Utilization of Biomass carriers in Anaerobic reactors

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INTRODUCTION

Anaerobic reactors are used for treatment of high strength industrial wastewater (C. Augusto de Lemos Chernicharo, 2007).
One of the limiting factors in the design of conventional anaerobic digesters (UASB, EGSB, etc.) is the hydraulic limitation of up flow velocity, which can induce biomass washout if exceeded.

Another limitation of use of granular sludge is the slow development of granules (C.Nicolella 2007) and the exact conditions required for granulation; this limitation is exacerbated under low loading conditions, where in fact granulation might be completely inhibited. Finally, anaerobic granules are sensitive to variations in influent salinity, and increased salinity might cause dispersion of the biological granules (R.Riffat, 2002).

It is therefore advantageous to develop a fixed biomass, grown on a plastic biomass carrier, to replace the anaerobic granules. Biomass carriers will be virtually immune to washout, can develop a Biofilm under low-loaded conditions, and will be less prone to disruption under changing levels of salinity.

The main goal of the study presented here is developing an anaerobic reactor with attached/immobilized biomass on biomass carriers. In addition, the influence of different operative parameter such as up flow velocity, maximal VLR and up/down flow configuration on the anaerobic attached biofilm, were evaluated.

KEY WORDS

Anaerobic reactor, Biomass carriers, VLR.

MATERIAL AND METHODS

The pilot scheme for the up flow configuration is presented in figure 1 (The scheme for the down flow configuration is not presented). In both down flow and up flow pilots, cylindrical reactors are used with a total volume of 19 and 13L respectively, using Aqwise HDPE ABC5 (effective surface area of 650 m^2/m^3, density 0.97 kg/l) carriers at a fill ratio of 54 and 50% respectively.
A pre-acidification tank was set prior to the anaerobic reactor. The reactors were operated at 30-35°C.

In the up flow configuration, the biomass carriers will float at the top of the reactor, and a sludge blanket will be formed at the bottom of the reactor. Initially, microbial activity will start in the sludge, degrading COD in the wastewater which enters the reactor. The partially degraded wastewater will flow to the upper part of the reactor, where attached anaerobic biomass carriers are floating, and additional degradation will occur (Y. Liu and J. H. Tay, 2001).

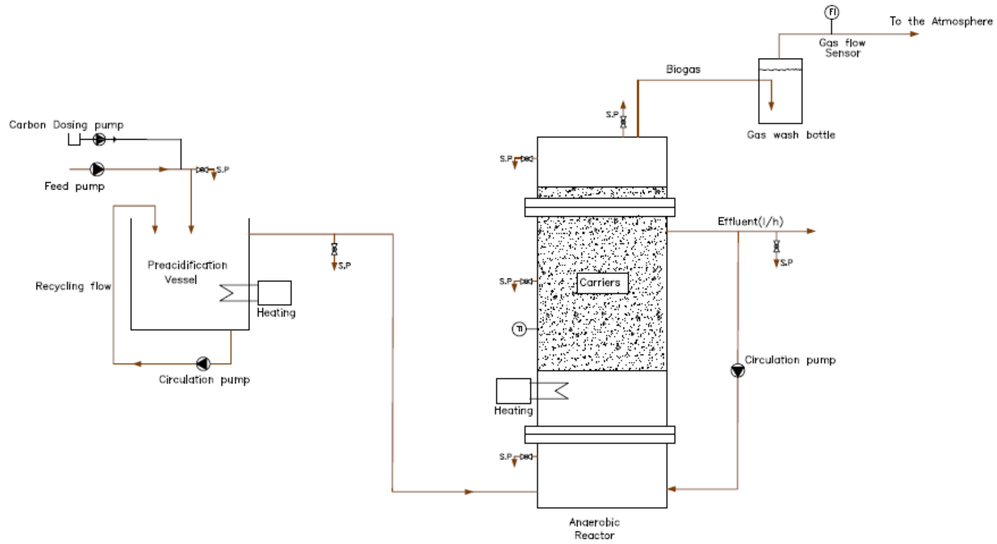

Figure 1 Up flow Pilot Set up

Using the down flow configuration the excess suspended biomass is continuously washed out of the system. Down flow configuration supports higher biomass yields on the biomass carrier, and as a result, the attached anaerobic biofilm is exposed to higher loading rates and shows an increase in biofilm thickness. In addition, the absence of suspended biomass allows higher hydraulic loading rates, as washout is not a limiting factor.

