EXTRACTION OF SOIL CONDITIONERS FROM FOOD WASTE

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ABSTRACT: *The foundation for this research study originally originated from the zeal and passion for improving methods to utilize food waste into a new form of fertilizer. As the world moves further into the organic world in developing countries, increasing the amount of waste due to rapid urbanization and economic growth. Food waste, however, may exhibit great potential for being converted into organic liquid fertilizer instead of disposing of away. The presented research describes the conversion of food waste especially fruit and vegetable waste into organic liquid fertilizer through anaerobic process and compression. For the anaerobic process, the food waste was processed in two air-tight containers with the addition of molasses solution in one container and yeast in another at anaerobic conditions where after a retention time of 72 hours. The waste sample started changing into digestate from which liquid extract is regarded as liquid organic fertilizer and a by-product solid residue as pulp. As for compression, an extractor is used by which a slurry type product is obtained. Different samples of liquid fertilizer are processed under different anaerobic conditions. Yield comparison of liquid fertilizer is done between the two processes. Experiments for pot culture in multiple combinations were carried out to examine the phytotoxicity of the extracted organic liquid fertilizer for different stages of plant growth, for instance, seed germination and also to find the growth effect of liquid fertilizer on grown-up plants.*

Keywords: Environmental protection; Food waste; Anaerobic digestion; Biogas; Liquid fertilizer; Molasses.

1. INTRODUCTION

Food waste is generated during agricultural production, industrial processing, manufacturing and distribution that are in all the phases of the life cycle of food. Agricultural production damages during mechanical harvest operation. Handling and storage include spillage and deterioration during handling, storage and transportation from farm to distributors. Processing includes damage during industrial or domestic processing for example beverages production, canning and baking. Losses occur during sorting out of crops which are not satisfactory to process or washing, peeling, chopping, accidental spillage and process disruptions. Distribution and consumption include losses and waste at wholesale markets, supermarkets, retailers and waste during consumption at the household level. Figure 1 shows the types of food wasted overall in the world [1, 2].

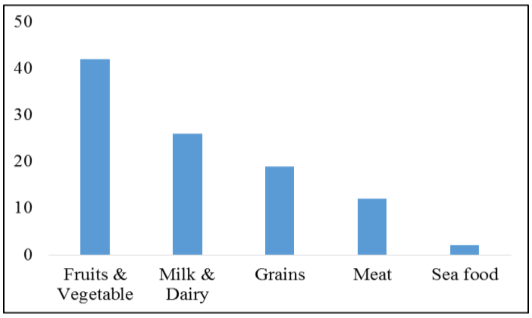


Figure 1. Types of food wasted

An approximated 35.5 million tons of food is wasted yearly in Pakistan. This is corresponding to each civilian of metropolitan cities throwing out their major portion of lunch and dinner on a daily basis. According to a report, in Pakistan, approximately 39 percent of food is wasted. The 43 percent population of the country facing the food insecurity, with 18 percent are having the problem of serious food shortage according to the director of the World Food Programme (WFP) Lola Castro. The Global Hunger Index 2018 positioned Pakistan as a country with “serious” hunger level [3, 4].

A massive amount of garbage is disposed improperly each day and this is one of the main subjects of interest of environmentalists as it has enormous economic and environmental effects. Food waste harms climate, land and biodiversity. Wastage of food charges money and also wastes the worthwhile water and energy resources used to produce the food. Throughout the world 70 percent water is used for the agriculture sector, food waste also contributes to abundant waste of resources of water. It is estimated that a volume of water approximately three times the volume of Lake Geneva is utilized just to produce food that is not eaten. They are approximately wasting 55,000 litres of water used to produce that meat when wasting one kilogram of beef. Similarly, when the waste one glass of milk nearly 1000 litres of water is wasted [4].

Food waste also affects natural resources in terms of land and soil deterioration. Agricultural cultivation utilizes pesticides and fertilizers; transportation uses fuel and storage involves electricity. All these resources go to waste when food is wasted. Almost $950 billion economic losses per year because of food waste, in addition, it also contributes to 8 percent of the global release of greenhouse gases. Figure 2 represents the greenhouse gas emissions from food waste [3, 5].

