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UTILIZATION OF FOOD WASTE AND ITS BIODEGRADATION FOR USEFUL PRODUCTS

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Abstract:

Kitchen food waste can be used for biogas and bio-fertilizer production. Biogas is used as a source of energy. Biogas and bio-fertilizer production from such waste shall be more cost effective, eco-friendly, and can cut down on landfill waste, generate a high-quality renewable fuel, and reduce CH_4 and CO_2 emissions in environment, thereby preventing pollution. These gases can also be employed in bio-fertilizer production, thereby replacing the chemical fertilizers. Anaerobic bacteria play a major role in the regulation of soil properties on the basis of their biological activity.

Keywords: *food, food waste, biodegradation, bacteria, anaerobic degradation*

Introduction:

"Food loss and waste" refers to the edible parts of plants and animals that are produced or harvested for human consumption but that are not ultimately consumed by people. In particular, "food loss" refers to food that spills, spoils, incurs an abnormal reduction in quality such as bruising or wilting, or otherwise gets lost before it reaches the consumer. Food loss is the unintended result of an agricultural process or technical limitation in storage, infrastructure, packaging, or marketing.

India stands second in the production of fruits and vegetables in the world. It contributes about 10% of fruits and 14 % of vegetables in the world production (Gautam & Guleria, 2007). Vegetable wastes are created during harvesting, transportation, storage, marketing and processing. Due to their nature and composition, they deteriorate easily and cause foul smell production. In recent years, solid waste treatment has become a serious issue worldwide. Material waste is a by-product of almost all human activities and results in stress and pollution in the environment (Park *et al.*, 2008).

The best thing that can happen to food is that it makes it to the plates and is enjoyed. By the year 2050 the world population shall be doubled and there will be a need to feed such increasing population. Saving food today shall help tomorrow feed the mouths and unnecessary load on soil to produce it.

How is it recycled?

In-vessel Composting involves mixing food waste with garden waste – shredding it and then composting it in an enclosed system for around 2-4 weeks (temperatures of up to 70°C speed up the process and ensure any harmful microbes are killed off). The material is then left outside to mature for a further 1-3 months with regular turning and checks to ensure quality before going to be used as soil conditioner.

Anaerobic Digestion uses microorganisms to break down food waste, animal manure, slurries and energy crops in the absence of oxygen, inside an enclosed system. As it breaks down it gives off methane, which is collected and converted into biogas and used to generate electricity, heat or transport fuels. It also creates a nutrient-rich digestat can be used as a fertilizer for agriculture and in land regeneration, which helps to growing healthy plants.

Environmental Impact:

Reducing food waste is a major issue and not just about good food going to waste; wasting food costs the average family with children almost Rs. 1200/- a month and has serious environmental implications too. The amount of food that is thrown away is a waste of resources, energy, water and packaging used in food production, transportation and storage. This all goes to waste when good food is thrown away.

Reducing Wasted Food Basics:

Most people don't realize how much food they throw away every day — from uneaten leftovers to spoiled produce. More than 96 percent of the food we throw away ends up in landfills. In 2011, it was estimated that land filled food waste was more than 36 million tons. Once in landfills, food breaks down to produce methane, a potent greenhouse gas which contributes to environment pollution and climate change.

Benefits of Reducing Wasted Food:

It Saves money from buying less food. **Reduces methane emissions** from landfills and lowers the carbon footprint. **Conserves energy and resources**, preventing pollution involved in the growing, manufacturing, transporting, and selling food. **Supports the community** by providing donated untouched food that would have otherwise gone to waste to those who might not have a steady food supply.

Environmental reasons:

- New research has found that almost half of the food waste in their rubbish bins could be easily composted.
- Composting at home for just one year can save global warming gases equivalent to all the CO_2 the kitchen produces annually and washing machine produces in three months.
- **Benefits for the garden**
- The compost is a nutrient-rich food product and shall help improve soil structure, maintain moisture levels, and keep soil's pH balance in check while helping to suppress plant disease. It will have everything needed by plants including nitrogen, phosphorus and potassium and it will help buffer soils that are very acidic or alkaline.

  A food chain shows how energy is transferred from one living organism to another via food. It is important to understand how the food chain works and how the ecology is balanced. Photosynthesis is only the beginning of the food chain. There are many types of animals that will eat the products of the photosynthesis process. Examples are deer eating shrub leaves, rabbits eating carrots, or worms eating grass. In the food chain, energy is transferred from one living organism through another in the form of food.

