Techno-economic analysis of thermo-alkali and biological pre-treatments applied to waste activated sludge

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Keywords: Biomethane; temperature-phased anaerobic digestion; biogas upgrading; membrane; two-stage process; energy neutrality.
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Improving the efficiency of anaerobic digestion (AD) of sewage sludge (SS) is a critical step toward achieving energy neutrality in wastewater treatment plants (WWTPs). The low degradability of WAS, due to its peculiar nature and composition, can be enhanced by using pre-treatments. This study carries out a comparative techno-economic analysis (TEA) between a thermo-alkali (4 g NaOH/100 g TS, 90 ◦C, 90 min) and a biological pre-treatment, the latter performed in the form of a temperature-phased anaerobic digestion (TPAD), with a combination of a short thermophilic process (3 days, 55°C) and a regular mesophilic AD (20 days, 38°C). Tests carried out at a pilot scale revealed that (i) the thermo-alkali process was three times more efficient in COD solubilization than biological hydrolysis (BH) (40% vs. 15%); (ii) the thermo-alkali pretreatment increased the specific methane production (SMP) by 110% compared to the control system (untreated WAS), conversely the over-production due to the BH was only of 24%. The surplus of biogas, over the amount necessary to sustain the AD process, was depolluted and upgraded to biomethane with a system which included an absorption tower and a condensation unit, for H_2S and water removal, and a double-stage permeation membrane plant. According to the findings of the economic analysis, a biomethane selling price of at least 290 €/MWh was required to cover the costs associated with the "base" scenario (digestion of untreated WAS). Following improved biomethane production due to the use of either BH or thermo-alkali pre-treatments, the selling price might be decreased to around 250 €/MWh and 115 €/MWh, respectively. This result confirms the thermo-alkali pre-treatment's advantages over BH.