture from the specimens

Empirical: based experiments and practical experience, not on ideas.

4.7 Ethical Consideration

The study wasconducted after obtaining ethical clearance fromJimma University,Institute of Health, Faculty of Public Health, Institutional Review Board (IRB); Department of Environmental Health Sciences and Technology.Official letter was also written from student dean office services to Jimma University Campuses food servicescoordinators and concerned bodies to communicate about the research and for required data.

4.8 Limitations of the study

Even though, the research wassucceeded its objective, there weresome limitations. Thereare nine staffs' lounge and five students' cafeteria. My sampling with mostly three students' cafeteria and three staffs' lounge at threeJimmaUniversity Campuses, due to time constraint. Human excreta sample collection was to collect from under graduate regular students.

4.9Result dissemination plan

The study findingtoJimmaUniversity, Institute of Health, Faculty of Public Health; Departmentof Environmental Health Sciences and Technology. The result will be also communicated to relevant and administratorsof threeJimma University campuses.

4.10 Data qualitycontrol

All the data was checked for completeness, accuracy, clarity and consistency by the principal investigator. The food waste and human excreta was collected by oriented people.For the quality of the data of food waste, first menu of the meal at eachcampus was checked from staffs' lounge and students' cafeteria. Collection materials were prepared, considering food waste for example, weight of dishes in kgwas known before food waste measured. Taking into accountthese wastes may not be generated on a daily basis of stationaries container without measured. For humanexcreta (feaces andurine), bottle plastics and plastic bags were disinfected. For the experimental work, the standard laboratory procedures were followed and well qualified laboratories in the country was chosen to perform the analysis. To minimize the variability with in the test a triplicate sample was used for each test. Temperature and time relationship was closely monitored during the wastes analysis.

Chapter Five: Results and Discussion

5.1 Generation rate

The results presented in the figures (3-6) the daily, weekly and annual generation food waste at students and staffs in Jimma university campuses. This was calculated based on the output results obtained from the food waste composition study in the cafeterias and lounges. The quantity of food wastes generated wasobtained from the data collected in the study areas. It was found from the study that dailyfood wastes generated around 1,662kg/day at students' cafeteria and staffs' lounge. This result shows that daily food waste generation rates from studentsduring preparation and leftover wasestimated to 270kg/day and 1,215 kg/day respectively. This means the result showed that waste generated daily from students was about 1,485kg/day.The daily waste generationfrom staffsduring preparation and leftoverwas estimated to107kg/day and 70kg/dayrespectively. Therefore,food waste generated from staffs of JUC was about 177kg/day.

The weekly average value of food waste generation from students during preparation and leftover wasestimated to 1,892kg/week and 8,503kg/week respectively. Whereas weekly food waste generation rate from staffs' cafeteria during preparation and leftover was estimated to 745kg/week and 492kg/week respectively. Taking this figure into account, weekly and an annual food waste generation rates were estimated to 11,632kg per week and 606,526 kg/ year respectively. A simple extrapolation of these figures to the entire population of the three university campuses involved results in 607 tons of food waste/year.Among these campuses 212,87, 243 and 65 for JUIT, JUCAVM and JUMC and JUSTAFin tons/year respectively.

The representative percent during preparation of food waste generated from the students' cafeteria was about 17.12% and 82.86% of leftover. Whereas the waste generation from the staff' lounge during preparation was about 60% and 40% of leftover. The study has shown that workers collect an average of percent (49.6%) food waswaste generated daily in JUC. Universities of Jimma have been used to collect these food wastes from their cafeterias and lounges, transported to a container in the campuses, finally decompose in an open land. Moreover, significant numbers of students are present at the campuses and generation become steady for the rest of the year.

To calculate overall average per capita generation rate, contributions of students and staffsin different cafeterias and loungesare taken in to account.

The mean students and staffs generation rate of one campus is different from the campus due to total population. The total waste generation rate sampling of Jimma university campuses were estimated depending on the data collected from the selected students' cafeteria and staffs' lounge.The JUCAM was generated small and JUMC was generated huge due to total of population.The figures (3-6) showed the amount of food wastes generation in daily, weekly and annually in JU

