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Fermentation and elutriation of primary sludge: Effect of SRT on process performance

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ABSTRACT

A primary sludge fermentation–elutriation pilot plant was operated using in-line and side-stream schemes. The influence of solids retention time, recirculation sludge flow-rate and solids concentration on the fermentation–elutriation process performance has been assessed in this paper. The use of high elutriation flows (12% of influent flow) improved the volatile fatty acids (VFA) concentration in the effluent stream. Suspended solids removal efficiency decreased in the primary settler when the solids retention time (SRT) was increased from 4 to 8 days. Disintegration step during hydrolysis process was pointed out as the main reason for that decrease. Maximum VFA productions were achieved at SRT between 6 and 8 days at the highest elutriation flow tested for both configurations. Propionic, butyric and valeric volatile fatty acids percentage increased when total solids sludge concentrations above 23,000 $mg\,l^{-1}$ were used. Hydrogen accumulation, causing acetogenic bacteria inhibition, was indicated as the reason for C_3–C_5 fatty acids accumulation.

1. Introduction

The number of wastewater treatment plants (WWTPs) equipped with biological nutrient removal (BNR) is increasing in Comunitat Valenciana (Spain). Many studies and practical experience have evidenced that high content of readily biodegradable chemical oxygen demand in the influent wastewater is needed to promote BNR in an activated sludge process (Maurer et al., 1997; Pitman et al., 1992). Besides, volatile fatty acids (VFA) have been demonstrated to be the most suitable carbon substrate for the biological phosphorus removal process (Barnard, 1984; Gerber et al., 1987).

Municipal wastewater has been shown as a potential source of readily biodegradable organic matter. Thus, acid fermentation of primary sludge as a VFA source has been the subject of several investigations (Danesh and Oleszkiewicz, 1997; Moser-Engeler et al., 1998; Bouzas et al., 2002). Several schemes of operation have been reported for VFA production from primary sludge fermentation (Pitman et al., 1992; Teichgräber, 2000). Full scale implementation includes both in-line and side-stream prefermentation configurations. In-line process consists basically in allowing settled raw sludge solids to accumulate in the bottom of the primary settler tanks and recycling partially this sludge to elutriate the fermentation products out of the sludge (Barnard, 1984). On the other hand, side-stream configurations, with primary sludge feeding, usually comprise a two-stage operation: a separate complete-mix fermenter coupled to either a thickener or a primary settler in order to attain VFA elutriation (Münch and Koch, 1999; Rössle and Pretorius, 2001). In both configurations part of the accumulated sludge is purged to avoid the VFA consumption by methane formation.

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Nomenclature

Alk	alkalinity
APT	activated primary tank
BNR	biological nutrient removal
fns	non-settleable solids fraction
GC	gas chromatography
HAc	acetic acid
NH_4-N	ammonia nitrogen
nsTSS	non-settleable total suspended solids
PO_4-P	orthophosphate
RSFR	recirculation sludge flow-rate
SBCOD	soluble biological oxygen demand
SBH	sludge blanket height
SCOD	soluble chemical oxygen demand
SRT	solids retention time
SSR	suspended solids removal efficiency
TBOD	total biological oxygen demand
TCOD	total chemical oxygen demand
TS	total solids
TSS	total suspended solids
TVS	total volatile solids
VFA	volatile fatty acids
VSS	volatile suspended solids
WSFR	waste sludge flow-rate
WWTP	wastewater treatment plant

The main objective of this study was to determine the optimal operating conditions of primary sludge fermentation–elutriation process. The experiments were conducted in a pilot plant fed with 40 l h^{-1} of municipal raw wastewater drawn from the degritter of the Carraixet WWTP in Valencia, Spain. The influence of solids retention time (SRT), recirculation sludge flow-rate (RSFR) and solids concentration on the process performance has been investigated. The two most common configurations have been used: a primary settler tank, usually known as activated primary tank (APT), and a complete-mix fermenter coupled to a primary settler.

2. Materials and methods

2.1. *Pilot plant description*

A pilot plant as represented in Fig. 1, with the characteristics shown in Table 1, was used in this research. The pilot plant consisted of a cylindrical equalization tank for wastewater characteristics homogenization, a primary settler provided with a bottom scraper and a stirred fermenter, all of them made of stainless steel. The bottom scraper was driven by a 1 rpm electrical motor. The plant was thermally isolated with a 3 cm thick glass-fibre cover and the system was maintained at 20±1 °C by means of a temperature controller. Peristaltic pumps and a piston pump were used to pump sludge and raw wastewater, respectively. The installation of manual valves allowed to study both side-stream and in-line configurations (see Fig. 1).

The side-stream configuration consisted of the primary settler coupled to the stirred fermenter. In this scheme, fermentation of primary sludge mainly takes place in the fermenter and the elutriation of VFA is carried out by recycling the fermented sludge to the primary settler. The SRT was controlled by wasting the appropriate volume from the fermenter by means of a temporized peristaltic pump. The fermenter configuration allowed to change very easily experimental conditions (solids and hydraulic retention times) by means of valves disposed in it (Fig. 1).

The in-line configuration, the APT system, consisted of the primary settler where primary sludge was accumulated in

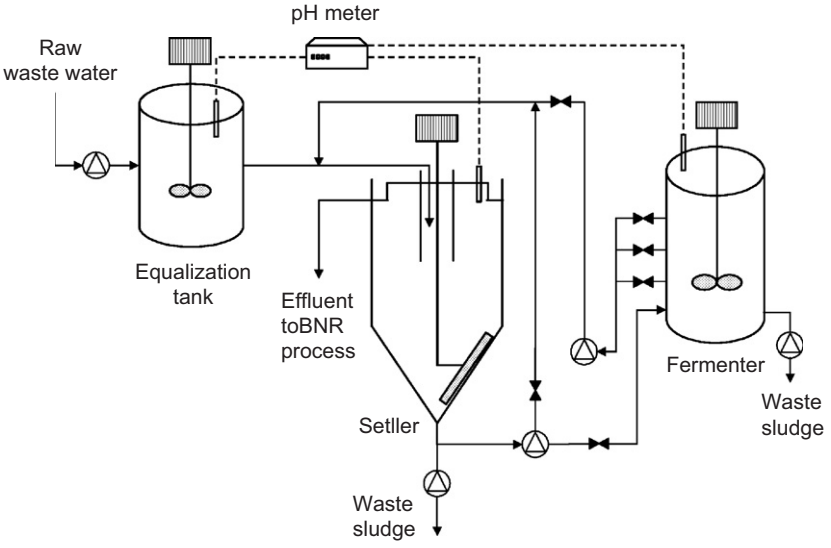

Fig. 1 – Pilot plant schematic layout.