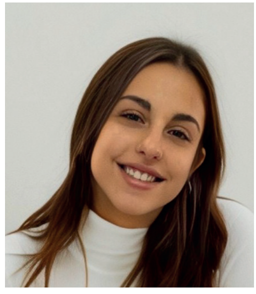
Removing Manganese as Pre-Treatment to Limit (Bio)Fouling in Oligotrophic Conditions



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Motivation

Manganese (Mn) is a common trace metal and a vital micronutrient for many organisms[1]. Soluble Mn (Mn^{2+}) is naturally present in various water sources[2]. When exposed to oxidizing agents (biotic or abiotic), Mn is oxidized to its insoluble forms (Mn^{3+} and Mn^{4+}), forming Mn oxides (MnOx). The accumulation of insoluble MnOx during water treatment can result in irreversible membrane fouling, recognizable by the black coloration of the fouling layers4. Mn-oxidizing bacteria (MnOB) can remove Mn^{2+} efficiently and selectively in oligotrophic conditions by converting it into Mn oxides. Recent Wetsus research demonstrated that when MnOB grow as a biofilm on biological activated carbon (BAC) granules, they continuously remove Mn^{2+} in oligotrophic conditions (low carbon availability). This resulted in the likely protection of the reverse osmosis (RO) units placed after BAC from significant and irreversible biofouling[4] (Fig. 1). Therefore, this project aims to assess the effectiveness of using highly selective Mn biological removal as a common practice in various engineered systems to prevent irreversible fouling under oligotrophic conditions.

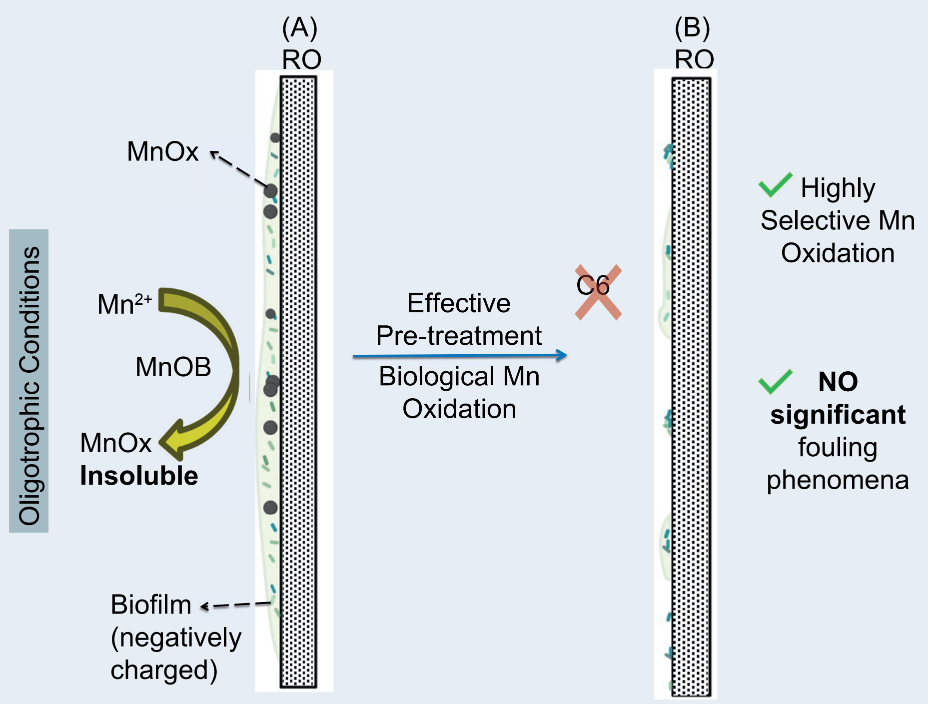

Fig. 1: Illustration of the project' hypothesis: fouling may be caused by manganese (A) and removing manganese can limit fouling (B).

Technological challenge

Implementing selective Mn biological removal as pre-treatment before fouling-prone engineered systems (e.g., RO) presents challenges which call for a nuanced understanding of biological functions and system parameters. Optimizing Mn oxidation for efficient removal, considering the diverse water and treatment system characteristics, is crucial in preventing irreversible fouling in oligotrophic conditions. This must ensure cost-effective, longterm operability.

