Tackling the Micropollutant Metaldehyde with Bioremediation

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Stream

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1 The Problem of Micropollutants

- Emerging micropollutants, such as metaldehyde (active ingredient commonly used in molluscides), threaten to adversely impact water quality. Most are persistent, mobile and toxic (PMT), and are found at concentrations of µg/L-pg/L [1]. In the UK metaldehyde is frequently detected above the European Union (EU) Drinking Water Directive individual pesticide consent limit of 0.1 µg/L, and will be banned as from 2020 [2].
- Current conventional treatment methods are either ineffective or not economically viable with respect to metaldehyde removal. However, slow sand filters (SSFs) and biobeds are promising bioremediation techniques which have shown great potential.

[1] Reemstma et al., 2016. Mind the Gap: Persistent and Mobile Organic Compounds-Water Contaminants That Slip Through. *Environmental Science and Technology*, 50, pp.10308–103015.
[2] Drinking Water Inspectorate, 2010. What are the drinking water standards? Available at: http://dwi.defra.gov.uk/consumers/advice-leaflets/standards.pdf [Accessed April 11, 2017].

2 What Are the Aims? What Have We Learnt so Far?

Field Sampling

- **Aims**

Assess metaldehyde removal from 4 industrially operated SSFs which receive the same influent water. And analyse the effect of selected environmental and operational parameters on metaldehyde removal.

- **Findings to date**

The 4 industrially operated SSFs possessed varying metaldehyde removal efficiencies (see *Figure 1*). Only SSF12 had a high removal, however, this decreased over time of operation. The other SSFs maintained a low removal rate of metaldehyde throughout their operation.

Figure 1. The metaldehyde removal efficiency observed for 4 industrially operated SSFs from September 2017 to March 2018. All data collected was undertaken in triplicate, the standard deviation is shown.

Biodegradation Studies

- **Aims**

Investigate the kinetics and removal of metaldehyde with SSF and biobed inocula, with isothermally operated batch bioreactors.

- **Findings to date**

Extent of mineralisation and time to achieve mineralisation varied for the 4 distinct SSFs and biobed media. In comparison to SSFs, biobeds generally possessed faster kinetics, however there was variability between replicates, (see *Figure 2*). It was concluded that these microorganisms are rare and heterogeneously distributed within SSFs and biobeds.

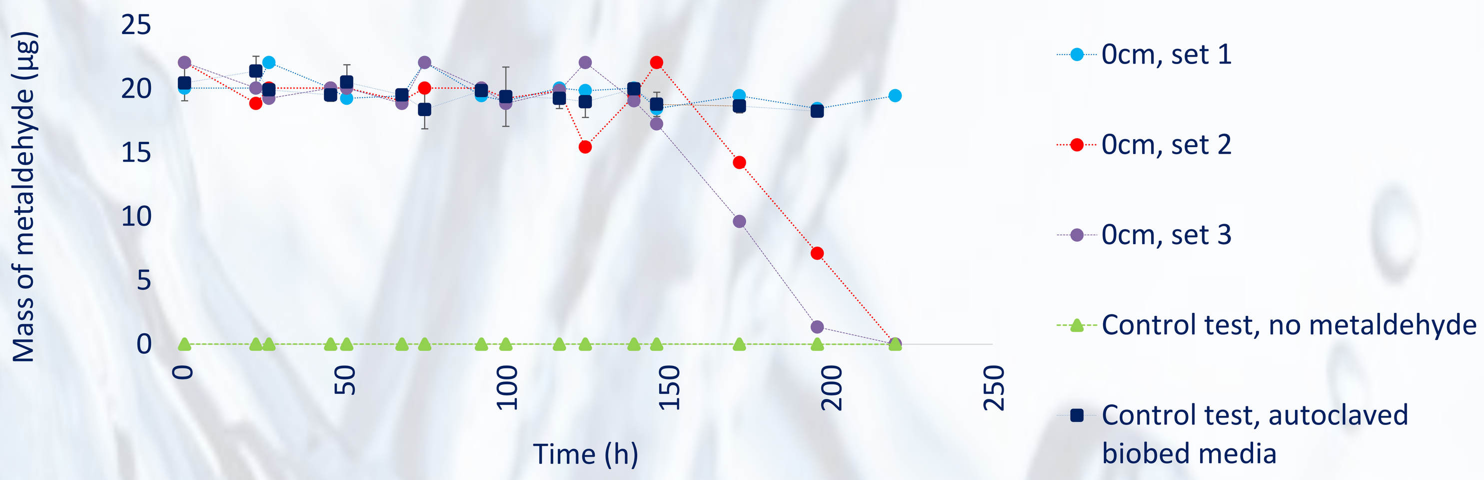

Figure 2. Biobed biodegradation studies, from a sampling depth of 0cm. This was operated at 15°C in batch, for a period of 11 days. The active media were undertaken in triplicate, the control studies with no metaldehyde and with the autoclaved biobed media were undertaken in duplicate. Where applicable the standard deviation is shown.

