**Natural Organic Matter Removal through Full-scale Sand-ballasted Clarification**

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**Learning Objectives:**

1. Examine the performance of sand-ballasted clarification (SBC) in municipal drinking water treatment
2. Determine organic carbon removal through SBC using traditional water quality parameters, such as TOC, and UV absorbance
3. Investigate natural organic matter (NOM) removal through SBC using a novel technique, liquid chromatography-organic carbon detection (LC-OCD)

**Extended Abstract**

**Introduction**

The removal of NOM in drinking water treatment is important to ensure the safety and aesthetic quality of water, as NOM contributes to colour, taste and odour, increased coagulant and disinfectant demand, and biological regrowth in distribution systems (Jacangelo et al., 1995). Specific NOM fractions, such as humic substances and biopolymers, can also affect downstream drinking water treatment processes. Humic substances have been shown to act as precursors to potentially harmful disinfection by-products (DBPs), while biopolymers have been associated with causing membrane fouling (Hallé, 2009; Singer, 1999). As such, investigations were undertaken to determine the efficiency of sand-ballasted clarification (SBC), trade name ACTIFLO™, for NOM removal. SBC is a high-rate clarification process which employs microsand to act as a seed and ballast for floc formation, and has previously been shown to produce water of equal quality to conventional coagulation processes (Desjardins et al, 2002).

**Material and Methods**

This study was undertaken at the Holmedale Water Treatment Plant (HWTP) in the City of Brantford, Ontario, Canada, over 14 consecutive months, to investigate the performance SBC for NOM removal. The HWTP consists of SBC, ozone, biofilters, UV disinfection, chlorination and chloramination. Water
samples were collected from the raw water, and after the following treatment processes: SBC, ozone, biofilters and chlorine. NOM fractions were characterized using a novel technique, liquid chromatography-organic carbon detection (LC-OCD), which fractionates NOM into five fractions through size exclusion chromatography (Huber et al, 2011). The five NOM fractions determined include biopolymers (high molecular weight compounds such as proteins and polysaccharides), humic substances, building blocks (breakdown products of humic substances), low molecular weight (LMW) acids and humics, and LMW neutrals (Huber et al, 2011).

In addition to using LC-OCD, NOM removal was also quantified using standard water quality methods, such as total organic carbon (TOC), ultraviolet absorbance at a wavelength of 254 nm (UVA$_{254}$), and specific ultraviolet absorbance (SUVA). TOC was quantified using a wet oxidation method. UVA$_{254}$ provides a measure of the aromatic compounds, such as humic substances, as they are known to strongly absorb ultraviolet radiation (Standard Methods, 2012). SUVA on the other hand provides an indication of the proportion of aromatic compounds in the dissolved organic carbon (DOC), and is calculated by dividing the UVA$_{254}$ ($\text{m}^2\text{L}^{-1}$) by the DOC (mg/L) (Standard Methods, 2012).

**Results and Discussion**

Analysis of NOM fractions, using LC-OCD, determined that humic substances made up the largest fraction of the raw water DOC, that of 57% in the raw water. The SBC process was responsible for the most considerable removal of biopolymers and humic substances through the HWTP, achieving 53% biopolymer removal and 41% humic substance removal. The building blocks, LMW acids and humics, and LMW neutrals were removed by between 11 and 15%.

Standard water quality methods demonstrated that SBC was able to remove 29% of influent TOC, contributing to the greatest removal of TOC through the HWTP (Figure 1). The removal of TOC observed through SBC was greater than that required by the USEPA National Primary Drinking Water Regulations: Disinfectants and Disinfection Byproducts based on the HWTP raw water TOC and alkalinity, which would require 25% TOC removal using enhanced coagulation (USEPA, 1998).
Results from UVA$_{254}$ analysis demonstrate that SBC was able to achieve a 44% UVA$_{254}$ reduction. This reduction is similar to the removal of humic substance observed through SBC, of 41%. Although the UVA$_{254}$ was significantly reduced, the SUVA was only reduced by 19% and remained above 2. The minimal change in SUVA is due to the decrease in both the UVA$_{254}$ and the DOC, which results in a minimal change in SUVA. Based on the guidelines developed by Edzwald and Tobaison (1999) for NOM, the SUVA of the raw water suggests that the composition of NOM is a mixture of aquatic humics, and other NOM, and that DOC removal through coagulation should be fair to good.

**Conclusions**

Overall, this study demonstrated that considerable removal of NOM was achieved through SBC at the Holmedale water treatment plant. LC-OCD provided a unique look into the removal of various NOM fractions, and results demonstrated that through SBC, biopolymers were removed by 51% and humic substances by 43%. The removal of these NOM fractions are of particular importance, as they have been shown to impact downstream processes, by fouling membranes (biopolymers) and acting as DBP precursors (humic substances). SBC also contributed to considerable TOC (29% removal), and UVA$_{254}$ (43% reduction).

**Disclaimer**

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