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Atmospheric Iron and Aluminium Deposition and Sea-Surface Dissolved Iron and Aluminium Concentrations in the South China Sea off Malaysia Borneo (Sarawak Waters)

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ABSTRACT

South China Sea (SCS) is an oligotrophic sea which usually receives low nutrients supply. However, massive atmospheric dust input was occurred during the haze event in Southeast Asia for almost every year. The input of dissolved iron (DFe) and dissolved aluminium (DAl) from dust and nearby land into SCS off Sarawak Borneo region during the worst haze event in 2015 of the Southeast Asia were investigated. The estimation dust deposition during this study was 0.162 mg/m^2/yr. The atmospheric fluxes of total Fe and total Al at the offshore Sarawak waters were 0.611 µmol/m^2/yr and 2.03 µmol/m^2/yr, respectively, where the readily available dissolved Fe and Al from the dust were 0.11 µmol/m2/yr (DFe) and 0.31 µmol/m^2/yr (DAl). Fe has higher solubility (17.78%) than Al (15.21%). The lateral fluxes (e.g. from the nearby land) were 37.08 nmol/m^2/yr (DFe) and 125 nmol/m^2/yr (DAl), with strong Fe organic ligand class L_1 (log K:22.43 – 24.33). High concentrations of DFe and DAl at the surface water of the offshore region, coincided with high concentration of macronutrients due to the prevailing south-westerly winds originated from the west Kalimantan. Low residence times, ~0.92 (DFe) and ~1.31 (DAl) years, corresponded well with DAl_{excess} in surface seawater due to biological utilization of DFe. Future works emphasize on natural organic Fe(III) ligands and phytoplankton study are needed for better understanding on biogeochemistry of Fe and Al at SCS off Malaysia Borneo.

Keywords: Atmospheric dust input, haze event 2015, Sarawak EEZ waters, South China Sea, trace metals

INTRODUCTION

Vegetation and peatland wildfires occurred every year across the Equatorial Asia, particularly at the Southeast Asia, during the dry season between September and October. The 2015 wildfire that started in Indonesia Borneo and then spread to Sarawak (Malaysia Borneo) began in July, resulted in thick smokes that blanketed Southeast Asia countries, such as, Malaysia, Brunei, Indonesia, Thailand and Singapore. It was likely the worst haze event since 1997 (Koplitz *et al.*, 2016). The combustion activities were worsening by drought conditions during the El Niño and the Indian Ocean Dipole, where the fire emissions can be rose up to 30 times greater than during La Niña (Crippa *et al.*, 2016). Moreover, the prevailing winds transported the wildfire smokes for hundreds to thousands miles away from the originating fires on the land to the sea, thus, the spatial and temporal effect of atmospheric inputs on surface seawater biogeochemistry may be seen even in remote oceanic areas.

South China Sea (SCS) is the largest marginal sea with oligotrophic condition (Wen *et al.*, 2006) which receives low nutrients supply (Guo *et al.*, 2012), where the nutrients may come from different sources such as coastal and atmospheric inputs (Chen *et al.*, 2021). Studies showed that there were significant inputs of micronutrients (*i.e.* Fe and Al) from atmospheric dust deposition in SCS due to the strategic location of SCS (Lin *et al.*, 2007; Wong *et al.*,