Mechanisms of iron uptake in the growth of red tide algae

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Summary

Iron is the essential bioactive trace metal for the growth of algae. However, dissolved iron fractions consist largely of colloidal hydrolysis species such as oxyhydroxide and most of those are bound by organic ligands in natural waters. As a result of above-mentioned iron speciation, the concentrations of directly bioavailable iron species are extremely low in natural waters. In coastal areas where red tides have frequently occurred, dissolved iron is present at concentrations of approximately 10 – 100 nM. It is hence difficult to explain the massive appearance of harmful algae. On the other hand, total or suspended iron exists abundantly in coastal waters. Therefore, it is supposed that red tide algae can utilize suspended iron or have other strategies of iron uptake for the growth under low iron conditions. The growths of the principal species of red tide phytoplankton were examined using a newly developed artificial synthetic medium in the presence of different iron species. Some microalgal species could utilize particulate $FePO_4$ and FeS for growth. Particulate $FePO_4$ was available for the growth of the raphidophyte *Heterosigma akashiwo*, the dinoflagellate *Heterocapsa triquetra* and the diatom *Ditylum brightwellii*. The dinoflagellates *Heterocapsa circularisquama* and *Karenia mikimotoi*, and the cryptophyte *Rhodomonas ovalis* utilized both particulate $FePO_4$ and particulate FeS for growth. In contrast, particulate FeO(OH) and Fe_2O_3 did not support the growth of any of the red tide microalgae examined. Except for *Chattonella* species (Raphidophyceae), the growth of red tide microalgae were confirmed in the medium with very easily soluble $FeCl_3$ added. And, our study demonstrated that the organic iron of different ligands was bioavailable to red tide phytoplankton. In iron salicylate chelates medium, the growths were confirmed for *H. akashiwo*, *H. circularisquama*, *H. triquetra*, *D. brightwellii*, *R. ovalis*, the green alga *Oltmannsiellopsis viridis*, and the coccolithophorid *Cricosphaera roscoffensis*. Furthermore, in iron citrate chelates medium, we also found the growths of the raphidophyte *Fibrocapsa japonica* besides the above-mentioned seven species. And all phytoplankton species examined could grow in iron ethylenediaminetetraacetate chelates medium. And the differences in concentration of organic ligands in each medium caused the changes of the growth (maximal growth yield and specific growth rate) of red tide algae examined. These results suggest that the iron speciation may be an important role in controlling the uptake of iron by red tide forming phytoplankton in coastal water. We here suggest that the occurrence of red tides in coastal areas may depend on the combination of microalgal species and iron species present.