Rapid methylmercury turnover in a sulfate-rich athalassic saline lake

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Saline lakes : ecological significance and Hg cycling

PERSPECTIVE
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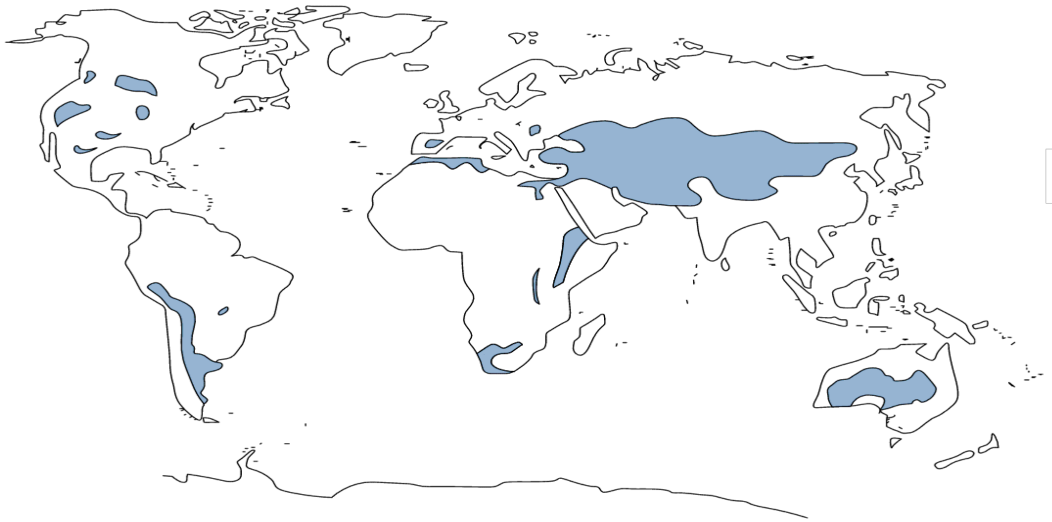
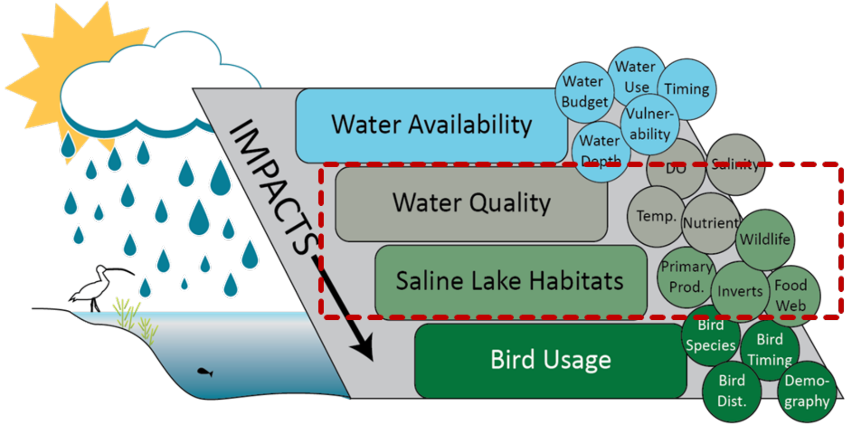
'World's saline lakes are shrinking…'

