Workshop Report

Slow Sand Filter Futures

hosted by the Water Biofilms Working Group of the Environmental Biotechnology Network (Environmental Biotechnology Network – A BBSRC/EPSRC NIBB)

Date: 22 January 2025 at the Royal Society of Chemistry, London

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WB WG https://ebnet.ac.uk/wg-details/wg-biofilms

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Contents

In person workshop delegates in the Grand Library of the Royal Society of Chemistry

Cite as: Summary report from Scientific Workshop in Measurement of Greenhouse Gases from Sanitation and their Relationship with Microbiological Processes within Sanitation Systems. Hosted by N2O Working Group, Environmental Biotechnology Network and the University of Leeds, UK. https://ebnet.ac.uk/resources/. *(EBNet). https://ebnet.ac.uk/resources/*

Summary

On 22 January 2025, a group of water professionals, researchers, and engineers convened at the Royal Society of Chemistry London to explore the ongoing relevance, operational innovations, and future potential of Slow Sand Filters (SSF) as a core drinking water treatment process. The gathering, titled "Slow Sand Filter Futures," was prompted by growing concerns about climate change, supply chain vulnerabilities, and the ever-expanding need for resilient water treatment technologies. Over the course of the discussion, participants shared insights into practical experiences, emerging research findings, and potential design improvements. This summary presents the main themes that emerged, highlighting how SSF can remain a critical component of modern water treatment. The workshop did not consider the sister scaled down version of the technology - the Biological Household Sand Filter.

Images of the venue and delegates who attended the event in person

Workshop Synopsis: 'Slow Sand Filter Futures'

Hosted with support from EBNet and the Water Biofilms Working Group, the "SSF Futures" workshop brought together academics, researchers, and water utility professionals from across the UK and Europe to share recent advancements in slow sand filtration. In a series of presentations and discussions, participants examined evolving SSF practices, innovative maintenance methods, and the latest microbiological research. The event also provided an opportunity to identify practical strategies for improving filter performance in real-world contexts. There were 17 in person delegates representing the United Kingdom, Nigeria and Sweden. Participants represented Thames Water, Cranfield University, Affinity Water, Bournemouth Water, University College London, Ross Engineering, Northumbrian Water Group, Southwest Water, Bristol Water and Lund University. There were 12 online delegates in total, representing three countries: the United Kingdom, Sweden, and the Netherlands. Online Participants from the United Kingdom were affiliated with Panton McLeod and Affinity Water. Those from Sweden represented SVOA (Stockholm Vatten och Avfall), Sydvatten, and Lund University. The Netherlands was represented by delegates from Het Waterlaboratorium and Evides.

Highlights included:

- **Welcome and Introduction**
  Dr Francis Hassard *(Reader in Public Health Engineering, Cranfield Water Sciences)*
  Dr Hassard opened the workshop with an overview of slow sand filtration's historical significance and current relevance, situating the day's discussions within the broader framework of EBNet and the Water Biofilms Working Group. He emphasized the pressing need for low-energy, adaptable water treatment solutions. He also presented an amusing summary that circa surface area of Malta would be needed to treat the worlds drinking water supply with SSF.

- **SANDSCAPE Project: Ofwat Water Breakthrough Challenge 5 Catalyst**
  Dr Michael Chipps *(Principal Research Scientist, Thames Water)*
  Dr Chipps presented on the SANDSCAPE project, highlighting how this initiative explores new ways to modernize slow sand filtration. His talk focused on pilot findings and on how adapting SSF to contemporary challenges, such as emerging contaminants and operational cost pressures—could yield more resilient, sustainable treatment processes.

- **Building New SSFin Sweden: Microbiology and Implementation**
  Dr Catherine Paul *(Associate Professor, Lund University)*
  Drawing on her experiences commissioning new SSF systems in Sweden, Dr Paul examined both practical and microbial aspects of setting up filters from scratch. She illustrated how the biofilm community develops under varying source water qualities and operational conditions, and how these insights can inform better design.

- **Approaches for Removing Pharmaceuticals and Personal Care Products in SSF**
  Professor Luiza Campos *(Environmental Engineering, University College London)*
  Professor Campos provided an overview of current research into the fate and removal of pharmaceutical and personal care product residues in SSF. She compared different operational strategies and discussed how SSF could be tailored or combined with other techniques to address these increasingly important micro-pollutants.

- **Biological Mechanisms of Cryptosporidium Removal in SSF**
  Sophie Bretagne (PhD Student, Cranfield Water Sciences)
  Ms. Bretagne presented the preliminary findings of her doctoral research, shedding light on the biological interactions that underpin *Cryptosporidium* removal. Her discussion focused on the ecological dynamics of the schmutzdecke, highlighting key organisms and factors that enhance pathogen interception.

- **Linking Microbial Ecology to Function in SSF**
  Tage Rosenqvist (PhD Student, Lund University)
  Mr. Rosenqvist delved more deeply into how the composition and spatial distribution of microbial communities correlate with overall filter performance. By linking shifts in species diversity to measurable outcomes, such as removal of turbidity or chemical contaminants—he demonstrated the potential for a more data-driven approach to SSF optimization.

- **Dissolved Oxygen Management in Underwater Skimming SSF**
  Tolu Elemo (Process Engineer, MottMac)
  Dr Elemo highlighted an innovative maintenance technique called underwater skimming—that reduces downtime and keeps filters in operation longer. Her work underscored the importance of managing dissolved oxygen levels for maintaining healthy microbial communities and preventing excessive headloss or other operational bottlenecks.

