Interactions of sediments with nutrients and pollutants – hydraulic flume experiments and implications for the aquatic environment

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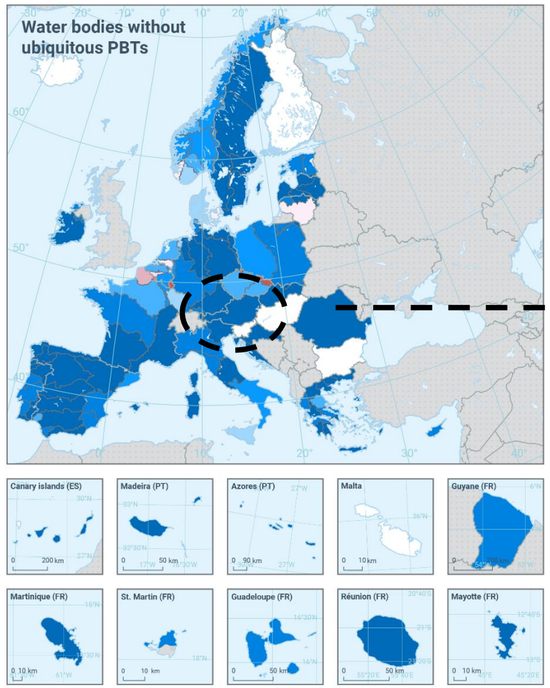
BOKU University

RIVER BASINS 2026
11–12 June 2026
Karlsruhe, Germany

Scope

Water bodies failing to achieve good chemical status in 2021 (3rd RBMP)



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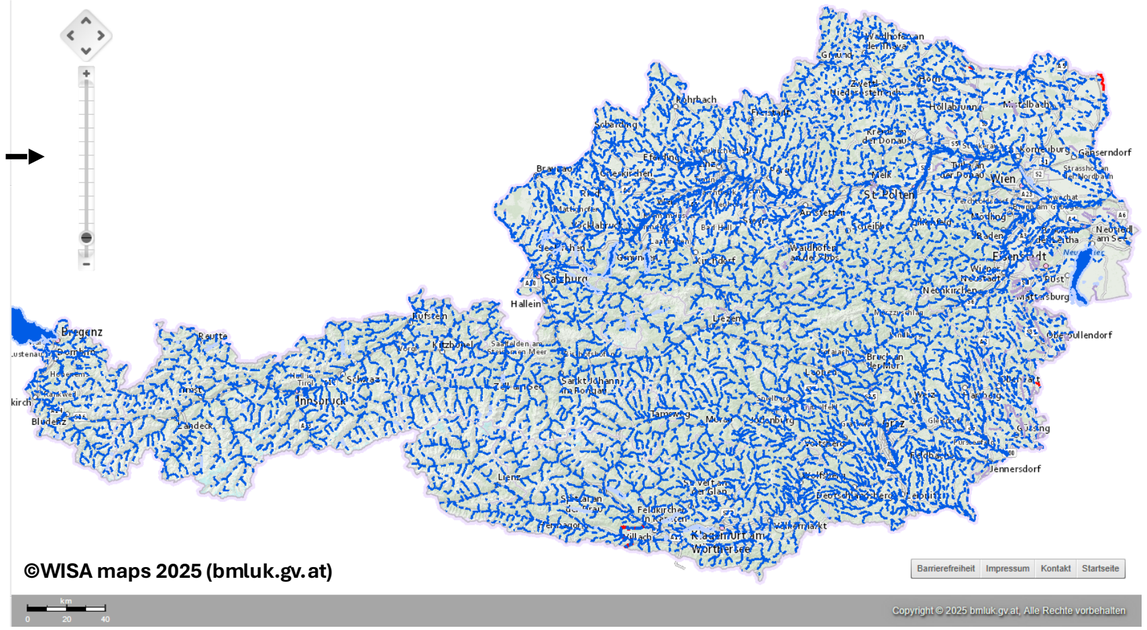
Current situation in Austria

Chemical status of surface waters without ubiquitous pollutants



Scope

Water bodies failing to achieve
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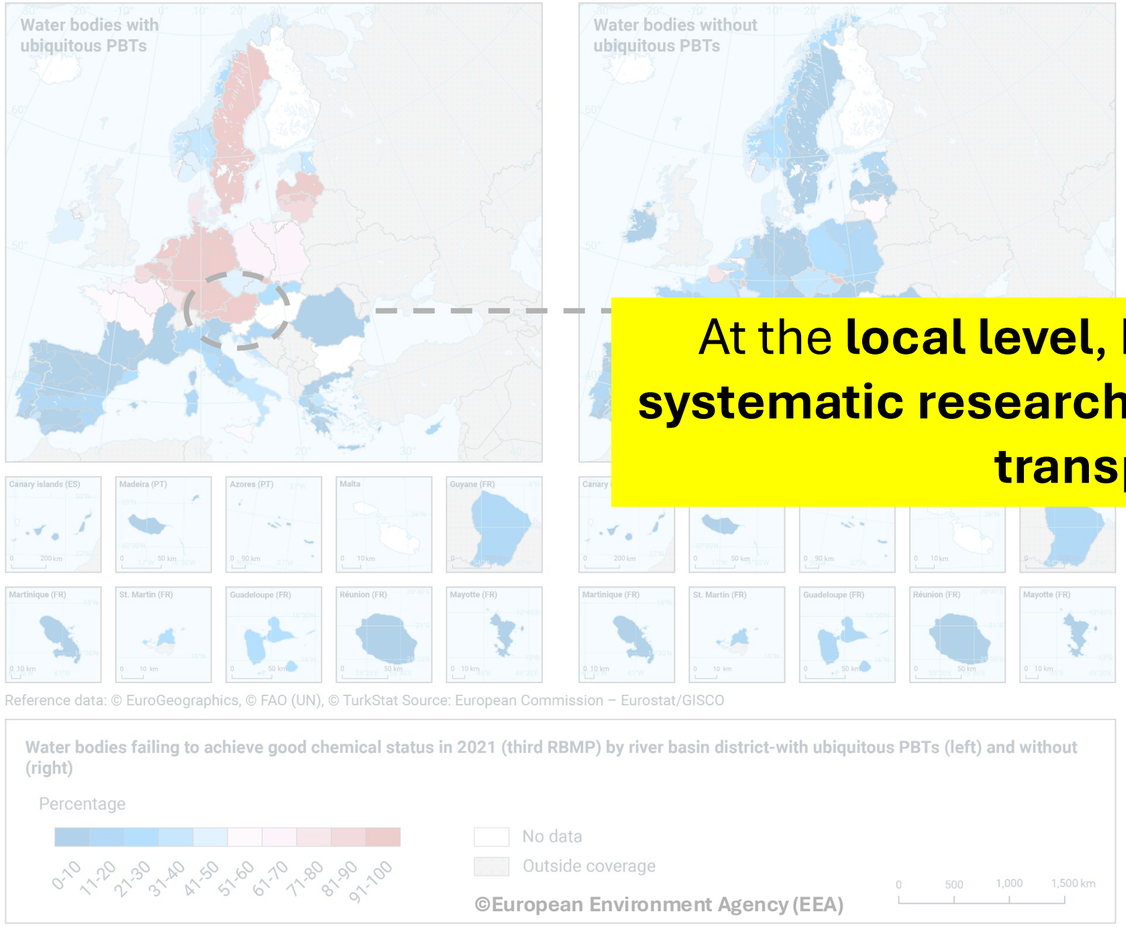
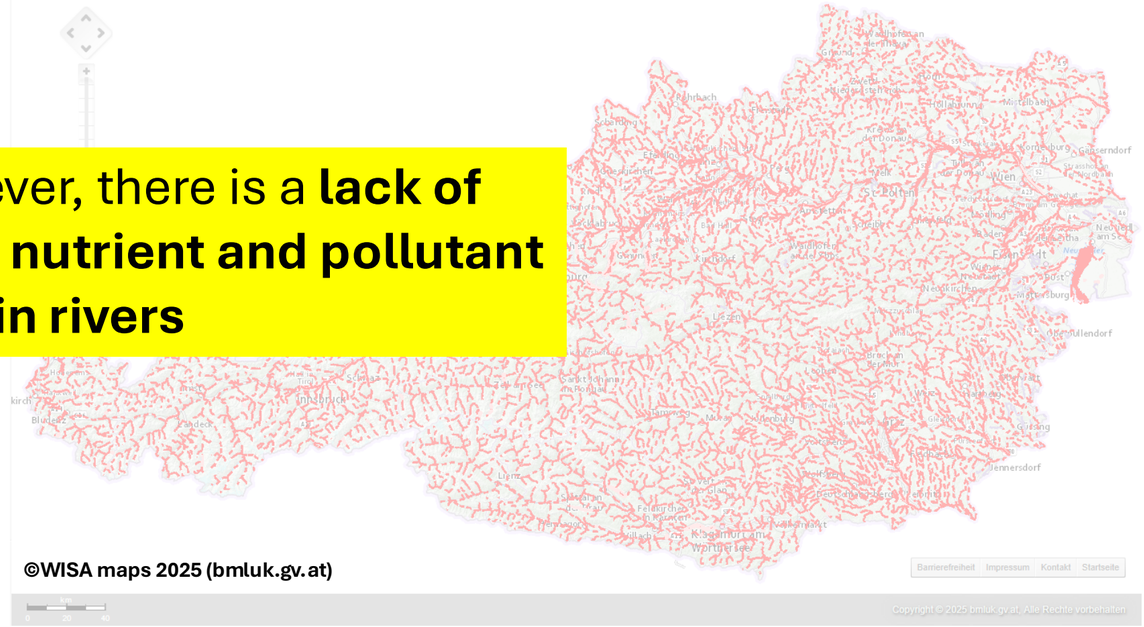


