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Nutritional composition of suspended particulate matter in a tropical mangrove creek during a tidal cycle (Can Gio, Vietnam)

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ABSTRACT

Mangrove forests are highly productive ecosystems and mangrove-derived organic matter has generally been assumed to play a basal role in sustaining coastal food webs. However, the mechanisms of mangrove-derived organic matter utilisation by consumers are not fully understood. In this study, we were interested in hourly changes in the nutritional quality of suspended particulate matter (SPM) entering and departing a mangrove creek during a tidal cycle. We determined the fatty acid composition and $\delta^{13}C$ stable isotope signature of SPM during a 26 h tidal cycle in a creek of the Can Gio Mangrove Biosphere Reserve (Southern Vietnam). Regarding fatty acids, the nutritional quality of SPM was low during most of the tidal cycle. However, it greatly increased during the first part of the strongest flood tide, occurring during daytime. The pulse of highly nutritive organic matter brought to the ecosystem was mostly composed of algal cells growing in specific shallow zones of the mangrove, that use nutrients and CO_2 exported during the preceding ebb tide and originating from the mineralisation of mangrove-derived organic matter, as evidenced by their $\delta^{13}C$ signatures. This study confirms that mangrove-derived carbon plays a basal role in sustaining trophic webs of mangrove tidal creeks, but that its nutritive value is greatly enhanced when a first step of mineralisation is achieved and CO_2 is photosynthesised by algal cells.

1. Introduction

Mangrove forests are highly productive ecosystems and various authors have suggested that mangrove-derived organic matter (OM) via tidal export plays a significant role in carbon budgets along tropical and subtropical coastlines (Jennerjahn and Ittekkot, 2002; Dittmar et al., 2006), as well as in sustaining trophic webs in coastal waters (Odum and Heald, 1975; Lee, 1995). Substantial amounts of suspended particulate matter (SPM), particulate organic carbon (POC) and dissolved inorganic carbon (DIC) are exported to tidal creeks and adjacent ecosystems during ebb tide, notably through tidal pumping which allows mangrove pore-water to circulate (Bouillon et al., 2007; Maher et al., 2013). OM sources in SPM have historically been traced using $\delta^{13}C$ stable isotope signature (Bouillon et al., 2008), however little attention has been paid to the nutritional quality of SPM entering and departing mangrove ecosystems during a tidal cycle.

The processes allowing mangrove-derived OM utilisation by consumers are not fully understood, either in mangrove tidal creeks or in adjacent waters (Lee, 1995; Bouillon et al., 2008). While quantitative information on carbon flows is necessary to construct carbon budgets, evaluating the nutritional quality of the carbon associated with each of these flows is perhaps as important to evaluate its possible trophic assimilation (Canuel, 2001). Fatty acids (FA) constitute only a small fraction of SPM but their contribution to trophic webs can be important nutritionally and they are organically traceable (Meziane and Tsuchiya, 2000; Dalsgaard et al., 2003; Alfaro et al., 2006).

Within this context, our objective was to determine the evolution of the composition of SPM during a tidal cycle, using fatty acids

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and $\delta^{13}C$ stable isotope, in a mangrove creek located in the Can Gio Mangrove Biosphere Reserve (Southern Vietnam). We hypothesised that mangrove-derived OM was mainly exported during ebb tide, increasing the nutritional quality of SPM, while flood tide brings diluted water.

2. Materials and methods

2.1. Study site

We conducted our study during the monsoon season in 2015 (19-20 October) in a 1400 m long mangrove tidal creek (10°30′24″N 106°52′57″E; Fig. 1), located in the core zone of the Can Gio Mangrove Biosphere Reserve (UNESCO/MAB Project, 2000). This creek does not receive any upstream freshwater inputs. The Can Gio mangrove is formed by the deltaic confluence of the Saigon, Dong Nai and Vam Co Rivers, which drain into the South China Sea, and covers an area of 720 km^2. The tidal regime is semidiurnal and tidal amplitude was 2.1 m during our study, with maximum and minimum water levels of 2.8 m and 0.7 m, respectively. The tidal cycle of low amplitude occurred at night and will be referred to as the weak tide and that of high amplitude occurring during day will be referred to as the strong tide. The forest is largely dominated by the species *Rhizophora apiculata* and our study creek is bordered by a 30 m wide fringe hosting seaward species such as *Avicennia alba* and *Sonneratia alba*.

