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Review: Anaerobic Biotechnology for Industrial Wastewater Treatment

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Abstract: There has been the microbiological formation of methane since ages in many diverse habitats such as paddies, marshes, hot springs, benthic deposits, deep ocean trenches, pigs, trees, cattle, termites, iguanas and human beings. Anaerobic digestion has been proved as the most appropriate technique for the treatment of high strength organic effluents. This technique is more reliable and advanced as compared to the conventional water treatment procedures. It uses very less amount of chemicals and treats the wastes in a facile and effective manner and has been considered as an attractive option for effluents treatment. The anaerobic technology causes the decrease of high level of waste materials and different reactors were developed for this particular purpose. It generates best level of fuels used as biogas. The biogas produced in anaerobic digestion burns cleanly and the biogas plants make more energy than they consume to operate, whereas the energy produced by aerobic digestion is very much lower than that produced by anaerobic digestion.

Keywords: Anaerobic, effluents, biogas, reactors, dyes.

Introduction

Anaerobic biotechnology utilizes the mechanism of decomposition of biodegradable material by microorganisms in the absence of oxygen. The technique provides the beneficial side products and bio-fuels that were not diminished after the treatment of waste such as in air, water etc. (Khanal, 2011). The protection of environment is the major problem of developing countries through which living organism are affected included humans, animals *etc*. Anaerobic technique was applied to remove wastes from water, it is self-controlled, based on the conditions of environments within reactors and not on the complexity of equipment (Foresti, 2001). Anaerobic technique is more developed to remove wastes than the conventional treatment of water and has been successfully applied for the removal of wastes from sewage, industries *etc*. Many industries like pharmaceutics industry produces large amount of wastes in water which are harmful to human health. For their treatment, convention methods are not used because they do not give attention on demand of biological oxygen (Daily, 2003; Madukasi et al., 2010; Speece, 1983).

Anaerobic water treatment technique has various advantages on the conventional technique:

- It reduces the large amount of dirty water, also known as sludge, produced in running days approximately 90%.
- The rates of chemical oxygen demand are raised up to 20-35 kg.
- Its working is faster using the seed material which is granular anaerobic sludge.
- It uses very less amount of chemicals and treats the wastes in a facile and effective manner (Van Lier, 2008).

A comparison between aerobic and aerobic techniques demonstrates that aerobic treatment is not much favorable for the treatment of waste water. The aerobic digestion requires higher capital cost for ventilation equipment, advanced operating cost (particularly energy for pumps or aerators), higher maintenance requirements and feasibly monitoring requirements for checking the dissolved oxygen level in the liquid. Aerobic digestion technology also demands an energy input to carry out the process and requires some knowledge about time. The operating costs are typically much greater for aerobic digestion than for anaerobic digestion because of energy used by the blowers, pumps and motors needed to add oxygen to the process as the aerobic technology requires lot of oxygen for aerobic bacteria, which increases the expense by using the bulk quantity of chemicals (Appels et al., 2008). One of the greatest disadvantages is that it does not release renewable energy resource that is methane gas but releases more heat and carbon dioxide that affects the environment. The fact that anaerobic digestion produces biogas which burns cleanly, and that biogas plants make more energy than they consume to operate. The energy produced by aerobic digestion is very much lower than that produced by anaerobic digestion. This is generally the factor that makes anaerobic digestion the more sustainable option than aerobic digestion (Stuart, 2006).

Benefits of Anaerobic Water Treatment

Some valuable benefits of anaerobic water treatment are given below (Agrawal et al., 2005; Bernard et al., 2001; Chan et al., 2009; Claassen et al., 1999; Kleerebezem and van Loosdrecht, 2007; Lettinga et al., 1980; McCarty et al., 2011):

Carbon Flow and Cell

In selecting between aerobic and anaerobic treatment options, the phenomenon of cell yield from influent organics have to be considered. The yield, for example, of a substrate is given below, which indicates that a lightly loaded aerobic system has much lower cell yield than highly anaerobic loaded systems.

