SENTRY Review:
Organica, Budapest, Hungary

April 5th, 2019.

ORGANICA

Executive Summary

SENTRY™ technology was installed at an Organica Food Chain Reactor with combined returned MLSS in Budapest, Hungary. The sensor was installed for a period in the influent and effluent. Local sampling was performed by Organica personnel to determine the correlation between the Microbial Electron Transfer (MET) value of the sensor and TBOD5, TCOD, fCOD.
The sensor was demonstrated to be a functional tool for the on-site operator in understanding key process factors, such as (1) real-time influent and effluent water quality monitoring, (2) daily and weekly trend identification, (3) identifying process upset events.

The major conclusions are outlined as follows:

- SENTRY data correlated well with TCOD/fCOD/TBOD5, with R2 ranging from 0.61 to 0.82 for the influent and R2 from 0.49 to 0.51 for the effluent. Combined influent and effluent data further increased this correlation.

- The sensor identified the days of the week with the highest organic strength in the influent (Wednesday-Friday) and time of day (after 5pm). The lowest organic strength in the influent occurred on Monday (also it was low on the weekend) and typically was lowest around noon. This information can be tied into understanding when the wastewater treatment process is underloaded or overloaded (or just at an improper carbon/nitrogen loading) and allows decisions to be made intelligently around things like plant down times, best times to schedule internal recycles, times for additional material to be received from offsite, etc. The real time data gives operations the maximum time period possible to respond and react to changes.

- October 24th, 29th, 30th and 31st were flagged due to high changes in MET on these days. Discoloured water and precipitation events were of note during imbalance event identification. Working with the on-site team these events were tracked to rain events or incoming water with an unusual color. Understanding what exactly happens on days of these will inform plant decision makers with this critical information showing wastewater conditions are changing and impacting biological performance. Smoothing out these events or moving them to more favorable time periods could significantly improve plant performance. Understanding what exactly happens on these days will inform plant decision makers with critical information showing wastewater conditions are changing and impacting biological performance. Smoothing out these events or moving them to more favorable time periods could significantly reduce operational costs.

- Data from SENTRY could be used to reduce the quantity of on-site water quality analysis, saving costs for the facility while simultaneously providing an improved monitoring solution for the process.

General Site Information

The sensor was installed at a municipal wastewater treatment plant in Budapest, Hungary. The treatment system is an Organica (www.organicawater.com) Food Chain Reactor (FCR) with combined returned MLSS. The plant consists of a primary clarifier, two anoxic tanks, six aerobic tanks, clarification, post nitrification and post denitrification. The plant treats as much as 80,000 m3/day, approximately 1/3rd of the municipal flow from Budapest. Anaerobic digestion is done at the facility, with the filtrate returning through sand traps and then back into the primary clarifier.

Figure 1. Installation of SENTRY system at primary clarifier.

SENTRY Installation and Testing Schedule

The SENTRY sensor ORG01 was installed in the primary clarifier (L5-L6) on October 10th, 2018 through November 12th ,2018. The sensor and panel were installed on the moving bridge on the primary clarifier. The moving bridge rotates approximately once per hour. The primary clarifier occasionally experiences blackening of the wastewater, hypothesized by Organica staff to be issues associated with increased hydraulic loading to the plant providing additional stress to the anaerobic digestion filtrate return. While the sensor itself turned black as shown in Figure 2, the sensor continued to function normally.

Figure 2. Left picture of clarifier during "blackening" event, right is picture of SENTRY sensor installed in that waste-water.

Results

MET and TCOD, fCOD, and TBOD5 sampling data

Organica team members took grab samples on-site which were analyzed for TCOD, fCOD, and TBOD5. Samples were taken taken between 9 am and 4 pm. Figure 3 below shows MET (blue line) and TCOD, fCOD, and TBOD5.

Manual wastewater sampling can be a useful method to understand changing wastewater conditions but when compared to a real-time monitoring solution the lack of detail and insight becomes very obvious. The MET data highlighted daily cycles in activity and correlated well to increasing and decreasing concentrations of COD and BOD5.