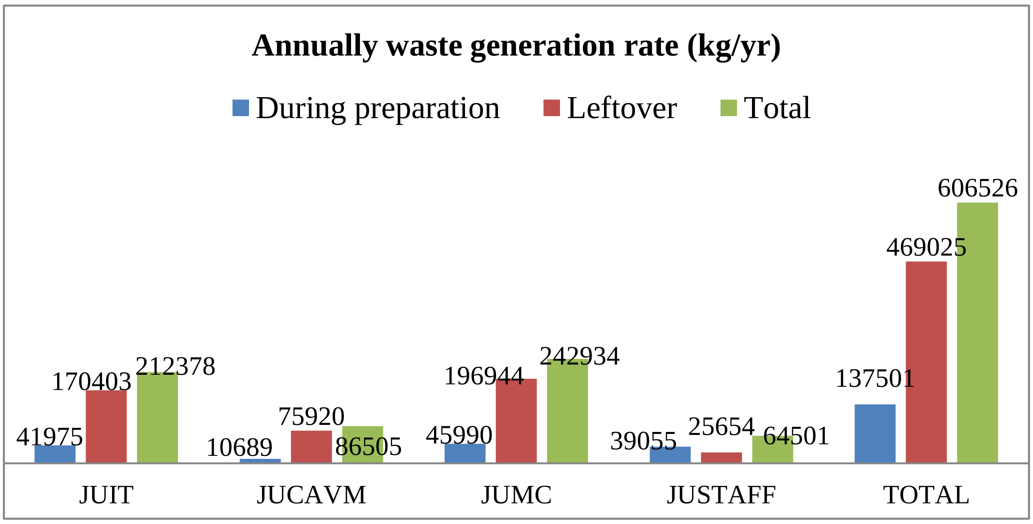

Figure 3: Food waste generation rate per day

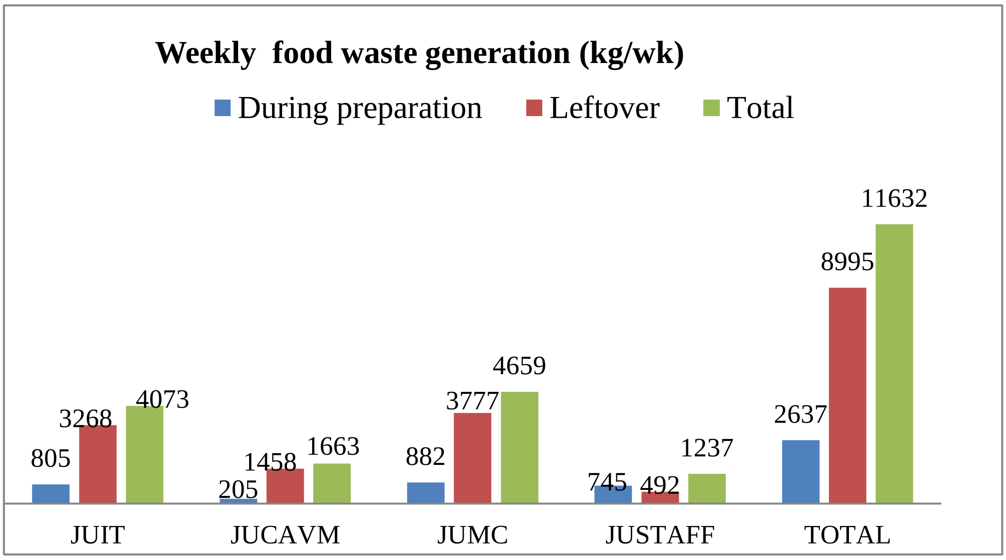

Figure 4: Food waste generation rate per week

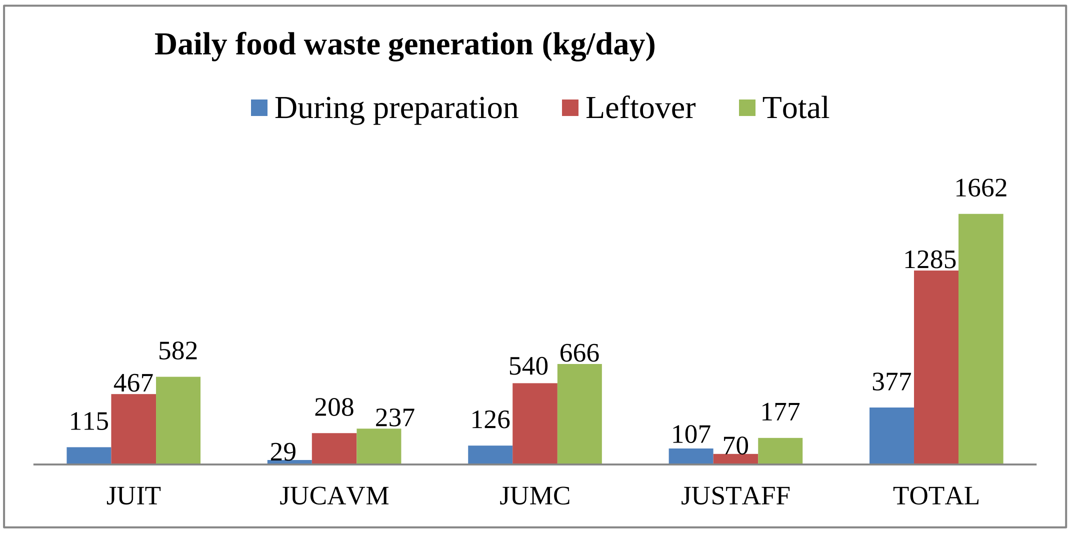

Figure 5: Food waste generation rate per year

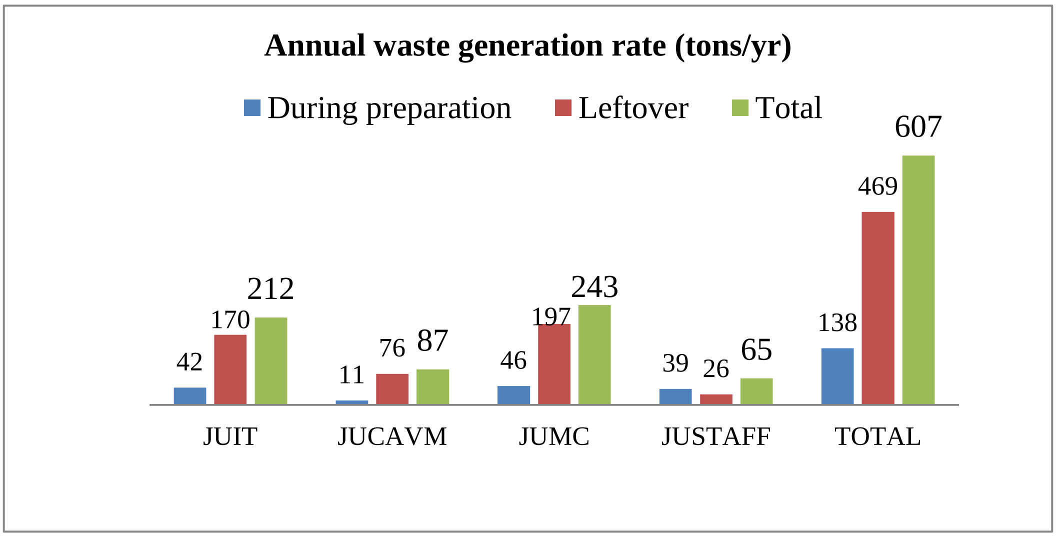

Figure 5: Food waste generation rates from the campuses in tons per year

5.2 Characterization (composition) of food waste

Knowing the composition of food waste enables to make sound decisions over food wastes quantity. The result in indicates the weekly average of food waste generation rates at three students' cafeteria. From the average total of food wastes generated during the study period, 10,395kg/week, an average weight of 4,073kg/week (39%) was from the JUIT students' cafeteria, 1,663kg/week (16%) from the JUCAVM students' cafeteria, 4,659kg /week (45%) from JUMC students' cafeteria.

Table 3:Weekly food waste generation rate (kg/wk) at students' cafeteria of JUC

Category	Waste	Campuses			Total
		JUIT	JUCAVM	JUMC	
During food preparation	onion peels	476	90	517	1083
	potato peels	251	73	275	599
	Cabbage peels	78	42	90	210
	sub-total	805	205	882	1892
Leftover	rice	513	210	607	1330
	firifir	336	173	392	901
	kenche	351	112	392	855
	misir	826	296	933	2055
	pototo	78	80	95	253
	aterkiki	1106	524	1288	2918
	meat	58	63	70	191
	sub-total	3268	1458	3777	8503

The results in Table4 shows the weekly total food waste generation rate from the three staffs' lounge of JUC. The average total of food wastes generated from staffs' lounge during study period was about 1,237kg/week, 283kg/week (23%) from JUIT staffs' lounge, 152kg/week (12%) from JUCAVM staffs' lounge, 802kg/week (65%) from JUMC staffs' lounge. Considering the three campuses, JUCAVM waste generated the very small food waste and JUMC generated great waste this account for different of population in the each campus.