Role of Women in Reducing Food Loss and Waste: Women comprise 41 percent of the agricultural workforce worldwide and make up the majority of agricultural workers. Close to the fork, surveys in a wide range of countries show that women are responsible for 85-90 percent of the time spent on household food preparation. Therefore, targeting women in food loss and

food waste reduction campaigns could result in greater reductions than pursuing an unfocused campaign (FAO, 2012b; FAO, 2013).

Biodegradation: Biodegradation is the chemical dissolution of materials by bacteria or other biological means. While biodegradable simply means to be consumed by microorganisms and return to compounds found in nature, "compostable" makes the specific demand that the object break down in a compost pile. The term is often used in relation to ecology, waste management, biomedicine, and the natural environment (bioremediation) and is now commonly associated with environmentally friendly products that are capable of decomposing back into natural elements (Sims & Cupples, 1999).

Anaerobic digestion: Anaerobic digestion is a collection of processes by which microorganisms break down biodegradable material in the absence of oxygen. The process is used for industrial or domestic purposes to manage waste and/or to produce fuels. Anaerobic digestion occurs naturally in some soils and in lake and oceanic basin sediments, where it is usually referred to as "anaerobic activity" (Ahring, 1992; Arsova, 2010). This is the source of marsh gas methane as discovered by Volta in 1776 (Kacprzak, 2009; Luque *et al.*, 2011).

Roles of major factors in bio-gas productions: The amount of biogas produced from the digestion process depends on several parameters like pH, temperature, composition of substrate, retention time and organic loading rate. The biodegradation process can be divided into: (1) aerobic and (2) anaerobic degradation (Swift, 1998; Rosez *et al.*, 2008).

Aerobic biodegradation:

Polymer + O2 → CO2 + H2O + biomass + residue(s)

Anaerobic biodegradation:

Polymer → CH4 + CO2 + H2O +biomass + residue(s)

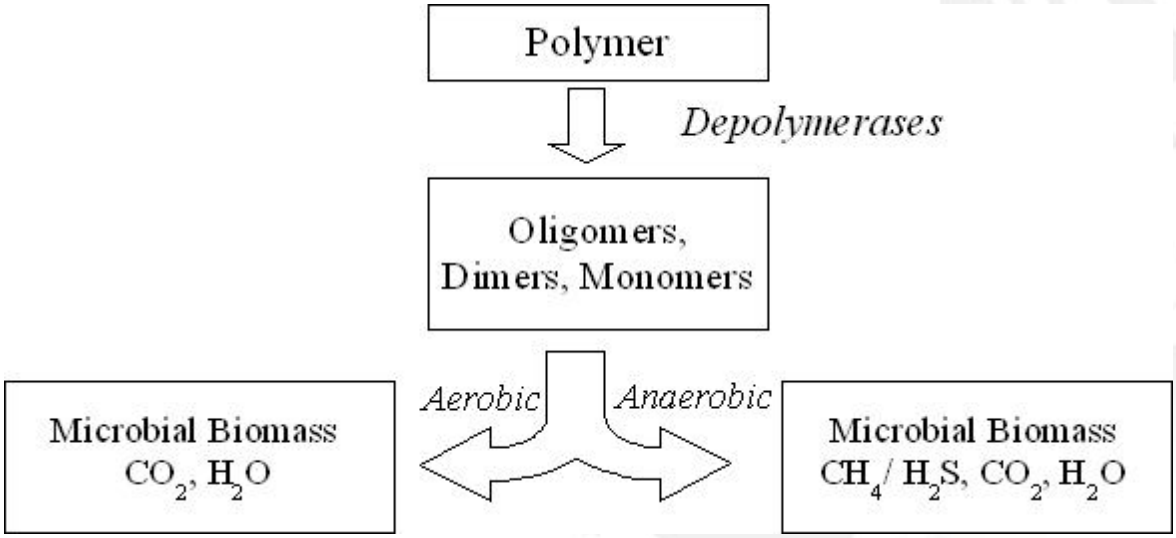

Fig.1. Schematic diagram of polymer degradation under aerobic and anaerobic conditions.

Activity of Anaerobic microorganisms in anaerobic digestion:

In anaerobic digesters, proteins serve as a source of carbon and energy for bacterial growth and a source of nitrogen. Proteins are hydrolyzed by proteolytic enzymes to peptides, amino acids, ammonia, and carbon dioxide. It has been shown that a specialized group of anaerobic bacteria such as the proteolytic Clostridia (e.g. *Clostridium perfringens, C.bifermentans, C. histolyticum, and C. sporogenes*) are responsible for protein degradation in digesters (Wang *et al,* 2005).

