NOTE

Vertical Distribution of ^{137}Cs and Its Accumulation Rate in Lake Sediments

Kokichi KAMIYAMA, Setsuo OKUDA and Mutsuo KOYAMA

Abstract

Vertical distributions of ^{137}Cs in the sediments of Lake Biwa, Lake Suigetsu and Lake Mikata were measured by the non-destructive gamma counting technique using a germanium-lithium detector. Possible sedimentation rates were estimated based upon the depth of ^{137}Cs penetrating into the sediments.

1. Introduction

In order to understand the circulation processes of substances in lakes, it is fundamental to know the deposition rate of substances onto the lake bottom, since the deposition process is a major removal process of substances from the water body. There has been a rapid increase in population in the catchment area of some lakes for the last 20 years, and rapid eutrophication has been observed in many lakes. Therefore the investigation of the circulation processes of substances in lakes will be important from both limnological and environmental points of view.

Recent sedimentation rates have been estimated using ^{210}Pb in some lakes in Japan (MATSUMOTO, 1975 a, b). The present study describes the vertical distribution of ^{137}Cs in the sediments, and possible sedimentation rates were estimated based upon the data.

Nuclear weapon tests have released several radionuclides, which have returned to the earth's surface as fallout. ^{137}Cs was first detected in the atmosphere in 1954. Annual deposition of ^{137}Cs in Tokyo was reported by MIYAKE and KATSURAGI (1969), and it was found that the maximum inputs occurred in 1959 and in 1963 as was reported in many places in the world (RICHIE *et al.*, 1973). ^{137}Cs is tightly adsorbed on soil particles and will provide information on the age of sediments.

2. Methods and Materials

Samplings of lake sediment cores were conducted in 1979 in several lakes of Japan (Fig. 1). Of these lakes, only Lake Suigetsu is brackish, whereas the others are fresh water. In Lake Biwa, the points O and S are located near the center of the north and the south basins respectively. The point Y in the north basin is located

Fig. 1. Location of the sampling points of bottom sediment cores.

off the mouth of the River Yasu, one of the large rivers flowing into Lake Biwa, and the points A, B, D and E are located at 10, 30, 70 and 90 m water depths, respectively, along a line from the River Amano toward the deepest point of Lake Biwa. The points SU and M are located near the center of Lake Suigetsu and Lake Mikata, respectively.

After sampling, each sediment core was pushed out from the sampling tube and was cut into 0.5 or 1.0 cm slices with a knife on the boat and brought back to the laboratory. After the measurement of moisture content, ^{137}Cs activity was measured using about 20 g of sediment samples. ^{137}Cs activity in each sample was directly determined by the non-destructive gamma counting technique using a germanium-lithium detector (53 cc) coupled to a 4 K channel pulse height analyser. This technique allows a clear separation of 661 KeV ^{137}Cs gamma rays in the presence of those from ^{208}Tl (583 KeV) and ^{214}Bi (609 KeV) (Fig. 2). The samples were counted for at least 80 K sec to obtain good statistical accuracy. The limit of detection for ^{137}Cs by this method is 0.05 p Ci/g and the counting error is about 5%. This method has been used for the determination of ^{137}Cs activity in lake sediments (KRISHNAS-

WAMI *et al.*, 1971) and in rocks (SATO *et al.*, 1977).

3. Results and Discussion

The vertical distributions of ^{137}Cs in the bottom sediments are shown in Fig. 3. Cores at the points A, Y and M are not deep enough for ^{137}Cs to disappear. LERMAN and LIETZKE (1975) reported that ^{137}Cs might move in sediment column by diffusion after burial. ROBBINS and EDGINGTON (1975) pointed out that the ^{137}Cs profile in sediments was perturbed by benthos. Therefore, the sedimentation rate calculated from the penetrating depth of ^{137}Cs in sediments is the roughly estimated value.

The penetrating depth and the calculated sedimentation rate of each core is given in Table 1. The sedimentation rates in the central area of Lake Biwa are ranged 0.12 to 0.26 cm/year and roughly agree with the rates by ^{210}Pb technique (MATSUMOTO, 1975 a). The rates in the coastal area of Lake Biwa seem to be higher than those in the central area, though sediment perturbation is undeniable. The rate in Lake Suigetsu is 0.12 cm/year, and the rate in Lake Mikata >0.20 cm/year. Since Lake Mikata is very shallow, it is undeniable that surface sediments were mixed by wave action and other factors.

Fig. 2. Gamma ray spectrum of a sediment core sample (1.0-1.5 cm depth core sample at the point D, 12.7 g dry weight sediments, counting time=80 K sec).

