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Food Waste to Energy

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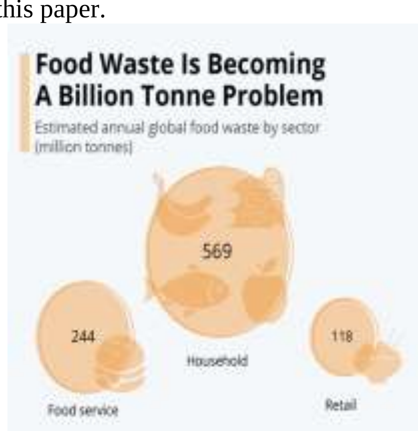
Abstract: *The development of food waste-to-energy systems necessitates a thorough understanding of the waste feedstocks accessible in a given geographic region, including total volumes and seasonal variations, physical and chemical qualities, and material phases. Many studies have shown that enormous amounts of food waste are created on a global scale, with estimates ranging from 30% to 40% of food produced for human use., However, waste distribution within the food supply chain can be very different. In developing countries, agriculture, and initial product handling account for the majority of losses, but in more developed economies, the loss profile is dominated by the consumption stage. Significant losses have been calculated across the food supply chain in the United States, with a total annual economic effect of more than $100 billion Food waste landfill bans have recently been enacted in several Northeasternstates, as well as California, due to the severe economic and environmental burdens associated with food waste. These bans require the diversion of these materials from large commercial generators to alternative beneficial uses.*

Key Word: *Food Waste; Bacteria; Biogas.*

I.INTRODUCTION

Food waste is a serious problem. Food waste (both precooked and leftover) is a biodegradable waste that comes from a variety of places, such as food processing plants, residences, and the hospitality. industry According to the FAO, almost 1.3 billion tons of food are lost throughout the food supply chain, including fresh vegetables, fruits, meat, bread, and dairy goods. Due to economic and demographic expansion, primarily in Asian countries, the amount of FW is expected to expand over the next 25 years. the yearly amount of urban FW in Asian countries might increase from 278 to 416 million tones' total of 1.4 billion hectares of arable land (or 28% of the world's agricultural acreage) are utilized to produce food that is lost or squandered each year. Every year, around 1.4 billion hectares of arable land are utilized to produce food that is lost or squandered. Food waste is expected to contribute to greenhouse gas (GHG) emissions by collecting around 3.3 billion tons of CO2 into the atmosphere each year, in addition to food and land resource waste. Food waste, which is a component of municipal solid trash, is typically burnt or dumped in open areas, posing serious health and environmental risks. When food waste with a high moisture content is burned, dioxins are released, which can cause a variety of environmental problems. In addition, burning diminishes the substrate's economic worth by preventing the recovery of nutrients and important chemical components from the burnt substrate. As a result, effective measures for the management of food waste are required. Anaerobic digestion, which uses food waste to generate biogas while also addressing waste management and nutrient recycling, could be an appealing choice for bolstering the world's energy security. The amount of wasted food around the world and its potential for bioenergy via anaerobic digestion have previously been published and are summarized in this paper.



II.ANAEROBIC DIGESTION

The anaerobic digestion facility collects food waste from homes and businesses and transports it to the facility. Any packaging and non-food materials are removed at the factory, and the food waste is pre-treated before being processed. After that, the food waste is placed in an anaerobic digestion container. Here, naturally existing microbes break down the meal. The natural decomposition process is accelerated by the tank's temperatures and conditions. The food produces biogas in the form of methane

as it decomposes. This gas is caught and then used to generate electricity.
Farmers employ digestate, the sludge-like material left over from the anaerobic digestion process, as fertilizer.
As you can see, anaerobic digestion keeps food waste out of landfills, where its methane contributes to global warming. Rather, the gas and other by-products are used to power houses and fertilize farms.

Anaerobic digestion is divided into four phases.

