TOC Online Analytics – Protecting the Environment and the Plant

TOC in Wastewater Treatment

For processes in a wastewater treatment plant to be controlled correctly, the relevant parameters are measured at a range of measuring points. The results are generated partly using laboratory methods for documentation purposes, as well as using online methods for process control. One of these parameters is total organic carbon (TOC), a sum parameter that measures the content of organic substances in wastewater. It is helpful to be able to determine TOC using analyzers at various stages in the treatment process.

The online measurement of TOC in the influent acts as an early warning system, which is important in wastewater treatment plants with a high proportion of industrial wastewater. Through the use of appropriate buffer tanks, the activated sludge of the biological cleaning stage can be protected against the introduction of high loads of organic compounds (refer to Example 1). An online TOC measurement in this area requires a particularly robust measuring device in terms of tolerance to problematic components such as fats, particles, and fibers.

A measurement during the primary sedimentation can be used to control and optimize the dosing of nutrient materials in wastewater with an unfavorable C:N:P ratio (too much carbon). A measurement in the effluent of the wastewater treatment plant documents compliance with official regulations 24 hours a day (refer to Example 2).

Organic Load: TOC – COD – BOD

The quantity of organic compounds in a wastewater sample is usually measured indirectly based on the biological oxygen demand (BOD), the chemical oxygen demand (COD), or directly via the TOC. The much shorter analysis time means that the TOC can be measured online and is therefore the only one of the above parameters that can be directly used for process control.

Many of the parameters required for compliance with official regulations are regularly analyzed internally or in an external laboratory. However, mixed samples or representative grab samples are often only tested between one and three times a day, and in some circumstances they're testd even less frequently. At best, a qualified measurement result is available hours later. In the case of the BOD, results are sometimes not available for several days. Further, the mixed and grab samples do not provide any information about the actual concentration profile of a parameter. If the limit value is exceeded or if there are possible problems in the plant, these are often discovered too late or not at all. Online analytics is a reliable tool for continuous monitoring of the wastewater flow. It is used to supplement routine laboratory analysis as well as for open-loop control of the treatment process.

Although the COD is still the decisive guideline value for the organic load in wastewater, in many countries the COD limit value can be replaced by the TOC limit value on arrangement with the authorities. In this case, a specified limit value for COD is then usually considered compliant if the TOC is no more than a quarter of the COD. This means that in addition to its function as an early warning system in the influent, an online TOC measurement can also be used for the documentation of limit value-related measurements in the effluent.

TOC: Analysis Methods

TOC analyzers are mainly differentiated by the type of oxidation method used. The basic instrument setup is fairly similar: a liquid sample is removed, and the sample is acidified to remove the inorganic carbon. The organic carbon components are then oxidized to form carbon dioxide (CO_2) and measured using an infrared detector in accordance with ISO/CEN EN 1484. The result is a carbon concentration value (mg/L). The oxidation of the organic components can be performed in various different ways:

- By high-temperature digestion, where all organic matter in the sample is incinerated at 650 °C, or 1,200 °F (supported by a catalyst).
- By wet chemical digestion with UV light using a powerful oxidizing agent, such as persulfate.

However, both methods meet their limitations when the water contains a certain load, e.g. due to fats, oils, salts, or a high particle content. This leads to contamination and deposits on the UV lamp or oven, and eventually causes drift and frequent maintenance intervals.

The patented Two-Stage Advanced Oxidation (TSAO) technology of the Biotector TOC analyzer, in which hydroxyl radicals are used as a powerful oxidant, not only achieves complete and reproducible oxidation of the sample, it is also immune to interference from the substances described above. Thanks to the self-cleaning oxidation technology, the service frequency of the Biotector can be six months or greater, which means that continuous process monitoring at the wastewater treatment plant is always guaranteed. The oxidation method is suitable for the analysis of both raw wastewater in industrial applications, which sometimes contains extreme loads, as well as the purified wastewater in the wastewater treatment plant effluent.

Example 1: TOC Measurement in the Influent Using Biotector B7000

Cooperation between a meat processing plant and municipal wastewater treatment plant

In this case, the company indirectly discharging the wastewater is a large meat processing company. With 5,400 employees and 24/7 operations, the company processes approximately 15,000 pigs per day at this location. This produces around 0.52 MG/d of wastewater, which in turn results in 200 tons of sludge (80 tons following dehydration). The discharge of wastewater is continually monitored to ensure maximum utilization of the wastewater treatment and to prevent overloading.

The wastewater treatment is outsourced to the local authority wastewater treatment plant, allowing the company to focus on its core business and optimally dedicate its space and resources to production. In 2013, significant increases in production reached a point where the company had to think again about wastewater treatment. The company commissioned an engineering consultancy to work out the best way to overcome the following requirements:

- A system that detects the loads in the wastewater at an early stage, therefore enabling capacity planning for wastewater treatment, and ultimately making sure that production runs smoothly
- Increase the capacities of the local wastewater treatment plant or use them more efficiently, without increasing the workload in their own company

They therefore needed a low-maintenance system with a reliable measuring process enabling the operators to guarantee reliable operation of the treatment plant 24 hours a day. Overloading the treatment plant with fractions that go unnoticed could slow production in the plant or even bring it to a complete stop. The head of production formulated the requirements as follows: "The local authority wanted continuous process monitoring in order to exclude any surprises or emergency situations."

The engineering consultancy drafted a solution in which the Biotector B7000 TOC analyzer was installed in the treatment plant in order to enable precise, reliable TOC measurement in the wastewater flows from the company. The analyzer was installed in a separate "analyzer house" (Figure 1) close to the buffer tank. The whole installation was financed by the company – an unusual but intelligent approach that benefits the company and the local authority in equal measure.

