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Microbial degradation rates of small peptides and amino acids in the oxygen minimum zone of Chilean coastal waters

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ABSTRACT

We found similar microbial degradation rates of labile dissolved organic matter in oxic and suboxic waters off northern Chile. Rates of peptide hydrolysis and amino acid uptake in unconcentrated water samples were not low in the water column where oxygen concentration was depleted. Hydrolysis rates ranged from 65 to 160 nmol peptide $L^{-1}\,h^{-1}$ in the top 20 m, 8–28 nmol peptide $L^{-1}\,h^{-1}$ between 100 and 300 m (O_2-depleted zone), and 14–19 nmol peptide $L^{-1}\,h^{-1}$ between 600 and 800 m. Dissolved free amino acid uptake rates were 9–26, 3–17, and 6 nmol $L^{-1}\,h^{-1}$ at similar depth intervals. Since these findings are consistent with a model of comparable potential activity of microbes in degrading labile substrates of planktonic origin, we suggest, as do other authors, that differences in decomposition rates with high and low oxygen concentrations may be a matter of substrate lability. The comparison between hydrolysis and uptake rates indicates that microbial peptide hydrolysis occurs at similar or faster rates than amino acid uptake in the water column, and that the hydrolysis of peptides is not a rate-limiting step for the complete remineralization of labile macromolecules. Low O_2 waters process about 10 tons of peptide carbon per h, double the amount processed in surface-oxygenated water. In the oxygen minimum zone, we suggest that the C balance may be affected by the low lability of the dissolved organic matter when this is upwelled to the surface. An important fraction of dissolved organic matter is processed in the oxygen minimum layer, a prominent feature of the coastal ocean in the highly productive Humboldt Current System.

1. Introduction

There is still considerable controversy as to the exact role of oxygen in and its effect on the overall degradation of organic matter (e.g., Henrichs and Reeburgh, 1987; Westrich and Berner, 1984; Canfield, 1989). The anaerobic degradation of organic matter is generally assumed to be slower than microbial aerobic degradation, mostly because organic matter is abundant in continental margin deposits underlying anoxic waters and the energy yield by anaerobic processes is lower than during oxygen reduction. Several researchers have examined microbial degradation using laboratory incubations under oxic and anoxic sediments (Westrich and Berner, 1984; Arnosti et al., 1994; Kristensen et al., 1995) and seawater (e.g., Otsuki and Hanya, 1972a, b; Lee, 1992; Nguyen and Harvey, 1997). Results from these experiments indicate that substrate lability is an important factor in determining degradation rates.

Dissolved organic matter (DOM), one of the largest active reservoirs of carbon in the ocean, is composed of molecules of varying lability against microbial degradation (Benner, 2002). Most DOM is smaller than 1000 D, but only about 1% is monomers known to be rapidly utilized by microbes in the ocean (Benner, 2002). According to our current model of organic matter degradation, particulate material transforms into dissolved material by extracellular enzymatic attacks that produce low molecular weight compounds, which are taken up across the cell membrane and subsequently respired or used for cellular biomass production (Hoppe et al., 1988; Arnosti et al., 1994; Azam, 1998). The production of small molecules amenable to incorporation (e.g., amino acids, sugars) is due to the hydrolysis of larger

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