2.1.1 Anaerobic:

1 unit substrate carbon ⟶ 0.95 units (CO_2 + CH_4) carbon + 0.05 units cell carbon

1 mole of glucose ⟶ a team of at least 3 microorganism partners get some 240 kJ

2.1.2 Aerobic:

1 unit substrate carbon ⟶ 0.5 units CO_2 carbon + 0.5 units cell carbon

1 mole of glucose ⟶ 1 organism gets 2400 kJ

The above equation demonstrates a comparison of the cell yields through aerobic and anaerobic treatment procedures. Both the techniques employ a given substrate that is carbon source. In aerobic process, the cell yield is very low as compared to the aerobic treatment. Moreover, the energy released by anaerobic is not consumed totally. Whereas, energy released by aerobic process is consumed totally by a single organism. This explains, why anaerobic digestion has become dominant (Gallert and Winter, 2008).

Environmental

- It reduces the production of dirty water, pathogens and fossil fuels.
- It also increases the chances of recycling.

Energy

- It produces energy in excess and energy is not consumed by it.
- It generates best level of fuels used as biogas that is used in various applications till the end.

Economic

- It is achieved at low cost.
- It requires less amount of nutrients (Aiyuk et al., 2006).

In developing countries, products of textile became popular, so their manufacturing at an increasing rate in industries produces various problems of pollution in the whole world. Through these industries, colored liquid waste goes down into the rivers and sea, which is harmful to the environment because the color of dyes and products are dissociated and affect human life. The other drawback of these textile industries is that they require a large amount of drinking water to continue their routine procedures, which is why the lack of water may cause serious problems because water is the basic need of all living organisms. Moreover, that waste water which is being released from textile industries has specific characteristics for identification and its composition consists of many compounds, chemicals and dyes which were applied in industrial manufacturing steps and have organic properties (Cornelis et al., 1988).

European parliament of Integrated Pollution Prevention and Control (IPPC) has planned to control the increasing pollution day by day under the Pollution and Control Act (1999). Its main target is to eliminate the waste material from air, water and land which is why this parliament played a major role in the numerous activities of various industries concerning the production of food. They checked whether they were made by raw material or not (Lema and Omil, 2001).

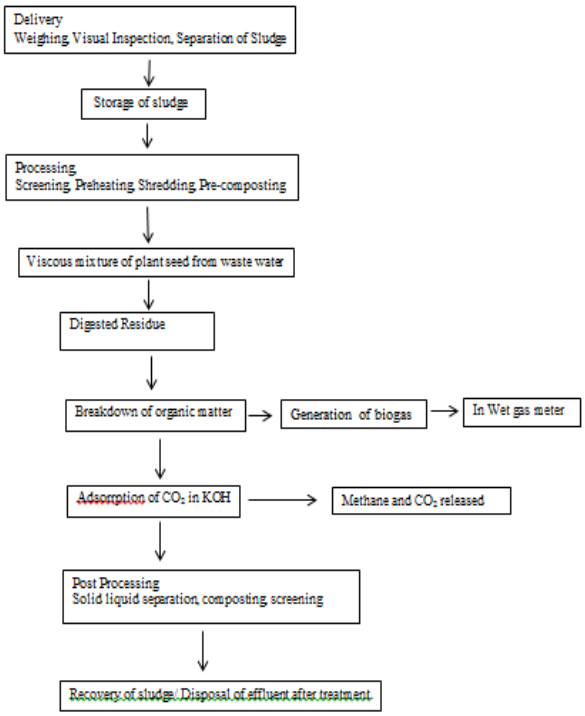

Fig. 1 Flow sheet diagram for the anaerobic biotechnology process.

It is well known that in anaerobic technique, there is less generation of very small organisms as compared to aerobic technique. For the cleaning of water from wastes, membrane filtration did its work in very well manner and biomass retention is the most important

aspect that increases the functions of membrane filtration which retains the flow of microorganisms. For the filtration procedure to run in a smooth way, there is a need of energy which is provided by the electric power generated by biogas (Fuchs et al., 2003).

Another reason of wastewater production is the manufacturing of enormous drugs and pharmaceutical units that result in the consumption of excess organic and inorganic materials. The physical appearance of waste water is different and found as suspended solids, re-fractural substances and in the form of organic substances which are toxic. The advancement in the biological treatment increases very rapidly and its main function is concerned with the treatment of wastewater from industries especially related to the manufacturing of drugs. This technique is used earlier for the removal of wastes from water that is eliminated during the continued procedures in various industries such as textiles, paper pulp, distilleries and processing of food. The anaerobic technology causes the decrease of high level of waste materials and different reactors were developed for this particular purpose. The only useful reactor is anaerobic fixed film reactor because the presence of large amount of biomass (Anuradha et al., 2006).

