Sulfate removal from mine drainage at low temperature: **Effects of three reactive porous media on microbial sulfate reduction**

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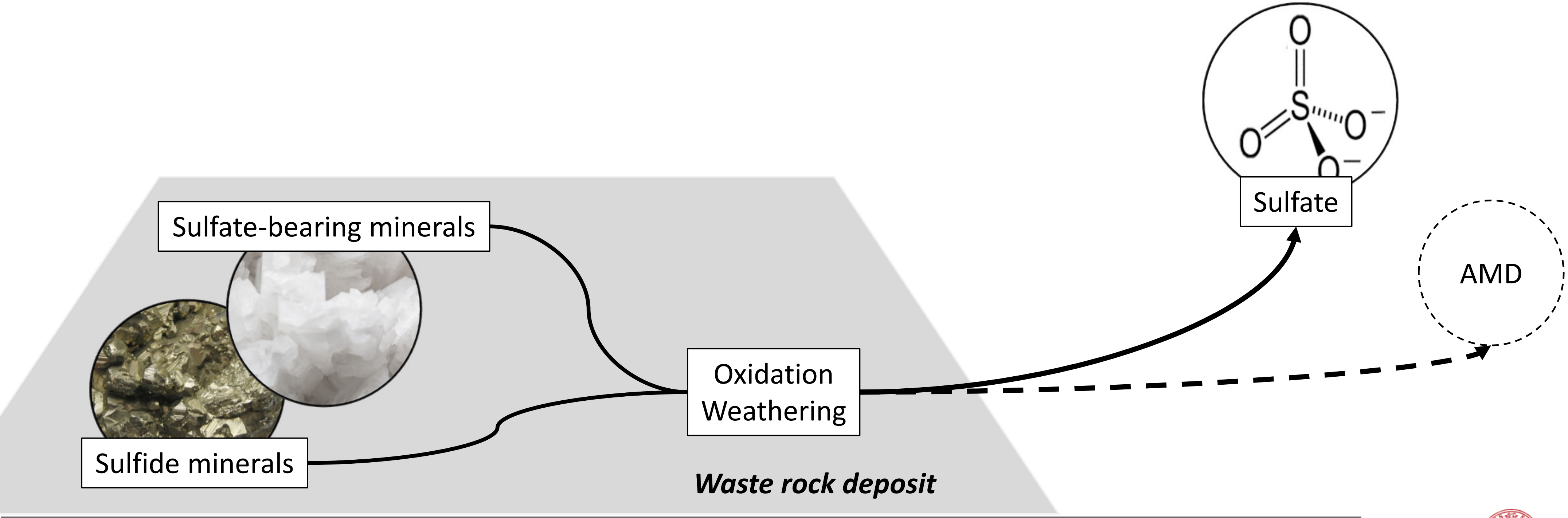
Laura Nina Bettoni & Roger Herbert

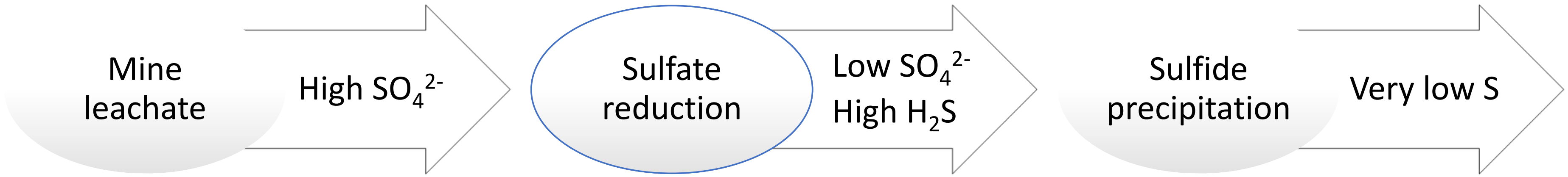
lauranina.bettoni@geo.uu.se, roger.herbert@geo.uu.se

Department of Earth Sciences, Uppsala University, Sweden.

The problem


Sulfate-bearing minerals
Sulfide minerals
Oxidation
Weathering
Waste rock deposit
Sulfate
AMD

The solution



- Dissimilatory sulfate reduction

$$SO_4^{2-} + 2CH_2O \xrightarrow[\text{(SRB)}]{\text{Sulfate reducing bacteria}} H_2S + 2HCO_3^-$$

Anaerobic process which can be used as a first step to remove sulfate in mining waters.

