

# ENVIRONMENTAL BIOTECHNOLOGY NETWORK

## Water Biofilms WG



# Water biofilms: from catchment to tap

## (WB WG)



This WG aims to explore and advance the positive applications of biofilms in environmental biotechnology, particularly focusing on engineered microbial communities in water treatment processes. Biofilms play an important role in technologies such as slow sand filtration, contributing to efficient water treatment and resource management. By bringing together experts from academia, industry, and government, the WG seeks to enhance the understanding of beneficial biofilm formation and function, develop innovative engineering strategies, and promote best practices for harnessing biofilms in sustainable water treatment systems.

### Activity synopsis

In collaboration with the National Biofilms Innovation Centre (NBIC), this WG organised two very well-attended webinars: the first on biofilms in drinking water and the second on a topic linked to anaerobic digestion (AD).

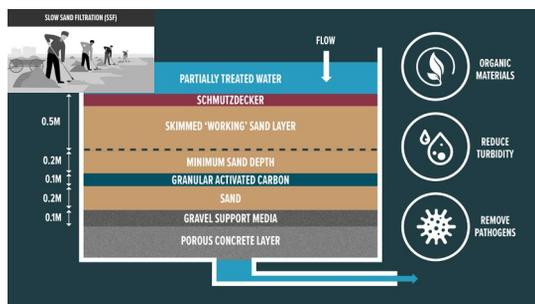
*Webinar* [What are biofilms doing in our drinking water pipes?](#)

*Webinar* [GAC Biofilms for Biomethanation from Wastewater](#)

The WG has an active outreach role, with Dr Hassard chairing our ECR24 conference. Seventeen abstracts at ECR conferences have addressed topics in the remit of this WG. Other outreach materials include a virtual challenge-based Escape Room on aspects of water biochemistry, hosted on the EBNet website for all to undertake.



The group produced an animation on past and future developments in [Slow Sand Filtration](#) as part of EBNet's *Microbiology/Engineering Interactions* theme. The animation uses clear, engaging visuals to chart the evolution and future potential of slow sand filtration - making it accessible to both academic and industry audiences. The concept of underwater skimming portrayed in the animation is now being [taken forward in large-scale trials](#) with funding from Ofwat's Water Breakthrough Challenge 5. For a series of peer-reviewed journal publications related to this work, see ongoing updates on the WB WG [News tag](#) and [webpage](#).



**CONTAMINATION CRISIS**

**Concept**  
Environmental Biotechnology Network  
Part of EBNet's Engineering / Microbiology Interactions theme.  
Technical concept by Dr Françoise Hassard, Dr Kirstell Le Corre Pidoux and Nicola Heaven  
And the EBNet Team: Sonia Heaven, Louise Byfield, Angela Bywater.

**Design and Development**  
Visual design and game development by Learning Enhancement and Design (LEAD) at Cranfield University.  
Music: "Doppelher" from beatsond.com

Logos: Engineering and Biological Sciences Research Council, EBNet, Engineering and Physical Sciences Research Council, Cranfield University.

## ACTIVITY SYNOPSIS ctd

EBNet supported three proof-of-concept (POC) projects on topics relevant to this area, leading to several conference presentations and journal papers.

POC202106 [Bio-engineering of water biofilter communities for enhanced degradation of DOM](#)

POC202113 [Fluorescent Microbiofilter Assay for Rapid Real-time Monitoring of Organic Micropollutants Biodegradation](#)

POC202015 [Fibre Highways: translocation of the microbiome for pollutant bioremediation](#)



A by-invitation workshop at the Royal Society of Chemistry, London in January 2025 gathered top academic and industry experts in person and online to discuss [Slow Sand Filter Futures](#). Outcomes are presented in a workshop report, a position statement and a set of research needs.

The workshop identified the following research priorities:

- Deepening our understanding of microbial and ecological dynamics
- Data-driven monitoring, modelling, and predictive control
- Rethinking filter design and maintenance for next-level performance
- Integrating SSF into broader water and resource cycles
- Bridging policy, regulation, and public acceptance
- Enabling collaboration and infrastructure for research at scale

Some key WG concepts are now going forward in the EPSRC TERC Network+ [Better water for all: Re-engineer water engineering for equitable and resilient access to high-quality water for future generations](#), with WG Lead Francis Hassard and Prof Tom Curtis who leads EBNet's [N2O WG](#) as Co-Investigators, and in the [EBIC Hub](#).

