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Characteristics of Lake Biwa from Stable Isotopic Viewpoints

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INTRODUCTION

Nitrogen is the most important biophilic element and consists of two stable isotopes: ^{14}N and ^{15}N. Although both physicochemical nature is quite similar ,more precisely ^{14}N and ^{15}N undergo fractionation in every physical and chemical processes. Consequently, each nitrogen bearing substance has its own inherent isotopic composition depending upon its position in material cyclings in nature [1], [2], [3]. It has been recognized that $\delta^{15}N$ of an animal is an useful indicator of its trophic level, while its carbon isotope ratio reflects $\delta^{13}C$ of the food base and is an available source indicator of its carbon[4], [5]. Therefore, the SI ratio($^{15}N/^{14}N$) can be possible indicator to trace transport of organic matter and to reconstruct a food web structure of natural ecosystems [6], [7], [8], [9]. In this paper, preliminary surveys were performed on the distribution of nitrogen isotope ratio among biogenic substances involving nitrate, POM, plankton and pisces in Lake Biwa, Japan, with emphasis on the construction of a possible isotopic geochemical structure of the lake ecosystem.

MATERIALS AND METHODS

Study area

Lake Biwa is the largest lake locates in the central part of Honshu Island, Japan. Its surface area is 647 km^2. The lake is separated into two parts: the north basin and south basin. The north basin occupies the major parts of the lake with maximum depth of 108m and a water volume of 27 thousand million tonnages. In contrast, the south basin is small with average depth of 4m and water volume of 2 hundred million tonnages. The lake water is supplied from the surrounding mountain areas. An estimated exchange rate of the lake water is around 10 years[10]. The lake is monomictic and the depth of a thermocline in the north basin becomes deeper during spring through autumn from 15m to 40m. The thermocline disappears commonly in January.

Analytical method

POM, phytoplankton, zooplankton and fishes were collected from April through August in 1993, together with nitrate at the deepest points(water depths of 70 and 90m) in the north basin in August. Zooplankton samples were collected by horizontal towing a net (150 μm mesh size) and were sorted under a stereoscopic microscope into each species. Phytoplankton samples were collected by various kinds of nets, of which mesh sizes were 70, 40, 20 μm, respectively. POM were collected on GF/D(2.7 μ m) and GF/F(1.2 μ m) glass fiber filters precombusted at 450 ℃ for 2 hours. Collected samples on the filter was washed with 0.05N hydrochloric acid and dried at 60 ℃. Samples for nitrogen isotope analysis were combusted by the sealed quartz tube method to N_2 gas[11]. 1 to 10mg of dry sample materials were sealed into an evacuated quartz tube with 1.0g of copper oxide, and 0.5g of copper and silver wires. The tube was heated up to 500℃ for 30 minutes and at 850℃ for 2 hours and then cooled down overnight in the farnace. N_2 gas was separated and purified cryogenically by using liquid nitrogen and dry ice-ethanol traps. Purified gases were introduced into a Delta-S mass spectrometer for ratiometry. Isotope ratio was expressed as parmil deviation from a standard as follows:

$\delta^{15}N(‰)=(R_{sample}/R_{air}-1)\times1000$,

where R donates $^{15}N/^{14}N$. L-alanine was used as a running standard for the isotope measurement.

RESULT AND DISCUSSION

Silurus biwaensis, Plecoglassus altivelis altivelis, zooplankton, phytoplankton, and POM had very high $\delta^{15}N$ values so far examined in the present lake. $\delta^{15}N$ value of POM and phytoplankton ranged 6 to 9‰. *Eodiaptomus japonicus* exhibited $\delta^{15}N$ value of 10 to 15‰. Temporal variation of $\delta^{15}N$ in *E. Japonicus* showed similar with those of POM, and phytoplankton of which mesh size was from 2.7(GF/D) to 70 μ m. Fishes exhibited rather high $\delta^{15}N$ value. For example, *Plecoglassus altivelis altivelis* had $\delta^{15}N$ values of 13 to 18‰ and *Silurus biwaensis,* ca.19‰. A relationship between an average $\delta^{15}N$ value of each organism collected during April to August in 1993 and its corresponding trophic level was summarized in Fig 1. A stepwise increase

