Water treatment operations to remove natural toxins from surface water

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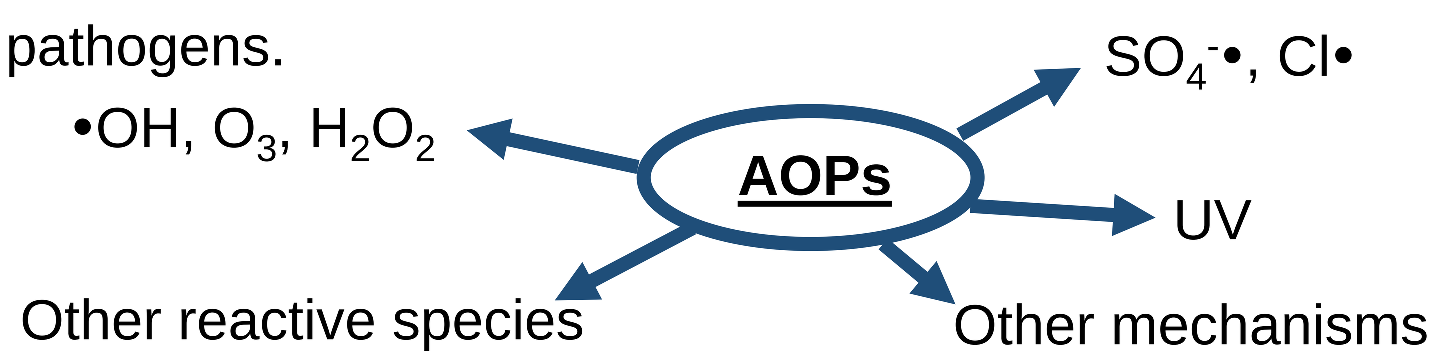
Advanced Oxidation Processes for the removal of cyanotoxins from drinking water

Cyanotoxins pose a risk to human health and surface waters intended for drinking water production. Conventional treatment methods are ineffective for the removal of dissolved toxins. Advanced Oxidation Processes (AOPs) are effective for the degradation of even recalcitrant pollutants and disinfection of pathogens.