Table 4: Weekly food waste generation rate at staffs lounge (kg/wk)

Category	Waste	Campuses			Total
		JUIT	JUCVM	JUMC	
During food preparation	onion peels	54	42	67	163
	potato peels	50	20	20	90
	cabbage peels	16	24	25	65
	fruit peels	101	0	326	427
	sub-total	221	86	438	745
Leftover	breakfast	41	31	203	275
	main dish	21	35	161	217
	sub-total	62	66	364	492

The presented results in Figures(7-9) representweight percentage of food waste each sub-category at students' cafeteria and at Staffs' lounge in JUC. Food waste consisted predominantly food waste leftover aterkiki(27%) from students of JUIT and JUMC and 31% from students of JUCAVM. The proportion of the meat from both JUIT and JUCM was l% and 3% from students of JUCAVM. Among these campuses, the percentage of food waste during preparation onion peels were high11% from JUIT and JUMC and 5% from JUCAVM due to activities throughout in all preparation of the day. The percent of cabbage peels from the three campuses were low the same percentage (2%).

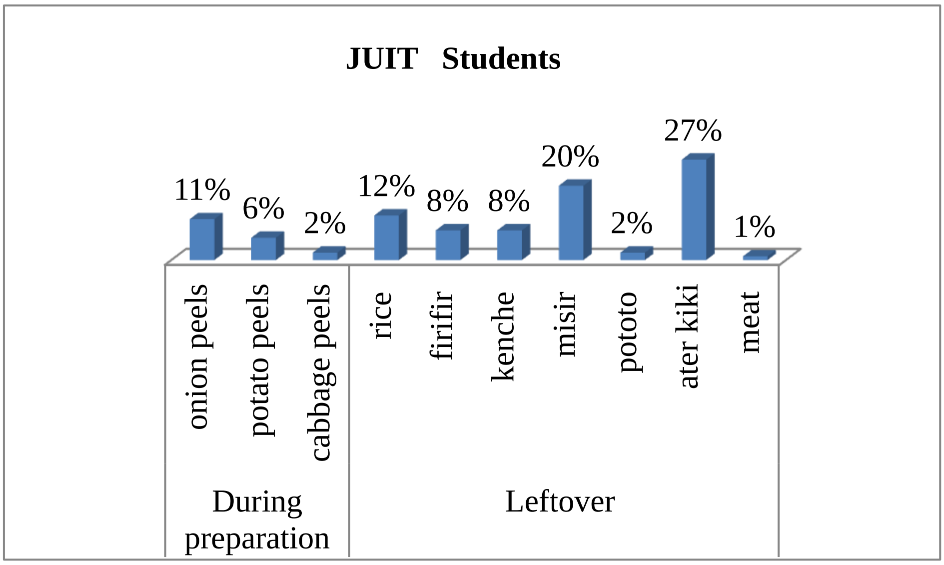

Figure 6:Weight Percentage of food waste each sub-category at students' cafeteria in JUIT

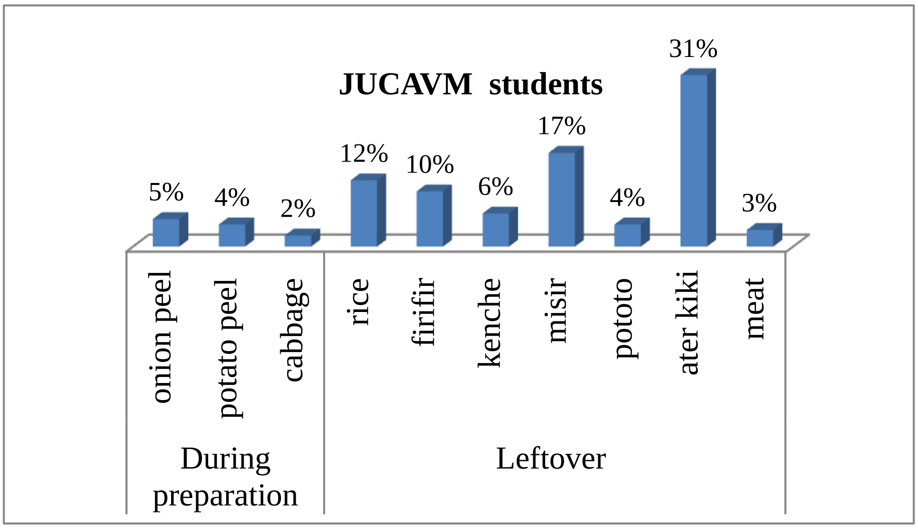

Figure 7: Weight Percentage of food waste each sub-category at students' cafeteria in JUCAVM

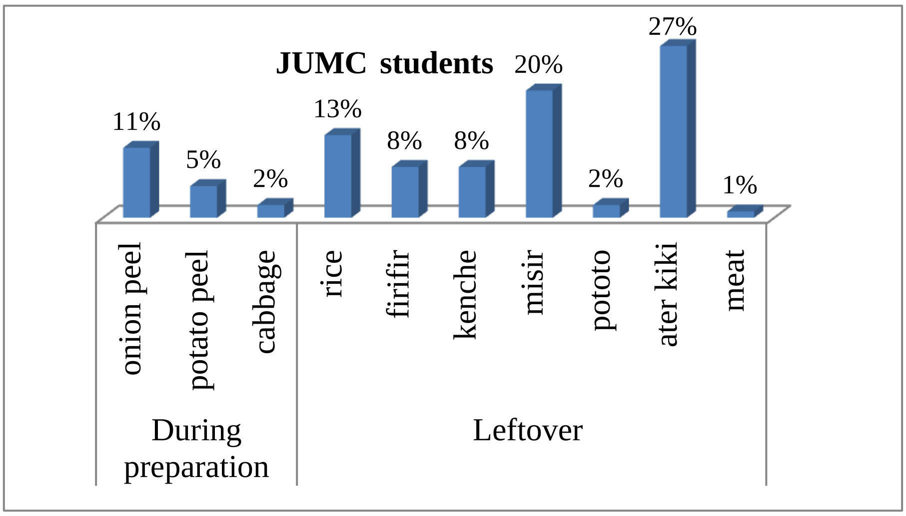

Figure 8: Weight Percentage of food waste each sub-category at students' cafeteria in JUMC

The data presented in the figure (10-12) shows the weight percentage of food waste sub-categories at staffs' lounge as during food preparation and leftover. The contribution of the staffs food waste generation rates from the leftover characterized as breakfast and main dish (that means the leftover at lunch and dinner).From the staffs waste generation in the three campuses, leftover was high percentage. The leftover breakfast from JUIT, JUCAVM and JUMC was 14%, 20% and 25% respectively. The main dish leftover was7%, 23% and 20% from JUIT, JUCAVM and JUMC respectively. The food waste generated during food preparation fruit peels (peels from avocadoes, mangoes) consisted predominant were high percentage. The percentage of fruit peels from JUIT, JUCAVM and JUMC was 30%, 0% and

40% respectively. There were no fruit peels in JUCAM during study period might be due to low demand of customers.