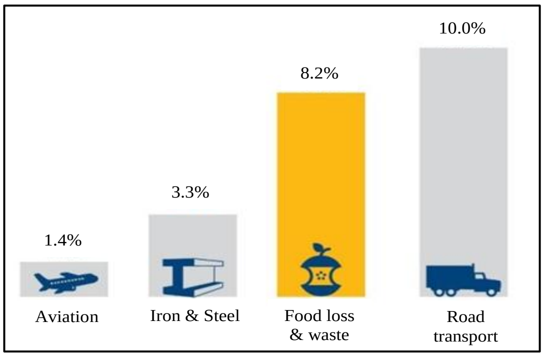


Figure 2. Greenhouse gas emissions from food waste

In fact, food waste would be the third-largest contributor to greenhouse gases, after China and the United States, if food loss and waste were its own country as shown in Figure 3. Food waste in a landfill or disposed originates the public health hazards and diseases like malaria, cholera, typhoid. Inappropriate management like inadequate dumping poses adverse consequences: It not only pollute the surface and groundwater through leaching and further contributes to the reproduction of flies, mosquitoes, rats and other disease-bearing organisms [6, 7].

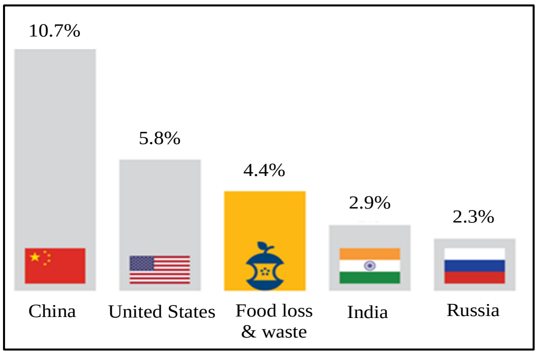


Figure 3. Third largest greenhouse gas emitter

An innovative start-up can allay this problem by utilizing waste beneficially. For the past few decades, efforts have been made to a great extent to establish such techniques and discover various methods and solutions to exploit therapeutically waste of fruit and vegetable. Commonly, agricultural wastes have been used greatly as fodder for animals or fertilizers. Using compost and another organic matter to strengthen the soil is an old practice. Research has shown that everyday kitchen scraps and waste from the garden can be used to increase the production of farmers' crops and curtail their requirement for traditional fertilizers [7]. The compost, made from domestic garden and food waste, enhances the health of soil, resulting in a greater crop outcome and cut down the requirement for nitrogen fertilizers, as well as recycling waste that may otherwise be subjected to landfills [5, 6].

The objective of this research is to convert food waste into soil conditioner (organic liquid fertilizer) by the process of anaerobic digestion and compression. Soil conditioners are substances added to soils or plants to improve their physical and/ or chemical properties and/ or their biological activity.

Many countries of the world are moving towards organic fertilization and making compost by organic waste and replacing chemical fertilization. Organic fertilizers are renewable, biodegradable, sustainable and eco-friendly. Chemical fertilizers can severely diminish the nutritional content of foods. Direct contact or exposure to chemical fertilizers may be toxic to the skin or respiratory system. Persistent use of chemical fertilizer can alter the pH of the soil, upset beneficial microbial ecosystems, boosts the number of pests, and even contribute to the emissions of greenhouse gases. Chemical fertilizers damage the friability of soil. Organics may improve water absorption into the soil and, meanwhile, enhances structure to the soil. It leaches away into groundwater without fully benefiting the plant. The effect of chemical fertilizers has degraded the soil while organic fertilizers sustain the soil [8].

Solid organics are overwhelming and difficult to spread over the millions of acres of farmland that need it. The fluid can be applied to crops with rancher's existing irrigation equipment, decreasing the need for additional labour or cost of equipment. Less water is required to grow specific crops where intense drought conditions prevail and the shortage of water is affecting farmer's capability to grow. Liquid fertilizer can be used with foliar technique. Foliar feeding is an approach of feeding plants by the application of liquid fertilizer instantly to their leaves. Plants are capable of taking fundamental elements through their leaves. The process of absorption takes place through their stomata and their epidermis. Plants are also capable to consume sources of nourishment through their bark [9].

Research tendencies reviews

While exploring the literature present relevant to the area of interest in various researchers, increased the generation of food waste is a global concern. Food waste is generated in all the stages of life cycle of food, for instance during production, commercial manufacturing, processing, packaging and distribution. As much as 42% of food waste is generated by domestic household activities, 39% waste produced in the manufacturing industry of food and 14% in service stages (fast food, catering and restaurants), meanwhile 5% is wasted during distribution stage. Food waste statistics show that it is probable to rise to approximately 126 Metric tons by 2020 if any policies or activities of prevention are not considered [3].