Wurtsbaugh et al., 2017

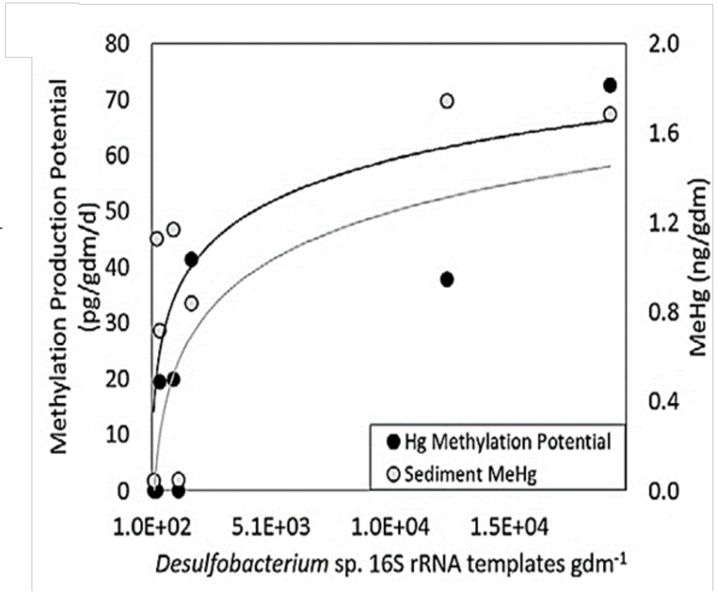


Williams 1996

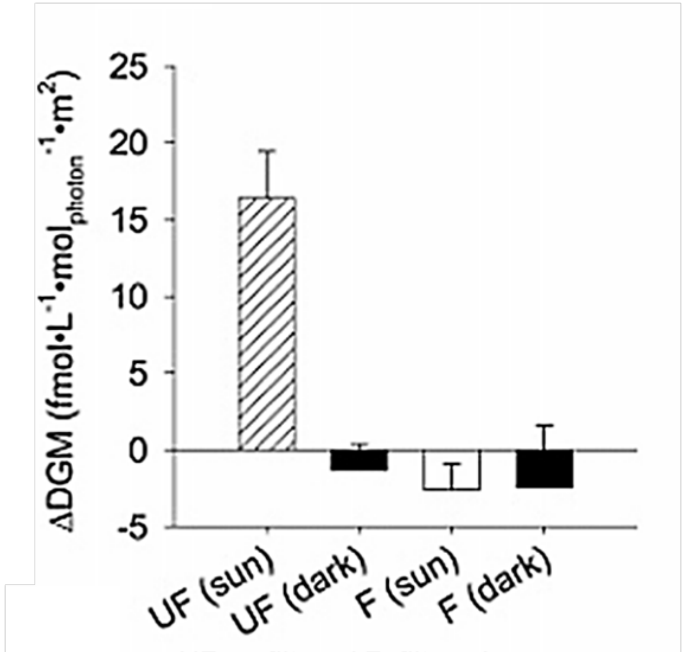


Rebecca Frus, USGS

❖ %MeHg (~31–60%) in water & sediment Hg methylation, Great Salt Lake *(Naftz et al., 2008; Boyd et al., 2017)*



❖ DGM production in saline waters *(Poulain et al, 2007)*



UF: unfiltered F: filtered

- **Hg methylation in sediments profile vs water column?**
- **Biotic or abiotic formations of DGM (mainly as Hg(0))?**
- **Net accumulation or rapid removal/turnover of MeHg?**

Sulfate-rich saline lake – Gallocanta Lake, NE Spain

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Upside down sulphate dynamics in a saline inland lake