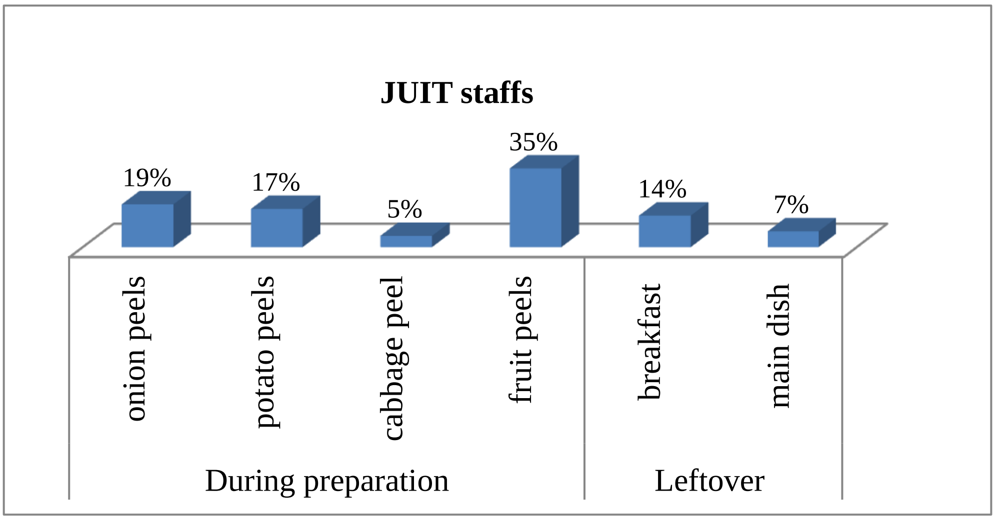

Figure 9: Weight Percentage of food waste each sub-category at staffs' lounge in JUIT

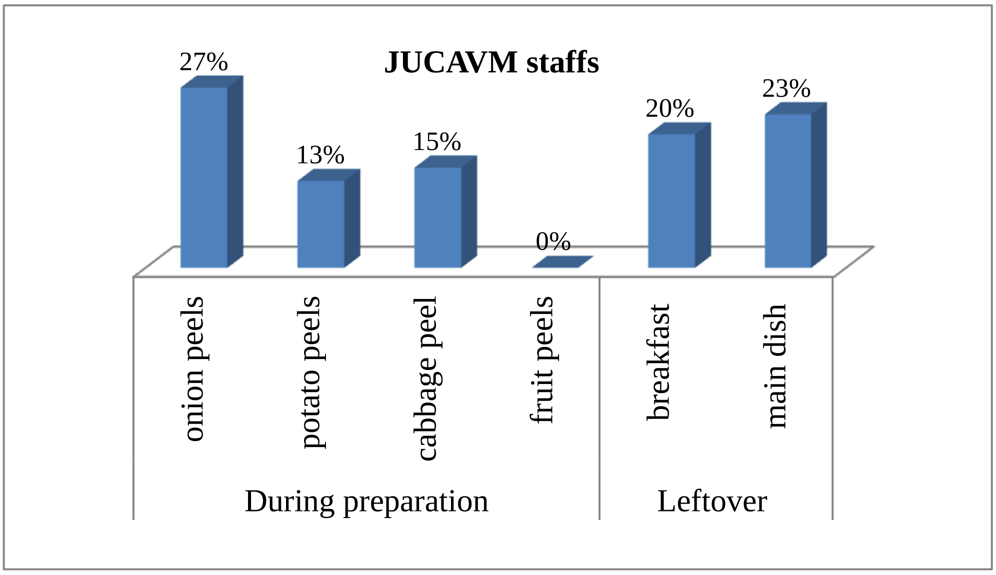

Figure 10: Weight Percentage of food waste each sub-category at three staffs' lounge in JUCAVM

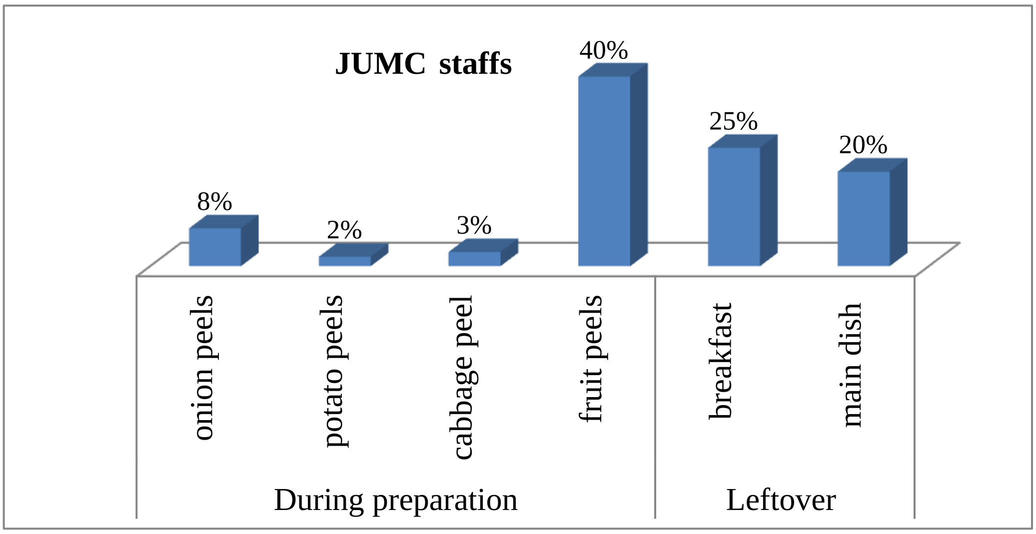

Figure 11: Percentage of food waste generators at staffs' lounge in JUMC

5.3 Generation rate of human waste

Human excreta or waste are the raw material which is the waste products of the body metabolism. The appearance, physical and chemical characteristics of urine and feaces depends largely on the health of person excreting the material, as well as on the amount and types of food and liquid consume. When estimating the urine volume produced, it is important to consider factors that will affect the liquid consumption and the amount of perspiration of a given person or population. These factors include eating and drinking habits, working conditions, climate, and the season in which urine is collected (Shaw, R., 2010).

