Particle-bound nutrients and trace substances in small streams: Implications for the aquatic environment and presentation of a novel sampling method

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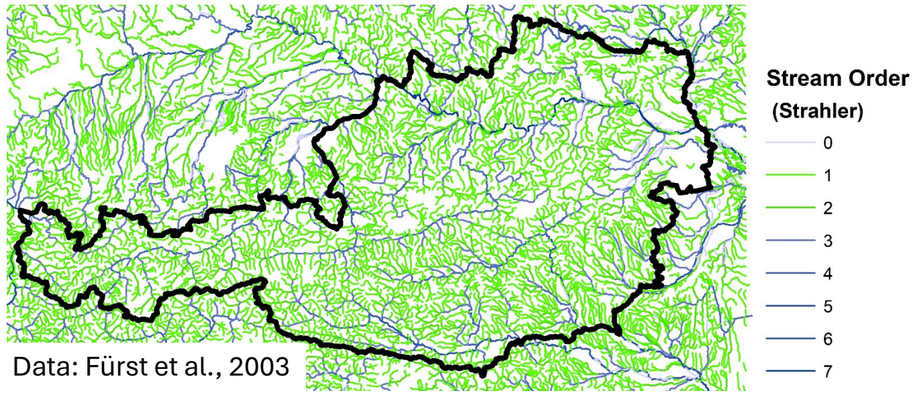
Scope

- **Why is it worth investigating small rivers?**
- **~ 70 % of the rivers are 1st or 2nd order rivers** (according to Strahler number) in Austria (cf. Fürst et al., 2003)
- Ecological **importance of tributaries** (e.g. Milner et al., 2018)

- **But, often not easy to sample..**
- low discharges, low velocities, low bed gradients
- Influences of **landuse** (e.g. soil erosion, surface run-off)
- **Remote places** (extensive maintenance not possible)

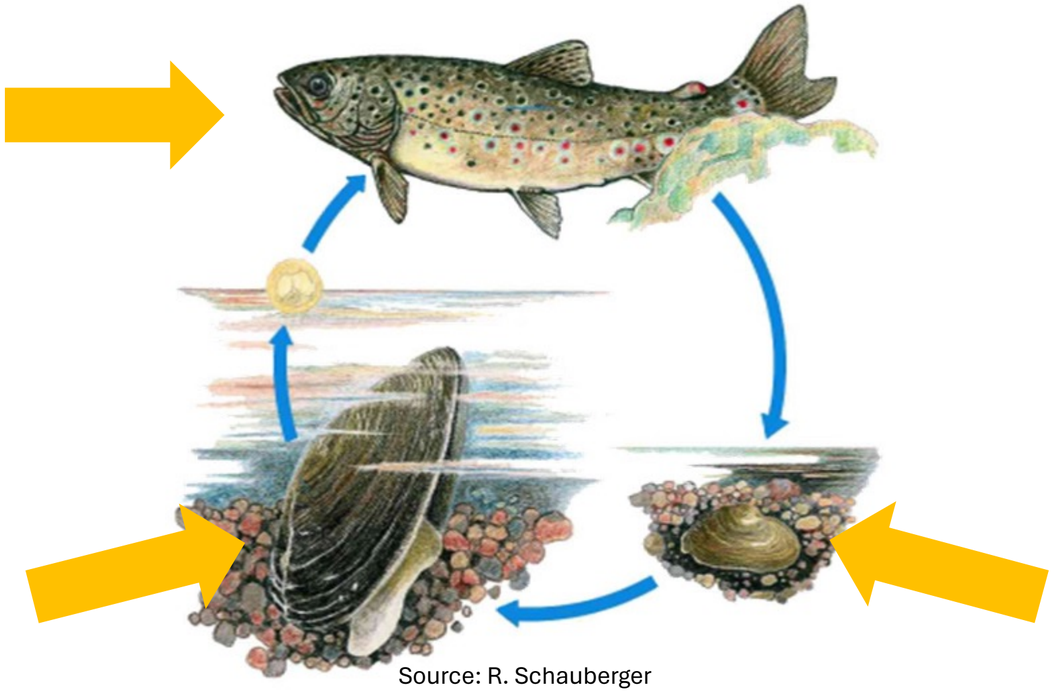
→ Lack of simple samplers for suspended sediment and floating matter



