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CHANGE OF TROPHIC STATUS IN LAKE SUWA DURING 20 YEARS
-ELUCIDATION BY RELATIVE ABUNDANCES OF LIPID COMPOUNDS IN SEDIMENTS-

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ABSTRACT

Sterols, normal alkanols, normal alkanoic acids, chlorophyll like substances, total lipid carbon, total organic carbon and C/N in the core sediment of Lake Suwa were determined. The profile of the relative abundances of these lipid compounds seemed to reflect a history of production rate in the lake during about 20 years.

key words: Lake Suwa, lipid compounds, sediment, history, eutrophication

INTRODUCTION

Sediments in lakes have good information about paleoenvironments in the lakes. Absolute contents and relative abundance of lipid compounds provide the information on primary production rates and other biological aspects. The authors have reported the relationship between chlorophyll like derivatives and the glacial periods(1,2) and other environments(3) by using a 1400 m long core of Lake Biwa. Lipid classes in sediments of contemporary five lakes have well implicated the concentrations of nutrients in lake water and the production rates(4).

Lake Suwa is now highly eutrophicated. But it is reported that the water quality improves since the Sewage Treatment Plant began to work about 20 years ago(5).

The object of this study is to examine the improvement of the water quality of Lake Suwa by the relative abundances of various lipid compounds, total organic carbon and C/N.

MATERIALS AND METHODS

Four 16 cm core sediment were taken from the deepest area of Lake Suwa, 7 m in water depth, on November 13, 1987.

Lipids in the wet sediment samples of every 4 cm in length (composites of the 4 core samples) were extracted with chloroform/methanol(2/1), followed by washing the mixtures with redistilled water. The lipids were then dissolved into chloroform.

Lipid classes were analyzed by TLC/FID analyzer(IATROSCAN HT-10, IATRON, Japan)(4). Total organic carbon and nitrogen were analyzed by CHN CORDER(YANACO MT-3, YANAGIMOTO). Radioactivity of ^{137}Cs in the sediments was determined by a Ge γ-ray spectrometer(ORTEC Ge γ-ray analyzer).

Analytical methods of lipid compounds were the same as described before(3).

RESULTS AND DISCUSSION

The vertical distributions of total organic carbon(TOC), C/N(weight ratio), total lipid carbon(TLC), and TLC/TOC in the samples are shown in Fig. 1. The low value of C/N, high abundances of TOC and TLC, and TLC/TOC at 8 ~ 12 cm in core depth relative to other layers, seem to indicate the higher production rate at the deposition period.

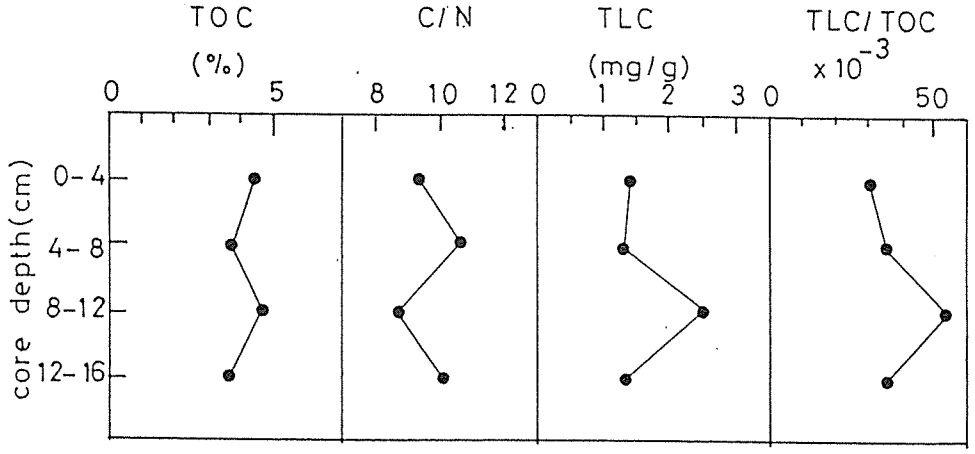

Fig. 1. Vertical distribution of concentrations of total organic carbon(TOC), and total lipid carbon(TLC), and C/N(weight ratio) and TLC/TOC in core sediments of Lake Suwa.