Current situation in Austria
Chemical status of surface waters
with ubiquitous pollutants (in particular Hg, PBDE)



At the **local level**, however, there is a **lack of systematic research into nutrient and pollutant transport in rivers**

Case study – River Maltsch (AT/CZ)

Contents lists available at ScienceDirect

Limnologica

journal homepage: www.elsevier.com/locate/limno

Determination of particle-bound nutrients and micropollutants concentrations and loads in small rivers – A novel sampling method

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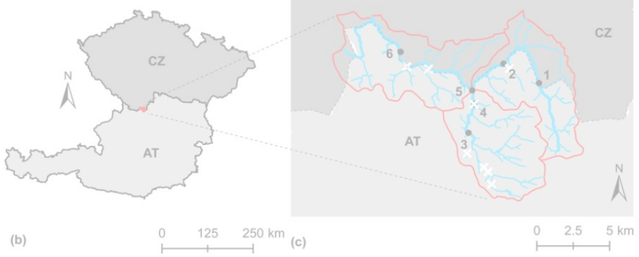
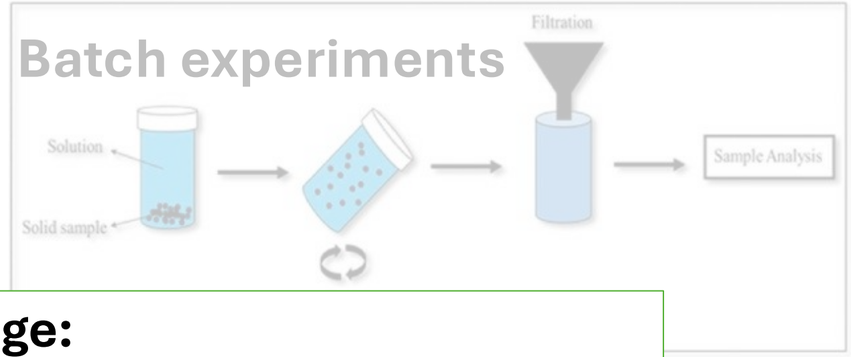
How can we apply these findings to other catchment areas and rivers?



Problem definition

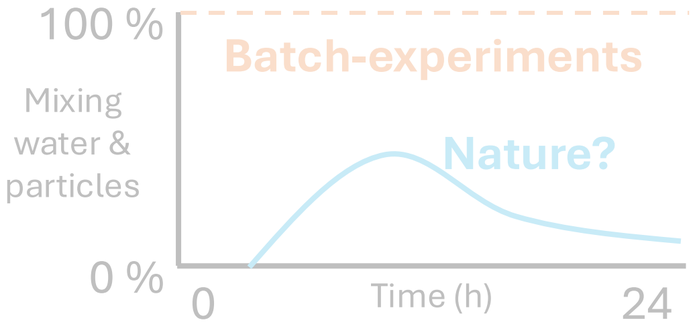
→How do the **main processes** (transport, deposition, remobilisation) influence the **distribution of nutrients and pollutants under natural conditions**?

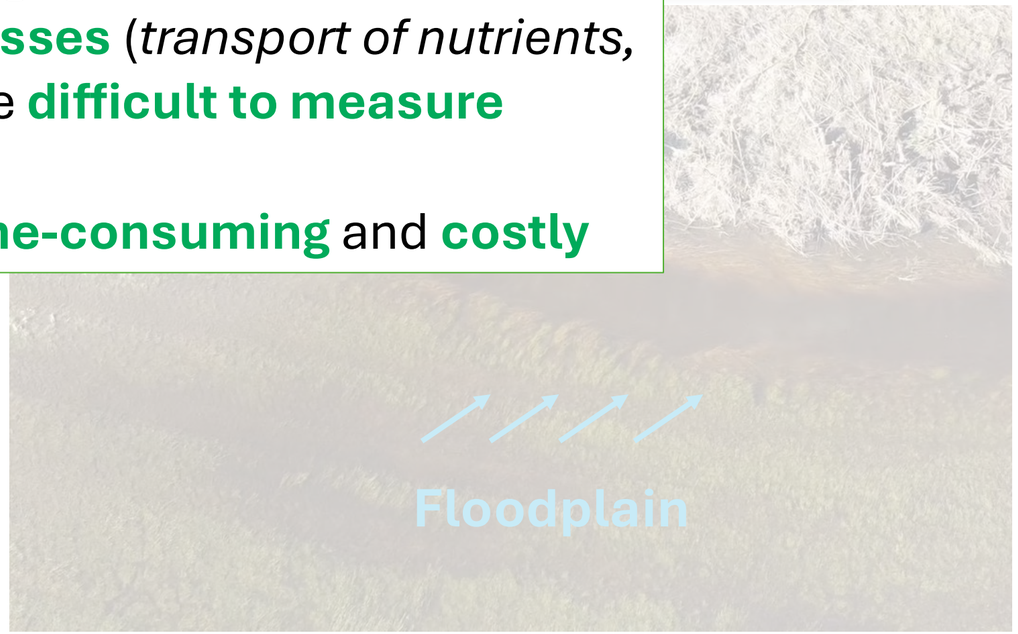


Key message:

In nature, there are **unsteady processes** (*transport of nutrients, pollutants, sediments*) that are **difficult to measure**

→ **Sampling and analysis** are **time-consuming** and **costly**





Project idea

Investigating **nutrient and pollutant transport in flume experiments** under controlled **morphological and physico-chemical conditions**