Data: Fürst et al., 2003

Biological importance in the study region – Freshwater Pearl Mussel (*Margaritifera margaritifera*)

- (mikro) **pollutants** and high loads of **nutrients affect** the **freshwater pearl mussel** in all age stages
- Phosphorus pollution is negatively correlated with FWPM population (e.g. Degerman et al., 2013)



Source: R. Schauberger

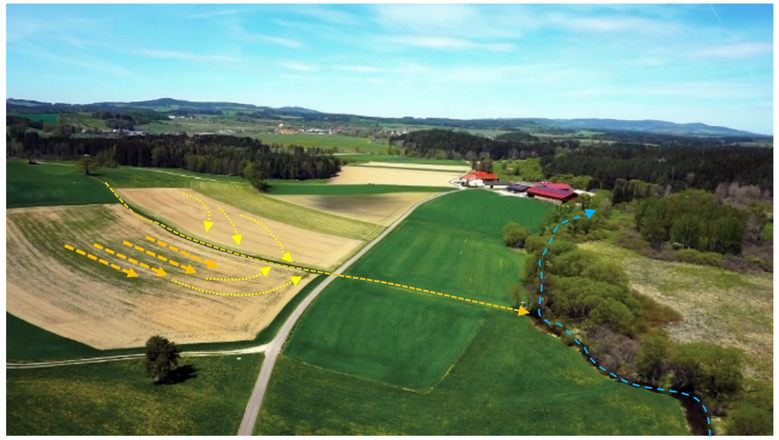
Causes and impact assessment

- **Ecological and chemical status** according to the EU WFD

  snapshot (grab samples) ← → long-term effects (biological status)

- In rivers with bi-modal grain size distribution and increased sediment load, the **main causes of FWPM decline are still unclear**

  qualitative problem (nutrients, pollutants) ← → quantitative issue (to much sand)



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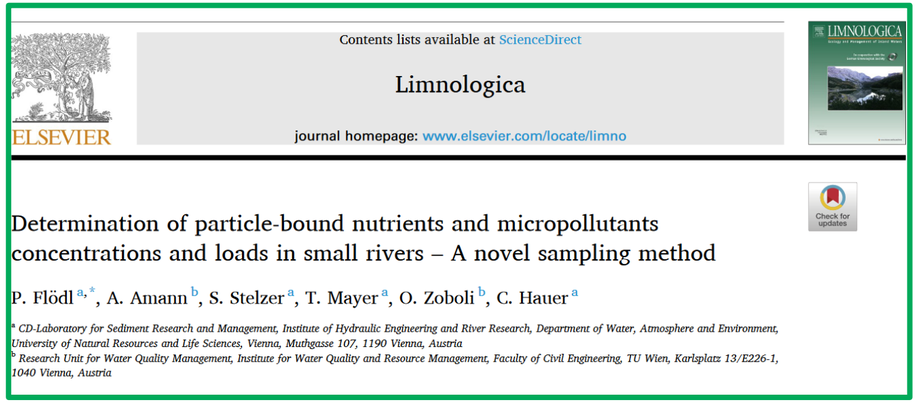
SOIS concept, Material and Methods



