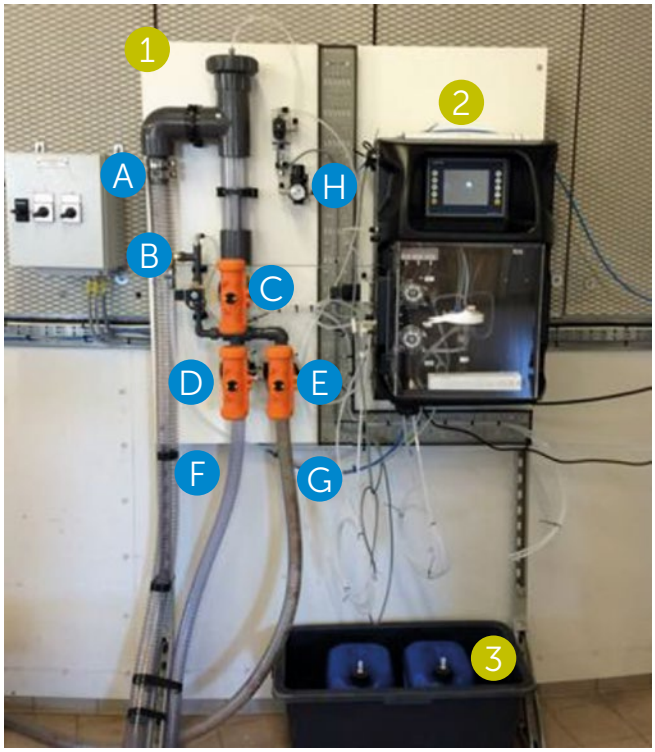
VIVAB tests Volatile Fatty Acids Online Analyser

Monitoring and optimizing the production of volatile fatty acids (VFA) and controlling the alkalinity and pH in anaerobic processes are essential factors to prevent acute failures and bottlenecks in digesters and biological phosphorous-removal (EBPR) plants.

Online measurement instruments present a good opportunity to monitor such processes, as they enable constant determination of the conditions inside a digester. One such instrument is the online analyser AnaSense*, which facilitates monitoring, controlling, optimising, and protecting the anaerobic process. This instrument measures the following parameters, namely, pH, VFA, bicarbonates, and total and partial alkalinity. It was tested by the Swedish Municipal Joint Stock Company (VIVAB [Vatten & Miljö i Väst AB]) at three different sites and the same samples were analysed using three different laboratory methods.



Installation on site
1 *Pre-treatment panel*
2 *Analyser*
3 *Reagents*

A *Overflow drain*
B *Rinse valve*
C *Inlet valve*
D *Drain valve*
E *Sample valve*
F *Drain tube*
G *Sample tube*
H *Pressure reducer*

Installation

The instrument consists of two units, namely, the pre-treatment and the analyser units. The pre-treatment panel consists of different types of valves, the pre-conditioning panel with the filter, and an air-pressure reducer.

Analysis procedure laboratory

The online measurements were compared to three different methods used in the evaluation.

AnaSense method

The AnaSense method mimics the analysis method protocol of the analyser. Therefore, 20 mL sample was titrated with 0.1 M sulphuric acid (H_2SO_4) from the original pH down to pH 5.75 to determine partial alkalinity, and down to pH 4.3 to determine total alkalinity. To calculate the bicarbonates, titration was continued until the pH reached 4.0, after which the sample was aerated for 90 seconds to strip off the carbonates. The sample was titrated from pH 4.0 to pH 5.0 with 0.02 M sodium hydroxide (NaOH) to determine the VFA.

Method VIVAB (Falkenberg)

The accredited laboratory in Falkenberg filtered the sample before examination. 50 mL of the sample was titrated with 0.1 M sulphuric acid from the original pH down to pH 5.75 to determine partial alkalinity, and down to pH 4.0 to determine total alkalinity. The titration continued until a pH between 3.3 and 3.5 was reached. Afterwards, the sample was boiled for at least three minutes. After cooling down to room temperature, the sample was titrated with 0.05 M sodium hydroxide from pH 4.0 up to pH 7.0 to determine the VFA.