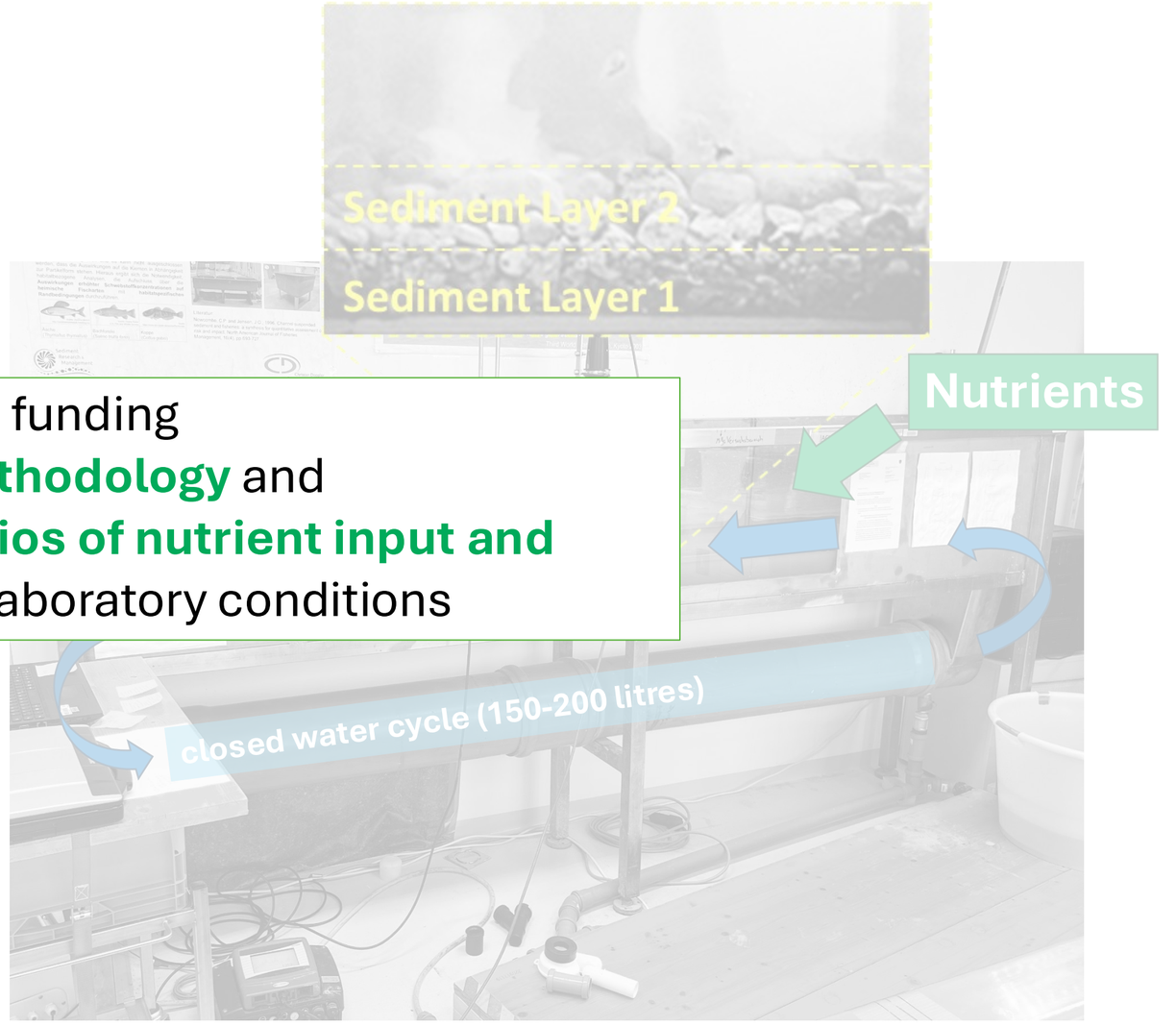
Sediment layer (i-iv)

We received funding
to **validate the methodology** and
investigate selected scenarios of nutrient input and sediment layers under laboratory conditions

Nutrient influx scenarios:

(a) liquid, (b) manure, (d) soil

(i) into the water, (ii) spiked sediment



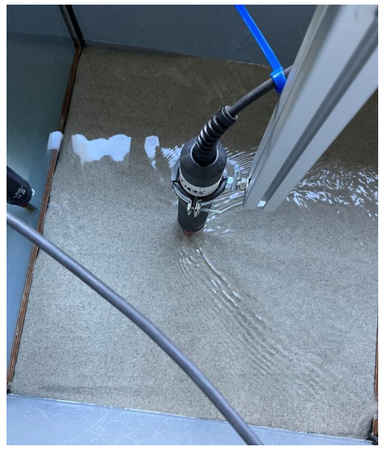
Experimental setup and methods (1)

- **Flume** (400 x 60 x 35 cm), circulating water circuit (150–200 L)
- **Sediment cores**: 1 or 2 layer quartz sand

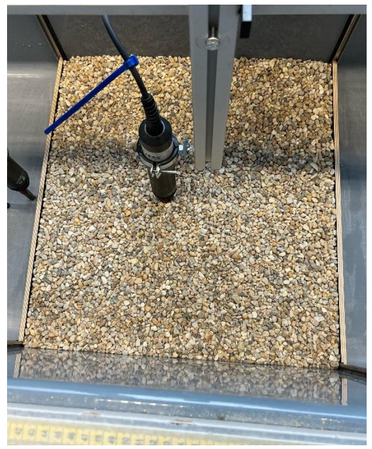
→ *Related to previous research work in the Bohemian Massif (AT, CZ)*

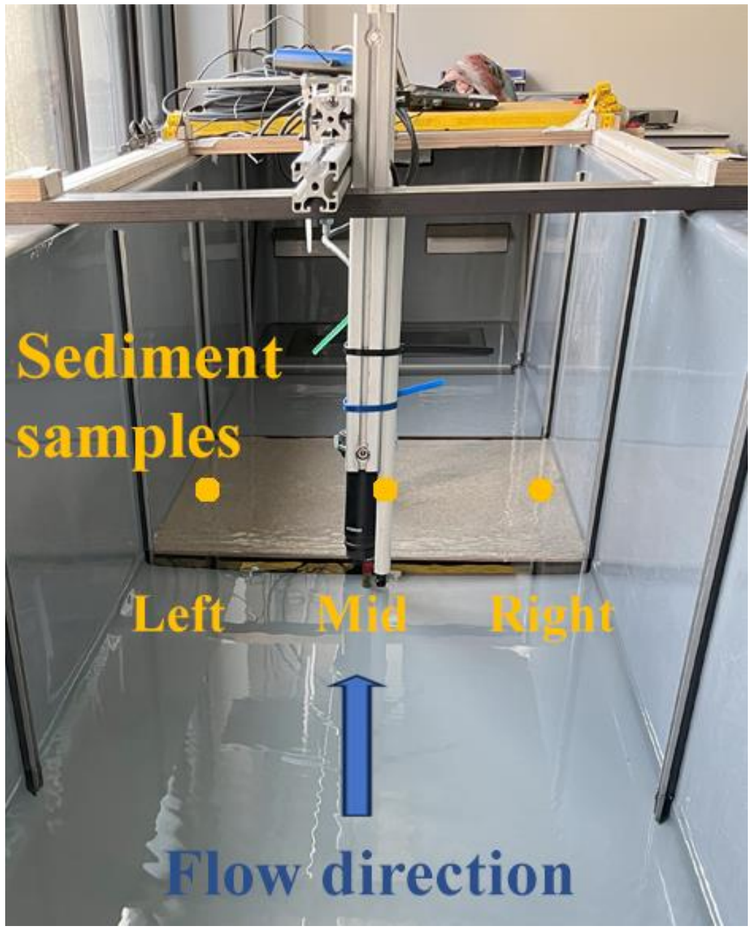
- **Selected nutrients**
  - **NPK liquid fertiliser**
  - Peat-free potting soil
  - Animal manure
- **Entry points**
  - **Into the water**
  - **Below the sediment core**

