EGU2020-8207
https://doi.org/10.5194/egusphere-egu2020-8207
EGU General Assembly 2020

224Ra/228Th disequilibrium in sediments of Lake Taihu: Implications of nitrogen fluxes across the sediment–water interface

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Radium-224 /Thorium-228 (^{224}Ra/^{228}Th) disequilibrium in sediments is an advanced proxy of benthic processes and has been gradually used to quantify the fluxes and solute transfer across the sediment–water interface (SWI). This study makes the first attempt to explore the nitrogen fluxes across the SWI of Lake Taihu, the third largest and highly eutrophic freshwater lake in eastern China, based on the plumbing of ^{224}Ra/^{228}Th disequilibrium in the lake sediments. The microscopic sediment cores (0-20 cm) were collected in different parts of the lake, and exchangeable ^{224}Ra and ^{228}Th in bulk sediments were measured. Dissolved inorganic nitrogen (DIN) in pore water and overlying lake water were also analyzed. Deficits of ^{224}Ra compared to its parent isotopes ^{228}Th were observed in the lake sediments, suggesting the influences of mixing processes. The deficits were relatively significant in the western and northern parts, which are consistent with the relative high-eutrophicated areas of the lake. One-dimensional (1D) radium-thorium diagenetic model in the sediment was used to estimate the benthic fluxes based on the ^{224}Ra deficits. Results show that the benthic fluxes of ^{224}Ra varied from -0.428 to 1.170 dpm cm^{-2} d^{-1}, and the bio-irrigation and molecular diffusion are considered to be the major factors. Specifically, in the severely eutrophicated area of the lake, the bio-irrigation predominates in benthic fluxes, reaching up to 97.1% of the deficit of ^{224}Ra. The DIN benthic fluxes were also quantified, leading to a flux estimation of 3.41 mol m^{-2} d^{-1}, which exceeds riverine input (2.63 mol m^{-2} d^{-1}) and the loading derived from lacustrine groundwater discharge (0.02~0.03 mol m^{-2} d^{-1}). This study reveals that sediment processes could be the vital factors for the lake nutrient loadings, and highly contribute to the lake eutrophication. This study is constructive for the water remediation and ecosystem restoration in Lake Taihu and other large eutrophic lakes elsewhere.