Overall Discussion and Future Directions

The workshop concluded with a roundtable discussion on next steps for both research and practice. Participants identified priorities such as scaling up pilot projects, refining real-time monitoring methods, and advocating for the low-energy and biological advantages of slow sand filtration. The importance of industry-academic collaboration, funding for demonstration sites, and regulatory engagement emerged as vital for integrating SSF into broader water treatment strategies. Key themes which emerged:

1. Introduction: Why Slow Sand Filtration Now?

In opening remarks, participants underscored that the world is facing unprecedented stressors on water systems. Climate change has made water sources less predictable, while global conflicts and logistics issues have underscored how fragile supply chains for chemicals and electrical power can be. Traditional or “conventional” treatment processes that rely on complex chemical dosing may become more vulnerable if chemical deliveries are interrupted or electricity costs soar.

Within this context, SSF technologies that came to prominence in the 19th century—offer a deceptively simple but highly effective form of water purification. One participant referred to SSFs as “robust assets from a time before electricity,” underscoring their fundamental design: water moves slowly through beds of sand and an active biological layer (the *schmutzdecke*), providing natural filtration and reducing reliance on external resources. The technology was noted as the original environmental biotechnology intervention, something important considering the EBNET core remit. The question posed to the group was whether these strengths remain relevant and how they can be leveraged in the modern era, especially when new contaminants, tighter regulations, and advanced treatment processes are all part of today’s water landscape.

2. Resilience and Adaptability in Uncertain Times

A prominent theme throughout the workshop was the resilience of SSF. Participants noted that SSFs do not rely on high chemical inputs or complex machinery. Although they require proper maintenance, including surface skimming when headloss becomes significant, the core design is inherently low-tech. Several water utility representatives observed that having at least one treatment asset that can operate with minimal electricity consumption and without a constant inflow of chemical reagents can be invaluable during power outages or disruptions in chemical supply.

Beyond physical robustness, attendees emphasized the *biological* resilience of SSF. The microbial communities established in the top layers of the sand adapt to new contaminants, including emergent pathogens. One speaker pointed out that "the microbial workforce" in SSF evolves naturally, providing ongoing protection without extensive operator intervention. This adaptive capacity distinguishes SSFs from strictly physicochemical systems, which may not respond as dynamically to sudden water quality changes.

3. Evolving Scientific Understanding of Biological Treatment

Despite their longstanding use, SSF continue to present intriguing scientific questions. Much of the interest centres on the *schmutzdecke*, the thin biological layer that develops on the top of the sand bed. Researchers are now using advanced tools, such as metagenomics, microbial community sequencing, and *in-situ* sensors—to identify which microorganisms dominate in stable, high-performing filters.

Workshop participants stressed that as we learn more about these microbial consortia, we gain the potential to fine-tune SSFs for specific needs. There is growing excitement about the possibility of introducing specialized microbes to degrade difficult pollutants, such as certain pesticides or "forever chemicals" like PFAS. One speaker noted that while PFAS are notoriously resistant to degradation, "the chemical engineers are showing us they're not truly forever," hinting that microbiologists may eventually devise biological solutions for them as well.

In addition, the group also recognized that SSFs are far more than mere physical filters. They are, in essence, living systems—"eco-technologies" whose performance depends on a balanced ecosystem of bacteria, protozoa, and potentially even bacteriophages. As regulations continue to focus on new contaminants, the biological adaptability of SSFs could become a major asset.

4. Combining Slow Sand Filtration with Advanced Processes

While the inherent simplicity of SSF is an advantage, most participants agreed that SSFs often work best as part of a *multi-barrier treatment train*. A water utility can strengthen its overall resilience by pairing slow sand filtration with more advanced or targeted processes, whether membrane filtration, ultraviolet (UV) disinfection, or even advanced oxidation processes.

A concrete example shared by one utility illustrated how adding a ceramic membrane downstream of the SSF eliminated the need for chemical coagulation, drastically cutting costs, reducing sludge, and simplifying operations. The membrane provided additional pathogen removal and confidence in meeting regulations; the SSF ensured that the membrane feed water was relatively low in turbidity and organics, thus preventing fouling and decreasing maintenance downtime. The synergy of a biological process followed by a physical membrane barrier offered the utility new flexibility, including the possibility of reintroducing a skimmed filter to production after only 24 hours of ripening time.

UV disinfection was also discussed as a possible downstream add-on. While UV offers a strong microbial barrier (especially for protozoa like *Cryptosporidium*), participants noted that it does not reduce the particulate load itself, meaning SSFs can serve an important clarification role upstream. This approach can be particularly appealing to utilities seeking multiple barriers without excessively large capital investments in chemical processes.

5. Practical Operational Innovations

Discussions also focused on how to optimize SSF operations. Although SSF are sometimes described as “set and forget,” workshop participants acknowledged that they still require systematic maintenance. Traditionally, operators perform surface skimming—removing the top layer of sand or the *schmutzdecke*—once headloss becomes unmanageable or water quality starts to drop. Because the filter bed must sometimes be taken off-line for days or even weeks to ripen before returning to service, this approach can affect production volumes.

Several participants described new machinery for underwater skimming, essentially vacuum-like systems that remove the clogging material without needing to drain the bed fully. Pilot tests suggest this can significantly shorten downtime and maintain more consistent production levels. In practice, improved cleaning routines allow operators to keep filters in service longer and bring them back online more quickly, which can result in higher overall output from the same infrastructure.