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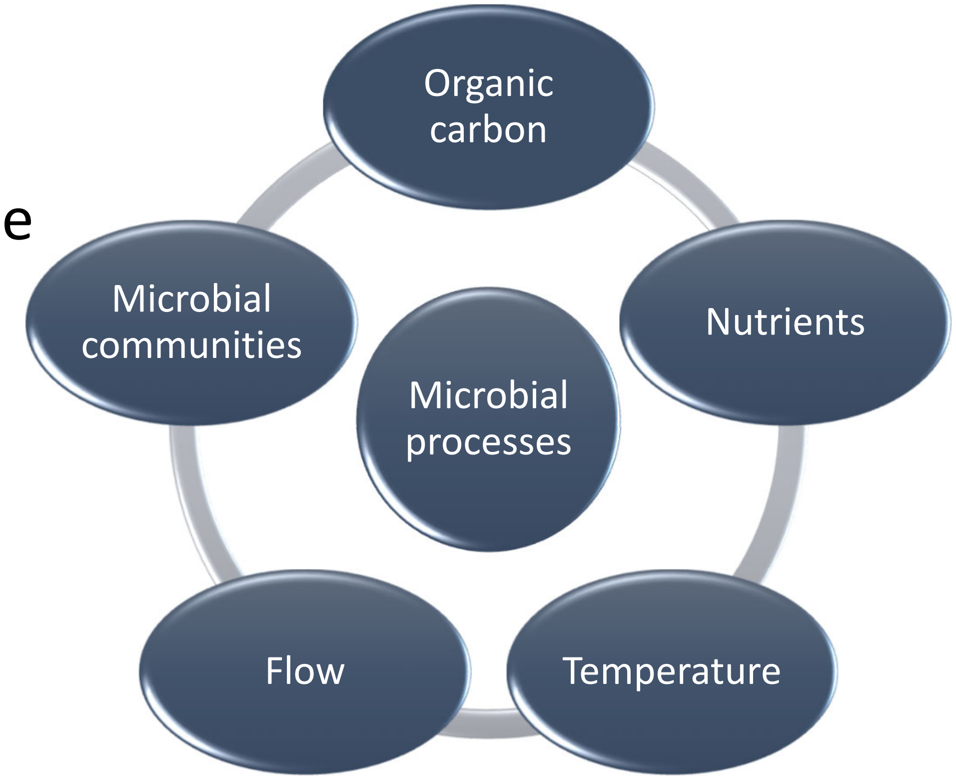
Study background

- Study site located in LKAB iron ore mine Kiruna, Sweden (≈1000 mg/L SO_4^{2-}).

- Arctic/Subarctic climate, the average groundwater temperature is 3 - 5°C during the year.



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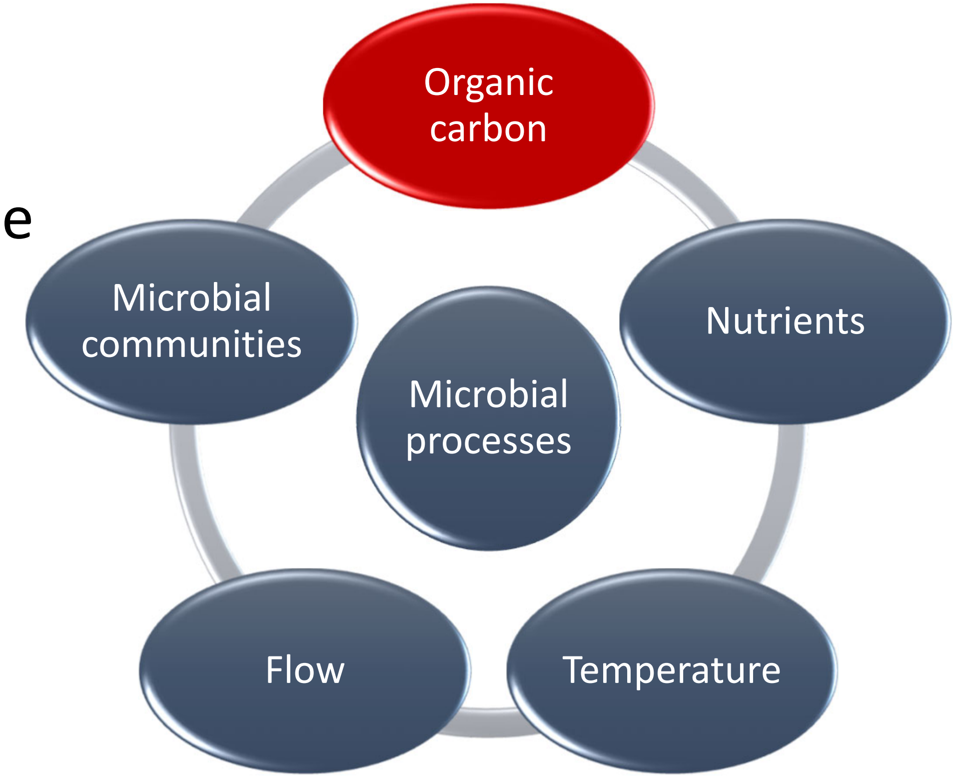

