How do River Channel Geometry and Sediment Calibre Affect the Degradation of Wastewater Pollutants?

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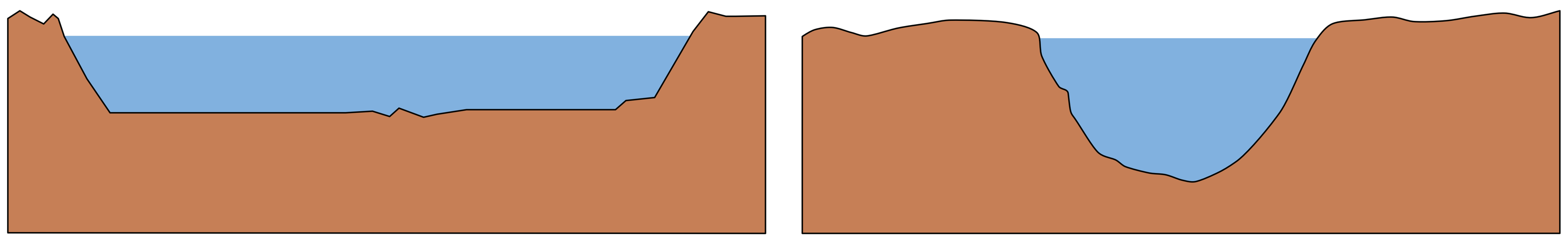
Introduction and Context

- Microbially-mediated transformations, such as biodegradation and nitrification, are important removal mechanisms for wastewater pollutants in rivers
- These processes are expected to predominantly take place in fixed biofilms [1-2]
- As a result, transformation rate constants (*k*) should vary with the size and shape of a river's channel because this controls how much of a chemical in the water column comes into contact with the biofilm on the bed and banks

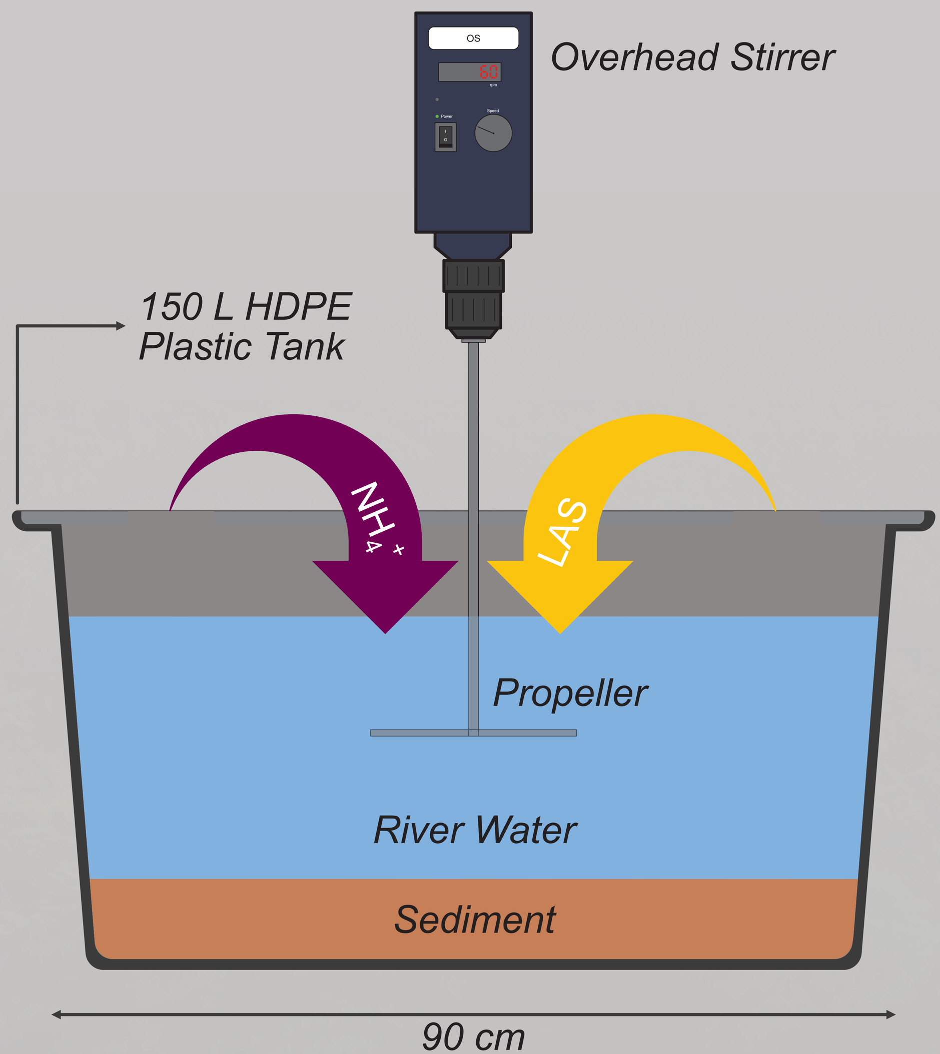


Wide and Shallow Channels	Narrow and Deep Channels
• Low Hydraulic Radius • High interaction between chemicals in solution and biofilm • Rapid degradation	• High Hydraulic Radius • Low interaction between chemicals in solution and biofilm • Slow degradation

