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Review

Phytoplankton communities of polar regions—Diversity depending on environmental conditions and chemical anthropopressure

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ABSTRACT

The polar regions (Arctic and Antarctic) constitute up to 14% of the biosphere and offer some of the coldest and most arid Earth's environments. Nevertheless several oxygenic phototrophs including some higher plants, mosses, lichens, various algal groups and cyanobacteria, survive that harsh climate and create the base of the trophic relationships in fragile ecosystems of polar environments. Ecosystems in polar regions are characterized by low primary productivity and slow growth rates, therefore they are more vulnerable to disturbance, than those in temperate regions. From this reason, chemical contaminants influencing the growth of photoautotrophic producers might induce serious disorders in the integrity of polar ecosystems. However, for a long time these areas were believed to be free of chemical contamination, and relatively protected from widespread anthropogenic pressure, due their remoteness and extreme climate conditions. Nowadays, there is a growing amount of data that prove that xenobiotics are transported thousands of kilometers by the air and ocean currents and then they are deposed in colder regions and accumulate in many environments, including the habitats of marine and freshwater cyanobacteria. Cyanobacteria (blue green algae), as a natural part of phytoplankton assemblages, are globally distributed, but in high polar ecosystems they represent the dominant primary producers. These microorganisms are continuously exposed to various concentration levels of the compounds that are present in their habitats and act as nourishment or the factors influencing the growth and development of cyanobacteria in other way. The most common group of contaminants in Arctic and Antarctic are persistent organic pollutants (POPs), characterized by durability and resistance to degradation. It is important to determine their concentrations in all phytoplankton species cells and in their environment to get to know the possibility of contaminants to transfer to higher trophic levels, considering however that some strains of microalgae are capable of metabolizing xenobiotics, make them less toxic or even remove them from the environment.

Contents

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1. Introduction

Phytoplankton is a taxonomically diverse group of photosynthetic aquatic microorganisms, mostly single-celled, that sometimes join together into colonies, drifting with the currents (Fig. 1). Phytoplankton plays a crucial role in primary production, nutrient cycling, and food webs and makes up a significant proportion of the primary production in aquatic ecosystems (Dawes, 1998). This group of organisms consists of approximately 20,000 species distributed among at least eight taxonomic divisions. In contrast, higher plants are comprised of more than 250,000 species, almost all of which are contained with one class in division.

Phytoplankton communities are phylogenetically diverse, which is reflected in their ecological function. Within this diverse group of organisms, there are some basic evolved species (Delwiche, 2000), for instance—all strains of prokaryotic oxygenic phytoplankton that belong to one class of bacteria, named cyanobacteria (Falkowski et al., 2003). Cyanobacteria (blue green algae) are one of the largest, extremely diverse morphologically and metabolically, and phylogenic unique group of Gram-negative, photosynthetic prokaryotes. For the sake of that, they show a wide range of tolerance to multiple environmental factors, they can be found in almost all ecological niches. These organisms were initially described as algae in the eighteenth century and the first classification system was based on the International Code of Botanical Nomenclature. In the botanical taxonomy, two major works may be noted: the first one described by Geitler in 1932 including 150 genera and 1500 species of cyanobacteria and the second one described by Anagnostidis and Komárek (e.g. Komárek and Anagnostidis, 2005) aimed at defining more genera, both based on the morphology. After the prokaryotic nature of cyanobacteria became more obvious on the basis of ultrastructural and molecular studies, it was proposed that their nomenclature should be governed by the International Code for Nomenclature of Bacteria (Stanier et al., 1978).

Cyanobacteria differ from other types of bacteria in that they have chlorophyll *a* and free oxygen is given off during the process of blue green algae photosynthesis. Many bacteria split H_2S instead of H_2O as a source of electrons during their photosynthesis—this is why they do not produce free O_2. Those other bacteria contain bacteriochlorophyll instead of chlorophyll *a* as their main photosynthetic pigment (Bold and Wynne, 1985). Cyanobacteria are prokaryotic microorganisms, which have only a haploid life cycle (while all algae life cycles have an alteration of generations), they reproduce through simple fission, since their DNA is not associated with histone proteins (Clark et al., 1998).

Cyanobacteria are commonly thought to be microbial phototrophs that are characteristic of warm water environments such as hot springs, stratified lakes during summer or tropical oceans (Steunou et al., 2006; Vazquez et al., 2005; Johnson et al., 2006). It is less known that cyanobacteria exist also in low-temperature habitats including permafrost, cryconites, rock surfaces, glacier pools, rivers and coastal areas, and offshore waters represent probably the largest untouched biological resource on our planet (Zakhia et al., 2008; Lyon and Mock, 2014). Microorganisms inhabiting cryoenvironments have to face the challenges of subzero temperatures, low water activity, and, often, high solute concentrations to sustain their viability (Lay et al., 2013). There are some unique characteristics of blue green algae that are responsible for this wide variety of habitats for example: the climate-resistant spores that

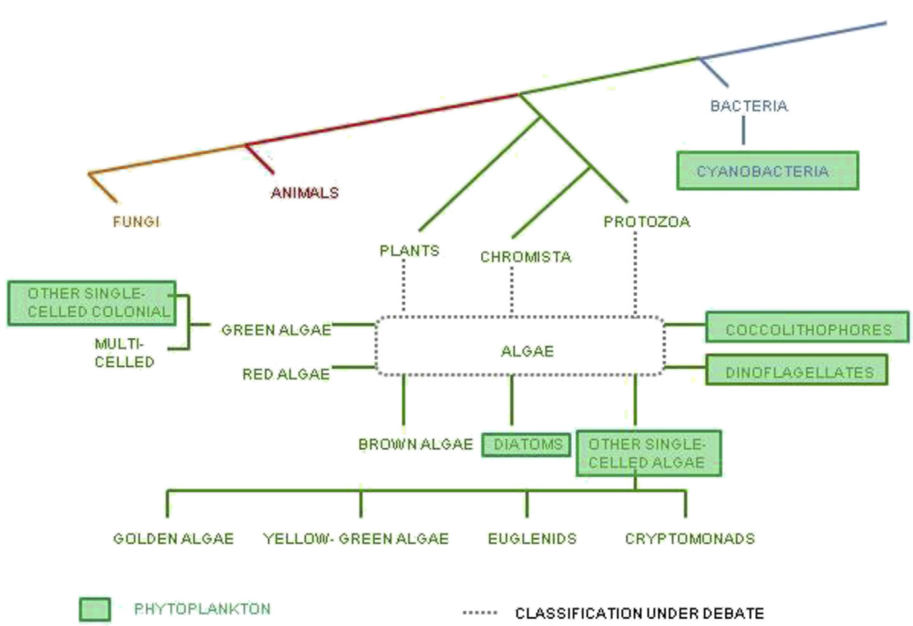

Fig. 1. Simplified taxonomic classification of phytoplankton.