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

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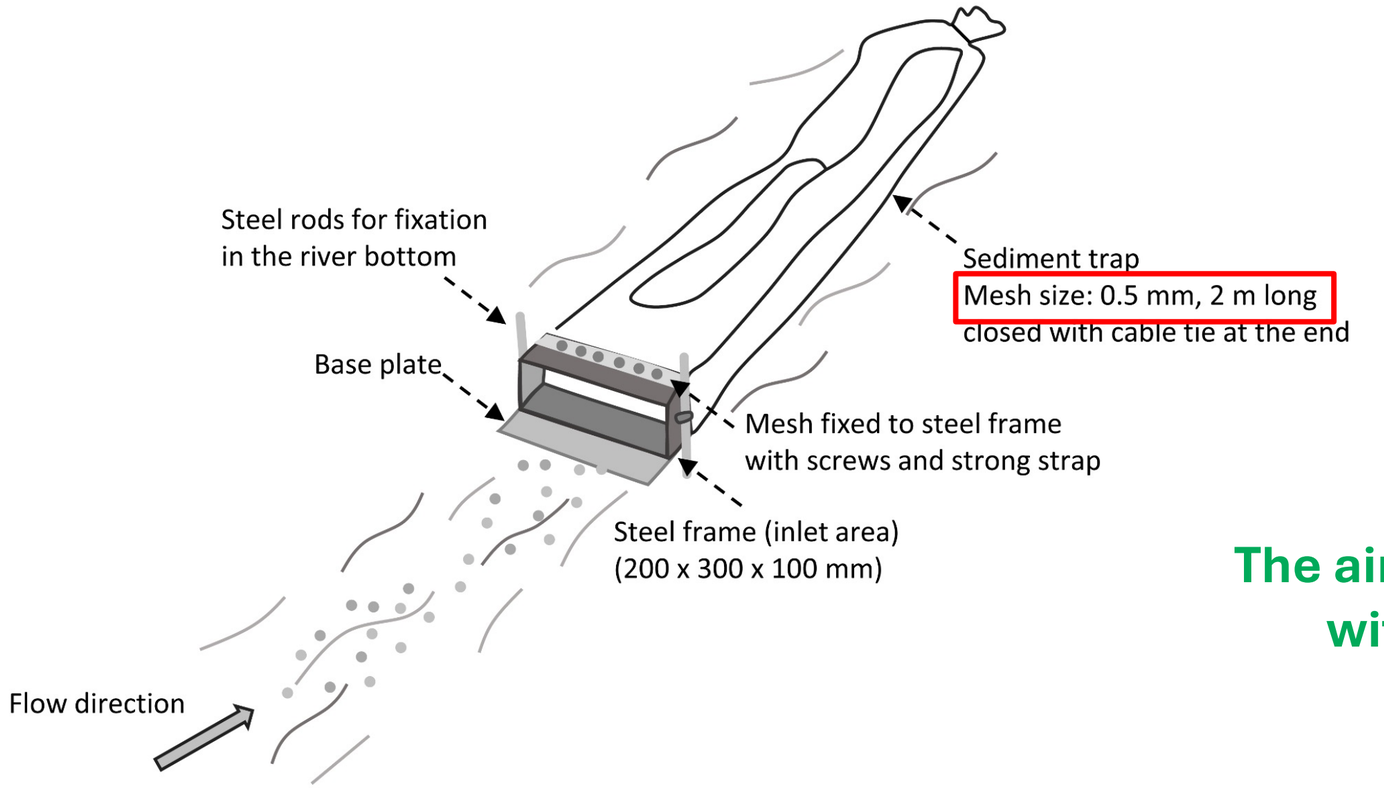
Monitoring of (ubiquitous) **trace substances**
was not included in the **project budget.**
The **investigations on particle-bound pollutants were carried** out on
our own initiative and **with limited resources**

BOKU

Concept of the novel sampling method: Stationary Organic and Inorganic Sampler (SOIS)



The aim is to collect sediments with a grain size < 2 mm

Based on the bedload trap of Bunte et al. (2004)

