Rep. Suwa Hydrobiol., *11* : 79-82 (1999)

CHARACTERISTICS OF ORGANIC SUBSTANCE IN WEST LAKE SEDIMENTS

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Abstract
Characteristics of organic substance of the sediments of the West Lake are discussed in detail, including humic substance components and IR characteristics. The results showed that humus in the sediments of the West Lake is a typical lake sediment humus, and its humification level is high. Analysis on components of humus in the West Lake showed humin (59-71%) > humic acid (11-19%) > fulvic acid (8-15%) > lipid (3-12%). The Qianjiang River diversion project along with the planting of a lotus have both changed the organic composition of the sediment and will likely have an impact on the carbon cycling and eutrophication status in the West Lake.

Key words: Sediment Humus, Eutrophication.

INTRODUCTION

Lake sediment is an important lake component as well as a product of lake-evolution. Its composition and characteristics reflect the biological, chemical and geochemical properties of the lake. Particularly for eutrophic shallow lakes such as the West Lake, the sediment, acting as both a sink and a source of nutrients, plays an important role in the eutrophication status in the West Lake.

Organic substances in sediment exist mainly as humus. Generally speaking, humus in sediment composes 70~80% of the total of organic substances. In same cases, it may even reach 99% of total organic materials (Oscarson *et al.*, 1981). It could originate from inner sources (such as acquatic organisms), or from outer sources (eg. surrounding runoff), and is essential for recycling of the lake carbon and nutrients.

The organic matter content in the sediment of the West Lake reaches to 200 g/kg, which is unusually high for lakes in China. A thorough study of its organic characteristics presented in view of furthering our understanding of carbon recycling and eutrophication in the West Lake.

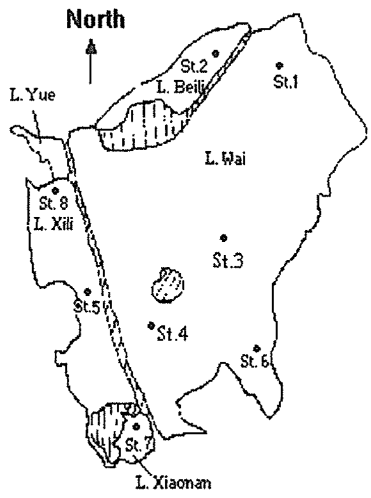

Figure 1. Location of sampling points in the West Lake.

1. Shaoniangong 2. L. Beili 3. L. ceter 4. Santan 5. L. Xili 6. Changqiao 7. L. Xiaonan 8. lotus area

MATERIALS AND METHODS

Sediment samples were collected in May 1995 from seven locations in West Lake (Fig. 1) using a clamshell sampler. The sampling depth was between 0 cm and 10 cm from the top of the sediment.

Sediment samples were air-dried for two weeks at room temperature. Dried samples were then ground to fine particles using 18, 60 and 100 mesh, respectively, and stored in plastic bottles to analysis.

The parcentage ignition weight loss (IG %) was calculated using the following equation :

$$IG (\%) = \{(Ws - Wr) / Ws\} \times 100$$

Where Ws = weight of sample dried for two hours at 105°C, and Wr = weight of sample dried for one hour at 550°C.

The total organic matter (OS) was determined following the Tyurin method, and total nitrogen (TN) determined using the Kjedahl digestion method. Humic acid isolation, preparation and characteristic analysis were conducted according to procedures described by Wen Qixiao *et al.* (1984).

RESULTS AND DISCUSSION

The organic matter and total nitrogen contents found in the seven sediment samples of the West Lake are listed in Table 1.