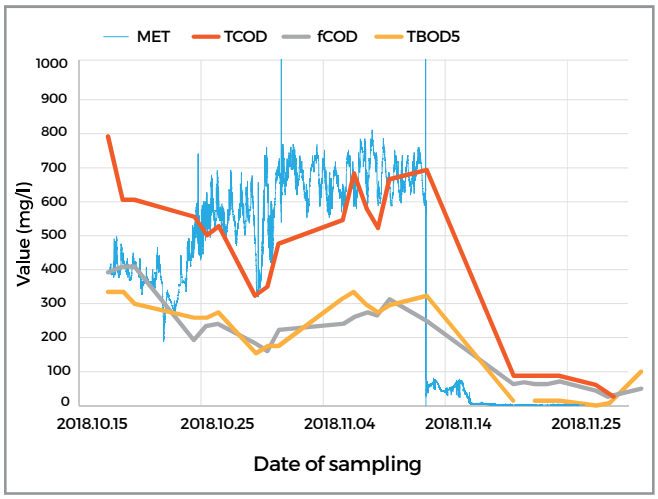

Figure 3. Measurement results from the influent and effluent sampling

Correlations of MET to water quality measurements can vary. It is important to note that microbial electron transfer (MET) readings are impacted by numerous factors (e.g. pH, toxicity). For this study we identified R2 values > 0.9 when comparing TBOD5 for influent and effluent wastewater samples.

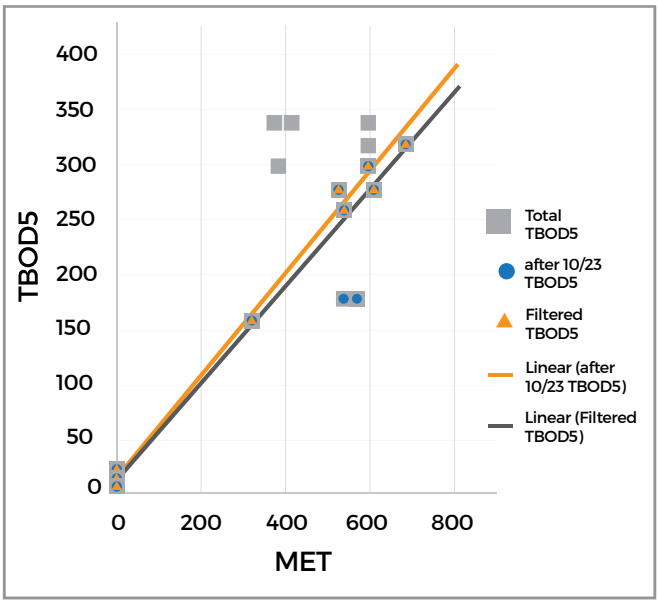

Figure 4. Correlations of MET to water quality

Signal Decomposition

Signal decomposition is a powerful tool that can be utilized with large data sets to create the "trends" of the data. The trend and repeating values represent a moving model of what is expected from the data, while the remaining information is used to show periods not explained by the created model.

The weekly trend showed that the MET was higher during the week from Wednesday to Friday and decreased on Saturday and Sunday with lowest activity on Monday and remained low on Tuesdays. Further analysis of data showed that typically higher activity at midnight was followed by a decrease for approximately 6 hours. Then there was a small peak around 8 in the morning, followed by the lowest activity around noon. The MET started to reach the maximum point after 5 in the evening.

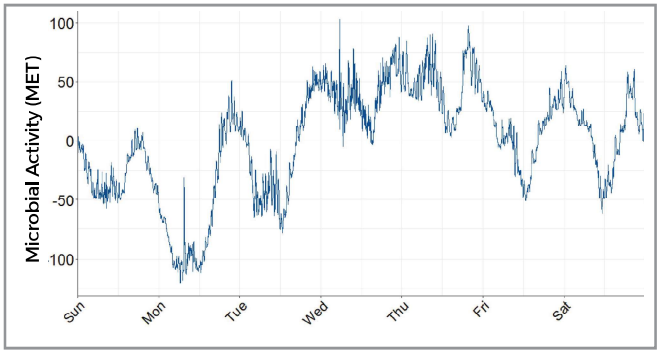

Figure 5. Weekly trend for the MET in influent

High Percent Change Events

It is typical at many wastewater plants to be impacted by changing influent wastewater conditions. One of the most typical events that triggers process imbalance is heavy rain and storm water entering the wastewater treatment plant.

