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RESEARCH ARTICLE OPEN ACCESS

Converting Waste Food into Organic Fertilizer

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I. INTRODUCTION

Fertilizers are inorganic or organic, synthetic and natural matters that are incorporated into soil thus enhancing the growth and production (Gellings, & Parmenter, 2016). Plants rely on the nutrients that are found in soil to carry out the different metabolic reactions because soil has the fundamental chemicals for the development of plants. Nevertheless, the supply of essential chemicals in soil to plants is constrained. When the harvesting of plants is taking place, the nutrient content decreases thus causing the lessening of quality and quantity of plants. The application of fertilizers is done with an objective of replacing chemical components in soil that are used by plants during their development and growth. Fertilizers are essential in the improvement of the growing potential of soil mainly because they have the ability to offer better growing circumstances for plants when compared to natural soils. Fertilizers offer huge quantities of micronutrients including potassium, nitrogen and phosphorus whereas natural soil might not have enough amounts of these micronutrients. Additionally, fertilizers further offer trace features including calcium, copper and magnesium that are considered as important components for the development of plants. Various types of fertilizers are used in diverse types of plants thus improving their production and growth. These types of fertilizers are grouped according to the percentage of nitrogen as well as other constituents.

Food wastes especially from businesses and households are usually disposed in landfills. Food that is rotten can be broken down to manufacture methane gas and is considered dangerous to human beings if not carefully handled. Methane is a strong greenhouse gas that leads to global warming and greenhouse effects. Food waste leads to the production of greenhouse gases that boost the temperatures of the surrounding during the production process as well as disposal (Lehmann & Joseph, 2015). Food waste products that are thrown away in landfills can decay and generate a smell that is offensive which can be dangerous to the environment and human beings. The reduction of food wastes can be done by changing them into a helpful type of organic fertilizer thus reducing health challenges that are caused by disposal of waste products. Food wastes can be reused into organic fertilizers thus reducing the amount of food wastes that are found in landfills as well as the discharge of greenhouse gases to the environment. The decomposition of food wastes in anaerobic digestive process by microorganisms therefore breaking down food waste into smaller components and also ensures that they become products that are useful. The entire procedure can be conducted in a system that is enclosed with the absence of oxygen. The methane gas that is produced during this procedure can later be collected and then converted into biogas which can be used in the transportation of fuels and also in the production of heat and electricity.

In the universe, there are more than 1.4 billion tonnes of food that goes to waste on an annual basis (Wade, 2016). Vegetables and fruits that include roots and tubers indicate the biggest percentage of food wastage on a global scale. There are almost 9000 tonnes of kitchen and food waste that are generated on a daily basis. These waste products that are generated from foods have the ability of feeding six million countries and waste management cost that is solid for food that is discarded. Much of the food waste products are disposed at the disposal locations thus leading to the lack of food waster resurgence in most countries. Food wastes are usually taken to the landfills for purposes of easy disposal even though it may also break down thus producing big levels of methane gas. The disposal of these food wastes can become a challenge since methane gas is 26 times more intoxicating than carbon dioxide since it brings about global warming and greenhouse effects. As a result, changing waste obtained from food products into organic fertilizers which are recognized as helpful products is important because it assists in reducing the amount of methane gas and food waste.

The procedures in the production of organic fertilizers starting from food waste include composting, fermentation and fermentation of the

solid state (Ballardo et al. 2017). In the process of fermentation, the substrate is regarded as the source of carbon and takes place near the absence of free water. Nevertheless, in the process of solid state fermentation, the procedure takes place in absence or near absence of free water through employment of natural substances as well as static substrate as solid support. Decomposition is another alternative aerobic handling of food waste which converts waste products into rich products that are humus that promotes conditions and plant soils. The fermentation of solid state, composting and fermentation are substitute methods of managing biological materials. These procedures change are responsible for the conversion of food wastes of fruits and vegetables into materials that are useful which include organic fertilizers for farming purposes.

Fermentation is considered as an aerobic procedure that changes sugar that is found in food wastes into alcohol, acids and gases (Dahiya et al. 2015). During the process of fermentation, microorganisms metabolize nutrients that are found in food waste thus producing acids, carbon dioxide and methane. Other microorganisms including yeast, bacteria and fungi are responsible for the digestion of organic components in food wastes thus producing organic acids like acetic acids, butyric acid and lactic acids. Microorganisms make use of simple food compound sources including protein, starch and sugar during fermentation. The components that have a high amount of carbon and nitrogen ratio as well as a high content of water are appropriate for the procedure of fermentation by microorganisms. An insignificant amount of water is released by bacteria and materials for fermenting during the entire process of fermentation. The most appropriate temperature for the purpose of fermentation to be complete is 26^{o}c to 38^{o}c as well as an optimal pH of around 4.1 to 5.6. Increased temperature can lead to the killing of microorganisms that are used during the procedure of fermentation since most of the microorganisms are found to be mesophilic and also develop at 21^{o}c to 45^{o}c. conditions that are either too acidic or too alkaline are not considered as appropriate since food waste becomes pasteurized thus leading to the preservation of nutrients for long periods whenever there is a reduction in the ph below 4.2.