Another area of discussion involved *covering* SSF. Light penetration increases the growth of algae or other phototrophic organisms, which in turn can cause rapid headloss. Attendees cited examples where simply installing a temporary fabric cover or a more permanent roof sharply reduced algal blooms, improved water quality, and lengthened filter runs. Nonetheless, the cost of constructing permanent covers can be substantial, often preventing utilities from justifying the expense without additional benefits. Participants discussed possibilities such as adding solar panels on top of covers to generate electricity, thereby offsetting capital costs.

6. Alternative Configurations and Wider Applications

The workshop explored the idea that “slow sand filtration by another name” might already be in use in related contexts. For instance, managed aquifer recharge (MAR) relies on infiltration basins that can act like large natural SSF, where water is purified by percolating through geological layers. In some regions, reclaimed water is infiltrated into groundwater aquifers for later extraction, an approach that effectively harnesses the same biological processes as an SSF but on a larger and more passive scale.

Participants also raised the intriguing notion of scaling *down* slow sand filtration for small communities or decentralized facilities analogous to biological household sand filters, but using continuous flow systems. While large utilities may benefit from the economy of scale, there could be a place for “packaged” SSF solutions for smaller installations or industries. However, the group recognized that such systems do not attract the same commercial attention as membranes or advanced oxidation units, partly because SSF technology is neither patented nor heavily marketed. Several attendees suggested that with modern instrumentation, remote monitoring, and improved operator guidance, smaller SSF setups could provide a reliable option for rural or decentralized water treatment.

7. Perception, Regulation, and the Path Forward

The regulator’s perspective was an important part of the conversation, as participants noted that *demonstrating control* is an important aspect of modern water treatment approval. Conventional processes like coagulation or membrane filtration appear more controllable because operators can measure coagulant dosage, monitor transmembrane pressures, or observe real-time residual disinfectant levels. By contrast, SSF rely heavily on biology, which can seem unpredictable. Several speakers reported that when performance anomalies occur in SSFs, such as unexpected spikes in particulates or colour—it can be challenging to pinpoint the cause or demonstrate swift corrective action.

Despite these challenges, the mood in the room was that improved understanding of microbial processes and the operational lessons gleaned from pilot-scale projects can help reassure regulators. There was agreement that the *multiple-barrier concept*—combining SSFs with a robust disinfection step—significantly alleviates concern about pathogen breakthroughs. Furthermore, participants observed that public opinion might already have shifted in favour of more "natural" processes if there is increasing skepticism about chemical dosing or if chemical supply chains become fragile. SSFs, as "nature-based" or biologically driven systems, might gain renewed interest under these circumstances. One utility representative pointed out that public perceptions of water treatment can change quickly, citing past cases where concerns about aluminium coagulants pushed some utilities to switch to iron-based coagulants or other processes. A similar pattern of public sentiment, potentially driven by environmental or sustainability arguments, could favour greater adoption of slow sand filtration—particularly if combined with tangible outcomes like lower carbon footprints and fewer chemicals in the supply chain and more natural solutions to drinking water provision. .

8. Conclusion: Charting the Future of SSFs

By the end of the workshop, there was broad consensus that slow sand filtration retains significant value in modern drinking water treatment, especially when viewed through a lens of resilience, sustainability, and adaptable biology. Even though it is a historic technology, SSF stands ready to be enhanced rather than replaced. The following points resonated most strongly among participants:

First, SSF are inherently robust. They can function with minimal dependence on electricity or chemicals, making them attractive assets in an era of global uncertainty. Second, their biological community is surprisingly adaptable to new contaminants, an aspect that may prove increasingly valuable as regulations evolve and new pollutants are discovered. Third, pairing SSFs with advanced processes such as ceramic membranes or UV disinfection can optimize both performance and safety, creating a synergistic approach that reduces operational costs while meeting stringent water quality targets.

Finally, industry-wide collaboration is needed to share operational innovations, such as underwater skimming, partial coverage, or other practical adjustments—that can significantly improve filter run times and reduce downtime. There is also a growing case for strategic research and communication with regulators to demonstrate how SSFs can be monitored, controlled, and integrated with other barriers. If these steps are taken, the "slow" in slow sand filtration will no longer be seen as an impediment, but rather as a stable, eco-technological pillar of safe and sustainable water treatment.

In short, the future of slow sand filtration is bright, yet it will require a collective effort from utility operators and design engineers, to microbiologists and regulators, to fully harness this technology's natural strengths in meeting the water challenges of tomorrow.

Position Statement from the 'Slow Sand Filter Futures' Workshop

Toward a Resilient, Low-Energy, and Ecologically Driven Drinking Water Treatment

Slow sand filtration has a longstanding record of success in drinking water treatment and now finds renewed relevance as the sector faces pressing global challenges. Climate change, supply chain uncertainties, and evolving water quality regulations highlight the need for robust, adaptable, and low-energy systems. SSF technology, which relies on a naturally formed biological layer (the *schmutzdecke*) within a bed of sand, offers precisely these qualities. Its capacity to remove pathogens and contaminants with minimal external inputs makes it well-suited to an era in which resilience and sustainability are paramount. However, despite these inherent strengths, important research and implementation gaps must be addressed to unlock SSF's full potential.

A clear theme emerging from the "Slow Sand Filter Futures" Workshop is the critical role of microbial ecology. SSF's principal advantage lies in its "microbial workforce" of bacteria, protozoa, and other microorganisms. This living community adapts to new pathogens and pollutants naturally, but deeper insight into fundamental biological processes will help utilities manage filters more precisely and reassure regulators about consistent performance. Researchers increasingly use genomics and advanced microbial monitoring tools to identify the organisms responsible for key treatment functions; building on these insights can guide the intentional seeding of SSF to accelerate ripening or target specific contaminants.

