Effect of the Hydraulic Retention Time (HRT) on the efficiency of a two-stage anaerobic digestion with intermediate treatments for Waste Activated Sludge (WAS)

A. Cerutti[1], G. Campo[1], M.C. Zanetti[1], L. Polimeno[1], G. Scibilia[2], E. Lorenzi[2], B. Ruffino[1]

[1]Department Environment, Land and Infrastructure Engineering, Politecnico di Torino, Torino, I-10129, Italy
[2]SMAT S.p.A., Società Metropolitana Acque Torino, Castiglione Torinese (TO), I-10090, Italy
Keywords: waste activated sludge, intermediate treatment, two-stage anaerobic digestion, hydraulic retention time.
Presenting author email: alberto.cerutti@polito.it

Waste activated sludge (WAS) is commonly treated by using anaerobic digestion (AD). Low efficiency of the AD process for WAS and the consequent low dewaterability of WAS digestates are well-known issues. Some authors identified the reason for poor AD of biological sludge in the complex structure that surrounds and bounds microbial cells, known as extra polymeric substances (EPS) (Shana et al. 2015; Williams et al. 2015). Two types of biological sludge EPS are involved in an AD process: one type is part of the biochemical composition of the WAS fed to the digester, the other is released by the sludge during the digestion process due to microbial metabolism, self-protective reaction and cell lysis. Because of the presence of the latter, the degradation of organic matter slows down gradually after the influent sludge is fed into digesters with the result that, at the end of the process, there are still some biodegradable organic substances remaining inside microbial cells and sludge particles (Li et al., 2013; Shana et al., 2015).

Intermediate hydrolysis treatment (IHT) configurations could be a solution to contrast the effect of the EPS produced during sludge digestion. Raw WAS is digested in a two-stage set up with an in-between hydrolysis treatment (Shana et al., 2013). However, until now this solution has attracted only a limited interest and very few examples are reported in the scientific literature. A recent study (Ortega-Martinez et al., 2016) demonstrated that thermal inter-treatments at high temperature values (110-200°C) improved the methane production of WAS by 45% and 20%, compared to a conventional one-stage AD process and an AD process preceded by pre-treatments, respectively. To the best of our knowledge, no studies were carried out to investigate the effect of the hydraulic retention time (HRT) of the first-stage AD process, of a set up made of a two stages of digestion with an in-between hydrolysis treatment, on the whole biogas/methane production.

The aim of this study was to compare the whole biogas/methane specific production of three two-phase AD systems, with an in-between hydrolysis treatment, characterized by different first-stage HRTs (5, 10 and 15 days). The hydrolysis treatment was carried out at a low temperature value (90°C) in the presence of sodium hydroxide (NaOH 4% TS content). The apparatus employed for the test is schematized in Figure 1.

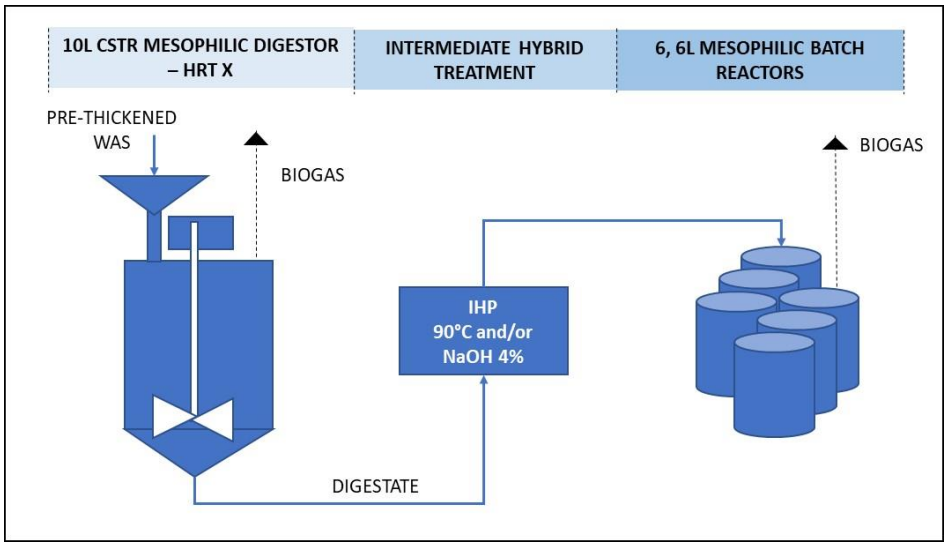

Figure 1. Set up of the tests

Digestates from the first-stage AD process were produced in an on-purpose built CSTR pilot scale digester. This digester had a useful volume of 10 liters, worked in mesophilic condition (38°C) and was fed daily with WAS samples collected from Castiglione Torinese WWTP (approximately 2M equivalent population). Each operating condition, corresponding to HRTs of 5, 10 and 15 days, was considered stable and characteristic of the chosen HRT after a time equal to 3 HRTs. The content of volatile solids (VS) introduced and extracted from the digester and the production of biogas and methane were measured daily. The measurements carried out on the CSTR digester returned a methane specific production of 0.069 Nm^3/kg VS, 0.095 Nm^3/kg VS and 0.109 Nm^3/kg VS, for the 5-day, 10-day, 15-day HRT condition respectively.

The three steady-state digestates, generated from the CSTR digester and with HRTs equal to 5, 10 and 15 days, were subjected to thermal or hybrid (thermo-alkali) treatments at 90°C for 90 minutes (with 4% NaOH in the case of hybrid treatments). Treated and control samples were subsequently digested under mesophilic conditions in 6-L batch reactors. The digestibility tests in batch mode were considered concluded when the daily biogas production of each digester was of less than 1% of the overall production recorded throughout the test. In order to compare the effect of the first-stage digestion HRT on the production of biogas/methane of the whole system, the specific production of the first stage was summed to the specific production that resulted from the batch test. The results indicated that, after an IHT, the difference in the overall methane specific production among the three systems was of limited extent. However, the system with a first stage HRT of 5 days performed better (+8%) than the systems with a longer duration of the CSTR digestion (10 and 15 days).

References

Li H., Zou S., Li C., Jin Y. (2013). Alkaline post-treatment for improved anaerobic digestion. Bioresource Technol. 140, 187-191.

Ortega-Martinez E., Sapkaite I., Fdz-Polanco F., Donoso-Bravo A., 2016. From pre-treatment toward inter-treatment. Getting some clues from sewage sludge biomethanation. Bioresource Technol 212, 227–235.

Shana A., Ouki S., Asaadi M., Pearce P., Mancini G. (2013). The impact of intermediate thermal hydrolysis on the degradation kinetics of carbohydrates in sewage sludge. Bioresource Technol 137, 239–244.

Shana A. D., Ouki S., Asaadi M., Pearce P. (2015). The impact of intermediate thermal hydrolysis process and conventional thermal hydrolysis process on biochemical composition during anaerobic digestion of sewage sludge. Proceedings of 20th European Biosolids and Organic Resources Conference and Exhibition, N. J. Horan, ed., Manchester, U.K., 1–15.

Williams T. O., Burrowes P., Fries K., Newbery C., Whitlock D. (2015). Treatment of WAS with thermal hydrolysis and mesophilic anaerobic digestion." Proceedings of 20th European Biosolids and Organic Resources Conference and Exhibition, N. J. Horan, ed., Manchester, U.K., 1–8.