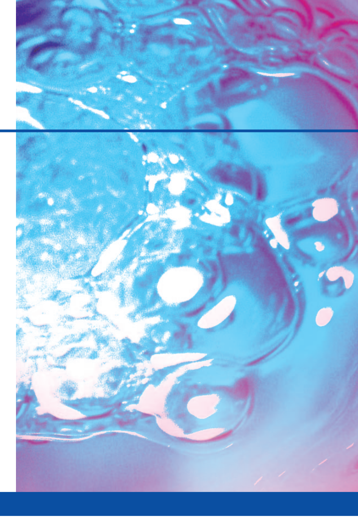

Simultaneous Algorithm-based Monitoring of Volatile Fatty Acids (VFA), Bicarbonate & Alkalinity

IN ANAEROBIC WASTEWATER OF BIO-DIGESTERS

WATER
Waste Water

Author Details

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The anaerobic process in Bio-digesters is based on a complex ecosystem of bacterial species that degrade organic matter in waste streams. In recent years this process has gained increasing importance at industrial scale. Especially in the agro and food industry big quantities of wastewater are treated using this process. The success of the anaerobic waste treatment is due to the low production of sludge (disposal of sludge is the highest cost for an aerobic treatment), recovering energy by combustion of the produced methane, and the possibility of treating wastewater with a high organic load. Figure 1 shows the schematic degradation process and the several involved bacterial species.

The anaerobic process however is susceptible to variations and therefore eventually less stable than the classical aerobic wastewater treatment. Methanogenic bacteria that are strictly anaerobic, grow slowly and are very sensitive to pH changes. The formation of methane from Volatile Fatty Acids (VFA) by these bacteria is also the slowest step in the process. Acidogenic bacteria however have a more rugged nature. Therefore a good balance between the several microbial populations is necessary.

After periods of non-activity of the Bio-digester, like in the agro-industry where production is season related, the process is extra vulnerable and needs to be monitored more frequently. Instability will lead to a less efficient process, instable gas production and a possible total failure of the Bio-digester.

The first step in destabilisation of the anaerobic process begins with an increase of the VFA concentration in the Bio-digester. Due to a high organic loading, failure of the heating or inhibition of the methanogenic bacteria (lack of nutrients or the presence of toxic compounds), VFA are more rapidly formed than degraded. While the concentration of VFA is increasing, the bicarbonate concentration will decrease and the CO2 concentration in the biogas will increase. If the biogas is used for energy recovery, an unstable gas production will result in a less efficient energy production.

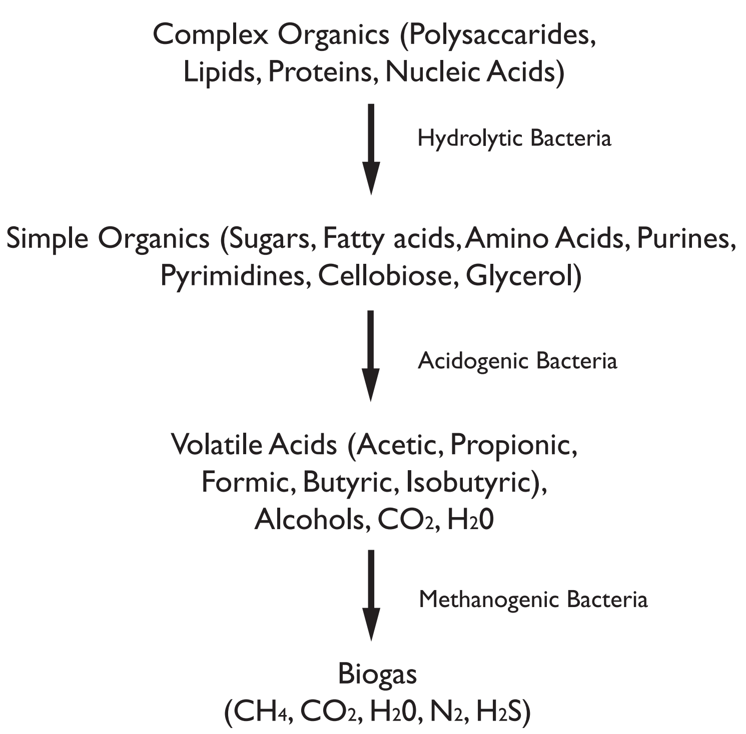

Figure 1: Schematic view of the degradation process and the involved bacterial species.