Alongside biological considerations, careful engineering enhancements can modernize SSF operations and improve cost-effectiveness. Although slow sand filtration is sometimes dismissed as land-intensive or lacking "knobs and levers," innovations such as underwater skimming—where the top clogging layer is removed without draining the bed—significantly reduce downtime and maintain production capacity. Covering filters to limit sunlight also curtails algal blooms, decreasing headloss and extending filter run times. While these solutions come with cost implications, strategic moves such as installing solar panels on covers or designing partial enclosures could yield operational savings and additional benefits.

Real-world application often involves combining SSF with complementary processes. Utilities have found that placing slow sand filtration upstream of a membrane system cuts down on chemical coagulation, produces less sludge, and achieves a more robust overall water quality barrier. Similarly, integrating UV disinfection further strengthens pathogen control, alleviating regulatory concerns. These multi-barrier designs allow operators to manage intermittent issues such as start-up after skimming—by relying on downstream safeguards while the SSF's microbial layer re-establishes itself.

Nonetheless, closing the remaining research gaps will require a multi-scale approach. Modelling tools that combine hydrodynamics with biological community modelling would allow operators to anticipate how changes in flow rate, temperature, or influent quality affect performance. In tandem, real-time monitoring technology can provide on-the-spot assessments, enabling swift responses to anomalies. Such advances will help demonstrate to regulators that SSFs are not “black boxes” but sophisticated ecological systems that can be managed proactively.

A further consideration relates to cultivating acceptance among the public, water utility managers, and regulators. Consumers are growing more conscious of sustainability, which can favour technologies that use fewer chemicals and consume less energy—strengths that SSF inherently provides. However, perceptions of controllability and the simpler appearance of the filter beds can create scepticism when compared to modern high-tech facilities. By communicating clear data on SSF resilience, safety records, and new operational strategies, advocates can illustrate that the technology meets rigorous standards and responds effectively to new contaminants.

Sustaining momentum will also depend on attracting investment, forging partnerships, and nurturing a new generation of talent. Researchers, industry practitioners, and policy-makers must collaborate on large-scale pilots and comprehensive studies. Such ventures should compare covered versus uncovered filters, evaluate different skimming approaches, explore hybrid SSF–membrane combinations, and delineate best practices for smaller-scale installations. Shared demonstration projects, co-funded by utilities and research bodies, would help pave the way for further innovation, including packaged solutions that benefit rural and decentralized water systems.

Ultimately, participants in the “Slow Sand Filter Futures” Workshop agree that slow sand filtration remains highly relevant to modern water treatment needs. Its ability to operate with minimal electricity and chemical inputs, combined with an evolving scientific understanding of its biological core, equips SSFs to meet challenges ranging from emergent contaminants to crisis resilience. By refining operations, deepening ecological knowledge, and proactively engaging regulators and the public, stakeholders can ensure that this “classic” technology continues to evolve as an integral component of safe, sustainable, and forward-looking water treatment. We therefore call on researchers, utilities, funding agencies, and policy-makers to champion a new era of SSF development—one that combines tradition and innovation to safeguard global water supplies for decades to come.

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On behalf of SSF futures workshop participants.

Outcomes of the Slow Sand Filters Future Workshop hosted by the Water Biofilms WG of the Environmental Biotechnology Network

Summary of Key Research Priorities for Advancing Slow Sand Filtration

1. Deepening Our Understanding of Microbial and Ecological Dynamics

A central feature of slow sand filtration is its reliance on a living system, most notably the microbial layer known as the *schmutzdecke*. Although this biofilm-based community has been recognized for well over a century, many gaps remain in our knowledge of how these microorganisms interact and adapt. Future research should therefore move beyond studying individual pathogens or contaminants and instead embrace a systems perspective. By examining the succession, competition, and cooperative relationships among different microbes, researchers can develop strategies for more predictable performance. It is equally important to consider non-traditional or extremophile species that might thrive under changing environmental conditions, including emerging pollutants such as PFAS and microplastics. Building on advanced molecular and cellular tools will enable the intentional introduction (or bioaugmentation) of specific microbial consortia, whether to accelerate initial ripening or enhance resilience against acute contamination events.

2. Data-Driven Monitoring, Modelling, and Predictive Control

New technology in sensors, data analytics, and computational modelling offers unprecedented opportunities to monitor and optimize slow sand filtration in real time. The development of reliable, low-cost devices that measure turbidity, microbial indicators, and dissolved oxygen can help operators detect early warning signs of performance decline. When combined with multi-scale modelling—where hydrodynamics, biofilm processes, and contaminant transformations are all integrated—utilities can more effectively test operational scenarios before implementing them. Machine learning approaches have begun to reveal subtle correlations between variables such as flow rate, temperature, and microbial community composition. Continued progress in these areas will strengthen the capability to predict when filters need maintenance and how they will respond to changing influent quality. By moving toward semi-automated or fully automated systems, water operators can improve decision-making and minimize downtime.

3. Rethinking Filter Design and Maintenance for Next-Level Performance

Slow sand filtration is often seen as a simple and relatively land-intensive process, yet engineers can update its design features in ways that simultaneously reduce cost and boost efficiency. New research can focus on refining basin geometries, distributing inflow more effectively, and exploring layered media—such as incorporating activated carbon or engineered aggregates—to enhance contaminant removal. Another avenue lies in innovations for skimming and cleaning. Techniques like underwater skimming, which remove the top clogging layer without fully draining the filter, can enable continuous operation and significantly reduce downtime. These maintenance methods require careful study to strike the right balance between clearing debris and preserving the deeper beneficial biofilm. Finally, modular and packaged SSF units hold potential for decentralized or smaller-scale installations, although these too must be tested under diverse flow regimes and raw water conditions to validate performance claims.

