Distribution and sources of organic carbon in a mangrove-seagrass ecosystem (Gazi Bay, Kenya)

Introduction

- Given the importance of the tropics in the global marine export of organic and inorganic carbon, the lack of data on the magnitude of carbon fluxes and transformations in river systems along the entire east African coastline represents one of the many gaps in our knowledge on carbon dynamics in the tropical coastal zone.
- The role of intertidal wetlands on carbon dynamics in estuaries is now widely recognized, since these highly productive ecosystems can induce major changes in the metabolic state of estuaries and the adjacent continental shelf (e.g. Cal et al. 1999 for salt marshes, Bouillon et al. 2003 for mangroves).
- Here, we report on the concentrations and stable isotope composition of different organic carbon pools in Gazi Bay (Kenya), a shallow tropical embayment with extensive mangrove forests bordering dense seagrass (Thalassodendron ciliatum) beds. A distinct spatial gradient in the relative contribution of seagrass- and mangrove-derived carbon was observed, and although a bidirectional exchange of material was clear, the data overall indicate that export of mangrove carbon is limited to an area close to the forest boundary and are unlikely to exert a major influence on nearshore waters.

Sampling area and Methods

- The carbon content and stable isotope composition of different organic carbon pools were studied in Gazi Bay (Kenya) 4.4°S 39.5°E, in July 2003. Gazi Bay is a shallow tropical coastal ecosystem, with extensive mangrove forests intersected by 2 main tidal creeks (Kidogoweni and Kinondo, see Map) and a shallow bay largely covered by dense Thalassodendron ciliatum seagrass beds.
- Samples for suspended matter (POC, PN, and δ^{13}CPOC), were collected from pre-combusted 25 mm Whatman GF/F filters, dried, and measured with standard techniques (EA and EA-IRMS).
- δ^{13}C-DIC and δ^{18}O-DIC were measured by headspace injection in an EA-IRMS setup.

Results & Discussion

- The distribution of particulate organic carbon along the salinity gradient of the tidal creeks indicated significant local inputs of organic carbon, with a δ^{13}C signature (~ -27 ‰) consistent with that of the dominant vegetation, i.e. mangroves (Figure 1 and 2).
- Low water column Chi a values and high POCl/Chi a ratios (Figure 3) are indicative of the predominance of macrophyte material or highly degraded organic material in the water column.
- At the boundary of the mangrove-seagrass interface, however, coinciding with a salinity of ~30, the carbon isotope composition of POC changes drastically, from about -27 ‰ to values as high as -14 ‰, indicating a geographically sharp change in the relative contribution of seagrass and mangrove-derived organic carbon (Figure 2). Note: seagrasses in the area have a spatially variable δ^{13}C signature, ranging between ~-19 ‰ and -11 ‰.
- δ^{15}N signatures of particulate N (Figure 4) show a distinct increase in the seagrass beds and in particular, in the eastern mangrove creek (Kinondo). Nutrient data will need to identify the mechanisms for these contrasting signatures.
- The sedimentary record, however, does indicate that mangrove carbon is exported from the system boundaries and trapped in the seagrass beds adjacent to the mangrove forest — δ^{13}C values of sediment organic C are significantly more depleted than those of local seagrass material. This exported mangrove C has also been shown to contribute significantly to benthic mineralization (Figure 5, 6). On the other hand, seagrass material is similarly imported into the mangrove areas, but the contribution of seagrass material in mangrove sediments appears to be limited, overall.
- The high spatial variability in the sources of the aquatic organic carbon pools is also mirrored in the distribution of δ^{15}NPOC (data not shown), δ^{13}CPOC, and δ^{18}OPOC (data not shown). The δ^{18}OPOC signature of dissolved O_2 (Figure 7), which indicate a distinct gradient from a highly heterotrophic system (mangrove creeks: marked undersaturation of O_2 concentrations with elevated δ^{18}OPOC due to microbial oxygen consumption which leaves the residual O_2 pool enriched in δ^{18}O) to a net autotrophic region (seagrass beds: high O_2 oversaturation, low δ^{18}OPOC due to the input of photosynthetically light O_2). Similarly, the δ^{15}NPOC profile (Figure 8) shows internal production of isotopically light DIC in the mangrove creeks, consistent with inputs from mineralization. Overall, the data indicate that export of mangrove-derived organic carbon is limited to a geographically limited area close to the forest boundary, and unlikely to reach the coastal shelf area, i.e. unlike the South Atlantic Bight saltmarsh-dominated system (Cai et al. 2003).

Acknowledgements

Financial support was granted by the FWO-Vlaanderen (contract G.0118.02) with which SB is a postdoctoral fellow, and by the FNRS (contracts 2.4596.01 and 1.5.066.03). J. Bosire and J. Kairo (KMFRI) are acknowledged for their assistance in the fieldwork. The contribution of macrophyte-derived organic matter to the metabolic state of estuaries and the adjacent continental shelf is limited to an area close to the forest boundary and are unlikely to exert a major influence on nearshore waters.