Scientific literature proposes that in developed nations food is transcendently squandered at the utilization phase of the food supply chain. This study expects to profile purchasers' demeanour to squander sustenance in Italy researching family units' practices prompting food to squander generation by tending to what is being squandered and why it is squandered by Silviagaiania, 2017 [10]. The work depends on a review performed in Italy on a heterogeneous sample of 3,087 respondents. A bunch examination was performed to recognize customers' profiles. Results, in light of self-revealing, permit drawing diverse 'squanderer' types, giving an image of sustenance squander identified with eating, shopping, and capacity practices and recommending various contrasts existing as far as saw amounts and reasons for created food squander. Out of the seven profiles recognized, four are the most delegate ones as far as size: the conscious-fussy type, who squanders since sustenance doesn't smell or look lovely; the conscious-forgetful type, who overlooks what is in the fridge or on the racks; the thrifty customer who tends not to devour foods grown from the ground and pronounces to squander nothing (or nothing); and the overstated cook, who overbuys and overcooks. Profiling explicit waste sorts can more readily comprehend if a group with normal attributes exist, what their particular highlights are and what switches can be utilized to invigorate an adjustment in their conduct [10].

Food waste (FW) is wealthy in biomass vitality, and expanding quantities of national projects are being set up to recuperate vitality from FW utilizing anaerobic digestion (AD) by Lei Li, 2017. Be that as it may, process precariousness is a typical operational issue for AD of FW. Procedure checking and control, just as a microbial organization, can be utilized to control change and increment the vitality transformation proficiency of anaerobic digesters. Here, the audit inquires about advancement identified with these strategies and distinguish existing impediments to proficient AD; suggestions for future research are additionally examined. Procedure observing and control are reasonable for assessing the current operational status of digesters, though microbial organization can encourage early finding and procedure optimization. Enhancing and joining these two strategies are important to improve AD effectiveness [11].

Henry Fisgativa, 2016 research, broad characterization of food waste (FW) was done with the point of contemplating the connection between FW qualities and its treatability through the process of anaerobic digestion. Although the typological composition (like; paper, meat, natural products, vegetable substance) and the physicochemical qualities, this examination gives a unique characterization of microbial populaces existing in FW. These populaces can effectively take an interest in aerobic and anaerobic degradation with the nearness of Firmicutes and Proteobacteria species for the microscopic organisms and of Ascomycota phylum for the parasites. Be that as it may, the characterization of FW bacterial and growths network shows to be a test due to the inclinations created by the non-microbial DNA originating from the plant and by the nearness of mushrooms in the food. Regarding relations, it was shown that some food waste attributes as the density, the volatile solids and the fibre content differ as an element of the typological composition. FW exhibits a high potential to convey methane (CH_4) by anaerobic digestion (AD). These characteristics make FW an astoundingly proper substrate to be valorized toward AD process [12].

Moreover, ongoing investigations demonstrated that the underlying attributes of FW affect the advancement of the AD procedure. Estimations of TS, VS, synthetic oxygen request (COD), C/N proportion, cellulose (CEL) and lignin content (LIG) among others, can be utilized as pointers of the FW biodegradability [12].

Pan Wang 2018, food waste (FW) is enriched in starch, protein, fat and cellulose. It is ease to decay and take along environmental pollution and some social issues. FW demonstrates a high potential to create methane by AD because of its high organic substance. Nevertheless, various inhibitors, for instance, accumulation of ammonia and volatile fatty acids (VFAs), generally result in inefficient performances and even process failure. Microorganisms play a vital role during the process of hydrolysis, acidogenesis, acetogenesis and methanogenesis. This audit gave a basic outline of microbial attributes to get interfaces of microbial network structure with operational conditions at different phases of AD. This article underlines that it is important to break down changes and mechanism of microbial networks in the lopsided framework and look for proficiency dynamic progression guidelines of the prevailing microorganisms [6].

Yangyang Li, 2017 anaerobic digestion of food waste (FW) has been generally researched, in any case, little is thought about the impact of organic composition on the FW digestion process. This investigation expects to distinguish the optimum composition proportions of protein (CP), sugar (CA) and lipid (EE) for keeping up high methane yield and procedure stability. The outcomes demonstrate that the CA-CP– EE proportion was essentially associated with execution and degradability parameters. Controlling the CA-CP– EE proportion higher than 1.89 (CA greater than 8.3%, CP lower than 5.0%, and EE is lower than 5.6%) could be a compelling method to keep up stable digestion and accomplish higher methane production (385–627 mL/g VS) and shorter digestion retention (196– 409 h) [13].

