Abstract

Methane production of waste activated sludge (WAS) is limited by poor and slow biodegradability when subjected to anaerobic digestion (AD).

In this dissertation alkali pre-treatments, low temperature (<100 °C) thermal pre-treatments and thermo-alkali pre-treatments (a combination of above-mentioned lysis techniques) were studied. In the research activity two experimental steps were carried out. The first step consisted in nine batch AD tests, the second step involved four pilot scale semi-continuous anaerobic tests.

In the first phase of the study, samples of WAS, collected from the Castiglione Torinese WWTP, were subjected to alkali, thermal and thermo-alkali pretreatments with NaOH and $Ca(OH)_2$ with dosage range from 0.04 to 0.20 g alkali/g TS, for 1.5 and 3 hours at 20, 70 and 90°C. The performance of each treatment processes was assessed first by determining the Disintegration Rate (DR) and later by performing a series of anaerobic digestion tests in batch modality 38 °C (Mesophilic conditions).

The aim of the second experimental step was to assess the impact of thermo-alkali pre-treatments of WAS (4g NaOH/100g TS, 90 min, 90°C) in a pilot scale-semi-continuous AD test (mesophilic condition 38 °C); this treatment was chosen because in the first experimental step it shown the best performance in term of methane production increase (+86.1%).

AD tests were carried out on raw and treated WAS in a 240-L semi-continuous reactor with an HRT equal to 20 days. At the same time 10 L-digester was employed for the semi-continuous anaerobic digestion test of primary sludge. The anaerobic biodegradability of tested substrates was assessed in terms of methane production increase (B_0) and hydrolysis rate constant (k). The couple of parameters for untreated WAS, treated WAS and primary sludge were estimated using a first order

kinetics model. Moreover, in this dissertation a revision of the first kinetic model applied to semi-continuous anaerobic digestion tests was proposed, used and validated.

Based on the data returned from the pilot-scale tests, it was observed that the thermo-alkali pre-treatment could increase B_0 by 61.3% and the k from 0.085 to 0.465 d^{-1}. The results of this study demonstrated that a thermo-alkali pre-treatment could increase the specific methane production of WAS in a full-scale, steady-state continuous stirred tank reactor (CSTR), with an HRT of 20 days, from 0.09 to 0.23 Nm^3/kgVS (+144 %). Conversely, by using the same working volume but in a two-stage AD configuration the methane production of WAS could increase of 167 %.