



Development of a non-membrane based innovative treatment approach including comprehensive assessment criteria for indirect potable reuse in urban water cycles

Project TrinkWave

Overview

TrinkWave aims to innovate a multi-barrier treatment concept for indirect potable water reuse based on sequential managed aquifer recharge technology (SMART). SMART_{plus} will manipulate sequential redox changes and primary substrate availability to stimulate microbial contaminant biodegradation (Figure 2). Additional parameters include:

- Monitoring of **viruses, antibiotic resistance, trace organic chemicals and transformation products**, focusing on human health protection;
- Identification of **novel biomolecular parameters for assessing biofilm-based treatment** systems and development of appropriate risk communication strategies;
- Selection of carbon sources and **oxidizing agents**, system longevity, downstream purification process compatibility, and operational flow rate attunement for **optimum target substance removal at minimal hydraulic retention times**;
- Results from SMART 1.0 and the TUM pilot-scale model (Figure 1) will inform the full-scale SMART_{plus} installation at the Berliner Wasserbetriebe;



Figure 1: Pilot-scale SMART_{plus} system at the Chair of Urban Water Systems Engineering at the Technical University of Munich, Germany.

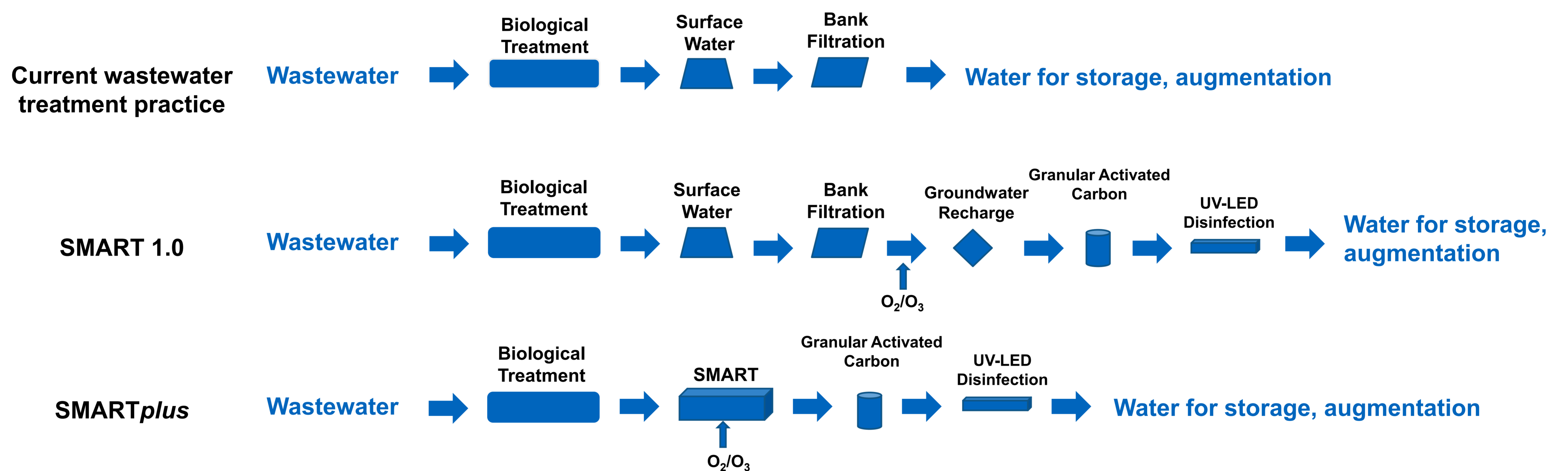


Figure 2: SMART_{plus} provides an in-situ oxidation step, reducing physical and carbon footprints of potable water reuse systems.

Goals of the TrinkWave Project:

Research goals emphasize a holistic approach to the development, implementation and approval of different alterations of SMART_{plus} processes, taking technical, economic, legislative, and societal aspects into account. In particular, the project will address the following topics:

- **Recommendations for managing** unplanned and planned potable **water reuse practices** to protect drinking water quality and public health;
- **Multidisciplinary water quality assessment framework for human health protection** with special attention to quantitative risk management;
- Alternative process combinations of **technically modified hybrid filtration systems** offering **multiple barriers for microbial and chemical contaminants**, a high level of **groundwater protection**, and high degrees of **robustness, process reliability and efficiency**;
- **Technical guidelines and validation approaches** to ensure proper performance of multi-barrier systems;
- New chemical and genetic parameters to better assess microbial degradation of novel pollutants in SMART systems;
- Recommendations for action, and risk management and communication concepts to establish sustainable potable water reuse schemes augmenting future drinking water supplies.



