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Distribution and behaviour of dissolved selenium in tropical peatland-draining rivers and estuaries of Malaysia

Yan Chang[1], Moritz Müller[2], Ying Wu[1], Shan Jiang[1], Wan Wan Cao[1], Jian Guo Qu[1], Jing Ling Ren[3], Xiao Na Wang[1], En Ming Rao[3], Xiao Lu Wang[1], Aazani Mujahid[4], Mohd Fakharuddin Muhamad[2], Edwin Sien Aun Sia[2], Faddrine Holt Ajon Jang[2], and Jing Zhang[1]

[1]State Key Laboratory of Estuarine and Coastal Research, East China Normal University, Shanghai 200062, China
[2]Faculty of Engineering, Computing and Science Swinburne, University of Technology, Kuching 93350, Malaysia
[3]Key Laboratory of Marine Chemistry Theory and Technology, Ministry of Education, Ocean University of China, Qingdao 266100, China
[4]Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, Kuching 93350, Malaysia

Correspondence: Yan Chang (ychang@sklec.ecnu.edu.cn)

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Abstract. Selenium (Se) is an essential micronutrient for aquatic organisms. Despite its importance, our current knowledge of the biogeochemical cycling of dissolved Se in tropical estuaries is limited, especially in Southeast Asia. To gain insights into Se cycling in tropical peat-draining rivers and estuaries, samples were collected from the Rajang, Maludam, Sebuyau, Simunjan, Sematan, Samunsam and Lunda rivers and estuaries in western Sarawak, Malaysia, in March and September 2017 and analysed for various forms of Se (dissolved inorganic and organic). Mean total dissolved Se (TDSe), dissolved inorganic Se (DISe) and dissolved organic Se concentrations (DOSe) were 2.2 nmol L^{-1} (range: 0.7 to 5.7 nmol L^{-1}), 0.18 nmol L^{-1} (range: less than the detection limit to 0.47 nmol L^{-1}) and 2.0 nmol L^{-1} (range: 0.42 to 5.7 nmol L^{-1}), respectively. In acidic, low-oxygen, organic-rich blackwater (peatland-draining) rivers, the concentrations of DISe were extremely low (near or below the detection limit, i.e. 0.0063 nmol L^{-1}), whereas those of DOSe were high. In rivers and estuaries that drained peatland, DOSe / TDSe ratios ranged from 0.67 to 0.99, showing that DOSe dominated. The positive relationship between DISe and salinity and the negative relationship between DOSe and salinity indicate marine and terrestrial origins of DISe and DOSe, respectively. The positive correlations of DOSe with the humification index and humic-like chromophoric dissolved organic matter components in freshwater river reaches suggest that peat soils are probably the main source of DOSe. The DOSe fractions may be associated with high molecular weight peatland-derived aromatic and black carbon compounds and may photodegrade to more bioavailable forms once transported to coastal waters. The TDSe flux delivered by the peat-draining rivers exceeded those reported for other small rivers and is quantitatively more significant than previously thought.

1 Introduction

Selenium (Se) is an essential trace element for aquatic organisms (Bodnar et al., 2014). Low levels of Se in the food chain lead to disease or death, whereas high levels are toxic (Lobanov et al., 2009; Winkel et al., 2015). Selenium depletion in the Phanerozoic oceans may have contributed to three major mass extinction scenarios (Long et al., 2016). Thus, there has been great interest in Se biogeochemical cycling in aquatic systems for many decades (e.g. Cutter and Bruland, 1984; Cutter and Cutter, 1995, 2001; Mason et al., 2018).

The bioavailability of Se is determined by its concentrations and species (Fernández and Charlet, 2009). The behaviour of Se in natural waters is complicated, as it exists in several oxidation states (−II, IV, VI) (Conde and Sanz Alaejos, 1997). A number of field and laboratory studies have found that selenite (Se(IV)) and selenate (Se(VI)) can be assimilated by marine phytoplankton with Se(IV) being