In Fig.2, ratios of contents of shorter chain, to longer chain even n-alkanol(ΣC14+C16+C18)/(ΣC20+C22+C24+C26+C28), and n-alkanoic acids(ΣC12 ~ C19)/(ΣC20 ~ C32) and ratios of contents of phytol to most abundant n-alkanol.

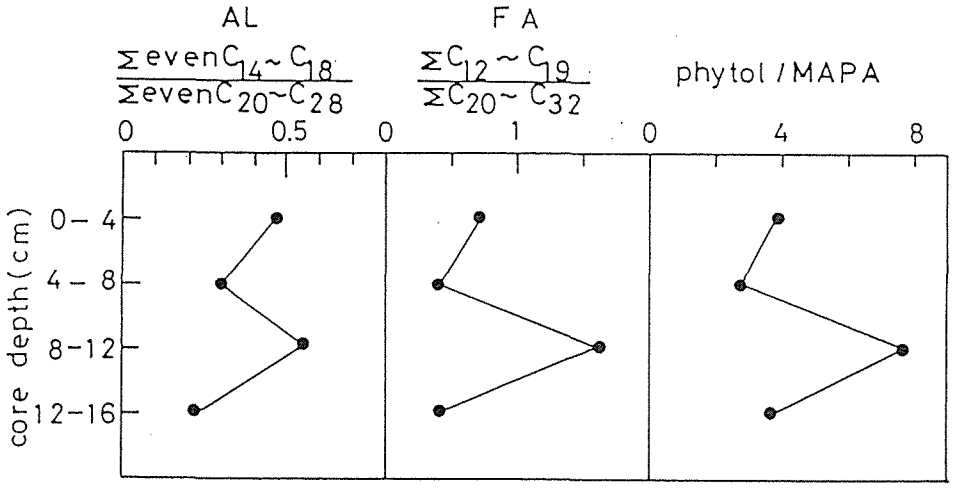

Fig. 2. Ratios of shorter chain to longer chain of n-alkanol ($\Sigma C_{14}+C_{16}+C_{18}$)/($\Sigma C_{20}+C_{22}+C_{24}+C_{26}+C_{28}$) and n-alkanoic acids ($\Sigma C_{12} \sim C_{19}$)/($\Sigma C_{20} \sim C_{32}$), and ratios of phytol to most abundant n-alkanol(MAPA) *versus* core depth.

The ratios of alkanols and alkanoic acids indicate relative contribution degree from autochthonous to allochthonous origin. The highest value was obtained in the sample, 8 ~ 12 cm, though it seems to increase recently again. Free phytol was rarely present in those samples. Therefore phytol obtained by alkaline hydrolysis, is considered to be derived from chlorophylls and their derivatives. Phytol is generally decomposed with time in water column and sediments. The highest ratio of phytol to the most abundant alkanol found in the 8 ~ 12 cm, suggests the presence of turbulence of sediments by benthos(bioturbation) and winds. However vertical distributions of metals, such as Cu, Zn and Pb in several core sediments, which were taken in Dec.1987(6), show similar patterns to this samples and also the improvement of water qualities in Lake Suwa after the construction of Treatment System(5) supported the vertical profile.

From those facts, the presence of bioturbation was denied and the most eutrophicated layer, 8 ~ 12 cm was estimated to be buried in 1977 ~ 1979, when the treatment plant began to work. The sedimentation rate is estimated to be 1 cm/year ~ 1.5 cm/year. This value is about three times that of Lake Aoki, Lake

Nakatsuna and Lake Kizaki which was determined by concentrations of ^{137}Cs.

In Fig. 3, ratios of 24-methylcholesta-5,22-dien-3β-ol($\Delta^{22}C28$), 24-methylchlolest-5-en-3β-ol(C28), and cholesterol(C27) with their corresponding 5α-stanols to 24-ethylcholest-5-en-3β-ol(C29) with their corresponding 5α-stanol are shown. The figure also includes ratios of totals of these 4 5α-stanols to totals of 4 Δ^5sterols(stanol/Δ^5).