Figure 1: Installation of the Biotector B7000 in the analyzer house

Thus, the company receives an ongoing professional service for wastewater disposal in order to use its own production to maximum capacity. The local authority benefits from a reliable and precise measuring instrument thereby allowing them to optimally control the processes within the treatment plant. As a result, both organizations can focus fully on their core competence. Once a week, the company receives the TOC measurement values from the treatment plant to compare against their own data. Peak loads detected by the Biotector are used to store the water arriving from the company in a buffer tank. In general, the buffer tank is used to a maximum of 80 %, which means a minimum reserve of 20 % is always available for possible extreme cases. If the COD limit is reached, an alarm starts and the engineer on duty can decide whether to direct the wastewater to the buffer tank, or in extreme cases, to halt the supply of wastewater from the company. However, the preventive and risk-averse solution described here has meant that this emergency has not occurred.

The treatment plant also treats wastewater from other industrial operations. The solution developed within this partnership enables clear allocation and regulation of the treatment capacities available to the company.

Example 2: TOC Measurement in the Effluent with Biotector B3500s

Municipal wastewater treatment plant

The treatment plant was built in 1982 and extended in 1992 with the addition of a third treatment stage. The plant is designed for a total of 15.2 MG/d. The actual wastewater load from the local municipal area averages around 7.1 MG/d. In addition to municipal wastewater, the plant also treats carbon-rich wastewater produced by the de-icing of aircraft at a nearby major airport, which uses de-icing agents containing glycol.

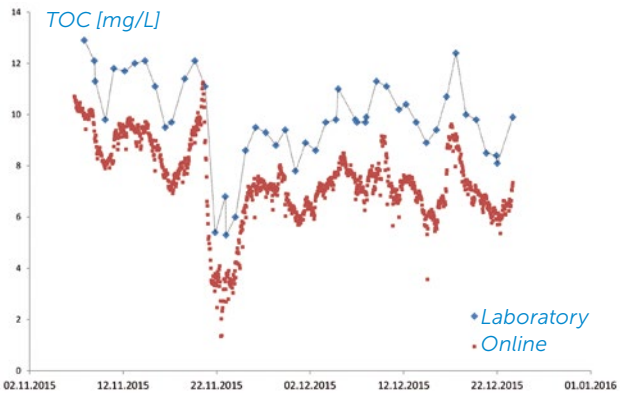

Figure 3: Online TOC measurement values from the B3500s compared with laboratory measurement values. The difference results from the incomplete removal of inorganic carbon in the laboratory test

According to the regional authority requirements, the TOC content must be continuously monitored in the effluent of wastewater treatment plants that handle ≥4.8 MG/d. Since part of the organically bound carbon exists in undissolved form, the measurement of TOC concentration requires the introduction of a representative solid fraction, and the sample must be homogenized by ultrasonic digestion in accordance with ISO/CEN EN 1484. Analysis of a filtered or sedimented sample would lead to incorrect measurement results.

Until 2013, the TOC content of water in the plant effluent was measured by a Toctax analyzer in combination with the Sigmatax ultrasonic homogenizer. While this instrument combination was robust and easily maintained, it had become outdated and was replaced by the Biotector B3500s analyzer and the Sigmatax 2 homogenizer, which had already demonstrated reliability in combination with other analyzers. Following a trial installation, in which the measurement data of the Biotector B3500s (Figure 2) was compared with laboratory measurement values and the measured values from the old instrument over a period of four weeks, the system was seamlessly transitioned to permanent operation.

Figure 2: View of the measuring room with Hach® analyzers for TOC, phosphate, and ammonia, including sample preparation

Figure 3 shows the results of the hourly online measurements performed from November 6 to December 23, compared to the laboratory measurements performed on a two-hour mixed sample. In this figure, a relatively constant difference of approximately 2 mg/L TOC can be detected between the laboratory values and the online measurements. The primary cause of this difference is the hard water in the intake area of the treatment plant, i.e. a high concentration of inorganic carbon (total inorganic carbon, or TIC). The degree of hardness of 18°dH corresponds to approximately 38 mg/L TIC. Before each actual TOC measurement, the inorganic carbon must be removed by acid treatment and extraction of the resulting carbon dioxide. In this laboratory test, neither the amount of acid used nor the exposure time is sufficient to fully remove the large quantity of inorganic carbon. This results in a higher value compared to the online measurement value because, in the online measurement, the TIC is fully removed.

The Biotector B3500s also works with reliable TSAO technology that has been tried and tested under the harshest conditions. Preventive service and maintenance work is only required on the instrument once every six months. Even the reagents only require refilling once a year, which reduces the maintenance requirements and operating costs to a minimum. The combination of the homogenizer that guarantees representative sampling and the B3500s therefore delivers reliable TOC measurement values for the treatment plant and the regulatory authority in compliance with all standards.

Further TOC Applications

One well known industrial application is the use of TOC analytics in dairies. Here, the measurement between production and the wastewater treatment plant is not only used to monitor the load on the treatment plant, but also acts as an early warning system for the early detection of product loss, e.g. caused by defective pipes.

TOC is monitored in the cooling water of power stations and other plants that generate steam. This enables leaks to be detected promptly and the necessary countermeasures to be implemented.

TOC analytics is also suitable for the monitoring of process water, for example, to monitor contamination in the rinse water from bottle cleaning in the beverage industry, making more effective use of the water and ensuring it is only replaced when necessary.

Technical details and additional information is available on hach.com

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