Jong-Hun Park, 2018 the impact of feeding mode and dilution was considered in anaerobic digestion of food waste. An up-flow anaerobic digester with a settler was fed at six distinctive organic loading rates (OLRs) from 4.6 to 8.6 kg COD/m^3/d for 200 days. The most astounding methane efficiency of 2.78 L CH_4/L/d was accomplished at 8.6 kg COD/m^3/d amid consistent sustaining of diluted FW. Continuous feeding of diluted food waste demonstrated more steady and productive execution than stepwise sustaining of undiluted food waste. The sharp increment in propionate focus credited to the decay of the digester exhibitions in the stepwise bolstering of undiluted nourishment squander. Microbial communities group at different OLRs disclosed that the microbial dissemination in the consistent encouragement of weakened sustenance squander was not fundamentally annoyed in spite of the expansion of OLR up to 8.6 kg COD/m^3/d, which was a differentiation to the unstable spreading in stepwise feeding of undiluted nourishment squander at 6.1 kg COD/m^3/d [14].

Fulvia Tambone, 2017 solid-liquid (S/L) separation of digestate (D) presents a simple innovation ready to deliver two portions having a different composition. The point of this work was to examine the impact of S/L separation on dry matter (DM), phosphorus (P_2O_5), nitrogen (TKN) and heavy metals (HM) repartition into these two divisions and to portray them. Thusly, thirteen full-scale digestion plants were considered and D, LF and SF were gathered amid three periods of the year. Results got showed that startlingly, on a mass balance, the fluid division still contains most of DM, for example, 67% of the aggregate of D. LF additionally contained 87% and 71% of TKN and P_2O_5 separately. HM substance were in accordance with the run of the mill NP- organic fertilizers [15].

Yuanyuan Ren, 2018 anaerobic digestion has been applied in agricultural and industrial waste treatment and perceived as a conservative compelling route for food waste transfer. This exploration introduced a review of examines about anaerobic digestion of sustenance squander. Advances (pretreatment, co-absorption, inhibition and mitigation, anaerobic digestion frameworks) were presented and assessed based on bibliometric examination. Results showed that ethanol and aerobic fermentation were novel ways to deal with upgrade substrates hydrolysis and methane yield. With the advancement of asset recuperation, more consideration ought to be paid to biorefinery innovations which can deliver increasingly valuable items toward zero emissions. Besides, an innovative course for food squanders transformation dependent on anaerobic digestion was proposed [4].

Food waste is deliberated as a manageable vitality source later on inferable from its supplements rich element. Amid the most recent 20 years, pretreatment, co-assimilation, hindrance and alleviation are still research hotspots. Contrasted and the single-organize framework, two-arrange anaerobic framework consolidated ethanol or hydrogen with methane ageing could enhance the vitality recuperation proficiency of the substrate and be viewed as a favourable innovation. Also, the biorefinery would enhance the business estimation of the anaerobic assimilation of sustenance squander because of the isolated treatment based on the part of the substrate. Anaerobic Digestion is a promising innovation to change over sustenance squanders to vitality. Be that as it may, specialized and monetary difficulties, for example, VFA collection, process unsteadiness, frothing, low cradle limit, and high money related cost, keep the wide utilization of nourishment squander in AD frameworks. Co-absorptions, expansion of small scale supplements and antifoaming operators, and diverse process outlines have been examined [5, 16].

Many promising outcomes have been gotten in spite of a few irregularities because of the diverse materials and strategies utilized in each investigation. Future research is as yet expected to comprehend and enhance AD of sustenance squanders. Joint efforts between the scholarly world, industry, and government are required for widespread use of this innovation.

Raw materials - past, present and future

The raw material used for carrying out the process is food waste which includes the rotten fruits and vegetables and peels of fruits and vegetables. As they contain a large amount of water and nutrients which are necessary for the growth of plant and crops. Table 1 represents the nutrients that are present in fruits and vegetables [2].

In the past, acts of metropolitan FW administration are a piece of strong waste administration. Incorporated strong waste administration framework that is landfilling and burning. Landfilling is a typical transfer strategy in the majority of the nations and also created nations. Before the first cremation innovation was connected in 1979, landfilling was the main treatment alternative for FW. Via landfilling FW straightforwardly, numerous natural issues start to happen. All the more precisely, high dampness substance of food waste advances high microbe debasement action, which discharges leachate and methane in an anaerobic situation subsequent to landfilling that extensively cause optional contamination to groundwater, soil and environment. Thusly, it is attractive to discover a treatment elective toward the end cremation is picked as the contrasting option to manage FW [17].

