Estuarine, Coastal and Shelf Science xxx (2012) 1–12

Contents lists available at SciVerse ScienceDirect

Estuarine, Coastal and Shelf Science

journal homepage: www.elsevier.com/locate/ecss

Microbial degradation at a shallow coastal site: Long-term spectra and rates of exoenzymatic activities in the NE Adriatic Sea

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ARTICLE INFO

Article history:
Received 30 June 2011
Accepted 5 February 2012
Available online xxx

Keywords:
glucosidase
galactosidase
lipase
phosphatase
protease
Adriatic Sea

ABSTRACT

The degradation of organic matter along the water column is mediated by enzymes released into the environment by planktonic organisms. Variations in enzymes profiles (types and levels of activity) reflect the trophic status of the environment and could be caused by shifts in the dominant species or in the level of enzyme expression by the same species in response to changes in the spectrum of organic substrates. To explore this issue, we examined the maximum rates of hydrolysis of 6 different enzymes (protease, α-glucosidase, β-glucosidase, β-galactosidase, alkaline phosphatase and lipase) along the water column (4 depths) at a coastal station in the Gulf of Trieste (northern Adriatic Sea), from 2000 to 2005. Most of the studied enzymes exhibited a pronounced seasonal variability with winter minima and maxima from April to October. During summer, alkaline phosphatase, lipase and protease reached the highest activities, while polysaccharide degradation prevailed in spring and autumn, associated to phytoplankton blooms. Phosphatase/protease activities ratio was generally low, indicating that microbial communities were rarely P-limited, possibly because of the use of organic P sources. A pronounced interannual variability of degradation patterns was found, with maximum rates of protease being the highest in most of the samples, followed by the alkaline phosphatase's ones. Water column features greatly affected hydrolysis rates, being degradation of linear polysaccharides, lipids, phosphorilated compounds and polypeptides significantly different at different depths during stratified condition. Mixing processes affected especially α-glucosidase activity, possibly as a consequence of resuspension of organic matter from the seabed. Large-impact phenomena such as the 2003 heat wave and mucilage influenced the degradation of specific substrates. Mucilage enhanced lipase, phosphatase and protease, whereas a pronounced inhibition characterised phosphatase and protease during summer 2003.

1. Introduction

Since 1988, the northern Adriatic sea episodically experiences massive flocculation of organic matter to form gels and aggregations of impressive dimensions and abundances. These "mucilage events" cause economic impact on coastal community also in the Gulf of Trieste due to reduced tourism and fishery. For these reasons a series of research projects has been supported by national and international authorities and foundations to understand the causes of mucilage formation and its influence on the ecosystem (Giani et al., 2005). There was a converged opinion that mucilage formation was the result of synergistic effects of biological and physico-chemical factors starting from the aggregation of dissolved and colloidal organic pool into larger flocs (Azam et al., 1999).

In the marine environment, the majority of the dissolved organic matter is in a polymerized form and thus cannot be assimilated directly by the prokaryotic cells, the most important players in the utilization and recycling of organic matter in aquatic environments. Since only small molecules (<600 Da), such as amino acids and monosaccharides, pass through the membrane due to the activity of permeases, prokaryotes induce exoenzymes that hydrolyse polymers and oligomers into monomers playing a key function in the transformation of organic matter (Chróst, 1992) being a limiting stage in the use of organic substrate in water.

Two commonly associated designations of non cytoplasmic enzymes are ecto- and extracellular enzymes, where ectoenzymes are attached to the outer cell wall of microrganisms or occur inside the periplasmic space of gram-negative bacteria and extracellular enzymes are freely dissolved in the water or associated with particles of non-parent origin (Martinez and Azam, 1993). Here, non cytoplasmatic enzymes are inclusively referred to as exoenzymes.

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doi:10.1016/j.ecss.2012.02.002