*AnaSense is the same as the Hach EZ7200 VFA Analyser

Accredited laboratory in Varberg

The accredited laboratory in Varberg used distilled water (ratio 1:1) to dilute the sludge. After dilution, the sample was filtered through a filter with pore size 6–10 µm. Subsequently, 10 mL filtrate and 90 mL distilled water were mixed and titrated with 0.05 M muriatic acid. Partial alkalinity was determined at pH 5.75 and total alkalinity at pH 4.00.

The VFA was determined by using a Hach® cuvette test (LCK 365) and the sample was centrifuged and filtered (filter pore size 6–10 µm).

Installation on sites

Getteröverket WWTP

Getteröverket, located in the municipality of Varberg, is one of the largest wastewater treatment plants of VIVAB. It has a treatment capacity of 5,600 kg BOD_7/day, which is equivalent to 80,000 PE (population equivalent). This conventional WWTP generally processes domestic sewage, with approximately only 7% of the inlet BOD_7 load originating from industrial wastewater, mainly from the fish industry. The WWTP has four digesters with a total volume of 3,600 m^3, i.e. each reactor has a volume of 900 m^3.

The AnaSense analyser was connected to the master reactor because the widest process variations were expected to occur in this reactor. Furthermore, it was expected that process instability owing to an increase of VFA and a decrease of alkalinity would be perceivable first in this reactor. Such developments could be caused, for instance, by changes in the organic load and pre-thickening.

Carlsberg Pre-treatment

Various industries are located in the Falkenberg municipal area or next to this city. Owing to the unstable conditions of industrial wastewater, treatment of the water at the largest WWTP, Smedjeholmen, presents a significant challenge. In particular, the wastewater from the Carlsberg brewery requires specific pre-treatment. The outlet process water from the brewery is pre-treated in an anaerobic internal circular reactor (IC reactor) located in the southern part of the municipality of Falkenberg. VIVAB is responsible for the maintenance and operation of this facility. The process water is treated in the IC reactor mainly for two purposes, namely to enhance biogas production and to decrease the BOD load prior to treatment at the Smedjeholmen WWTP.

Ullared WWTP

The WWTP at Ullared is located in the municipal area of Falkenberg. It treats mainly influent water from the premises at the shopping centre at Gekås, which houses shops, restaurants, and a camping site. Accordingly, drastic changes and fluctuations occur in the hydraulic and the BOD loads in the inlet water during shopping hours and holidays. The WWTP at Ullared has a treatment capacity of 518 kg BOD_7/day, which is equivalent to 7,400 PE. The WWTP was constructed as a biological phosphorous-removal plant (BIO-P) and a recirculated activated sludge process (ARP) for VFA production is used. The wastewater treatment process at Ullared WWTP consists of three main steps, namely, mechanical treatment, followed by biological treatment, and, finally, treatment in the polishing ponds.

