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POC202106

EBNet Environmental Biotechnology

Biotechnology and Biological Sciences Research Council

Engineering and Physical Sciences Research Council

Bio-engineering of water biofilter communities for enhanced degradation of dissolved organic matter

"Microbial degradation of complex and high molecular organic matter offers significant opportunities to remove disinfection by-product precursors for the water industry and potentially high value products to be produced in the process. This PoC has presented an exciting and tantalising pathway toward more sustainable water and carbon management."

Dr Ryan Pereira, Carbon-Water Dynamics Team Leader

The Problem

Dissolved Organic Matter (DOM) is ubiquitous in natural aquatic systems such as surface waters and deep or shallow groundwater, which are often the main sources for drinking water production. DOM is the prime contributor to heterotrophic regrowth in drinking water distribution systems and the main precursor of carcinogenic disinfection by-products. Thus, its removal is an essential component of water treatment and a primary concern for water utilities.

Removal via biofiltration is an appealing technology: biofilters have been shown to degrade DOM biodegradable fractions; furthermore, they are characterised by lower chemical and energy consumption than conventional methods. However, the complexity of the ecological mechanisms controlling the microbial communities that drive the overall treatment process makes them unpredictable and difficult to control.

Our Approach

With this proposal, we aimed to identify the ecological mechanisms underpinning the development of microbial communities at different depths of a biofilter with different abilities to degrade DOM fractions. We aimed to translate these fundamental ecological theories into practical tools for biofilter design.

Results

The primary goal of this project was to uncover the ecological mechanisms governing the development of microbial communities within biofilters. We wanted to understand how these communities impact the breakdown of different components of DOM.

Microbial communities are complex assemblies of various microorganisms, some of which may work together while others may not. In our research, we observed that the more microorganisms collaborate within a community, the better they become at breaking down complex molecules. We also noticed that when these communities face challenging conditions, like the ones in the bottom layers of a biofilter, microorganisms tend to collaborate even more to ensure their survival. This insight suggests a promising avenue for enhancing water treatment systems. By encouraging these microbial communities to become more resilient and efficient, we can improve their capacity to break down complex and recalcitrant molecules, which are typically challenging to remove from the environment.

This project has led to the preparation of two scientific manuscripts and results shared at national/international conferences.

PUBLICATIONS & MANUSCRIPTS

[1] Microbial Stratification and DOM Removal in Drinking Water Biofilters: Implications for Enhanced Performance
By: Xiang Shi *et al*. In: Water Research. https://www.sciencedirect.com/science/article/pii/S0043135424009539
[2] Understanding the relationship between the sizes of dissolved organic carbon (DOC) and their bioavailability for the improvement of DOC removal in biofilters. By: X. Shi, R. Pereira, M. Vignola. (under preparation)