- Microbial transformations are also predicted to be more rapid in fine-bedded, versus coarse-bedded, streams because the sediment surface area available for biofilm colonisation is greater [3-4]
- However, the reduced permeability of fine sediment may inhibit solute penetration and reduce microbial transformations [4]

Mesocosm Experiments

- Two mesocosm experiments were set up to investigate the influence of: **(1)** channel geometry and **(2)** sediment size on microbially-mediated transformations (see below)
- Each experiment used river water and was acclimatised for three weeks before being spiked with high concentrations of ammonium (NH_4^+) and linear alkylbenzene sulphonate (LAS, CAS No: 25155-30-0), a surfactant widely used in home care products



- Nine tanks were set up, allowing for three replicates of three treatments per experiment:

(1)

(2)

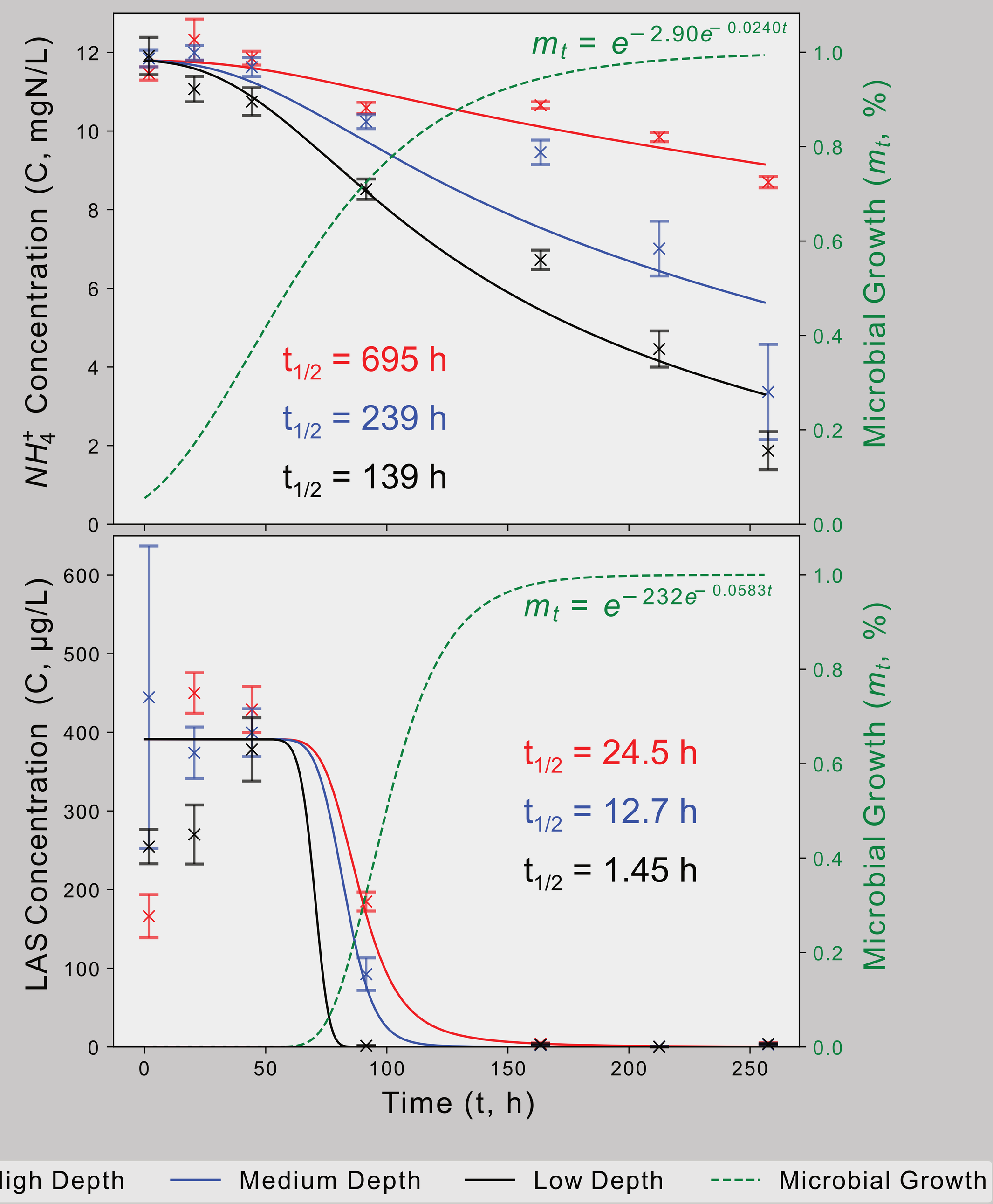
Sand **Gravel** **Cobbles**

Results

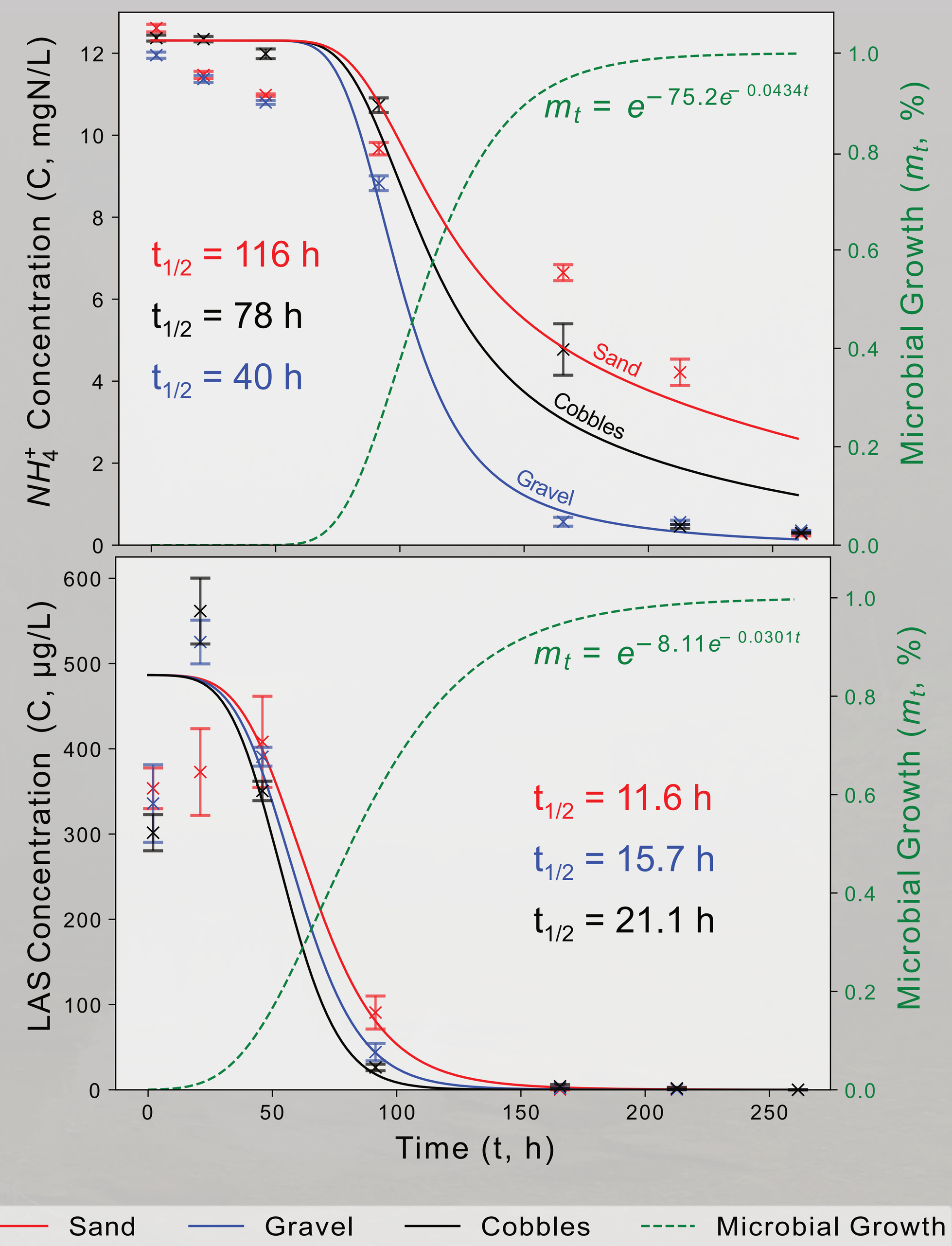
- Modified degradation kinetic equations, which account for a lag period for microbial adaptation, were developed to describe observed concentrations (*C*) of NH_4^+ and LAS
- First order degradation rate constants (*k*) were modified depending on the extent of microbial adaptation (m_t)
- m_t is Gompertz function and is calibrated during the optimization procedure

$$C = \overline{C_{max}} \cdot e^{(-k \cdot m_t \cdot t)}$$

Channel Geometry Experiment



Sediment Size Experiment



Conclusions

- Transformation rates of wastewater pollutants were inversely proportional to depth
- Sediment size controls were more complex, probably reflecting a combination of sediment surface area for biofilm growth and bed permeability
- Higher-tier chemical exposure models and associated risk assessments should consider the morphology of receiving environments

Scan to Connect

[1] Boeije et al. (2000) *Wat. Res. 34 (5)*
[2] Honti et al. (2018) *Wat. Resour. Res 54*
[3] Cook et al. (2020) *STOTEN 749*
[4] Parker et al. (2018) *Ecosphere 9 (3)*

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