Table 1. Organic matter content and humic level in the sediment of the West Lake

location	Shaonian gong	Lake Beili	Lake Xili	Santan	Changqiao	Lake center	lotus area
OG(g.Kg^{-1})	198.0	203.3	168.5	220.1	205.4	219.0	202.8
IG(g.Kg^{-1})	266.6	256.7	221.0	307.7	252.5	285.8	264.1
TN(g.Kg^{-1})	10.2	11.3	8.8	12.6	11.2	12.2	8.6
IG/TN	26.14	22.72	25.11	24.42	22.54	23.43	30.71
Humic level	polyhumus	intermediate humus	polyhu-mus	intermediate humus	intermediate humus	intermediate humus	polyhumus

The ratio of organic content to total nitrogen can be used to classify lakes whose sediment IG is over 200 g/kg into three humic levels: oligo humic lake (IG/TN < 20), intermediate humic lake (20 < IG/TN < 25), and polyhumic lake (IG/TN > 25) (Hakanson and Janson, 1992). According to this classification, the West Lake is between intermediate humic and polyhumic lake.

Infrared spectra of humic acid and humic acid in the West Lake sediments are shown in Figure 2 and 3. The main absorption bands for fulvic acid occurred at around 3400cm^{-1} , 2920cm^{-1} , 1650cm^{-1} , 1550cm^{-1} , 1450cm^{-1} and 1100cm^{-1} (Fig. 1). The absorption bands of humic acid were similar to those for fulvic acid, except the absorption band at 1450 cm^{-1} was weaked (Fig. 3). These results coincide with the results reported by Ishwatari on infrared absorption bands of sediments and peat humic acid (Aiken *et al.*, 1985).

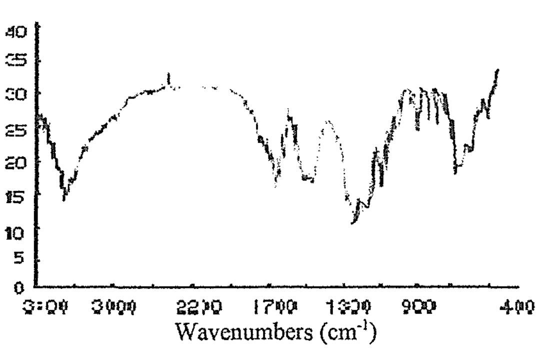

Figure 2. IR spectrogram of fulvic acid in the West Lake sediment

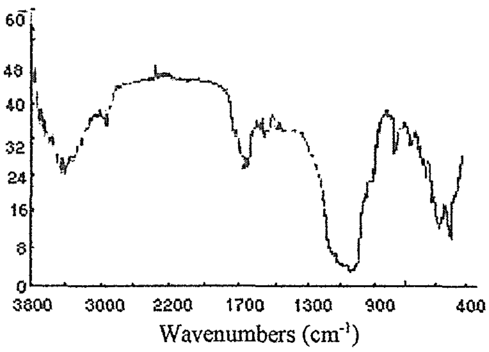

Fig.3 IR spectrogram of humic acid of West Lake sediment

Stevenson and Goh (1994) divided infrared spectra of humus into three types. I is a typical spectra of humic acid, II is a spectra of low molecular weight fulvic acid, and III is a spectra contained main absorption bands of type I and II, as well as absorption band at 2900cm^{-1} and 1540 cm^{-1}, indicating the existence of carbohydrates and protein.

The infrared spectrum of humic acid in the West Lake sediment agrees with band D taken from the sediment of Florida Lake, which according to the above classification on infrared spectra of humus, is typical of humus type III (Stevenson, 1994). These results prove that the West Lake sediment has bog and peat characteristics, and arises mostly from deposition *in situ*.

The E4/E6 ratio refers to the absorption quotient of humus at the wave length of 465nm and 665nm. As an index of humification, it can be used to describe humus feature. Namely, the molecular weight and condensation levels of humus increase with a decreasing E4/E6 ratio. Normally, E4/E6 ratios of soil humic and fulvic acid is around 3.0-5.0 and 6.0-8.5, respectively (Stevenson, 1994). For the West Lake (L. Xili) sediments, (after extraction by 0.05 mol NaOH solution) the ratio was 1.94. This is lower than normal soil humus, and is similar to the lower value found for sediment in Kunming Lake of Beijing (Wang *et al.*, 1995). This suggests that the humus in the West Lake sediment had a higher condensation level and longer duration, and thus a higher humification level.

