# Layered biofiltration to improve the biological removal of organic carbon species in drinking water production

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## Motivation

Drinking water treatment systems are increasingly challenged by the presence of natural organic matter (NOM), particularly dissolved organic carbon (DOC), and organic micropollutants (OMPs) in both ground and surface water sources. Biofiltration is a sustainable treatment approach that harnesses microbial activity to remove these contaminants. Common biofiltration technologies include slow sand filtration (SSF) and granular activated carbon (GAC) filtration, with each having advantages and limitations. SSF is effective for removing biodegradable DOC but has limited capacity for OMP removal. GAC efficiently removes OMPs by adsorption, though its performance declines as adsorption sites saturate and DOC competes for available sites.

A layered biofilter, combining the sand and GAC properties, can integrate the strengths of both processes. In such a hypothetical configuration (see Figure 1), an upper biologically active sand layer promotes biodegradation, a GAC layer adsorbs recalcitrant compounds, and a lower sand layer minimises the potential for biological particles and GAC fines in the effluent [1]. This approach can spatially separate the removal of DOC species and OMPs, alleviating competition between them.

## Technological challenge

The implementation of layered sand–GAC–sand biofiltration systems in slow filtration mode presents several technological and mechanistic challenges. A major knowledge gap exists regarding the systematic design of layer configuration, particularly the optimal position and thickness of GAC and sand layers to optimise the removal of DOC species. Moreover, the performance potential of these systems is a complex black box, depending on biological and physicochemical processes occurring across different filter layers, including biodegradation, adsorption, and desorption. Interactions between microbial biofilms, adsorption behaviour, and layer-specific removal performance remain insufficiently understood, limiting the mechanistic optimisation of layered biofiltration systems.

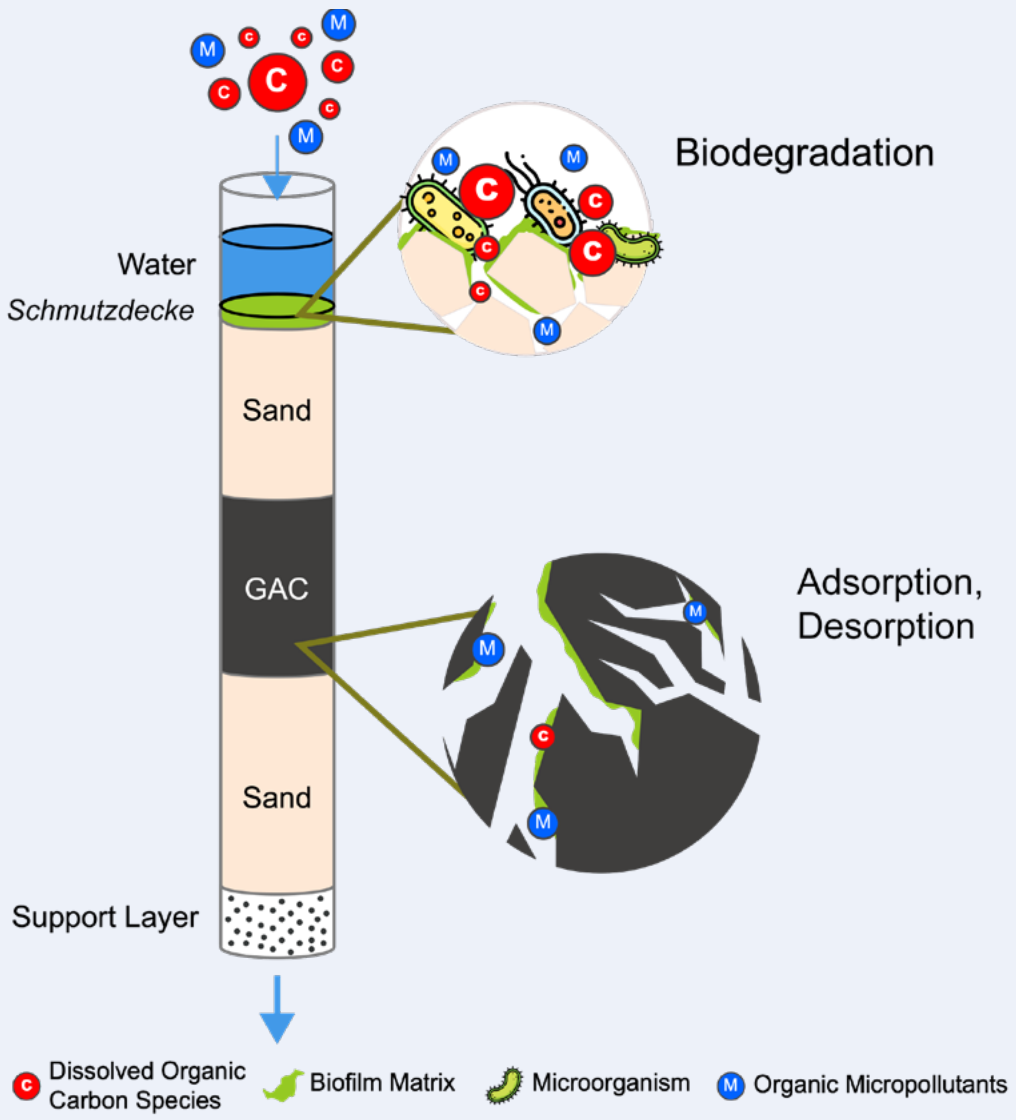


*Fig 1. Schematic representation of layered biofiltration operated in slow filtration mode with a sand–GAC–sand configuration.*

## Research goals

1. To investigate the influence of layered biofilter (sand-GAC-sand) configuration and operational conditions on the removal of DOC fractions and OMPs.
2. To characterise microbial communities and biofilms establishing in the different layers and assess how these relate to each layer's removal performance.
3. To decouple and understand the contribution of biodegradation and adsorption processes in layered biofilters.
4. To evaluate the potential for upscaling and integration of layered biofiltration systems into existing drinking water treatment trains.

## References

[1] Li et al., Science of the Total Environment 635 (2018) 1182-1190

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