The Summit of Sensor Struggles

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Practical Experiences with Controlling Ozonation in Full-Scale Quaternary Treatment for Micropollutant Removal from Municipal Wastewater

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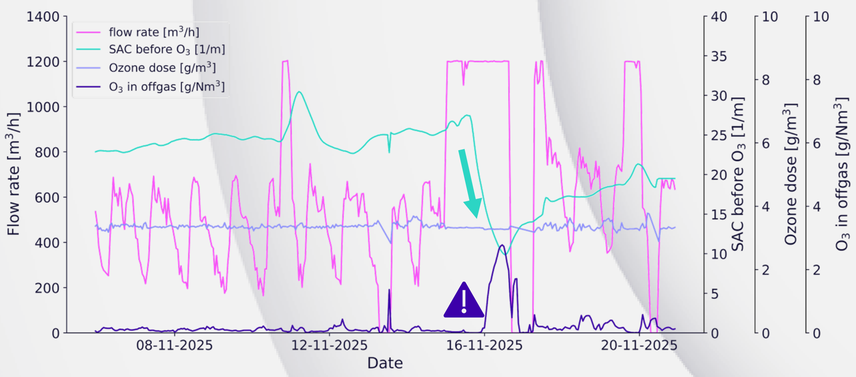
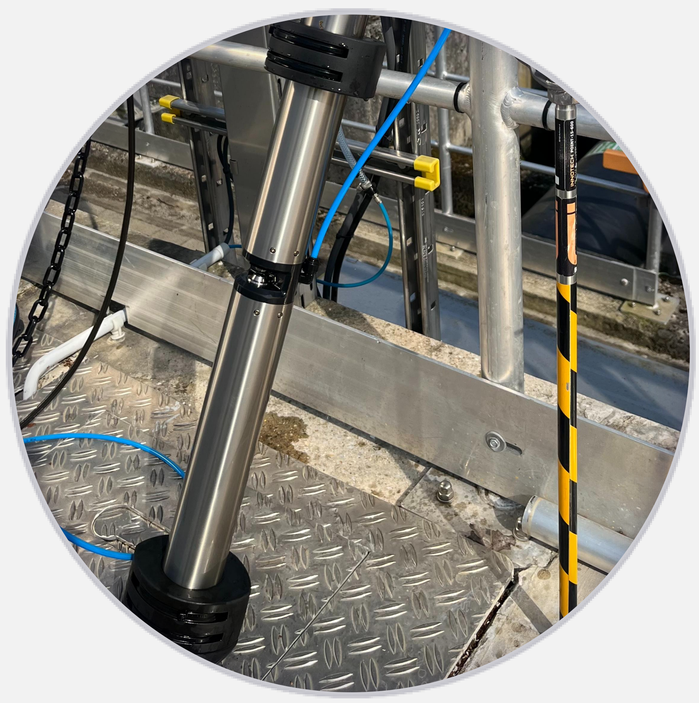
Quaternary treatment for micropollutant removal in municipal wastewater treatment plants, to meet revised Urban Wastewater Treatment Directive (UWWTD, EU 2024/3019) requirements, can be done by combining disk filtration (DF), ozone (O3) and granular activated carbon filters (AKF). Although ozonation is an effective oxidation process, its performance strongly depends on advanced control strategies, which remain challenging under full-scale conditions. Literature and lab scale research advocate online control based on dissolved organic carbon (DOC) or UV absorbance at 254 nm (SAC – spectral absorption coefficient) to account for load variability and interference. At a full-scale quaternary treatment, three UV-VIS sensors were installed at key process locations. Operational experience revealed several practical difficulties, demonstrating a gap between theoretical recommendations and operational realities in full-scale wastewater ozonation systems.

Volume based control

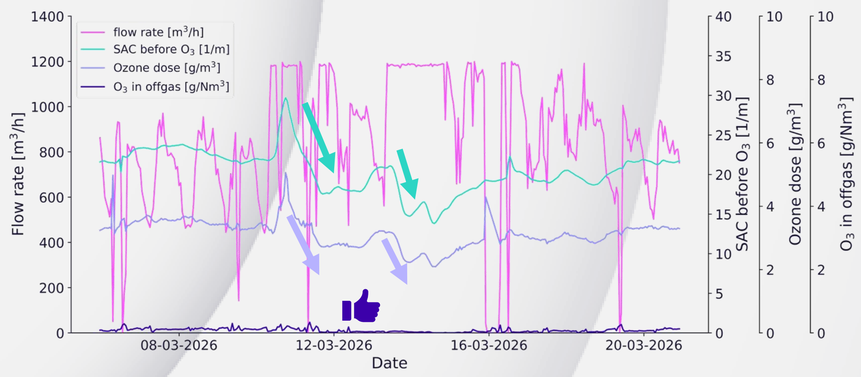
In the absence of sensor-based control, ozone dosage is typically regulated by hydraulic flow alone, neglecting fluctuations in influent quality such as first-flush peaks or dilution during high-flow conditions. This may result in under- or overdosing. Overdosing increases the risk of residual ozone emissions via effluent stripping or gas leakage, posing environmental impacts and significant operational safety hazards.





