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Can Polyphosphate Metabolism be Responsible for the Co-appearance of Cyanobacteria and Heterotrophic Bacteria?

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Microbial Polyphosphate (poly-P) plays a vital role in phosphorus (P) storage, recycling, and bioavailability in aquatic systems, yet it is overlooked in investigations of microbial and phytoplankton communities and in the global P budget. In aquatic environments, autotrophs and heterotrophs coexist and form consortia [1-2] that may regulate poly-P turnover and recycling through metabolic coupling [3]. In cyanobacteria-bacteria consortia, bacteria depend on cyanobacterial organic exudates for energy and, in return, remineralize and excrete P that support cyanobacterial growth even under environmental low P [2]. However, the specific influence of heterotrophic bacteria on cyanobacterial poly-P metabolism and dynamics, and on overall P fluxes within microbial consortia remain poorly understood.

This study aims to investigate the poly-P accumulation and hydrolysis in laboratory cyanobacteria-bacteria co-cultures with the objective of linking gene expression to observed poly-P fluxes. *Synechocystis* sp. PCC 6803 and *Pseudomonas putida* KT2440 are co-cultured in a modified BG-11 medium under P downshift and upshift conditions, alongside axenic and abiotic controls. Temporal changes in dissolved and cellular poly-P are quantified using the novel fluorescence dye JC-D7, while soluble reactive P (SRP), total particulate P (TPP), biomass, and alkaline phosphatase activity (APase) are monitored at various growth phases. Intracellular poly-P distribution and elemental mapping are assessed using Scanning Transmission Electron Microscopy with Energy Dispersive X-ray Spectroscopy (STEM-EDS). In addition, targeted genes expression of P transport (*pstS*) and poly-P synthesis (*ppk*) and hydrolysis (*ppx* and *phoA*) is quantified using RT-qPCR to establish links to poly-P fluxes.

This study tests the hypothesis that heterotrophic bacterial interactions accelerate poly-P turnover by enhancing P remineralization and enzymatic hydrolysis, regulating P availability under P-limited conditions, and altering cyanobacterial poly-P metabolism and overall P dynamics through metabolic coupling and nutrient cross-exchange. The results provide mechanistic insight into microbial controls on P accumulation and recycling in aquatic systems.

References

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[2] Christie-Oleza et al. (2017), *Nature Microbiology* 2, 17100.

[3] Li et al. (2019), *Scientific Reports* 9, 19563.