Performance evaluation of a new (Biobed Advanced) EGSB settler

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Abstract
A new EGSB settler (Biobed Advanced) concept was developed and evaluated by comparing the performance of a 7 m^3 pilot. The pilot was operated in parallel to full-scale systems treating recycle paper wastewater and potato-processing water. At the paper factory it was possible to operate the pilot at a volumetric loading rate (VLR) 44% and 200% higher than in the full-scale EGSB and UASB systems. At the same time the COD removal in the pilot was comparable to that achieved in the UASB while the TSS concentration in the effluent of the pilot was lower. The performance of the pilot at the potato-process plant was also excellent and it was possible to apply an average VLR of 19 kg COD/m^3.d which was 5.8 times higher than that applied in the UASB system again with similar performance.

Keywords: EGSB, UASB, Biobed Advanced, settler, high rate, Anaerobic,

INTRODUCTION

The UASB (upflow anaerobic sludge bed) technology for treating industrial wastewaters was developed and introduced to the market in the late 1970’s. Since then the uptake of granular sludge based anaerobic systems has been extraordinary and as of 2008 there were over 2,200 full-scale references worldwide (van Lier, 2008). The success of the systems has been driven by advantages such as; reduced construction costs, reduced energy requirements, energy production, valuable biomass production and reduced nutrients consumption.

The UASB system dominated the industrial wastewater treatment market in the 1980’s and early 1990’s (Frankin, 2001). However in the late 1980’s a new anaerobic granular sludge reactor concept was developed. This system would become known as the expanded granular sludge bed (EGSB). The basic principle of EGSB systems is the same as the UASB, i.e. a combination of a GLS separator and granular sludge, however much higher liquid up-flow velocities are applied in the reactor. As a result the sludge bed is more expanded (better mixed) and it is possible to apply much higher volumetric loading rates (20-35 kg COD/m^3.d). Perhaps more importantly it is also possible to apply much higher upflow velocities in the settler. As a result surface area required for settling is much lower. Thus EGSB type systems have smaller volumes and also smaller footprints than UASB systems and are therefore cheaper to construct.

Despite the lower costs of EGSB type reactors the UASB technology still remains a relatively popular technology today. Between 2002 – 2007 34% of all anaerobic systems sold worldwide were UASB systems while 52% were EGSB type reactors (van Lier, 2008). There are two main reasons for the remaining popularity of the UASB system. First, the UASB system can handle higher TSS and FOG (fat, oil and grease) concentrations than EGSB systems. Second, UASB systems can be more robust; they can in some cases be perceived as more stable with respect to net biomass growth. In order to address these issues Biothane have developed a new settler which is marketed as Biobed Advanced. A 7 m^3 pilot plant was constructed with this new settler and operated in parallel to a full-scale UASB and EGSB reactor at two locations, to test the performance of this new settler.

METHODS

Pilot and settler design

A Biobed Advanced pilot plant system was designed to simulate, as precisely as possible, the conditions in a full scale system. The pilot consisted of a 7 m^3 Biobed EGSB reactor and a conditioning tank (Figure 1). The height of the reactor was 11 m, which is close to a full-scale EGSB system. Caustic was dosed to the 0.8 m^3 conditioning tank to control the pH. The key feature of the pilot was the Biobed Advanced settler. The settler was designed at a 1:1 scale, in relation to a full-scale system, to give the most representative results. The key hydraulic parameters of the full scale Biobed Advanced were adhered to, both in reactor and settler. The settler consisted of a deflector and baffle plates with a titled plate separator located above them.

