A variety of indicators can be used to measure the level of organic contamination of a sample, or simply the quantity of organic compounds contained in it. But one of these parameters is on the advance: total organic carbon (TOC). In analyses of drinking water and waste water as well in the pharmaceutical and chemical industries, the TOC provides information about the sample's contamination level. Its talents don't end there, however, even extending to applications in electronics production where it can be used to monitor organic additives in electroplating baths. The requirements placed on TOC measurement by the various industries are varied. The new ADI 7010 TOC Analyzer from Metrohm Applikon enables rapid, precise online process control of the TOC in liquid samples. Using the example of waste water analysis, this article will give you an introduction to the measuring parameter TOC.

It all adds up

The TOC denotes a sample's total content of organically bound carbon. As a sum parameter (see information box on the next page), it provides an easy, quick, and accurate way of assessing the amount of organic substances in a sample. Depending on the context, increased quantities of organic substances facilitate microbial growth, but also damage machinery and cause unwanted byproducts to develop.

TOC measurement is more than simply a shortcut to determining the total amount of organic substances in a sample: given the sheer number of different organic compounds present in samples such as waste water, it is all but impossible to identify and quantify every single one – and this fact makes sum parameters like the TOC not only convenient, but the only way of coming to a conclusion about organic contamination in such samples.

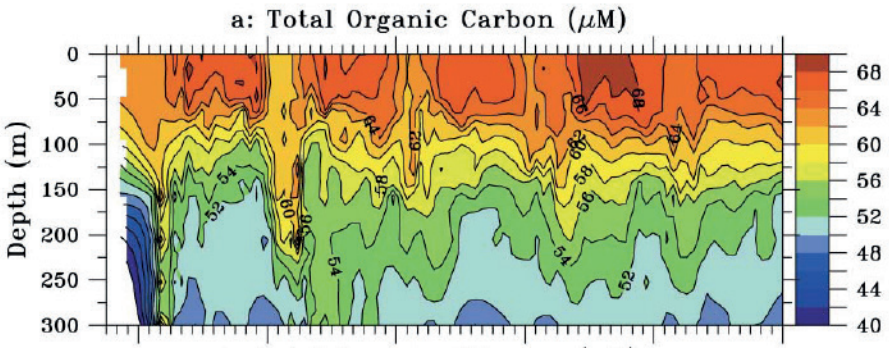

Figure 1. The TOC is used in many applications; an example from biogeochemistry is illustrated here. The contour diagram shows the TOC distribution in the surface layer of the Sargasso Sea. The purpose of these TOC measurements is to gain a better understanding of the carbon cycle in sea waters. Source: Hansell, D.A. and C.A. Carlson (2001) Deep-Sea Res. II 48, 1649–1667

TOC in urban waste water

There are other measuring parameters besides the TOC that can be used to estimate the organic load affecting a sample. For urban waste water treatment, two of them are of particular importance: Firstly, the biochemical oxygen demand (BOD_5) which refers to the volume of oxygen that microorganisms in one liter of water consume within five days. And secondly, the chemical oxygen demand (COD), whose measurement requires toxic reagents containing chromium – and if particularly precise determination is required, then mercury compounds have to be used in addition. By comparison, the TOC offers impressive advantages, from its far less toxic reagents to its short analysis times to the option of continuous online determination.

While EU directive 91/271/EEC does refer to the BOD_5 – stating that it may not exceed 25 mg/L in discharges from urban waste water treatment plants – it also explicitly allows the TOC to be determined instead, if it is possible to establish a relationship between the two parameters. The advantage of this is that determining the TOC involves considerably fewer resources. The COD, meanwhile, continues to play an important role in monitoring wastewater treatment.

About

Sum parameters are measured quantities that combine various substances present in a medium on the basis of a common feature – this might be a particular element, as is the case with the TOC (where carbon is the element concerned). It is possible to calculate sum parameters if the composition of the sample being analyzed is known. For instance, the TOC can be calculated from the type and the quantity of all organic substances present in a sample of waste water – if these are known. Conversely, however, a sum parameter cannot be used to make any deductions about its components, unless the measurement was carried out by taking the rather more circuitous route of determining the individual components. What makes sum parameters advantageous is that, instead of involving a whole range of parameters, they provide an immediate way of determining the very property of a sample that is of interest – and do so in a single measurement.

Figure 2. The ADI 7010 TOC Analyzer for continuous TOC monitoring directly within the process

Replacing the COD

In some countries, for example Germany, it is possible to replace the COD with the TOC as well, but this is not a straightforward process. The difficulty lies in the fact that there is no universal correlation factor: depending on the compounds in which carbon is present, the correlation factor can range from < 1 to 4. As a result, the COD cannot be readily deduced from the TOC, meaning that there is no immediate way of monitoring compliance with the COD limit value of 125 mg oxygen per liter of water.

Common practice in Germany is that the COD limit value can be deemed as being adhered to if the TOC amounts to no more than a quarter of it. Switzerland, on the other hand, expressly requires the TOC to be determined instead of the COD during routine inspections; the ban on using mercury compounds means that it is not possible to use COD determination as a substitute method[1].

Other industry sectors

The TOC has become an indispensable measurand in numerous industry sectors, with uses extending beyond quality control of products and the components that make them up. In the pharmaceutical industry, for instance, the TOC is used as part of cleaning validation procedures in production plants. In power plant analytics, it sheds light on the quality of boiler feed water, acting as a criterion in determining whether purified condensates can be fed back into the water-steam cycle. And at airports, the TOC is used to monitor the organic load of the waste water from aircraft deicing which is due to residual deicing agent.

TOC determination not only plays a part in enhancing product quality – it also helps to make processes more efficient and cut down on costs.

References

[1] http://www.bafu.admin.ch/publikationen/publikation/00413/index.html?lang=de

New

The new ADI 7010 TOC Analyzer from Metrohm Applikon (Figure 2) enables continuous online TOC measurements in liquid samples. Other standout features are:

- Measuring range: 0–5 mg/L to 50,000 mg/L
- Autoclean, autocalibration, and autovalidation functions
- Integrated gas management
- Automatic carrier gas checks
- Long service life thanks to sturdy materials

For more information on the ADI 7010 TOC Analyzer, see the brochure (*document number: 8.000.5113*) and visit our website.