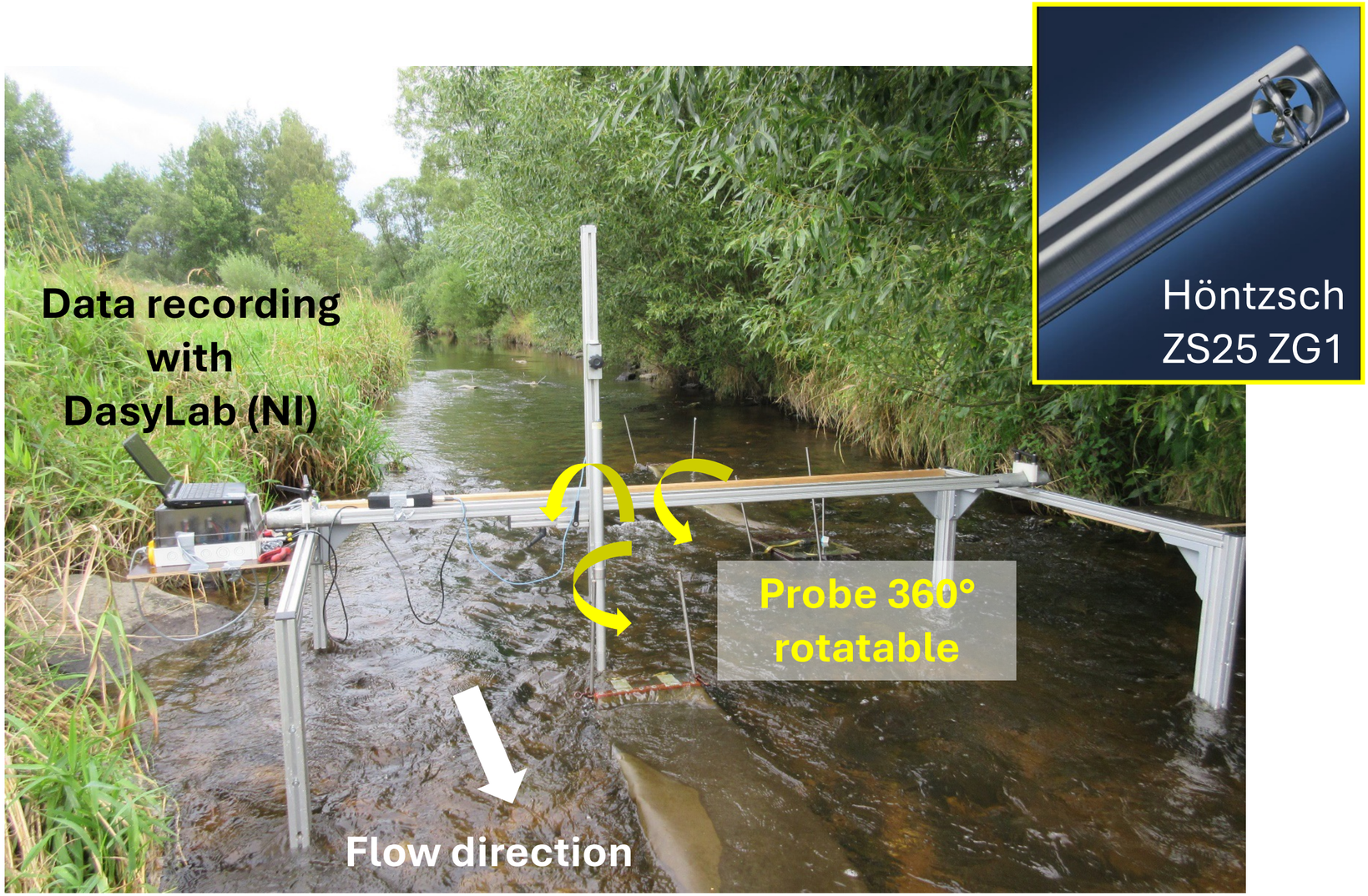
Concept of the novel sampling method: Stationary Organic and Inorganic Sampler (SOIS)

