Biological soil crusts along a climatic gradient in Chile: Richness and imprints of phototrophic microorganisms in phosphorus biogeochemical cycling

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Abstract

Biodiversity of phototrophic microorganisms in South American biological soil crusts (BSCs) and their role in the biogeochemical phosphorus (P)-cycle are unknown. Richness of BSC green algae and cyanobacteria was investigated at four climatically different Chilean sites (arid, semi-arid, Mediterranean, humid). Carbon (C), nitrogen (N), sulfur (S), and P contents, P pools and P speciation as well as spatial P species distribution within the BSCs were investigated. Morphological identification of enrichment cultures revealed 24 green algal and 18 cyanobacterial taxa in total. Irrespective of climatic conditions, each BSC comprised 12 to 15 different phototrophic species. Thereby, green algal richness increased, while cyanobacterial richness decreased with increasing humidity/decreasing mean annual temperature (North to South). Total C, N, and S contents ranged between 6.7 and 41.1 g C kg^{-1}, 0.6–2.8 g N kg^{-1} and 0.2–0.7 g S kg^{-1}, respectively, and increased in the order crust-free soil < crust-adhering soil < BSC. The total P content in BSCs ranged from 310 to 777 mg kg^{-1} with lowest concentrations at the arid site and highest concentrations at the semi-arid site. Labile P was highest in BSCs from semi-arid and Mediterranean climate implying no P-shortage for BSC organisms at these sites. In BSCs of all sites, stable and non-extractable P was identified as the major P pool (sequential P fractionation) with Ca-P species dominating at all sites except for the humid site at which Al-P was the main P species as determined by P K-edge X-ray absorption near edge structure, XANES. P K-edge μ-XANES of BSC cross sections revealed apatite hotspots, a potential P source for BSC organisms except for the arid site, where other Ca-P species dominated. Further, elemental mapping of the arid BSC cross section showed distinct accumulation of S and chloride (Cl) containing compounds within green algae and on their outer surface, respectively, raising the question of function/origin of these compounds. In conclusion, this work expands our knowledge on the richness of phototrophic organisms in South American BSCs and characterizes their possible position in the P-cycle along a strong climatic gradient. Our findings suggest that biotic and abiotic factors shape the structure of BSCs phototrophic communities as well as P pools and species at each habitat.

Keywords

Cyanobacteria, Green algae, Richness, Phosphorus, XANES.