Solid state fermentation is considered as the procedure that involves the growth of different microorganisms that are found on solid materials whenever there are no liquids that are present (Behera & Ray, 2016). This procedure involves the growth and inoculation of microorganisms on particulate solid substances that are porous and contains reduced moisture content. The water and nutrients that are present in the solid substrates are essential in offering support to the development of microorganisms thus causing these microorganisms to generate enzymes that are helpful when they grow in solid substrates. The manufacture of solid state fermentation as well as the development of fungi are affected by the increase or decrease in temperature. Enormous amounts of heat are produced during the process of solid state fermentation and the amount of heat that is produced is usually comparative to metabolic processes of microorganisms. Funguses have the ability to grow within a big range of 21^{o}c to 56^{o}c. The metabolic activities of microbes as well as the process of aeration during fermentation are connected to the movement of heat of solid state fermentation. High amounts of temperature can consequently lead to other effects of germination, sporulation of the fungi and the formation of metabolites. The growth of fungi reduced when the temperature for the development of fungi exceed or go beyond maximum temperature. Fermentation moments and the temperature of fermentation are checked during fermentation since these aspects can have a consequence on fertilizers production. The appropriate temperature required for the manufacture of organic fertilizers is 24.8^{o}c and the fermentation days were 37.3. The microorganisms that utilized solid state fermentation include bacteria, fungi, algae and yeast. The yeast is utilized in the production of ethanol and was grown together with yeast and glucose at a temperature of 32^{o}c. The pH was changed to almost 5.5 since those which were either too alkaline or too acidic circumstance might have an effect on the metabolic action of different microorganisms.

Composting is a natural procedure of decomposing and recycling of organic components into rich soil that is humus known as compost. Microorganisms including fungi, actinomycetes and bacteria utilize energy and nutrients in organic components and changes hydrocarbons into water and carbon dioxide through the process of oxidation. Microorganisms in fertilizers begin to reproduce and continue the decomposition of food waste products (Lim et al. 2015). Hydrogen, oxygen and carbon that are initially found in solid components are then changed into gaseous forms and later released into the atmosphere. Temperature is important in the procedure of composting since the increase in temperature can lead to the enhancement of microbial rate of development, the rate of degradation and the production of enzymes in food waste. Increased rate of degradation can lead to the release of increased energy, temperature increase for food that is composting thus enhancing the procedure of composting. The most appropriate temperature for the decomposition of food waste is

52^{o}c to 60^{o}c (Van Fan et al. 2016). The pH for suitable composting was neutral in 6.0 to 7.0 pH. Organic fertilizer is fertilizer that can be produced by waste items including manure and compost. Organic fertilizer obtained from organic products obtained from animals and plants under decomposition procedure that can be in either liquid or solid form. The organic products that are found in organic fertilizers have the ability to boost the physical, chemical and biological aspects of soil when incorporated into soil. Organic fertilizer obtained from waste products can improve the quality of soil and improve the value of agricultural production. The manufacture of organic fertilizers can reduce the environmental pollution thus increasing the quality of sustainable land. The waste items including manure, sewage sludge, food waste and agricultural waste can be changed into helpful substances including organic fertilizer.

Sewage sludge is material that is semi solid that left from industrial waste water and sewage treatment. Sewage mud can be eliminated through diverse means which include agricultural, composting, land filling and incineration. The treatment of waste water in sewage sludge amounts in the production of huge amounts of excess sludge. The sludge later becomes reused and compost as soil conditioner and organic fertilizers in agriculture. The application of sludge compost includes treatment that is sustainable when compared to land filling and incineration since sludge that is composed can recycle nutrients and organic components. The nutrients and organic components, including potassium and phosphorus are reused and recycled as natural fertilizers thus enhancing plant growth and the fertility of soil.