4. Integrating SSF into Broader Water and Resource Cycles

Slow sand filters seldom operate in isolation and benefit considerably when placed within comprehensive treatment trains that may include membrane processes, UV disinfection, or advanced oxidation. In such integrated systems, SSF often cuts down on chemical use and produces less waste, while the subsequent steps can provide additional safeguards and polish the final effluent. A more expansive view of SSF also extends to nature-based solutions, where wetlands or infiltration basins might precede or complement the filter, delivering ecological co-benefits such as flood mitigation or habitat creation. Embracing circular economy principles encourages the recovery and reuse of waste streams, including spent sand or skimmed biomass, which may find applications in agriculture, energy production, or materials manufacturing. Studying these wider resource flows helps position SSF as part of a resilient, ecologically beneficial strategy for water management.

5. Bridging Policy, Regulation, and Public Acceptance

Transforming the perception of slow sand filtration from an old-fashioned method to a modern solution requires targeted engagement with regulators, policy-makers, and local communities. Although SSF has a robust record of dependable performance, particularly in removing pathogens and reducing turbidity, its reliance on biological processes can appear less controllable compared to fully mechanized or chemical-based systems. Gathering and sharing high-quality evidence, including real-time monitoring data and comparative cost–benefit analyses, will make it easier to satisfy regulatory demands and build public trust. Clear risk communication is essential to clarify that SSF's apparent simplicity conceals a sophisticated ecological system that can adapt to emerging threats. Demonstrating how SSF aligns with goals of chemical reduction and lower carbon footprints also resonates with growing societal emphasis on sustainable and "natural" solutions.

6. Enabling Collaboration and Infrastructure for Research at Scale

Addressing these diverse research priorities will require not only technological and scientific advances but also a supportive research environment. The creation of pilot and demonstration sites where researchers, utilities, and private firms can pool resources will ensure that laboratory findings can quickly be tested and refined under real-world conditions. At the same time, there is a need for training and interdisciplinary collaboration, given that SSF spans fields ranging from microbiology and biofilm science to fluid mechanics, environmental economics, and public health. Funding bodies and water sector stakeholders can accelerate these efforts by investing in shared facilities and endorsing open data principles, making it easier to compare different strategies and catalyze continuous improvement. Such initiatives will also help nurture a new generation of scientists and engineers who can translate SSF's fundamental biological processes into reliable, low-energy systems tailored to twenty-first-century water challenges.

By prioritizing these areas—ecological understanding, data-driven operation, innovative design, multi-barrier integration, policy alignment, and collaborative research—slow sand filtration can evolve from a historical cornerstone to a pioneering front in resilient and sustainable water treatment.

Further information:

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For the full report see https://ebnet.ac.uk/resources

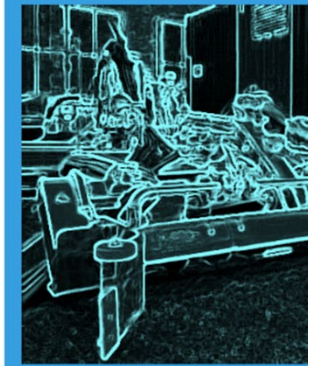
Appendix - Workshop slides

It's everyone's water

Catalyst Stream of Water Breakthrough 5

SandSCAPE:
Science and novel devices for sustainable cleaning and productivity enhancement

Dr Michael Chipps
Thames Water



Sandscape

Science **a**nd **N**ovel **D**evices for **S**ustainable **C**leaning and **P**roducti

Slow sand filtration is an amazing **nature based** chemical free dri
needs **modernising** by adopting new technologies to facilitate mo

A and B: two different full-scale **robotic underwater sand skimmi**
C: robotic machine to **remove algae** from the filters.

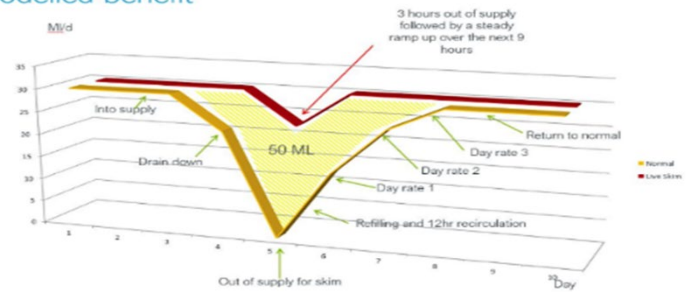
Wet skimming will make the process more **efficient** and **resilient**,
productivity, benefitting **customers** and the **environment** and re

Slow sand filtration

- Nature Based Barrier
- No Coagulants
- Gravity Fed
- Lowest Cost Treatment
- Resilient to *Cryptosporidium*
- 2.3 billion litres per day
- 8 million customers in UK
- 7 water companies

Estimated 300 Ml/d recovery in England

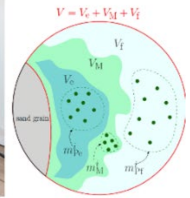
Modelled benefit



Yellow line = dry skimming output (large filter)

Red line = estimated wet skimming output

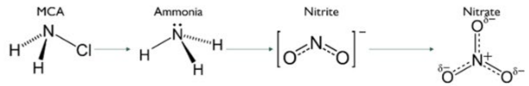
Building new slow sand filters in Sweden.

