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MOST ADVANTAGEOUS BIOGAS PRODUCTION THROUGH THE TWO STAGE ANAEROBIC DIGESTION OF MSW

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Abstract

The objective of this study was to develop a two stage anaerobic digester for co-digestion of Organic Fraction of MSW (OFMSW) and Algae biomass of sewage sludge (ABSS) from most beneficial for higher biogas generation. The scum floating problems introduce in single stage anaerobic digestion to solve in two stage anaerobic digestion process. The 3 mesh wire filter introduces to give the moisture free digested sludge for direct using in agriculture farm land. The studies have shown that co-digestion can increase the anaerobic digestibility of taking subtracts (OFMSW and algae biomass) by improving the substrate composition. Sewage Sludge micro algae improve the digestibility of OFMSW and enhance the production of biogas. Co-digestion of OFMSW and algal sludge could efficiently balance the feedstock Carbon–Nitrogen (C/N) ratio between 20–25 likely to benefit them ethane production rate. This paper reviews recent experimental findings of the co digestion of algae with OFMSW and the methods to enhance the methane production and the factors affecting the growth of the biogas.

Key Words: Anaerobic Digestion, Two Stage, Co-digestion, Algae biomass, MSW, Biogas.

Introduction

In present time the untreated and undisposed municipal solid waste (MSW) generated through different sources is a major concern of the world. There are millions of tones of MSW produced every year with respect to population. So an increase the environmental problems, large area required for disposal of MSW. Due to changing the life style of human being also increases the demand of energy. The various methods adopted in this time for treatment of MSW, Like Landfills, Gasification, Anaerobic Digestion, composting, Incineration and Pyrolysis. The global energy demand is growing rapidly, and about 88%of this demand is met at present by fossil fuels. At the same time, concentration of green house gases (GHG) in the atmosphere is mounting up, with fossil fuel –derived CO2 emissions being the most important contribution. After the study we found the anaerobic digestion is the most advantageous method for treatment of MSW and generation of energy. Anaerobic digestion gains more attention now-a-days, both as a solution to environmental concerns and also as an energy resource for today's energy demanding life style. Anaerobic digestion is considered as the most promising technology to give a proper treatment disposal method to the biodegradable waste coming from source or separate collecting systems. As per the Central Pollution Control Board (CPCB, 2000) report that more than 90% of Municipal Solid Wastes in India is directly disposed of on land in an unscientific manner. As per the Municipal Solid Wastes (Management and Handling) Rules, 2000, "Land-filling shall be restricted to non-biodegradable, inert waste and other waste that are not suitable either for recycling or for biological processing". Municipal Solid Waste (MSW) in India is defined as the non-industrial and non-hazardous solid waste. Anaerobic digestion of bio-degradable solid wastes can be considered an alternative technique to improve the environment condition caused by organic solid waste and as an environmental-friendly byproduct of methane. This paper is reviewed the process of two stage anaerobic digestion for biogas generation from Municipal Solid Waste and Algae biomass from sewage sludge [1].

The production of biogas through anaerobic digestion offer significant advantages over the other forms of bio energy production. It has been evaluated as one of the most energy-efficient and environmentally beneficial technology for bio energy production. Several studies has been conducted for enhancing the methane production by the co digestion of Algae with various substrates. Although research on anaerobic digestion of algal bio mass can be traced back over 40 years, there is little information on co- digestion of algae with organic fraction of MSW, the performance of anaerobic digesters [2].

Anaerobic Digestion (AD)

Anaerobic Digestion (AD) is a biological process that happens naturally when bacteria breaks down organic matter in environments with little or no oxygen. It is effectively a controlled and enclosed version of the anaerobic breakdown of organic waste in landfill which releases methane. Almost any organic material can be processed with AD, including waste paper and cardboard (which is of too low a grade to recycle,

e.g. because of food contamination), grass clippings, leftover food, industrial effluents, sewage and animal waste [3].

Materials and Methods

This chapter explains the proposed research methodology that will be used in order to get the objectives mentioned. This chapter gives an outline of major experiments done through the two stage anaerobic digestion of OFMSW with Co-digestion of micro algae from sewage sludge from the water treatment plant at mesophilic temperature.

Co-digestion

Co-Digestion of OFMSW with microalgae of sewage sludge in two stage anaerobic digestion systems. The experiment will be performed with two batch type bio digester. The characteristics of feeding substrates OFMSW and Micro algae will be collected from an open dump site of MSW and microalgae (WS) from water treatment plant at Jabalpur. Effect of Co-digestion of OFMSW and microalgae on performance of two-stage anaerobic digester was preliminary investigated using laboratory scale experiment. Here, two bio digesters were used as the acidific and methanogenic digester.