The procedure of converting food waste into organic fertilizers through solid state fermentation, composing or fermentation is universally carried out with an objective of reducing the quantity of food waste that is produced on a daily basis (De Clercq et al. 2017). Food waste that does not undergo proper handling procedures can amount to pollution of groundwater, release of harmful gas, attraction of vermin and release of oduor. The appropriate decomposition of food wastes can amount in the reduction of oduor and pathogens. Food wastes including vegetables, fruits, grain, eggshells and bread can be decomposed and changed into natural fertilizers. Food wastes including bones and red meat can further be converted to fertilizers even though they take a longer period to decompose. Food waste mostly undergoes the process of recycling thus leading to the production of fertilizers mainly because waste material s from food products has unique aspects as raw compost agents. Most waste products that are obtained from food have high amounts of energy and have a higher suitability for producing energy and stabilization of waste. The proportion of carbon to nutrients in organic wastes is important during the process of composition and fermentation. These procedures rely on microorganisms that utilize different sources of carbon to offer nitrogen and energy that is used in the construction of cell proteins. Nitrogen is considered as an essential nutrient that involves insignificant amounts of phosphorus as well as other components. The ratio of carbon to nitrates on a range of 28:27:1 is regarded as the most favorable. The low amounts of C:N ratio that is less than 25 causes loss of nitrogen from compost through the volatilization of ammonia. Nevertheless, the increased ratio of C: N can amount in nitrogen immobilization in compost thus reducing the decomposition rate. Wastes from fruits and vegetables have a C: N ratio of less than 28:2 and are moderately appropriate in composting and fermentation.

The most essential features in the composting of food waste include chemical and physical aspects of substrate that include the size of the particle and the composition. Food waste also has a high amount of moisture and reduced physical arrangement when compared to manure and sewage sludge. Food waste is usually mixed with bulking agents including sawdust and yard waste that have a high amount of C: N ratio for purposes of absorbing additional wetness and improve the structure to the mixture therefore improving the decomposition of food waste. Environmental aspects which include pH and temperature have an effect on the degradation of every food component waste into natural fertilizers. Protein, cellulose and carbohydrate have diverse optimal pH, temperature and periods of retention for the process of composting.

Waste products from foods can be composed or fermented into fertilizers without undergoing the procedure of adding any materials that are rich in carbon (Pham et al. 2015). Nevertheless, the production of natural fertilizers can be improved through the incorporation of other sources of carbon including molasses and brown sugar. The process of composting food wastes can be enhanced through addition of sugar sources since many of the microorganisms includes organisms that love sugar and therefore are able to utilize the sugar in the process of breaking down the food waste in composting or fermentation procedure. Brown sugar is a form of sucrose that is in crystalline form that contains fructose and glucose as well as an insignificant quantity of molasses which provides the brown color that is found in sugar. Brown sugar is a type of food that is found under the class of

medium acid that makes the different components that are included in it become acidic. Brown sugar is utilized in plant juices that are fermented and constitutes leaves, fruits and grasses. Brown sugar has the ability of drawing out the microorganism, nutrients and lactic acids that are contained on the leaves of plants. Brown sugar is included to the waste thus increasing the rate of fermentation in food wastes mainly because it contains glucose which is one of the components that can be used as a resource for food by different microorganisms. Microorganisms make use of the source of carbon that is found in sugar to fasten the breakdown of food waste.

The process of composting and recycling food waste into fertilizers is regarded as a part of the incorporated waste management procedure that is being steadily identified by authorities on a local level with regards to environmental, technical and financial aspects. Fermentation of food wastes can offer cost savings for the local management in the management of waste and bring down the cost incurred in waste and refuse disposal (Tong et al. 2018). Through production of composts obtained from waste products, the cost of purchasing commercial fertilizers that offer nutrients to the soil and plants are reduced. The compost that is produced can be utilized as organic fertilizers for purposes of soil nourishment and conditioning. The compost manufactures materials that can be utilized as fertilizer for slow release in plantation. The satisfaction can be obtained from elevated development and growth of plants in compost soil. The conversion of waste food into organic fertilizers further offers sustainable management in the household waste that is biodegradable. In this regard, the producer has the responsibility of separation, treatment and eventual use of waste products. Compost and natural products that are gotten from the recycling of waste products is a resource that is sustainable and renewable where the process of composting can lead to the conservation of natural peat habitats. The replacement of peat by compost is conducted without boosting the cost for elevating the conditions of soil. As most countries around the globe are developing environmental consciousness, there are substantial efforts on the recycling of food wastes as well as recovery that have become an issue of recognition. This research indicates that the production of fertilizers through the conversion of waste food into organic fertilizer is a procedure that has proven to be successful and therefore it is supposed to be embraced and encouraged across the universe.

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