Biogeosciences, 13, 691–705, 2016
www.biogeosciences.net/13/691/2016/
doi:10.5194/bg-13-691-2016

Biogeosciences Open Access EGU

Fate of terrestrial organic carbon and associated CO_2 and CO emissions from two Southeast Asian estuaries

D. Müller[1,2], T. Warneke[1], T. Rixen[2,3], M. Müller[4], A. Mujahid[5], H. W. Bange[6], and J. Notholt[1,7]

[1]Institute of Environmental Physics, University of Bremen, Otto-Hahn-Allee 1, 28359 Bremen, Germany
[2]Leibniz Center for Tropical Marine Ecology, Fahrenheitstr. 6, 28359 Bremen, Germany
[3]Institute of Geology, University of Hamburg, Bundesstr. 55, 20146 Hamburg, Germany
[4]Swinburne University of Technology, Faculty of Engineering, Computing and Science, Jalan Simpang Tiga, 93350 Kuching, Sarawak, Malaysia
[5]Department of Aquatic Science, Faculty of Resource Science and Technology, University Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia
[6]GEOMAR Helmholtz Centre for Ocean Research Kiel, Düsternbrooker Weg 20, 24105 Kiel, Germany
[7]MARUM Center for Marine Environmental Sciences, University of Bremen, Leobener Str., 28359 Bremen, Germany

Correspondence to: D. Müller (dmueller@iup.physik.uni-bremen.de)

Received: 4 May 2015 – Published in Biogeosciences Discuss.: 5 June 2015
Revised: 6 January 2016 – Accepted: 14 January 2016 – Published: 4 February 2016

Abstract. Southeast Asian rivers convey large amounts of organic carbon, but little is known about the fate of this terrestrial material in estuaries. Although Southeast Asia is, by area, considered a hotspot of estuarine carbon dioxide (CO_2) emissions, studies in this region are very scarce. We measured dissolved and particulate organic carbon, as well as CO_2 partial pressures and carbon monoxide (CO) concentrations in two tropical estuaries in Sarawak, Malaysia, whose coastal area is covered by carbon-rich peatlands. We surveyed the estuaries of the rivers Lupar and Saribas during the wet and dry season, respectively. Carbon-to-nitrogen ratios suggest that dissolved organic matter (DOM) is largely of terrestrial origin. We found evidence that a large fraction of this carbon is respired. The median pCO_2 in the estuaries ranged between 640 and 5065 µatm with little seasonal variation. CO_2 fluxes were determined with a floating chamber and estimated to amount to 14–268 mol m^{-2} yr^{-1}, which is high compared to other studies from tropical and subtropical sites. Estimates derived from a merely wind-driven turbulent diffusivity model were considerably lower, indicating that these models might be inappropriate in estuaries, where tidal currents and river discharge make an important contribution to the turbulence driving water–air gas exchange. Although an observed diurnal variability of CO concentrations suggested that CO was photochemically produced, the overall concentrations and fluxes were relatively moderate (0.4–1.3 nmol L^{-1} and 0.7–1.8 mmol m^{-2} yr^{-1}) if compared to published data for oceanic or upwelling systems. We attributed this to the large amounts of suspended matter (4–5004 mg L^{-1}), limiting the light penetration depth and thereby inhibiting CO photoproduction. We concluded that estuaries in this region function as an efficient filter for terrestrial organic carbon and release large amounts of CO_2 to the atmosphere. The Lupar and Saribas rivers deliver 0.3 ± 0.2 Tg C yr^{-1} to the South China Sea as organic carbon and their mid-estuaries release approximately 0.4 ± 0.2 Tg C yr^{-1} into the atmosphere as CO_2.

1 Introduction

Estuaries are net heterotrophic systems (Duarte and Prairie, 2005; Cole et al., 2007) and act as a source of carbon dioxide (CO_2) to the atmosphere, releasing 150 Tg C annually (Laruelle et al., 2013). Southeast Asia is considered one of the hotspot regions of aquatic CO_2 emissions to the atmosphere (Regnier et al., 2013), because many Southeast Asian rivers exhibit high organic carbon concentrations (Alkhatib et al., 2007; Moore et al., 2011, 2013; Müller et al., 2015). It has been estimated that Indonesian rivers alone account for