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Dissolved inorganic nitrogen in a tropical estuary in Malaysia: transport and transformation

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Abstract. Dissolved inorganic nitrogen (DIN), including nitrate, nitrite and ammonium, frequently acts as the limitation for primary productivity. Our study focused on the transport and transformation of DIN in a tropical estuary, i.e., the Rajang River estuary, in Borneo, Malaysia. Three cruises were conducted in August 2016 and February–March and September 2017, covering both dry and wet seasons. Before entering the coastal delta, decomposition of the terrestrial organic matter and the subsequent soil leaching was assumed to be the main source of DIN in the river water. In the estuary, decomposition of dissolved organic nitrogen was an additional DIN source, which markedly increased DIN concentrations in August 2016 (dry season). In the wet season (February 2017), ammonium concentrations showed a relatively conservative distribution during the mixing, and the nitrate addition was weak. La Niña events induced high precipitations and discharge rates, decreased reaction intensities of ammonification and nitrification. Hence similar distribution patterns of DIN species in the estuary were found in September 2017 (end of the dry season). The magnitude of riverine DIN flux varied between 77.2 and 101.5 $\mathrm{t\,N\,d^{-1}}$, which might be an important support for the coastal primary productivity.

1 Introduction

Nitrogen (N) is an essential element for life. The concentration of N may significantly influence species composition and diversity in terrestrial, freshwater and ocean ecosystems (Vitousek et al., 1997). Apart from nitrogen gas (N_2), N is bioactive with highly variable chemical forms. Dissolved inorganic nitrogen (DIN), including nitrate (NO_3^-), ammonium (NH_4^+) and nitrite (NO_2^-), can be easily assimilated by terrestrial plants, algae and bacterial communities (Seitzinger et al., 2002). In addition, due to the high solubility, DIN can be easily transported among ecosystems as a part of the hydrologic cycle (Galloway et al., 2004). Consequently, DIN is assumed to be the most active component in the N cycle, and the transport of DIN among ecosystems is a hotspot in biogeochemical research on a global scale (Gruber and Galloway, 2008).

Estuaries are the linkage between terrestrial surface water and coastal sea (Seitzinger et al., 2002) and have received much attention from researchers and coastal managers with regard to the quantification of terrestrial DIN transport (e.g., Falco et al., 2010; Holmes et al., 2012; Li et al., 2013; Kuo et al., 2017). The mixing between freshwater and saline water develops physiochemical gradients in various parameters such as dissolved oxygen (DO), salinity and pH (Spiteri et al., 2008), which influence the growth of distinct bacterial communities (e.g., Goñi-Urriza et al., 2007; Spietz et al., 2015). These bacteria actively participate in DIN transformation processes, such as denitrification, DNRA (dissimilatory nitrate reduction to ammonium) and anammox (anaerobic ammonium oxidation; Burgin and Hamilton, 2007). These processes strongly influence DIN concentrations (Canfield et al., 2010), adding uncertainties to the precise estimation of DIN fluxes. Moreover, environmental parameters related to

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