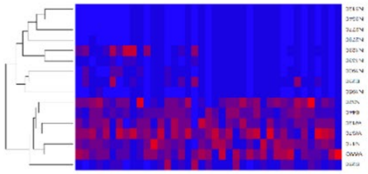


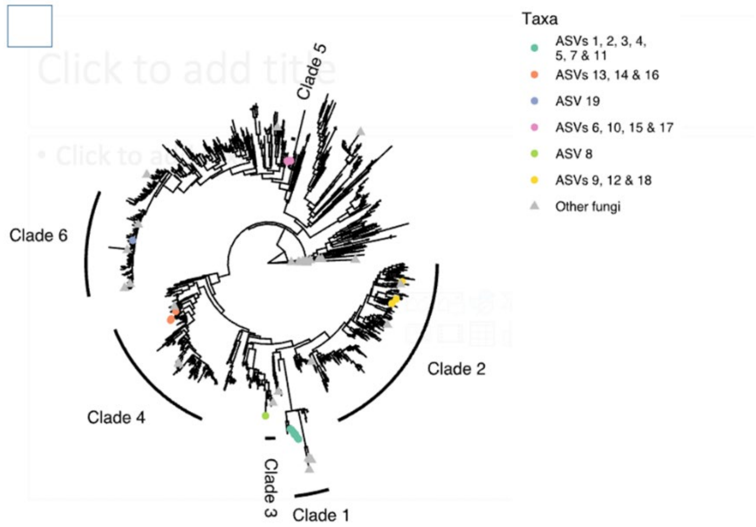
Associate Professor Catherine J. Paul

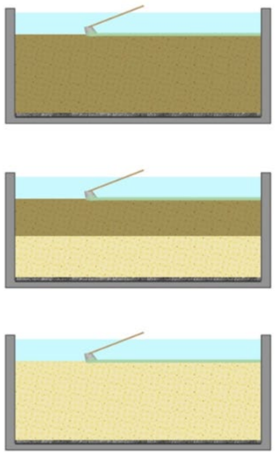
Division of Water Resources Engineering
Division of Applied Microbiology

Department of Building and Environmental Technology
Department of Chemistry
Faculty of Engineering
Lund University

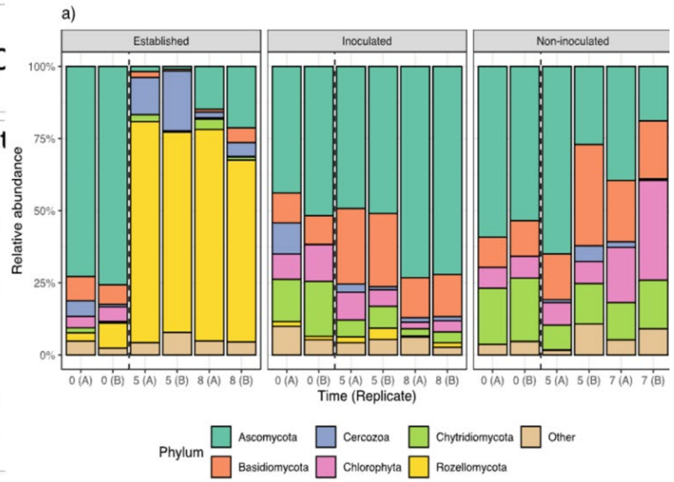








Chan, S., Pullerits, K., Riechelmann, J., Persson, K.M., Rådström, P. and Paul, C.J., 2018. Monitoring biofilm function in new and matured full-scale slow sand filters using flow cytometric histogram image comparison (CHIC). Water research, 138, pp.27-36.



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Slow Sand Filter Futures Workshop

Approaches for Removing Pharmaceuticals & Personal Care Products in SSF

Prof. LUIZA C. CAMPOS
Professor of Environmental Engineering
Co-Director of the Centre for Urban Sustainability and Resilience
Director of MSc in Engineering for International Development

22 January 2025
Royal Society of Chemistry
London, UK

Removal of estrogens by SSF after photolysis

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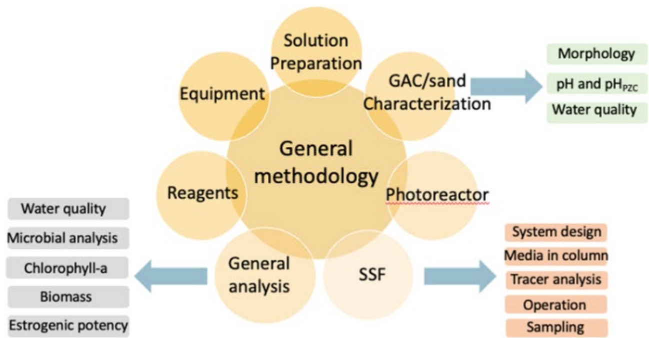
Methodology



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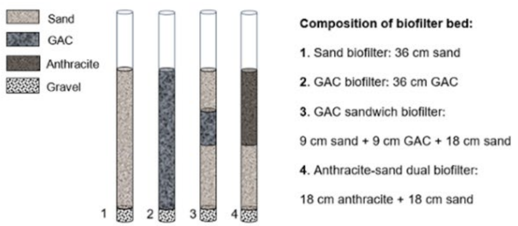
Contents lists available at ScienceDirect
Chemosphere
journal homepage: www.elsevier.com/locate/chemosphere
ELSEVIER

Removal of antibiotics in sand, GAC, GAC sandwich and anthracite/sand biofiltration systems

Like Xu [a], Luiza C. Campos [a], Jianan Li [a,b], Kersti Karu [c], Lena Ciric [a,*]



Antibiotics
amoxicillin (AMOX)
clarithromycin (CTM)
oxytetracycline (OTC)
sulfamethoxazole (SMX)
trimethoprim (TMP)

at 2 µg/L, except for amoxicillin which was spiked at 5 µg/L due to the analytical method constraints

3-month operation

Filters in duplicate

UCL

Thank you for listening!