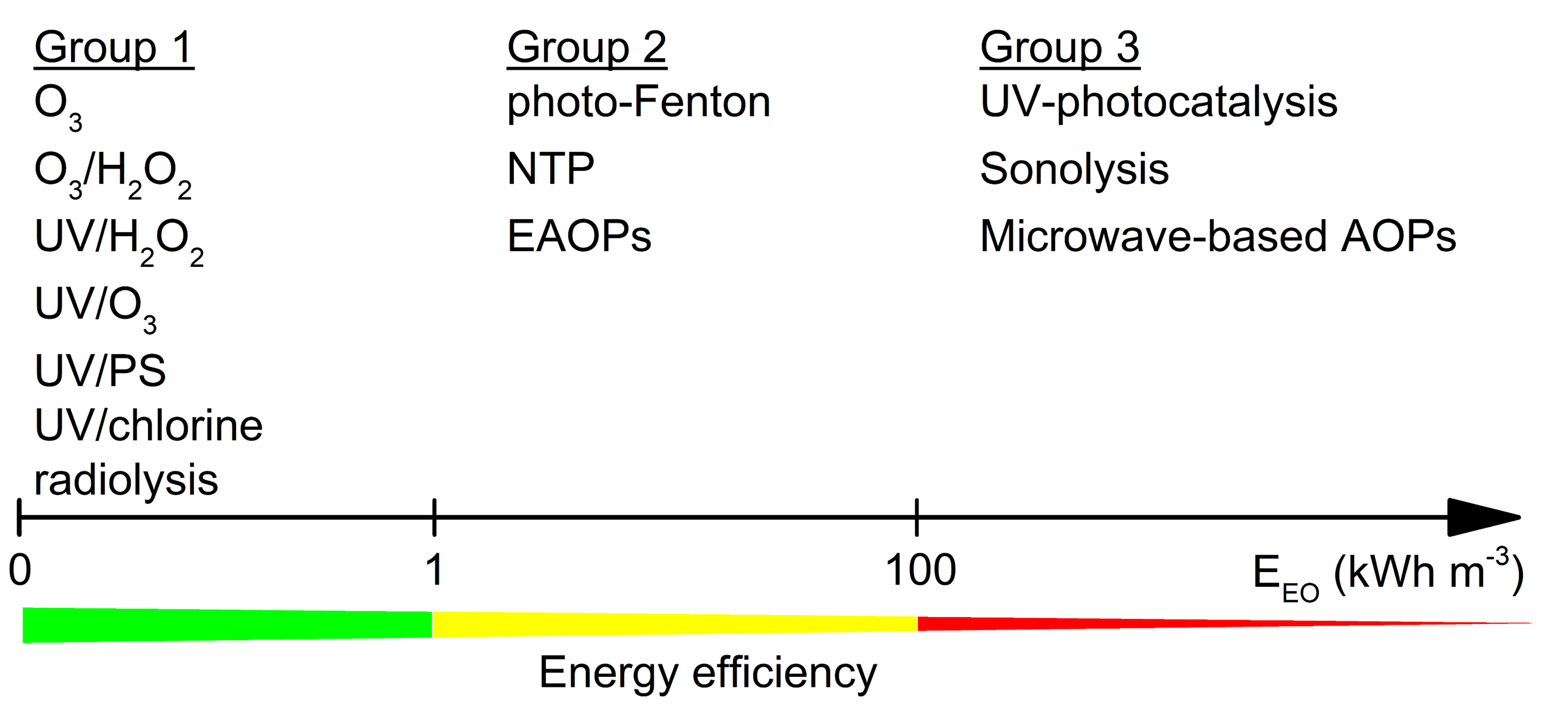
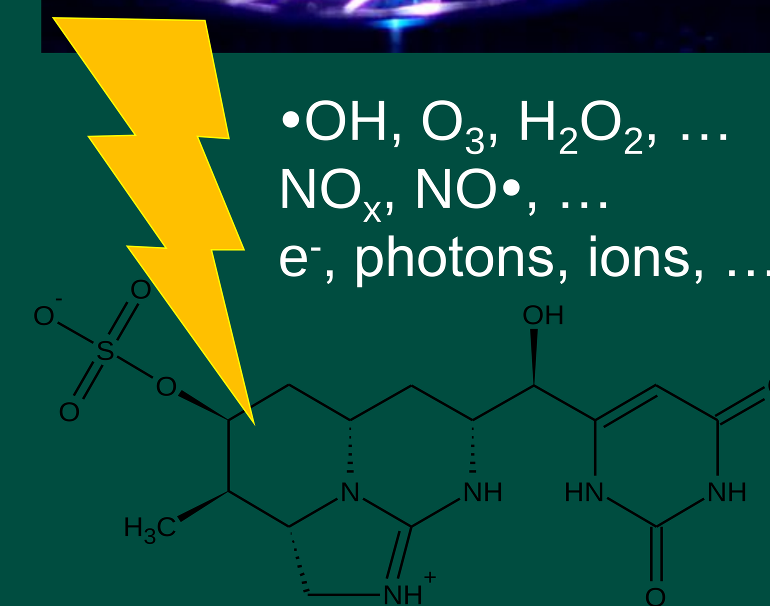


Fig. 1. Grouping of established and emerging AOPs according to their median Electrical Energy per Order (E_{EO}) values representing their energy efficiency.

AOP effectivity is strongly impacted by water quality parameters like natural organic matter, alkalinity and pH. Additionally, technique- and toxin-specific issues need to be considered, especially with regard to economic aspects. So far, treatment of toxin mixtures, treatment of real surface waters and assessment of residual toxicity are rarely addressed.

Non-thermal plasmas are a promising technology for drinking water treatment

Non-thermal plasmas are generated by electric discharges in water or in gas under atmospheric or low pressure. Even compounds persistent to conventional or other advanced treatments can effectively be degraded.



Cylindrospermopsin (CYN)