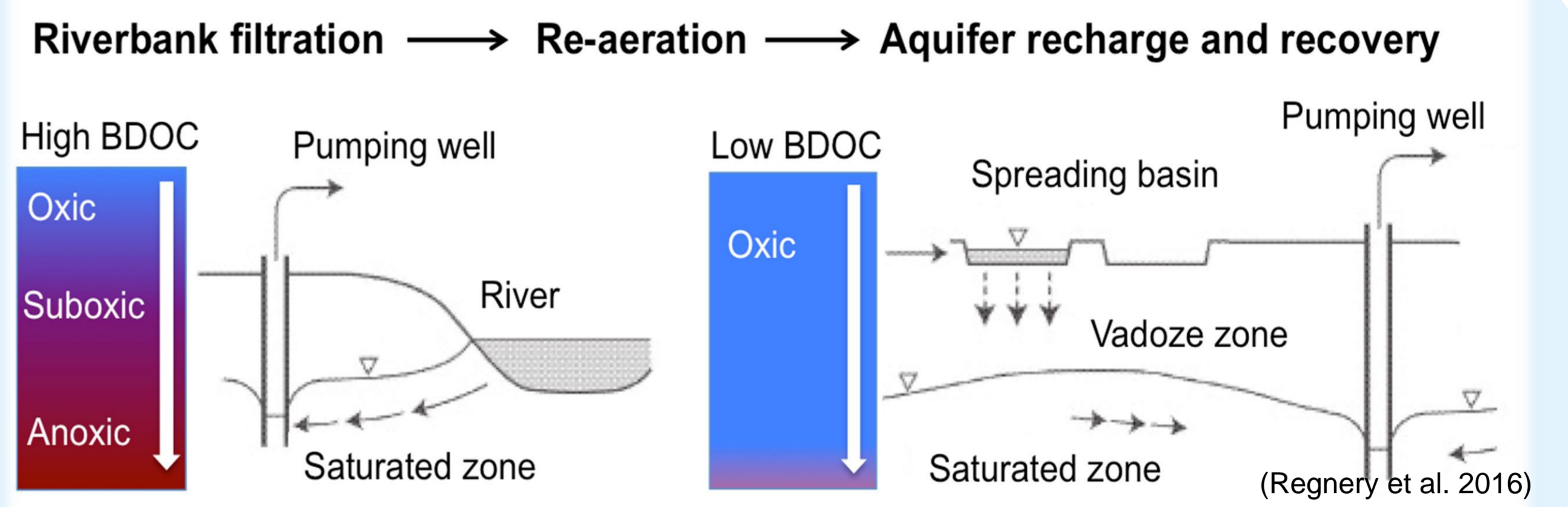
Figure 3: Point sampling and online measurements provide high resolution monitoring of the SMART_{plus} system.

