Landscape factors affect persistence and accumulation of organic carbon in sediment of secondary mangrove forests: A preliminary study

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Mangroves are swamp forest ecosystem that predominates in low-energy brackish environment of subtropical and tropical coastal systems. Mangroves have a remarkable capacity to capture CO_2 by primary production and sequester organic carbon (OC) in the sediment, thereby contributing to climate change mitigation. Typical carbon sequestration rate and OC stock in top 1 m of mangrove sediment have been estimated to be 1030 kg C ha^{-1} $year^{-1}$ and 723 Mg C ha^{-1}, respectively (median values of available data; Alongi 2018). Mangroves have been vastly degraded by human activities and reclaimed and/or converted to aquacultures and agricultural fields for past a few centuries. Current global loss rate of mangroves has been estimated to be up to 2% per year, which corresponds to an emission of 0.27 to 0.59 Pg CO_2 $year^{-1}$ at the maximum, if OC in top 1 m of sediment is assumed to be entirely reoxidized after reclamation and conversion (Alongi 2018, Atwood et al. 2017). However, the degree to which and the rate at which sediment OC is returned to the atmosphere as CO_2 after degradation of mangroves are still uncertain, and presumably depend on land use pattern and hydrodynamic conditions after conversion. Some part of sediment OC may be reoxidized shortly after conversion, while other parts may remain unoxidized in the soil for long term or be flushed out to the ocean by tidal exchange. To estimate the rate of OC loss after degradation and conversion of mangroves and evaluate how the sediment OC stock may be recovered by reforestation, we are now conducting a multidisciplinary research project in coastal areas of Panay Island, Philippines, where various types of habitats typical to once degraded and converted mangroves are found, such as naturally recovered secondary mangroves, artificially reforested mangroves, artificial mangroves planted on originally seagrass-dominated habitats, and tidal marshes and shrubs growing on abandoned aquaculture plots. Here, we introduce first preliminary results on OC characteristics in sediment cores collected from a naturally-recovered secondary mangrove in an estuarine delta (Ibajay) and a replanted mangrove in a well-protected embayment (Batan Bay). Estimated OC stocks in top 1 m of sediment ranged from 40 Mg C ha^{-1} in lower estuary of Ibajay to 420 Mg C ha^{-1} in Batan Bay, which are significantly lower than the world-median OC stock for natural mangroves mentioned above. Radiocarbon dating showed that the cores from the lower estuarine secondary mangrove were predominated by modern carbon down to a depth of 1 m, which suggests that old OC originally stored in the primary mangrove had been reoxidized and/or washed out to the sea soon after the conversion. In contrast, sediment OC in the upper estuarine secondary mangrove showed a radiocarbon age of 400 –1200 yBP throughout the cores, suggesting that old OC stored in original mangroves persisted at least partially through conversion and subsequent regrowth of the forest. The OC loading, i.e. the amount of OC per unit surface area of sediment grains, seemed to be constrained by the hydrodynamic stability of sediment. This implies that detrital particles derived from mangrove litter was stored at the higher concentrations in sediment of the more protected environment. The curvilinear correlation of stable carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) isotope ratios to the OC loading suggests that

mangrove-derived detritus typically exhibits the $\delta^{13}C$ of −28‰ vs. VPDB and the $\delta^{15}N$ of +0.5‰ vs. atmospheric N_2. The other endmember of sediment OC, putatively marine seston, is represented by the $\delta^{13}C$ of around −25‰ and the $\delta^{15}N$ of +3‰ and tended to decrease with increasing sediment depth. Our results overall showed that both the persistence of old sediment OC and the accumulation of newly supplied detrital OC in secondary mangroves are strongly constrained by the hydrodynamic setting of habitat.

Keywords: carbon sequestration function, mangroves, reforestation