Test different reactive media (high carbon content) at low temperature for dissimilatory sulfate reduction.

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Material selection

Woodchips (WC)

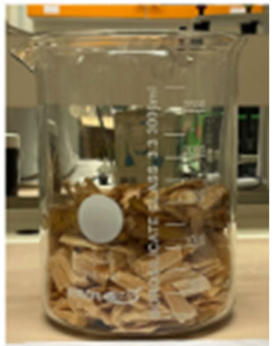
Reliable material that has been used in previous bioreactor design.

Woodchips + Biochar (BC)

Highly porous which is beneficial as it may host a larger SRB community.

Woodchips + Potato peels (PP)

Carbon is more readily released from potato peels. Nutrients (N-compounds & P) can be released.



Lactate was later added to the system as it is commonly used as an external carbon source promoting sulfate reduction

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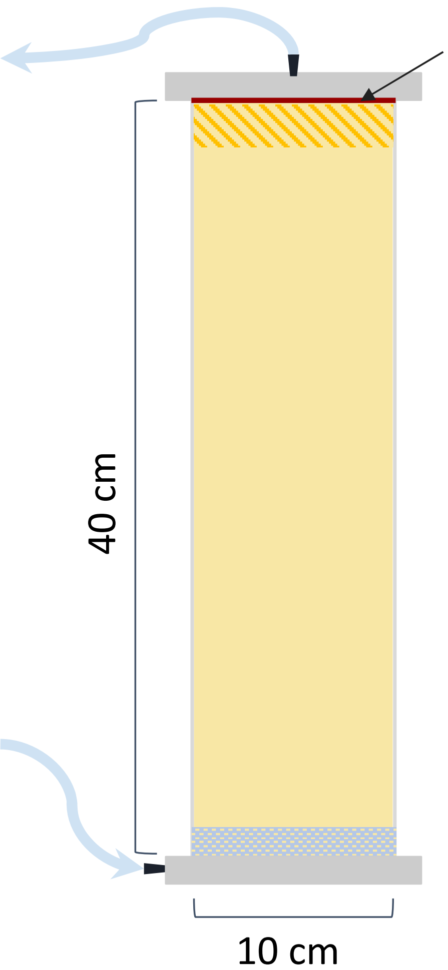
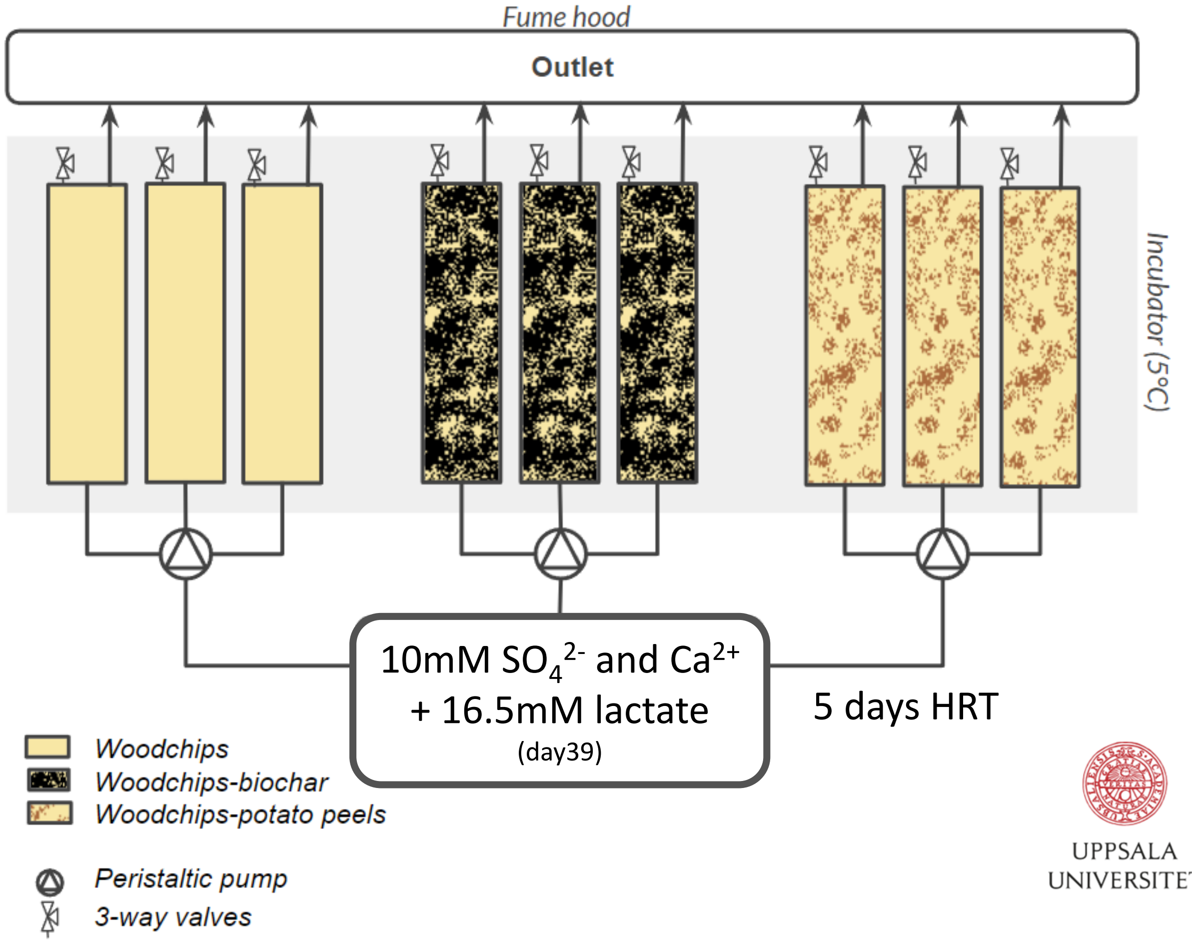
Experiment set-up