d = 0,4 – 0,8 mm



d = 4 – 8 mm

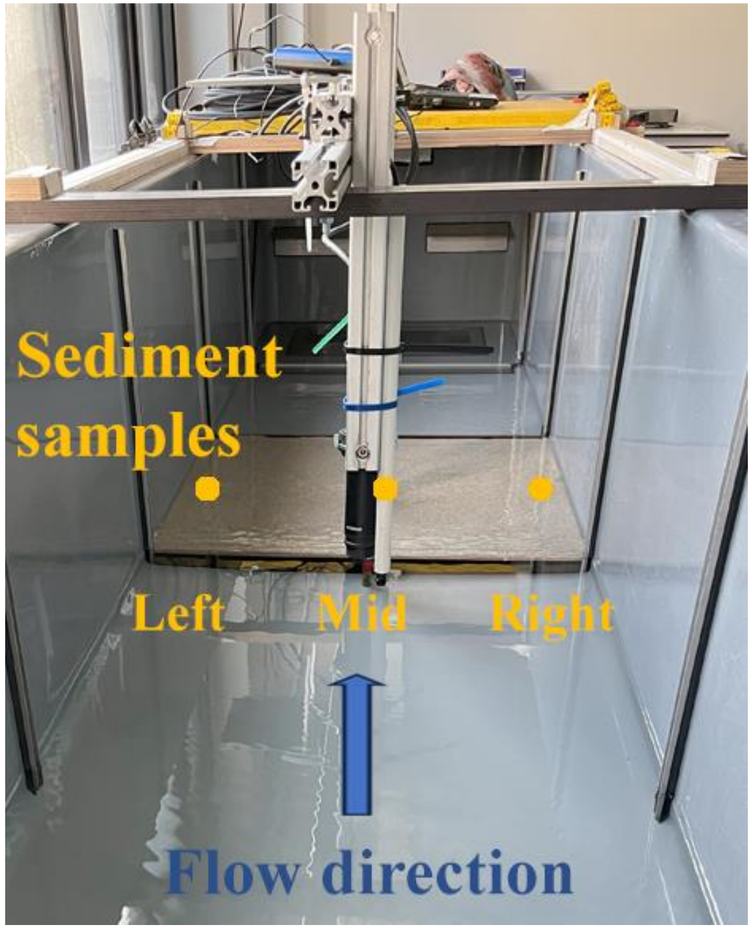




Experimental setup and methods (2)

- Each experiment lasted **24 hours**
- **One water sample** and **three sediment samples**
- Trace element and nutrient analysis using ICP-OES

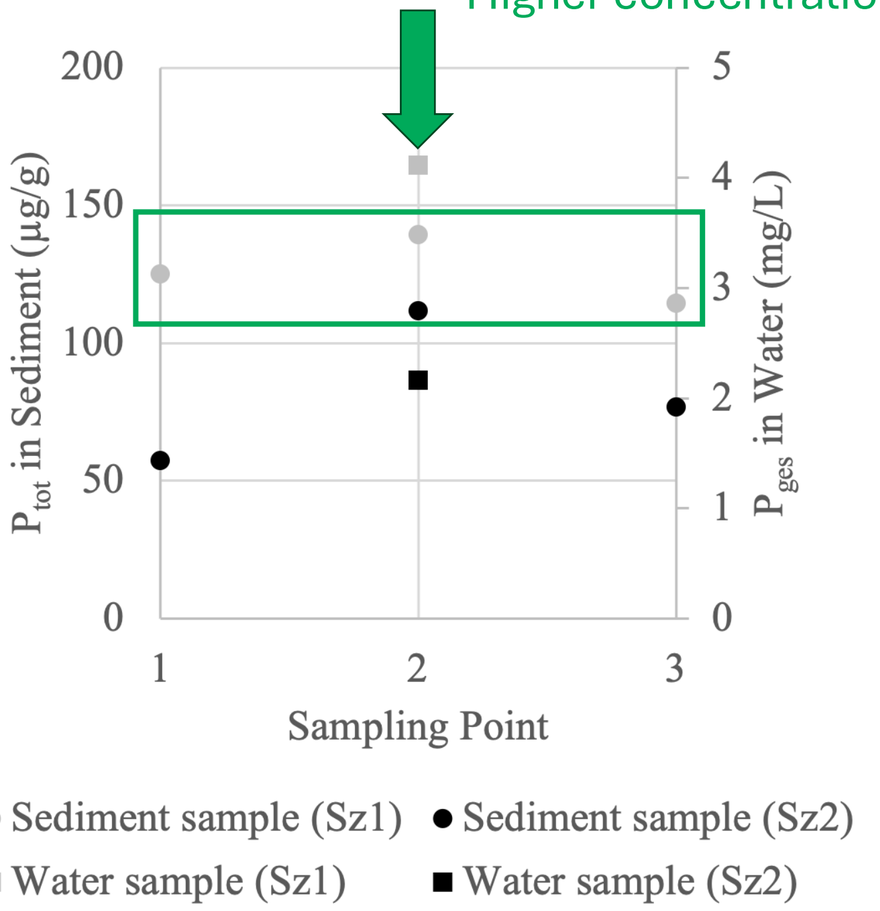
- **Continuous recording of ppm ammonium concentrations** *(Hanna Instruments HI9829; ISE HI7609829-10)*
- In addition, standard physical-chemical parameters