During study five imbalance events were detected using the SENTRY platform. Investigation by on-site staff revealed that these days had high precipitation events or the incoming wastewater was flagged as unusual in water colour. As an example Figure 6 shows the MET over the course of the day on October 29 and 30. The MET for the next week (but same weekday) is added to for visual comparison. On Monday October 29 there was rainfall, and there was a significant decrease in MET showing the dilution effect of the storm water. The MET on this day was generally lower compared to Monday (November 5), and there was 51% change in MET during the day.

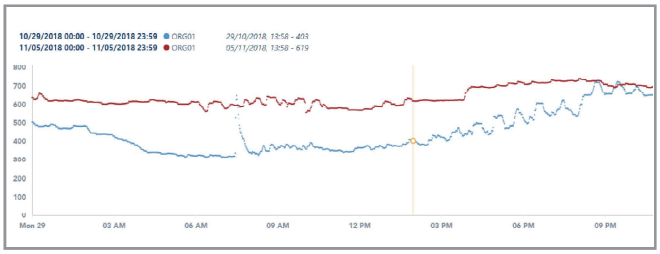

Figure 6. High change in MET on October 29 (blue line). November 5 (red line, one week later) is added for comparison.

The SENTRY platform was demonstrated as an effective tool in alerting on-site operators to high rain events that had a negative impact (reduced activity of 51%) on the biological activity in the process. This alert can prime operators to be on the watch for issues with biological wash-out, toxic impacts or for effluent quality impacts.

Potential Cost Savings

Based on the successful application of the SENTRY platform there are key opportunities for cost saving at the wastewater treatment facility.

(1) Understanding Organic Loading:

Monitoring days with large percent changes in MET can help flag known and unknown events where excess organic carbon is entering into the system. Tying these back to known events (e.g filtrate return) and looking to optimize the timing of this return can even out biological activity and system performance. If these loading events turn out to be external industrial contribution, further investigation of the timing and frequency of their dumping process could start the framework for them to (a) do additional treatment, (b) change their discharge schedule or (c) look to reimburse the municipality for the cost to treat their abnormal wastewater. A better understanding of what and when organic load is coming can be a useful tool to an operator in optimizing the downstream WWTP process.

(2) Daily / Weekly Patterns:

Understanding the typical "repeating" weekly pattern of the signal allows operators to further understand the carbon being fed into the bioreactors. Combining this data with ammonia or TKN measurements can fine tune the expected ratios required for BNR optimization. Managing additional loads outside of the typical wastewater influent (ex. internal plant recycles, processing stored loads, receiving additional septage/WAS, etc.) to maintain a stable BOD/TKN ratio should increase plant performance and consistency. This aggregated data can allow operators to predict the best times of day and days of the week to (a) take additional organic loads / septage / WAS while maintaining high levels of treatment, (b) schedule maintenance cleaning and downtimes for the plant around when the plant is being less loaded

(3) Early Warning for Effluent Issues.

Trends in the influent can be used to predict when / if the operators can expect there to be potential discharge quality issues on the effluent. If operators get alerted in real-time to imbalance at the front end of the facility it now gives them every opportunity to fine tune plant performance to ensure discharge is within compliance limits. By receiving pro-active alerts that can predict downstream events, operators have increased opportunity to remedy potential treatment issues before they result in discharge issues and potential fines.

Conclusion

The SENTRY bio-electrode technology is validated as a real-time monitoring platform for biological activity in municipal wastewater treatment plants. The sensor is demonstrated to function from influ-net, bioeactor and effluent tie-in locations. The sensor output was correlated to measure BOD concentrations in the influent and effluent of a plant with the MET value also valued for indicating the changes of biologically degradable materials in the water.

The following potential commercial use-cases were defined for the sensor:

- Protection of WWTP in industrial parks from industrial discharges, used to monitor discharge from industrial users discharging to the system.
- Used by industrial users to control their own discharged effluent.
- Used for sophisticated process control (e.g. aeration or carbon/chemical dosing optimization).