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Food Waste Utilization: An Insight into Research and Studies

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***Abstract*— Treatment of domestic waste is generally carried out by activated sludge process. The waste solid sludge can be treated by various aerobic and anaerobic treatment processes. Aerobic treatment methods need space and time. Anaerobic treatments have advantages such as space utilization and production of fuel gases such as methane. Up flow anaerobic sludge digester or fluidized bed digester can be used for anaerobic treatment. Vermi-composting of domestic sludge is also practically feasible and economical alternative. The waste food is sizeable part of domestic sludge. This waste food can be used as a feedstock for synthesis of ethanol like compounds. Current review summarizes investigations and literature studies carried out on utilization of waste food for various applications**

***Index Terms*— Nutrients, organic waste, chemical oxygen demand, biogas, bioplastic, fuel.**

I. INTRODUCTION

Domestic waste treatment includes wastewater treatment and treatment of solid waste. Treatment of domestic wastewater is generally carried out by using various biological treatment methods. High biological oxygen demand calls for effective treatment of the waste to decompose and stabilize unsaturated organic matter. The treatment by using activated sludge process and trickling filters is employed for domestic waste treatment [1,2,3,4,5]. Removal of organic matter by using low cost adsorbent is also widely explored area of investigation[6,7,8,9,10]. Flyash, coconut shell, tamarind bean, groundnut shell and other agricultural waste can be used for removal of organic matter. Removal of nitrites and nitrates can be carried out by aerobic and anaerobic biological methods [11,12,13]. Also phosphate removal can be carried out by various chemical and biological treatment methods [14,15,16,17,18]. The domestic solid waste treatment is gaining importance because of two aspects. Firstly, its hazardous effects and nuisance value and second is its potential as feed stock. This domestic waste can be treated by aerobic and anaerobic biological methods[19,20,21]. Anaerobic decomposition with methane generation is feasible and potentially beneficial alternative. Also composting and vermicomposting are being explored for domestic waste treatment. This method in addition to waste sludge treatment, provides manure for farming. One major research area in biotechnology explores the possibilities of use of waste feed stock for synthesis of various compounds. Compounds like acetic acid, oxalic acid, lactic acid, amino acid, glucose, starch etc. are being synthesized on laboratory, pilot plant and in some cases commercial scale[22,23,24,25,26,27].The domestic food waste contains high carbohydrate and other compounds. Various investigators have carried out investigations on synthesis of various chemicals from food waste. Also other treatment options for the food waste and possible utility of the waste is being explored by various investigators. Current review summarizes research and studies on use waste food for synthesis of various compounds and its treatment.

II. FOOD WASTE UTILIZATION: AN INSIGHT INTO RESEARCH AND STUDIES

Akpan et.al. carried out an investigation on organic and food wastes utilization for production of ethanol[27].They carried out acid and microbial hydrolysis for obtaining fermentable sugar wort. They used sacchromyces ceverisiae for ethanol fermentation. They observed that it was more economical to produce ethanol from food waste (maize) than old organic waste (old newspaper). They estimated kinetic parameters and predicted data by using a non-linear kinetic model. Dlabaja and Malatak performed laboratory experiments of wet anaerobic fermentation in a continuous reactor and in batch reactors under mesophilic conditions[28]. Under mesophilic conditions, they performed the investigation to study effects of hydraulic retention time, organic loading rate, period of feeding and recirculation of digestate in a continuous reactor. In case of batch reactor, they examined factors like effects of substrate pre-treatment (crushing, heating, freezing).They observed an increase in ammonia concentration because of recirculation of digestate. They found that degree of degradation was not affected by 20 days fermentation. Kapdan and Kargi carried out an experimentation on use of waste material for production of biohydrogen[29]. According to them, the methods like electrolysis of water, steam reforming of hydrocarbons and auto-thermal processes are widely known. Requirement of energy is drawback of most of these methods. They explained that the selection criteria for waste material for biohydrogen production. They summarized common waste materials used for hydrogen production. They found that use of photosynthetic algae is one of the important method for hydrogen synthesis from waste. Second method includes dark fermentation of carbohydrate rich wastes. The third significant method is photo-fermentation of organic acid rich wastewaters. According to them, low rates and yields of

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hydrogen formation are major problems in hydrogen synthesis.

