Analytical Chemistry Trust Fund, ACTF Summer Studentship 2022

Optimizing Low-Cost 3D-Printed Passive Samplers for Emerging Contaminant Monitoring in River Waters

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Grant status: Successful
Duration: 2022-2023

The project seeks funding to support an undergraduate student to develop advanced sampling and analytical skills in environmental monitoring. The student will evaluate the effectiveness of a low-cost 3D-printed passive sampler in monitoring emerging contaminants in river water.

1 Background

Caffeine, acetaminophen, and carbamazepine will be monitored since they are frequently detected in surface water and often exhibit sublethal effects to aquatic species. For example, caffeine was found at 0.21-1.32 µg/L in Ireland while acetaminophen had concentrations of up to 0.12 µg/L.[1] A study in Thames River found concentrations of up to 0.25 µg/L.[2] Interestingly, 0.01 µg/L carbamazepine was recently shown to cause reproductive impairment in aquatic species, hence the need for monitoring emerging contaminants in surface water.

Passive sampling offers a reliable approach for measuring the bioavailable component of contaminants in the environment. However, commercially available passive samplers often have a problem of long lag-times ranging 3-11 days, particularly for moderately hydrophobic compounds. Additionally, the membranes widely used such as polyethersulfone are prone to biofouling. A previous study showed 3D-printed integrated porous membranes based on a hyper-crosslinked polystyrene sorbent (HCPS), MN150 where effective for sampling atrazine a moderately hydrophobic compound.[3]

1.1 Research aims

1. To evaluate the effectiveness of a low-cost 3D-printed passive sampler in monitoring emerging contaminants (caffeine, acetaminophen, and carbamazepine) in river water.
2. To help an undergraduate student develop advanced sampling and analytical competencies in environmental monitoring.

1.2 Research objectives

1. To evaluate the performance of the 3D-printed passive sampler in terms of lag-time and recovery.

2. To assess the effects of dissolved organic matter on the performance of the 3D-printed passive sampler.
3. To train an undergraduate student in environmental monitoring and analytical techniques through hands-on experience with the 3D-printed passive sampler and a liquid chromatography mass spectrometer.

2 Methodology

Assessing the performance of the 3D-printed passive sampler: Simulated river water will be prepared in a batch 2-L container and spiked with caffeine, carbamazepine, and acetaminophen (1 to 10.0 µg/L). Duplicate samples will be collected four times over a two-week period, and the concentrations of the compounds absorbed by the membranes determined using LC-MS after extraction. The lag-phase will be determined using a linear regression of the absorption profiles of each compound.[4]

Effect of dissolved organic matter on 3D-printed passive sampler performance: The experiment above will be reported using simulated water with dissolved organic matter added. The recovery and lag-phase will be used to evaluate the effect of dissolved organic matter.

Extraction and analysis: Caffeine, acetaminophen, and carbamazepine will be washed off the membranes using methanol under gravity. The time-weighted concentrations of the three compounds will be determined using LC-MS and a C18 column.

3 Deliverables

Poster presentation: The student will receive guidance in preparing a poster for presenting at an academic conference where they will share their findings to the academic community. Through the presentation, they will contribute to the field by providing valuable data on the optimization of 3D-printed passive samplers.

Data to support future grant applications: The data collected on the performance of the 3D-printed passive sampler with an integrated porous membrane will be used to support a grant application for a long-term monitoring program of emerging contaminants.

4 Student support and development

4.1 Learning outcomes

By the end of the Summer Studentship, the student will be to:

- Evaluate the performance of a passive sampler in monitoring emerging contaminants in a simulated river.
- Demonstrate competency in using and troubleshooting LC-MS in analysis of emerging contaminants.

4.2 Student benefits

Academic skill development – the student will be trained on using LC-MS from analytical in Week 1, passive sampling in Week 2, and research design and conduct throughout the studentship.

Professional skill development – students will be mentored and monitored to develop their soft skills such as problem-solving and time management through weekly meetings with records kept.

5 Total cost for studentship

8 weeks outside London [redacted]

6 References

1. Aherne, J. *et al*. *Chemosphere* **311**, (2023).
2. Munro, K. *et al. Science of the Total Environment* **657**, 1099–1111 (2019).
3. Kalsoom, U. *et al. Anal Chem* **90**, 12081–12089 (2018).
4. Vermeirssen, E. L. M., *Environ Sci Technol* **46**, 6759–6766 (2012).