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Decoupling of the sulphur cycle between the water column and sediments of a seasonally stratified freshwater lake

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The geochemistry and multiple isotopic composition of sulphur species in the water column and sediments of a stratified lake (Lake Aha, China) were characterised in August 2016. Despite porous sediments that allow solute exchange across the sediment/water interface, the sulphur cycle in the water column and sediments of Lake Aha is dominated by different geochemical regimes, with manganese (≤ 22 µM) prevailing in the water column and iron in the sediments. Sulphide is present in the water column and the multiple sulphur isotopic composition of sulphate and sulphide is consistent with microbial sulphate reduction ($\delta^{34}S_{H2S\text{-}SO4}$ -17 - -30 $^{0}/_{00}$ and $\Delta^{33}S_{H2S\text{-}SO4}$ 0.04 - 0.09).

Sulphate concentrations in the surface sediment are twice higher than those in the water column (3 mM). Acid Volatile Sulphides (AVS) are high relative to pyrite (CRS) and zero-valent sulphur is present throughout the sediment column. The multiple isotopic signature of AVS, CRS and ZVS are similar (within 1-2 $^{0}/_{00}$). Sulphate in the surface sediment layer is heavier than the coexisting AVS ($\delta^{34}S_{AVS\text{-}SO4} = - 4.17$ $^{0}/_{00}$); however, the difference decreases in the second layer ($\delta^{34}S_{AVS\text{-}SO4} = - 1.53$ $^{0}/_{00}$).

Although the isotopic composition of sulphide and sulphate in the water column is clearly consistent with MSR, this signal is not translated to the sediments. The small difference in the isotopic composition between all measured sulphur species throughout the sediment combined with high concentrations of sulphate and ZVS indicate a dynamic reoxidative sulphur cycle that overwrites the fractionation between sulphate and sulphide expressed in the water column.