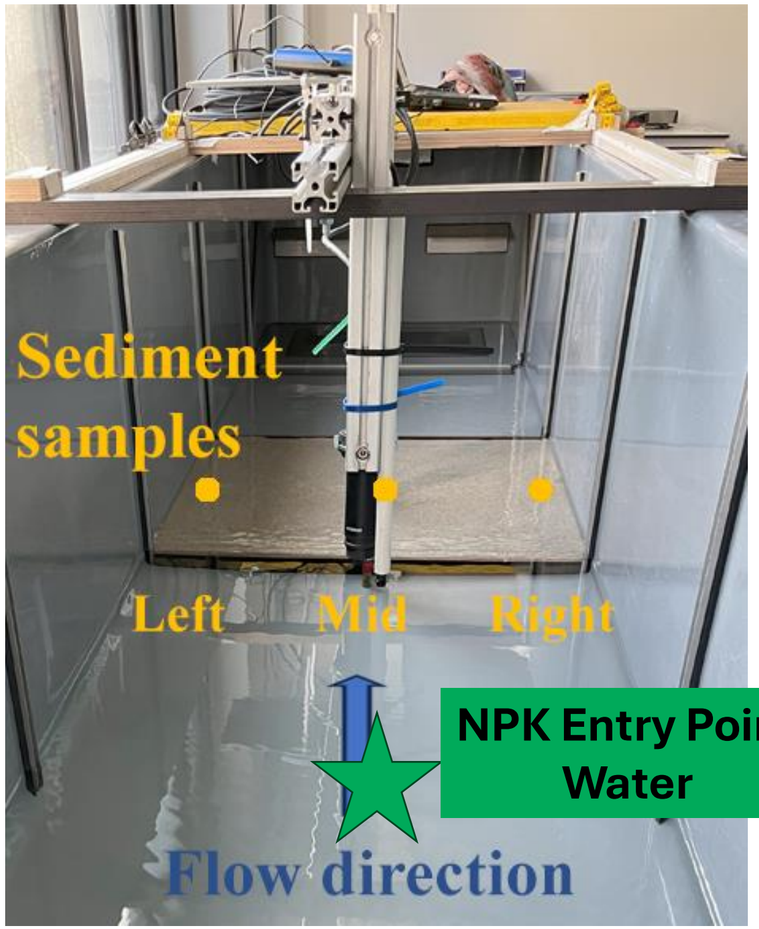


Results (1) – Spatial distribution of nutrients

Concentration differences in the cross-section

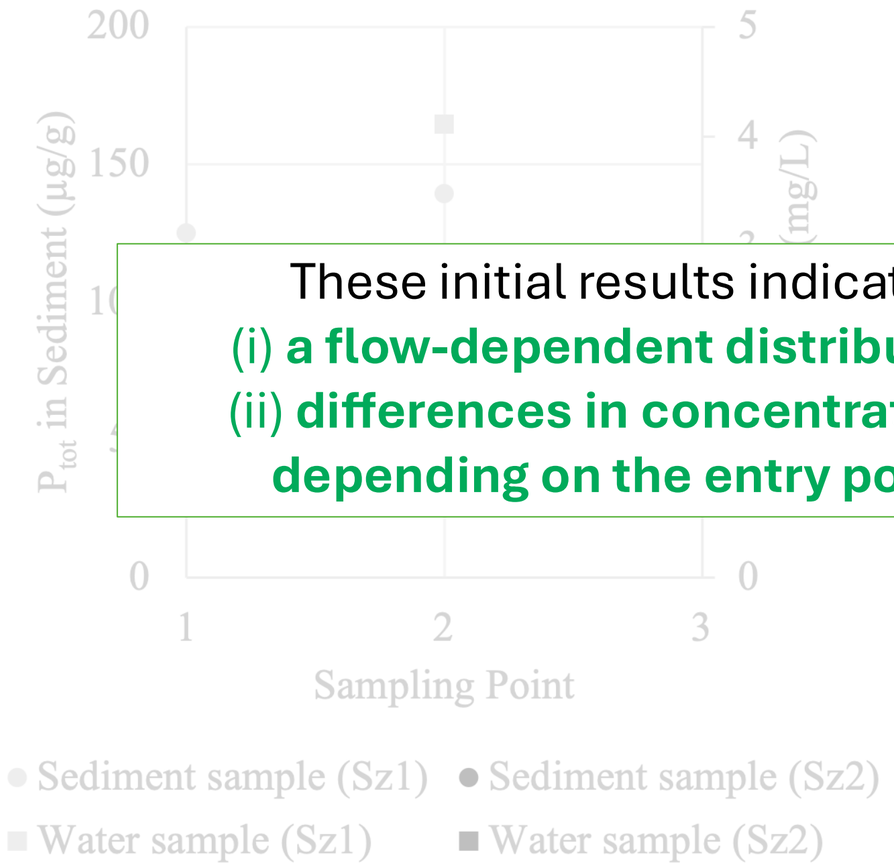
Higher concentration of P_{tot} in water



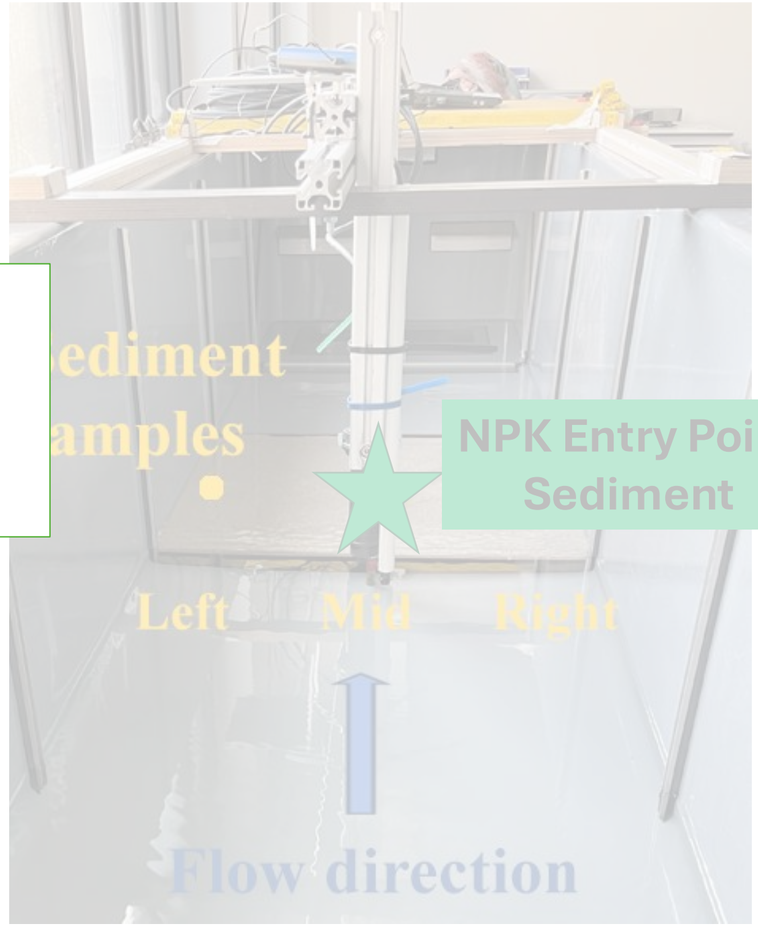


Results (2) – Spatial distribution of nutrients

Concentration differences in the cross-section



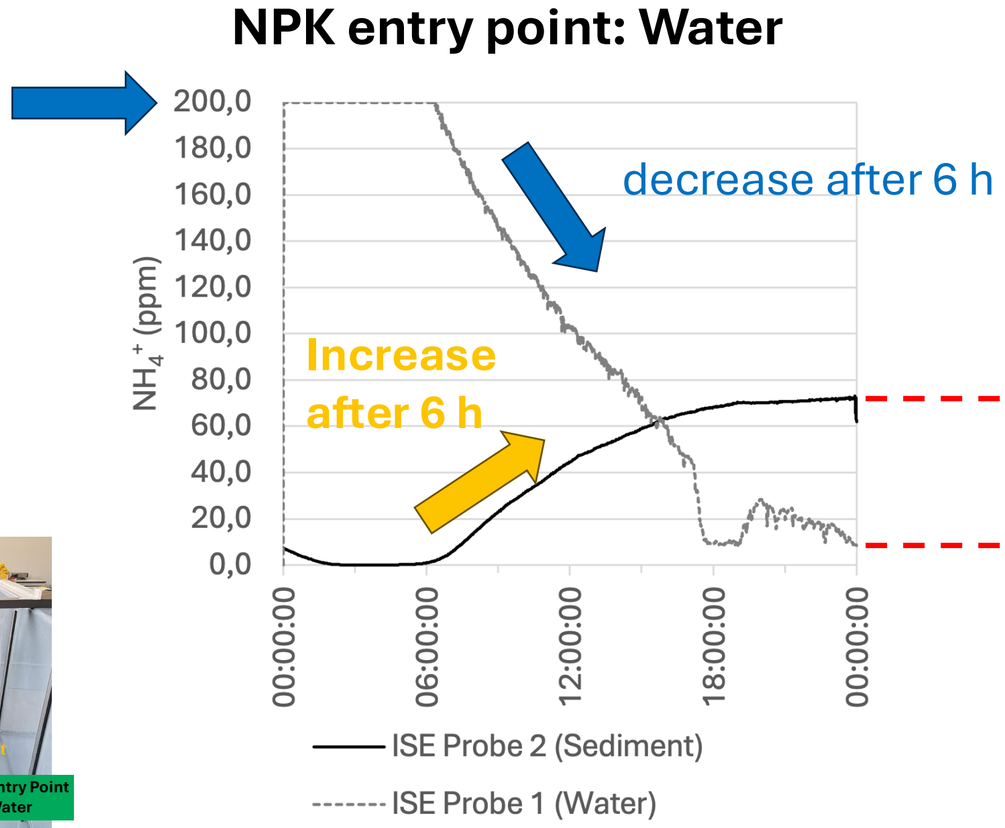
These initial results indicate:
(i) **a flow-dependent distribution**
(ii) **differences in concentrations depending on the entry point**

