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Causes and consequences of the variations in natural organic matter properties

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Natural organic matter (NOM) is commonly contained in surface water bodies, including those that serve as sources for drinking water treatment plants (DWTPs). The composition of NOM may be very diverse, and can be further divided into humic substances (HS) and algal organic matter (AOM). Recently, increasing content of AOM is becoming a challenge for many DWTPs, owing to the global proliferation of cyanobacteria and algae. This phenomenon is most often attributed to climate changes and enhanced input of nutrients to aquatic environments.

We investigated the evolution of NOM character in a selected water reservoir (located in the Vysočina Region, Czech Republic), that serves as an irreplaceable drinking water source, for a period of 12 years (starting in the year 2006). Besides the quantitation of NOM, it was divided into fractions according to its character, i.e., VHA (very hydrophobic acids), SHA (slightly hydrophobic acids), CHA (charged hydrophilics), and NEU (neutral hydrophilics). Within the observed timescale, the relative proportion of VHA and SHA (that both belong to HS) decreased, while CHA and NEU (associated to AOM) significantly increased and comprised majority since 2016. Additionally, seasonal variations were also observed. This points out to the rising occurrence of phytoplankton in the reservoir, while its seasonal dynamic must not be neglected.

To elucidate the dependence of AOM properties on the species and the growth phase, we investigated the composition of AOM produced by green alga, diatom, and cyanobacteria. They were grown under laboratory conditions and harvested at different growth phases; extracellular and cellular AOM (EOM and COM, resp.) was investigated separately. The distinct AOM fractions were analysed in terms of peptide-protein and non-proteinaceous content, hydrophilicity/hydrophobicity, specific UV absorbance (SUVA), and molecular weights (MW). In general, both EOM and COM of all the species was mainly hydrophilic and had low SUVA values; however, the proportions of peptides-proteins and non-proteinaceous fraction and MW distribution greatly differed. For example, EOM and COM of the cyanobacteria (Microcystis aeruginosa and Merismopedia tenuissima) contained larger portions of peptides-proteins and had wider MW distributions than the green alga (Chlamydomonas geitleri) or the diatom (Fragilaria crotonensis). Changes were observed also along their growth phase.

Additionally, we studied coagulation behaviour of the distinct NOM fractions (i.e., HS versus AOM, and also AOM peptides-proteins and non-proteinaceous fraction separately), since coagulation is an essential treatment steps at most DWTPs supplied by surface waters. It has shown that the non-

proteinaceous fraction (corresponding to NEU) is the most difficult to coagulate (max. removal efficiency of 25%), while the removal of AOM peptides-proteins (corresponding to CHA) reached up to approx. 80%. HS were removed with 65% efficiency. It is of note that substantial optimization of coagulation conditions (especially the dose of coagulant and coagulation pH) was a nuisance, and that the coagulation optimums differed between the NOM fractions.

Thus, our results imply that continuous characterization of NOM is essential for an effective control over the processes at DWTPs.