A special thank you to the following researchers:
Dr Jianan Li
Dr Fan Huang
Dr Caroline Pompei
Dr Fernando de Souza
Dr Like Xu

Prof. Luiza Campos (l.campos@ucl.ac.uk)

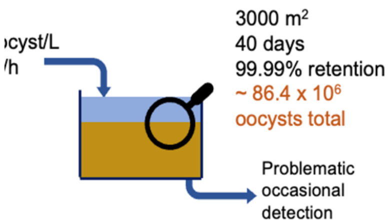
Examining biological mechanisms of *Cryptosporidium* removal in SSF

S.L Bretagne, T. Elemo, M. C. J. Bradwell, M. Chipps, J. A. Harris, F. Hassard

22/01/2025

www.cranfield.ac.uk

The challenge of Cryptosporidium in slow sand filters



Public health

Compliance

Reputation

Monetary implications

- What is the fate of the retained *Cryptosporidium* oocysts?
- Which processes impact the retention and/or degradation of *Cryptosporidium* oocysts in SSF?

Cores – Results & discussion

Oocysts detection model

- Decrease in detectable number of total oocysts in cores with time
- First order reduction regression model

$$y_i = y_0 \cdot e^{-k_i \cdot t}$$

Where i is the skim regime

- Pre-skim cores (Day 12, 19 and 37) included
- k_{USW} = -0.03 [day $^{-1}$] and k_{DS} = - 0.031 [day $^{-1}$]
- Difference between predicted oocyst counts and measured (post-skim) shows that 4% of the total oocyst dose removed in the UWS filters and 5.5% in the DS filters can be attributed to skimming.

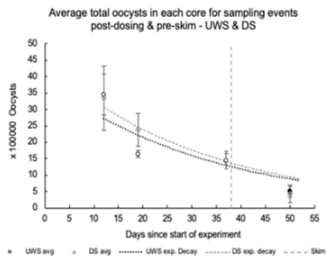
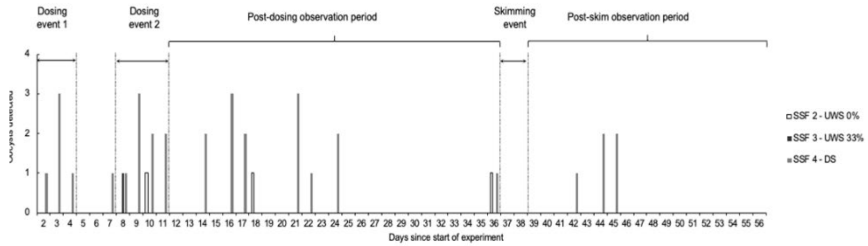


Figure 1 – Averaged total number of oocysts detected in post-dosing and pre-skim cores Days 12, 19 and 37 (with standard error bars) and first order decay regression curves to model the decrease in oocysts with time. R^2_{UWS} = 0.58 and R^2_{DS} = 0.65.

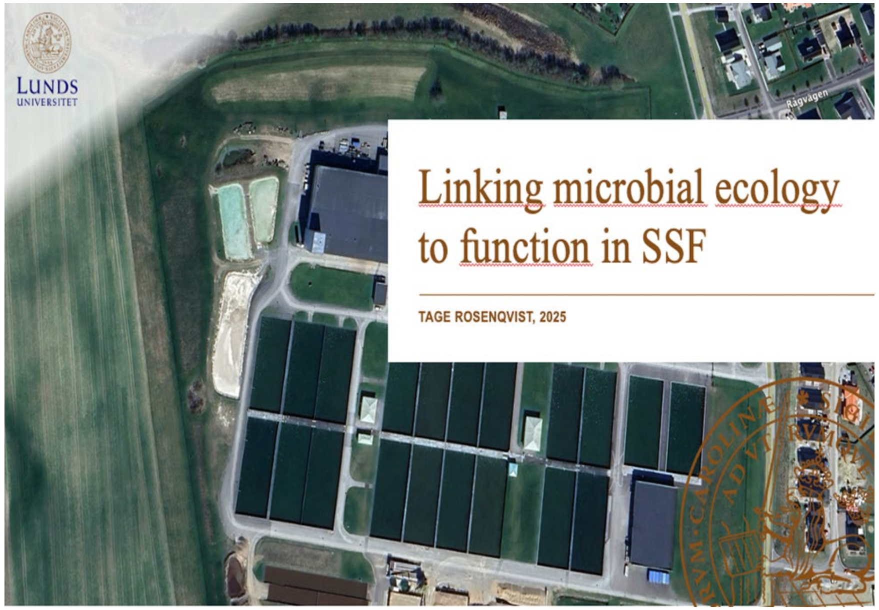
NB: Data points from cores on day 50 (filled markers) were not included in the regression as this would bias the calculations, but they are represented on the graph to show the difference between the observed and predicted values.