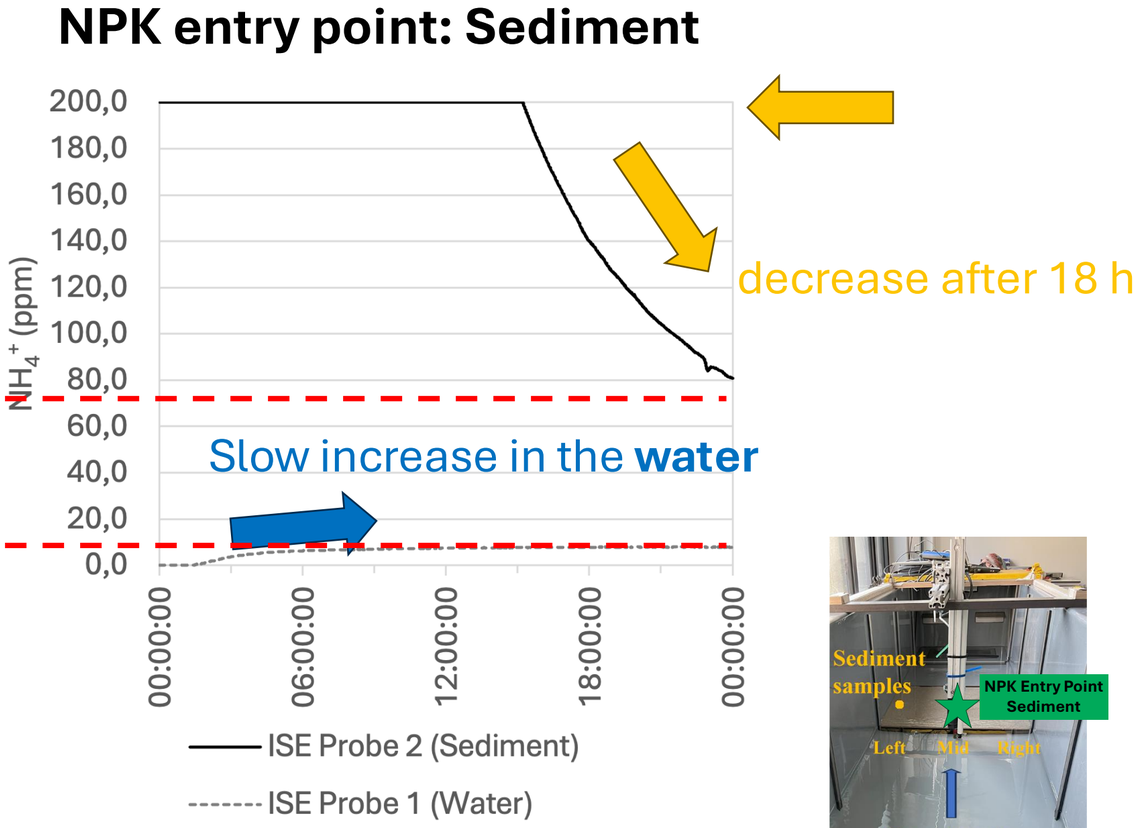


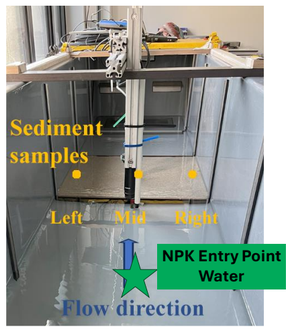
Results – Temporal distribution of nutrients

NH_4^+ peak in the **water**

NH_4^+ peak in the **sediment**





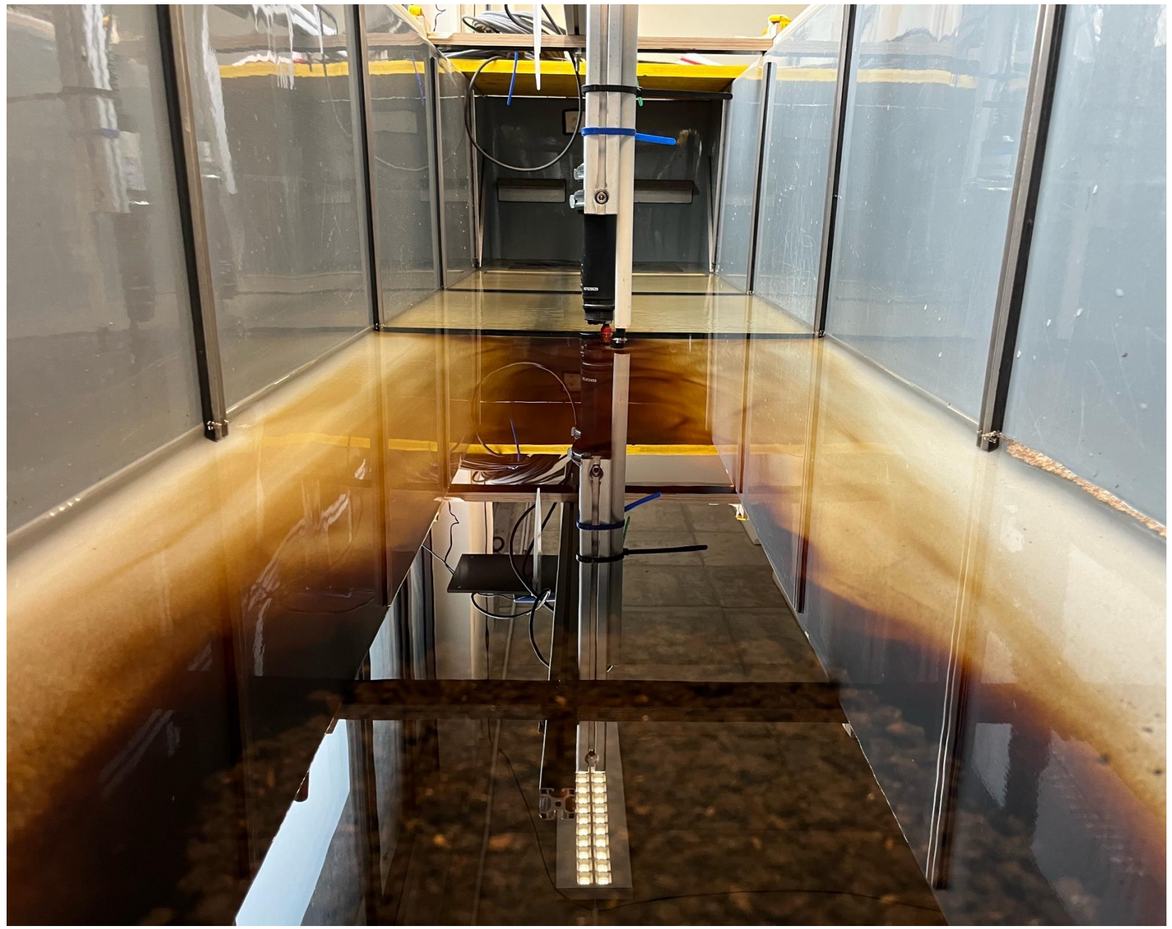


Summary of findings from this project

- The initial results indicate a **flow-dependent distribution**
- The **entry point** shows clear **differences in nutrient distribution**
- The **nutrient medium** had an **influence on the total concentrations** in the sediment/water
- The duration of the experiment is likely to have an impact

→unsteady processes in a (natural) river!