Here it was observed why anaerobic treatment is better than aerobic treatment.

- Numerous substrates were changed into pure and clear source of energy that is methane.
- Lesser quantity of nutrients is needed by them.
- This technique does not require aeration.
- For fertilization, it generates good level of solids.
- It reduces the residues of pollutants through which environment is affected (Saddoud et al., 2007).

Many industries are working on the synthesis of dyes and their residues go to water, which is harmful. The de-colorization of these dyes is not an easy process because their structure is complicated and some traces of useful dyes were indicated in effluent of industries. Oxidation technique is used for the de-colorization of dyes. For this purpose, activated H_2O_2 is used, the techniques should be modified according to the strength of activation of H_2O_2 , so it may remove the dye from the effluent by using this technique (Lettinga et al., 1997).

Experimental Set up

This technique acts as a core procedure for the prevention of resources and society needs this sustainable advanced technology for protection of environment (Lettinga et al., 1997).

Its mechanistic setup involves a tank reactor, which has link to the external and consisted of:

- Recirculation pump
- Ceramic cross-flow membrane
- The membrane has following properties:
  - ✓ This membrane is made of Al_2O_3.
  - ✓ The size of pores in membrane is 0.2 µm.

The reactor volume is fixed that is 7 L. The fixed volume in the reactor is maintained by a level sensor, which controls a valve on the permeate side of the filtration unit. In this technique different types of wastewater is used, which is given below:

- Artificial waste water
- Wastewater during the processing of vegetables in industries.
- Waste water of that place, where the animals are killed.
- The composition of artificial waste water depends upon yeast extract, peptone, glucose, sodium acetate.
- The waste water of slaughter house of chicken is a mixture, which is obtained by the washing of the guts and through the de-feathering line (Al-Marzoqi et al., 2016; Khan et al., 2008; Welch, 2002).

The tank reactor is capped to avoid the contact with incoming oxygen and to prevent the CH_4 methane gas from it. The wastewater treatment of sludge involves both primary and secondary treatment steps that consist of two main phases.

First step involves flowing of all incoming sludge that is combined. The mixtures obtained are heated at mild temperature to speed up biological conversion. The residence time in this tank is from 10 to 20 days.

Second step involves further digestion. In this process, heat is not required, as the process generates its own heat (Hellgren et al., 2015; Zhu and Beland, 2006).

Viscous mixture of seed can be obtained from the sludge of anaerobic digester from a plant of municipal waste water treatment and during the procedure different steps should be observed which are:

- Temperature must be maintained at 310°.
- Break down of organic matter
- The rate of generation of gas
- Amount of methane present in biogas.

In final processes, the settled sludge is dewatered and thickened. The aim is to separate water, as much as possible so that the volume of material can be reduced. Sludge stabilization moderates the level of pathogens in the residual solids to remove unpleasant odors, and

decreases the potential for decomposition (Carrère et al., 2010). Generally, 40 to 60% of organic solids are converted to methane CH_4 (biogas) and CO_2. Small quantities of H_2, N_2, H_2S and H_2O.Methane is the most valuable because it is a hydrocarbon fuel in combustion process (Lema and Omil, 2001).

The generation of biogas can be determined with the specific meter known as wet gas meter which consists of the instrument that measure the temperature and pressure and these values are again calculated according the standard conditions. The digesters are designed with an extraction system so that it can prevent gas being transported to dewatering. It requires continuous stirring. The trace of methane gas is determined by the adsorption of carbon-dioxide in KOH that is 10%. The increased degradation of membrane shows the removal of COD and gives the good level of effluents, so the digestion procedure for membrane are very stable and gain the high rates of loading that forces them to gain the stable properties of action. Thus, high yield of biomass can be obtained that shows the efficiency of the whole method (Cornelis et al., 1988; Delee et al., 1998; Fuchs et al., 2003; Weemaes and Verstraete, 1998). The overall anaerobic biotechnology process has been summarized as a flow sheet diagram (Fig. 1).

Conclusion

Anaerobic digestion is considered to be the most appropriate technique for the treatment of high strength organic effluents. This technique is more developed to remove wastes than the conventional treatment of water and is an attractive option for effluents treatment. The generation of biogas during treatment can be determined with the specific meter known as wet gas meter. The traces of methane gas are determined by the adsorption of carbon-dioxide in KOH that is 10%.

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