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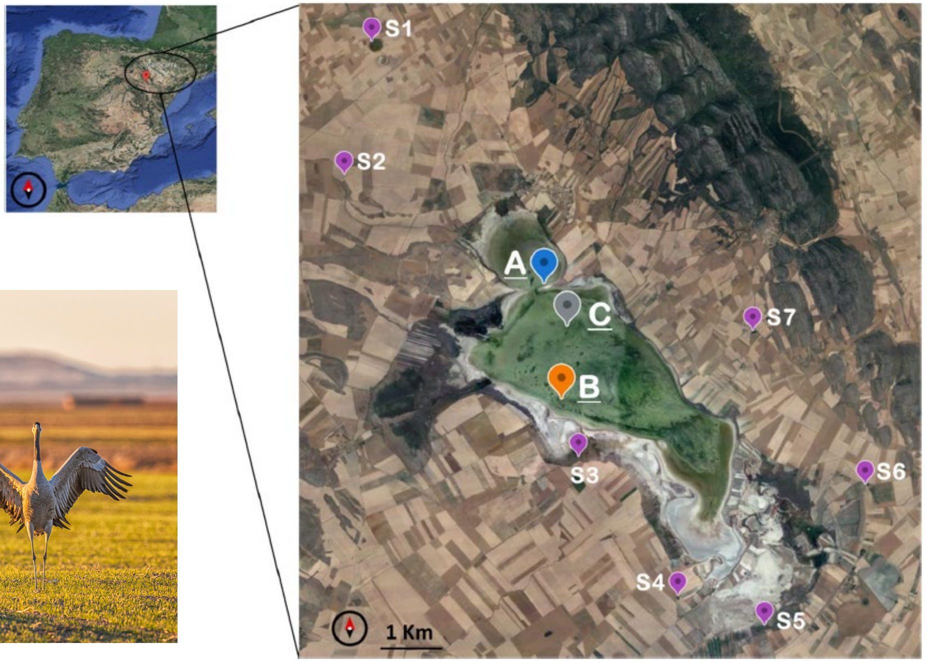
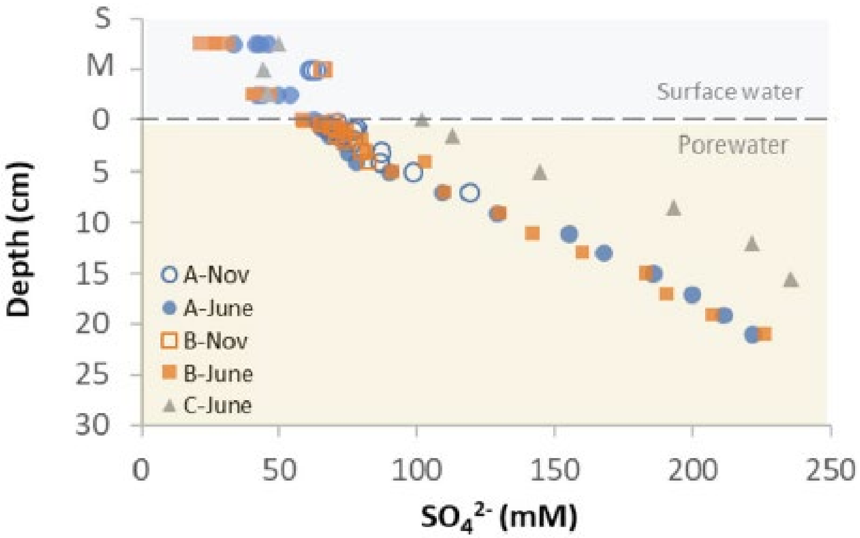
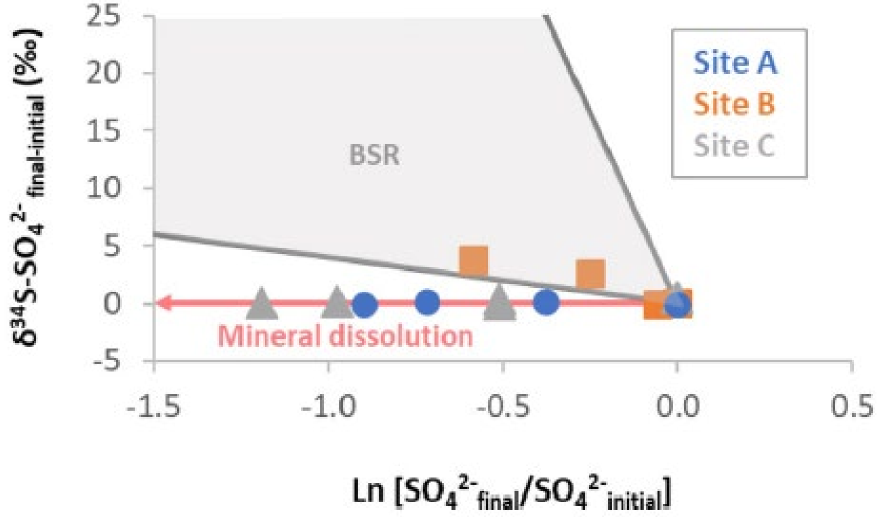
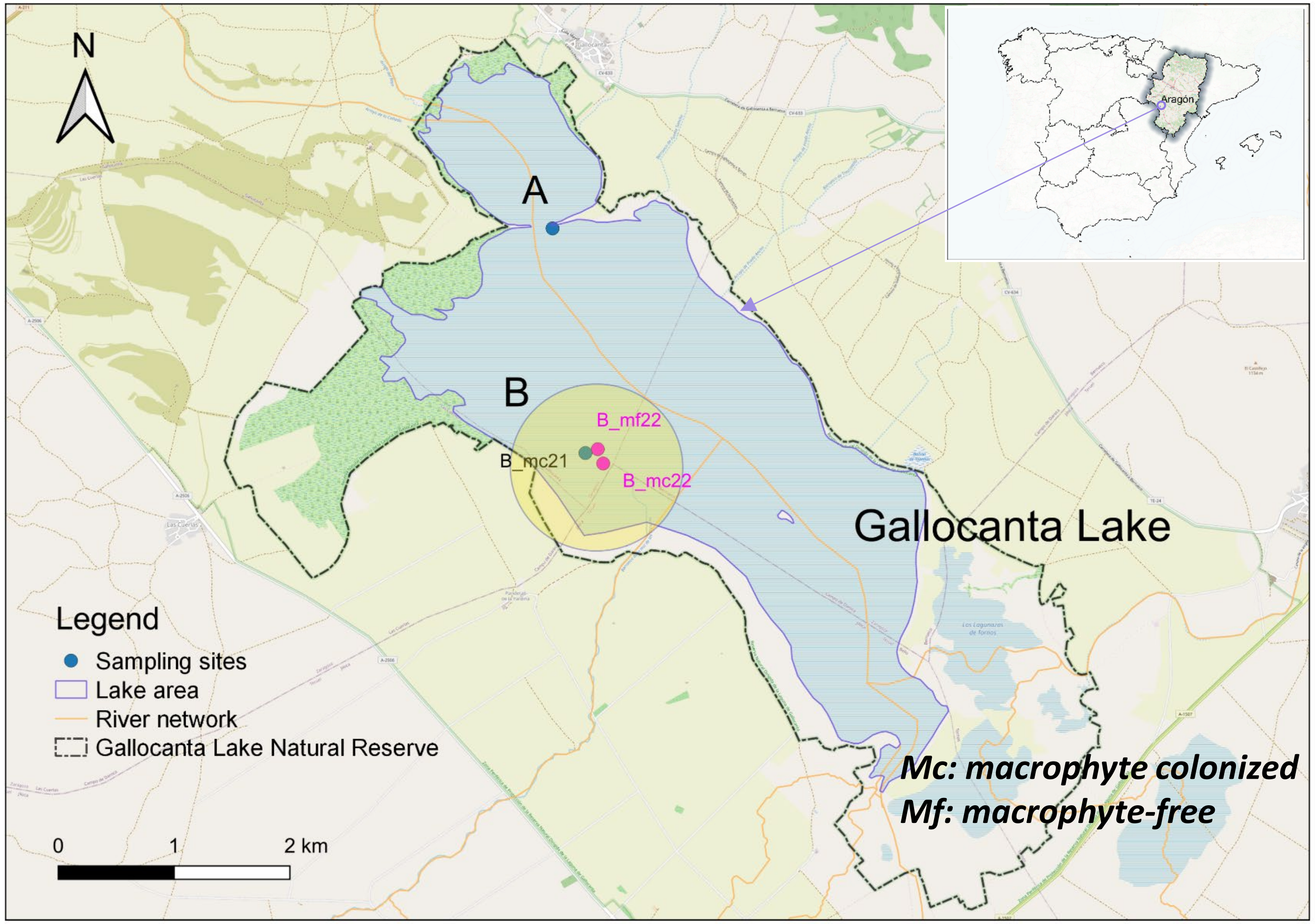