- Ion selective probes (ISE) should only be used as a supplement



Implications for sediment research and management

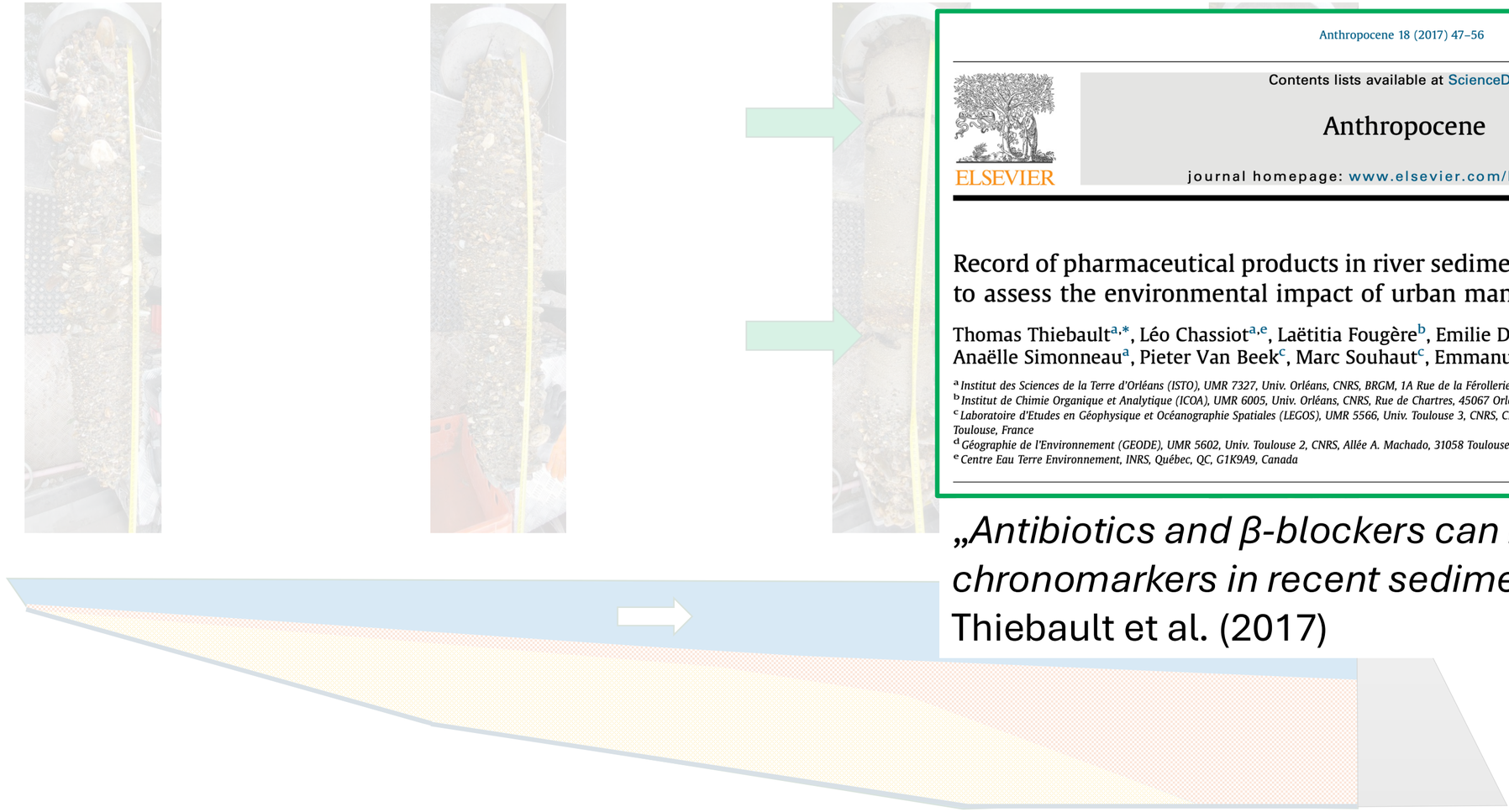
Funded by the European Union

iNNOvative SEDiment management in the Danube River Basin

- **Natural rivers are characterised by unsteady processes** (discharge, sediment transport)
- (natural) variability of the river causes the determination of pollutants to be very complex
- The degree of **contamination of sediments with pollutants may also depend on the river morphology** → Economic aspects of flood protection and hydropower plants
- **Challenges** even with well-researched **particle-bound nutrients and pollutants** → a large number of samples is required
- **In addition to the** often cited **influence of grain size** on nutrient and trace element concentrations, the **hydraulic conditions should also be taken into account**

→ **Maintenance work** on **flood protection and hydropower facilities** is becoming **more** complicated and **expensive** due to the **presence of contaminated sediments**

...what we know from previous studies



Anthropocene 18 (2017) 47–56

Contents lists available at ScienceDirect

Anthropocene

journal homepage: www.elsevier.com/locate/ancene

Record of pharmaceutical products in river sediments: A powerful tool to assess the environmental impact of urban management?

Thomas Thiebault[a,*], Léo Chassiot[a,e], Laëtitia Fougère[b], Emilie Destandau[b], Anaëlle Simonneau[a], Pieter Van Beek[c], Marc Souhaut[c], Emmanuel Chapron[a,d]

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[d] Géographie de l'Environnement (GEODE), UMR 5602, Univ. Toulouse 2, CNRS, Allée A. Machado, 31058 Toulouse, France
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„*Antibiotics and β-blockers can be used as new chronomarkers in recent sediments.*“
Thiebault et al. (2017)

Solutions for the complexities of scaling

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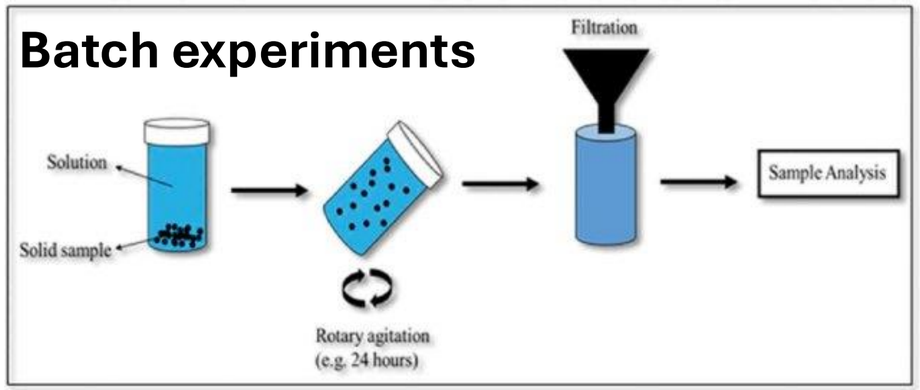
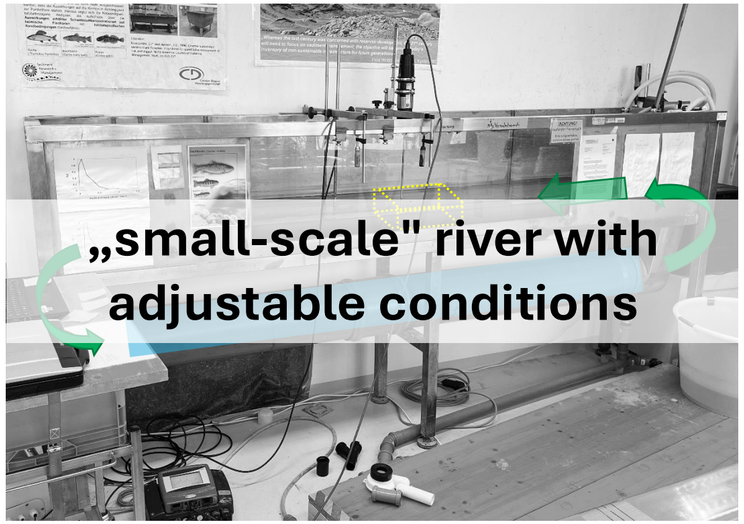
iNNOvative SEDiment management in the Danube River Basin





