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Potential impact of predicted sea level rise on carbon sink function of mangrove ecosystems with special reference to Negombo estuary, Sri Lanka

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ABSTRACT

Unique location in the land-sea interface makes mangrove ecosystems most vulnerable to the impacts of predicted sea level rise due to increasing anthropogenic CO_2 emissions. Among others, carbon sink function of these tropical ecosystems that contribute to reduce rising atmospheric CO_2 and temperature, could potentially be affected most. Present study was undertaken to explore the extent of impact of the predicted sea level rise for the region on total organic carbon (TOC) pools of the mangrove ecosystems in Negombo estuary located on the west coast of Sri Lanka. Extents of the coastal inundations under minimum (0.09 m) and maximum (0.88 m) sea level rise scenarios of IPCC for 2100 and an intermediate level of 0.48 m were determined with GIS tools. Estimated total capacity of organic carbon retention by these mangrove areas was 499.45 Mg C ha^{-1} of which 84% (418.98 Mg C ha^{-1}) sequestered in the mangrove soil and 16% (80.56 Mg C ha^{-1}) in the vegetation. Total extent of land area potentially affected by inundation under lowest sea level rise scenario was 218.9 ha, while it was 476.2 ha under intermediate rise and 696.0 ha with the predicted maximum sea level rise. Estimated rate of loss of carbon sink function due to inundation by the sea level rise of 0.09 m is 6.30 Mg C ha^{-1} y^{-1} while the intermediate sea level rise indicated a loss of 9.92 Mg C ha^{-1} y^{-1} and under maximum sea level rise scenario, this loss further increases up to 11.32 Mg C ha^{-1} y^{-1}. Adaptation of mangrove plants to withstand inundation and landward migration along with escalated photosynthetic rates, augmented by changing rainfall patterns and availability of nutrients may contribute to reduce the rate of loss of carbon sink function of these mangrove ecosystems. Predictions over change in carbon sequestration function of mangroves in Negombo estuary reveals that it is not only affected by oceanographic and hydrological alterations associated with sea level rise but also by anthropogenic processes, therefore the impacts are site specific in terms of distribution and magnitude.

1. Introduction

A global climate change due to increasing greenhouse gas content in the atmosphere is widely accepted. Sea level rise is a major consequence of increasing atmospheric temperature and associated changes in precipitation and incidence of storms. This is primarily due to thermal expansion and loss of mass from glaciers and ice caps that contribute to increasing volume of water in the oceans (Church et al., 2001). Based on tide gauge data, the rate of global mean sea level rise during the 20th century is in the range 1.0 to 2.0 mm/year (Intergovernmental Panel on Climate Change — IPCC, 2001). Several climate models project an accelerated rate of sea level rise over the coming decades. Global mean sea level is projected to rise by 0.09 to 0.88 m between 1990 and 2100 (Houghton et al., 2001) which particularly threaten the small islands and coastal ecosystems such as mangroves (Field, 1995; Lovelock and Ellison, 2007; IUCN, 1989; Cahoon & Hensel, 2006; McLeod & Salm, 2006; Gilman et al., 2007). Based on available evidence, relative sea level rise may be the greatest threat to mangroves (Gilman et al., 2008). However, the increased surface temperature combined with atmospheric CO_2 is expected to affect mangroves not only by changing both species composition and the phenological patterns (Field, 1995; Ellison, 2000), but also the metabolic activities (UNEP, 1994; Ball et al., 1997). Thus, it will threaten the resilience of mangrove ecosystems that typically occupy intertidal zones.

Mangrove ecosystems are able to store large amounts of organic carbon (Matsui, 1998; Fujimoto et al., 1999; Perera and Amarasinghe, 2010; Donato et al., 2011) and in some mangrove ecosystems organic-rich sediment of several meters deep have been found (Twilley et al., 1992; Perera and Amarasinghe, 2015). Deep organic matter-rich soil and dense vegetation, qualify mangroves to be ranked among the most carbon-dense forests in the tropics. (Fujimoto et al., 1999; Donato et al.,

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