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RESEARCH ARTICLE

BIODEGRADABILITY AND BIO METHANE POTENTIAL OF VEGETABLE, FRUIT AND OIL FRACTION IN ANAEROBIC CO-DIGESTION

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ABSTRACT

Vegetable and fruit wastes are generated in large quantities at central vegetable market. Redirection of this waste from landfills to biological treatment can reduce environmental issues. Cooked oil from restaurants discharged to common sewer interferes with common effluent treatment plants that treat municipal wastewater. The current study focused on co-digestion of vegetable and fruit waste along with oil residue. Experiments carried out in a laboratory scale anaerobic batch reactors showed that addition oil residue to vegetable and fruit waste has shown an increase in methane yield of 30%. Oil as mono substrates in anaerobic digestion shown a delayed degradation at start up and could not reach a stable state.

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INTRODUCTION

The focus on handling and treatment of organic waste has increased in the last few years. Biological treatment instead of the conventional treatment methods, landfilling and incineration, is considered in many places since it involves environmental benefits as recycling with recovery of nutrients and energy (Gomez *et al*., 2006). Fruit and vegetable wastes (FVW) are produced in large quantities in markets, and constitute a source of nuisance in municipal landfills because of their high biodegradability (Verrier *et al*., 1987). A possible way to dispose of these wastes is using the anaerobic digestion process (Mata-Alvarez *et al*., 2000 and Bouallagui *et al*., 2003). The successful application of anaerobic technology to the treatment of solid wastes is critically dependent on the development and the use of high rate anaerobic bioreactors. In light of rapidly rising costs associated with energy supply and waste disposal and increasing concerns with environmental quality degradation, conversion of vegetable market waste to energy appears to be a more and more economically viable solution (Zhang *et al*., 2008). In fact, due to the relatively high moisture content of vegetable market waste, bioconversion technologies such as anaerobic digestion (AD) are more suitable compared to thermochemical conversion technologies such as combustion and gasification. Because of the decrease of fossil energy resources and of the production of regenerative CH_4 combined with the low energy demand of anaerobic digestion, the energy balance is positive in the anaerobic process (Kubler *et al*., 1999). Fruit and vegetable waste have a high ratio of volatile solids to total solids (86 -92%) and have a very interesting methane potential (Bouallagui *et al*., 2003)investigated the anaerobic digestion of fruit and vegetable waste from a vegetable market in Tunis. Co-digestion is one of the advantages of anaerobic digestion process because several wastes having complimentary characteristics can be treated in a single process (Ferna´ndez *et al*., 2005). The anaerobic co-digestion process, which can be defined as the simultaneous treatment of two –or more – organic biodegradable waste streams by anaerobic digestion (Pavan *et al*., 1999) offers great potential for the proper disposal of the organic fraction of solid waste coming from source or separate collection systems. Anaerobic co-digestion of bio-waste and fatty residues can be considered a sustainable solution for small and large wastewater treatment plants in rural areas, where several different kinds of bio-waste are

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available to enhance biogas production (Pavan *et al*., 1999). The current study focuses on management of waste generated from central vegetable market at Al Mawelah (local entity) by anaerobic co-digestion along with the cooked oil from the restaurants and evaluate the influence of cooked oil in biogas yield.

MATERIALS AND METHODS

The experiments were carried out in two,6 l double-walled glass reactors (R1 & R2), maintained at 35 °C by a regulated water bath. Mixing in the reactors was done by a system of magnetic stirring. The biogas production was measured on-line by Milligascounter MGC-1 flow meters (Ritter gas meters) fitted with a 4-20 mA output, connected to a computer and data acquired through software (RIGAMO) supplied by Ritter.The reactor was inoculated with 700g of settled anaerobic granules taken from an Up Flow Anaerobic Sludge Blanket (UASB) treating an effluent from a sugar refinery. The reactor was initially fed with ethanol to test the activity of the anaerobic sludge. The reactor was fed with 2ml and 4 ml of ethanol in two batches to study the bioactivity of the inoculum.The pH inside the reactor was continuously monitored online using Metler Toledo pH probe Inpro 4260i and maintained at 7.5±0.5. Reactors were connected to an online methane gas analyzer, Bluesens (Germany), which measures the methane percentage and data acquired through the software supplied by the manufacturer. The vegetable, fruit and oil substrates were characterized for suspended solids (SS) and Volatile suspended solids (VS) as per APHA methods. The reactor was first fed with substrates individually to study the biodegradation of each of the substrate.