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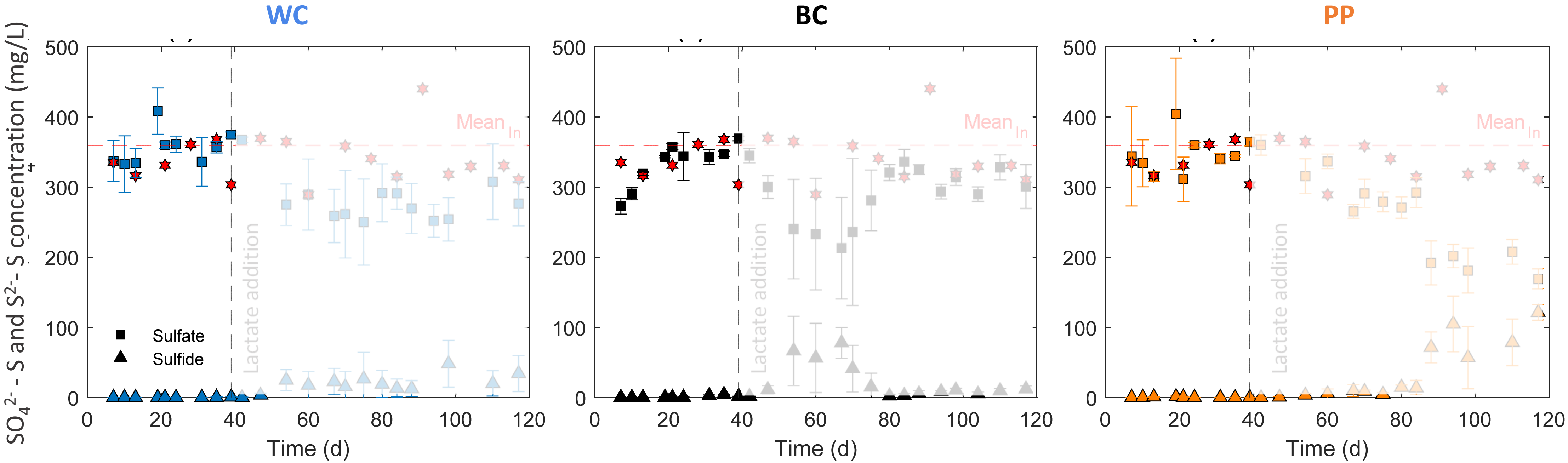
Column experiments performance