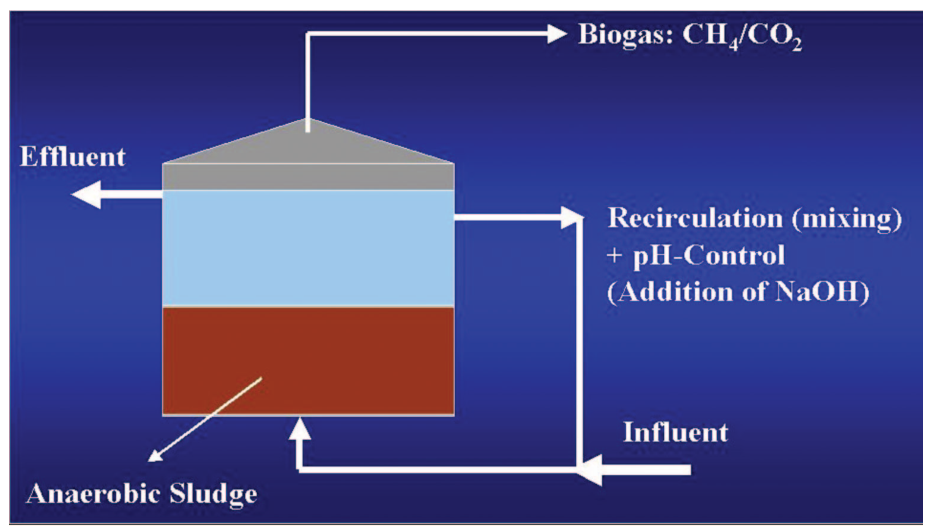

Figure 2: Schematic view of a Bio-digester

As long as bicarbonate in the water buffers and protects the Bio-digester, organic molecules will be degraded. However, if no action is taken, VFA concentration will continue to increase and when all the bicarbonate is consumed, the pH of the Bio-digester will drop very fast. Such a drop in the pH will cause a destruction of the bacterial ecosystem, and finally the methanogenic bacteria are killed. The recovery of the Bio-digester can take several months.

Thus, it is clear that a stable process is very important. In order to avoid instability of the anaerobic process, a Bio-digester should be controlled via measurements of VFA, which is one of the most sensitive parameters, in combination with measurements of bicarbonate, alkalinity and pH.

In industry however, few laboratories are equipped for VFA measurements because the standard techniques like Gas Chromatography (GC) require specialised equipment, high investment, high operating costs and highly trained personnel. Because of the complex sample preparation, GC analysis is time consuming. If the process needs to be monitored very frequently (every 15 minutes), in case the Bio-digester is being restarted after a period of non-activity, it is almost impossible to do so with GC.

Because of these issues industrial bio-digesters are usually not extensively monitored. Only pH and gas production are continuously measured. Nevertheless, using only these parameters, the organic loading rate (and the efficiency) of the digester needs to be kept low due to safety precautions. This leads to an inefficient and less controlled process what also results in a bad quality of the produced biogas.

In order to improve the anaerobic digestion process and to offer the industry a better solution for this monitoring problem, an on-line analyser for measuring VFA, bicarbonate, alkalinity and pH is developed by AppliTek in the framework of a European project TELEMAC with a/o technology of INRA (French National Institute in Agronomic Research, Narbonne, France). This algorithm-based