Installation

24h later

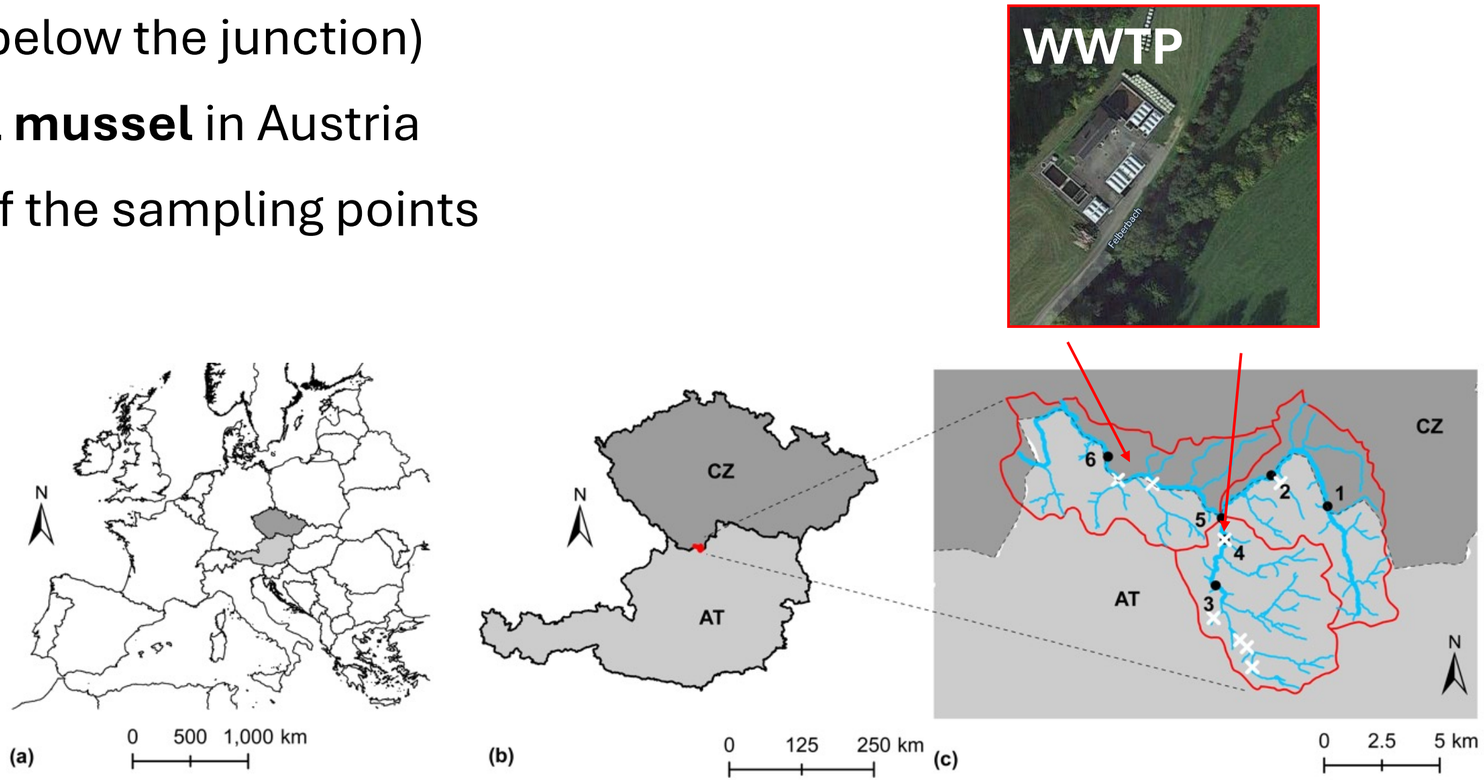
Good collection performance of floating matter, sediments and suspended sediments (grain sizes < 2mm)

Material and Methods



Material and Methods

- **Maltsch river** (Elbe catchment)
- **Catchment size ~ 100 km^2 with 3 main subcatchments** (Maltsch, Felberbach and Maltsch below the junction)
- Last stocks of the **freshwater pearl mussel** in Austria
- **2 WWTP** in the immediate vicinity of the sampling points
- Sampling sites (n = 6)
  - Sampling with SOIS
  - Volumetric sediment samples (n = 2)



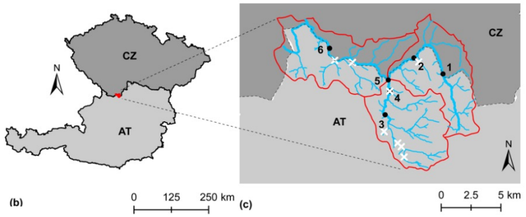
Results

Results of the novel sampling method: Stationary Organic and Inorganic Sampler (SOIS)

- In the field, the **water flow was qualitatively visible**
- A **reduction in the flow velocity was measured** as a result of the mesh clogging
- **Flow velocities are still high enough to transport sediments with a grain size < 2 mm**

