TOC Removal in Drinking Water Applications

Problem

The intake/raw water taken from rivers, lakes, aquifers and reservoirs contain organic contamination and naturally occurring organic matter (NOM). When raw water is chlorinated for the disinfection process, residual chlorine reacts with the organics. Due to this, potential carcinogens, known as disinfection by products (DBPs), such as trihalomethanes (THMs), are formed.

Solution

The NOM, which is the precursor of DBP formation, can be measured by total organic carbon (TOC) analysis. The Hach® BioTector B3500dw Online TOC Analyzer, which is developed specifically for the drinking water industry, optimizes the monitoring and the removal of organics based on real time TOC measurements. BioTector utilizes an advanced oxidation technology, which is a US EPA approved method, and supplies accurate and reliable detection of organics, assisting and ensuring optimal water treatment process.

Benefits

BioTector's reliable TOC analysis leads to efficient TOC removal from raw water, and helps optimize the chlorination and the coagulant/flocculent feed within the water treatment process. BioTector's efficient oxidation process, accurate analysis and rapid response provide stability in the treatment process; prevent overdosing and unnecessary treatment, and deliver cost savings.

Background

The measurement of NOM in raw waters has been critical for municipal drinking water plants. The chlorination, carried out in the presence of NOM during the disinfection process, forms DBPs, which are potential carcinogenic compounds and have adverse health affects to humans. Chlorine, hypochlorite, ozone, chlorine dioxide, and chloramines are some of the most common chemicals used during the water disinfection process.

There is a direct correlation between the TOC and the NOM. Therefore, online TOC measurement is an efficient method to determine and to control the NO for the prevention of DBP formation. Lowering the organic levels in the raw water, and controlling the TOC removal by accurate and reliable TOC analysis, increase the efficiency of the treatment plant, reduce costs, and provide safe drinking water.

On July 19, 2016, the Hach TOC Method 10261, used in Hach BioTector B3500dw, became an official method within the Federal Register, as published in Federal Register, Volume 81, Number 138.

The method uses an advanced oxidation process and non-dispersive infrared spectroscopy. In this method, ozone and a high pH reagent are added to water to produce hydroxyl radicals. The hydroxyl radicals oxidize organic carbon to produce carbon dioxide and sodium oxalate. The sodium oxalate is further oxidized to carbon dioxide using acidification and a manganese catalyst. The carbon dioxide produced by both oxidation processes is then measured using non-dispersive infrared spectroscopy. Unlike the conventional approved oxidation method, Standard Method 5310 C-00 (APHA 2000b), which may not completely oxidize certain organic compounds, the Hach Method 10261 uses a more efficient advanced oxidation process to ensure more complete oxidation.

How Does TOC Removal Work?

The DW, "Drinking Water," program in BioTector B3500dw analyzers allows the user to program site-specific drinking water parameters for the display and reporting of the "% TOC Removal" and the "Pass/Fail" results.

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D W    P R O G R A M      0 9 : 1 7 : 2 8    2 2 - 0 6 - 1 6

  1 <    D I S P L A Y                              Y E S
  2      D E T E N T I O N   T I M E                3 2 m
  3      T O C    <          2 . 0   m g C / L          0 %
  4      T O C    <          4 . 0   m g C / L       3 5 %
  5      T O C    <          8 . 0   m g C / L       4 5 %
  6      T O C    >          8 . 0   m g C / L       5 0 %
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Figure 1: DW "Drinking Water" Program