Theresult of human waste generation rates per student per a day and per year was presented in the Table 5.Human urine generation rate per day and per student was 1.37litres. Taking in to account, the generation of urine for annual estimated to 500litre per year. It is evident that the study agreed with Swedish data which reported that an average human produces ranged from 1.25 to 1.40 litersof urine per day, showing 465.25 to 511 liters per person per year (Vinneras via Jonsson*et al*, 2004: 7).The finding presents data an average wet weight of humanfeacesgeneration rates per day per student was 121 g/cap/day. In this study, the annual generation rate offeaces was estimated to44, 165g per a year (44.165kg per a year). Therefore, this result agreed with 15 individuals in different areas of South Thailand andobtained wet fecal generation rates of 120-400 g/cap/daythat annual estimated ranging from 43800 to 146,000g/p/ year (Schouw*etal.*, 2002).

Table5: Generation rate of human waste from students

Human waste	Urine	Feaces
Total generation	61.75Litres	5,470g
Average daily	20.58 L/day	364 g/day
Average/ cap/day	1.37Litres	121g/cap/day
Average /cap/year	500Litres	44,165g/cap/year

The present result nutrient contents of food waste the Table 6was 78,861.9 Kg N and 7537.25kg P /cap/year.

Table 6: Nutrient contents of food waste

Nutrients	Kg/cap/day	Kg/cap/year
Nitrogen	216.06	78,861.9
Phosphorous	20.65	7537.25

The amounts of nutrients found in urine and faeces vary from person to person and from region to region depending on the nutrient content of the food consumed (Vinnerås and Jönsson, 2002).Urine has a high content of readily available nitrogen, phosphorus and potassium and its fertilising effect is reported to be similar to that of nitrogen-rich chemical fertilizer. Faeces on the other hand have high contents of phosphorus and potassium in ionic form but the nitrogen is only slowly released as it is organically bound in undigested food remains (Kirchman and Petterson, 1995). Both waste materials, however, have great potential for improving the fertility of impoverished soils.

In order to extrapolate these data to a population, the survey data was known it is necessary to assume a single set of figures for waste generation rate. For the purpose of this thesis assumption generation of feaces was about 121g/cap/d (0.121kg/p/d) and 1.37L/cap/d urine (equivalent to 1.37kg/cap/d) has been used in the Table5. In this result assumption of total human excreta was 544kg/cap/year.The presents study showed that the total amount nutrient contents of human excreta were 15.9g of N /cap/d and 1.5g of P/cap/d. The study results showed that total nutrients of human excreta produced in annually is estimated to be 5.8 kg of N and 0.5 kg of P per year presented inTable 7.This is comparable with the study conducted by (Wolgast, 1993) who reported that one person produced human excreta about 5.7 kg of N and 0.6 kg of P per year.

Table7: Nutrient contents of human excreta or waste

Nutrients	Feaces+ Urine (g/p/d)	Total (Kg/cap/year)
Nitrogen	15.9	5.8
Phosphorous	1.5	0.5

5.4 Physical characteristics of the food waste

The results presented of physical analysis onmoisture content, ash content, fat, protein, carbohydrate and energyvalue of food waste used for the study presents Table8.The moisture content of food waste in present results ranged from 53.05-84.01%.The result shows that food waste composed abundantly of water.The ash content ranged from 2.33-13.33%.The maximum value of ash content obtained from potatoespeeling(13.33%)followed by meat (*siga watt*)reason an amount of different inorganic minerals that would remain after burning.

This resultwork is comparable with studied by (Zhang *et al.*, 2007) who worked on food waste and found that the optimum moisture content ranged from 74 to 90%. The present results of food waste moisture contents obtained from individual typical waste mango peels, avocado peels, cooked rice, and injera leftover was 52.76%,73.61%,80.39%, and 69.88% respectively.Whereas ash content obtained from individual typical food waste, mango peels, avocado peels, cocked rice and leftover injera was 6.77%, 3.77%, 2.33 and 3.09% respectively. This work is comparable with values reported by (LetaDeressa, 2015) who carried out the study on food waste an individual and found that the optimum moisture content of mango peels 83.6%, avocado peels 73.2%, and cooked rice 76.88 % and mixed leftover injera was 64.66% .His experiments also reported on ash contents of mango, avocado, cooked rice and mixed leftover injera was 5.2%, 7.19%, 8.75%, and 3.96% respectively.

The fat contents ranged from 1-18.75%.The 1% value of fat content was recorded in potato peels.Protein ranged from 2.1-13.75%. The minimum value of protein was recorded in mango peels (2.1%). The maximum value of proteins and fat obtained in *siga*13.75% and 18.75% respectively. Carbohydrate ranged from 0.2-78.09%. The maximum carbohydrate recorded in onion 78.09% this might be due to high moisture content.Energy value ranged from 45-365.68%. The maximum energy value recorded in onion (365.68%) and minimum in potato 35.84% this might be due to evaluation of energy content in fat, protein and carbohydrate.

The present results of left over injera fat range from 2.2-18.75%, protein ranged from 6.16-13.35% and carbohydrates ranged from 0.2-14.76%.In this experiment low percentage of carbohydrates might be due to high amount of moisture contents in food.Here presents result of leftover injeracompared with the study of (Alemayehu*et al.*, 2014)who worked on Ethiopian higher institutions cafeteria wastes such as leftover of injera, which is made of teff contains 15% protein, 3% fat and 82% complex carbohydrates and has high calorie content.

Table 8: Physical characteristics of food waste

S.no	**Type wastes**	**% M.C**	**% Ash**	**% Fat**	**% Protein**	**% Carb.**	**Energy Value**
1	Avocado peels	73.61	3.77	17.25	3.11	2.26	176.73
2	Potato peels	78.6	13.33	1	4.91	1.8	35.84
3	Mango peels	52.76	6.77	3.5	2.1	32.21	168.38
4	Onion peels	1	11.33	3	6.58	78.09	365.68
5	Kenche	79.61	2.99	5	8	0.4	78.6
6	Cooked rice	80.39	2.33	3.75	8.13	1.4	71.87
7	Aterkiki	69.3	3.44	3.5	8.34	14.76	123.9
8	Misir	71.36	3.35	6	7.16	0.8	85.84
9	Dinichbesiga	84.01	5.03	2.2	6.1	0.2	45
10	Meat(siga)	53.05	12.02	18.75	13.35	2.53	232.27

5.5 Physical characteristics of human feaces

For experimental works, raw human feaces were collected by using separation of urine and feaces. The collected raw feaces have been analyzed and the key properties (proximate and ultimate composition) have been examined. The physical/proximate analysis of the presented data on the moisture content, ash, volatile matter, fixed carbon of the wastes used for the study presents in the Table 9.The proximate composition of raw human feaces in the percent wet weight (w%/w) with the standard error. The moisture content (70.39 ±0.577) and the ash contents (2.44 ±0.577). The presents result was comparable with (WakgariRegassa, 2015) who reported his experiment on human raw feaces which was 61.8 moisture content and 4.69 ash content.The purpose was to evaluate the energy heating value.

