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Effect of organic loading rate on the biohythane production in the continuous two-stage anaerobic digestion of confectionery wastewater

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Motivation and Aim: A mixture of hydrogen and methane obtained as a result of two-stage anaerobic digestion (TSAD) of various organic wastes is called biohythane. It is attracting particular attention due to its excellent performance in terms of lower greenhouse gas emissions (CO, CO_2 and NO_x) and high thermal efficiency, so in the future, biohythane could be a potential gaseous alternative energy source [1]. Organic loading rate (OLR) and hydraulic retention time (HRT) are among the main factors affecting biohythane production performance. The purpose of this work was to study the effect of different OLR and HRT on the efficiency of biohythane production, energy recovery and microbial community structure during TSAD of confectionery wastewater.

Methods and Algorithms: The TSAD process was carried out in a laboratory biogas plant, consisting of 4 biofilter type reactors, each with polyurethane carriers for biomass immobilization, with a working volume of 900 ml and with an upward liquid flow of 3 m/h. The hydrogen producing reactor (RH) operated in mesophilic mode (37 ± 1) °C with an HRT of 0.42 days, and three methanogenic reactors (R1, R2 and R3) operated in a thermophilic mode (55 ± 1) °C with an HRT of 3, 2 and 1 days respectively. During the 2 phases of the experiment, the OLR was increased, from 12.8, 1.79, 2.69 and 5.38 g COD/(L d) respectively, in RH, R1, R2 and R3, by 2.05 times. Microbial community analysis in planktonic and attached biomass was performed based on the 16S rRNA gene sequencing on the Illumina platform.

Results: Butyric acid type fermentation was the main pathway of H_2 production in RH. Both the highest H_2 yield of 87.8 ml/g COD and H_2 production rate of 2352 ml/(L d) were obtained at an OLR of 26.8 g COD/(L d). The highest CH_4 yield of 335 ml/g COD and overall energy yield of 13.36 кJ/g COD were achieved in OLR_{RH} of 12.8 g COD/(L·d) and OLR_{R1} of 1.79 g COD/(L d) configuration of TSAD. CH_4 and overall energy production rate (1543 and 91.56 kJ/(L d) respectively) were highest at OLR_{RH} of 26.8 g COD/(L d) and OLR_{R2} of 5.5 g COD/(L d). R3, having the lowest HRT of 1 day, failed to produce biomethane. Microbial community in RH was dominated by *Lactobacillus, Bifidobacterium, Clostridium sensu stricto 12* and *Caproiciproducens* (Fig. 1); methanogenic archaea were effectively inactivated. Methane was produced through hydrogenotrophic route by representatives of *Methanothermobacter*. The planktonic bacterial communities of methanogenic reactors were dominated by *Bifidobacterium; Caproiciproducens* and *Proteiniphilum* were most abundant at lower and higher OLRs respectively. The attached biomass was more diverse and dominated by *Anaerolinea*, *Bifidobacterium*, *Defluviitoga* and *Proteiniphilum* (Fig. 2).

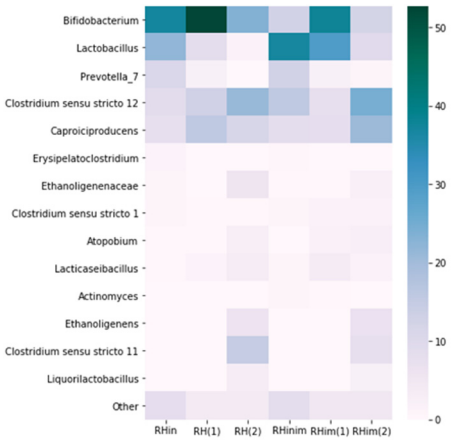
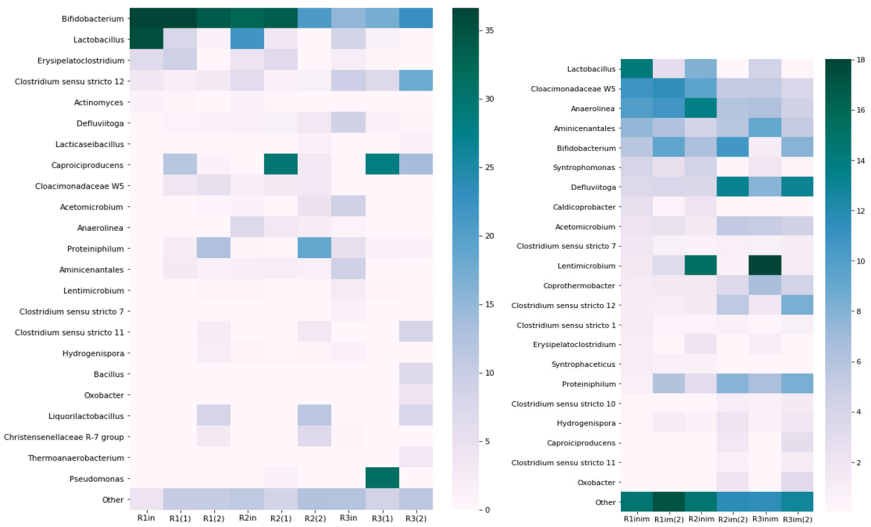


Fig. 1. Heatmap of the profile of planktonic and immobilized bacterial communities at the genera level for RH



a *b*

Fig. 2. Heatmap of the profile of planktonic (*a*) and immobilized (*b*) bacterial communities at the genera level for R1, R2, and R3

Conclusion: Mesophilic-thermophilic mode of TSAD was found to be effective for production of biohythane from confectionery wastewater. The most efficient configurations in terms of OLR and HRT have been found to maximize gas and energy yields and productions rates. Dominant microbial groups were identified to assess their contribution to the performance of TSAD.

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References

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