Light dependence of phosphorus uptake by microorganisms in the North and South Pacific subtropical gyres

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Abstract

The effect of light on phosphorus (P) uptake is not well established and the few studies that have been conducted have led to contradictory results. In theory, smaller non-pigmented picoplankton should be more efficient at nutrient capture due to their larger surface to volume ratio compared to larger pigmented picoplankton, and experimental work generally confirms this prediction. Light stimulation of P-uptake would offer a competitive advantage to pigmented organisms over non-pigmented ones, particularly when P is limiting. In heterogeneous natural populations of planktonic organisms, it is challenging to attribute P-uptake to different taxonomic groups when using traditional filtration techniques, as their size spectra often overlap and hence do not allow for their unique separation. Recently, the cell sorting capacity of flow cytometry has been used to measure group-specific uptake rates of radiolabeled compounds. The combination of flow cytometric sorting and radioisotopic tracer techniques is a promising approach to reassess the effect of light on P-uptake in natural assemblages. We investigated the light and dark PO4 uptake of several microbial groups within the euphotic zone, in three different nutrient regimes with contrasting community compositions. The average (± S.E.) total (> 0.2 μm) light enhancement was a factor of 1.45 ± 0.05 (n = 130). Group-specific uptake rates measured in the North Pacific subtropical gyre (NPSG) demonstrated that Prochlorococcus but not non-pigmented picoplankton PO4 uptake was enhanced by ambient light. Adenosine-5-triphosphate (ATP) utilization by Prochlorococcus was also enhanced in the light, both for the uptake of the terminal PO4 ([γ-33P]ATP) and of the adenine ([2,8-3H]ATP) moiety. Group-specific uptake rates measured in the NPSG demonstrated that non-pigmented picoplankton were the main contributors of [γ-33P]ATP utilization but there was no effect of light in this subpopulation. Although cell-specific [γ-33P]ATP uptake rates for Prochlorococcus were only 1-18% those of the non-pigmented picoplankton, they were stimulated by light with highest enhancement at ambient ATP concentrations (L:D=14.2x). Our results suggest that phototrophic ATP and PO4 uptake are largely mediated by light energy. Moreover phototrophs may use light energy to transport adenine (and possibly adenosine) and can possibly spare the energy otherwise required for de novo purine synthesis. This competitive advantage over non-pigmented picoplankton, that are the main contributors of ATP consumption, could influence the functioning of the microbial loop and modify the bacterial degradation of organic matter when P is scarce.

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