Kim et.al. studied effect of feeding dry or fermented (aerobically or anaerobically with or without lactic acid bacteria) restaurant food residue mixture on animal performance and blood profiles[30]. They used rats as model animals. They observed that aerobically or anaerobically fermented diets showed better animal performance than feeding a dry food residue-containing diet. Khanto and Banjerdkij carried out experiments for studying the chemical oxygen demand (COD) removal and biogas production from night soil[31]. In their experiment they obtained 88.27 % COD removal after 15 days experiment in anaerobic reactor resulting to the biogas production. Bubacz and Goldsberry carried out an investigation on bioplastic obtained from food waste[32]. According to them, only a few percents of plastics are recovered for recycling. The processes for manufacturing emits considerable amount of carbon dioxide to atmosphere. The synthesis of bioplastic, according to them, can reduce this problem. Bioplastic can be derived from biological sources including starch, cellulose, fatty acids, sugars and proteins. These raw materials can be obtained from food industries. Chiranjeevi et.al. carried out experimentation on hydrolysis for vegetable waste [33]. They also studied the kinetic aspects of the hydrolysis reaction. They discussed various steps in subsequent ethanol fermentation from this waste material. They also studied hydraulic reaction conditions including enzyme dosage, substrate loadings and incubation time. Yang et.al. carried out an investigation to study effect of lactic acid bacteria on the microbial, physical and chemical properties of food waste mixture (FWM)[34].They observed that non-anaerobic storage of FWM showed microbial putrefaction with the loss of water and water soluble carbohydrate. The results obtained by them indicated that non-anaerobic storage of FWM resulted in microbial putrefaction.

Sakai et.al. investigated fermentation of food waste at high temperature for lactic acid[35]. They inoculated minced model kitchen refuse by Bacillus coagulans. They incubated it under non sterilizing conditions. Their investigation confirmed predominance of mesophilic lactic acid bacteria at lower temperature, and of Bacillus coagulans at higher temperature. Kader et.al. carried out an experimentation on production of biogas by anaerobic digestion of food waste [36]. They studied and optimized the production of biogas from food waste (rice). They observed increase in the percentage of methane in the outlet gas with increase in the methanogenic bacteria. They also observed that, the amount of methane in the biogas slowly attained approximate constant value of 69%. There was 25-30 percent difference in simulated and experimentally observed results. According to them, the lack of controlled environment and leakage of the gas and rain water out and in to the system were responsible factors for this. Oliveira and Doelle carried out a review on production of biogas from food waste[37]. According to them, one of the major application of anaerobic digestion is degradation of food waste and energy recovery. Important factors in bioreactor operation, according to them are, organic loading rate, temperature, time, pH, carbon to nitrogen ratio. They observed that a two-stage reactor leads to higher biogas and methane yields if compared to a single stage reactors. According to them, selection of proper optimal conditions, temperature and methodology as well the feedstock loading can lead to high waste to fuel or energy conversion.

Thongdumyu et.al. carried out investigation on ethanol production from food waste hydrolysate[38]. Their study was focused on optimization of ethanol production. In their investigation, they used co-culture of Zymomonas mobilis and Candida shehatae under non-sterile condition. They employed response surface methodology (RSM) to optimize the effects of nitrogen source [$(NH4)_2SO_4$], phosphorus source (KH_2PO_4), yeast extract and inoculum size on ethanol production. They concluded that food waste was a promising biomass resource for ethanol production. Shukla et.al. carried out preliminary studies on biohydrogen production propensity of mixed consortium on food waste[39]. With the help of anaerobic chamber, they carried out isolation of the bacteria for mixed consortia. Their results indicated that the initial cultivation of pH affected the hydrogen production to a considerable extent. They observed approximately 70 percent reduction in chemical oxygen demand during experiment. Bodik et.al. explored possibilities of anaerobic fermentation of food waste[40]. They discussed long-term operation of a laboratory anaerobic reactor processing food waste. They operated mixed anaerobic reactor under mesophilic conditions with organic load. They concluded that collected food waste was promising source for co-fermentation and biogas production on real wastewater treatment plants.

Fazeli, in his investigation studied application of anaerobic digestion of municipal solid food wastes in treating wastewaters [41]. He explored possibility of use of volatile fatty acids(VFA) from the anaerobic acidogenesis of the urban food waste. He found that the ethanol cultivated biomass was more successful in using the effluent of the food waste digestion compared to methanol cultivated biomass. He also observed that amount of biomass produced during denitrification with VFA mixture was larger. Moukamnerd et.al. studied feasibility study of ethanol production from food wastes[42]. They used consolidated continuous solid-state fermentation. They observed that salt contained in food wastes had a direct negative effect on yeast activity but the enzyme activity was not affected. Matsakas and Christakopoulos explored the possibility of using source-separated household food waste for the production of ethanol [43]. In their investigation, they explored the possibility of using source-separated household food waste for the production of ethanol. They observed that this approach of production of these thermophilic enzymes was beneficial. They observed that with increasing concentration of household food waste (HFW), cellulolytic activity also increased.

III. CONCLUSION

The waste food is sizeable part of domestic sludge. This waste food can be used as a feedstock for synthesis of ethanol like compounds. Current review summarizes investigations and literature studies carried out on utilization of waste food for various applications. The domestic solid waste treatment is

gaining importance because of two aspects. First is, its hazardous effects and nuisance value and second is its potential as feed stock. The domestic waste can be treated by aerobic and anaerobic biological methods. Anaerobic decomposition with methane generation is feasible and potentially beneficial alternative. Also composting and vermicomposting are being explored for domestic waste treatment. This method in addition to waste sludge treatment, provides manure for farming.

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