Linking knowledge on nutrient and pollutant interactions between water and sediment

... and ehance this with laboratory experiments and hydrodynamic modelling

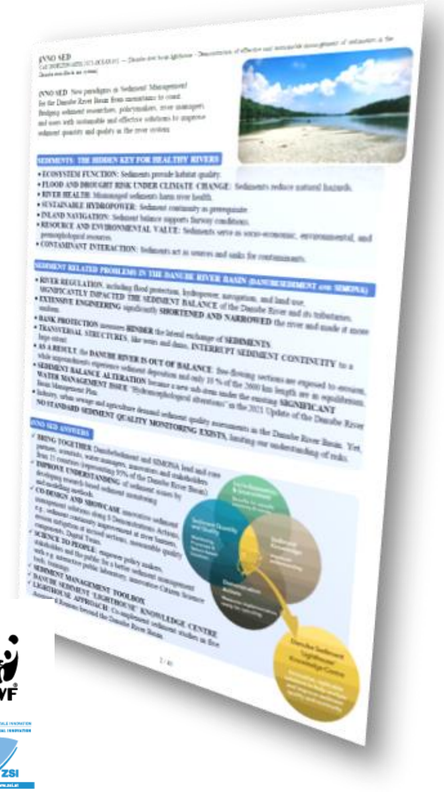
Introduction to iNNO SED

Funded by the European Union

iNNO SED
iNNOvative SEDiment management in the Danube River Basin

- Call: Danube river basin lighthouse – Demonstration of effective and sustainable management of sediments in the Danube river-Black sea system TOPIC ID: HORIZON-MISS-2023-OCEAN-01-02

- Project start date: 1 September 2024
- Project end date: 31 August 2029
- Project duration: 60 months
- Consortium: 46 Funded Partners and associated Partners



iNNO SED answers

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iNNO SED

iNNOvative SEDiment management in the Danube River Basin

- Bring together scientists, water managers, innovators and stakeholders from 15 countries
- Improve understanding of sediment issues by developing research-based sediment monitoring and modelling methods
- Co-design and showcase innovative sediment management solutions along 8 Demonstrations Actions
- Science to people: empower policy makers, stakeholders and the public for a better sediment management
- Sediment Management Toolbox
- Danube Sediment 'Lighthouse' Knowledge Centre
- LIGHTHOUSE APPROACH: Co-implement sediment studies in five Associated Regions beyond the Danube River Basin

iNNO SED – next steps

- Sedimentary stratigraphy surveys at our **demonstration site** (Aschach, Austria)
- Analyses of **particle size distribution, trace elements** and **selected particle-bound pollutants** in accordance with the EU-Environmental Quality Standard (EQS)
- Overall objective: **improved process understanding regarding the sediment quantity and quality**
- For this purpose, we are **currently developing** an **add-on module for HydroAS** that calculates the **transport of nutrients and pollutants** within these hydrodynamic 2D models

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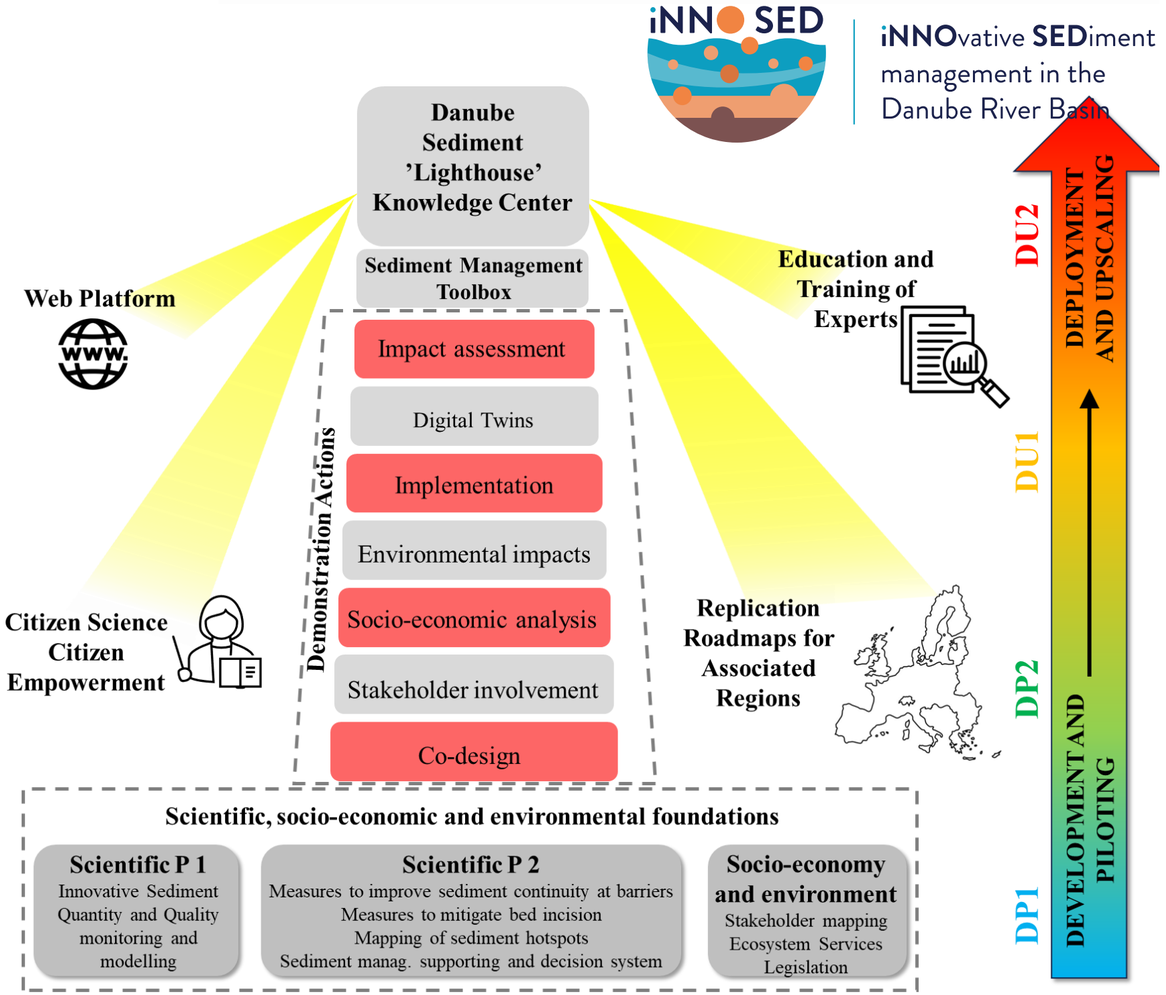

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Acknowledgements

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FWF Österreichischer Wissenschaftsfonds ÖAW ÖSTERREICHISCHE AKADEMIE DER WISSENSCHAFTEN

This research has **received funding** from the **European Union's Horizon Europe research and innovation programme** under grant **agreement No. 101157360** (iNNO SED–iNNOvative SEDiment management in the Danube River Basin).

Funded by the European Union

iNNO SED iNNOvative SEDiment management in the Danube River Basin

Thank you for your attention!

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