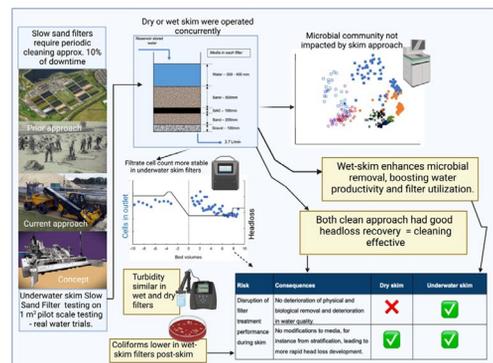
### Selected WG Journal papers

#### [Microbial stratification and DOM removal in drinking water biofilters: Implications for enhanced performance.](#)

Shi, X., Pereira, R., Savage, L., Poursat, B., Quinn, D., Kostyrsia, A., Cholet, F., Smith, C.J., Gauchotte-Lindsay, C., Sloan, W.T. and Ijaz, U.Z., 2024. *Water Research*, 262, p.122053.

#### [Biohybrids: Textile fibres provide scaffolds and highways for microbial translocation.](#)

Sherry, A., Dell'Agnese, B.M. and Scott, J., 2023. *Biohybrids: Textile fibres provide scaffolds and highways for microbial translocation.* *Frontiers in Bioengineering and Biotechnology*, 11, p.1188965.



For more information see the WG [Webpage](#), [News](#) tag and YouTube [Playlist](#)



**Dr Marta Vignola**  
University of Glasgow  
POC202106

# 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. (in preparation)





Dr Caroline Gauchotte-Lindsay  
University of Glasgow  
POC202113



# Fluorescent microbiofilter assay for rapid real-time monitoring of organic micropollutants biodegradation

## AIM

Microbial communities on biofilters form stochastically, based on the chemistry and biology in the raw water. We contend that targeted design of microbial ecology for degradation of difficult-to-treat organic micropollutants (OMPs) could be achieved by optimising said chemistry and biology using genetic algorithms. While this would require *in situ* testing of the responses of microbial communities to OMPs, no fast, inexpensive, reliable analytical methods to measure OMPs in microbial cultures are currently available.

Current gold standard methods provide precise and accurate results, but at best hours and most likely days after sampling, by which time conditions in the biological systems may have changed drastically. We aim to design and validate a new microwell plate assay to measure the biological removal of OMPs in microscale biofilters.

The plate wells will be filled with a transparent porous medium that acts as the substratum for biofilms, whose degradation of fluorescently tagged OMPs will be monitored using fluorescent excitation-emission. By the end of the project, we hope to deliver a robust, precise and sensitive assay that can be further integrated to high-throughput robotic platforms for rapid and site-specific optimisation of microbial seeds of full-scale biofiltration systems.

For video see :

[https://youtu.be/SiC\\_MceeNAs](https://youtu.be/SiC_MceeNAs)

## WHAT NEXT?

Research is continuing within the EPSRC Decentralised Water Technologies (EP/V030515/1) programme grant, in which Caroline Gauchotte-Lindsay (CGL) is a Co-I. Validation with relevant natural communities will be carried out within this grant. Once validated, she will take the project to the Converge Challenge.

## RESULTS

With the EBNet PoC funding, we were able to demonstrate the feasibility of a high throughput assay for rapid selection of microbial seeds for the degradation of 17 $\beta$  estradiol (E2).

Click chemistry was employed to attach a linker on a labile hydrogen of E2, and a green fluorescent BODIPY to the linker. The fluorescent tag enabled specific detection and quantification of the tagged compound in the media using a spectrofluorometer, with limits of detection much lower than standard analytical methods.

We further demonstrated in batch planktonic experiments that the fluorescent E2 could be taken up and degraded by known heterotroph E2 degraders; we were also able to accelerate this with an additional carbon source. Cell culture inserts for wells with a porous membrane at the base were shown to be a suitable medium for growth of the biofilm.

We were able to establish the conditions, necessary controls, quality control and quality assurance, and final protocol of a 24-well plate assay to select the most efficient of three degrading communities using real time fluorescence monitoring in a plate reader.



## PUBLICATION:

BODIPY-labelled estrogens for fluorescence analysis of environmental microbial degradation  
By: Felion, C., Lopez-Gonzalez, R., Sewell, A. L., Marquez, R. and Gauchotte-Lindsay, C. In: ACS Omega, 7(45), pp. 41284-41295.





