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Variation in the oxygen isotope ratio of dissolved orthophosphate induced by uptake process by hermatypic corals

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The oxygen isotope ratio (δ^{18}O) of dissolved orthophosphate (PO_4^{3-}) has been recognized as a promising tool to evaluate the contributions of both external sources and internal recycling of phosphorus (P) to the P budget in natural aquatic ecosystems. However, coexistence of many biological processes that can significantly alter the phosphate δ^{18}O ($\delta^{18}O_p$) in a given system often complicates quantitative interpretation of this parameter. To use the information of $\delta^{18}O_p$ effectively in biogeochemical researches, we have to know both the magnitudes of oxygen isotope effect and the reaction kinetics of major biological processes that take part in the P cycle of the concerned ecosystem. In this study, we conducted a model incubation experiment using natural hermatypic corals to evaluate the influence of uptake process of PO_4^{3-} by corals on the $\delta^{18}O_p$. Live coral samples (*Porites cylindrica*, *Heliopora coerulea*, *Acropora digitifera*) were collected from coral reefs around Ishigaki Island (Okinawa) and Bolinao (northern Luzon), acclimatized in incubation aquaria for a few days, and then incubated for 3 to 5 days under natural light conditions with elevated concentrations of NO_3^- and PO_4^{3-}. Subsamples of seawater were regularly collected and analyzed for the concentration and the δ^{18}O of PO_4^{3-}. PO_4^{3-} was usually taken up by corals linearly with incubation time, and the uptake rate apparently depended on temperature. Difference in the uptake rate between coral species was not significant. The $\delta^{18}O_p$ was initially approx. 3 ‰ lower than the equilibrium value with regard to oxygen-isotope exchange with ambient seawater. In a few cases, the $\delta^{18}O_p$ remained unchanged during the incubation even though uptake proceeded. In the other cases, however, the $\delta^{18}O_p$ gradually increased with time, and in some cases became even higher than the equilibrium value at the end of incubation. This observation suggests that kinetic isotope fractionation rather than simple equilibration operated during the uptake of PO_4^{3-} by corals and influenced the $\delta^{18}O_p$. The magnitude of isotope effect associated with uptake seemed to depend on coral species, being the largest with *A. digitifera* and the smallest with *H. coerulea*. In natural environments where the concentration of PO_4^{3-} is much lower than the incubation conditions we used, PO_4^{3-} is presumably turned over much faster and the $\delta^{18}O_p$ is easily altered by corals and other major primary producers. This fact may limit the advantage of the $\delta^{18}O_p$ as an indicator of external PO_4^{3-} sources.

Keywords: Phosphate, Isotope effect, Stable isotopes of oxygen, Hermatypic coral, Coastal marine ecosystem