Microbial community dynamics in the Arctic Kongsfjorden: changes in abundances, activity and composition

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Abstract

Recent climate changes in Arctic regions have caused retreat of glaciers, increases in meltwater outflow and massive inputs of suspended sediment load to the coastal marine environment (Malone et al., 2016). Moreover, climate warming in the Arctic can potentially affect large-scale microbial processes including population dynamics and trophic level interactions. Viral, prokaryotic and phytoplanktonic communities play a key role in relevant processes such as carbon fluxes and nutrient regeneration and can be viewed both as sentinels and amplifiers of global change. Monitoring of environmental changes, especially those related to ice melting, requires the availability of advanced technologies, able to promptly record phenomena occurring at different spatial and time scales. Moreover, the development of new sampling technology in extreme environments can be used in areas not reachable by vessels or subject to oil spill.

In the context of ARCA project the main aims of our research unit were: i) to assess the variability of planktonic abundance and activities over short time scales in a site of the study area; ii) to design and built an automatic sampler for extreme polar environments; iii) to search for cold-adapted OIL/PAH(Polycyclic aromatic hydrocarbons)-degrading bacteria in the Arctic region.

To achieve the first objective, in June 2015 a study was performed at a coastal station (MDI) of the Kongsfjorden (Svalbard Islands) influenced by the freshwater runoff from land and glaciers (Fig. 1). The survey repeated a previous experiment carried out in September 2013 (Azzaro et al., 2014; Azzaro et al., 2015; Azzaro et al., 2016; Caroppo et al., 2016) at the same site, with the novelty of focusing on the sea surface microlayer and the bottom boundary layer. During this study, lasting 10 days, changes both in abiotic and biotic parameters were detected. In particular, the variability over short time scales of planktonic abundances (virio-, bacterio- and microphytoplankton) and microbial activities, was assessed in relation to environmental variables. The following results were obtained: lower biotic and abiotic variability in June 2015 compared to September 2013; prevalence of viruses over bacteria; a greater abundance of autotrophic than heterotrophic components and increased presence of temperate-warm species -including harmful and toxic species- compared to the previous survey; higher microbial activity levels in June 2015 than in September 2013, resulting in an increased efficiency of the Biological pump.

The second aim was addressed to the development of new technological devices for the study of extreme polar environments. In particular, a first prototype of an automatic multisampler was tested in the Kongsfjorden (Zappalà et al., 2016a,b). It constitutes a practical low-cost system to obtain data with good spatio-temporal resolution both for the initial characterization and for the study of possible natural or anthropogenic disturbance in water quality. The developed multisampler has been successfully applied along a transect from offshore sea to the Kronebreen glacier (Fig. 2). Data obtained through this device allowed to study the heterotrophic bacterial distribution and functional metabolism in the Svalbard Islands. High enzymatic activity and

abundance of culturable heterotrophic bacteria were observed close to the Kronebreen glacier. The extracellular enzymatic profiles of the bacterial isolates showed that lipids, proteins and organic phosphates play a major role in bacterial metabolism in this area of the Arctic Ocean. Thanks to its feasibility, the proposed technology can be applied to monitor the response of polar ocean ecosystems to the effects of climate changes.

The third aim focused on the isolation and characterization of marine hydrocarbons-degrading bacteria from a cold region (Crisafi et al., 2016). Seawater samples were collected in the Ny-Ålesund Harbor and in the proximity of Kronebreen glacier (Kongsfjorden, Svalbard), and immediately enriched with nutrients and hydrocarbons a sole source of carbon. Samples were maintained at 4 °C for 90 days. Most Probable Number analyses showed a high number of hydrocarbons degraders from the samples collected in the harbor, while were not able to detect hydrocarbon degraders in samples collected in the sea-ice region. The isolation was carried out at 4 and 15 °C, and a list of 38 strains was obtained in pure culture using both oil and polycyclic aromatic hydrocarbons as substrates. The selection inferred by the two different substrates was evident, as oil favorites the growth of strains belonging to the γ-Proteobacteria: Pseudoalteromonas, Marinobacter, Oleispira, and Alcanivorax genera while naphthalene and phenanthrene selected mostly α-Proteobacteria: Sphingopyxis, Rhodobacter, and Hyphomonas genera. The isolated have been further selected for the formulation of a microbial consortium to test their potential to degrade both oil and polycyclic aromatic hydrocarbons at low temperature (Fig. 3). Results demonstrated that the consortium was very active at 15 °C at which the almost 90 % of Total Petroleum hydrocarbons (TPH) were degraded; at 4 °C almost 80 % of degradation was detected. Moreover, parallel single culture of each strain was not as efficient as in consortium.

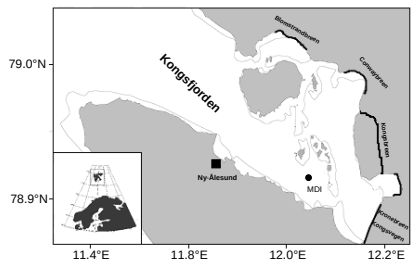

Figure 1: *Location of the MDI station. Thick lines indicates the fronts of the glaciers.*

Figure 2: *The multisampler (right) towed by an Unmanned Semi-Submersible Vehicle (USSV; left).*

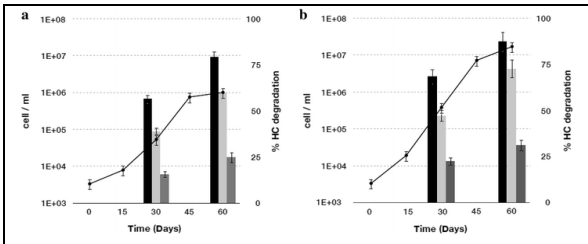

Figure 3: *Degradation rates of oil (black histograms), naphthalene (dark gray histograms) and phenanthrene (light gray histograms) of microbial consortium maintained at 4 °C (a) and at 15 °C (b) and relative cells growth measured by DAPI.*

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