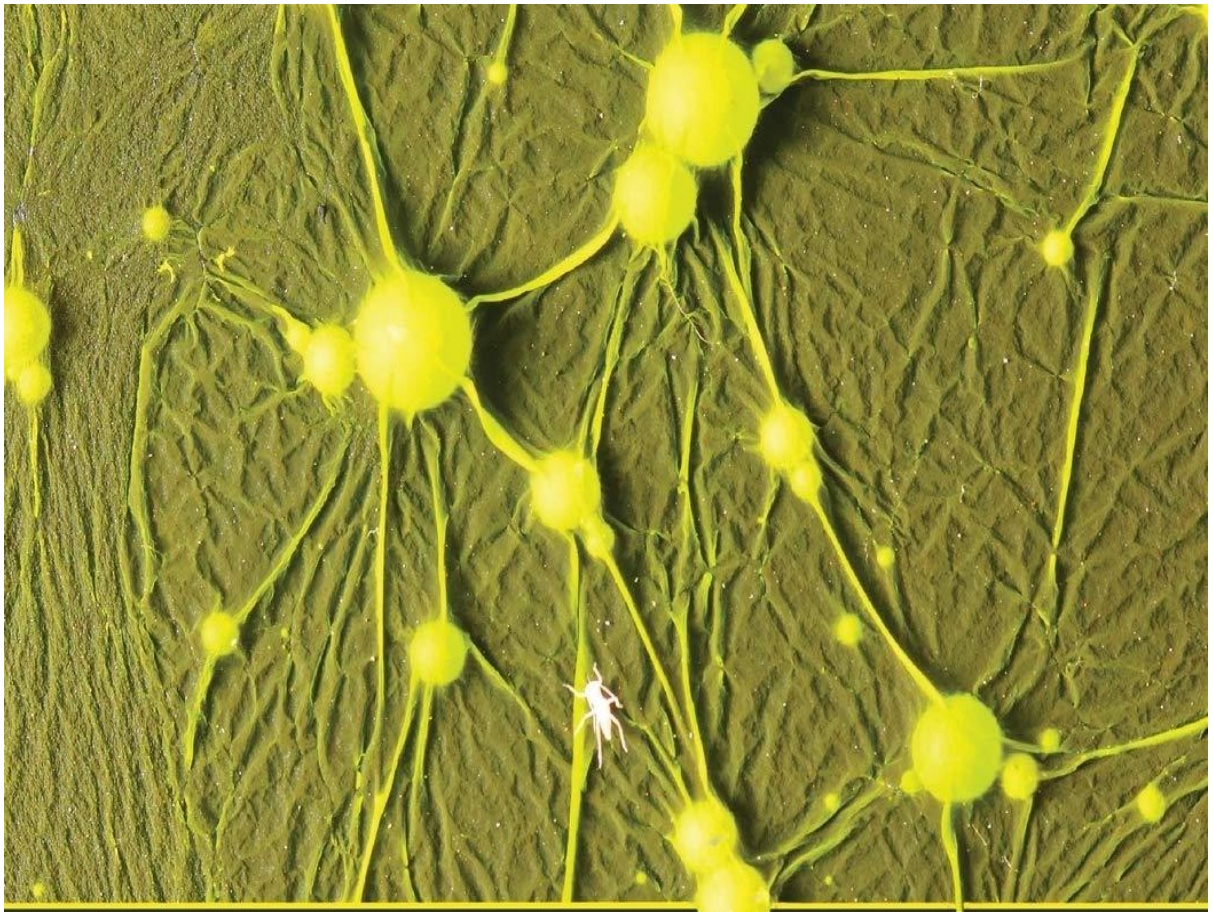

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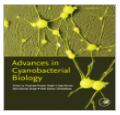

Chapter 3 - Cyanobacteria in tropical and subtropical marine environments: bloom formation and ecological role

