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Engineered nature-based systems to protect drinking water aquifers against organic micropollutants

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Motivation

The water quality of groundwater is much higher than that of surface water, therefore, in the Netherlands, 60% of the drinking water is produced from groundwater. However, to be able to extract enough groundwater in the future, there is a need to increase aquifer recharge without introducing the organic micropollutants (OMP) present in surface water. Groundwater abstraction sites may be engineered for that purpose.

Nature-based systems, e.g. constructed wetlands, are considered a promising solution for removing OMP from surface water, as they are easy to construct, have a very low energy requirement, are chemical-free, and provide an ecological and recreational value. However, the challenge is to engineer a constructed wetland for optimal OMP removal, i.e. an Advanced Constructive Wetland, which can further utilize biological FeO_x & MnO_x system and microbially driven ROS to achieve better OMP removal efficiency.

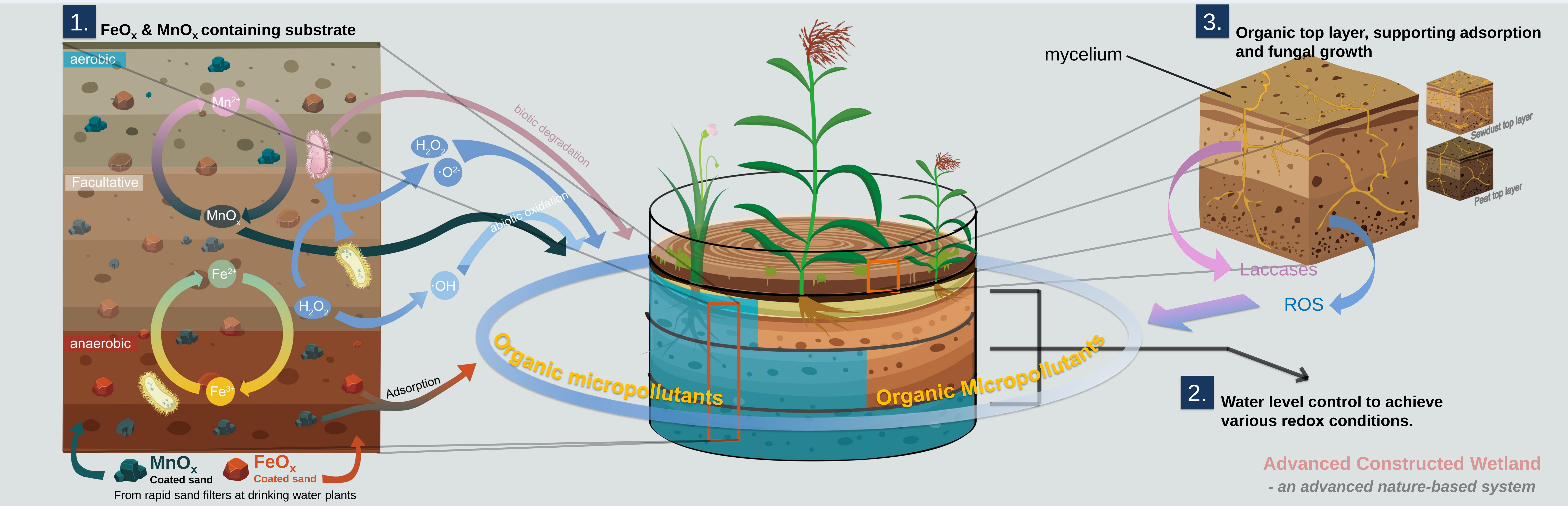

Fig 1. Strategies to increase OMP degradation in a constructive wetlands

Technological challenge

A nature-based system should sustain itself and not require active aeration, temperature/pH control or chemicals addition. However, the application of different substrate layers, and the control of the water flow and level are parameters to be optimised. These parameters can affect the following **OMP removal mechanisms (Fig 1):**

1. The enzymatic degradation by bacteria/fungi.
2. Oxidation by reactive oxygen species (**ROS**) produced by bacteria/fungi
3. Oxidation by (biogenic) **MnO_x**. The Mn would be reduced to Mn^{2+} in the process, but regeneration might be feasible by Mn-oxidizing bacteria in a sufficiently aerobic compartment.
4. Oxidation by $\cdot OH$ from Fenton(like) reactions, fuelled by H_2O_2 from bacteria/fungi. This does the require the wetland to comprise anaerobic compartment to allow the Fe^{3+} to be converted back to $Fe^{2+}$by metal-reducing bacteria .
5. Temporary immobilization (during peak load) by adsorption to Organic matter and **FeO_x & MnO_x** particles .

Research goals

To develop an Advanced Constructed Wetland, that utilizes the synergistic effects of Organic Matter, FeO_x & MnO_x species, bacteria, fungi, and plants, for optimal OMP removal.

To answer the following research questions:

1. To what extent can ROS/MnO_x/Fenton reactions contribute to OMP removal efficiency in a constructed wetland?
2. How to engineer a constructed wetland to generated the environmental conditions (fx. Redox condition) for optimal OMP removal?
3. What is the fate of OMP and their transformation compounds in an Advanced constructed wetland?

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