Labyrinth - Anaerobic BioConverter

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BioConverter

BioConverter is a biological reactor where selected microorganisms operate the break down of biodegradable matter to more simple and bioavailable forms. Not only organic material is degraded: a huge range of compounds could be biologically converted, even when present in admixture. Azo-dyes, pharmaceutical compounds, xenobiotics, or recalcitrant compounds such as phenols are biologically converted to substrates readily degradable by a wide range of aerobic bacteria.

The Anaerobic BioConverter is a fixed bed biological reactor with three or more filtration chambers in series (see Fig. 1). As wastewater flows through the filter media, particles are trapped and matter degraded by the active biomass attached to the surface of the filter material. Filtration chambers in series, which can be described as "*a series of UASBs which does not require granulation for its operation*" boost the development of selected microbial population within any chambers, with fixed beds successfully retaining the biomass for lesser washout and improved efficiency.

This reactor is versatile, robust and shows promise for treatment of wastewaters which cannot be readily treated.

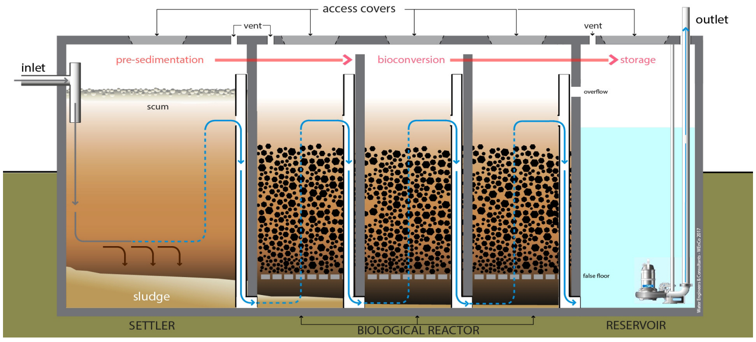

Fig. 1 BioConverter Cross-Sectional view

When BioConversion

Industrial wastewaters are often a mixture of three main groups of compounds: organics, inorganics and heavy metals. Industrial wastewaters can often fluctuate in composition and flowrate, creating also problems for any physical and biological treatments. The aerobic biological treatment of the wastewater is maybe the cheapest way to remove organics, but is known for suffering from problems of bulking with toxic wastes of fluctuating composition. One solution is to use a physical-chemical pretreatment, pre-precipitating the toxic compounds as sulphide or hydroxide salts as sludge, to be treated and disposed.

Owing to its reduced size and maintenance required, along with inherent two-phase behaviour, the Anaerobic BioConverter could become an alternative solution, maybe one of the most viable in the following circumstances:

- **When there is just small space for treatment**. *Reactor volume is divided into compartments, interconnected by a downflow pipe. No mixing between biomass: gas phase remains separate. The enhanced treatment rates allow smaller treatment volumes.*
- **When toxic or inhibitory compounds are in the wastewater**. *The retention time of a slug of wastewater containing a toxic or inhibitory compound in each compartment is much less than in a single compartment reactor with the same total hydraulic retention time (HRT). More rapid recovery from process up-sets.*
- **When fluctuations are in the wastewater flowrate**. *Concentration gradients of organic components should result in the development of populations that are microbiologically selected to best suit the conditions in each compartment. Differing populations of bacteria across the compartments has been shown to increase resistance to variations in feed load, temperature and pH.*
- **When little or no maintenance is possible**. *No mechanical mixing is required, no power requirements during operation. Long service life at low operating cost.*
- **When particulate fraction of organics exceeds the soluble**. *Along with particulate settling, BioConversion promotes a partial conversion of particulate fraction into soluble.*

Design considerations

The physical configuration of the BioConverter affects not only the hydrodynamics but also influence the development of the microbial population within the reactor, accounting for its high efficiency. Settling of particulate components of the feed occurs in the upflow region, resulting in thick sludge blanket in the bottom of the chambers. Fixed bed media in the upflow section, improving micro mixing, provides a better control over localised velocities: the media is successful at retaining the biomass with very low washout. Owing to the very slow movement of cells down the reactor, cells selected for by forced evolution would be retained in the reactor for months.

The overall cell yields are in the range of 0.04 g cells/g substrate, and hence very little sludge will be generated. The biomass -*sludge*- in each compartment will treat wastewater in that compartment better than biomass -*sludge*- with the average composition of sludges (see Figure 2). The end compartments promote endogenous respiration and are designed for low sludge carry-over rates.

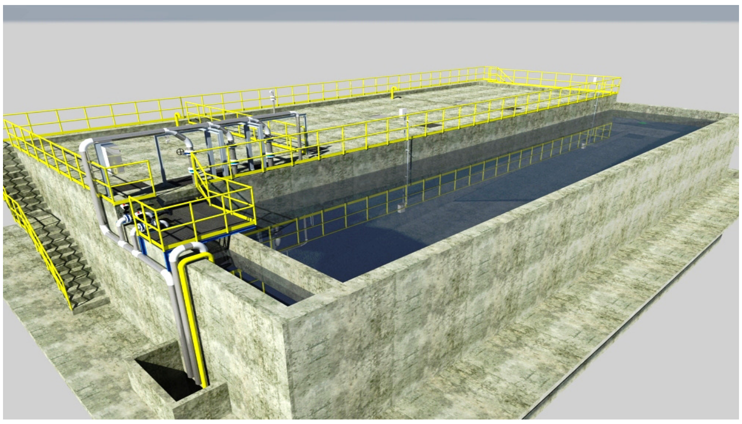

Fig. 2 Render of 3.600 m^3/day BioConverter

BioConverter

Today's known applications of BioConverter

With the Anaerobic BioConverter suspended solids and BOD removal can be as high as 90%, but typically between 50% and 80%. Nitrogen removal is limited and normally does not exceed 15% in terms of Total Nitrogen: Nitrates and Nitrites, acting as electron acceptors, and are easily reduced to nitrogen. As of today, BioConverter is already successfully used to treat feedstocks containing carbohydrates, phenols, or discharged from slaughterhouses and pulp-and-paper-mills. Handling both high and low strenght wastewater - 0.5÷20 g/l COD- with removal efficiencies as high as 90÷92% at hydraulic retention times of 10÷20 hours, capital costs are significantly reduced.