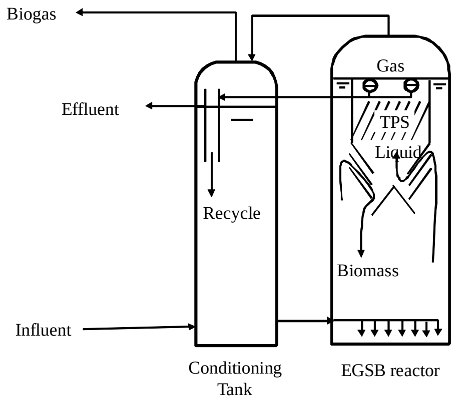

Figure 1: Schematic representation of the Biobed Advanced reactor

Test locations

Two locations were selected to test the performance of the Biobed Advanced settler; a paper factory located in Germany and a potato-processing factory located in Netherlands. The paper factory uses full-scale Biothane UASB and Biobed EGSB reactors to treat their wastewater. Thus it was an ideal location to compare the performance of the new settler with existing conventional technologies. It is known that granular systems treating recycle paper wastewater are characterised by well settling sludge due to the high calcium concentration in the wastewater. However, high calcium concentrations provide other type of challenging conditions. Still, the main question was whether the pilot would outperform the existing EGSB and UASB reactors.

The wastewater produced in the potato-processing factory is characterised by high TSS and FOG concentrations which provide challenging conditions for EGSB type reactors. Additionally, the granular sludge that develops with this wastewater is known to be “light”. The potato-processing plant uses an UASB reactor to treat their wastewater.

Reactor operation

The Biobed Advanced pilot was installed in parallel to the full-scale Biobed EGSB and UASB reactors. Chemical dosing for all reactors took place in the shared buffer tank. The performance of the pilot was assessed based on the VLRs that were possible to apply. In addition the effluent TCOD, SCOD and TSS concentrations were key parameters used to assess the system.

RESULTS AND DISCUSSION

Performance at the pulp and paper factory

The pilot plant was operated at the paper factory for a period of 5 months. The performance of the Pilot, Biobed EGSB and UASB systems is presented in Table 1 below. The VLR applied in the Biobed Advanced pilot was of 12.8 kg COD/m^3.d which was 44% and 200% higher than those applied in the Biobed EGSB and UASB reactors respectively.

The anaerobic effluent TSS concentrations were 155, 380 and 235 mg/l for the pilot, the Biobed EGSB and the UASB systems respectively. This is a very significant result because the pilot not only outperformed the Biobed but also had a much better solids retention than the UASB. The COD removal efficiencies (TCOD and SCOD) for the pilot and the full-scale Biobed were almost identical. However the UASB marginally outperformed the pilot for TCOD and SCOD removal.

Table 1: Performance comparison between the Biobed Advanced pilot, Biobed EGSB and UASB full-scale reactors treating paper wastewater

Parameter	Pilot	Biobed	UASB	UoM
VLR (avg)	12.8	8.9	4.3	kg COD/m^3.d
TSS	155	380	235	mg/l
TCOD removal	72.8	73	74.3	%
SCOD removal	79.4	79.1	80.6	%

Biobed advance performance at the potato -processing factory

The performance of the Biobed Advanced pilot and the UASB systems treating potato-processing wastewater is presented Table 2. As stated above the wastewater produced in the potato-processing factory is known to be challenging for EGSB type reactors because by high TSS and FOG concentrations. However the pilot had no difficulties treating the wastewater, the most striking result being that it was possible to operate the pilot at an average VLR of 19 kg COD/m^3.d which is 5.8 times higher than the VLR applied in the UASB. To put this into prospective the current UASB reactor volume is 1,820 m^3. Applying a VLR of 19 kg COD/m^3.d it would be possible to treat the wastewater in a reactor of just 306 m^3 with Biobed Advanced.

Table 2: Performance comparison between the Biobed Advanced pilot and full-scale UASB reactor treating potato-processing wastewater

Parameter	Pilot	UASB	UoM
VLR (avg.)	19	3.2	kg COD/m^3.d
TSS	326	461	mg/l
TCOD %	70%	73%	%
SCOD %	84%	87%	%

The organic loading rate applied in the pilot (0.7 kg COD/kg VSS.d) was almost double that measured in the UASB (0.37 kg COD/kg VSS.d). This can be due to better mixing and selection in the pilot resulting in a more stable granular biomass culture. The influent TSS concentration was on average 615 mg/l, therefore the removal TSS in the pilot was an excellent 47% compared to just 25% in the UASB. The fact that TSS removal was higher in the much higher loaded pilot demonstrated the excellent performance of the new settler. The TCOD and SCOD removal efficiencies achieved in the pilot were lower than those achieved in the UASB reactor. In particular the SCOD removal efficiency in the pilot (84%) was 3 percentage points lower when compared to the UASB system (87%).