The substrates were fed to the reactors in successive batches without withdrawal. The biogas production rate by endogenous respiration was measured in the few hours following the end of the reaction time. It was assumed that endogenous activity was constant all over the batch and biogas production by endogenous respiration was removed from the total volume of biogas produced. The end of reaction was identified when the biogas volume produced was low. It was difficult to differentiate the biogas produced during the endogenous phase. Towards the end of the batches, the biogas production rate became very low and a specific method was developed to find out the time when the sludge was back to its endogenous activity, that is to say the time when it could be assumed that the reaction was over and the organic matter added was eliminated. Biogas volume and biodegradation of substrate was calculated as a function of time. The samples from the reactor was collected before the feed of each of the batch and analysed for TS, SS, VS and COD and pH as per the standard methods (APHA1995). The biogas volume and flow rate was recorded online through data acquisition software RIGAMO supplied by Ritter. The methane content in biogas was determined using BLUESENS online methane analyser.

RESULTS AND DISCUSSION

Experiments were conducted to find the biodegradability of vegetable, fruit and oil fraction. The volume of biogas produced over time was monitored online making it possible to measure the total volume of biogas and the kinetics of biogas production for each batch. It was very difficult to mark the end of the cycle or batch, since the biogas production was low. It was difficult to differentiate the biogas produced during the endogenous phase. Towards the end of the batches, the biogas production rate became very low and a specific method was developed to find out the time when the sludge was back to its endogenous activity, that is to say the time when it could be assumed that the reaction was over and the organic matter added was eliminated. In this aim, a "biogas activity curve" was plotted with time for fruit, vegetable and oil substrate (Figure 1,2 and 3). This curve is a kind of derivative with respect to the last available biogas flow rate measurement.The biogas production rate by endogenous respiration was measured in the few hours following the end of the reaction time. It was assumed that endogenous activity was constant all over the batch and biogas production by endogenous respiration was removed from the total volume of biogas produced. The average specific kinetic of degradation was calculated by dividing the quantity of substrate added (in VSS) by the duration of the batch and by the volatile suspended solids (VSS) concentration in the reactor. This parameter was also measured when 80% of the total volume of biogas was produced.

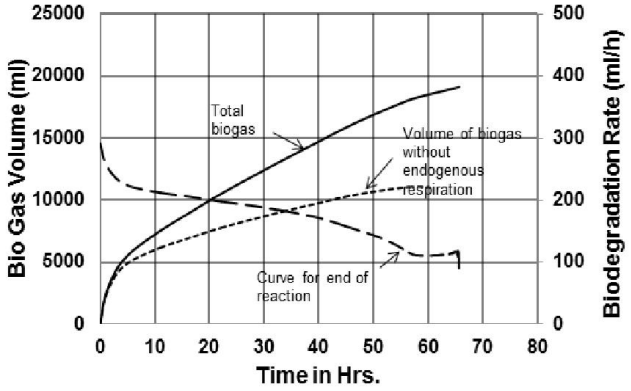

Fig. 1. Evolution overtime of the volume of biogas produced, of the volume of biogas withoutendogenous respiration and of the curve used to identify the end of the reaction (Biogasactivity curve, fruit substrate)

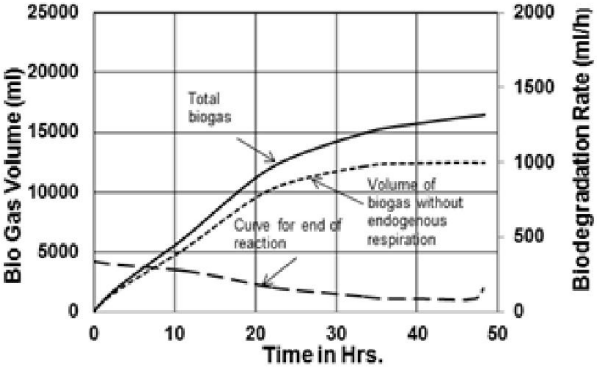

Fig. 2. Evolution overtime of the volume of biogas produced, of the volume of biogas without endogenous respiration and of the curve used to identify the end of the reaction (Biogas activity curve, vegetable substrate)

