Monitoring granular stability in an industrial UASB reactor treating brewery wastewater

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Abstract An industrial scale UASB reactor treating a brewery wastewater was monitored during several months, in order to assess the usefulness of a morphological parameter relating the filaments length to the projected area of aggregates, LfA, to anticipate washout problems. It was observed that a selective washout of filamentous bacterial forms could explain the decrease of the acetoclastic and hydrogenophilic activity observed in the trial period. This selective washout was predicted by a peak in LfA that occurred just before a steady increase in the effluent VSS values.

Keywords UASB, Granular stability, image analysis

Introduction

Operation of industrial UASB reactors is a complex task. Without proper monitoring, even small fluctuations in operational conditions or in the feed streams composition could originate granule disintegration, loss of blanket stability, biomass washout or acidification. Together with other regular analysis techniques, image analysis could be used as an indicator of granule stability. In this scope, the aim of this work was to monitor granular stability in an industrial UASB reactor treating brewery wastewater. Settling velocity, the filaments to aggregates ratio (LfA) and the specific methanogenic activity in presence of acetate, propionate, butyrate, ethanol and H_2/CO_2, were monitored during an experimental period of 4 months.

Materials and Methods

The industrial UASB reactor is located in the brewery "UNICER" near Oporto city, in Portugal. The reactor volume is about 1560 m^3 and the organic loading rate was about 4.1 kg COD/m^3.day, during the trial period.

Granule sampling. Granules samples were taken every two months from the industrial UASB reactor, collecting the volume of granules from one sampling port at the bottom of the reactor.

Specific methanogenic activity. Specific methanogenic activity (SMA) measurements were made in batch assays as described by Colleran et al., 1992.

Settling velocity. The settling velocity of 100 granules of each sample was measured at ambient temperature in a column of water of 30 cm.

Volatile suspended solids. VSS were determined according to Standard Methods (APHA et al., 1989).

Image analysis. LfA was calculated based on previously developed image analysis techniques (Amaral, 2003, Araya Kroff et al., 2004).

Results and discussions

LfA represents the ratio between the total filament length and the projected area of aggregates. It is expected that LfA could be a sensitive indicator of granular morphological stability. In a previous work, it was hypothesized that LfA could be an early indicator and even a predictor of biomass washout in UASB and EGSB reactors. A significant washout was anticipated about 1 month by the increase in LfA value when operating a lab scale EGSB reactor. Figure 1 presents the LfA values alongside the average effluent VSS values, which increased from about 250 mgVSS/L to about 800 mgVSS/L, during the trial period.

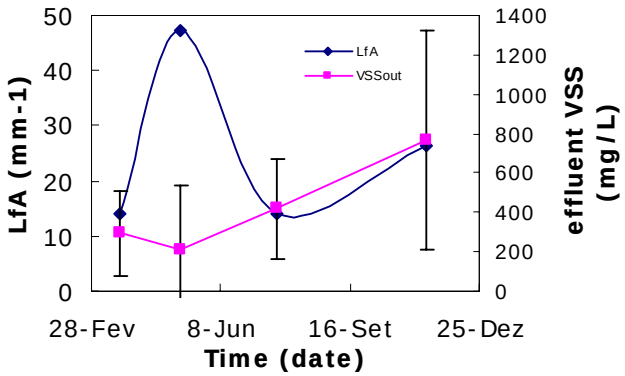

Figure 1 – Time course of LfA and effluent VSS concentration

LfA peaked in May and decreased afterwards. It can be hypothesized that the LfA increase can be due to initiation of filaments release from the granular sludge. The increase in washout observed in July and November may be due to complete liberation of this filamentous biomass. The results presented prove that washout prediction properties of LfA could be applied at industrial scale. Fragmentation of granules due to the gain of biogas bubbles could also explain fluctuations in LfA. The evaluation of settling velocities and the total area of aggregates (Micro- equivalent diameter lower that 0.2 mm, and Macro–equivalent diameter higher than 0.2 mm), showed the occurrence of fragmentation of low density granules that split into smaller fragments with comparatively higher settling velocities. Figure 2 shows the histograms for settling velocity of samples of biomass from the UASB reactor, Table 1 summarizes the values obtained for LfA, VSS in the effluent and settling velocity.

