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# Monitoring Of Specific Ultraviolet Absorbance (SUVA) In Drinking Water Treatment to Optimize Chemical Usage and Minimize DBP Formation

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**Abstract:** The raw water taken from the surface and ground sources may contain natural organic matter (NOM) and other organic contaminants. When source water is chlorinated for the disinfection process, residual chlorine can react with the organics forming disinfection by products (DBPs), such as trihalomethanes (THMs), that are regulated due to potential carcinogenicity. NOM can be classified into two fractions: hydrophobic or hydrophilic. The hydrophobic materials tend to form higher THMs levels, while the hydrophilic fraction is a relatively poor precursor. The specific UV absorbance (SUVA) is a measure of the dissolved organic carbon (DOC) concentration available to form DBP concentration. SUVA values correlate well with the aromaticity and the hydrophobicity of the DOC and hence with the THM formation potential. Therefore, SUVA can be used to optimize the drinking water treatment processes aimed at organics removal to reduce DBP formation.

**Keywords**: Coagulation; DPB; Monitoring; NOM; SUVA

## INTRODUCTION

Drinking water comes from many different sources such as rivers, lakes, aquifers, and man-made reservoirs. Treatment processes for source water varies widely depending on the source itself, as well as the impurities of the source water. One of the most prevalent impurities in source water is organic material. Organics in source water come from naturally occurring organic matter (NOM) as well as introduced organics coming from pollution. Organic materials in drinking water affect the color, taste, and odor of water. In addition, during the disinfection process, residual chlorine can react with the organics to form disinfection byproducts (DBPs), such as trihalomethanes (THMs) and haloacetic acids that are potentially carcinogenic. Humans can be exposed to DBPs through consuming water, showering, and even inhaling the vapors. DBPs, especially trihalomethanes, could potentially lead to adverse health effects to humans. For this reason, the amount of DBPs permitted in drinking water is tightly regulated in most countries and geographies.

## MATERIALS AND METHODS

Chemical treatment typically is applied prior to sedimentation and filtration to enhance the ability of a treatment process to remove particles. Two steps typically are employed: coagulation and flocculation. Enhanced coagulation is the phase used to define the process of improved removal of disinfection byproduct (DBP) precursors by conventional treatment. The effectiveness of enhanced coagulation is normally expressed in percent reduction in total organic carbon (TOC) for regulatory purposes.

The efficiency of particulates and organics removal by clarification and filtration processes depends highly on preceding coagulation.

Dissolved NOM is the major DBP formation precursor and is converted into particles by adding coagulation chemicals followed by either direct precipitation or by adsorption onto flocs. NOM can be classified into two fractions: hydrophobic and hydrophilic. In surface water, hydrophobic acids, rich in aromatic carbon, are described as humic substances and constitute the major NOM fraction, more than half of the dissolved organic carbon (DOC) in water. Hydrophobic (water repelling) fraction of organic matter has a high SUVA characteristic of humic substances. The aromatic hydrophobic humic materials tend to form higher THMs levels.

Hydrophilic (water absorbing) fraction of organic matter is composed of primarily fulvic material, such as carbohydrates, and is a relatively poor THM precursor.

To avoid or minimize the formation of DBPs, it is important to monitor and measure NOM. The monitoring of NOM in raw water is also a first step to respond to events and it helps to calculate the capacity of a treatment process. A well-established method for monitoring organic load is to measure UV absorbance at 254 nm, as many organics absorb UV light at that wavelength. The common parameter for characterization of NOM is the TOC, which can be measured online and in the lab. While UV absorption detects only dissolved matter and double bonded carbon, TOC provides a quantitative result for total organic load in your water.

Previous studies established a relationship between SUVA (Specific UV Absorbance) and the levels of humic substances (Aromatics). Utilizing this relationship allows for a cheap and easy method to determine the enhanced coagulation process performances. SUVA is an excellent indicator of the humic content, as well as the molecular weight distribution of NOM in the water. SUVA correlates well with the aromaticity and the hydrophobicity of the organic carbon and hence its potential to form THMs. SUVA measurement is therefore a good predictor of general chemical characteristics of DOC, such as its aromatic content. Theoretically, SUVA determination requires measurement of DOC, however, in most DW applications the difference between TOC and DOC is negligible. The equation for determination of SUVA is presented in Figure 1.

$$\text{SUVA} = \text{SAC254 (cm-1)} / \text{DOC (mg/l)} * \frac{1000\ (\text{mm})}{\text{OPL}\ (\text{mm})}$$

**Figure 1** Formula for calculating SUVA values, where DOC can be replaced with TOC results.

Therefore, the system utilized for this test and other similar studies comprised a UV sensor and an online TOC analyzer, Figure 2.