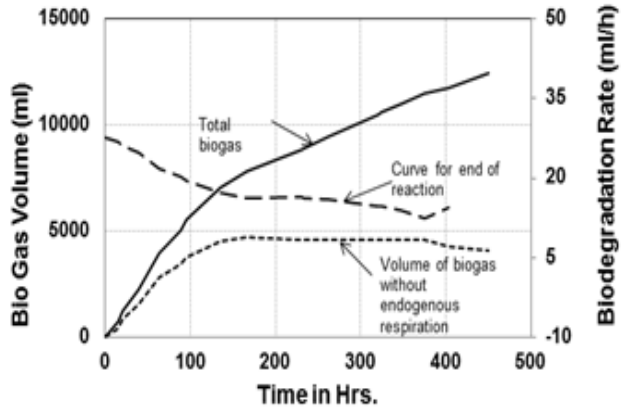

Fig. 3. Evolution overtime of the volume of biogas produced, of the volume of biogas without endogenous respiration and of the curve used to identify the end of the reaction (Biogas activity curve, Oil substrate)

The reactor R1&R2 was initially fed with different batches of vegetable substrates (carrot, potato, spinach) and fruit substrate (Orange and Grape), as mixture, respectively, for different charges varying from 0.5 – 6.0 g VS/L. The sequence of batch feeding was, once, twice, alternate days and daily in a week. The biogas production varied from 200– 325 ml/h for OLR of 0.5 – 6.0 g VS/L respectively.The reactor R2 was fed with fruit substrate in the same manner for different charges varying from 0.5 – 6.0 g VS/L. The biogas production varied from 330-340 ml/hr for OLR of 0.5 – 6.0 g VS/L respectively. The biodegradation study for oil has shown a higher volume of biogas, but could not reach a stable condition (Davidsson *et al*., 2008), Theco-digestion of vegetable, fruit along with oil was carried out at varied OLR from 4 – 6 g VS/Lwherein the volume of oil added was 5 ml. Addition of oil increased the gas flow rate to 425 ml/h at an OLR of 6 g VS/L. This shows that there is an increase in biogas production by 30% (Thanikal *et al*., 2014, 2015).

The average specific reaction kinetics was evaluated at two different phases. The first phase was at the end of the reaction phase when the substrate was at endogenous respiration, and the second one, when 80% of the reaction was completed. The results of the methane yield and of the kinetics at 80% of the reaction are reported at figure 4 for combined vegetable, fruit and oil substrates and co-digestion of combined vegetable and substrates along with oil. For fruits and vegetables, the methane yields were all between 230 and 360 ml CH4/(g·VS) when used as mono substrates. However, the range of specific degradation kinetics was quite large with values in the range 0.03-0.1 (g·VS)/ (g·VS·d) The methane yield for combined vegetable substrates were 325 ml CH4/(g·VS) and the degradation kinetics was 0.03 g VS/ g VS .d. The methane yield for co-digestion of vegetable and oil substrate was more, 680 ml CH4/g·VS and the degradation kinetics was 0.06 g·VS/ g·VS ·d. Co-digestion had higher degradation rate compared to the degradation rate of fat or oil when used as a mono substrate (Figure 4). This may be due to the fact that vegetables had readily degradable carbon material. Further the co-digestion of vegetable, fruit and oil augmented the methane yield by 800 ml CH4/g.VS and the degradation rate has increased to 0.08 g·VS/ g·VS ·d, similar observation was reported by (Pavan*et al*., 1999).