Fig. 3. Vertical distribution of ^{137}Cs in sediment samples.

Acknowledgements

We are sincerely grateful to Dr. Y. ISOZUMI of the Radioisotope Research Center, Kyoto University, for his advice in gamma ray counting. We also thank Dr. A. KAWAI of the Research Institute for Food Science, Kyoto University and Mr. K. YOKOYAMA of the Disaster Prevention Research Institute, Kyoto University, for their help and advice in obtaining the sediment cores. A part of the gamma ray analyses was carried out in the Radioisotope Research Center, Kyoto University.

摘 要

湖沼における近年の堆積速度を推定することは、陸水学的また環境科学的見地から重要な問題である。

セシウム-137は、核実験によって出現した人工放射性元素であり、土壌粒子に非常に吸着されやすい。したがって、セシウム-137の底泥中への侵入深度を明らかにすることは、過去30年間の堆積速度を推定するための基礎的な知見となる。

琵琶湖北湖、南湖、三方湖、水月湖において底泥中のセシウム-137の鉛直分布を明らかにした。とりわけ琵琶湖北湖については、天野川河口から最大水深部に向かって、10、30、70、90 m 水深の地点でも調査

Table 1. Penetrating depth of ^{137}Cs in the sediments and the sedimentation rate estimated.

Point	Water depth (m)	Penetrating depth (cm)	Sedimentation rate		Sampling date
			($\text{cm}\cdot\text{year}^{-1}$)	($\text{g}\cdot\text{cm}^{-2}\cdot\text{year}^{-1}$)	
S U	32	3.0	0.12	0.010	Aug. 1979
M	2	>5.0	>0.20	>0.055	"
Y	28	>5.0	>0.20		Mar. 1979
S	4	6.0	0.24		Jan. 1979
A	10	>10.0	>0.40	>0.41	Dec. 1979
B	30	6.5	0.26	0.13	"
D	70	4.0	0.16	0.037	"
E	90	3.5	0.14	0.019	"
O	73	3.0	0.12	0.039	Aug. 1979

を行ない、濃度には大きな違いがみられないが、侵入深度が地点によって異なっていることが明らかになった。とりわけ水深の浅い沿岸部での侵入深度は中央部に比べて大きかった。

セシウム-137の侵入深度から堆積速度を推定した結果は、ほぼ、山本ら(1973)、松本(1975)の推定値と一定した。

References

- KRISHNASWAMI, S., D. LAL, J. M. MARTIN and M. MEYBECK (1971): Geochronology of lake sediments. *Earth Planet. Sci. Lett.*, 11: 407-414.
- LERMAN, A. and T. A. LIETZKE (1975): Uptake and migration of tracers in lake sediments. *Limnol. Oceanogr.*, 20: 497-510.
- MATSUMOTO, E. (1975 a): Accumulation rate of Lake Biwa sediments by ^{210}Pb method. *J. Geol. Soc. Japan*, 81: 301-306.
- MATSUMOTO, E. (1975 b): ^{210}Pb geochronology of sediments from Lake Shinji. *Geochem. J.*, 9: 167-172.
- MIYAKE, Y. and Y. KATSURAGI (1969): *Abstract of 11th Research Report on Radioactivity*, p. 6.
- RICHIE, J. C., J. R. McHENRY and A. C. GILL (1973): Dating recent reservoir sediments. *Limnol. Oceanogr.*, 18: 254-263.
- ROBBINS, J. A. and D. N. EDGINGTON (1975): Determination of recent sedimentation rates in Lake Michigan using Pb-210 and Cs-137. *Geochimica et Cosmochimica Acta*, 39: 285-304.
- SATO, J., K. SATO and N. SAITO (1977): ^{137}Cs in volcanic rocks. *Geochem. J.*, 11: 49-52.
- YAMAMOTO, A., S. KANARI and Y. FUKUO (1973): Grain size analysis of sediments and their consolidation in a core from Lake Biwa-ko. *Jap. J. Limnol.*, 34: 63-74.
- (著者: 神山孝吉, 京都大学地球物理学研究施設, 大分県別府市野口原; 奥田節夫, 京都大学防災研究所, 京都府宇治市五ヶ庄; 小山睦夫, 京都大学原子炉実験所, 大阪府泉南郡熊取町: Kokichi KAMIYAMA, Geophysical Research Station, Kyoto University, Beppu, 874; Setsuo OKUDA, Disaster Prevention Research Institute, Kyoto University, Uji, 611; Mutsuo KOYAMA, Research Reactor Institute, Kyoto University, Kumatori-cho, Sennan-gun, Osaka 590-04)

Accepted: 22 August 1981