- Three main experiments phases:
  - I. Prior to lactate addition
  - II. 30-days following lactate addition
  - III. Final phase
- Maximum sulfate removal
  - WC: 24%
  - BC: 38%
  - PP: 55%

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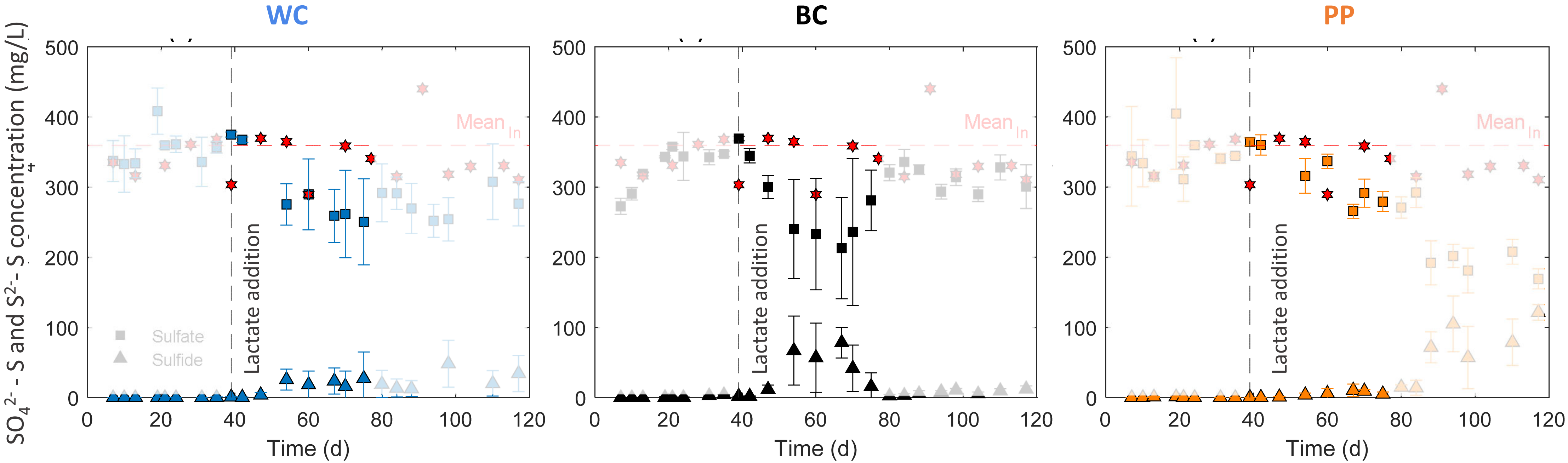