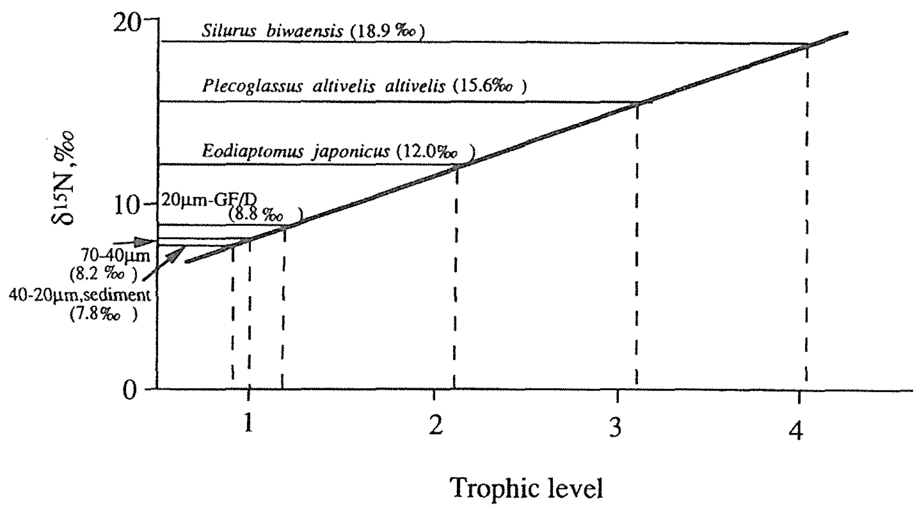

Fig. 1 A relationship between $\delta^{15}N$ of an organism and its corresponding trophic level. The straight line was obtained using the $\delta^{15}N$ value of POM and

of ^{15}N was clearly demonstrated along a food chain in the following manner: phytoplankton and POM, *E. japonicus, Plecoglassus altivelis altivelis,* and *Silurus biwaensis.* The fact strongly suggested that the stepwise enrichment of $\delta^{15}N$ was also confirmed in Lake Biwa with a enrichment factor of 3.3‰/T.L.. Therefore, the $\delta^{15}N$ could be a very clear indicator of trophic level of an organism as has been shown in Lake Suwa, the estuaries, and marine environments[2], [4], [5], [8]. Rather high $\delta^{15}N$ value of the whole food web in Lake Biwa(Fig. 1) coincided with high $\delta^{15}N$ value of nitrate(5 to 6‰) in spite of the supply of nitrate with low $\delta^{15}N$(0 to 2 ‰) through precipitation onto the surrounding mountain areas.

In Lake Biwa, loss of ca.40% of nitrate was reported from a mass balance calculation of nitrogen[12]. If high $\delta^{15}N$ value is caused by denitrification, the occurrence of denitrification with rather high fractionation factor of 1.009 was strongly suggested in Lake Biwa.

REFERENCES

1.Wada, E.,1976: Measurement and availability of ^{15}N using massspectroscopy. Radioisotope,25:1088-89.(in Japanese)

2. Minagawa, M. and Wada, E.,1984: Stepwise enrichment of ^{15}N along food chains: further evidence and the relation between $\delta^{15}N$ and animal age. Geochemica et Cosmochimica Acta., 48:1135-1140.

3.Wada, E. and Hattori, A.,1991: Nitrogen in the sea; Forms, Abundances and Rate Process. CRC press, Florida, USA.

4.Wada, E. et al.,1987: ^{15}N and ^{13}C abundances in the Antarctic Ocean with emphasis on the biogeochemical structure of the food web. Deep-sea Res., 34:829-841.

5.Wada, E. et al.,1993: Stable isotopic structure of aquatic ecosystem. J.Biosci., 18:483-499.

6.Yoshioka, T. et al.,1988a: Analysis of lacustrine food web with natural carbon and nitrogen isotope ratios. Internationale Vereinigung fur theoretische und angewandte Limnologie, Verhandlunegen, 23:573-578.

7.Yoshioka, T. et al., 1988b: Isotope Characterization of Lake Kizaki and Suwa. Jpn. J. Limnol.,49:119-128.

8.Yoshioka, T.,1991: Assessment of primary production in a eutrophic lake from carbon and nitrogen isotope ratios of carnivorous fish(a pond smelt). Mass Spectroscopy, 39:277-278.

9.Yoshioka, T. et al.,1994: A stable isotope study on seasonal food web dynamics in a eutrophic lake.Ecology, 75:835-846.

10.Okamato, I.,1992: The Circulation of water in Lake Biwa. Symposium of Biwa science, News latter No.3.

11.Minagawa, M. et al.,1984: Comparison of Kjeldahl and combustion methods for measurement of nitrogen isotope ratios in organic matter.Anal. Chem., 56:1859.

12.Miyazima, T., 1994: Mud water fluxes of inorganic nitrogen and manganese in the pelagic region Lake Biwa: Seasonal dynamics and impact on the hypolimnetic metabolism.Arch. Hydrobiol.,(in press)