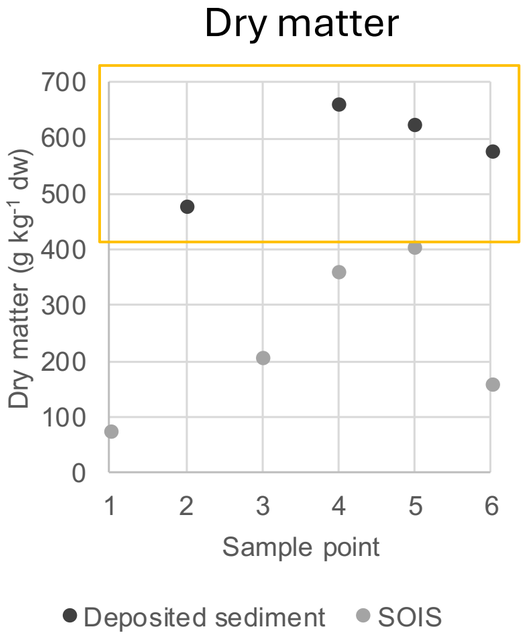
	Flow velocities close to the **river bed**				Flow velocities close to the **water surface**			
	v_{d0} (m/s)	v_{d3} (m/s)	v alteration (m/s)	v alteration (%)	v_{d0} (m/s)	v_{d3} (m/s)	v alteration (m/s)	v alteration (%)
Ref. left	0.04	0.05	-0.01	-22%	0.27	0.27	0.00	0%
Ref. mid	0.14	0.09	0.05	63%	0.28	0.26	0.03	10%
Ref. right	0.09	0.09	0.00	0%	0.25	0.27	-0.02	-9%
SOIS left	0.11	0.06	0.05	93%	0.28	0.23	0.05	22%
SOIS mid	0.10	0.06	0.04	74%	0.29	0.23	0.06	27%
SOIS right	0.13	0.11	0.03	25%	0.28	0.22	0.06	26%

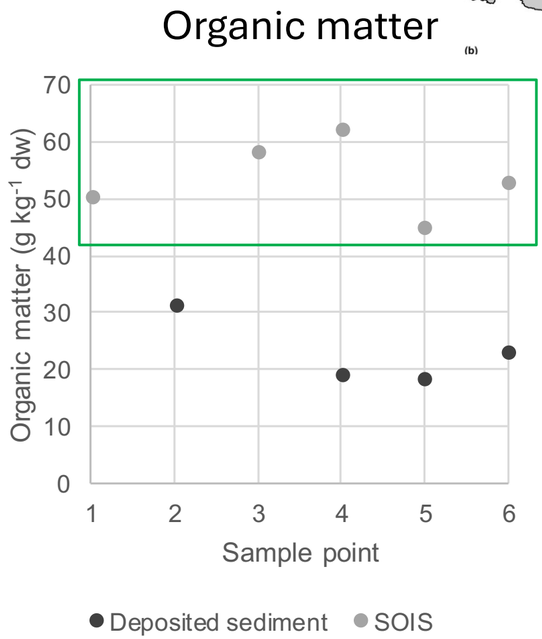
Results – particle-bound nutrients and pollutants (1)



Comparison of streambed samples and SOIS material

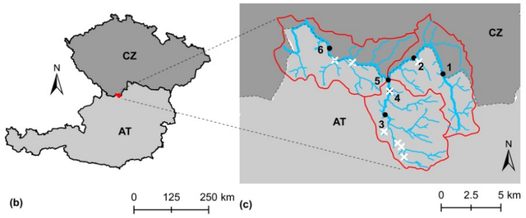
- Higher proportion of organic material in SOIS samples
- Proportion of (easily) **bio available phosphorus was higher in SOIS samples**

