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# Long-term comparison of dissolved nitrogen species in tropical estuarine and coastal water systems

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ABSTRACT

Long-term observation of aquatic habitat is invaluable as it reveals trends that are not evident from shorter-term measurements. In this study, we assessed measurements of dissolved nitrogen species over a 12-year period (2004–2015) at Port Klang estuary and Port Dickson coastal water. Total suspended solids (TSS) was also measured, and increased at 6–9 mg $L^{-1}$ $yr^{-1}$. In contrast, total dissolved nitrogen (TDN) did not increase but was higher at Port Klang (8–320 μM) relative to Port Dickson (2–30 μM). Chl *a* concentration was also higher at Port Klang (5.18 ± 7.79 μg $L^{-1}$) than at Port Dickson (2.27 ± 1.39 μg $L^{-1}$). Among the dissolved nitrogen species, we found that ammonium ($NH_4$) was predominant at Port Klang where dissolved inorganic nitrogen (DIN) contributed 71 ± 3% of TDN. At Port Dickson, dissolved organic nitrogen (DON) predominated, contributing 92 ± 7% of TDN. When we calculated the nitrogen loading at Port Klang, dissolved nitrogen load increased over time (1.13 ± 0.29 kg $d^{-1}$ for TDN, 1.11 ± 0.29 kg $d^{-1}$ for DIN, and 0.15 ± 0.06 kg $d^{-1}$ for DON). We showed that the nitrogen loading increase at Port Klang was not due to climatic forcing but was most probably due to urbanization occurring upstream that inevitably increased river discharge rates (4.04 ± 0.12 $m^3$ $s^{-1}$ $yr^{-1}$).

## 1. Introduction

Over the last few decades, the rapid increase in anthropogenic activities (e.g. effluent discharge, agriculture and land development) and changes in patterns of precipitation due to a changing climate are increasing the nutrient load to coastal habitats around the world (Strauch et al., 2015; Williams et al., 2015). Although nutrients are essential to sustain primary productivity, excessive nutrient input particularly nitrogen and phosphorus will lead to eutrophication which is generally detrimental to the ecosystem (Peyman et al., 2017). At present, most studies on the influence of excessive nutrient inputs towards eutrophication are from temperate waters even though tropical oceans cover about 40% of the global ocean. Therefore, it is necessary to study the distribution of different dissolved nitrogen species in the tropical waters of South-East Asia. The distribution of different phosphorus pool in these waters was published earlier in Lim et al. (2018).

In marine ecosystem, total dissolved nitrogen (TDN) can be divided into inorganic nitrogen (DIN) and organic nitrogen (DON) pools (Flynn, 2008; Voss et al., 2013). DIN comprises mainly of ammonium ($NH_4$), nitrate ($NO_3$) and nitrite ($NO_2$) which plays an important role in regulating autotrophic processes such as primary productivity. In contrast, DON is typically more important in regulating bacterial heterotrophic processes (Letscher et al., 2013). DIN and DON may come from both autochthonous processes and allochthonous input. The former includes natural nitrogen fixation by different biogeochemical and microbial processes in the nitrogen cycle (Gruber, 2008; Letscher et al., 2013; Voss et al., 2013) whereas the latter generally refers to nitrogen inputs from extraneous habitats. Estuaries in particular, receive a large supply of allochthonous material via riverine input (Flynn, 2008; Brandini et al., 2016).

Long-term observation of aquatic habitats is invaluable as it reveals trends otherwise hidden, and establish relationships with potential drivers for example anthropogenic pressure and climate change. However most of the published reports in South-East Asia focussed on different DIN pools over sampling periods of two years or less (e.g. Tanaka and Choo, 2000; Lee et al., 2009; Teoh et al., 2016; Peyman et al., 2017). These studies are not able to reveal long-term trends as the effects of anthropogenic pressure and climate change on many ecological processes vary over longer time frames (Burt et al., 2010; Dodds et al., 2012). At present, most of the long-term reports are from

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