**Figure 2** Test setup with an online TOC analyzer with a 140-micron filter integrated in the sample line, an online UV sensor (UVAS), both connected to a controller with integrated calculation of the SUVA.

The value of SUVA is generally interpreted according to the following guidelines:

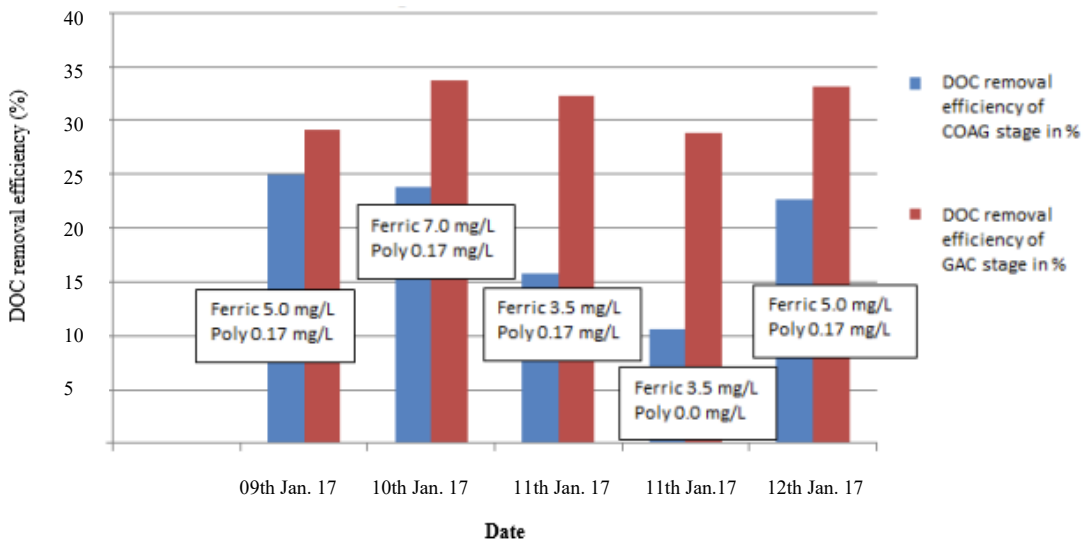
- For source water with SUVA of 4 or greater, the NOM composition is dominated by humic substances, therefore high TOC values and percent reduction are expected.
- For source water with SUVA of 2 to 4, the water contains a mixture of hydrophobic humic and hydrophilic non-humic substances. Intermediate TOC values and percent reduction are expected.
- For source water with SUVA of 2 or less, indicate a high fraction of hydrophilic non-humic substances and low TOC values and percent reduction are expected (GAC filters may need to be employed).

RESULTS AND DISCUSSION

The test conducted at a DW facility in UK using conventional treatment of surface water included two online instruments: Hach UVAS (UV-254) sensor and BioTector TOC analyzer (Fig. 2) measuring raw water intake. The instruments were connected to a Hach sc1000 controller programmed to calculate SUVA. The grab samples taken after the coagulation phase and after GAC filter (post-media filtration) were analysed for TOC using the grab sample port of the BioTector online analyzer. The SUVA values were used to correlate DOC percent removal with various feed rates of the coagulants and to optimize the dosage based on the test results.

For the raw water intake, SUVA showed low levels of organics at approximately 2.2 mgC/Lm. The organics removal efficiency of the coagulation stage with the given ferric dosing rate and polymer addition was constantly below 30% (TOC/DOC reduction). In the test the dosing rate was varied to monitor the SUVA response and confirm strategy for enhanced coagulation. Both ferric and polymer dosing rates were adjusted during testing, Table 1.

**Table 1** DOC removal efficiency for the stages COAGULATION / GAC.




As seen in Table 1, the increase of the ferric dose from 5.0 mg/L to 7.0 mg/L (+20%) did not improve the DOC removal efficiency by coagulation (-1%), while some improvement was observed after the GAC. The reduction of the dosing rate from 5.0 mg/L to 3.5 mg/L (-15%) provided a noticeable reduction of the DOC removal efficiency (-9%). Interesting that with stopping any polymer dosing the DOC removal efficiency dropped even further (-5%) or to -14% from the original dosage rate. The DOC removal efficiency of the combination of coagulation,

sand and GAC filters showed more consistent results. This is an indication that the sand and especially GAC filtration compensated a decrease in DOC removal efficiency of the coagulation phase. However, elimination of the polymer dosing at coagulation stage showed a reduction of DOC removal efficiency even after the filtration phase of the water treatment process.

## CONCLUSIONS

A correlation between the SUVA at inlet of the water plant and the coagulant dosing rate was established. Specific to this test site, the additional polymer dosing may have a significant impact on the removal of small particles, which cannot be removed by ferric alone. All findings point to the suitability of enhanced coagulation process control based on SUVA measurement.

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