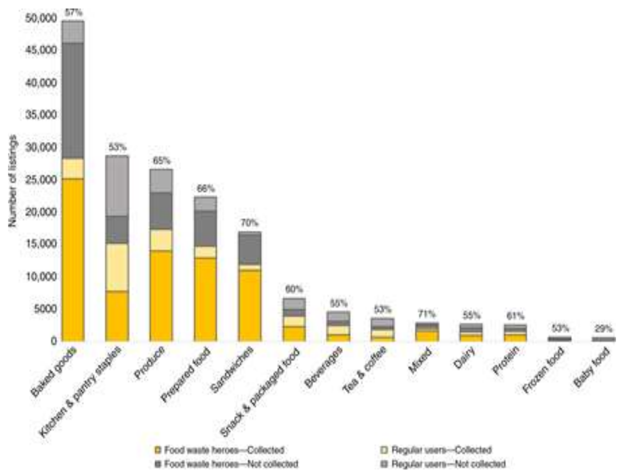
- Enzymatic Hydrolysis
- Acidogenesis Phase
- Acetogenesis
- Methanogenesis

Each stage of the process breaks down distinct aspects of the food waste, and the AD tank is intended to nurture and support all of them. The tank is entirely sealed and oxygen-free, and it maintains a temperature of roughly 35 degrees, which is ideal for all the microorganisms involved in the process.

A. Enzymatic Hydrolysis:
Long-chain polymers, such as amino acids, fatty acids, and carbohydrates, are broken down into smaller pieces (monomers) in the first phase. The rate of hydrolysis is slower than the rate of acid production in anaerobic settings, and it is determined by the type of substrate, bacterial concentration, pH, and bioreactor temperature. The hydrolysis rate is also affected by other factors such as substrate particle size and pH. Exclusion criteria**:**

$$(C_6H_{10}O_5)_n \xrightarrow{\textit{Endoglucanase}} (C_6H_{10}O_5)_{n-x} + (C_6H_{10}O_5)_x \quad \textit{Solid phase}$$
$$(C_6H_{10}O_5)_n \xrightarrow{\textit{Exoglucanase}} (C_6H_{10}O_5)_{n-2} + (C_6H_{10}O_5)_2$$
$$(C_6H_{10}O_5)_2 \xrightarrow{\beta\textit{-glucosidase}} 2(C_6H_{10}O_5) \quad \textit{Liquid phase}$$

Knowledge Break



B. Acidogenesis Phase
Acidogenesis is the fermentation step in which abiogenic bacteria breakdown hydrolysis products to create alcohols, alkenes, and (VF As), as well as H2 and CO2.Ammonia gas is produced during the breakdown of amino acids and acids (NH3). Bacteria that cause acidosis might be facultative or stringent anaerobes.
Active fermenters have been identified as those belonging to the Enterobacteriaceae family (Manila et al., 2013). Lactobacillus, Staphylococcus, Pseudogenes, Desulfovibrio, Selenomonas, Sarcina, Streptococcus, Desulfobacter, and Desulforomonas are among the anaerobic bacteria.

Amino acids are converted to fatty acids, acetate, and NH3 by these enzymes.

Reaction
$CH_3CH_2COOH + 2H_2O \rightarrow CH_3COOH + CO_2 + 3H_2$
$CH_3CH_2CH_2COOH + 2H_2O \rightarrow 2CH_3COOH + 2H_2$
$CH_3COOH \rightarrow CO_2 + H_2$

C. **Acetogenesis**

Acetogenesis species are separated between those that are not obligately proton-reducing, that is, hydrogen-producing, and those that are obligately proton-reducing, that is, hydrogen-producing. The homoeologous and species that can orient their metabolisms to proton reduction in the presence of an efficient hydrogen-removing mechanism make up the first category.

Acetobacterium, Acetoanaerobium, Acetogenium, Butyribacterium, Clostridium, Eubacterium, and Pelobacter have homoacetogenic species. Although the homoacetogens' capacity to compete for H2 in mixed cultures has yet to be determined, they can develop permanent mutualistic partnerships with H2-producing bacteria, and numerous thermophilic mutualistic co-cultures have been identified (Archer and Kirsop, 1990). They grow well in slightly acidic environments. Only an efficient electron-removing environment, such as monoxenic culture with a hydrogen-removing or formatted-removing species, can grow obligately proton-reducing acetogenic bacteria.A culture including the acetogen and a hydrogen-removing bacteria such as a methanogen is the simplest mixed culture exhibiting this sort of "mutualistic" interaction.Desulfovibrio spp. are obligatory proton-reducing acetogens when metabolising ethanol or lactate in the absence of sulphate, and may be cultivated in mutualistic co-culture with methanogens.There have been reports of other obligatory proton-reducing acetogens:

Reactions
$CH_3\text{-}CH_2\text{-}COO^- + 3H_2O \rightarrow CH_3COO^- + HCO_3^- + 2H^+ + 2H_2$
$CH_3\text{-}CH_2\text{-}CH_2\text{-}COO^- + 2H_2O \rightarrow 2\,CH_3COO^- + 2H^+ + 2H_2$

D. Methanogenesis

Methanogenesis was once thought to be a unique sort of fermentation.

