Nutrient cycling and CO_2 fluxes linked to algal wrack strandings in beaches of Deception Island, Antarctica

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Abstract

Nutrients flow between ecosystems are of relevance due to their involvement in the primary production, trophic structure and biodiversity. This study analyses the role of algal wrack and intertidal sediments in the processing of organic matter and nutrients cycling in Foster Bay, Deception Island, in the South Shetland Archipelago, North of the Antarctic Peninsula.

Eleven beaches with different physical characteristics and receiving different macroalgal wrack supply were sampled during the austral summers of 2016 and 2017. On each beach, 6 transects perpendicular to the shore were chosen at random along a 100 m stretch, with a minimum separation of 5 m. The macroalgal coverage across beach profile and biomass, the nutrients concentration in the interstitial pore water (IPW) and the CO_2 fluxes, were measured in each transect. Nutrient samples were collected by making pits 20 cm deep in the sediment in the upper swash zone at low tide. Samples were collected using 150 ml Polypropilen bottles. The samples were analysed in the "Elemental Analysis Unit" of the University of Vigo, and the concentrations of NO_3-, NO_2-, NH_4+ and PO_4^{-3} were quantified. The CO_2 measurements were made both in patches of stranded algae and in bare sediment. The flow of CO_2 was measured with a "portable diffuse flux meter with LI-COR CO_2 detector".

The macroalgal coverage and biomass values were similar to those found in temperate ecosystems (7% and 164 g dry weight m^{-1}, respectively). CO_2 emissions in the sediment ranged within normal values in the upper tide level and exceptionally high in some points of the low tide level, caused by the volcanic activity of the island.

The mean concentration of dissolved nitrogen and inorganic phosphate in the interstitial water increased significantly on beaches with the highest macroalgal subsidy. The amount of algal wrack were significantly correlated ($p<0.01$) with nitrates and ammonium, as well as with total dissolved inorganic nitrogen (DIN). High correlations ($R^2 = 0.4$, $p<0.01$) were also found between the CO_2 fluxes in the macroalgal patches and the DIN output toward the sedimentary environment. The CO_2 fluxes showed a clear and significant allometric relationship with the macroalgal biomass ($R^2 = 0.78$, $p <0.001$). The correlations found were similar to those obtained in temperate latitudes; the results point out to a coupling between the stranded algal biomass and the concentration of inorganic nutrients in the interstitial pore water for the ice-free Antarctic shores.

Likewise, these results provide evidence of the active role of the beaches in the processing of organic matter and in the nutrient cycling of the algal subsidies, which highlights the connectivity between beaches and their neighbouring ecosystems in the Antarctic shores.