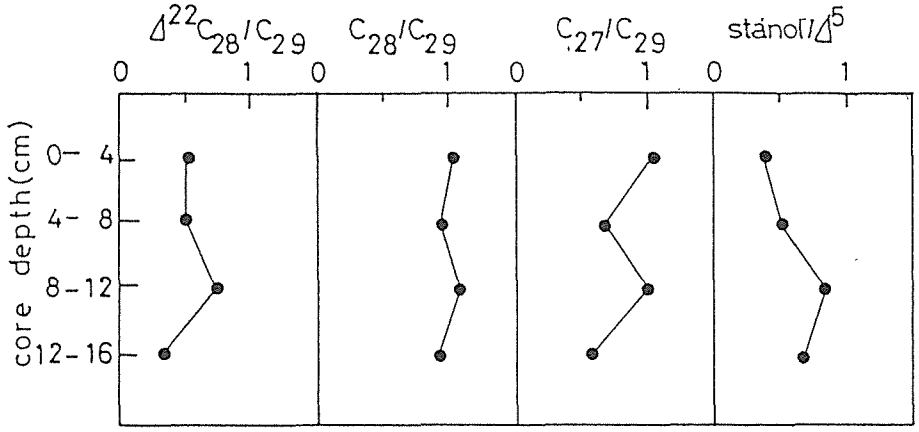

Fig. 3. Ratios of sterols, 24-methylcholesta-5,22-dien-3β-ol 24-methylcholest-5-en-3β-ol and cholesterol to 24-ethylcholest-5-en-3β-ol, and 5α-stanols to stenols *versus* core depth.
$\Delta^{22}C_{28}$: 24-methylcholesta-5,22-dien-3β-ol + 5α-stanol.
C_{28}: 24-methylcholest-5-en-3β-ol + 5α-stanol.
C_{27}: cholesterol + 5α-stanol.
C_{29}: 24-ethylcholest-5-en-3β-ol + 5α-stanol.
stanols: summation of four 5α-stanols.
Δ^5 : summation of four stenols.

Sterols are good biomarkers. $\Delta^{22}C28$ is abundant in diatoms such as *Asterionella*(4). C29 is abundant in higher plants. C28 is present in several plankton and also in soils. C27 is abundant in zooplankton but in polluted area, C27 is derived from untreated sewages. Ratio C27/C29 in contemporary sediments and a 1400 m long core of Lake Biwa, correlated to C/N except for heavily polluted area, such as in Lake Suwa(4). High values of C27/C29 in 0 ~ 4 cm and 8

~ 12 cm indicate anthropogenic pollution including animal farming. Relatively higher ratios of Δ^{22}C28/C29 and C28/C29 found in 8 ~ 12 cm indicate higher production rates of diatoms and green algae and/or cyanobacteria, respectively.

The highest ratio of stanol/Δ^5 was found in 8 ~ 12 cm. The higher ratio indicates relatively anoxic sedimentary environments, and generally increases with depth. However the extraordinary high value at 8 ~ 12 cm layer shows the large sedimentation rate and also explains the relatively large amount of total lipid carbon, and highest relative abundances of hydrocarbons and free fatty acids in total lipid carbon, separated on TLC-FID. The hydrocarbon fraction contains unresolved complex mixtures which is characteristics of oil pollution. Fatty acids are consisted of shorter chain acids which are indicative of living organisms. It proved that phytol is likely preserved in these anoxic sedimentary environments.

This study is a part of comparative study of lipid compounds in core sediments of several contemporary lakes with different environments: contents of nutrients in lake water, water depth, lake size, lake history, and others. The details of the study will be published elsewhere.

CONCLUSION

The improvement of water qualities in Lake Suwa by the construction of the Treatment Plant in 1979 was confirmed by determination of lipid compounds in sediments.

1.The presence of bioturbation in sediments was denied.
2.Relatively large amounts of total organic carbon and total lipid carbon, and relatively low ratio of C/N(weight ratio) to that in other layers were found in 8 ~ 12 cm sample.
3.The sample, 8 ~ 12 cm, seems to correspond to deposits just before the construction of the Treatment System in 1979.The sedimentation rate is estimated to be 1 cm/year ~ 1.5 cm/year.
4.Biomarkers characteristic of autochthonous origin are relatively abundant in the sample, 8 ~ 12 cm.
5.Anthropogenic molecules are relatively abundant in the sample, 8 ~ 12 cm.
6.Anoxic sedimentary environment at 8 ~ 12 cm, tends to change to oxic condition.
7.Production rates seems to decrease from 1979 but tend to increase these few years. Is this the effects of the increasing Solar Activity, the Global Warming and the increasing of the *atmospheric* carbon dioxide or is there anything else?

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