The biological and biogeochemical consequences of phosphate scavenging onto phytoplankton cell surfaces

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Limnol. Oceanogr., 50(5), 2005, 1459-1472 | DOI: 10.4319/lo.2005.50.5.1459

ABSTRACT: Phytoplankton carbon (C) and nitrogen (N) content is commonly normalized to phosphorus (P) quotas as Redfield C:N: P ratios. We examined how surface-bound P pools affect Redfield stoichiometry and P uptake kinetics in cultures and natural blooms of diatoms, raphidophytes, dinoflagellates, pelagophytes, prasinophytes, and cyanobacteria. The amount of surface-adsorbed P on exponential growth phase cultures ranged from 14% to 57% of the total cellular P. The C: total P and N: total P ratios (surface-adsorbed P + intracellular P) for all species were near Redfield values, with lower values for the diatoms and higher ratios for the dinoflagellates and cyanobacteria. However, when corrected for the P adsorbed to exterior surfaces, intracellular or “biological” C: P and N: P ratios are 1.2-2 times higher. As with the cultured isolates, the amount of surface-adsorbed P for the natural bloom samples ranged from 15% to 46%. Carbon : total P ratios ranged from 71 to 151, whereas C: intracellular P ratios were 1.3-1.7 times higher. N: P ratios for the natural samples showed similar trends. Phosphate uptake rates into the intracellular pool were as little as half those measured for uptake into total cellular P pools for both the natural blooms and cultures. Cells can, however, access some of the surface-bound P over time to support growth, and the partitioning of P between adsorbed and interior pools is affected by growth stage, cellular P demand, and external phosphate concentrations. We conclude that, as with iron (Fe) and other particle-reactive elements, bulk particulate C:N: P ratios do not necessarily reflect the true biological P quotas of eukaryotic and prokaryotic algae and that P scavenging onto cell surfaces is likely to exert a large influence on the biogeochemical cycling of this nutrient.

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