**Dr Angela Sherry**  
Northumbria University



**Dr Jane Scott**  
Newcastle University  
POC202015 – a joint cross-disciplinary collaborative project of £100k



# Fibre Highways: Translocation of the microbiome for pollutant bioremediation

*'The support the EBNet PoC Award provided really was very useful to both mine and Jane's research profiles as ECRs forging independent careers in new roles at new institutions at the time of the award. We've successfully navigated the challenges of not really speaking each other's languages in the beginning to producing interdisciplinary research outputs, which we're both very proud of and we continue to work closely together. The Award continues to act as a springboard. It has led to further discussions between academia and industry, and enabled us to secure more funding and employ researchers to explore new avenues around the original PoC research ideas'. Dr Angela Sherry*

## PROJECT

The research combined expertise in environmental molecular microbiology and material and textile science to demonstrate translocation of the microbiome along 'fungal or fibre highways' to facilitate pollutant biodegradation.

Demonstrating the directional movement and dispersal of microbes enabled a deeper understanding of the interactive dynamics of motility in hydrocarbon-degrading multispecies microbiomes along fungal mycelium and natural/synthetic fibres, with multiple potential areas of application such as the bioremediation of environmental pollutants.

It is hoped the study will ultimately lead to development of environmentally responsive textile systems, composed of natural and sustainable materials, that could be used to increase the contact time of microbes with the pollutant for more efficient bioremediation, or to 'seed' polluted sites with microbes.

## IMPACT

The Fibres Highways design collection was exhibited at the prestigious 12th International Design Biennale Saint-Étienne, France. Dr Jane Scott was Lead Co-ordinator and organiser of the 3-day hybrid ARCINTEX Symposium. After the project finished, Jane and Angela continued to evolve the research together and secured funding for joint supervision of a researcher in microbial: textile interactions at Northumbria University.



## OTHER FUNDING

1. Enzymatic upcycling of textile waste into biodegradable mycelium leather. PI Dr Paul James, Co-I Dr Jane Scott. Northumbria University. £303,297. Feb 2023 - 2025. BBSRC. BB/X01133X/1
2. Fibre Fusion: Circular Manufacturing of Water Repelling Bacterial Cellulose Through a Biological Approach. PI Dr Meng Zhang, Co-I Dr Jane Scott. Northumbria University. £302,929. Feb 2023 - 2025. BBSRC. BB/X011402/1

### PUBLICATIONS:

**Biohybrids: Textile fibres provide scaffolds and highways for microbial translocation** By: Angela Sherry, et al.

In: *Front. Bioeng. Biotechnol.*, 13 June 2023 Sec. *Biomaterials* Volume 11 – 2023

**BioKnit: development of mycelium paste for use with permanent textile formwork** By: Romy Kaiser et al.

In: *Front. Bioeng. Biotechnol.*, 14 July 2023 Sec. *Biomaterials* Volume 11 – 2023

[YouTube: Fibre Highways 2021 - Microbial Textiles for Remediation](#)



## ‘I am an Environmental Biotechnologist because...’

### Selected examples from EBNet ECR Conferences in 2023 and 2024

I am an environmental biotechnologist because I am fascinated by biological systems and passionate about harnessing biology to solve the world’s greatest challenges in climate and sustainability.

*Reuben Duncan, Cranfield University*

I am a PhD student in environmental microbiology. I currently work in wastewater treatment looking for new biological control techniques for engineering the microbial community.

*Matt Irwin, University of Southampton*

I am an environmental biotechnologist because I am passionate about unravelling the intricate microbiology of drinking water biofilters and harnessing this knowledge to enhance biofilter performance through targeted bioengineering strategies. My work aims to optimize microbial communities within biofilters, improving water treatment processes and ensuring safe and high-quality drinking water for communities worldwide.

*Xiang Shi, University of Glasgow*

I am a PhD candidate working on eroded biofilm in drinking water networks under different hydrological conditions. I measure particle size distribution by using flow cytometry and microscopy, then analyse the data to build a mathematical modelling for the relationship between the two methods' results. This research is to know how PSD relates to the number of pathogens and how much they are a risk to human health.

*Vironika Bahat, University of Glasgow*

I have a Civil Engineering background from my undergraduate studies. In the last 10 years though I worked in the Water and Environmental Engineering field focusing on biofilms that form in drinking water distribution pipes. I am passionate about my research and I hope it may support efficient strategies to improve drinking water quality.

*Erifyli Tsagkari, University of Glasgow*

I am passionate about finding sustainable solutions to environmental challenges. My work helps protect natural resources and improve ecological health for future generations.

*Ilgaz Calkin, University of the Highlands and Islands*

I am an Environmental Biotechnology student. I am currently developing a bio-electrochemical system for water desalination.

*Clement Nyadroh, University of Westminster*

I am an environmental biotechnologist because I want to understand how we can use microbes in biofilms to degrade microplastics in the ocean. I am passionate about our planet and want to help tackle plastic pollution using bioremediation tools.

