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Biofilm formation behaviour of marine filamentous cyanobacterial strains in controlled hydrodynamic conditions

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Summary

Marine biofouling has severe economic impacts and cyanobacteria play a significant role as early surface colonizers. Despite this fact, cyanobacterial biofilm formation studies in controlled hydrodynamic conditions are scarce. In this work, computational fluid dynamics was used to determine the shear rate field on coupons that were placed inside the wells of agitated 12-well microtiter plates. Biofilm formation by three different cyanobacterial strains was assessed at two different shear rates (4 and 40 s^{-1}) which can be found in natural ecosystems and using different surfaces (glass and perspex). Biofilm formation was higher under low shear conditions, and differences obtained between surfaces were not always statistically significant. The hydrodynamic effect was more noticeable during the biofilm maturation phase rather than during initial cell adhesion and optical coherence tomography showed that different shear rates can affect biofilm architecture. This study is particularly relevant given the cosmopolitan distribution of these cyanobacterial strains and the biofouling potential of these organisms.

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Introduction

Biofouling is an ongoing concern in aquatic environments and marine applications, leading to material deterioration, surface corrosion, decrease of hydrodynamic performance and significant economic losses (Salta *et al*., 2013). Moreover, biofilms are recognized as a permanent or temporary refuge for bacterial pathogens in aquaculture facilities (King *et al*., 2006). Additional problems related to biofouling on marine environments are present in marine underwater support structures, sensors and housings, which are used for on-site monitoring with weekly, monthly or continuous measuring. On these devices, the most obvious problems are related to optical and electrochemical sensors, because even a thin biofilm on the optics can give rise to incorrect measurements (Delauney *et al*., 2010). Although marine biofouling is a dynamic process encompassing different agents and their interactions, it has been considered that biofilm formation by bacteria and algae is a primordial step that occurs prior to the adhesion of macrofouler organisms such as invertebrate larvae, mussels, seaweeds and barnacles (Mieszkin *et al*., 2013). Cyanobacteria are a widespread group of photosynthetic prokaryotes which, together with diatoms, constitute the major components of marine biofilms (Salta *et al*., 2013; Bharti *et al*., 2017; Di Pippo and Congestri, 2017). Moreover, cyanobacteria produce large amounts of extracellular polymeric substances (EPS), which increase biofilm cohesion (Rossi and De Philippis, 2015). This is particularly important because it has been shown that the main challenge in marine biofouling control is associated with microorganisms which are also responsible for the initiation of biofilm formation and those which are also able to excrete large amounts of EPS (Mieszkin *et al*., 2013; Salta *et al*., 2013; Telegdi *et al*., 2016). Thus, a promising approach to delay macrofouling is to prevent the adhesion and biofilm formation by cyanobacteria.