Table 1

DISPLAY	**YES**	DISPLAY function allows the user to program the DW "Drinking Water" parameters, which are % REMOVAL and PASS/FAIL RESULT. When DISPLAY is programmed as "YES", the system displays the % REMOVAL and PASS/FAIL result parameters on screen. The relevant 4-20 mA signals for REMOVAL (in %) is also sent to the relevant result output channels.
DETENTION TIME	**32m**	When the display of the DW "Drinking Water" parameter is activated with the DISPLAY function, BioTector calculates the % REMOVAL values using the measured TOC results on STREAM 1 (SAMPLE 1) and STREAM 2 (SAMPLE 2), which must be installed and connected to the INLET and OUTLET streams, respectively. DETENTION TIME is a site specific time interval, during which the water flows through the water treatment plant or a treatment system to achieve a certain level of organic removal (in %) from the inlet stream (STREAM 1). This time must be programmed on site depending on site specific process conditions and requirements. BioTector uses this time to synchronize the inlet and outlet TOC measurements for the calculation of % REMOVAL. The % REMOVAL (organic removal) value is calculated as follows: REMOVAL (%) = { [(STREAM 1 TOC Result) – (STREAM 2 TOC RESULT)] / (STREAM 1 TOC Result) } * 100 Note that STREAM 2 (OUTLET) TOC result in above equation, is the STREAM 2 result, which is evaluated by the system after the completion of the DETENTION TIME described above. When display of the drinking water parameters is activated, the % REMOVAL values are displayed on the Analysis Data Screen and also in the reaction archive menus. TOC < (LESS THAN) XmgC/L and X% values define various concentration levels at which
TOC < 2.0 mgC/L	**0%**	
TOC < 4.0 mgC/L	**35%**	
TOC < 8.0 mgC/L	**45%**	
TOC > 8.0 mgC/L	**50%**	

	a certain % REMOVAL must be achieved for a PASS or a FAIL condition. When the TOC result is measured for the INLET stream (STREAM 1), BioTector evaluates the TOC result for the OUTLET stream (STREAM 2), which is available at the end of the DETENTION TIME, and based on the measured concentration levels, the % REMOVAL value is calculated. If the calculated % REMOVAL value is less than the corresponding expected % level programmed in this menu, BioTector displays FAIL as the RESULT on the Analysis Data Screen and records into the reaction archives. If the calculated % REMOVAL value is greater than the corresponding expected % level programmed in this menu, BioTector displays PASS as the RESULT on the Analysis Data Screen and records into the reaction archives. For example, when the TOC result of the inlet stream (STREAM 1) is 3.4 mgC/L at a given time during online operation, this result falls into the "TOC < 4.0 mgC/L 35%" category in this menu. If the outlet stream (STREAM 2) result available after the completion of the Detention Time, which is 32 minutes in this example menu, is 2.1 mgC/L, the % REMOVAL value is 38.2%. As the 38.2% is greater than the defined 35% at this category, this is a PASS condition, because the defined minimum % organic removal from the inlet stream is achieved. If the outlet stream (STREAM 2) result is 2.8 mgC/L, the % REMOVAL value is 17.6%. As the 17.6% is less than the defined 35% at this category, this is a FAIL condition, because the defined minimum % organic removal from the inlet stream is not achieved. In other words, in this example and programmed category, the TOC result of the outlet stream (STREAM 2) available at the end of the Detention Time, must be less than 2.21 mgC/L for a PASS condition.

Why is BioTector Better?

Most TOC analyzers in the market were designed initially as laboratory systems. These systems were then converted to online analyzers using the same conventional TOC technologies. Therefore, the laboratory analyzer limitations, and conventional TOC issues, are carried to online systems.

The Hach BioTector B3500dw analyzer is designed and developed as a true "online" analyzer, solving the industry needs and requirements. This approach results in a system providing accurate and reliable operation.

BioTector utilizes a chemical oxidation process, which takes place at atmospheric pressure and at ambient temperatures. The analyzer is built from robust materials such as Teflon, Hastelloy and stainless steel. The analyzed liquid is discharged from the reactor in liquid phase without any build up. The reactor is self-cleaned by the oxidation process.

BioTector provides stable and accurate response on samples containing high levels of inorganic carbon. It has a certified 99.86% uptime. The system requires minimal maintenance in six month intervals. The significant cost savings in maintenance, the low cost of ownership of the analyzer, the self-cleaning technology, and the superior uptime, makes the system the most reliable TOC analyzer in the market.

Conclusion

DBPs are formed during water treatment process by the reaction of chemical disinfectants with NOM, which are the most significant DBPs precursors. All commonly used chemical disinfectants (e.g. chlorine, chlorine dioxide, chloramines and ozone) react with organic matter to form different DBPs such as THMs, which are one of the most common DBP.

The Hach BioTector B3500dw Online TOC Analyzer helps control the TOC removal process with accurate and reliable real time measurement of organics. BioTector TOC analysis helps optimize the disinfectant feed, provide stability, and deliver cost savings in the water treatment process.

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