Detection of Organophosphonates and Phosphite in Suspended Matter of P-limited Lakes

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Introduction

Bacteria possibly utilize phosphite and organophosphonates as P resources in freshwater lakes. At the subsurface layer of Lake Saiko (P-limited lake: Yamanashi, Japan), maximum methane concentration is observed under stratified condition in summer. This subsurface methane maximum (SMM) is considered to be formed by metabolism of methylphosphonate (MPn) by cyanobacterium *Synecococcus* to ingest phosphorus [Khatun et al., 2019]. In Lake Fukami-Ike (Nagano, Japan), a eutrophic lake, methane maximum layer is also formed in the epilimnion during summer stratification, probably because of the same reason as in Lake Saiko. However, there is no report concerning the detection of MPn and 2-hydroxyethylphosphonate (2-HEP), which is the precursor of MPn, while phosphite (iP(+3)) was detected in the water of some eutrophic lakes and rivers. We developed simultaneous determination methods to detect organophosphonates and iP(+3) in water and particulate matters in by ion chromatography.

Methods

Analytical condition for the determination of MPn in water was already established by ion chromatography with high volume injection [Tsuji et al., 2019; Maruo et al., 2016]. By optimizing elution condition, we applied this method to separate MPn, 2-HEP and iP(+3), with the detection limits of these analytes at the order of some nmol L^{-1}. This method was applied to the analysis of water sampled at the north basin of Lake Biwa (Shiga, Japan), inflowing rivers at the northeast part of the watershed, spring waters and treated waste water, in Nov. - Dec. of 2017 and 2018. Water samples of Lake Saiko were collected in Jul., 2018 and Aug., 2019 at the center of the lake (Max. depth 70 m). Water samples of Lake Fukami-Ike were obtained in Dec., 2019 (max. depth 7.5 m).

Sampled waters were immediately filtered with capsule filter (pore size 0.2/0.8 micrometer: Acropak 200). Particulate matters were collected on track etched membrane filters (pore size 0.2 micrometer: Nuclepore) from approx. 1.5 - 2.0 L of water. Tthe filters were heated at 60 ℃ in pure water for 1 hour to extract organophosphonates and iP(+3) from the particulates.

Results and Discussion

Dissolved MPn was detected from the waters of anoxic spring (2.9 nmol L^{-1}) and River Amano near the

spring (2.3 nmol L^{-1}) (Maibara, Shiga, Japan), though no MPn and iP(+3) were detected from any other waters sampled in Lake Biwa and its watershed. Only iP(+3) was detected from the water samples of Lake Fukami-Ike.

During the analysis of extracted solution from particulate matters, MPn (0.08 nmol L^{-1}) and iP(+3) (0.06 nmol L^{-1}) were detected from the samples of anoxic spring. From the samples of Lake Biwa, iP(+3) was detected (0.38 nmol L^{-1}), while MPn (0.03 nmol L^{-1}) and iP(+3) (2.7 nmol L^{-1}) were detected from the sample of Lake Saiko obtained at 12.5 m in depth. In Lake Fukami-Ike, 2-HEP was also detected at the depth of 2.5 m and 7.5 m (close to the lake bottom), including MPn (2.5 m), and iP(+3) (2.5 m, 7.5 m).

Dissolved organophosphonates and iP(+3) were merely detected in the freshwaters, but MPn and 2-HEP were detected from particulate matters of these lake waters. Microorganisms in lake water (cf. cyanobacteria) might produce these phosphorous (+3) compounds in their bodies during their metabolic cycles of phosphorus. Methane might be excluded to the water during these processes.

References

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