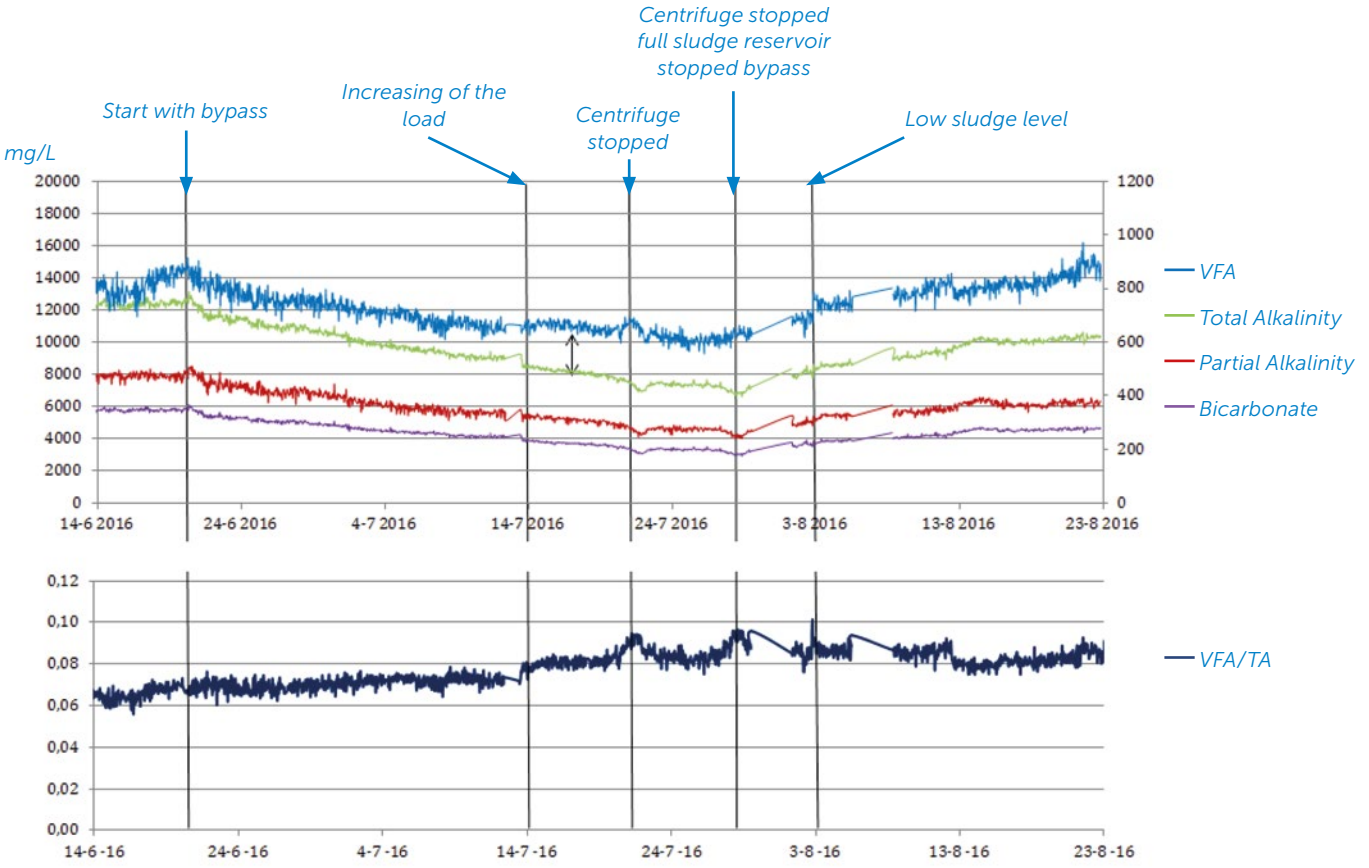


Figure 1: Results of the online measurements from 14 June to 23 August 2016 at Getteröverket WWTP

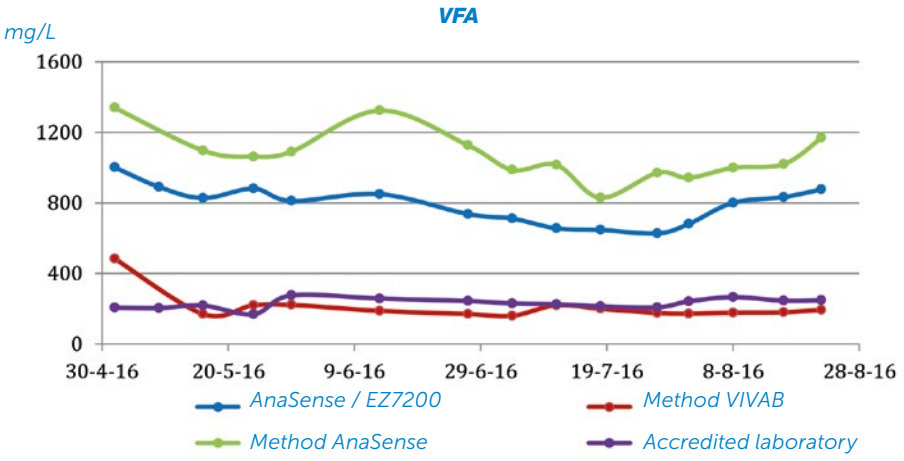


Figure 2: Comparison between the online measurements and the weekly laboratory results at Getteröverket WWTP