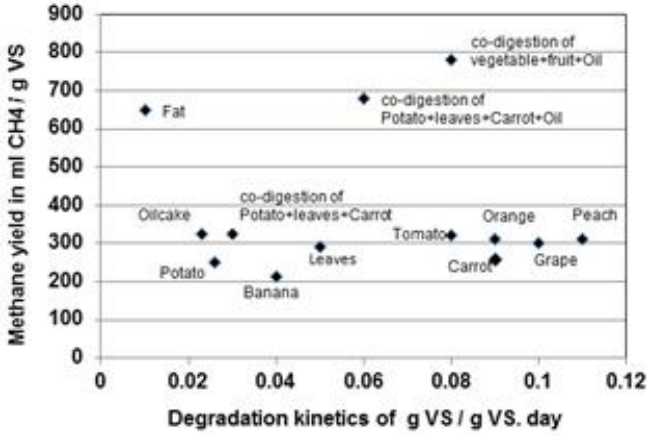

Fig. 4. Methane yield and degradation kinetics for the different substrates

Conclusion

This case study was carried out to know the potential degradation of vegetable, fruit substrate along with the cooked oil that appears to be waste from restaurants to look at the methane yield. The results are compared with similar studies done for different individual vegetable, fruit and fat substrates. The digestion of mixture of vegetable substrates remained in the same compartment of vegetables as mono substrates. Addition of oil to vegetable and fruit substrate has shown considerable increase in CH4 yield as well the biodegradation rate. The system proved to be stable at high OLR with constant pH and no accumulation of volatile fatty acids.

Acknowledgement

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Nomenclature

COD Chemical Oxygen Demand
OLR Organic loading rate
SS Suspended Solids
TS Total solids
VS Volatile Suspended solids

REFERENCES

Davidsson, A., C. Lovstedt, J. la Cour Jansen, C. Gruvberger and H. Aspegren, 2008. Co-digestion of grease trap sludge and sewage sludge. *Waste Management*, 28: 986–992.

Bouallagui, H., Ben Cheikh, R., Marouani, L. and Hamdi, M. 2003. Mesophilic biogas production from fruit and vegetable waste in a tubular digester. *Bioresource Technology,* 86: 85-89.

Ferna´ndez, A., A. Sa´nchez and X. Font, 2005.Anaerobic co-digestion of a simulated organic fraction of municipal solid wastes and fats of animal and vegetable origin. *Biochem. Eng. J*., 26: 22–28.

Gomez, X., Cuetos, MJ., Cara, J., Moran, A. and Garcia, AI. 2006. Anaerobic co-digestion of primary sludge and the fruit and vegetable fraction of the municipal solid wastes. Conditions for mixing and evaluation of the organic loading rate. *Renew. Energy*, 31: 2017–2024.

Mata-Alvarez, J., S. Mace and P. Llabres, 2000.Anaerobic digestion of organic solid wastes.An overview of research achievements and perspectives. *Bioresource Technology*, 74: 3-16.

Kubler, H., Hoppenheidt, K., Hirsch, P., Nimmrichter, R., Kottmair, A., Nordsieck, H., Swerev, M. and Mucke, W. 1999. Full scale codigestion of organic waste. Proceedings of the Second International Symposium on Anaerobic Digestion of Solid Wastes, June 15-18, Barcelona.175-182.

Pavan, P., Battistoni, P., Mata-Alvarez, J. and Cecchi, F. 1999. Performance of thermophilic semi-dry anaerobic digestion process changing the feed biodegradability. Proceedings of the Second International Symposium on Anaerobic Digestion of Solid Wastes, June 15-18, Barcelona.

Thanikal, J.V., Torrijos, M., Sousbie, P., Rizwan, S. M.,Senthil Kumar, R. and Yazidi, H. 2014. Municipal sewage sludge as co-substrate in anaerobic digestion of vegetable waste and biogas yield. Proceedings of IWA International conference on Small water and wastewater systems and Resources oriented sanitation, November2-4. Muscat, sultanate of Oman.

Thanikal, J.V., Rizwan, S. M., Torrijos, M., Al Hasani, K., Yazidi, H. and Sousbie, P. 2015. Bio-Methane productivity from Co-digestion of Vegetable, Fruit and sewage sludge fractions – biodegradability studies, proceeding of ADTech- 2015 International conference on Anaerobic Digestion, February 2-6. Chiang Mai, Thailand.

Verrier, D., Roy, F. and Albagnac, G. 1987. Two-phase Methanization of Solid Vegetables Wastes.Biological Wastes. 22: 163-177.

Zhang, P., Zeng, G., Zhang, G., Li, Y., Zhang, B. and Fan, M. 2008. Anaerobic co-digestion of biosolids and organic fraction of municipal solid waste by sequencing batch process.*Fuel Process Technology*, 89:485–489.

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