# Towards A Predictive Framework For Filter Clogging In Hypolimnetic Withdrawal And Treatment Systems


## Abstract

Hypolimnetic withdrawal is a lake restoration technique that targets internal nutrient loading by extracting water from the anoxic hypolimnion, where phosphorus is released from sediments. This method is currently implemented at Lake Kymijärvi in Lahti, Finland, where hypolimnetic water is pumped through a treatment system comprising filtration units and a constructed wetland before being returned to the lake. However, the system's primary sand filter tends to clog rapidly due to the accumulation of precipitated solids, significantly limiting its operational lifespan.

This study aims to provide a conceptual framework to support the creation of a numerical model capable of simulating porosity and permeability loss in filter materials over time. A two-dimensional model will be built using COMSOL Multiphysics and MATLAB LiveLink. The model will incorporate chemical reactions responsible for phosphorus retention and coprecipitation with ferrihydrite, implemented through the Chemical Reaction Engineering interface. Water flow and solute transport through the porous media will be described using the Subsurface Flow Module.

To capture filter clogging dynamics, mathematical functions will relate porosity changes to the mass and volume of accumulated precipitates, allowing for the estimation of operational longevity. The modeling approach builds upon the methodologies of Samsó and Garcia (2013) and Hamisi et al. (2019), among others.


## Reference


R., Hamisi, et al., Modelling Phosphorus Sorption Kinetics and the Longevity of Reactive Filter Materials Used for On-Site Wastewater Treatment, Water, 811(2019), https://doi.org/10.3390/w11040811

R. Samsó, J., Garcia, BIO PORE, a mathematical model to simulate biofilm growth and water quality improvement in porous media: Application and calibration for constructed
wetlands, Ecological Engineering, 116-127(2013), http://dx.doi.org/10.1016/j.ecoleng.2013.01.021


## Figures used in the abstract

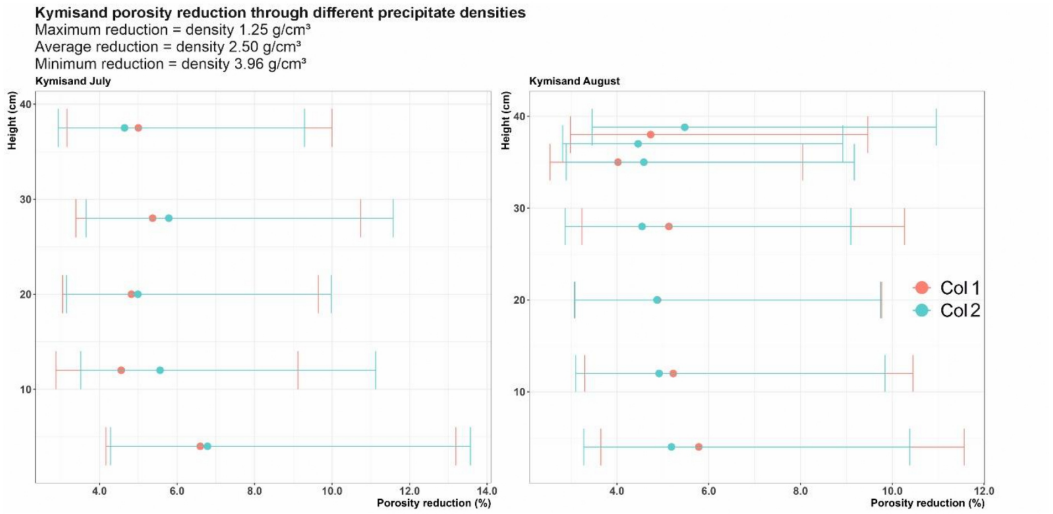


Fig 1 – Porosity reduction estimation scenarios due to accumulation of precipitates into the pore spaces of a filter sand used in the Kymijärvi HWTS, replicates included.

**Figure 1** : Fig 1 – Porosity reduction estimation scenarios due to accumulation of precipitates into the pore spaces of a sand filter used in the Kymijärvi hypolimnetic withdrawal and treatment system (HWTS), replicates included.

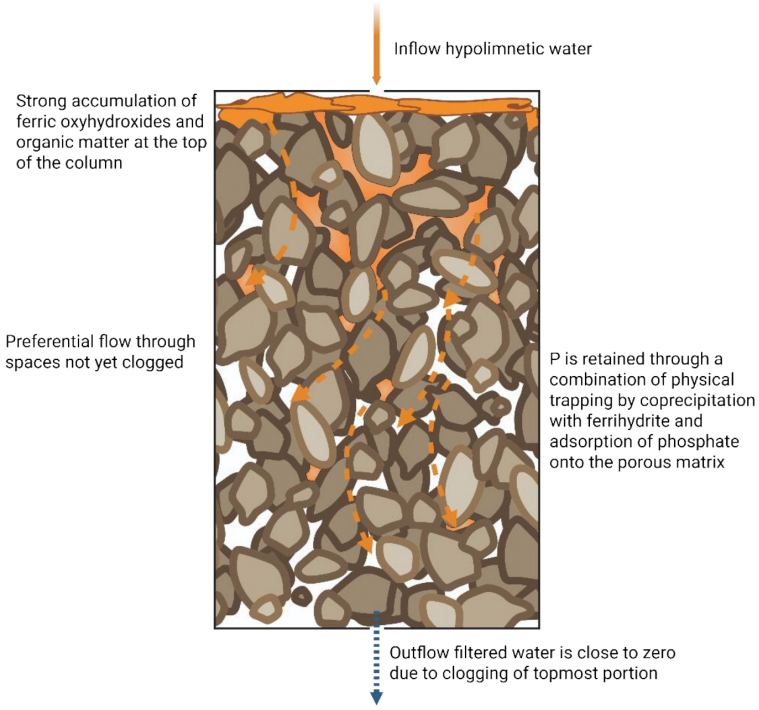


Fig 2 – Schematic of filter clogging upon a downward flow. The accumulation of precipitates represented by ferrihydrite and organic matter at the very top portion of the column can be enough to promote clogging and nearly cease the outward flow from the bottom end, even if the porous matrix still contains a high amount of pore spaces.

**Figure 2** : Fig 2 – Schematic of filter clogging upon a downward flow. The accumulation of precipitates represented by ferrihydrite and organic matter at the very top portion of the column can be enough to promote clogging and nearly cease the outward flow from the b