Development of automatic analysis apparatus for triple oxygen isotopes of dissolved oxygen

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Oxygen molecules (O₂) consist of triple oxygen isotopes (mass numbers 16, 17 and 18) providing additional unique information such as triple oxygen isotopic compositions (Δ¹⁷O = ln(δ¹⁷O + 1) - 0.518ln(δ¹⁷O + 1)). In most of the terrestrial processes (e.g. photosynthesis and respiration) fractionate O isotopes in a mass-dependent way, such that ¹⁷Ο enrichment is about half of the ¹⁸Ο enrichment relative to ¹⁶Ο. As a result, δ¹⁷Ο and δ¹⁸Ο in terrestrial materials plot along a single line with a mass-dependent slope of about 0.52. In contrast to these mass-dependent processes, ultraviolet-induced interactions among O₂, O₃, and CO₂ in the stratosphere cause mass-independent fractionation with equal lowering of δ¹⁷Ο and δ¹⁸Ο in atmospheric O₂. Therefore, Δ¹⁷Ο of photosynthetically-produced O₂ in the hydrosphere shows higher values of about +150 ~ 250 per meg compared to atmospheric O₂. Since the δ¹⁷Ο and δ¹⁸Ο of O₂ fractionated by respiration vary along a line with a mass-dependent slope, which means the Δ¹⁷Ο will not change, we can estimate a mixing ratio of O₂ produced from photosynthesis in the hydrosphere (Δ¹⁷Ο = ca. +150 ~ 250 per meg) and atmospheric O₂ (Δ¹⁷Ο = ca. +150 ~ 250 per meg) dissolved in water. This will make it possible to estimate gross primary production in the lake and ocean or the air-water gas exchange coefficient by measuring the Δ¹⁷Ο of dissolved O₂. In this study, we constructed the new purge and trap system to measure Δ¹⁷Ο of dissolved O₂. The system is fully automated, extracting dissolved gases from the water samples, separate O₂ from all the other gases including Ar, and collecting pure O₂ using a cryogenic temperature cooling sampling device (ca. 10K). We will report Δ¹⁷Ο values of dissolved O₂ in Lake Biwa where remarkable eutrophication and hypoxia have been observed in recent years.

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