Two-stage Anaerobic Process

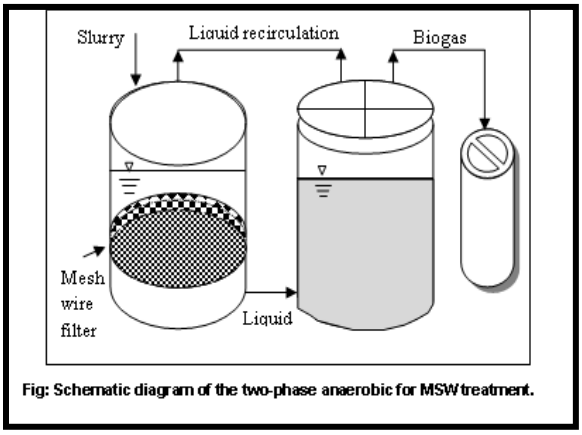

Fig: Schematic diagram of the two-phase anaerobic for MSW treatment.

In a two-stage digestion system, different digestion vessels are optimised to bring maximum control over the bacterial communities living within the digesters. Acidogenic bacteria produce organic acids and more quickly grow and reproduce than methanogenic bacteria. Methanogenic bacteria require stable pH and temperature to optimize their performance. The two stage process was introduced to improve the digestate by separating methanogenesis stage from hydrolysis, acidogenesis and acetogenesis stage so that each reaction could be close to optimum. Typical two reactors are used, the first for hydrolysis/liquefaction-acetogenesis and second reactor for methanogenesis. The schematic diagram of the overall process is shown in Fig. The acidogenic reactor, an anaerobic batch type combining a 3 layer of mesh wire filter, pH value of acidogenic reactor was 5-6 and methanogenic rector was 7.5-8.0.At temperatures of the acidogenic and methanogenic reactor were maintained at 35oC -40oC.

Experimental findings of co digestion of various substrates and problems due to single stage AD

Several studies have been conducted for the co digestion of Algae with Organic Fraction of MSW for enhancing the Biogas production.

In 2017, B.K.T. Samarasiri et al [4] discussed in his research Waste management practices such as open dumping and composting are widely used for the management of municipal solid waste (MSW). In order to evaluate the feasibility of this strategy, a mechanistic model was developed using a steady state single stage anaerobic digestion model which was modified using improved Chen–Hashimoto kinetic equations. It was applied to treat OFMSW generated in open dumping site. The volatile solid reduction efficiency of 76.62%, methane yield of 0.26 m^3 per kg of volatile solids added, electricity generation of 10.31 W per kg of OFMSW per day and carbon dioxide generation of 0.21 kg per kg of OFMSW were achieved at these optimized process conditions. The model was limited to apply for continuously fed anaerobic bioreactors operated at temperature ranging from 30°C to 40°C.

In 2017, Wei Li et al. [5] experimental proved the viability of hydrothermal pretreatment (HTP) to improve the efficiency of biogas production from municipal solid wastes (MSWs) is uncertain because there is always a trade-off between organic matters hydrolysis and recalcitrant melanoidins (Scum) formation when applying HTP on. These findings indicated that the recalcitrant melanoidins formed in the HTP process were probably removed in the acidogenic digester. Energy balance estimation of the four defined scenarios indicated that the combined HTP and two-phase AD in the MSWs treatment can achieve higher net energy output by 50.5–97.4% compared to the other three scenarios. This enables the combined process of HTP and two-phase AD to be a promising alternative way in the treatment of feedstock rich in protein and sugar.

In 2016, Bijoy Kumar Majhi et. al. [6] initiated the investigation of the biogas production from vegetable market

waste (VMW) fraction of municipal solid waste (MSW) by two phase anaerobic digestion system should be preferred over the single-stage reactors. This is because VMW undergoes rapid acidification leading to accumulation of volatile fatty acids and consequent low pH resulting in frequent failure of digesters. The weakest part in the two-phase anaerobic reactors was the techniques applied for solid-liquid phase separation of digestate in the first reactor where solubilization, hydrolysis and acidogenesis of solid organic waste occur. In this study, a two-phase reactor which consisted of a solid-phase reactor and a methane reactor was designed, built and operated with VMW fraction of Indian MSW.

