Pretreatment of urban wastewaters in a hydrolytic upflow digester

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Abstract

Domestic wastewater was fed continuously to a laboratory-scale upflow digester operated at short hydraulic retention times (HRT < 4 h). The digester acts as a system for sedimentation and hydrolysis of suspended solids (SS) and for acidification of solubilised substances. Optimum results were obtained at an HRT of 2.3 h. Over 60% SS are retained in the digester and hydrolysed. Average influent SS content is 230 mg/ℓ, whereas effluent SS is 90 mg/ℓ. Effluent SS concentrations shows very stable behaviour, varying little with influent concentration, as with HRT. Retention and hydrolysis of SS causes an increase in volatile fatty acid (VFA) concentration, from about 20 mg/ℓ in the influent to above 100 mg/ℓ in the effluent, also contributing toward soluble fraction acidification. Thus, VFA reached 25% of effluent chemical oxygen demand (COD), while influent VFA_{COD} was below 4%. During the process, a reduction in domestic wastewater COD of between 30 and 40% was observed.

Nomenclature

COD	Chemical oxygen demand ($_t$: total, $_s$: soluble).
HRT	Hydraulic retention time
OLR	Organic load rate
SS	Suspended solids
VSS	Volatile suspended solids
SRT	Solids retention time
VFA	Volatile fatty acids
VFA_{COD}	Volatile fatty acids expressed as COD
HUSB	Hydrolytic upflow sludge bed (anaerobic digester)

Introduction

Anaerobic and aerobic treatments constitute two major processes for biological purification of wastewaters and biodegradable organic wastes. Anaerobic digestion is very favourable in terms of energy due to the fact that aeration is not necessary and that biogas is produced which could be used at the same plant as an energy source, allowing in many cases for the autonomy or self-sufficiency of the treatment plant. Another major advantage is that sludge is generated in much lower amounts than those obtained with aerobic processes. As a result, energy and sludge management costs are reduced, making anaerobic digestion the most frequently used biological system for treatment of waste effluents with medium- and high-organic loads (Lettinga et al, 1993).

Moreover, during the 1980s and especially during the 1990s some research groups paid attention to the development of anaerobic digestion for application in the treatment of low concentration effluents (Jewell, 1987; Sanz and Fdz.-Polanco, 1990; Lettinga et al., 1993; Vieira et al., 1994; Kato, 1994). The principal application of anaerobic digestion in urban wastewater treatment consists of the utilisation of single-step methanogenic digesters for organic load removal (Ruiz et al, 1998).

In the case of urban waste effluents, some authors have reported 30 to 60% reductions in operating costs as a result of introducing one or more anaerobic steps in treatment systems (Schelinkhout, 1993; Alaerts et al., 1993; Wang, 1994). However, further research on the process and better technological development are necessary to consolidate this technology.

Another option is the separation of phases, in which wastewater undergoes a pre- hydrolysis–acidification step before anaerobic digestion. Some advantages of the direct hydrolytic pretreatment of domestic wastewaters are the following (Wang, 1994; Gonçalves et al, 1994):

- removes an elevated percentage of SS, substituting the primary settler at a similar HRT
- stabilises the sludge, totally or partially
- increases the biodegradability of the remaining COD
- favours the subsequent biological elimination of nutrients (N, P)
- avoids or reduces bulking in the activated sludge process.

To achieve the separation of phases, raw wastewater is fed into an upflow sludge bed reactor, in which the HRT is sufficiently reduced, thereby avoiding the conversion of certain organic fractions into methane. The SS settle in the digester where they remain for a longer period of time than the liquid (SRT, higher than HRT), forming a sludge bed, where some soluble substances are also adsorbed. In this way, both the particulate and the soluble organic matter that are retained can undergo solubilisation and fermentation.

The influence of different variables, such as wastewater characteristics, type of digester, mixing mechanism, HRT and SRT on this process is not yet well understood. The objective of this study was to determine the conversion during the hydrolytic pretreatment of actual urban wastewater, in a system operating at an elevated SRT and at different HRTs.

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