Methane and Volatile Fatty Acid Production from Toxic Substrates

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Abstract

Challenges caused by climate change and global warming have created a demand for improvements in resource recovery and the promotion of a circular economy. Waste management is one such challenge for which more recycling options are required for producing materials and energy sources from wastes. Toxic organic waste such as fruit waste has been conventionally disposed into landfills; however, anaerobic digestion can be performed to produce biogas or volatile fatty acids (VFAs) from these wastes.

The main objective of this research was to develop an anaerobic digestion method for patchouli oil distillery waste and citrus processing residuals for biogas and VFA production using a membrane bioreactor and two-stage digestion system. To this end, a reverse membrane bioreactor with a membrane-encased mixed culture was used for both one-stage and two-stage digestion. The membrane encasement was used to protect the microorganisms from toxic compounds (e.g., D-limonene or patchouli alcohol). The membrane improved the methane yield of patchouli oil distillery waste (73%) and filtrate from citrus waste digestate from the acidification reactor (50%). Two-stage digestion of citrus waste was improved by performing effluent recirculation from the second-stage reactor into first-stage reactor (79% increase in methane yield).

In addition to biogas, VFAs, as intermediate products of anaerobic digestion, are considered as valuable products. A two-stage digestion experiment showed that citrus waste can also be converted into VFAs. However, several factors influencing biogas and VFA production differed between the two processes. Batch experiments of anaerobic digestion were performed to investigate important factors affecting VFA production from citrus waste and food waste (as an example of a non-toxic substrate). The results showed that pH, moderate substrate loading, and inoculum adaptation were significant factors affecting VFA production, whereas additions of a methanogen inhibitor and the presence of oxygen did not significantly affect the VFA yield. At high citrus waste loading, D-limonene loading was also high and negatively impacted the VFA yield.

To reduce product inhibition in the anaerobic digestion of citrus waste, a tubular membrane as a cross-flow filtration device was used for downstream processing of VFAs. Continuous extraction of VFAs from the reactor improved the VFA yield by two-fold compared with the reactor in which the membrane was not used. The cross-flow filtration allows the system to remain stable during continuous cake-layer removal, as the highest trans-membrane pressure detected was below 67.5 mbar.

Keywords: *toxic substrate, methane, volatile fatty acid, anaerobic digestion, membrane bioreactor, factor, tubular membrane, two-stage digestion*