Sulfate-rich saline lake – Gallocanta Lake, NE Spain

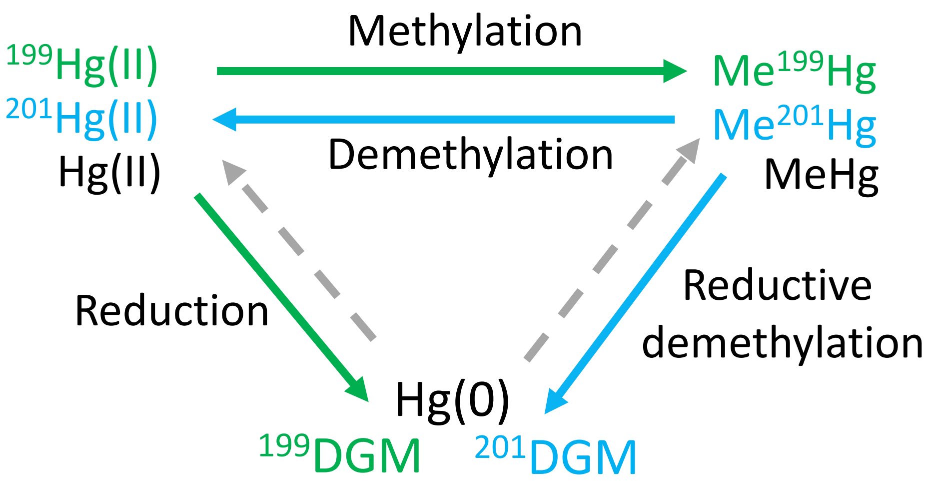
1) Hg species biotic / abiotic (light) transformations capacities in waters as a souce or sink of MMHg and Hg(0)
2) Hg species microbial transformations and geochemical controls along sediment depth as a source of MMHg.



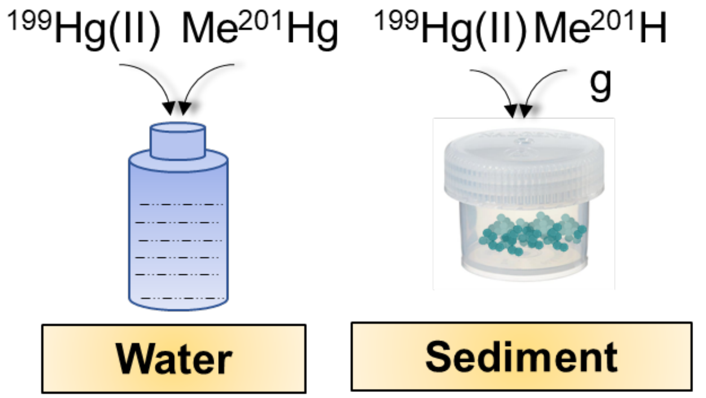
Water/sediment, Oct. 2022

Sampling and experimental methods

Nov. 2020	**Hg speciation**	**Sediment** profile A & B sites	
Jun. 2021	**Hg speciation**	**Sediment** profile A & B sites	**Waters** at A & B sites
Oct. 2022	**Hg speciation**	**Sediment** profile **Macrophyte** **Porewaters** – B_{mc} site	**Waters** at Bmc & Bmf
	Transformation	**Sediment** profile – B_{mc} site	**Waters** at Bmc & Bmf
	Microbial diversity	**Sediment** profile – B_{mc} site	
Apr. 2024			