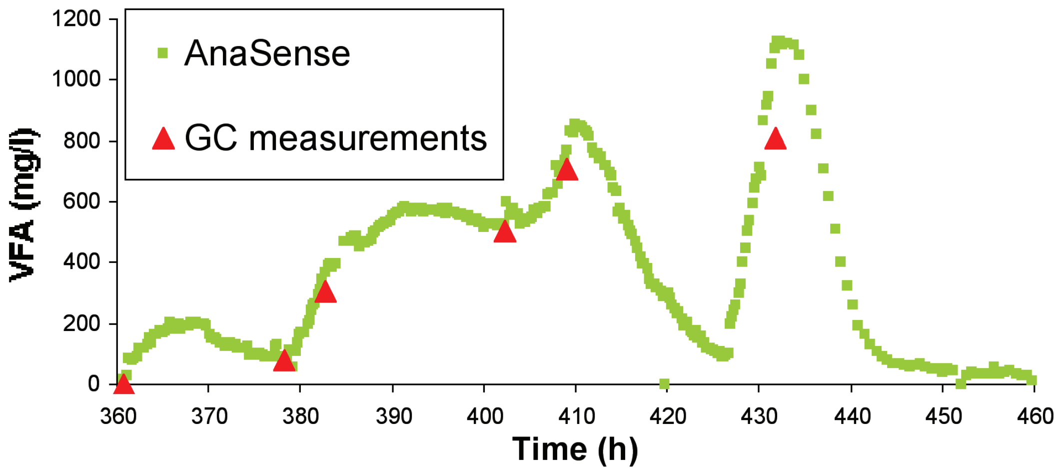

Figure 4: Measurement results for VFA in comparison with GC results

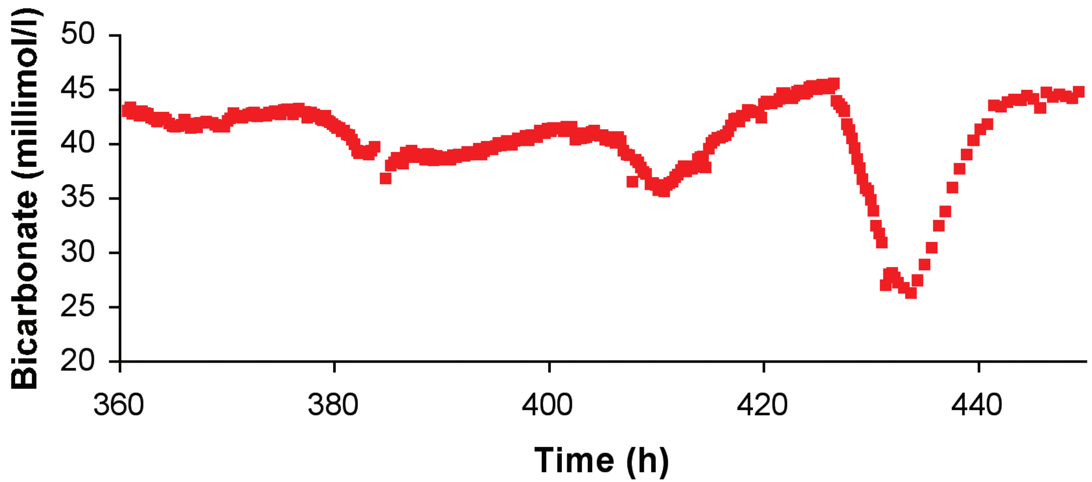

Figure 5: Measurement results for bicarbonate

analyser measures in about 10 to 15 minutes, the concentration of VFA, bicarbonate & alkalinity in a harsh environment, allowing the operator to keep the process stable while the process is optimized. In figure 3 the newly developed analyser named AnaSense®, is shown.

The AnaSense®, was tested on anaerobic digesters with successful results. In the graphs to the left the VFA results and the bicarbonate results are shown (Figure 4 and 5). The VFA results were compared with the results obtained by GC and no difference was noticed. From the graphs one can also see that when concentration of VFA is increasing very fast due to a higher organic loading, the concentration of bicarbonate is decreasing.

Conclusion

On-line measurement of volatile fatty acids, bicarbonate and alkalinity was successfully implemented for the effluent of anaerobic digesters with fluctuating concentrations of bicarbonate. The newly developed AnaSense®, was tested on-line and is a cost-effective and robust alternative for existing techniques like GC. This analyser offers the possibility to control the anaerobic process and increase the efficiency of the anaerobic treatment.