Table (1): Nutrient Facts

Nutrients Facts	
Cauliflower	Nitrogen
Banana peels	Potassium, Magnesium
Orange peels	Calcium, Magnesium
Coffee ground	Nitrogen
Tomatoes	Phosphorous, Potassium, Nitrogen
Bottle gourd	Potassium
Pees peels	Potassium, Calcium
Cabbage	Magnesium, Calcium, Phosphorous, Nitrogen
Cucumber peels	Potassium, Nitrogen
Ridge gourd	Magnesium
Lady finger	Calcium, Magnesium, Potassium
Potato Peels	Potassium, Magnesium
Coriander	Phosphorous, Potassium, Zinc, Calcium, Magnesium
Spanish	Magnesium, Phosphorous, Nitrogen
Carrot peels	Potassium
Grapefruit	Potassium

The disadvantages of landfilling are limited space put all loss into a landfill, you would before long be attempting to discover spots to say everything. Wasteful when not required, if recyclable materials are put into landfill destinations to utilize more vitality and assets endeavouring to make new materials. Spoiling sustenance squanders grant methane and carbon dioxide to leak out of the ground and up into the air. Both these gases contribute incredibly to global warming. Chemical substances can likewise drain out of repression into groundwater and streams. Landfills ought to be checked for long once they are closed and topped. The continuous expenses can be a few hundred thousand dollars every year (or more, contingent upon the size) [17].

In present emerging technologies incineration, composting, aerobic digestion, liquefaction and large-scale anaerobic digestion were used. The future analysis research deals with the conversion of waste generated from numerous stages of the life cycle of food. Liquid fertilizer has several blessing attributes to the straight forward method, low cost and no aspect effect. The ensuing advantages to fertilize crops, take care of the soundness of nutrient elements in the soil and decreasing the dangerous effects of chemical fertilizers. Additionally to a liquid fertilizer that can be sold within the market, liquid fertilizer can be utilized for agriculture purpose or within the premises for plantation.

Food waste process converted into organic liquid fertilizer

Food waste is converted into organic liquid fertilizer by two different methods anaerobic digestion and compression. Efficiency and selection of process were based on the yield of liquid fertilizers from these two methods.

Anaerobic digestion is a natural biological process in which breakdown of biodegradable material (organic matter) occurs in an environment with no oxygen by the micro-organisms. In the reduction of volume and mass of the input waste material, anaerobic digestion is commonly used to treat waste. Waste paper, grass clippings, cardboard, leftover food, sewage, industrial effluents and animal waste almost every type of organic material is capable to be processed with anaerobic digestion. An anaerobic digestion process is considered as the basis of renewable energy as the method produces methane and CO_2 rich biogas for production of energy which can replace fossil fuels. Also, anaerobic digestion produces solids called digestate, rich in nutrients that are used as fertilizer. Amount of biogas and the quality of digestate may differ according to the feedstock used. More gas would be produced if the feedstock is used putrescible which means it's more liable to decompose [18].

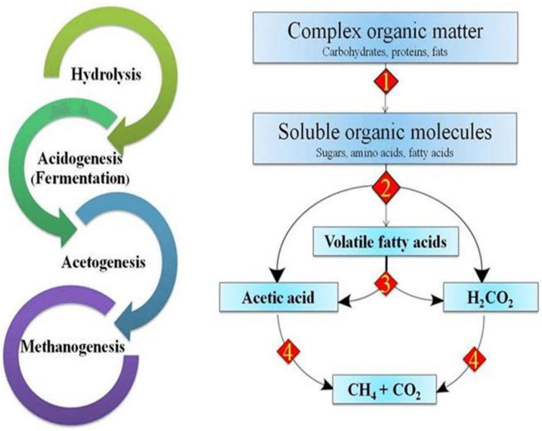


Figure 4. Stages of anaerobic digestion

The four biological stages of the AD process are hydrolysis, acetogenesis, acidogenesis and methanogenesis. Figure 4 represents the different stages of anaerobic digestion. The digestion process starts with bacterial hydrolysis of the input materials to facilitate breakdown insoluble organic polymers such as carbohydrate and to make them available for other bacteria. In many cases, biomass is made up of large organic polymers for example carbohydrates, fats and proteins. In an anaerobic digester, the microbes to get to the vital capacity of the materials these chains should be separated into their tiny essential parts. These monomers or constituent parts for example sugars are effectively accessible to other micro-organisms. The process of breakdown of these chains and dissolving the smaller molecules (glucose, glycerol and amino acids) into solution is termed hydrolysis. Hence hydrolysis of these high molecular weight polymeric components is the essential first step in anaerobic digestion. In the production of biogas hydrolysis is mostly the rate determining step [19, 20].