The up flow and down flow reactors were fed with municipal wastewater enriched with sodium acetate and fermented products containing molasses, bacteria and yeast, respectively.

Analysis of pH, Temp., VFA, total and soluble COD, NH_4-N and PO_4-P for both influent and effluent were performed according to Standard Method.
pH was adjusted to 6.8-7.2 and nutrients were added as required.
The gas production was determined using Ritter's gas counter.

COD analysis

COD analysis was performed ccording to modified Standards method 5220 D and iso15705, using cell tests (Range: 25 - 1500 mgCOD/l)- MERCK Cat. No. 1.14541.
Thermo reactor - ROCKER model COD Reactor CR25 or MRC model MD-01N.
Photometer – MERCK model Spectroquant NOVA 60.
The COD concentrations varied from 0.6 to 9 g/L, and from 0.6 to 5 g/L in the down flow and up flow configurations respectively, according to the desired VLR.

TSS

TSS tests were performed according to Standards method 2540.B. The test used:
filter paper - MUNKTELL 1.2µm.
Desiccator
Oven (105°C) - DAHAN TECHNOLOGIES model Thermoplus.

NH_4-N

NH_4 analysis method was an analogue to the Standards Method 4500-NH_3 D, using NH_4 cell tests (Range: 2 - 150 mgNH_4-N/l)- MERCK Cat. No. 1.00683
Photometer – MERCK model Spectroquant NOVA 60

Volatile Fatty acid (VFA)

The analysis used the following materials:
Filter paper (MUNKTELL 1.2 µm)
Sodium hydroxide – FINKELMAN LTD. (Cat. No.: 2-26-37/39)
Hydrochloric acid– FRUTAROM LTD. (Cat. No.: 2355519700)
Burette 25ml ±0.05 at 20°C
Magnetic stirrer - Fried Electric model F-13
pH meter - WTW model multiline P4 with SCHOTT electrode model Blueline 24

To define the VFA concentration, the titration method was performed, as follows:
In order to define alkalinity (Eq. 1), 25 ml sample were filtered and titrated with HCl 0.1N to pH = 4. The titration volume was saved and the titration continue until a pH = 3.2 was reached. The sample was boiled for 3 min. and cooled down to room temperature, for 30 min.

Alk (mg/l) = A*200 (Eq. 1)
Wherein:
A- ml of standard HCl 0.1N used to reach pH 3.2

Second titration was performed in two steps, with NaOH 0.01N. First the pH was raised to 4 following with further elevation to pH 7 (from 4). The titration volume required to raise the pH to 7, defines the VFA (Eq 2).

VFA (mg/l) = (C-B)*20 (Eq. 2)
Wherein:
B- ml of NaOH 0.01N used to increase pH from 3.2 to 4.
C- ml of NaOH 0.01N used to increase pH from 4 to 7.

RESULTS AND DISCUSSION

Gas production and COD/VFA reduction are used as indicators of biological activity in anaerobic reactors. Figure 2, presents gas production as a function of the VLR.
As can be seen in figure 2, the difference in gas production between the up flow and down flow configurations is 10-30%, in favor of the down flow reactor. The highest gas volume produced in the upflow reactor was approximately 90 l/day for a VLR of 13.5 KgCOD/m^3/d.

For both flow configurations, COD and VFA removal were calculated. As can be seen in figure 3, the COD removal obtained using the down flow configuration, for VLR ranges of 0.91 to 13 Kg COD/m^3/d is higher when compared to the up flow configuration. The down flow values for COD removal are 1 to 3 times higher compared to the values obtained in the up flow configuration. A similar phenomenon can be observed for VFA removal.