1) Comparison of six discharges

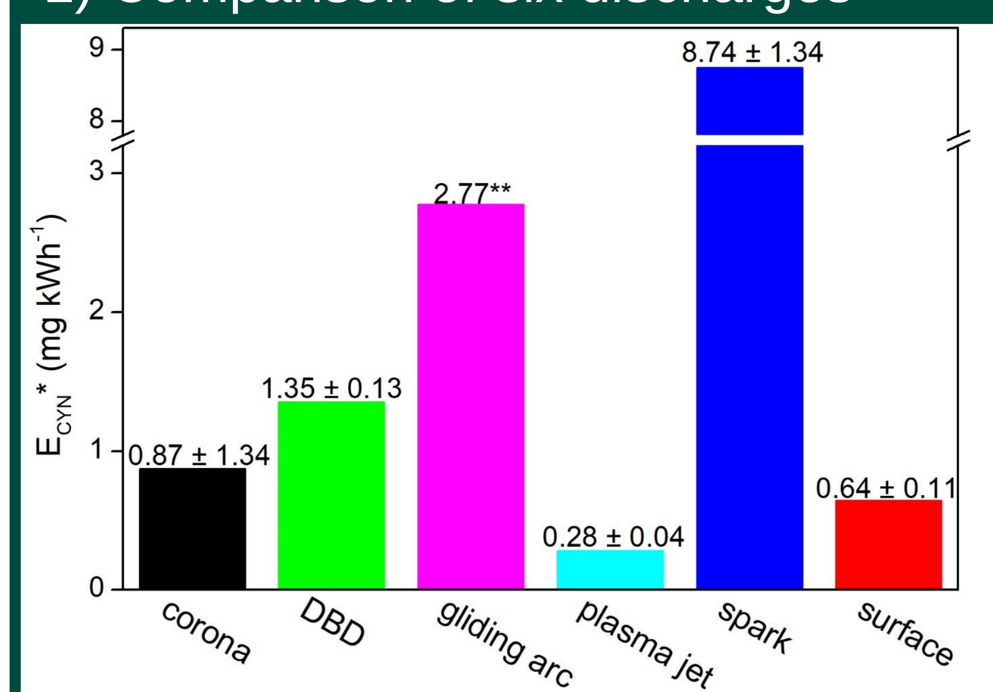


Fig. 2. CYN degradation efficacy (* E_{CYN} in mg kWh^{-1}) for six different discharges (** n = 1).

2) Detailed study of corona-like and Dielectric Barrier Discharges (DBD)

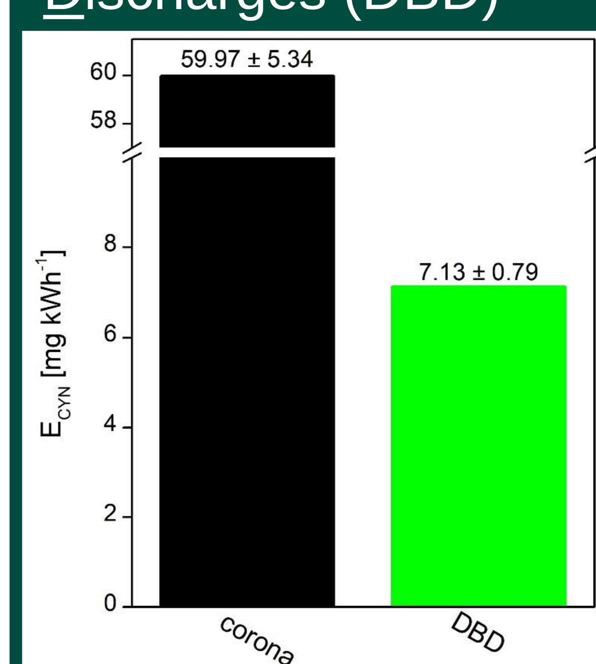


Fig. 3. CYN degradation efficacy of corona-like discharge in water and DBD in air around a water mist after optimization of operating voltage, electrode diameter and solution pH.

Degradation and detoxification of CYN by •OH and SO$_4^-$•

SO$_4^-$• is more selective and has a higher redox potential compared to •OH and is thus more suitable for water treatment across a broader pH. SO$_4^-$• can be produced in AOPs similar to •OH using peroxymono- or –disulfate as precursors. Furthermore, simultaneous production of SO$_4^-$• and •OH is possible.

Radical production in Fenton (-like) reactions:

$$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + \bullet OH + OH^-$$

$$Co^{2+} + HSO_5^- \rightarrow Co^{3+} + SO_4^-\bullet + OH^-$$

$$Ag^+ + S_2O_8^{2-} \rightarrow Ag^{2+} + SO_4^-\bullet + SO_4^{2-}$$

1) Optimization of treatment: metal to oxidant ratio, solution pH and metal/oxidant to CYN ratio