In the organic procedure of acidogenesis, there is further change of the rest of the segments by an acidogenic (fermentative) micro-organism. This stage, unsaturated fats, ethanol are delivered alongside ammonia, CO_2 and H_2 and additionally other results. The process of milk sour is similar to acidgenesis. Acetogenic bacteria then convert the organic acids that were produced in acidogenesis into acetic acids accompanied by additional NH_3, H_2 and CO_2. Through acetogens, simple molecules created with the acidogenesis phase are more digested to produce largely acidic acids. Methanogenic bacteria at long last can change over these items to methane and CO_2. Acetate and hydrogen obtained in the initial stages can be used by methanogens. Methanogenesis is responsive to both high and low pH and happens between pH 6.3 and pH 8. The rest of the undigested material, which the microbes cannot feed upon along with any dead bacteria constitute the digestate [20].

The compression method mechanical volume and size reduction is a vital factor in the advancement and performance of any waste management framework. The main reason is to reduce the volume (amount) and size of waste, as compared to its original form as well as manufacture a convenient product from waste. The compressibility of solid waste is of engineering interest as it influences the short-term and long-term operations of landfills. Food waste contains a moisture content of about 75%, this nutritious moisture content can be extracted by compressing or squeezing the food waste mechanically. For this purpose, many compressing devices or gadgets can be utilized which tenderly squeezes the waste to remove most of the overabundance liquid leaving moist shredded food waste particles that can be additionally utilized for fertilizing the soil and livestock feed. These squeezers produce a mulch-like end product that is appropriate for use as a soil amendment. The favourable point of this strategy of squeezing is that it requires no enzyme or catalyst, additives or fresh water during the entirety of the decaying process unlike anaerobic digestion (in the absence of oxygen) but the squeezers or compressors demand perpetuation and some of them require power (electricity) to run them [21].

2. MATERIALS & METHODOLOGY

The aim of the research was to utilize the food waste that is generated every day into soil conditioner as liquid fertilizer by anaerobic digestion and compression process. The steps of this research were worked out a collection of waste, compression of food waste using squeezer (juice extractor), anaerobic digestion of food waste at room temperature (about 30˚C) with and without net bag using molasses. Comparison of compression and AD with respect to yield (volume per kg of food waste, % Liquid content by mass) and collection of produced biogas over water. Anaerobic digestion of food waste at elevated temperature 40 ˚C and without net bag using different fermentation solution (yeast, molasses). Then, Pot culture experiments consist of effect on seed germination, optimum dilution, the effect on growth phase of plants and comparison of fertilization ability of liquid fertilizer obtained by AD with different media and compression.

Collection of raw material

The raw material was collected domestically at the homes. Specifically, fruit and vegetable peels and leftovers were gathered. A variety of fruits and vegetable waste was obtained depending upon the seasons and social backgrounds. Mostly raw material consisted of banana peels, orange peels, cabbage leftovers, peas peels, arwi (colocasia/taro root) peels, bathua (chenopodium album) leftovers, carrot peels and leftovers, cucumber peels, guava peels, Loki (bottle gourd) peels, grapefruit peels, potato peels, coriander leftovers, melon peels, spinach leftovers, tomato leftovers and peels, onion peels, spring onion leftovers, watermelon peels, capsicum peels, chili leftovers, strawberry leftovers, curry leaves, and cheeko (mud apple) peels.

Since raw material tends to deteriorate with the time and causes bed smell, therefore it was stored no longer than a week. The collection has to be done every time before any experiment. Also, food waste was kept in an open area to ensure ventilation and inhibit rotting before the actual process.

Compression of food waste using a squeezer

It was intended to extract liquid out from the waste. An ordinary home juice extractor was used for this purpose that works by squeezing the raw material and separating it out into a thick slurry type liquid and solid meshed residue as shown in Figure 5. The blade rotates by the help of an electrically powered motor. 2 kg of waste was squeezed from which 0.53L of liquid was extracted and a small quantity of compressed residue was obtained.