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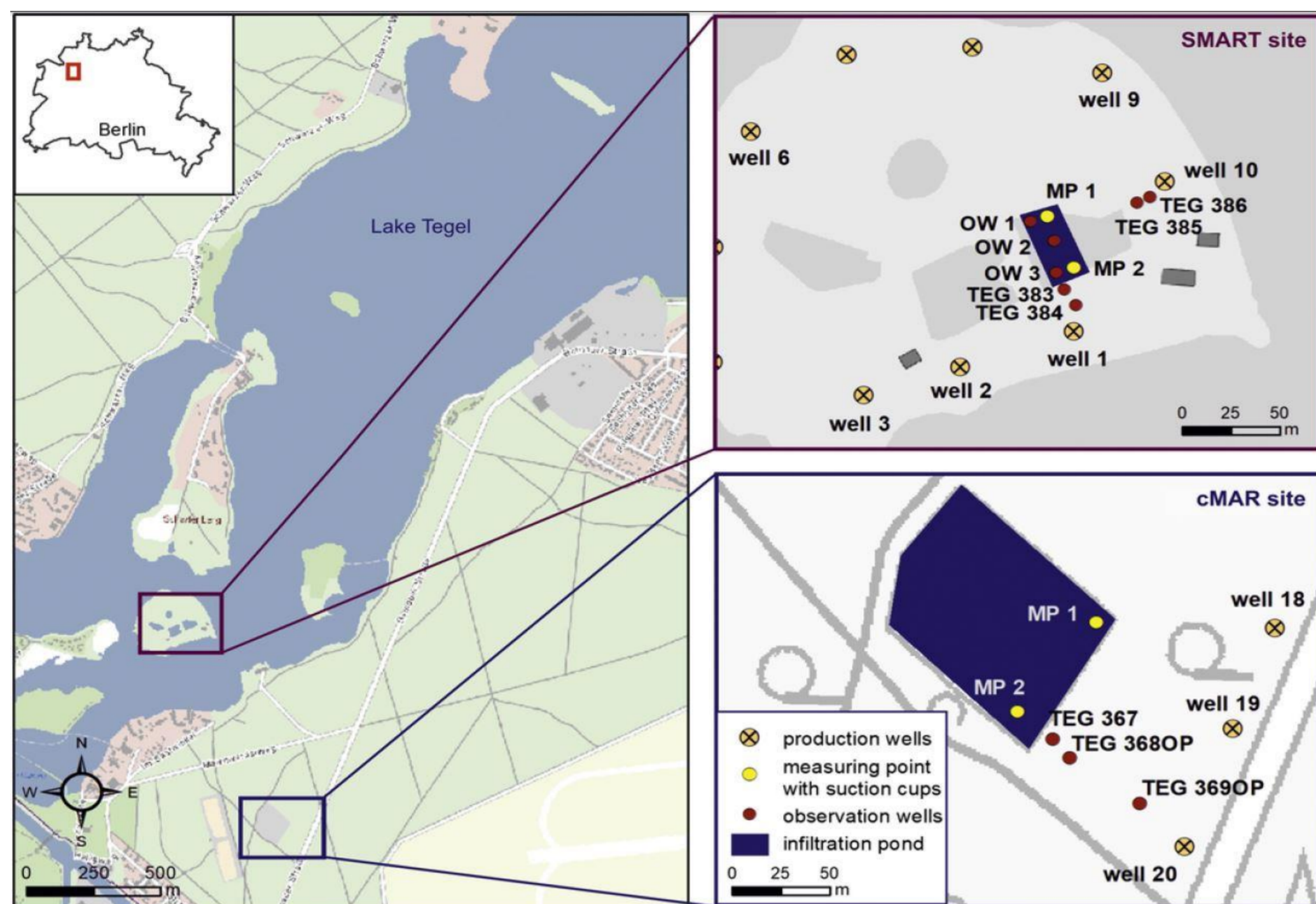


The concept of SMART

- Combination of two infiltration systems with intermediate aeration to establish oxic and carbon-limited conditions in the second infiltration stage
- High diversity of the microbial community
- Enhanced removal of trace organic chemicals (TOrcs)
- Enhanced biodegradation results in shorter hydraulic retention times