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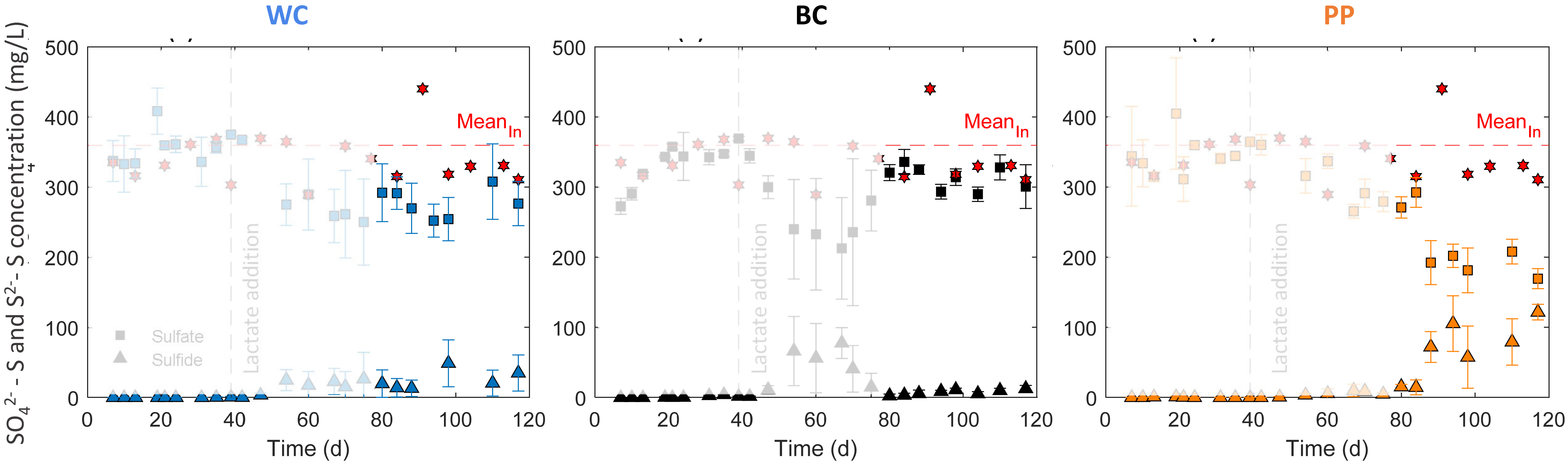

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Nutrients – nitrogen compounds

Table 1 Mean nitrogen concentrations in outflows during the different phases for woodchips (WC), woodchips-biochar (BC) and woodchips-potato peels (PP).

	Nitrate-N mg/L N	**Nitrite-N** mg/L N	**Ammonium-N** mg/L N
Phase 1- Prior to lactate addition			
WC	0.34	0.01	0.29
BC	0.23	0.03	0.25
PP	0.68	1.40	*4.28
Phase 2-After lactate addition			
WC	0.59	0.09	0.47
BC	0.63	0.12	0.52
PP	0.43	0.22	*4.12
Phase 3-After lactate addition			
WC	0.86	0.06	0.28
BC	0.38	0.04	0.30
PP	0.81	0.08	0.42

***Ammonium concentration >15** NH_4^+-N mg/L on day 35 and day 42.

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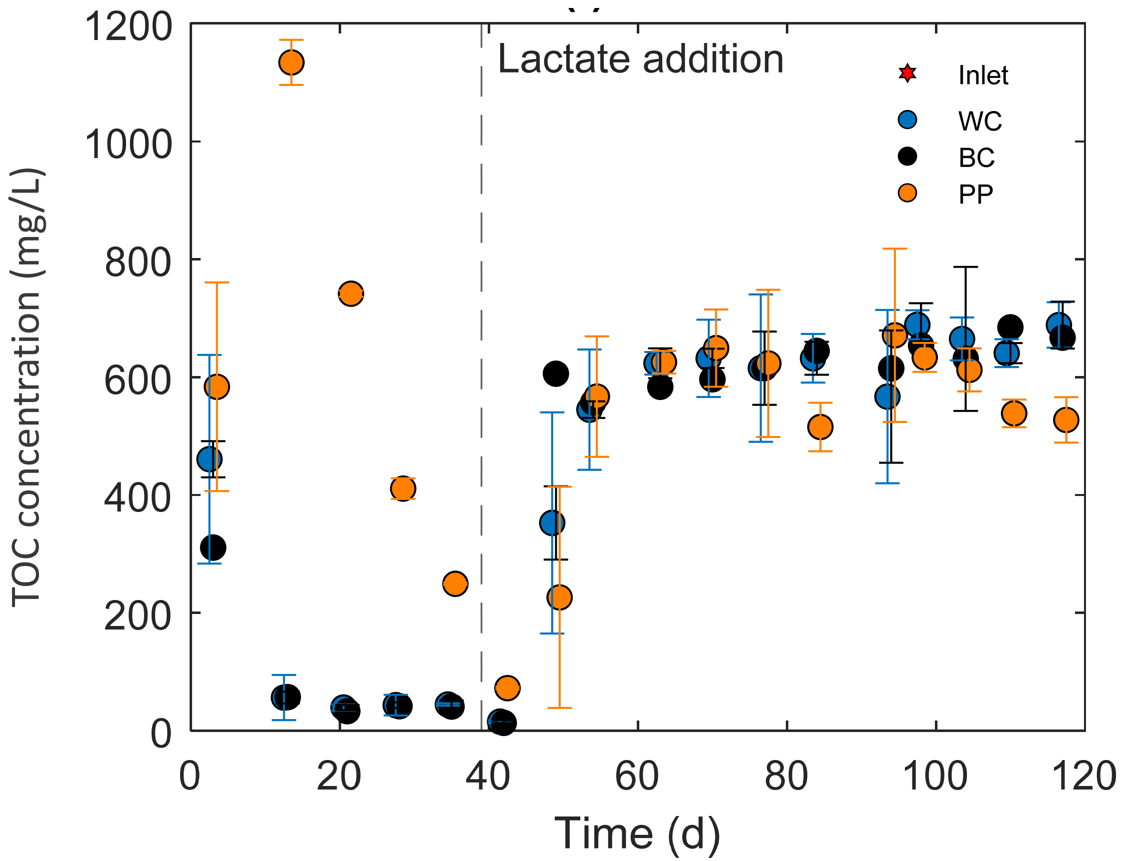
Total organic carbon (TOC)