In 2015, Amritha Ajeej et al [7] studied that Municipal sludge from primary settling tanks of the Sewage treatment plant (STP) is a potentially important biomass for the production of biogas. Early studies have shown that due to the difference in anaerobic inocula, waste composition, and the experimental environment the quantity and the quality of the methane production vary widely. Sewage Sludge improves the digestibility of micro algae and enhances the production of methane. Co-digestion of waste paper and algal sludge could efficiently balance the feed stock Carbon–Nitrogen (C/N) ratio between20–25 likely to benefit them ethane production rate. This paper reviews recent experimental findings of the co digestion of algae with sewage and several substrates and the methods to enhance them ethane production and the factors affecting the augmentation of the biogas.

In 2015, C. Ratanatamskul et al [8] initiated to investigation of the on-site pilot-scale anaerobic co-digestion system, especially for high-rise building application. The objective of this study was to develop an on-site prototype two stage anaerobic digester for co-digestion of food waste and sewage sludge from high-rise building for biogas production. The optimal mixing ratio of food waste to sewage sludge, obtained from laboratory scale, was found to be 7:1. Then, the prototype two-stage anaerobic digester was further designed and constructed. The results showed that COD and total volatile solid (TVS) reduction could be achieved up to 89 and 74%, respectively with the applied hydraulic retention time (HRT) of 24 days. The methane content of biogas was 64 percent. Up to now, the biogas from on-site production has been utilized for cooking at Chulalongkorn University as a model case study for high-rise building application.

In 2013, Taranveer Singh Mann et al [9] in his research the degradation of sewage sludge in single stage and 2 phase anaerobic systems was investigated in bench-scale batch reactors. Average COD reduction efficiency in 2 phase system in this initial phase of the study was 4.5% (30 days HRT) and 3.3% (20 days HRT) higher compared to single stage system. Reducing the HRT from 30 days to 20 days had little influence in VS reduction in the two systems. The average methane content in the biogas was 61.8%, 66.5%, and 64.8% (30 days HRT) in acid reactor, methane reactor and single stage reactor, respectively, and the corresponding values were 57.7%, 66.5% and 64.9% at 20 days HRT.

In 2010, Zhu Yichun Feng Xiujuan et al [10] analyzed As a new high-rate anaerobic reactor, technological features of ABSBR (Anaerobic Biofilm Sequencing Batch Reactor) and its preliminary study are introduced in this work. Two-phase ABSBR was used to treat wastewater under low concentration. The results showed that Two-phase ABSBR system can improve removal ratio of organism and suspend solid to 90% and 95% respectively with the hydraulic retention time (HRT) 6 hours. In addition, the system is more capable to resist impact on load and low temperature, which could improve the load capacity and discharged water quality of the reactor through the biofilm produced in the filler. The sequencing water level operation has solved ecological environment changes caused by the water level changes of ASBR.

Conclusion

This review critically focuses on expanding the biogas potential by the co-digestion of different substrates such as organic fraction of MSW, algae biomass sewage sludge carbon rich substrates. In the co-digestion of organic fraction is a source of nutrients, and it improves the volatile solid reduction to 60–70%. Addition of certain carbon rich wastes with the sewage sludge improves markedly the activity of methonogenic bacteria for both methane yield and methane productivity. Also, methanogenic bacteria found in the anaerobic digestion were very sensitive to the chemical composition and the C/N ratio of the substrates. Co-digestion with high-carbon, low- nitrogen substrates has potential for diminishing any ammonia toxicity and also increasing the biogas production per unit volume of digester tank. For these purposes development of cost-effective two-stage anaerobic fermentation process with bio-gas production was introduced. Hence, addition of carbon- rich wastes improve the anaerobic digestion of algal biomass and further more the combination of these substrates can produce a synergistic effect. The above findings summarizes that organic fraction of MSW, algae biomass sewage sludge and high carbon materials are producing methane and also the co digestion with different concentration of these substrates has also proved to be a mechanism to augment the methane production. Anaerobic co-digestion has been found to be an effective technique to expand the methane production while treating the municipal

sludge with the addition of micro-algae and the sub- strates of carbon rich materials like waste paper to balance the C/N ratio and Ammonia toxicity and to increase the cellulose activity. Comparing energy data for two-stage anaerobic digestion with those for single-stage process resulting solely in bio-methane production shows that energy output from biodegradable fraction of MSW increases by 23 - 26% under two-stage anaerobic process. Bio -methane combined production can be implemented at large scale biogas plants improving process economy. Introduction of such technology at the existing biogas plants needs low investments.

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