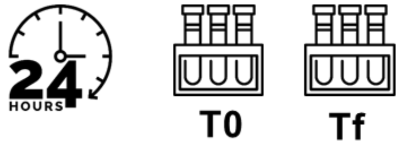


Rodriguez-Gonzalez et al., 2013

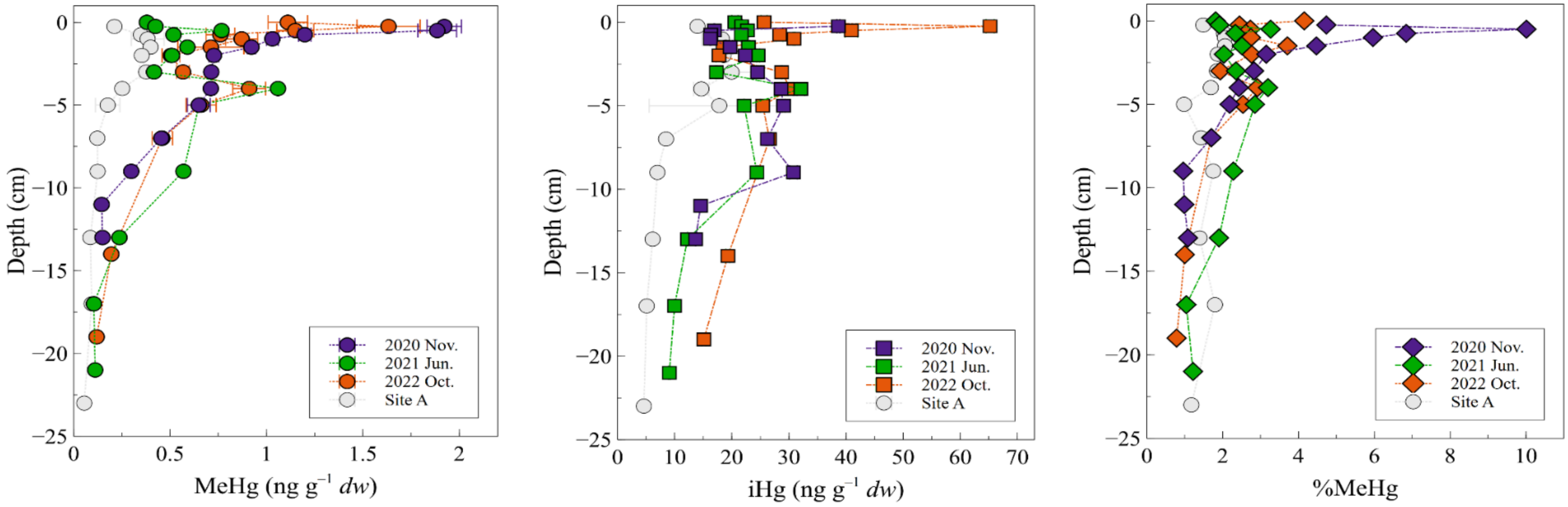


Treatments

- Light & dark
- Bulk/filtration, dark/light, Purging
- Metabolic inhibitors (diuron & Na_2MoO_4)