Biomass growth

In some cases EGSB type reactors show limited net granular biomass growth. In some cases UASB systems can be more reliable producers of biomass than EGSB type reactors. Biomass growth in the pilot was monitored by determining the sludge mass in the reactor once per month (Figure 2). The reactor was seeded with 100 kg TS in January however by March the biomass in the system had increased to 150 kg TS. At that point biomass was extracted from the reactor to prevent biomass entering into the settler. After the extraction of biomass there was in 80 kg TS in the reactor, however two months later this had increased to 170 kg TS and biomass was again extracted.

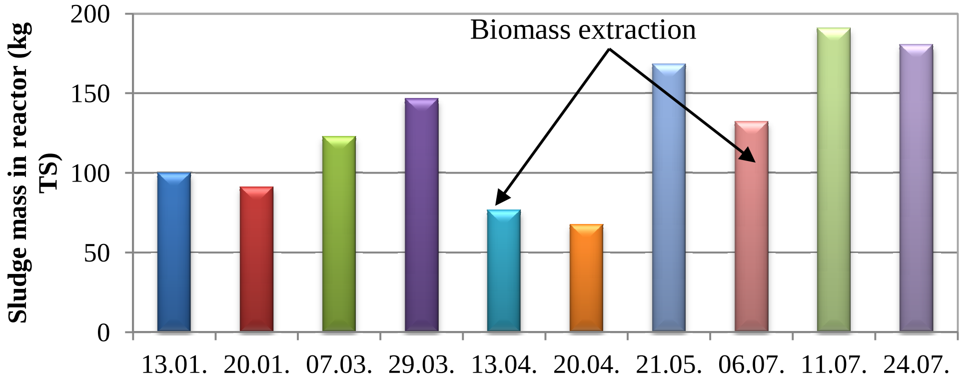

Figure 2: Sludge mass in reactor throughout experimental period at the potato-processing factory

During this project Biothane successfully developed a unique camera capable of taking image of biomass *in situ*. Images taken with this camera are shown in Figure 3. There was a lot of flocculent debris mixed with the granules in the UASB. In contrast the sludge in the pilot plant was almost entirely granule in nature.

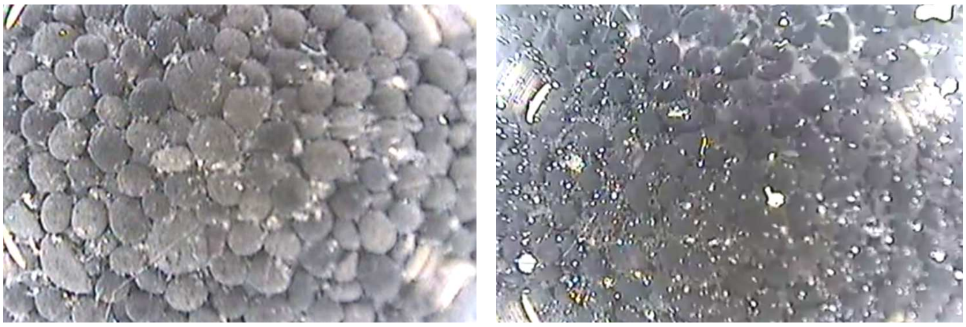

Figure 3: The first photo shows granules from the pilot while the second are granules from full scale UASB.

CONCLUSIONS

The performance of the new Biobed Advanced settler has proven to be excellent. It was possible to apply much higher volumetric loading rates in the pilot with the new settler compared to full-scale UASB and EGSB systems operated in parallel. These results were achieved without compromising on COD removal performance. TSS removal performance in the pilot was also excellent. This is in line with the finding that significant sludge growth was observed while treating the potato-processing wastewater. This is an important finding considering that typically an EGSB type reactor would not be applied for this type of wastewater.

REFERENCES

Frankin R.J. (2001) Full scale experiences with anaerobic treatment of industrial wastewater. *Wat. Sci. Technol.* 44 (8): 1-6

Van Lier J.B. (2008) High rate anaerobic wastewater treatment: diversifying from end-of-pipe treatment to resource-oriented conversion techniques. *Wat. Sci. Technol.* 57 (8): 1137-1147