Load based control

In presence of a reliable sensor at the ozonation influent, ozone dosage can be controlled in a feedforward manner based on spectral absorbance, enabling adaptation to influent quality variations. Under diluted conditions, ozone demand is reduced, limiting overdosing and associated safety risks. Additional monitoring at the ozonation effluent enables feedback control, improving process stability and treatment efficiency.



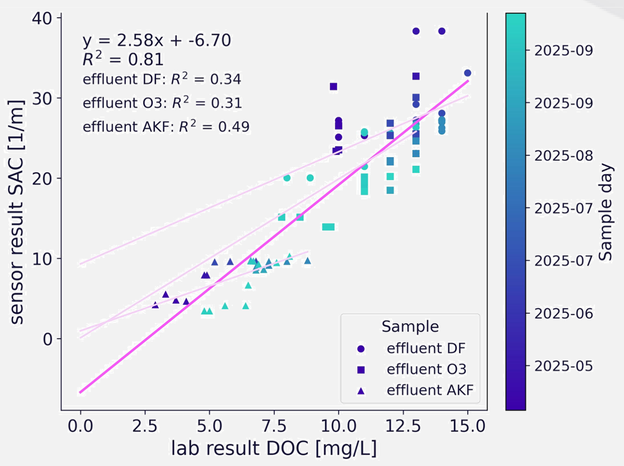
Barriers

Fouling & maintenance requirements

Fouling and drift appear within a week and after each period of high flow. Fouling is especially present with the sensor after O_3, resulting the SAC signal after O_3 to surpass the SAC signal before O_3. The sensor after O_3 had to be corrected too often so that supplier interference is now required and the sensor is out of service.

Weak DOC correlation

The correlation between SAC and DOC is weak for all the individual sensors. Although literature frequently relates ozone dosing to DOC concentrations, under practical conditions it is more appropriate to rely on SAC measurements for dosing control.



Lessons Learned

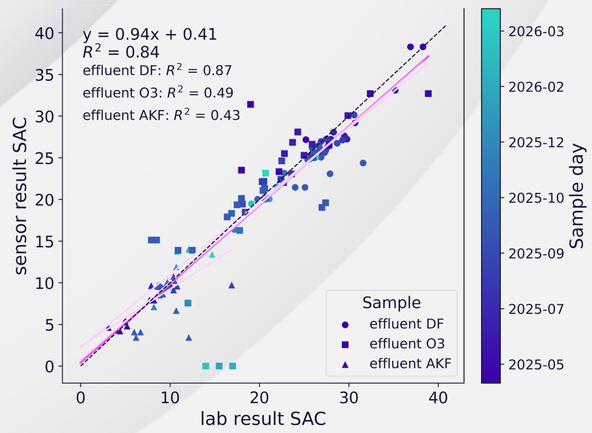
Optimized maintenance protocol

The investigated sensors are installed submerged. Available automated cleaning methods were limited to ultrasonic cleaning, showing no effect, and pressurized air cleaning, yielding a slight improvement in stability. A mechanical wiper is recommended if permitted by sensor design. A manual maintenance protocol was optimized, including weekly HCl cleaning with zero adjustment, additional cleaning after flush events, and biweekly two-point calibration checks. If feasible, bypass installation is recommended to enable frequent automated acid cleaning.

Opportunities

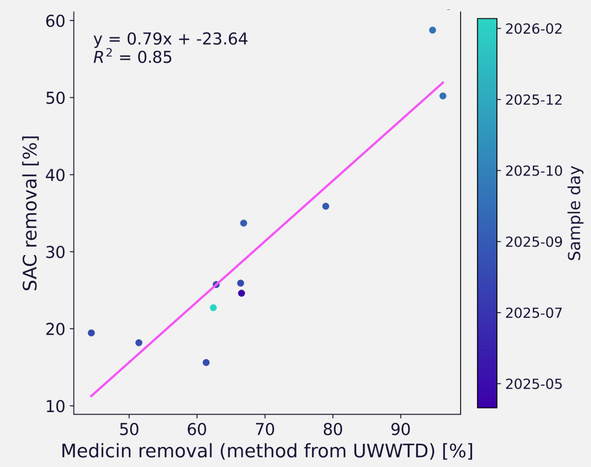
Strong SAC correlation before O_3

The sensor before O_3 (effluent DF) correlates well with lab data and can be used for dose control.



Micropollutant removal correlation

SAC and medicin removal by O_3 correlate well. This is the favourable method for dosing, if reliable sensors are available.



CONCLUSION

UV–VIS sensors represent a promising technology for ozone dose control, as they reduce overdosing and show good correlation with the removal of UWWTD indicator substances. However, practical implementation requires attention to fouling mitigation, including automated cleaning mechanisms, frequent calibration and chemical cleaning. Correlation with DOC is not recommended, as direct use of SAC provides a more robust basis for process control.

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