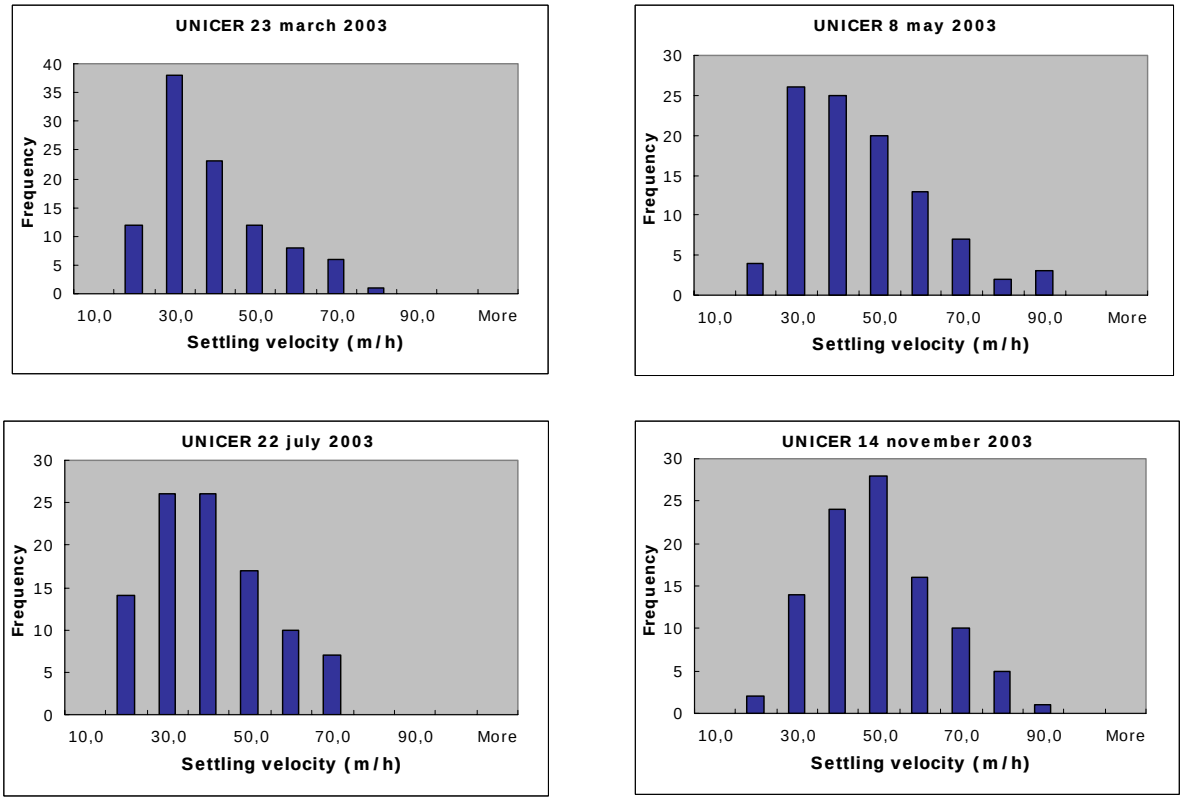

Figure 2 – Settling velocity histograms for samples of granules from the UASB reactor. Profiles were calculated over measurements of 100 granules of each sample.

The specific methanogenic activity values did not change in a defined way. In the last month, when a more severe washout ocurred, a decrease in the specific methanogenic activity with acetate, butyrate and H_2/CO_2 was observed. This may suggest that filamentous forms of acetoclastic and hydrogenophilic bacteria could have been selectively washed out from the reactor .(Table 2). However the ratio filaments length/aggregates area had increased at and early stage, which underlines to possible usefulness of LfA as an early alert indicator for washout events in UASB/EGSB reactors.

Table 1 - LfA values average efluent VSS and maximum, minimum and average values of the settling velocity of each sample studied.

Date of sample	LfA (mm^{-1})	VSS out (gVSS/L)	$V_{settling}$ (m/h) Average	Max	Min
23-03-2003	14,1	293,9	33,7	70,8	13,7
08-05-2003	47,2	214,9	40,2	87,7	15,3
22-07-2003	14,0	418,7	35,8	69,9	13,6
14-11-2003	26,3	770,0	44,8	82,5	17,2

Table 2 - SMA values obtained for samples of the sludge on the industrial scale UASB reactor ($mLCH4_{@PTN}$/gVSS.d).

Date of sample	Acetate	Propionate	Butyrate	Ethanol	H_2/CO_2
23-03-2003	343,7±69,7	167,3±16,7	69,4±9,0	663,0±78,6	1029,9±14,2
08-05-2003	524,7±53,7	39,2±1,1	79,4±10,5	627,3±40,7	812,3±48,6
22-07-2003	513,4±13,1	30,0±2,4	156,2±17,0	709,6±41,3	830,7±1,9
14-11-2003	340,1±69,7	34,9±3,7	45,5±5,6	721,9±56,7	655,7±37,5

Conclusions

The ratio between the filaments length and the projected area of aggregates, LfA, showed a significant increase during the operation of an industrial scale UASB reactor treating a brewery wastewater. This increase was related to the specific methanogenic activity against different trophic groups of the anaerobic consortium and also to the effluent VSS concentration that increase continuously after the peak in LfA. Image analysis can be an important tool to monitor sludge blanket stability in UASB reactors.

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