However, methanogenesis differs from fermentation and respiration in certain ways due to the specific biochemistry involved.

Methanobacteriales, Methanococcales, Methanomicrobiales, Methanopyrales, and Methanosarcinales are all strictly anaerobic bacteria that belong to the phylum Euryarchaeota, which is divided into five orders that range from mesophiles to thermophiles.

Methanogens can be found in freshwater and marine settings, cold sediments, and hydrothermal vents, as free-living cells and as symbionts with protists and animals that help with methane generation, as well as symbionts with bacteria that help with anaerobic methane oxidation. Methanogenesis can occur in three different ways.

According to CH3COOHCO2+CH4, acetoclastic methanogens dismutase acetate.

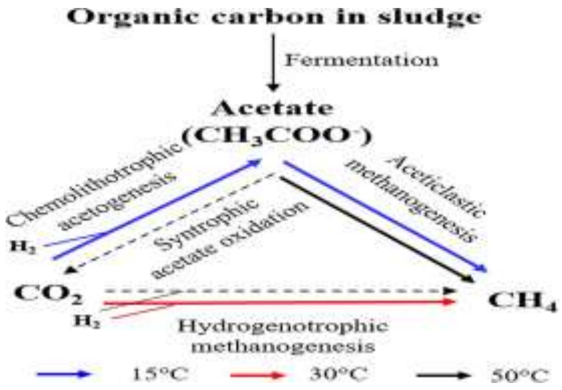
Methanosarcinales include acetoclastic methanogens (e.g., Methanosarcina and Methanosaeta).

Acetate dismutation is technically a sort of fermentation, however unlike other fermentation routes, ATP generation during methanogenesis is reliant on electron transport-linked phosphorylation rather than substrate level phosphorylation.

A second process, methylotrophic methanogenesis, can be used by certain acetoclastic Methanosarcinales and at least one member of the Methanomicrobiales, in which methanol or methylamines are used as substrates. Freshwater sediments and anaerobic digestors are the most active and essential sites for acetoclastic methanogenesis, with acetate accounting for nearly two-thirds of total methane generation.

In some marine sediments and other anoxic systems with methylated substrates, methylotrohic methanogenesisis essential. Hydrogenotrophic methanogenesis, the third mechanism for methane synthesis, occurs in all five orders above. Hydrogenotrophic methanogens use H2 to reduce CO2 (or CO or formate) according to the following equation: 4H2+CO2CH4+2H2O. This is a sort of respiration, and the organisms that employ it can develop autotrophically. A conventional electron transport chain, on the other hand, is not discovered. Instead, methanogens produce several unique coenzymes, such as F420, which aids in the activation of H2, and coenzyme M, which aids in the final reduction of CH3-groups to methane.

Coenzyme F420 fluoresces violet in an oxidised state, allowing for the microscopic detection of methanogens in mixed bacterial populations.



III.WHAT'S SO GOOD ABOUT ANAEROBIC DIGESTION?

Anaerobic digestion has the advantage of simultaneously addressing two environmental challenges. For starters, it reduces the amount of food waste that ends up in landfills. Food waste that is thrown away and ends up in landfills is an issue for the environment since the gases emitted during decomposition end up in the atmosphere, adding to global warming. When you consider that by 2030, scientists expect a 33 percent rise in the quantity of food waste generated, this might become a serious problem. Anaerobic digestion keeps part of this gas from entering the atmosphere and puts it to good use. Second, because the raw materials required to fuel it are constantly accessible, it is classified as renewable energy.

Food waste to energy conversion via anaerobic digestion is beneficial since it helps the UK meet its current renewable energy goal of 30% renewable energy by 2030. Anaerobic digestion is being used to power over one million households in the United Kingdom, and the sector is expanding.

IV.CONCLUSION

Food waste disposal has become a major financial and environmental problem. In terms of methane, it appears that converting food waste into energy via anaerobic processes is economically viable. However, the obstacles that come with collecting and transporting food waste must also be recognized. Nonetheless, the low or no cost of food waste, as well as environmental assistance for waste disposal, would offset the biorefineries' initial high investment costs.

V.ACKNOWLEDGEMENT

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