Mechanism of anaerobic digestion process: The anaerobic digestion process normally consists of four steps, each of these is completed by different groups of bacteria. These are hydrolysis, acidogenesis, and methanogenesis . All reactions happen simultaneously and are interdependent. Nevertheless, the overall chemical reaction can be simplified to:

Organic matter → CH_4 + CO_2 + H_2 + NH_3 + H_2S

Hydrolysis: In this step which large organic molecules viz. proteins, carbohydrates and fats are enzymatically broken down into smaller molecules.

The rate of the hydrolysis step depends on substrate characteristics, bacteria concentration, and also environmental factors such as pH and temperature. Carbohydrate → Sugars; Protein → Amino Acids
Fat → long chains fatty acids & glycerols.

Acidogenesis: Acidogenesis of kitchen waste produces biogas and soluble organic products such as organic acids. Organic acids such as lactic acid followed by acetic and propionic acids were found to be the main products of kitchen waste fermentation.

Conversion of glucose into ethanol:

$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2 + heat$

Conversion of glucose into propionic acid:

$C_6H_{12}O_6 + 2H_2 \rightarrow 2CH_3\,CH_2COOH + 2H_2O$

Methanogenesis: The methanogens convert acetic acid, simple alcohols (methanol, ethanol) or carbon dioxide and hydrogen into methane. Approximately 70 % of total methane production is acquired from the conversion of acetic acid or by fermentation of alcohols, while 30 % of the methane production comes from the reduction of carbon dioxide by hydrogen. The reactions in methanogenesis are as follows:

Conversion of acetic acid: $2CH_3CH_2OH + CO_2 \rightarrow 2CH_3COOH + CH_4$

$CH_3COOH \rightarrow CH_4 + CO_2$

Conversion of methanol: $CH_3OH + H_2 \rightarrow CH_4 + H_2O$

Reduction of carbon dioxide by hydrogen: $CO_2 + 4H_2 \rightarrow CH_4 + 2H_2O$

Conclusion and Discussion: Kitchen bio-wastes which constitute the main ingredient of municipal bio-wastes are considered as valuable co-substrates of anaerobic digestion. Such bio-wastes are relatively easily accessible and include a large proportion of biodegradable organic matter (approx. 90% of total solids).Biological treatment already demonstrated that is one of the most advantageous methods for maximizing recycle and recovering its components. This process also results in a lower production of leachate and easier handle of digested residues that can be further treated by composting process or be used as fertilizer.

References:

- Ahring B.K. (1992): Turn-over of acetate in hot springs at 70°C. Proc. Of Thermophilies: Science and Technology, Pp.130.
- Arsova L. (2010); Anaerobic digestion of food waste - Current status, problems and an alternative product. M.Sc.thesis, Department of Earth and Environmental Engineering, Columbia University. NYC, USA.
- FAO. (2012b):*Save Food: Global Initiative on Food Losses and Waste Reduction.* Rome: FAO
- FAO. (2013); "Food Loss and Waste: Definition and Scope." Unpublished.
- Gautam Harender Raj, and Guleria S.P.S. (2007): Science & Technology Entrepreneur.
- Kacprzak A., Krzystek L., and Ledakowicz S. (2009): Codigestion of agricultural and industrial wastes. Chemical Papers; 64(2): Pp. 127-131.
- Luque R., Campelo J., and Clark J. (2011): Handbook of Biofuels Production Processes and Technologies, Wood head publishing.
- Park Y.J., Tsuno H., and Hidaka T. (2008): Evaluation of operational parameters in thermophilic acid fermentation of Kitchen waste. Journal of Material Cycles and Waste Management; 10: Pp. 46-52.
- Rozej A., Montusiewicz A., and Lebiocka M. (2008): No Title. Archives of Env. Protection; 34(3): Pp. 299- 304.
- Sims, G. K. and Cupples, A.M. (1999): Factors controlling degradation of pesticides in soil. Pesticide Science 55: Pp.598–601.
- Swift G.(1998): Requirements for biodegradable watersoluble polymers. Polym. Degrad. Stabil; Pp.59.
- Wang X.M., Wang Q.H., Ren N.Q., and Wang X.Q. (2005): Lactic acid production from kitchen waste with a newly characterized strains of *Lactobacillus plantarum.* Chem. Bioche. Eng. Q.; 19 (4): Pp. 383- 389.

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