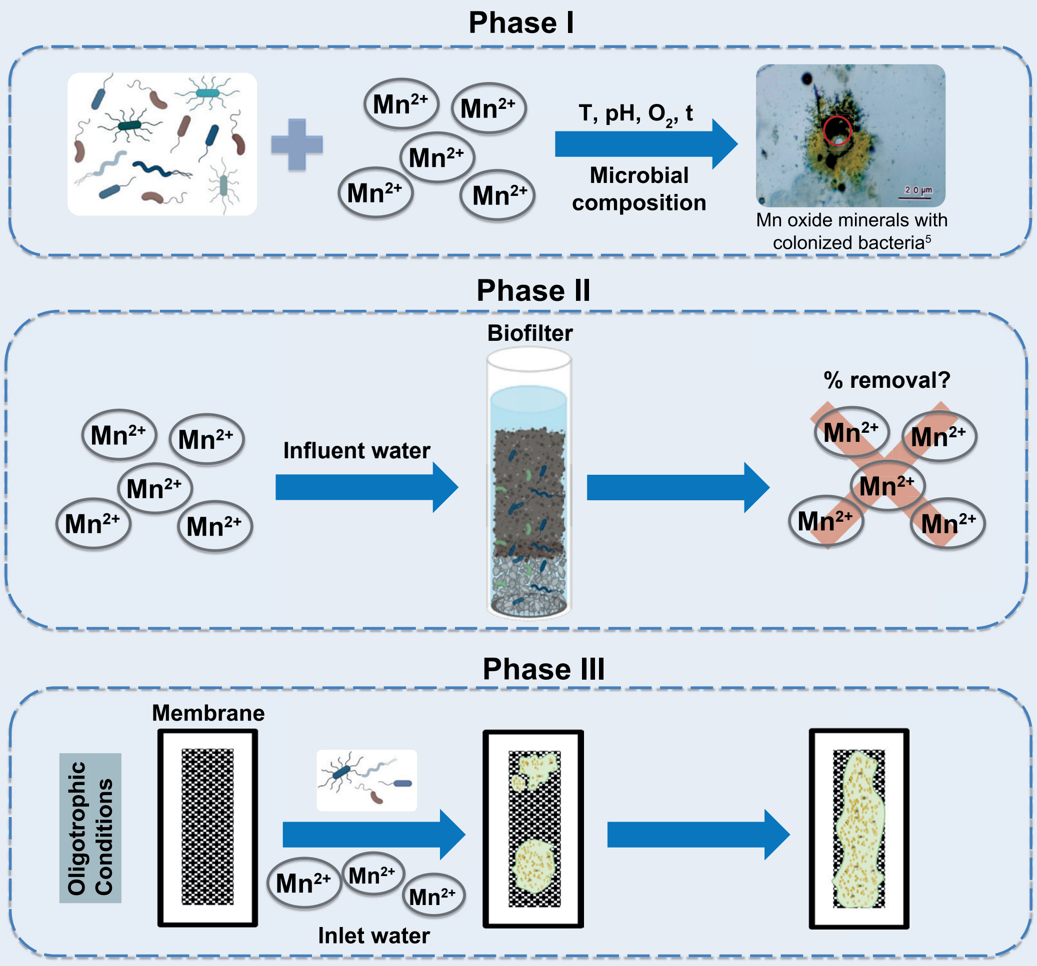

Fig. 2: Schematic representation of the three phases of the project.

Research goals

The project consists of three phases (Fig. 2): (I) exploring the dynamics/kinetics of biogenic Mn oxidation by mixed microbial consortia, (II) studying Mn removal in diverse lab-scale biofilters (e.g., sand and activated carbon-based), and (III) understand the fouling dynamics related to this metal in oligotrophic conditions. This experimental strategy aims to generate missing knowledge in biological Mn removal in engineered systems. The goals are:

- Determine the kinetics of biological Mn removal in various biofilters (in carbon-limited conditions), connecting with operational parameter influence (such as oxygen availability or pH).
- Design the proper biofilter for efficient water pre-treatment
- Generate models for predicting Mn-induced fouling in several engineered systems (RO and ultrafiltration membranes, cooling towers, etc .)

Additionally, we will evaluate the possibility of recovering biogenic MnOx for further use, such as catalyzers for micropollutant removal.

References:

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