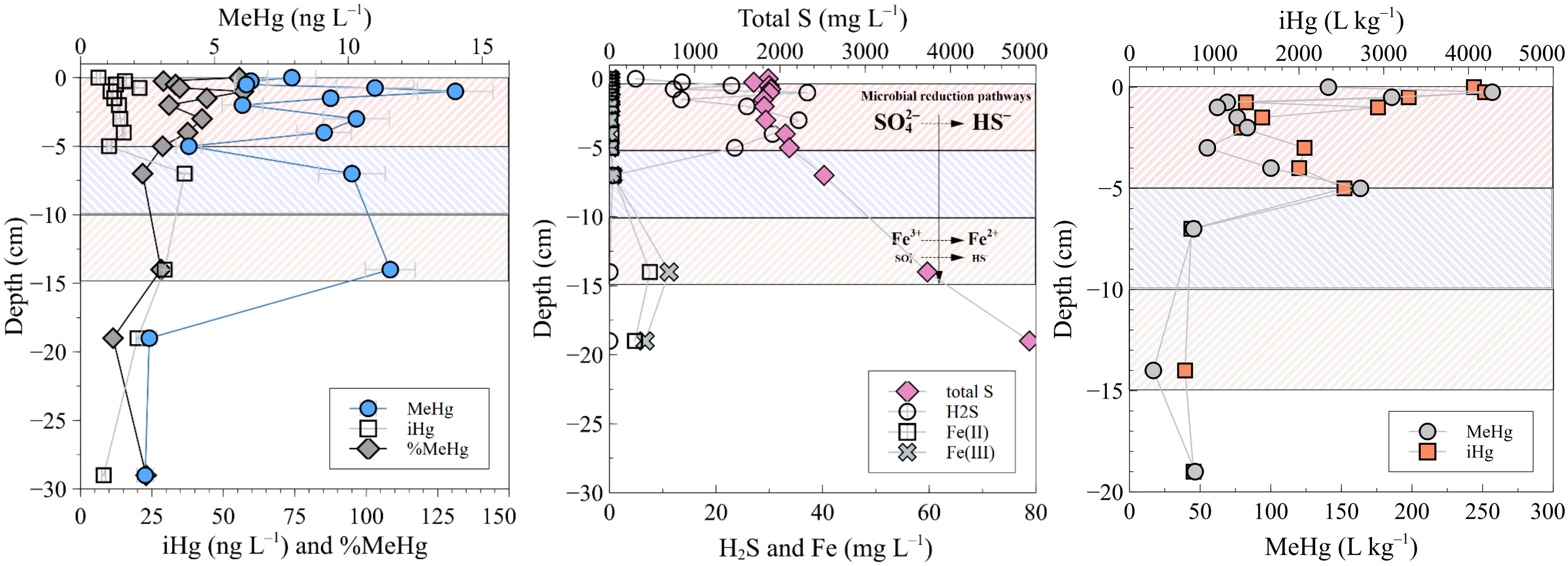


Mercury speciation in bulk sediment



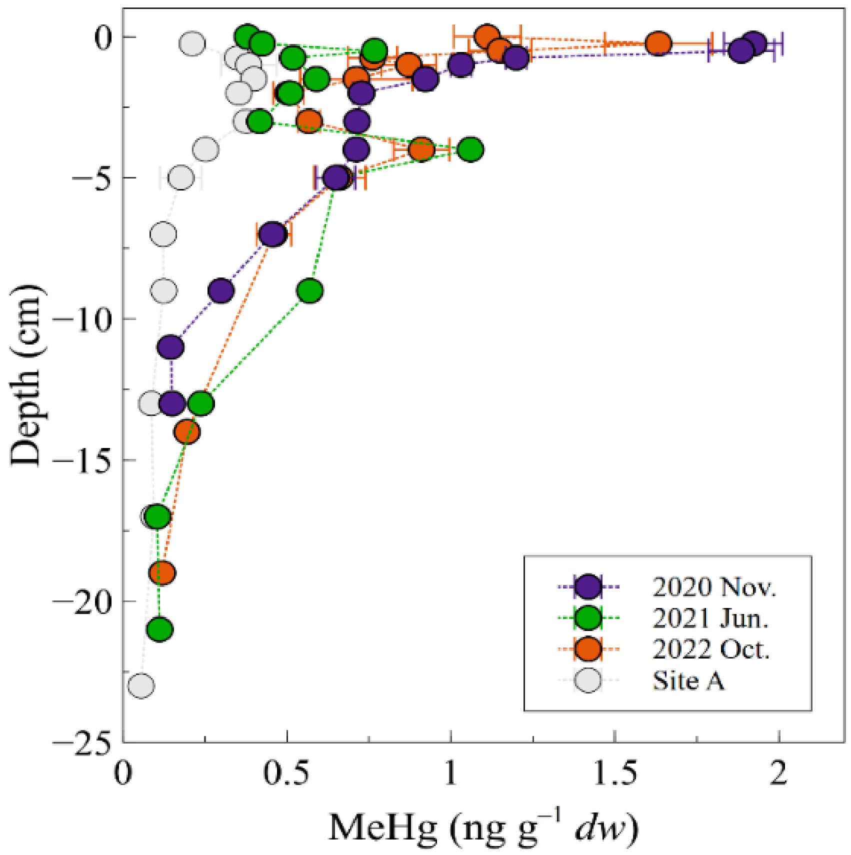
- **Significant seasonal variations of MeHg accumulation, but not for iHg**
- **MeHg peaking close to the surface sediment (organic & sulfidic layer)**

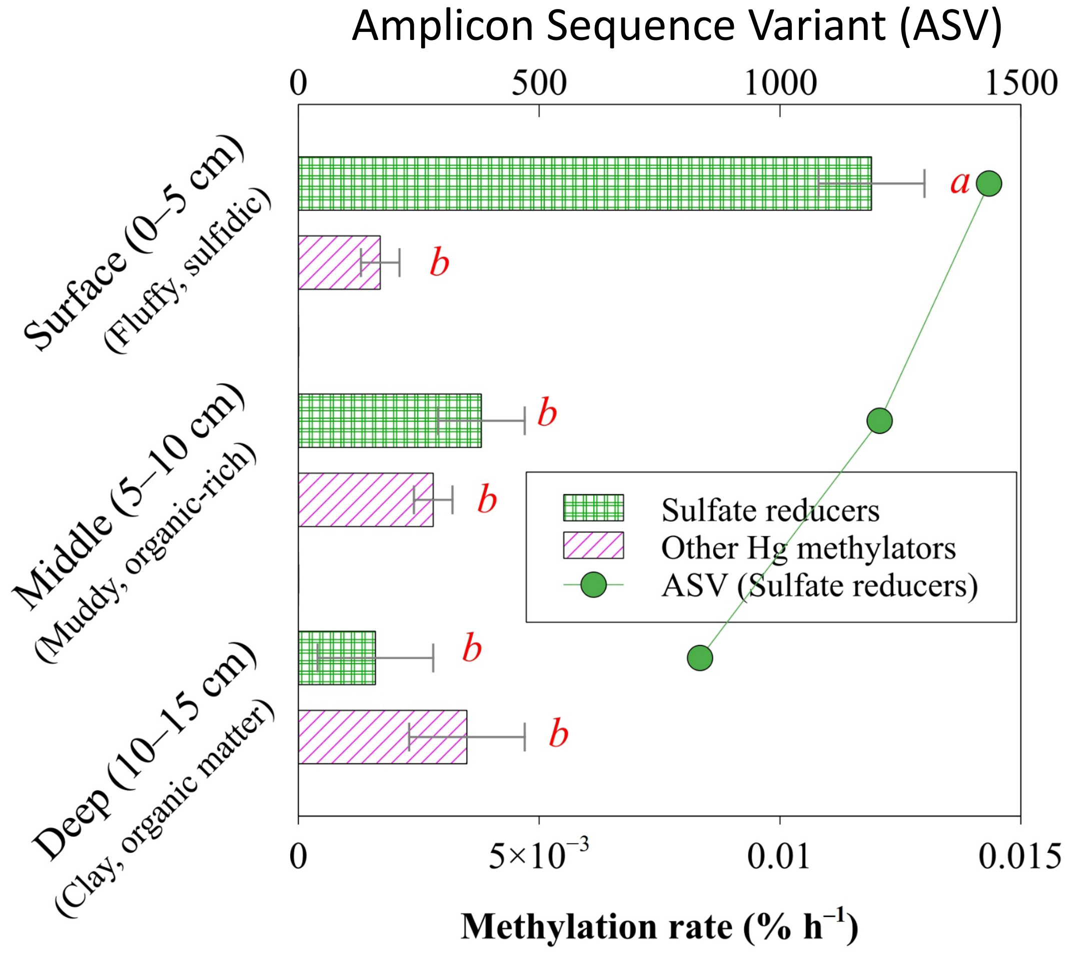
Mercury speciation and major ions in porewaters