*Jennifer Scott, Heriot Watt University*

## ‘I am an Environmental Biotechnologist because...’

### Selected examples from EBNet ECR Conferences in 2023 and 2024

I am an environmental biotechnologist because I am leveraging the biological processes in constructed wetlands to treat wastewater.

*Ayesha Affo Souleymane, Cranfield University*

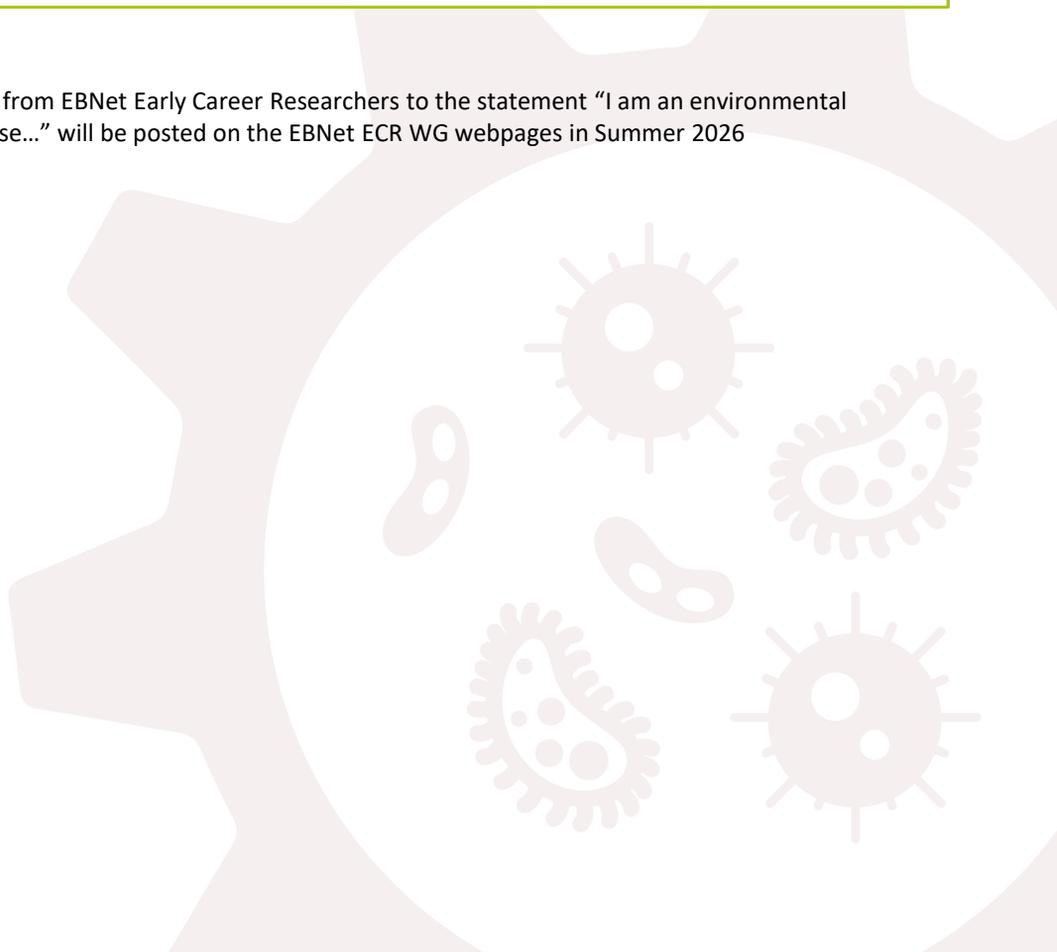
I am working to minimize the overall public health risk due to microbial processes occurring within drinking water distribution systems (DWDS).

*Dinesh Singh Bhandari, University of Glasgow*

Currently, I am a bioinformatics PDRA in a Water Environmental Group. I am working on the dataset of biofilter applications, focusing on 18S rRNA, which represents eukaryotes, and 16S rRNA, which represents bacteria. My goal is to analyze the community profile, with a particular focus on identifying taxa that are correlated with pathogens. Investigating the interplay between eukaryotes and bacteria offers insights into fundamental ecological processes and the complex microbial networks that underpin environmental systems. Consequently, this contributes valuable insights towards developing more efficient and sustainable water treatment strategies by optimizing SSF processes and understanding the dynamics of microbial communities in biofilters.

*Uzma Uzma, University of Glasgow*

A full set of responses from EBNet Early Career Researchers to the statement “I am an environmental biotechnologist because...” will be posted on the EBNet ECR WG webpages in Summer 2026





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<https://ebnet.ac.uk/wg-details/wg-biofilms/>

**For more information** see the WG [News](#) tag and YouTube [Playlist](#)