- «Flushing» of organic carbon in the initial phase of the experiment.
- Common behavior in woodchip bioreactor systems.
- TOC in WC and BC columns decreased quickly to low levels, PP columns required more time.

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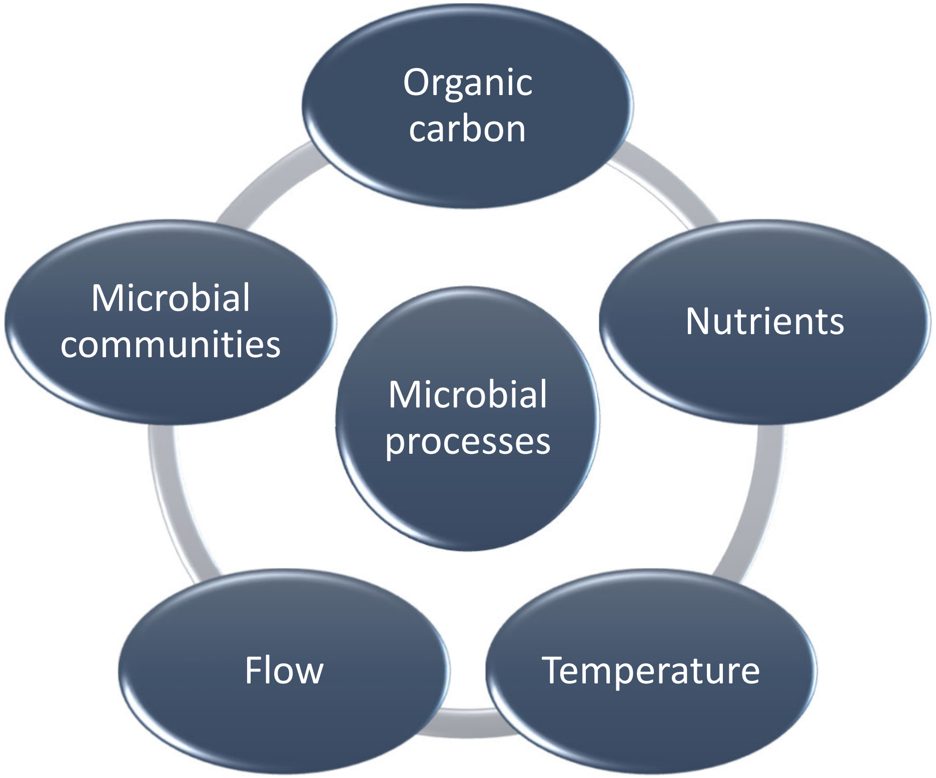
Implications for field applications

- Consistent sulfate removal in WC columns makes it the preferred material for field application.
- Lactate is necessary to achieve a high sulfate reduction rate. However, with variable sulfate concentrations, it is important to have an automated dosing system to avoid over- or under- dosing.
- High release of TOC will require an additional treatment unit for TOC removal as it can be detrimental for aquatic life.
- Sulfide removal can be achieved through precipitation as elemental sulfur (oxygenation) and ferrous sulfide (reaction with ferrous iron).

Biological processes are complex and and many factors need to be considered to implement efficient bioremediation.



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Questions?

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This work was conducted within the Strategic innovation program Swedish Mining Innovation, a collaborative effort between Vinnova, Formas and the Swedish Energy Agency.