Table 9: Physical characteristics of human raw feaces

Parameters	Unit	Mean ±SE
Moisture content	%w/w	70.39 ±0.577
Ash content	%w/w	2.44 ±0.577
Volatile matter	%w/w	23.5 ±0.577
Fixed carbon	%w/w	3.67 ±0.577

5.6Elemental analysis of food waste

The results of the ultimate analysis are used to characterizethe chemical composition of the organic matter in the food waste. They are used to define the proper mix of the waste materials to achieve suitable C: N ratio for biological conversion processes commonly known as compost.The data on the elemental analysis of the individual food waste components are presented in Table10.The value of the elemental analysis results in this study all the carbon content of food waste components higher than percent of total nitrogen. The Carbon content of food waste was ranged from 6.3%-53.89% and total nitrogen content ranged from 0.50%-4.47%. The C: N ratio was range from 3.36-153. The results obtained from the present work for food waste components are comparable with values carbon content was 51% and 0.68% nitrogen which has C: N was 18.46 reported by Mekonnen (2012).The researcher can decide that, the variation of lab results of the conducted sample and the ultimate value is due to the accuracy of the sample collected. The C: N ratio of 15 to 30 is recommended because in this range, nitrogen is present in excess and no rate limitation should be imposed (Haung, 1983). Therefore, the result is more likely similar to this researcher.

There literatures recommended that if the initial C: N ratio is greater than 35, the microorganisms must go through many life cycles, oxidising off the excess carbon until a convenient C: N ratio for their metabolism is reached (de Bertoldi*et al.*, 1983). The C: N ratio is considered among the important factors affecting the compost process and compost quality (Golueke, 1977; Michel *et al.*, 1996).The standard carbon to nitrogen ratio of MSW to be composted is 25-50:1(Awasthi, 2010).

Table 10:Elemental analysis of food waste

S.no	**Food waste**	**%Total N**	**% Total C**	**C:N ratio**
1	Avocado peels	0.50	53.51	107.02
2	Potato peels	0.72	48.15	66.87
3	Mango peels	0.34	51.79	153
4	Onion peels	1.00	49.26	49.26
5	Kenche	1.40	53.89	38.49
6	Cooked rice	1.36	54.26	39.89
7	Aterkiki	1.34	53.64	40.02
8	Misir	1.35	53.52	39.64
9	Potato/dinich	4.47	52.79	11.81
10	Meat(*Siga*)	2.14	48.87	21.81

5.7 Elemental analysis of human urine

The elemental analysis of human urine which was to determine the total nitrogen (N) (mg/L), potassium (K) (mg/L) and ortho-phosphorous (P)(mg/L) are showed in the Table11. The ratio of (K: P) is higher than the ratio of (N: P) analyzed for the human urine. The total nitrogen constitute the highest percentage (0.38%), followed by potassium (0.07%) and phosphorous (0.01%) in human urine. In presented results of human urine have fertilizers N/P/K ratio can be 38:1:7.13.This result is comparable with (Linden, B., 1997) who reported that human urine has a fertilizer of N/P/K 18:2:5.The researcher can recommended that human urine contains NPK (Nitrogen, Phosphorous, and Potassium) which are present in organic fertilizer, urine can be used as a fertilizer. FAO (2009) suggested that the chemical fertilizers contain NPK and the global NPK fertilizer demand is increasing day by day and is basically affected by population and economic growth, agriculture productions, price and governances.

Table 11: Elemental analysis of raw human urine

Parameters	Mg/L(%)
Potassium(K)	725.00(0.07)
Total Nitrogen(N)	3804.75(0.38)
Phosphorous(P)	101.68(0.01)
Potassium to phosphorous ratio (K:P)	37.42
Nitrogen to phosphorous ratio(N:P)	7.13
N:P:K ratio	38:1:7.13

5.8Elemental analysis of human feaces

The presented data on total organic carbons content (mg/kg) and total nitrogen content (mg/kg) used for the study presents Table12. The ratio of C: N analyzed for human feaceswas 1.85.The total organic carbon constitutes higher 12.24 %than the percent of total nitrogen 6.59 %). The presents result is disagreed with worked of (WakgariRegassa, 2015) who his experiments analyzed for human feacesthe total nitrogen content 4.57% and total carbon content 46.08%. The researcher can conclude that varies of the lab results and the types of sample collected.

In compost substrates with low C: N ratios, nitrogen loss occurs via ammonia volatilisation at high PH and temperature .The loss of N reduces the value of the compost as a fertilizer. For optimum composting, C/N ratio of the starting substrate should be about 25 (de bertoldi et al., 1983; Eklind*et al.*, 2007).

Table 12:Elemental analysis raw human feaces

Parameters	Mg/Kg (%)
Total organic carbon (C)	122,400(12.24)
Total nitrogen (N)	65,900(6.59)
Carbon to nitrogen (C:N) ratio	1.85

5.9Physical and chemical characteristics of the food waste and human waste used in co-digestion potential for fertilizer

The Physical and chemical characteristics of food waste and human waste mixed in different ratios were determined digestion and the results are shown in Table 13.Characterization of food waste and human waste approach was required mixing the each waste streams with different proportions.

Table 13:Comparison of %ash and %m.ccontents with in between treatment co-digestion and ratio of organic fertilizers of N/P/K/Ca

S.no	Ratio	Parameters		Mg/kg (%)				Fertilizers ratio
T	FW:HW	%TN	%Ash	%m.c	%TP	%K	%Ca	N/P/K/Ca
T1	100:0	5.96	14.15	65.90	1.45	0.15	0.78	39.73:5.2:1:7.6
T2	70:30	6.75	14.01	74.13	1.45	1.72	0.77	8.76:1:2.23:1.88
T3	50:50	6.87	15.13	78.42	1.60	1.82	0.44	15.6:1:4.14:3.64
T4	30:70	7.38	15.56	80.76	1.63	1.92	0.69	10.69:1:2.78:2.36
T5	0:100	7.68	17.12	85.66	1.93	2.19	0.55	13.96:1:3.98:3.5

Treatments(T),T1=100%Foodwastealone(FW),T2=70%Foodwaste(FW)+Humanwaste (HU)(15% Urine(U) +15% Feaces (F) ,T3=50% Food waste(FW) +25% Urine (U)+25% Feaces(F),T4=30% Food waste(FW) +70%(HU) (35%Urine(U)+35%Feaces (F)),T5=100% Human waste alone (HU) 50%Urine(U)+50%Feaces.