Future prospects for BioConverter: the Coupled Processes

As shown, the Anaerobic BioConverter technology is easily adaptable and can be used for secondary treatment, to reduce the organic loading rate to a subsequent aerobic treatment, for polishing or applied as a single step treatment. Not so infrequent are processes which inherenthly require both anaerobic and aerobic treatment: detoxifications in petrochemical, coal processing and extractive industry, textile dye wastewaters can be dealth with and significantly helped by an Anaerobic BioConverter.

In early 2016, a research project was carried out to assess the ability of a combination anaerobic and aerobic processes to treat a denim process wastewater, along with all its design applications in industrial scale. Research activity consisted of the design, construction and operation of a pilot plant, with the objective to produce water of desired – *fixed* – quality for a tertiary treatment and reuse, in the smallest treatment volumes. Experiments were conducted with the varied hydraulic retention time (HRT) in anaerobic process of 8, 12, 18 hours. In the aerobic process the HRT were 16, 32, 44 hours, and the SRT (solid retention time) was maintained at 13 days. The experimental set-up is shown in Figure 3.

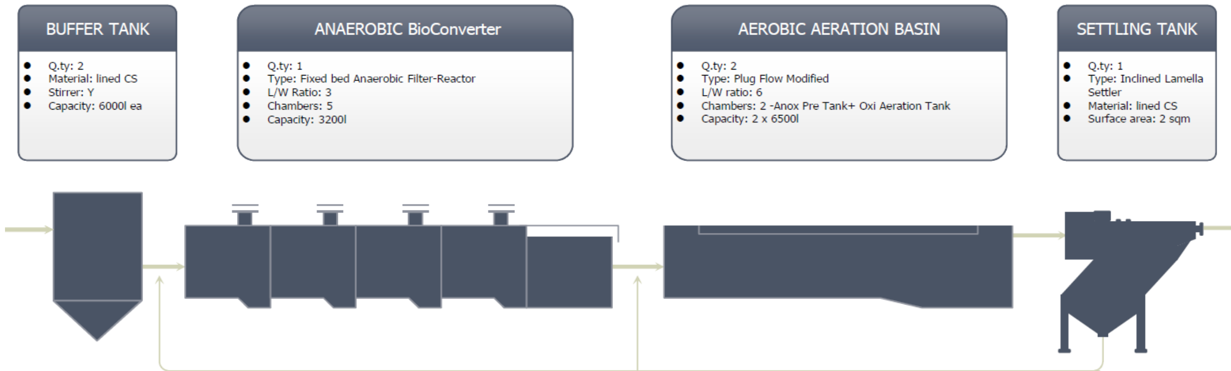

Fig. 3 Experimental set-up for Treating Textile Wastewater by combined Anaerobic – Aerobic Process.

Conclusions and results

The acclimatization period was completed in just 20 days, then the performance of both the anaerobic and aerobic steps separately and in-series was measured at variable operative conditions, multiple sequences and combinations tested. Along five months trials, once the steady states were achieved, combined system provided constant and stable outputs, regardless of the changed composition of the influent, while single processes separately either didn't meet the required output or yielded to various bulking phenomena further to the same step changes in feed composition.

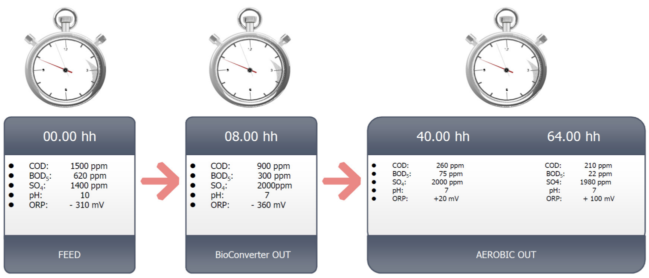

Fig. 4 Average COD, BOD abatement profile

It was found was that the majority of color was removed in the anaerobic process while the majority of COD was removed in the aerobic process. Combinations of two processes were found to be able to reduce COD, BOD and color up to 95, 92 and 95% respectively, as expected, for the higher HRT and lower OLR.

It was found, though, that beyond some waste-specific values of HRT and OLR, COD, BOD and color abatements slow down Any further volume increase have very little additional effect on the performances indeed, considering all design implications, costs and real advantages borne (see Figure 4).

Industrial scale

Over the last years several new projects of Effluent Treating Plants (ETPs) featuring a combined treatment have been awarded. Several projects for the retrofitting and revamping of conventional ETPs are also on the way with preliminary performances that differ not much to the pilot scale results.

More compact ETPs, reduced aeration systems, along with ease and unparalleled stability of operation are just some of the highly welcomed responses gathered.

For more info follow the link in the QR.