

Occurrence of Transparent Exopolymer Particles (TEP) Through Drinking Water Treatment Plants

Sam Van Nevel, Tom Hennebel, Willy Verstraete, Nico Boon*

* Laboratory of Microbial Ecology and Technology (LabMET), Ghent University, Coupure Links 653, B-9000 Ghent, Belgium. Nico.Boon@ugent.be, tel +32(9)2645976, fax +32(9)2646248

Abstract

Numerous membrane fouling studies have been conducted to predict and prevent membrane fouling. It was only recently that a new parameter, TEP, was introduced in this research. The deposition of TEP on reverse osmosis (RO) membranes has already been imaged, correlations between ultrafiltration (UF) fouling and TEP concentrations have been reported. Furthermore, TEP deposition takes place in an early stage of biofilms formation, making TEP one of the accused in search for biofilm initiation factors. After literature reporting about TEP in marine, surface and wastewater, this is the first research focusing on TEP through in drinking water. Each treatment step in three completely different drinking water production plants was evaluated on TEP removal and it could be concluded that a limited restfraction or no TEP could reach the drinking water. Coagulation + sand filtration proved efficient in strongly reducing TEP levels, UF + RO can provide a total TEP removal.

Keywords

Transparent exopolymer particles, drinking water, biofouling

Biofouling is one of the major problems to face when using membrane technology. TEP is a new parameter, only since recently getting attention in this context. These are transparent, gel-like, extremely sticky particles and can be regarded as a particular fraction of EPS, dispersed in the water phase. They consist mainly of acidic polysaccharides and are predominantly formed out of exudates, bacterial mucus and sloughed off particular material from the gelatinous envelopes surrounding phytoplankton. They are found abundantly in the ocean as well as in surface and wastewater. In addition to 'particular TEP' or pTEP ($> 0.4\mu\text{m}$), colloidal TEP or cTEP (in between 0.05 and $0.4\mu\text{m}$) is studied these days. This fraction contributes for up to 90% of total TEP-concentrations (Passow, 2002; Villacorte *et al.*, 2009).

Based on the ubiquity of TEP in natural waters, the stickiness and the colonisation by bacteria, Berman and Hoenberg (2005) introduced the idea of TEP, ideally designed to induce biofouling. Once attached to a membrane surface, these particles start blocking pores and serve as both an attachment site and nutritious substrate for microbial growth. Villacorte *et al.* (2009) verified the efficiency of reverse osmosis (RO) pretreatment systems in preventing TEP from reaching the sensitive RO membranes. Micro- and ultrafiltration (MF or UF), possibly combined with sand filtration and/or coagulation were able to remove pTEP with rather good efficiency while cTEP was seldom removed for more than 50%. Moreover, this fraction can easily transform to new pTEP. It was shown that 30 up to 70% of TEP in RO-

feedwater was deposited on RO membranes in all of the investigated plants. Furthermore, Berman *et al.* (In Press) showed that early EPS deposition on membranes only originates from TEP in the feedwater instead of being excreted by active bacteria developing in a biofilm. This indicates that TEP can be an important factor in the initiation of biofilms.

To our knowledge, many reported the abundance of TEP in marine, surface, waste- and groundwater but not a single study examined the occurrence in drinking water. The limited TEP removal efficiencies reported by Villacorte *et al.* (2009) suggest that TEP can reach the drinking water. The conclusions about biofilm formation would have serious safety implications in this case, since waterborne pathogens (*e.g. Legionella*) use biofilms both for growth and protection against biocides. TEP occurrence in drinking water would give us new insights about biofilm prevention pathways and the control of *Legionella* outbreaks in drinking water systems. Besides, a measurement of TEP concentrations after each treatment step of a drinking water production plant would also give us valuable information about the suitability of these methods as RO pretreatment step for TEP removal.

Within this research, the occurrence of TEP within 3 drinking water production plants was examined. Three research questions were set up. (i) What is the importance of the water resource? (ii) What is the effect of the individual treatment steps on TEP? (iii) Does TEP appear in the final drinking water? The set-up of the examined installations and the

sampling points, as well as the measured TEP-concentrations are given in Figure 1.

The importance of the water resource? Plant A and B were fed with respectively surface water and effluent from a wastewater treatment plant (WWTP). Both contained TEP and cTEP accounted for more than 90% of total TEP concentrations. This stresses the importance of taking this fraction into account. In our measurements, TEP concentrations in plant B tripled these in plant A. In plant C, fed with groundwater, we could not measure any considerable TEP-amount. Consequently this installation is omitted in this discussion.