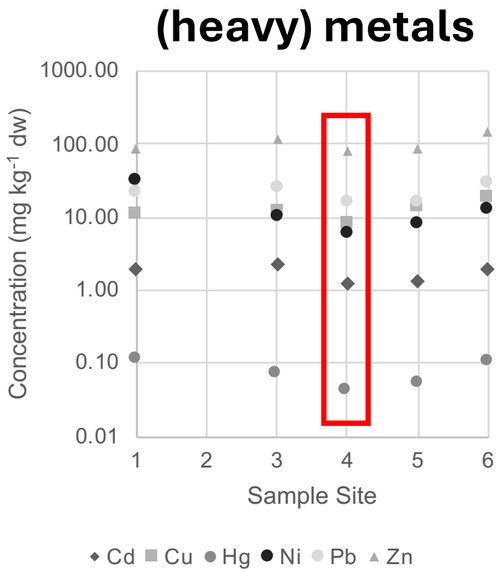


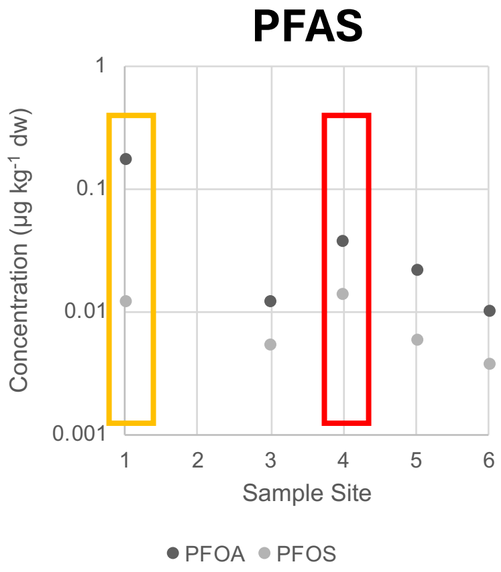


(b)

Results – particle-bound nutrients and pollutants (2)







Implications for the aquatic environment

Implications for the aquatic environment

- Possible **underestimation of nutrient and pollutant concentrations** if **only one medium** (water / sediment) **is analyzed**

- In addition, **(biological) conversion and decomposition processes in the riverbed** can lead to an underestimation of nutrient and pollutant concentrations

- In the case of **barriers and dams, sediment stratification** with different **grain sizes and pollutant concentrations** can also be detected (cf. Thiebault et al., 2021)

Implications for the aquatic environment

- The (natural) **variability of the river** makes **predictions and modeling of trace substances quite complex**
- In bi-modal rivers of the **Bohemian Massif, high sediment loads are mobile even at low discharges** (influence through sampling time)
- **Major challenges** even with well-researched **particle-bound nutrients and pollutants**
- Even in **small streams, a high number of samples is required**

Implications for the aquatic environment

- **PAHs**: depending on the molecular weight **different hydrophobic / hydrophil characteristics** (possible reason why only PAHs with higher molecular weight were detected in this study)
- Similar results for **PFAS group (hydrophobic / hydrophil characteristics)**

→**Sampling design is particularly important in small rivers with (very) low pollutant concentrations**

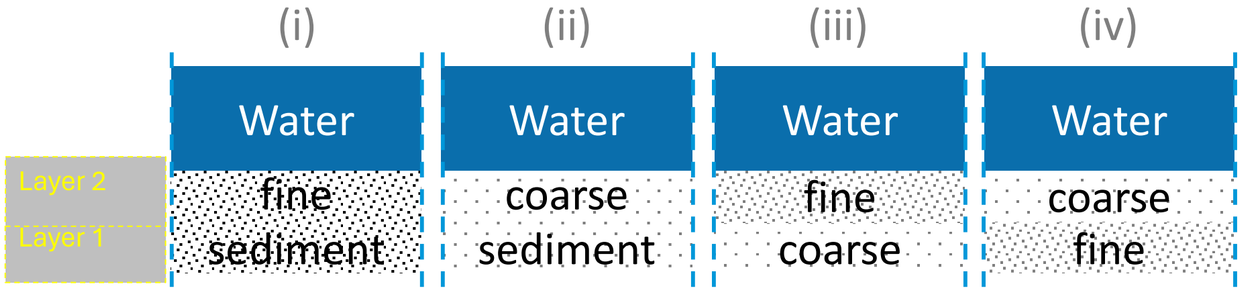
- Regarding **EU WFD**: possible risk of **inadequate recommendations for action** if **low concentrations of nutrients and pollutants are detected**