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Abstract

Cyanobacteria have played a significant role in the evolution of life on Earth by creating an oxygenic atmosphere through photosynthesis. They have unique adaptive strategies to survive in extreme environments. They are ubiquitous in marine and freshwater ecosystems and are especially abundant in oligotrophic waters of the tropical and subtropical marine environment, where nitrogen fixation or dissolved organic carbon released by these organisms benefit host organisms in symbiotic relationships. Among the cyanobacteria, picophytoplankton is the smallest group of organisms; it comprises mainly of Prochlorococcus and Synechococcus. Advanced instrumentation techniques such as epifluorescence microscopy and flow

in the marine environment in terms of abundance and primary production. *Prochlorococcus* is the smallest known phytoplankton observed only in oligotrophic waters. *Synechococcus* proliferates in well-lit, eutrophic coastal ecosystems and is present in comparatively lower numbers in oligotrophic open ocean waters. These groups are capable of indicating certain environmental conditions such as stratification and eutrophication. Other than these, Trichodesmium is another predominant and major bloom-forming cyanobacterium in Indian coastal waters. With the use of techniques such as flow cytometry, high performance liquid chromatography (HPLC), and remote sensing, studying cyanobacterial ecology has been made less laborious and more accurate. Since these cyanobacteria are known to occur in high numbers and contribute significantly to the total phytoplankton biomass, food web structure, primary production in oceanic and coastal regions of India, it is worthwhile to understand their ecology.

Chapter 3

Cyanobacteria in tropical and subtropical marine environments: bloom formation and ecological role

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3.1 Introduction

Cyanobacteria are Gram-negative photosynthetic organisms referred to as the "blue-green algae." It is well known that cyanobacteria played a pivotal role in the Earth's life forms by creating an oxygenic atmosphere through their photosynthesis (Bendall et al., 2008). Probably, these photosynthetic microorganisms were the chief primary producers of organic matter at that time and, therefore, were crucial for the evolution of multicellular life forms. Cyanobacteria occupy almost any well-lit habitat, ranging from aquatic to terrestrial environments. Though they are ancient organisms, they have special adaptive strategies to survive in some extreme environments such as hot springs, hypersaline waters, deserts, and polar regions (Abed et al., 2009). They continue to play an important role in the composition of the atmosphere and account for approximately 20%−30% of the total photosynthesis (Sharma et al., 2011). In marine environments the nitrogen fixation or dissolved organic carbon released by these organisms benefit the host organism in the symbiotic relationships, especially important in oligotrophic waters (Carpenter and Foster, 2002).

Cyanobacteria consist of 150 genera, containing approximately 2000 species (Hoek et al., 1995). Among these, *Prochlorococcus* and *Synechococcus* are the smallest known cyanobacteria in the aquatic environments, which are referred to as picophytoplankton (<3 μm in size). These smallest organisms form a major component of phytoplankton in both marine and freshwater including nutrient-rich to poor ecosystems (Shiomoto et al., 1997), contributing significantly to primary productivity and total phytoplankton biomass (Paerl, 1977; Azam et al., 1983). Among these, *Synechococcus* was the first group to be studied in detail (Waterbury et al., 1979). They are rod- to coccoid-shaped organisms with size ranging from 0.8 to 1.5 μm and divided by binary fission into equal halves in one plane (Holt et al., 1994). They are the dominant phycobilisome-containing cyanobacteria found in all types of aquatic ecosystems from freshwater to marine, generally being more abundant in nutrient-rich than oligotrophic regions. Based on phycobilisome composition, *Synechococcus* is classified into two groups: one containing phycoerythrin and the other phycocyanin (Murrell and Lores, 2004). The former group is present in all kinds of aquatic systems, whereas the latter is present only in freshwater and estuarine environments.

Prochlorococcus discovery was a breakthrough in biological oceanography research (Chisholm et al., 1988). They represent the tiny little plant in the marine ecosystem. Members of this genus are small (0.6−0.8 μm) in diameter and are capable of thriving in oligotrophic regions. They are coccoid shaped, nonmotile, and free-living cells, which are the most abundant photosynthetic organism on the planet (Partensky et al., 1999; Flombaum et al., 2013). *Prochlorococcus* can account for 21%−43% of the photosynthetic biomass in oligotrophic oceans and 13%−48% of the net primary production (Campbell et al., 1994; Partensky et al., 1999; Johnson et al., 2006; Buitenhuis et al., 2012; Flombaum et al., 2013).

Apart from *Prochlorococcus* and *Synechococcus*, it is a well-known fact that *Trichodesmium* often represents a large fraction of nitrogen-fixing cyanobacterium in tropical, oligotrophic waters and contributes a substantial component to

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