Fermentation of a low VFA wastewater in an activated primary tank

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Abstract

A low volatile fatty acid wastewater from a Barcelona residential area was prefermented in a laboratory-scale primary clarifier operated as a prefermenter -an activated primary tank. Total suspended solids (TSS), oxidation-reduction potential (ORP) and temperature were measured in the prefermenter. Influent and effluent were characterised through chemical oxygen demand (COD), soluble COD, volatile fatty acids (VFA), VFA potential, soluble PO₄-P, NH₄-N, pH and alkalinity. Solids retention times (SRT) of 5 d and 10 d were tested. Best results were obtained for the 5 d SRT with the prefermenter covered for better temperature and ORP control. For these conditions, COD solubilisation was measured as 22 mg COD/ℓ, 66 mg COD/g influent particulate COD, or 91 mg COD/g influent VSS. VFA-formation was measured as 34 mg VFA-COD/l, 142 mg VFA-COD/g influent VSS, or 77 mg VFA-COD/g influent COD. These values indicate remarkable solubilisation and fermentation in the prefermenter. The VFA/PO₄-P ratio was improved from 0.9 to 5.5 mg VFA-COD/mg PO₄-P, but did not approach the recommended value for biological P removal (20 mg/mg). VFA production could not reach the influent VFA-potential either (110 mg VFA-COD/t) and VFA-potential was lower in effluent than in influent. With a 5 d SRT and the prefermenter uncovered, a small VFA formation and no solubilisation were observed. This was interpreted as the VFA being formed from the influent soluble COD. With a 10 d SRT, a very low ORP was measured. Neither solubilisation nor VFA production were detected in the prefermenter. Concurrent acidogenic cofermentation and methanogenesis are compatible with these results. P and N solubilisation was low or moderate in the prefermenter over all periods, and increased with increasing SRT and TSS, and decreasing ORP, and pH and alkalinity were quite stable, due to the high influent alkalinity and the moderate VFA formation and N solubilisation.

Introduction

Soluble organic compounds are required for biological nutrient removal (BNR) in wastewater treatment plants. Denitrification requires readily-biodegradable COD as a carbon source, while volatile fatty acids (a fraction of soluble COD) are required by Paccumulating organisms (PAO) for enhanced biological P removal (Abu-Ghararah and Randall, 1991; Henze et al., 1995a; Maurer et al., 1997). In full-scale BNR plants, soluble COD (including VFA) should be present in the influent, in order to avoid costly external source addition. About 20 mg VFA-COD are required for removing 1 mg P (Abu-ghararah and Randall, 1991). These amounts of VFA are not always available in wastewater, particularly when COD is low. Hydrolysis and fermentation in the anaerobic stage of a BNR plant provide an additional supply of soluble COD, including VFA. However, a substantial fraction of particulate COD is retained in primary clarification, thus reducing the wastewater potential for hydrolysis and fermentation in the BNR process. Fermentation of primary sludge has been used as a means of increasing soluble COD, including VFA, in the BNR plant influent (Pitman et al., 1992; Skalsky and Daigger, 1995; Christensson, 1997).

Fermentation of primary sludge can be carried out in either primary clarifiers or separate prefermenters receiving primary sludge. Primary clarifiers can be operated as prefermenters by increasing SRT and recycling sludge to the clarifier influent, in order to elutriate soluble fermentation products from sludge. These prefermenters are known as primary activated tanks. Separate prefermenters have been classified in completely mixed, static and two-stage prefermenters (Münch and Koch, 1999). The primary activated tank is one of the simplest ways of producing VFA (Randall et al., 1992), because it does not require additional tanks when applied to continuous BNR plants.

In this study, a laboratory-scale primary activated tank was built and operated, in order to study COD solubilisation and fermentation in the wastewater from a residential area in Barcelona (Catalonia, Spain). Design and performance of the prefermenter are presented in this paper. Typical prefermenter parameters are presented (TSS, HRT, SRT, temperature and oxidation-reduction potential). Solubilisation and fermentation are studied by analysing different parameters in influent and effluent, namely TSS, COD, soluble COD, VFA, VFA-potential, soluble PO_4 -P, NH_4 -N, pH and alkalinity.

Experimental

Raw wastewater was taken daily from a street sewer in the residential area around the university laboratory in Barcelona, and was pumped to a stirred 200 ℓ tank, from where it was fed to the prefermenter. Influent and effluent parameters were determined by analysing 8 h daytime composite samples.

Prefermenter features

Figure 1 shows a scheme of the activated primary tank, including inner mechanisms and feed, waste, and recycle streams. Table 1 displays the main prefermenter features and operational parameters.

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