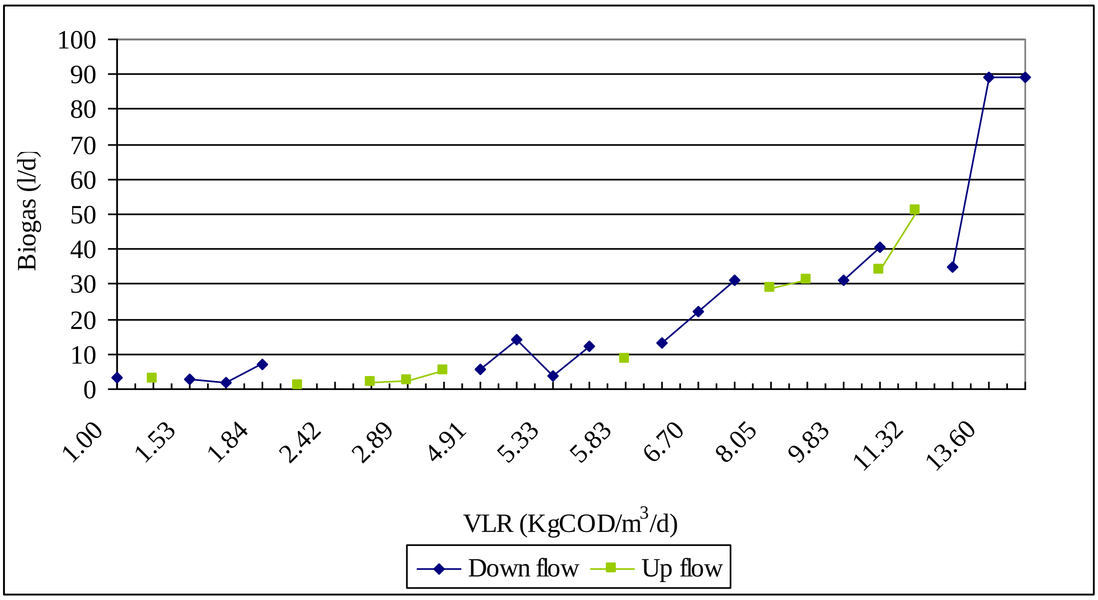

Figure 2 Gas production in down flow and up flow configurations

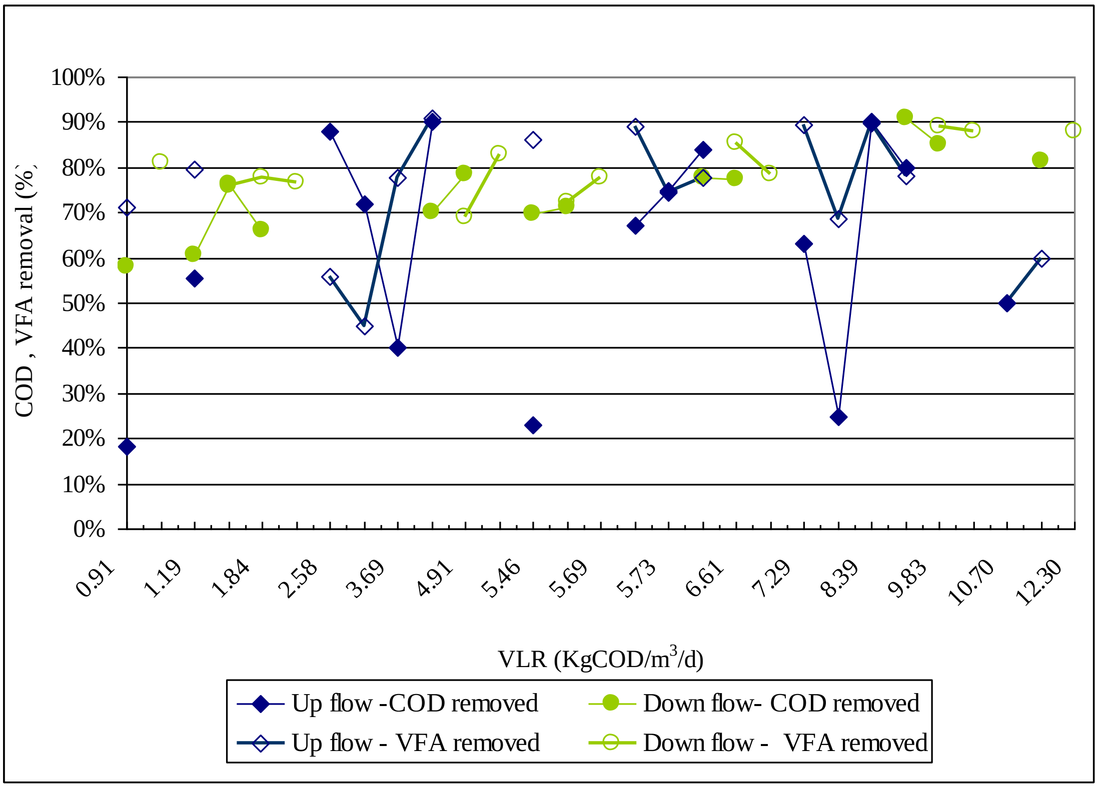

Figure 3 COD&VFA removed as function of VLR in both configurations

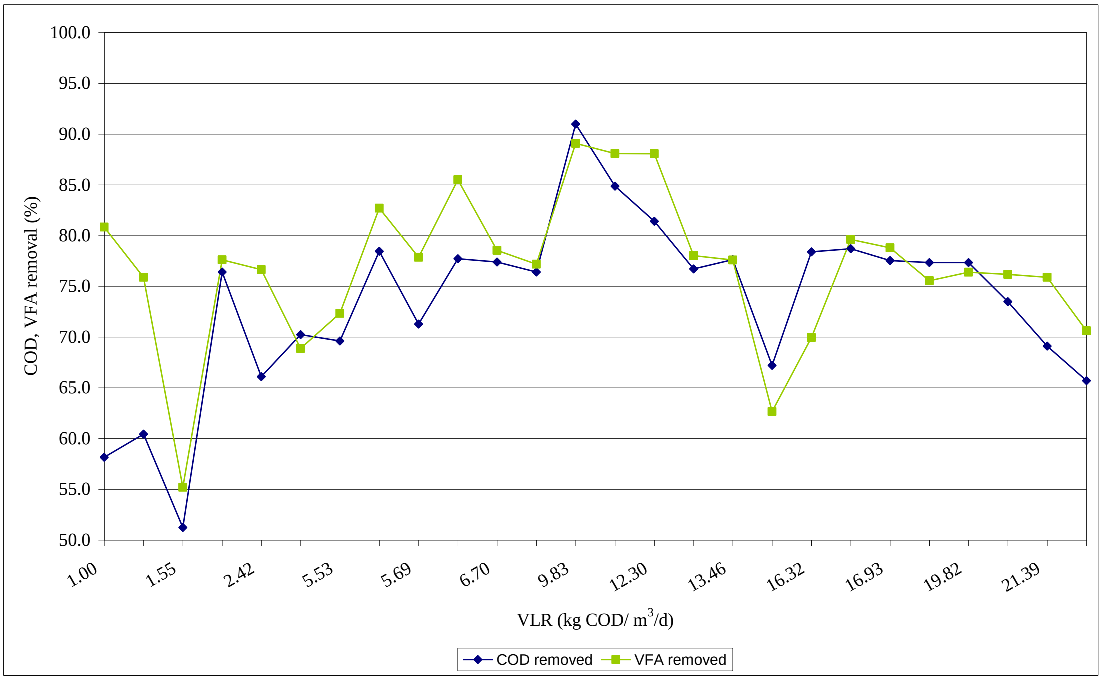

Figure 4 COD&VFA removed as function of VLR in down flow configuration

In the down flow configuration maximal VLR value of 22 KgCOD/m^3/day was obtained without deterioration in the treatment capacity, as can be seen in figure 4.
In the up flow configuration, an average methane and CO_2 production was 85 and 13 % respectively.

REFERENCES

C.Augusto de Lemos Chernicharo, 2007, Anaerobic reactors, Biological Wastewater treatment series, volume 4, IWA.

C.Nicolella, M.C.M. van Loosdrecht ,S.J. Heijnen, 2007, Particle – bsed biofilm reactor technology, TIBTECH, Vol. 18.

R.Riffat, K.Jahan, R.Tallent, K. Krongthamchat, S. Darar, 2002, Literature Review, Water Environment Federation,Water Environment Research, Volume 74, Number 5.2 .

Standard Method for water and wastewater examination, 20th edition, 1998, AWWA APHA.