Optimisation of advanced oxidation processes in view of organic (micro)pollutant removal from (waste) water in view of water reuse

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Removing organic (micro)pollutants from (waste) water is a challenging task in modern water treatment. Especially trace organic contaminants (TrOCs) occuring in the aquatic environment at concentrations in the order of ng/L to µg/L are of concern. TrOCs is a collective term for different groups of chemicals such as pharmaceuticals and personal care products, perfluoroalkyl and polyfluoroalkyl substances, polycyclic aromatic hydrocarbons, steroid hormones and pesticides. Some of these TrOCs are also known as contaminants of emerging concern (CECs) because of the lacking information about their occurrence, environmental fate and effects (Deniere, 2022). Removing these TrOCs would improve effluent quality and would increase the possibilities for reuse of this effluent.

Different techniques are put forward for the removal of TrOCs, such as membrane filtration, activated carbon adsorption and advanced oxidation processes (AOPs). Especially AOPs, such as ozonation, have already been demonstrated to be very effective for TrOCs abatement. Nevertheless, improvement of these AOPs is still possible in different domains. These include: (i) combining pretreatment with AOP processes, (ii) polishing AOP effluent with activated carbon adsorption, (iii) on-line monitoring and control of the (combined) processes, (iv) optimal use of additional chemicals for improved removal and (v) cost effective operation.

Several of these issues are addressed in this contribution. For example, the operational cost to obtain a 90% TrOCs elimination with ozonation, was reduced with 22% after applying sand filtration as pretreatment step during secondary effluent treatment (Liu et al;, 2020). Regarding the combination of ozone treatment and activated carbon adsorption, it was observed that for landfill leachate treatment, the ozonation led to a decrease of the affinity of organic matter towards adsorption. However, this does not necessarily decrease the adsorption capacity as the oxidation of organic matter by ozonation led to a reduced occupancy of adsorption sites, resulting in an improved removal of TrOCs. This is most pronounced for hydrophobic TrOCs such as alachlor and atrazine (Yang et al., 2022). The use of spectral surrogates for on-line monitoring and control is demonstrated in secondary WWTP effluent as well as landfill leachate. Fluorescence-based models are more sensitive than UVA_{254}-based models (Deniere, 2022). Related to optimal operation, it was demonstrated that using packed columns improved both ozone transfer and TrOC removal. For example, organic matter removal efficiency increased from 47% in an empty bubble column to 72% in a lava rock packed column. Simultaneously, the ozone utilization efficiency increased from 21% to 68% (Yang et al., 2021). Finally, using additional oxidants such as H_2O_2 or peroxymonosulfate increased TrOCs removal if the dosing is correctly applied.

In conclusion, important organic (micro)pollutant removal efficiency gains can be obtained by applying the above mentioned improvements during AOP treatment. Further scale-up and implementation is therefore foreseen.

References

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