The effect of the individual treatment steps? In plant A, decantation was not able to lower total TEP concentrations, although the positive Al-ions neutralize the negatively charged TEP. Due to this, most cTEP is coagulated to pTEP, an easier fraction to remove. Combined hydroantracite and sand filtration managed to

do this, while in next steps, cTEP was further gradually decreased to low levels. The cTEP concentrations in these samples were too low to give a good quantification of the efficiency of every single step.

In plant B, concentrations increased after addition of chlorine. This was probably due to cell lysis and TEP release, induced by chlorine in aquatic microorganisms. In this installation, UF proved to be a very efficient TEP removal method for both pTEP and cTEP, in contrast to the earlier discussed examples of Villacorte *et al.*, 2009. RO is known to be a very powerful method and completely removed the TEP fraction, however the aquatic life in the infiltration pond caused the reappearance of this fraction. Infiltration reduced the TEP amounts again until a minimal and stable level.

TEP in the final drinking water? It can be concluded that, as stated above, only limited (plant A and B) or no TEP (plant C) could reach the drinking water.

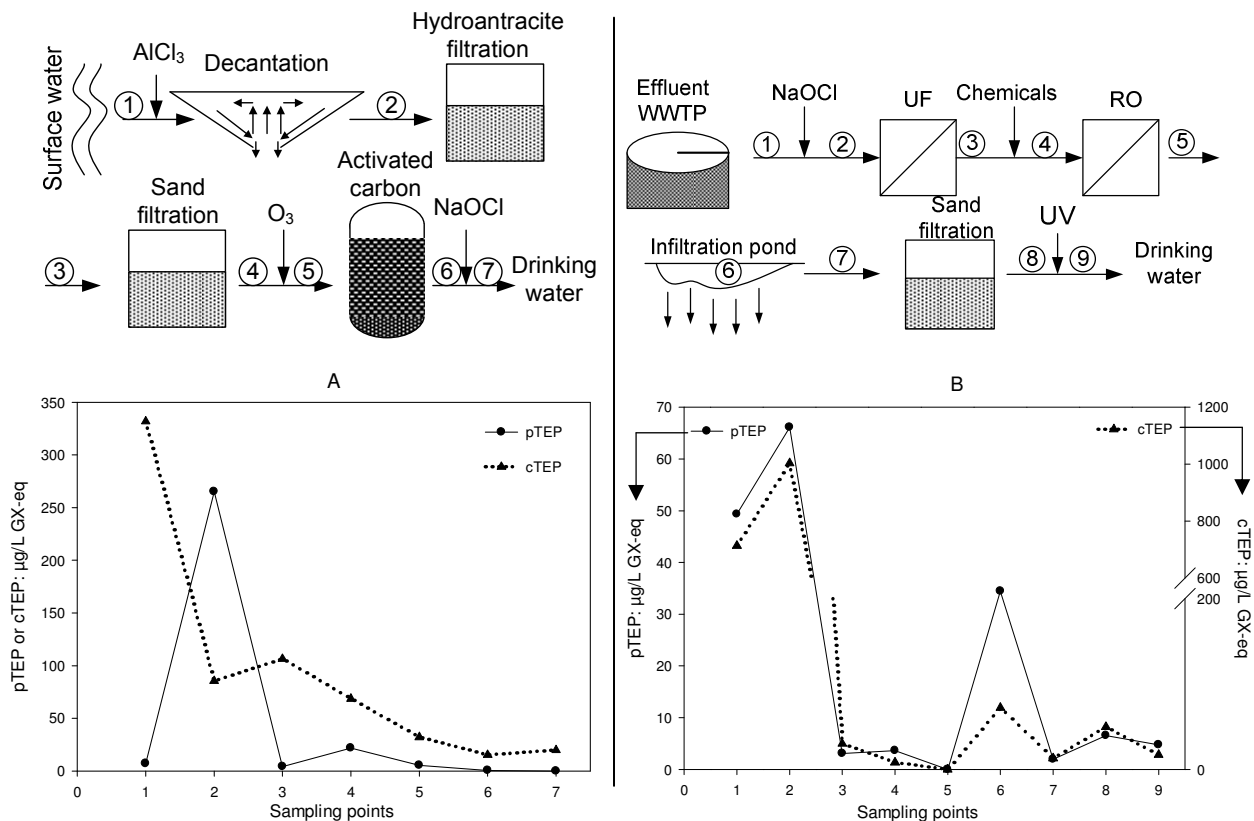


Figure 1 Schematic representation of installation A (top left) and B (top right). Sampling points are indicated as numbers in a circle. The corresponding pTEP and cTEP-concentrations at each sampling point are indicated on the graphs and are expressed in µg/L gum xanthan-equivalent.

References

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