Filtrate – Results & discussion

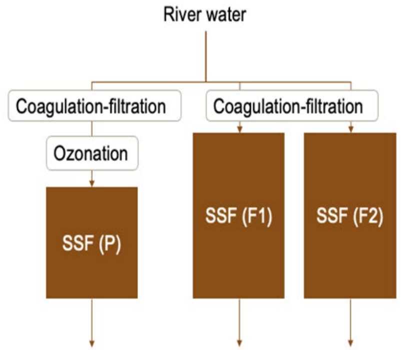
Oocyst breakthrough – high volume sampling

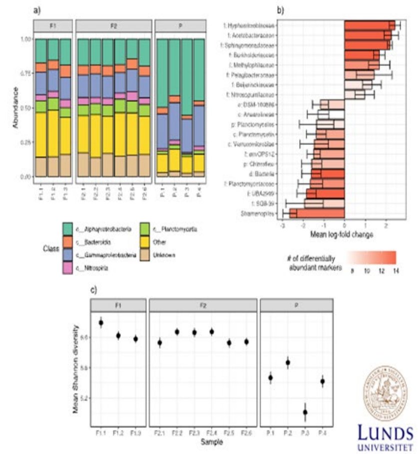


- Filtrate monitoring post-dosing and post-skim
- Delayed breakthrough post-dosing and post-skim for DS beds

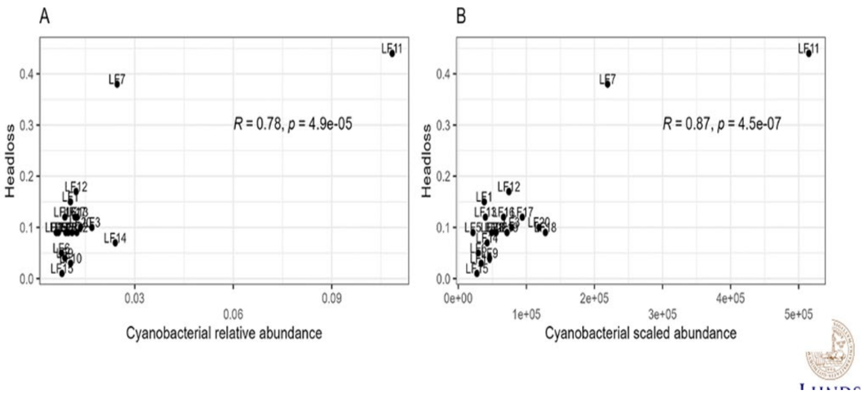


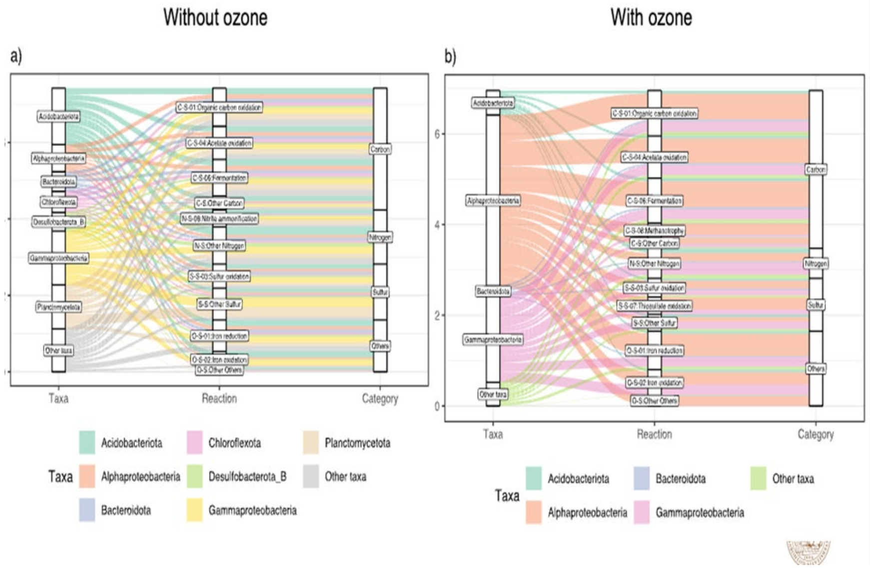
Ozonation changes the biofilter community





Cyanobacteria are identified as the group most related to clogging





Understanding the Risks of Underwater Skimming of Slow Sand Filters

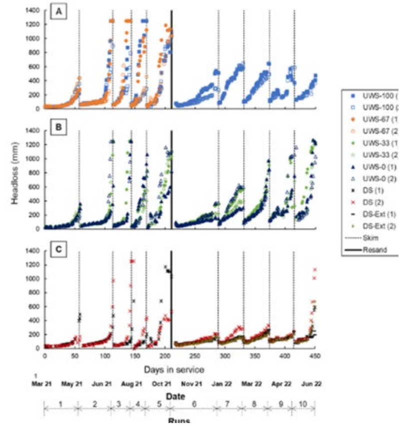
"Slow Sand Filter Futures Workshop", London.
22 January 2025

Tolu Elemo
Water Sector Analyst, Mott MacDonald

Impact of UWS on SSF Performance and Operation

Key findings

- UWS was found to be comparable with DS in terms of filtrate water quality.
- Despite quicker head loss development, UWS filters adhered to regular seasonal operational cycles.
- UWS filters exhibited less disruption post-skimming, showing quicker recovery to microbial compliance compared to DS filters.
- Various sweetening flow rates applied to the UWS did not impact filter operation, water quality, or head loss development.



Underwater Skimming (UWS) of SSF

https://doi.org/10.1021/acsestwater.2c00313

1 Based on typical operation of full-scale filters at Thames Water Ltd.
2 Considering no "run-to-waste"

Impact of project

Operational time saved has the potential to increase production capacity without additional filters built.

Cleaning duration and equivalent water production associated with DS (typical) and UWS (predicted) with different sweetening flows. (A) Operational downtime, and (B) equivalent water produced.