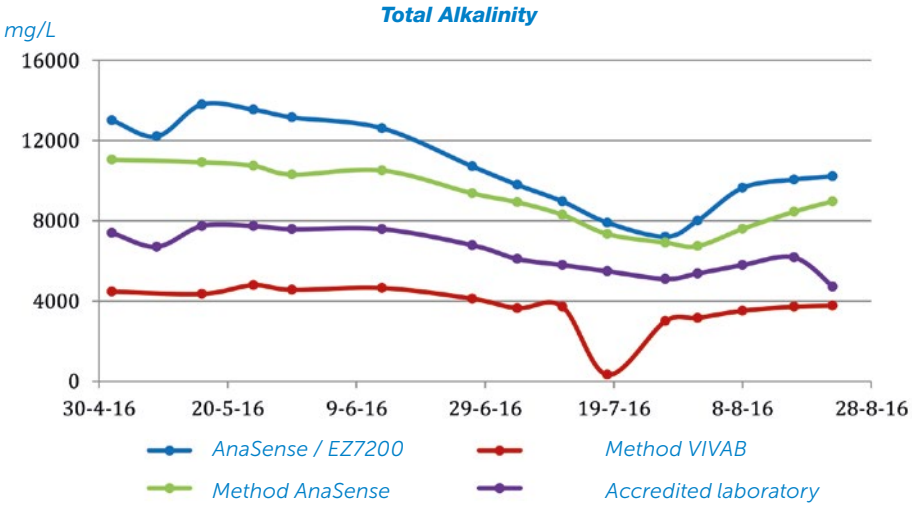


Figure 3: Comparison between the online measurements and the weekly laboratory results at Getteröverket WWTP

Results and Discussion

Getteröverket WWTP

The results facilitate evaluating and enhancing the processes of the digesters at Getteröverket WWTP.

The alkalinity and VFA values in the digester were quite stable because of the steady inlet flow. On closer examination of the online measurements, it was evident that even small changes or occurrences in the process, such as stopping of the centrifuge, were discernible immediately. It was possible to show there was potential to improve the process, reduce the energy consumption, and lower the costs. Saving on the polymers for the pre-thickener could lower the cost by up to 150,000 SEK per year when the pre-thickener is bypassed for the entire year, as polymer consumption is reduced from 3.8 ton/year (2015) to zero. Furthermore, improving the dewaterability of the sludge (suspended materials rejecting water) results in lower sludge transportation costs and a decrease in internal circulation.

A comparison between the online measurements shows that, after optimization, all the graphs followed the same trend (figure 1).

Values from the VIVAB method were lower than were the online measurement values due to additional filtration. The range of values obtained by the AnaSense method was similar to that of the online method, with the exception of the VFA values, which were higher. The values obtained from the Falkenberg method were constantly lower than were the online measurements, which is attributed to the additional filtering of the sample.

The results of the accredited laboratory in Varberg indicate that all the measurement values were in different ranges but followed the same trend (figures 2+3).

Carlsberg

The alkalinity values changed quite fast and irregularly, whereas the ordinary VFA values were quite stable and fluctuated in a small range from 30 mg/L to 55 mg/L.

VFA measurements are more useful if combined with online monitoring of Total Organic Carbon (TOC) at the inlet flow. Based on these key parameters, the inlet flow into the reactor can be adjusted.

A comparison between the online measurement values and the laboratory values showed that all the values were following the same trend, indicating that the analyser was working properly (figure 4+5).

Ullared WWTP

In contrast with previous trials, the overall online results obtained were more unstable. This is attributed to the significantly lower alkalinity and VFA content in the ARP compared with the levels normally obtained in anaerobic digesters. Nevertheless, the results obtained show that the trends were accurate and followed the expected variations in the ARP process, facilitating reliable monitoring.

A comparison was conducted over the entire period between the online measurements and the results in the laboratory. The laboratory values showed that all the values were following the same trend, indicating that the analyser was working properly (figure 6).

Conclusion

The focus during the test trials with the AnaSense instrument was establishing whether the analysis results were trustworthy and whether the analyser was a useful instrument to monitor the processes at wastewater treatment plants. The evaluation of the instrument indicated that the online measurement values were indeed correct. A comparison between the online measurements and the measurements obtained in the laboratory indicated that the given values from the analyser were reliable and that all the values followed the same trend. Even small changes in the process were identifiable, based on these results. Therefore, it is possible to optimize the process without the risk of acidification of the reactor. At Getteröverket WWTP, it was possible to improve the process by bypassing the pre-thickener, which could save up to 150,000 SEK per year and could lower the cost of transport of the sludge.