Figure 5. Squeezing

Anaerobic digestion of food waste at room temperature (about 30˚c) with and without net bag using molasses

Anaerobic digestion (AD) was performed to convert food waste into usable digestate after which digestate can be diluted to be used as liquid fertilizer. Pilot Scale digesters were made for the experiment. A plastic bottle of capacity 3L was painted black to ensure maximum radiation absorption as shown in Figure 6.

Figure 6. Painted bottles for pilot digesters

The Molasses preparation 1 kg of fine brown sugar was used. The brown sugar was heated after adding 500 ml of water to reasonable fluidity. 800 ml of molasses was obtained as shown in Figure 7.

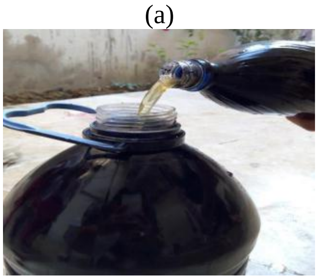
(a)

(b)

Figure 7. (a) Brown sugar for molasses (b) Molasses prepared

The 2 kg of waste was weighed and placed into a net bag. The net bag was placed into the bottle and the 1.6 L of molasses solution (0.4 L made up to 1.6 L) was added and without a net bag, 2 kg of waste was mixed with 1.6 L of molasses solution in a bottle of 5 L capacity as shown in Figure 8. The bottle was filled to capacity in order to provide the anaerobic environment. The airtight closed bottle was placed outdoors for a month at average room temperature of 30 ˚C.

(a)



(b)

Figure 8. Anaerobic digestion (a) net bag (b) without a net bag

After a month the bottle was opened. First, it was checked for the production of biogas and the net bag was squeezed to give 1.13L and without a net bag, 1.316 L of liquid was obtained from the bottle of liquid and the solid digestate.

3. RESULT AND DISCUSSION

Food waste that leads up in landfills generates a large amount of CH_4, a more harmful greenhouse gas than even CO_2. The uncontrolled, huge amounts of greenhouse gases like CH_4, CO_2 and CFCs (chlorofluorocarbons) absorb infrared radiations and raise the temperature of the earth's ecosystem, causing climate change and global warming. An innovative start-up can allay this problem by utilizing waste beneficially. Several attempts have been made extensively for the past few decades to discover ways and find different methods to utilize fruit and vegetable wastes sensibly [21, 22].

Volume per kg of food waste and the percentage of liquid content by mass

The yield was compared for the three processes explained above. It was observed that AD using molasses without net bag resulted in greatest volume as shown in Table 2.

Table (2): Volume per kg of waste

Squeezing	**AD with a net bag**	**AD without a net bag**
0.265 L	0.565 L	0.658 L

Liquid content for the fertilizer was obtained by evaporative heating of the fertilizer in the china dish. Heating was done in an open environment at a temperature of about 250˚C. Change of mass occurred during heating the percent liquid content by mass of squeezing is 87% and anaerobic digestion is 75%.

Anaerobic digestion of food waste at elevated temperatures

To observe the effect of temperature on the anaerobic digestion process, the process was carried out at elevated temperatures. The temperature was kept uniform by a specially designed heater. A cardboard box of suitable dimension was taken. The walls and the base were insulated with the thermo pole sheets. The heat was supplied through 50-watt bulbs. Electrical connections were provided as required. A thermometer was fitted to observe the temperature.

The temperature of the heater could be regulated by changing the aperture of the box. AD sample was placed in the heater. The temperature of digester was kept at 40˚C. Bottles were squeezed to provide an anaerobic condition. An arrangement was made to collect gas to find the actual volume produced. At 40 ˚C the samples yielded a greater volume of the liquid fertilizer. The sample with yeast was observed to produce 400 ml of gas and 400 ml of liquid.

Anaerobic digestion of food waste at elevated temperatures without net bag using different fermentation solution

To observe the effect of the fermentation solution on the process of anaerobic digestion. Molasses and yeast were used as a fermentation solution for AD. 0.5 L of molasses (0.2 L made up to 0.5 L) and 0.5 kg of food waste was used. 0.5 kg of food waste was mixed with 33 g of yeast dissolved in 30 ml of water. A pilot digester of capacity 1.5

L was used. The sample was kept at a constant temperature of 30 ˚C. The sample with the molasses gave 705 ml of liquid while the sample using yeast yielded 360 ml of liquid.