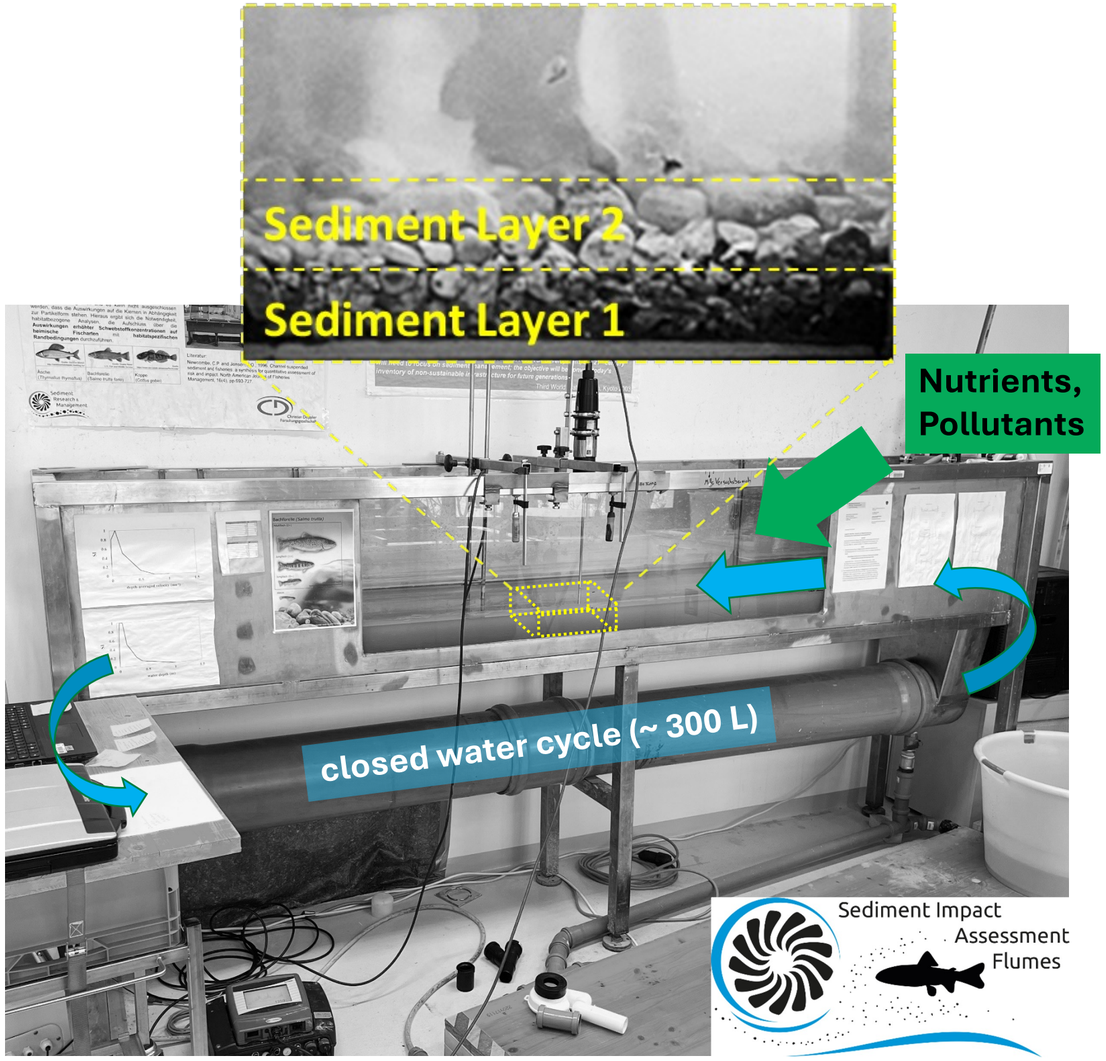
→ **urgent need for research into the behaviour (mobility, fate) of ubiquitous substances in freshwater ecosystems**

Ongoing research in the new BOKU River Lab

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

Substrate scenarios (i-iv)





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