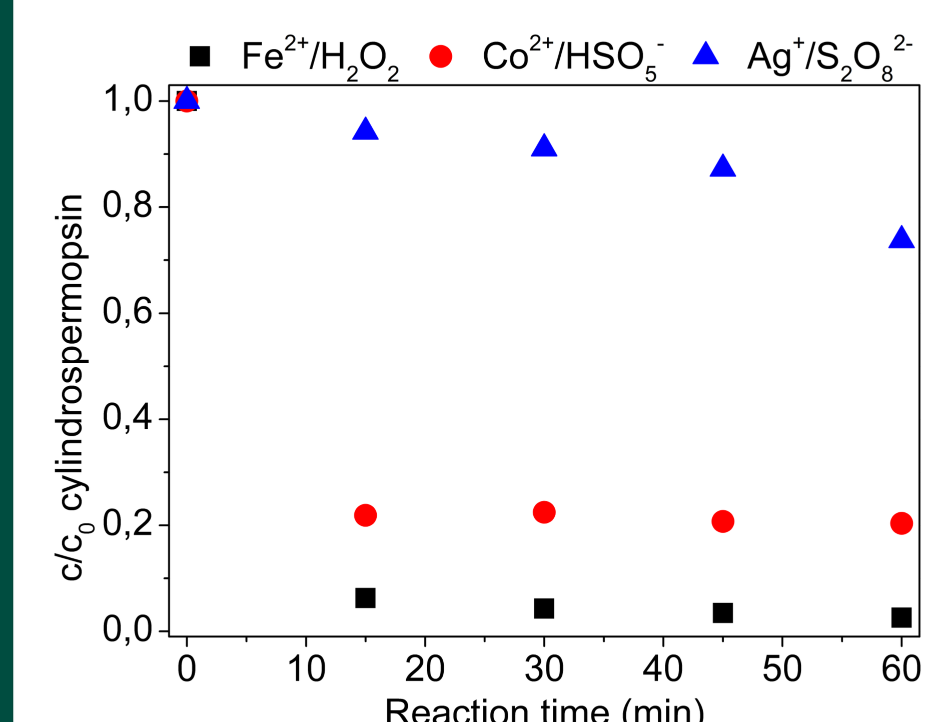
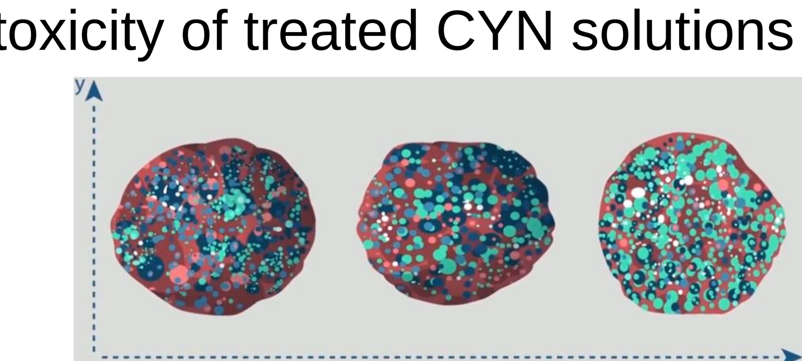


Fig. 4. CYN degradation by SO$_4^-$• and •OH produced in Fenton (-like) reactions under optimized conditions.

What to expect in the near future:

2) Identification of degradation products to study the degradation mechanisms/pathways

3) Assessment of toxicity of treated CYN solutions using hepatospheroids



Papers

M. Schneider and L. Bláha. Advanced oxidation processes for the removal of cyanobacterial toxins from drinking water (under review). *Environ. Sci. Eur.* doi (preprint): 10.21203/rs.3.rs-22199/v1.

M. Schneider et al. Cylindrospermopsin is effectively degraded in water by pulsed corona-like and dielectric barrier discharges (under review). *Environ. Pollut.*

M. Schneider et al. Comparison of six plasmas for their application in drinking water treatment using cylindrospermopsin as a model water pollutant (in preparation).

M. Schneider et al. Degradation and detoxification of cylindrospermopsin by hydroxyl and sulfate radical-based advanced oxidation processes (in preparation).

Conferences

M. Schneider and L. Bláha. Emerging treatment methods for the removal of cyanotoxins from drinking water with focus on Advanced Oxidation Processes (poster). SETAC Europe 28th Annaul Meeting 2018, Rome, Italy.

M. Schneider et al. Degradation of cylindrospermopsin using advanced non-thermal plasma technologies (oral). 11th International Conference on Toxic Cyanobacteria 2019, Krakow, Poland.

M. Schneider et al. Degradation of cylindrospermopsin using advanced non-thermal plasma technologies (oral). 16th International Conference on Environmental Science and Technology 2019, Rhodes, Greece.

Research stays abroad

Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany (2.5 mth in 2018).

St. Galler Stadtwerke, Sankt Gallen, Switzerland (1 mth in 2018).

Aigües de Barcelona, Barcelona, Spain (3 weeks in 2019).

Krüger A/S – Veolia Water Technologies, Copenhagen, Denmark (2 mth in 2019).

NaToxAq

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