Field-scale Validation of SMART

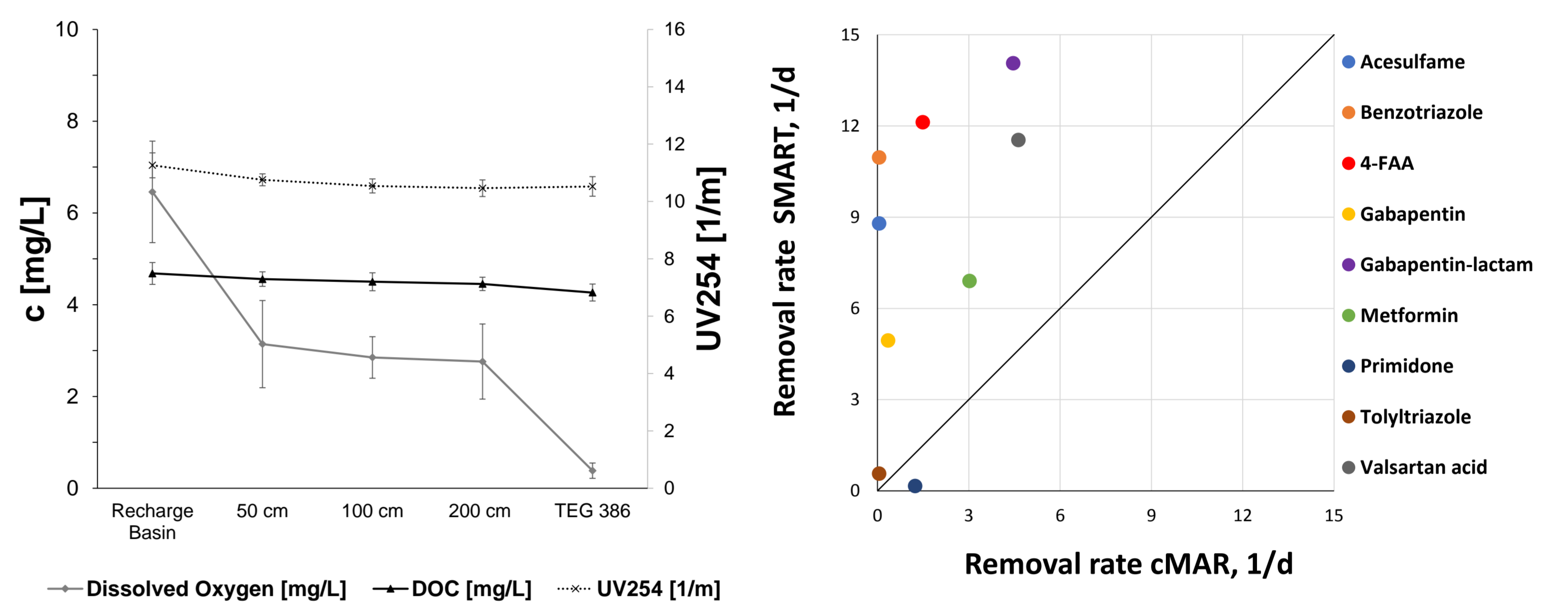


Location of field sites in Berlin: SMART on Baumwerder Island (top) and conventional MAR in Saatwinkel (bottom)

- 2 measuring points equipped with suction cups and oxygen sensors at different depths (50, 100 and 200 cm)
- 4 groundwater observation wells: TEG383, TEG384, TEG385, TEG386
- Analysis: DOC, UV₂₅₄, 3D-fluorescence, dissolved oxygen (DO), NO₃-N, NH₄⁺-N, Fe, Mn, TOrcs, sediment samples for molecular biological analyses
- Comparison with conventional groundwater recharge (cMAR)

Results

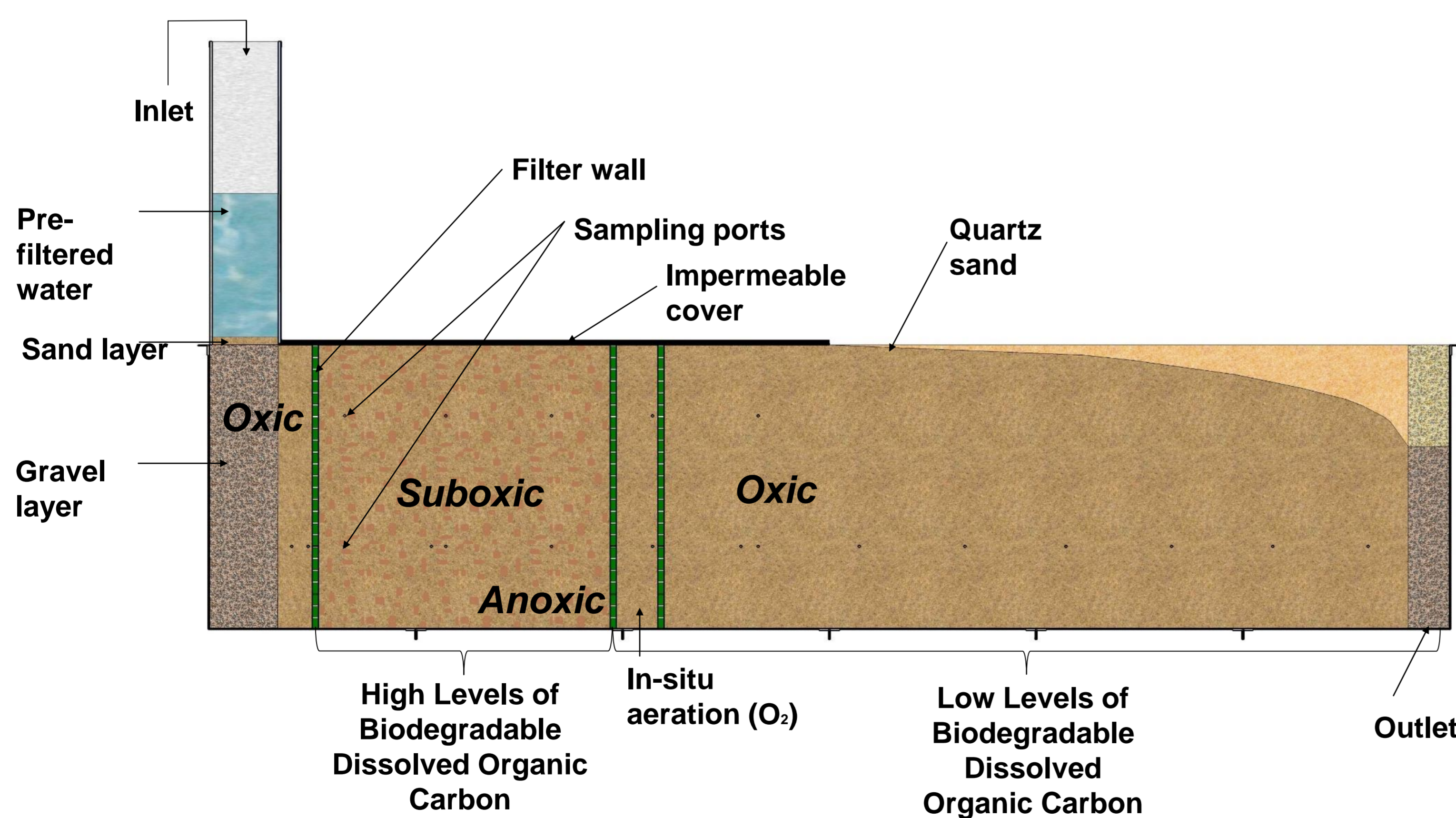
- Oxidic conditions established at all depths (first 200 cm) and in observation wells except for suboxic conditions in TEG386
- Carbon-limited conditions throughout infiltration
- Improved removal of many compounds, e.g. acesulfame, benzotriazole, gabapentin
- Some compounds like carbamazepine and oxipurinol persistent