Molecular Analysis

- **Aims**

Characterise the microbial community from the SSFs and biobed. Quantify and identify the metaldehyde degrading microorganisms.

- **Findings to date**

The Granular Activated Carbon (GAC) and top layers of sand possess the highest bacterial concentration, (see *Figure 3*).

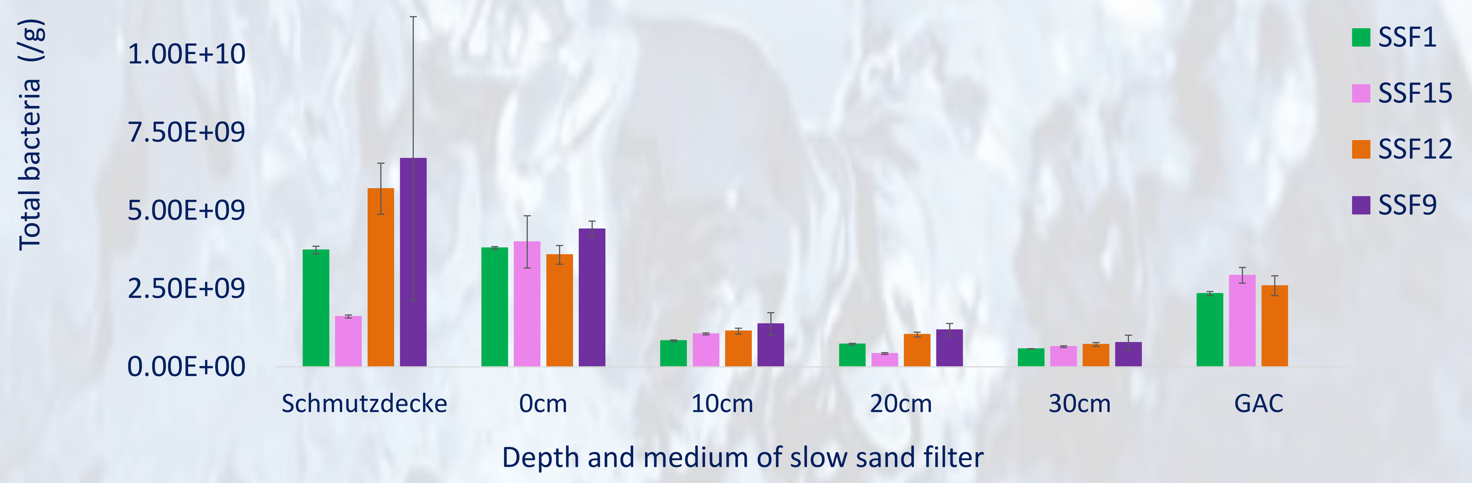

Figure 3. The total bacteria (/g) observed for the 4 industrially operated SSFs from the top depth (Schmutzdecke) to the middle depth of 50cm (GAC). This was undertaken with the use of flow cytometry. Note all the SSFs had a GAC layer sandwiched between the layers of sand, however SSF9 does not have a GAC layer present.

3 Future Work

- Use statistical analysis to assess why there are differing performances from industrially operated SSFs.
- Characterise the microbial community assembly in SSFs and biobeds and identify and quantify the metaldehyde degrading microorganisms.
- Use metaldehyde degraders to bioaugment laboratory scale biobeds and/or SSFs to assess whether there is improved removal.
- If SSFs and biobeds are better understood and optimised, in line with Sustainable Development Goal 6 (SDG) Clean Water and Sanitation, they could contribute towards ensuring that future generations have access to safe, sustainably produced drinking water. Advantages of these bioremediation technologies include: negligible waste generation; effective removal of xenobiotics; low energy requirements; utilisation of natural processes and low operational and capital costs [3][4].

[3] Juwarkar et al., 2010. A comprehensive overview of elements in bioremediation. *Review Environment Science Biotechnology*, 9, pp.215–288.
[4] Vidali, 2001. Bioremediation. An overview. *Pure Applied Chemistry*, 73(7), pp.1163–1172.

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