Experimental analysis showed that the physical analysis of %100 FW (T1) alone substrate was14.15% of Ash and 65.90% of M.C. The chemical analysis of substrate of FW (T1) from TP, K and Cawas 5.96, 1.45, 0.15 and 0.78 respectively.FW (T1) alone has fertilizers of N/P/K/Ca ratio can be 39.73:5.2:1:7.6.Whereas %100 of HW(T5) alone, %50Urine+%50Feacessubstrate result physical analysis was17.12 ash content and 85.66 of m.c,The results show from chemical analysis substrate of HW(T5) the TN, Ash, M.C., TP, K and Ca was7.681.93,2.19 and 0.55 respectively. Human waste (HW,T5) has fertilizer of N/P/K/Ca ratio can be 13.96:1:3.98:3.5.The researcher can recommend by comparing the food waste and human waste in fertilizer ratio, food waste is higher than human waste for fertilizers.

T2 (FW) 70:30(HW) substrate the physical analysis was 14.01% of ash content and 74.13% ofm.c. These substrates the chemical analysis shows that the TN, TP, K and Ca was6.75, 1.45,1.72 and 0.77 respectively.T2has fertilizers ratio can be N/P/K/Ca8.76:1:2.23:1.88.T4 (FW) 30:70(HW) the physical analysis result of substrateswas15.56and 80.76ash and M.c respectively. From the chemical analysis of this substrates the TN, TP, K and Ca the presented result was7.38, 1.63, 1.92 and 0.69 respectively. The fertilizers of N/P/K/Ca has ratio can be10.69:1:2.78:2.36. The T3%50FW and %50 HW substrate of the physical analysis of Ash and M.c. was 15.13 and 78.42 respectively. Form these substrates chemical analysis of TN, TP, K and Ca was 6.87,1.60, 1.82and 0.44 respectively. The fertilizers of N/P/K/Ca ratio can be 15.6:1:4.14:3.64.

In food waste and human excreta in the substrate, moisture content and ash content was high in the all treatments. Human excreta treatment composition alone was higher moisture contents when compare with other substrates.From the experiment, the proximate analysis ofmixed human waste alone100% (50% urine and 50% feaces) results showed that the high moisture content 85.66%.This figure helps the researcher to conclude that, as the moisture content increases the energy value of the waste decreases.

The chemical characteristics of food waste and human waste treatments composition in the presented result, nitrogen is the most dominant nutrients. While phosphorous is the lowest comparing with other typical nutrients in all different of waste composition, except in food waste alone.For many plants, “The use ofN is usually higher than the total use of the other nutrients” (Jonsson, H. S., 2004). Even if plants are growing, unsatisfactory nitrogen in soils will lower the protein content of many plants and feeder crops (Esrey*etal.,* 2001). Nitrogen, therefore, is vital for both the growth of plants that will provide valuable vitamins and nutrients for the people consuming the plants, and nitrogen is also essential in the amount of protein that will be used up. Plants consume a large amount of nitrogen from the soil, and when plant material is removed during harvest, the nitrogen goes with it. Large nitrogen losses also occur when people burn their fields after harvest, for example (Abdulai, 2006). An optimum amount of nitrogen is therefore rarely present in farming systems, with soils being particularly deficient in nitrogen and other nutrients (Shaw, R., 2010).This figure helps the researcher to conclude that, as the moisture content increases the energy value of the waste decreases.

5.10 Physical and elemental characteristics of waste for energy

Theproximate and elemental analysis results from the raw feaces were used for predictive model to correlate to its heating value.The heating value measured purpose was for plant nutritional value as macronutrients constituent to recover nutrients to agricultural field.The predictive modelsused (Equation 10-11) as described in Table 9 has predictive comparable energy content measured experimentally through heating of human feces (17.09MJ/kg).In this experimentally was model based on predictive the physical and elemental analysis. However, the model (Equations12-14)predictions were far more than the experimentally measured.

Table 14: Empirical model for predicting energy content raw human feaces

Name	Proximate analysis	HHV in MJ/kg	Reference
Equation -----10	19.91-0.232 Ash	19.34	Sheng C,A.J.(2005)
Equation------ 11	0.196FC+14.12	14.83	Dermirbas, A.(1997)
Equation-------12	0.312FC+0.153VM	4.74	Dermirbas, A.(1997
Equation-------13	0.354FC+0.171VM	5.31	Cordero T, M. F.M.(2001)
	Elemental analysis		
Equation-------14	0.32C+3.46	7.37	Sheng C, A.J.(2005)

In many developing countries it is common for feaces sludge to be applied to agricultural land after little treatment. For example, farmers in the Tamale (northern Ghana) receive sludge on their land directly from cesspit trucks (Cofie&Adamtey, 2009).Feaces sludge is very rich in nutrients and organic matter and is attractive to farmers as supplement or replacement for commercial fertilizers. However,there is great health risk using feaceswithoutcomplete activation for agriculture purpose (Shaw, R., 2010).The significance of this study is the application of waste technology has economic, environmental benefits (fertilizers substitution, less greenhouse gas emission), health and social benefits. Transformation of organic waste into high quality fertilizers and reduces fertilizer requirements.

The experimentally feaces in this study has high heating value. High percentage of carbon in human feaces derived char is in the form ofaliphatic hydrocarbons compared to wood char (Hertel, 2013).More over the alkenes present in the fecal char are more energy rich (Fabbri*etal*, 2012).Thus, this might be the reason for the observed high heating value of the feaces carbon compared with literature value s of the other biomass. Calculating the energy value and comparing it with commercially availableoil value.Atotal of 36.46litter/year is equivalent oil can be recorded from an individual. The similar way converting this value to the electricity energy value it will be425kwh/year. Now aday average Ethiopian consumes 36kwh/year(Electrics and corporation, 2010).Energy recovery from feaces will be significance energy sources at least for household purpose like cooking.Taking in to account the total population of Ethiopian more over those inhabiting in urban areas,it will up huge impact on revenue where the majority of people in urban setup slum area where is no sufficient energy supply (UN, 2000).