Co-digestion could improve the synergistic association among the substrates and an ultimate outcome in the high CH_4 production. The anaerobic digestion methodology in biogas plants fundamentally degrade the organic parts of feedstock to CH_4, CO_2 and digested residues, rationing N predominantly as NH_4^+ [23]. Fundamental nutrients as K, N, P, Mg, and some trace elements essential for plants are preserved in the buildup and consequently improving harvest yield when utilized as a fertilizer in plant generation. The occurrence of imperative nutrients in the biogas-digestate connected in this research additionally prompted a positive fertilizing impact for the plants [10, 24].

Effect on seed germination of pot culture

The quality of the extracted liquid macro-testing was done as pot culture experiments. Effects of liquid fertilizer were observed at different phases of plant growth. Tomato, bajra (millet), sunflower seeds were used to determine the impact of liquid fertilizer on the seed germination phase. Seeds were sown according to the general practice of sowing. The soil was watered daily with 10% by volume solution of liquid fertilizer. The increasing concentration of liquid fertilizer has no adversative effect on seed germination. Liquid fertilizer has shown a positive impact on the germination phase of the plants. All of them germinated within 5 to 6 days. The subsequent advantages from liquid fertilizer are especially similar to fertilize crops, to keep up the stability of nutrient components in soil and can diminish the effect of organic waste in the area. It has not only aided in the growth, the liquid fertilizer remarkably replaced water for the watering of plants.

For optimum dilution, four stalks of mint at the same stage of growth were taken. Each of them was watered with the liquid having different dilution percentages. Growth was observed for several days. Different dilution percentages 10%, 20%, 30% and 40% that were used. It was observed that a concentration of up to 40 percent by volume is acceptable and don’t cause any harmful impacts on the growth of plants. Hence, the extracted liquid could be a good substitute for the water especially in the places of water shortage. To observe the effects of liquid on the growth phase of plants, four stalks of mint at the same stage of growth were taken. Each of them was watered with the extracted liquid. It was observed that the liquid fertilizer didn’t pose any negative impact on the growth of plants. The plants continue to grow at a satisfactory rate.

To observe the impact of different methods of liquid extraction on the extracted liquid and its fertilization ability, four plants of mint were taken. Liquid extracted by squeezing (diluted to 3% by volume), liquid extracted by AD with molasses, liquid extracted by AD with yeast and water only were used to water the plants. The plant growth was observed for several days. It was observed that the method of extraction didn’t pose any significant impact upon the fertilization quality of the liquid fertilizer.

Organic Liquid fertilizer has several benefits owing to easy production, affordable and negligible side effects. These virtues are very favourable to fertilize plants, to uphold the constancy of essential nutrient elements required by the soil and eliminating the adverse effects of chemical fertilization. Not only as an organic liquid fertilizer that can be traded in the market, but this liquid fertilizer can also be useful for agriculture purposes or in the field of the plantation [11, 23].

4. CONCLUSION

The dumping of the enormous amount of food scraps has posed great environmental pollution and economic costs over the world. One of the key practices for resource conservation and environmental protection is proper waste management. Wastage of food has many consequences. With agriculture responsible for 70 percent of the water supply throughout the world, food scraps also represent an enormous waste of freshwater and groundwater resources. Biomass is an all-around and sufficient resource, which can be utilized in the production of energy via diverse routes, inclusive of fermentation and anaerobic catabolism. As a primary objective of this research, the first task was to extract soil conditioners (liquid fertilizer) from food scraps especially vegetables and fruits. Two different procedures for extraction were studied that is compression and anaerobic digestion. The objective was successfully achieved by pilot scale experiments. AD comes out to be a more plausible solution as judged on the basis of yield. The process was performed repeatedly with varying parameters temperature, feed and composition. In addition, two different fermentation media were used for anaerobic digestion. Both of the processes were analyzed. AD performed with yeast proved to be more productive than that with molasses. Careful study about temperature showed that 40˚C is the optimum temperature for AD of food waste which in close agreement with the values stated in the literature.

Pot culture experiments were done on a number of different plants and the effects on different growth phases were studied. No phytotoxicity was detected. Hence, Liquid fertilizer proved itself to be an attractive alternative for the water especially in the areas facing water shortage, reducing the dependence on chemical fertilization additionally.

The further recommendations are certain varieties of biomass can be employed either or production of bioethanol or biogas, although broadly concerned in diagnostic literature, presently it is impossible to judge the better treatment opportunity for a specific substrate.

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