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S. Riggio[1], M. Torrijos[1], J.P. Steyer[1], R. Escudié[1], R. Debord[2], G. Esposito[3], E.D. Van Hullebusch
[1]INRA, UR0050, Laboratoire de Biotechnologie de l'Environnement, Avenue des Etangs, F-11100 Narbonne, France, [2]Naskeo Environnement, 52 rue Paul Vaillant Couturier - 92240 Malakoff, France, [3]Department of Civil and Mechanical Engineering, University of Cassino and Southern Lazio, Via Di Biasio 43, 03043 Cassino (FR), Italy, Université Paris-Est, Laboratoire Géomatériaux et Environnement (LGE), EA 4508, UPEMLV, 77454 Marne-la-Vallée, France
Contact: Renaud Escudié, INRA, UR0050, Laboratoire de Biotechnologie de l'Environnement, Avenue des Etangs, F-11100 Narbonne, France. Mail : renaud.escudie@supagro.inra.fr, tel. +33468425173

EXECUTIVE SUMMARY

In anaerobic digestion plants, the accumulation of volatile fatty acids (VFAs) is one of the most important issues especially when treating easily degradable wastes. Leach bed reactors (LBRs) is an innovative system where a leachate is sprinkled on the top of a static solid phase and percolates through it. This process is spreading rapidly because of its undiscussed advantages in respect to wet anaerobic digestion systems such as acceptance of solid dry waste, high volatile solid load, reduced liquid phase and no need in phase separation at the end of cycle. Leachate recycling the most important process parameter in such a system since it ensures a good humidity in the digester, it provides external inoculation and most of all it allows mass transfer among different reactors. This last role makes the recirculation an important key in order to solve inhibition due to intermediates accumulation. In fact, VFAs can be moved easily from a batch where they can be inhibitory to another where they can be consumed (Chynoweth, 1992). For this reason, on industrial scale, LBRs are often coupled together making the leachate recycle from one to another, thus creating a very synergic system able to treat even really putrescible wastes.
In this work six LBRs of 6 L were used to test three different recycle conditions in duplicate. The same substrate, composed (on an total solid basis) of 45% cow manure, 40% carrots (used as easily degradable substrate) and 15% cereals residues, was charged with 2,1 kg of fresh substrate at a global total solid (TS) of 17% (360g TS). External leachate was sprinkled on the top and extracted daily from the bottom. The leachate volumes were fixed at 0.5, 1 and 2 L/kgTS/day and corresponded respectively to a volume of 180 mL, 360 mL and 720 mL of leachate. In the first part of the study (about 4 weeks), the experiment focused on the VFA extraction while in the second part it focused on the VFA consumption.
Results from the first phase showed that recycling is an effective way to solve VFA inhibition and to establish a proper methanogenesis since all the produced VFA are extracted from the bulk phase. The cumulated extracted VFA and produced CH_4 showed that recycling more allows to increase degradation kinetics consistently. That could be an important information in order to diminish solid retention time even when VFA inhibition delays the process. Moreover recycling at 1 L/kg TS/day is showed to be the most efficient in term of total mass of VFA extracted on the total recycled volume.
The second phase started when methanogenesis was established (i.e., no more extraction of VFA and constant methane composition of about 60%). A synthetic VFA solution was injected into the system. Concentrations going from 5 g/L to 20 g/L were tested while the recycled volume was kept constant at 360 mL. During a first period, only C2 was used while after that a mixture of C2 and C4 (the VFA extracted most during the first phase) was injected. The results prove that with the injection volume used the average VFA retention was of 36% by mass, and this for any VFA concentration used. Whatever the VFA composition, VFA were rapidly consumed in about 10 h, 20 h and 30 h for an initial concentration of 5g/L, 10g/L and 20g/L respectively. Results show that the initial concentration in the leachate, the VFA mass retained and the degradation kinetics are the three parameters that would allow to optimize the VFA degradation in old reactors without putting at risk their biological equilibrium. A further analysis can help to design the recycling frequency of an industrial site based on this approach thus improving the system efficiency and substrate degradation.

Chynoweth, D.P., 1992. Sequential Batch Anaerobic Composting of the Organic Fraction of Municipal Solid Waste. Water Sci. Technol. 25, 327–339.