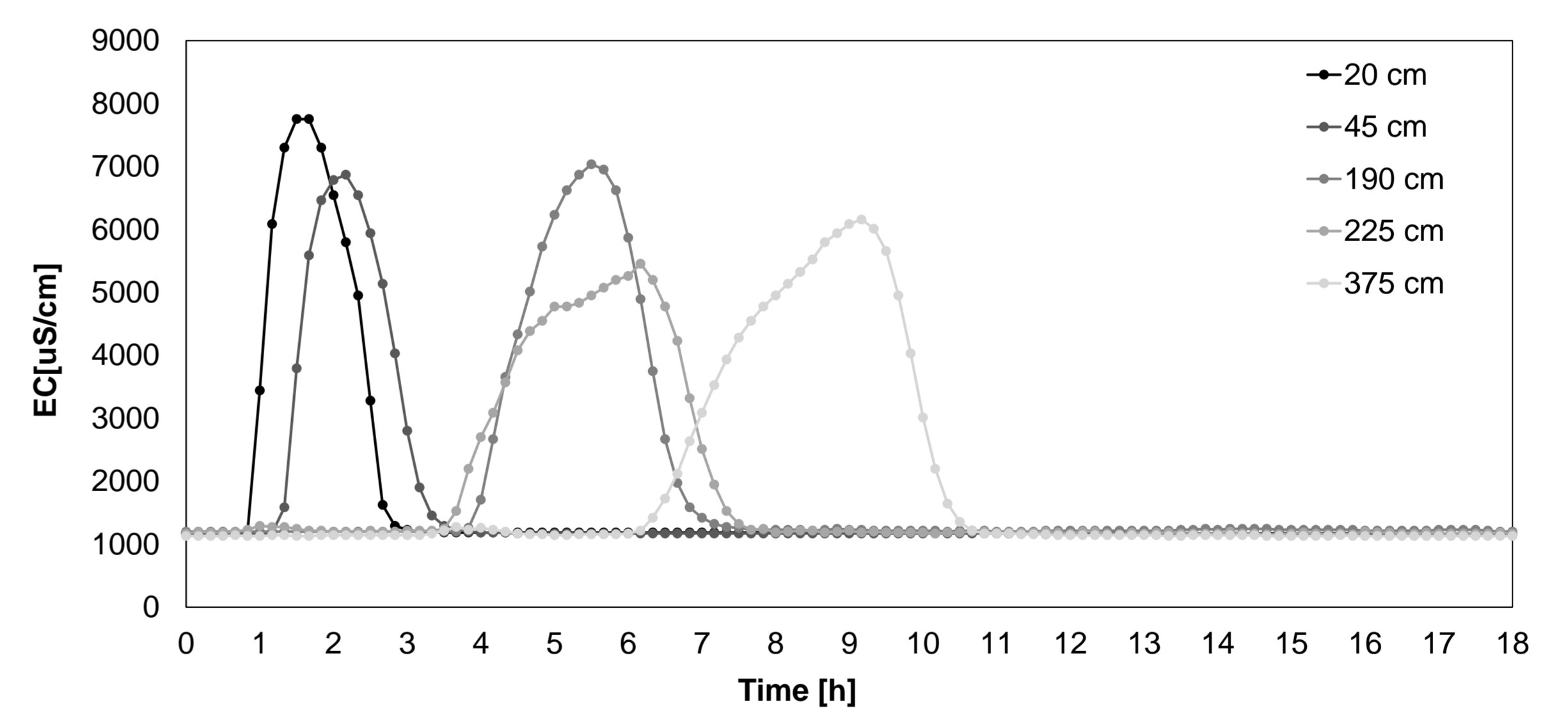
UV adsorbance, dissolved oxygen and DOC concentrations (left) and removal rates of TOrcs (right) during field-scale validation of SMART and conventional MAR site in Tegel-Berlin.