2.2. Data collection

We collected SPM during a 26 h asymmetric tidal cycle. Four samples of surface water were taken at 2 min interval every 2 h (14 samplings; 56 samples) using a 10 L bucket. They were immediately vacuum-filtered through pre-combusted and pre-weighted glass fibre filters (Whatman® GF/F 0.7 μm) until clogging (requiring 250 mL to 1.2 L of water). They were freeze-dried and weighted for SPM determination. Then, one filter of SPM per sample was used for the analysis of fatty acids and two filters per sampling event were used for $\delta^{13}C$ and particulate organic carbon (POC) determination. Dissolved oxygen (DO) was measured continuously using a Hobo® data logger (HOBO U26-001) immersed 30 cm below water surface. Water depth was measured with a Plastimo® Echotest II depth sounder directed towards the creek bottom.

2.3. Sample processing

We extracted lipids following a slightly modified protocol of Bligh and Dyer (1959), as described in Meziane et al. (2007). Briefly, we quantified fatty acid methyl esters (FAME) using a GC-FID (Varian 3800-GC). Tricosanoic acid (23:0) was used as an internal standard. FA identification was performed using a GC-MS (Varian 450-GC; Varian 220-MS), and comparison of GC retention times with commercial standards (Supelco® 37 component FAME mix and marine source polyunsaturated FAME n°1 mix).

Isotopic analyses and POC determination were performed after filters fumigation for 16 h using HCl 37% to remove all carbonates. Analyses were done at the GEOTOP research centre, Université du Québec (Montréal, Canada). Unexpected $\delta^{13}C$ values were obtained, and thus another set of samples were analysed at the University of California Davis Stable Isotope Facility (Department of Plant Sciences, UC Davis, Davis, California). Results were similar to the first

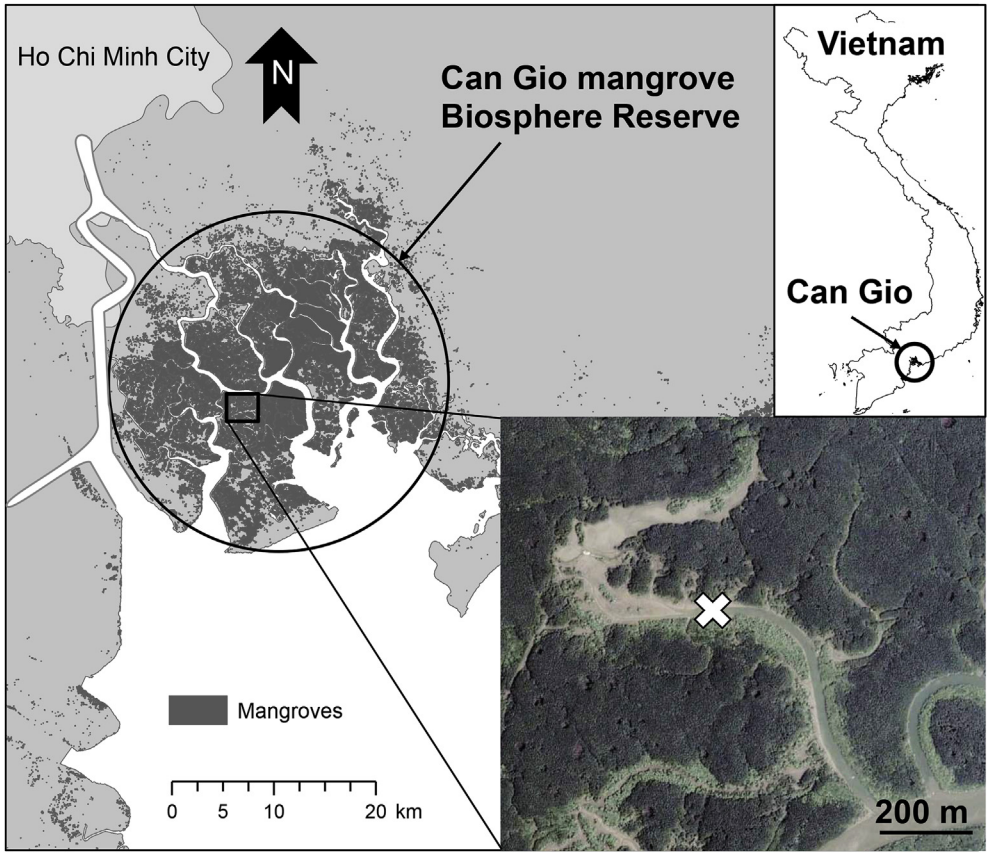

Fig. 1. Map of the sampling site in Can Gio Mangrove Biosphere Reserve (Southern Vietnam). The white × on the aerial picture marks the spot where samples were taken.