- **High MeHg conc and %MeHg in porewaters corresponded to free sulfide levels (indicative of SRB activity)**
- **Diffusive flux of MeHg (6.3 ± 0.6 ng m^{-2} h^{-1}), comparable with Uru Uru Lake (~1.5–9.5 ng m^{-2} h^{-1})** ***(Alanoca et al., 2016; Guédron et al., 2020)***

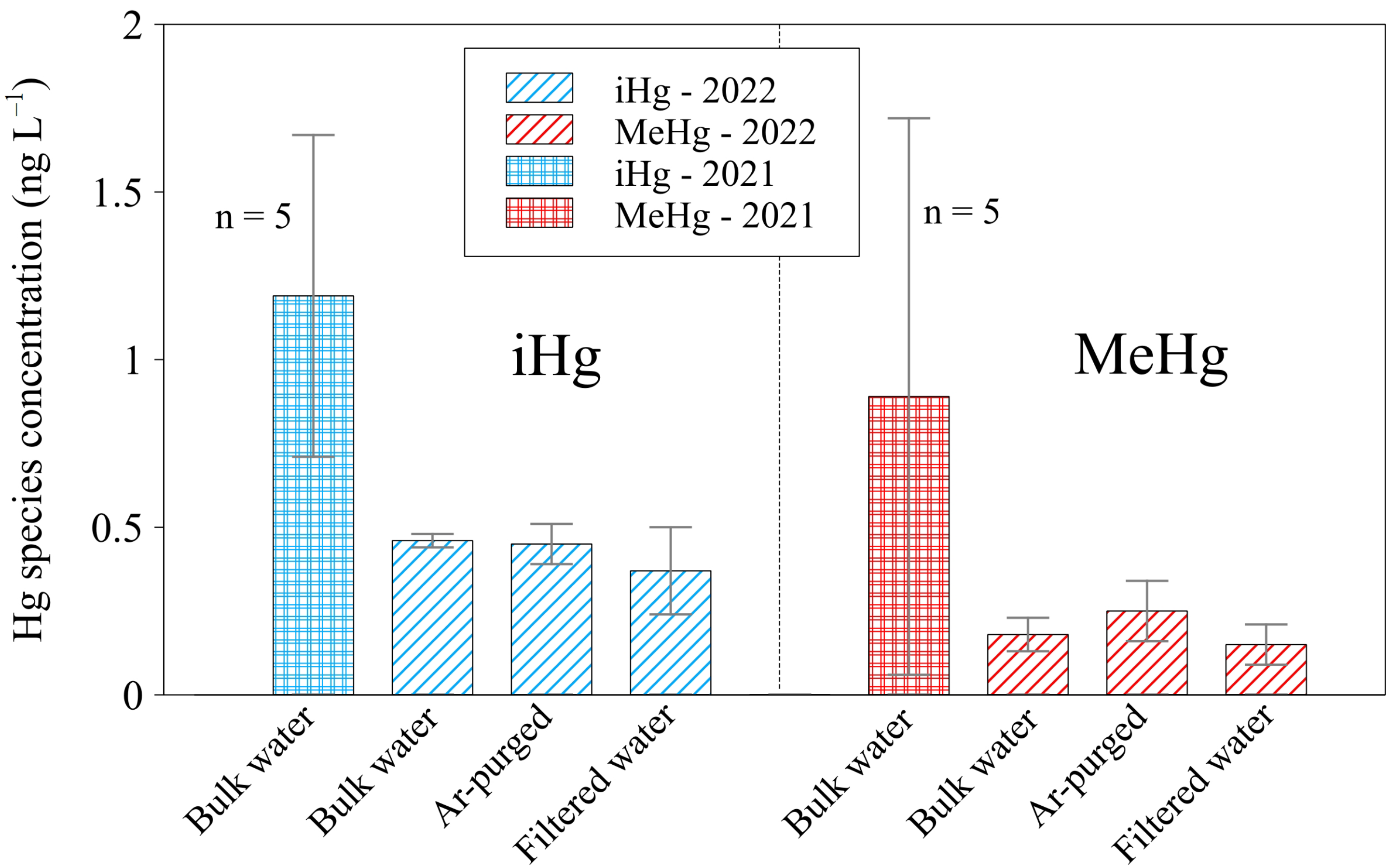
Mercury methylation in sediment (station B_{mc})