Chapter Six: Conclusion and Recommendations

6.1 Conclusion

From the study conducted, Jimma university campuses have generated food wastes were around 1,662 kg/day. Thatmeans finding of this paper indicated that 49.6% of the food wastes generated in JUC. For the total population of the study area 607 tons of food waste is generated from JUC in year. Elemental analysis of food waste, mangoes peel was high carbon to nitrogen ratio. From human raw feaces, elemental analysis of total organic carbon constitutes is higher than total nitrogen.The relatively less carbon to nitrogen ratio in human raw feaces is due to the fact that nitrogen content in organic form and thus released slowly as the composed decomposes.The nutrients content in human excreta was produced about 5.8 kg of N and 0.5 kg of P per year.Anaerobic digestion was carried out to obtain suitable mix ratio for maximum biogas production from co-digestion of human excreta with leftover food at 5 different treatments with different ratio.The results of this study have shown clearly that food wastes and human excreta, when used in combination are good substrates for organic fertilizers generation potential.

6.2 Recommendations

The waste components requiring priority attention in Jimma university campuses are leftover food. The Jimma University campuses administrators should thinkto suggest possible solution for huge generation of leftover from student's cafeterias. From the research conducted, the contents of carbon and nitrogen in food waste are ranged from 48.15-54.26% and 0.50-4.47% respectively. These values vary somewhat from the elemental values which are51% and 0.68% for carbon and nitrogen respectively. Even though the values vary, the finding shows that the food waste at the study area is suitable for compost in particular. Collection of human excreta and food wastes should be recommended as fertilizers. The fertilizing value (micro-nutrient content of treatments of human urine should be studied.Further studies are needed to identify more suitable treatment co-digestionfood left-over and human feaces alone to improve the quantity of organic fertilizers.

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Annex I

Table1: Data sheet for classification of food waste before and after processed according to the their composition at staffs' lounge and students' cafeteria in JUC

Food waste before processed	Food waste after processed
Type of waste-vegetables and fruits	**Waste description –leftover food**
-Cabbage peels	-Cooked rice with *silsie*
-Mango peels	-Cookedkenche with salt
-Avocado peels	-*Injerafirfir*
-Onion peels	-Misir be atikilt
-Potato peels	- peas(*Aterkikwatt*)
	-lentils (*Misirkik watt*)
	-Meat with potatoes/*didnich be siga*
	-Meat stew/ *sigawatt*
	-Other mixed food wastes

Table2:(a)Analytical testing methods services laboratory

Parameters-protein	**Conversion factor**	**Test Methods**
Cooked Kenche	5.95	AOAC Official method 979.09
Cooked rice	5.83	AOAC Official method 979.09
Onion Peeled	6.25	AOAC Official method 978.04
Potato Peeled	6.25	AOAC Official method 978.04
Mango Peeled	6.25	AOAC Official method 978.04
Avocado Peeled	6.25	AOAC Official method 978.04

Table2: (b) Analytical testing methods services laboratory

Parameters	Test methods
Orthophosphate ($PO4^{3}$-)	APHA 4500-P C. Vanadomolybdophosphoric Acid Colorimetric
Total phosphorous (TP)	AOAC Official methods 923.03 Vanadomolybdophosphoric
Total Nitrogen (TN)	APHA 4500-Norg C. Semi-Micro-Kjeldhal Method
Calcium (Ca)	APHA 3500-Ca B. EDTA Titration Method
Total Potassium (K)	APHA 3111 C. Air-Acetylene Flame Method
Potassium(K)	AOAC Official method -923.03.flame photometer
Ash/Total organic carbon (TOC	AOAC Official Method 923.03
Moisture	AOAC Official Method 925.10
Total nitrogen (TN)	Modified ES ISO 1871:2013

Table 3:Interpretation of the total sufficient range plants macronutrients in soil Nitrogen (N) from (Chapman, 1971 and Unger, 1972)

	sufficiency level	**Total-N%**
	very low	<0.1
Human excreta	Low	0.1-0.2
	Medium	0.2-0.3
	High	0.3-0.4
	very high	>0.4

The total nitrogen of is 6.59% when compare the standard it show very high

Annex II

Equation 1: Calculation of nutrient contents of food waste and human waste

A. Use known data or (Equation 8) from Jonsson *et al* (2004: 5) to determine total excreted nitrogen and phosphorous.

(1) Datagives 122.37(1.37L/cap/d of urine +121 g/cap/d of feaces) proteins per capita per day for theparticipators.

N = 0.13 x Total Food Protein = 0.13 x (122.37 g/day) = 15.9 grams N/day in excreta or 5.8kgN/year

(2)Using daily per capita human excreta volume to determine excreta phosphorous concentration.

This thesis uses 122.37 g/day from the equation above

P=0.011X (Total food proteins+ proteins comes from plant sources)

P=0.011x (122.37+15.9) =1.5g/cap/d or 0.5kg/cap/year

Determine the nutrient contents of food waste the known data gives 1662kg/day

N= 0.13X1662=216kg/cap/day or 78,862.kg/cap/year

P=0.011x (1662+216.06)=21kg/cap/day or7,537kg/cap/year.

Annex III

Jimma University, Institute of Public Health, Department of Environmental Health Sciences and Technology

Checklist for study to quantity the amount of food waste and human wastes generated from three Jimma university campuses based on the menu in lounges and cafeterias.

General information:

Name of campus: JU_____ Total of cafeterias: ________& selected cafeteria (s) ______

Total of café users: ________Total oflounges_________& selected lounge(s): _______

Total of staffs: ______Staff users: _______ Date: ______/___2017

Data:

1. Completed 2. Partially complete 3. Refuse

Table 1: Food wastes category and sub-category generation during preparation and leftover at staff's lounges in JUC

waste category	Campuses			Total
waste sub-categories	JUMC	JUIIT	JUCVM	kg/average
onion peels				
potato peels				
cabbage peels				
mango peels				
avocado peels				
Leftover				
Breakfast				
Main dish				

Table 2: Food wastes category and sub- categories generation during and leftover at student's cafeterias in JUC

Waste category	Campuses			Total
Wastes sub-categories	JUMC	JUIT	JUCAVM	kg /average
During preparation				
Onion peels				
Potato peels				
Cabbage peels				
Leftover				
Breakfast				
Lunch				
Dinner				

Annex IV

Jimma University, Institute of Public Health Department of Environmental Health Sciences and Technology

Checklist form for collection of human waste generation from students in from JUC

Name of campus: JU____& Block____

Sample code: _________

Collection date______/___2017

Eligible criteria:

1. If Students are willing to participate in the study

A) Yes _____ B) No------

If she/he says yes, say thanks and proceed to the consent form. If say no, say thanks, good bye.

Table 3: Human waste generation for consecutive three days at 24 hours

Code sample	Feaces				Urine L/d			Total
No_student	Day1	Day2	Day3	g/d	Day1.	Day2.	Day 3	Average L/d
St1								
St2								
St3								
St4								
St5								
St6								
St7								
St7								
St8								
St9								
St10								
St11								
St12								
St13								