The concept of SMARTplus

- Further increase in efficiency for the establishment of a multi-barrier system
- Low-energy and low-carbon footprint
- In-situ manipulation of redox zones
- High infiltration rates and plug flow accommodated by infiltration trench technology
- Online monitoring and process control
- Enhanced treatment with reactive/sorptive media

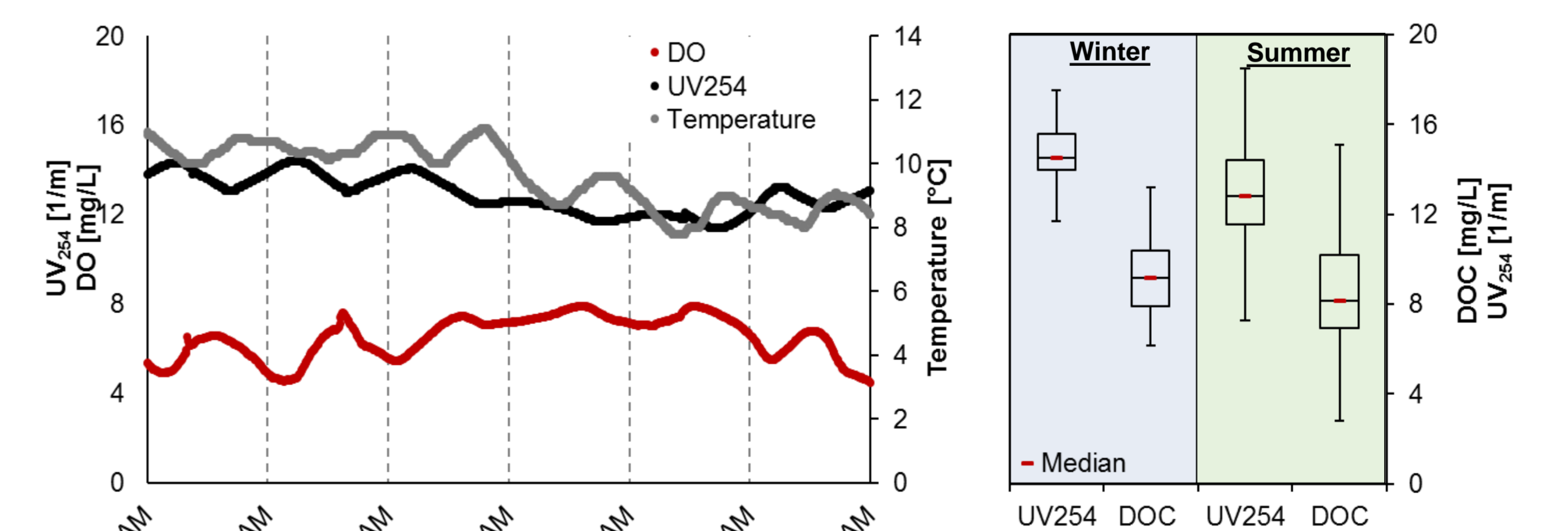


Plug-flow validation – Results from tracer tests



Breakthrough curve results of KBr impuls tracer test for the validation of plug-flow in SMARTplus bioreactor

Variability of feed water from WWTP



Daily (left) and seasonal (right) variability of the feed water quality from WWTP Garching

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