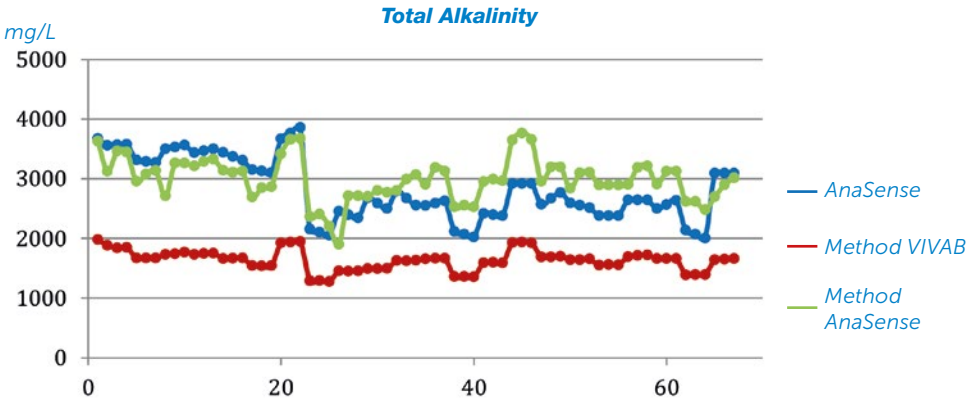


Figure 4: Comparison between the online measurements and the laboratory results at Carlsberg

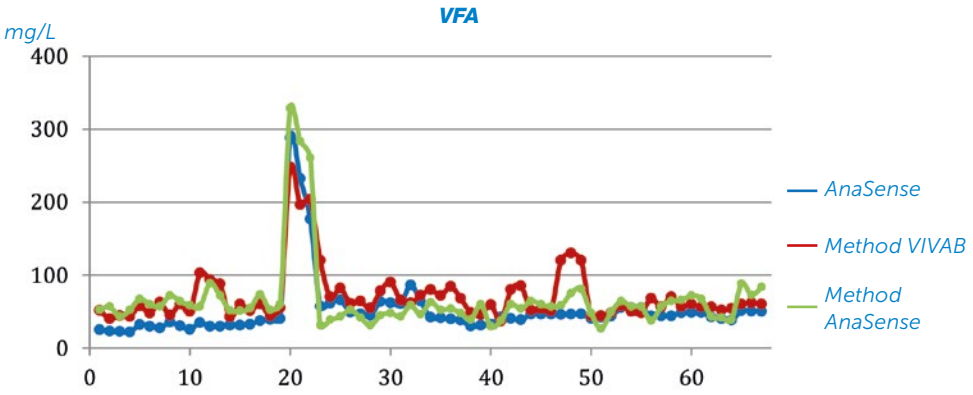


Figure 5: Comparison between the online measurements and the laboratory results at Carlsberg

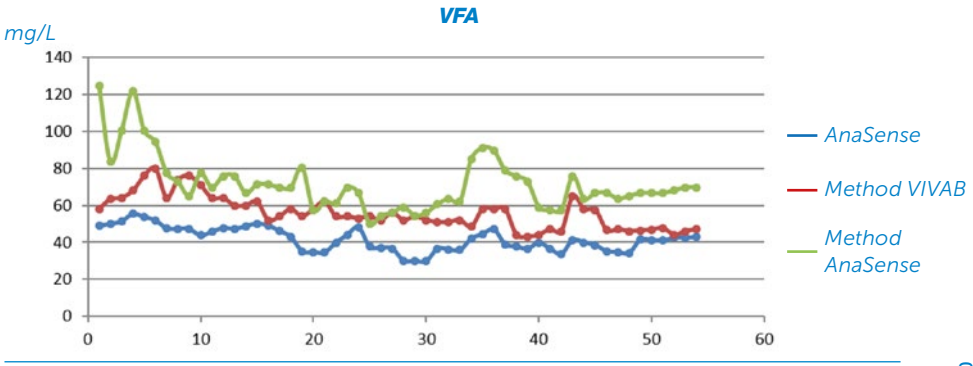


Figure 6: Comparison between the online measurements and the laboratory results at Ullared

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