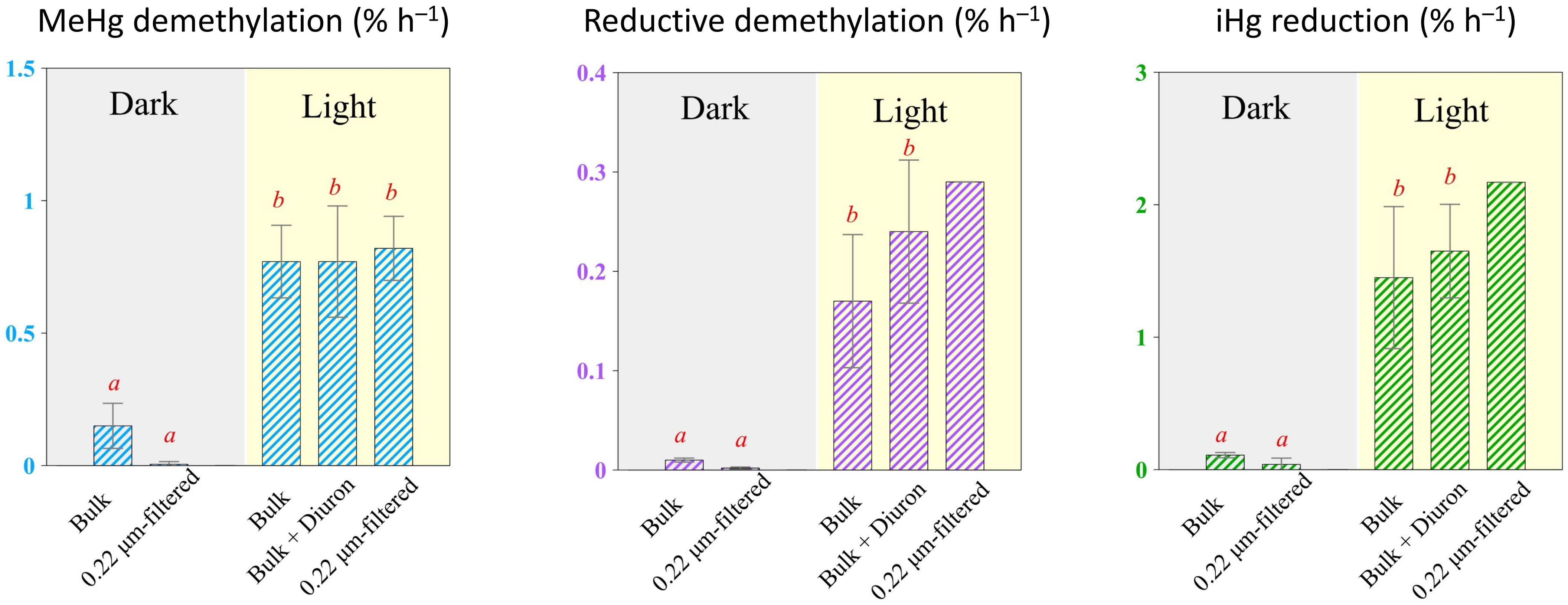
- **Elevated surface MeHg production driven by sulfate-reducing bacteria (e.g. *desulfobacterota*) – Low demethylation**
- **Along the sediment profile, other Hg methylators are equally important (e.g. iron reducers, others?)**

Mercury speciation in saline waters (B_{mc})



- **Seasonal variations in Hg species concentrations**
- **High proportion of MeHg & low DGM : low Hg(0) and undetectable DMHg**
- **Hg species mostly in the dissolved phase ("filter passing")**

Mercury species transformations in waters (station B_{mc})



- **No Methylation in the water column**
- **iHg reduction > MMHg demethylation > reductive demethylation**
- **Photosynthetic bacteria including *Cyanobacteria* and *Rhodobacteraceae* detected – but no significant biotic reductive demethylation and iHg reduction**

DGM production in sulfate and/or saline ecosystems

Type of ecosystem	DGM formation rates (% h^{-1})	Reference
Seawater & freshwaters	0.04–0.42	Mason 1995
Lake Uru Uru (SS)	0.025–0.04 (iHg reduction)	Alanoca et al., 2016
Canadian lakes	0.005	Eckley and hintelmann 2006
A tidal bay	0.26–0.50	Bouchet 2013
Coastal and marine waters	0.13–0.70 (iHg reduction)	Monperrus et al., 2007
Temperate lakes	0.002–0.07	Amyot et al., 1994
Arctic Alaskan lakes	0.03	Tseng et al., 2003
Gallocanta Lake	**~2 (iHg reduction)**	**Present study**
Gallocanta Lake	**~1 (MeHg demethylation)**	**Present study**

- **Rates of DGM formation within the uppermost range**
- **Rapid turnover of MeHg in such saline ecosystems**

Conclusion : MeHg sources and fate in a sulfate-rich saline lake

- **SRB-driven iHg methylation largely in surface sediment (< 5 cm),**
- **but significant methylation by both SRB and other Hg methylators in deeper sediments (> 5-15 cm)**

- **Sediment as a major source of MeHg to surface waters**

- **Photochemical MeHg demethylation to both iHg(II) and Hg(0) dominates in saline waters.**

- **Sediment MMHg production is rapidly compensated by water column demethylation in such saline lake (mass balance)**