ABSTRACT

Submerged anaerobic MBRs (SAnMBRs) are considered as a candidate technology to improve sustainability in wastewater treatment field, broadening the range of application of anaerobic biotechnology to low-strength wastewaters (*e.g.* urban ones) or extreme environmental conditions (*e.g.* low operating temperatures). This alternative technology is more sustainable (rather than aerobic-based technologies) because wastewater turns into a renewable source of energy and nutrients, whilst providing a recyclable water resource. SAnMBRs not only has the main advantages of MBRs (*i.e.* high quality effluent, and reduced space requirements) but also the main advantages of anaerobic processes. In this regard, low sludge production can be obtained due to the low biomass yield of anaerobic organisms, low energy demand is required since aeration is not needed, and methane is produced – a renewable energy source that improves the energy balance in this system. Mention must also be made of the potential nutrient recovery from wastewater either when the effluent can be used for direct irrigation or when it must be further treated by using nutrient recovery technologies.

The main aim of this Ph.D. thesis is therefore to investigate the potential of SAnMBR as core technology for urban wastewater treatment at ambient temperature. Specifically, this thesis focusses on the following aspects: (1) set-up, calibration and start-up of the required instrumentation, control, and automation (ICA) system; (2) identification of the key operating parameters affecting membrane performance; (3) modelling and simulation of the filtration process; and (4) development of different control strategies aimed to optimise filtration process under the minimum operating cost.

In this research work, an ICA system is proposed for SAnMBRs, which is required for enabling suitable and stable process performance towards perturbations. Membrane performance in the studied SAnMBR system was comparable to aerobic full-scale MBR plants. After more than two years of continuous operation no significant irreversible fouling problems were detected, and low fouling rates were observed even when MLTS was high (up to 25 g L^{-1}). A resistance-in-series-based filtration model is presented, which was able to accurately reproduce the filtration process. Moreover, a knowledge-based supervisory controller for filtration is proposed, which resulted in high energy savings during membrane scouring, low physical cleaning downtimes of total operating time, and low average operating costs.

This Ph.D. thesis is enclosed in a national research project funded by the Spanish Ministry of Science and Innovation entitled “*Using membrane technology for the energetic recovery of wastewater*

organic matter and the minimization of the sludge produced" (MICINN project CTM2008-06809-C02-01/02). To obtain representative results that could be extrapolated to full-scale plants, this research work was carried out in an SAnMBR system featuring industrial-scale hollow-fibre membrane units that was operated using effluent from the pre-treatment of the Carraixet WWTP (Valencia, Spain).