The contents of each humus component are listed in Table 2a and 2b belows:

Table 2a. Carbon contents (g/kg) of humic substance components in the West Lake

Sample	Lipid	Humic acid				Fulvic acid				Disolved in	Humin
		Part I	PartII	PartIII	Total	Part I	PartII	PartIII	Total	0.1N, 1N H_2SO_4	PartIV
A	13.40	13.90		7.90	21.80	7.24		2.00	9.24	2.06	68.7
B	3.05	1.80	3.20	5.05	10.05	2.89		5.65	8.54	2.66	58.3
C	9.36	2.70		12.75	15.45	3.86	1.89	14.05	19.80	3.30	85.4

Table 2b. Components of humus (%) in the West Lake

Sample	Lipid	Humic acid (HA)				Fulvic acid (FA)				Disolved in	Humin
		Part I	PartII	PartIII	Total	Part I	PartII	PartIII	Total	0.1,1N H_2SO_4	PartIV
A	11.6	12.1	-	6.9	18.9	6.3	-	1.74	8.0	1.8	59.6
B	3.7	2.2	3.9	6.1	12.1	3.5	-	6.8	10.3	3.2	70.6
C	7.0	2.0	-	9.6	11.6	2.9	1.4	10.5	14.9	2.5	64.1

A: Lotus area (lotus planted) B: Lake Xiaonan (inlet of Qiantang river diversion works) C: Lake center

Part I: Free or combinded with sesquioxides, soluble in dilute alkali

Part II: Bound to calcium soluble in dilute alkali after calcium removal

Part III: Bound to stable sesquioxides ; soluble in dilute alkali after acid treatment

Part IV: Humin, firmly bound to inorganic colloid

Comparing the contents of humic acid and fulvic acid shown in Table 2a and 2b, significant differences in the contents for Part I and Part III in lotus area 1.8 and 3.6 times that for HA and FA, respectively. In samples from Lake Xiaonan and the lake center, Part III is greater than Part I by factors of 2.8 and 4.7 for HA; and 2.0 and 3.6 for FA, respectively. The lake center had the highest ratio of that of Part III : Part I, followed by L. Xiaonan, were the lotus area had the smallest ratio. This is due to residual plants in the lotus area altering the humus composition, resulting increase in Part I, thus decreasing the ratio of Part Ⅲ to Part I. Lake Xiaonan is situated at the inlet of Qianjiang river diversion project, and consequently is directly influenced by sedimint from the river, which also affect the humus composition of this lake. Therefore, the combined stability for humus and minerals in sediments in the three sample areas follow the order: Lake center > Lake Xiaonan > Lotus area.

In the humic acid column of the above tables, Part II represents the composition of humic acid bound to calcium. In Lake Xiaonan, this amounted to 3.9%, while in the lotus area and lake center, it was negligible. This indicates that the adjacent Qianjiang river was the source of calcium bound humus in the sediment of Lake Qiaonan.

A further destination between the different samples studied was in their lipid content, which included fatty acid, sterols, terpenes, polynuclearhydrocarbons, chlorophylls, fats, waxes, resins and so on. The lipid content of the lotus area sludge was higher than among the other samples and its benzene-alcohol extracts appeared dark green to brown. This shows that residual new organisms increase the lipid content in humus. The pigmentation comes mainly from the chlorophyll component. Humification processes could initially transform the chlorophyll component into phaeophytin, which are then transformed to comprise humus. The fact that Lake Xiaonan had the lowest lipid content reveals that the diversion project not only improves the water quality, but also changes the sediment composition.

Compared with the research by Ishwatari on the humus composition of Japanese lake sediments (lipid =5.8 $\pm$1.0%, humic acid =22$\pm$6%, fulvic acid= 25$\pm$5%, humin =47$\pm$3%), the humic acid and fulvic acid component in the West Lake sediment was lower, while the humin component was higher. The compositional ranking of these components: humin (59-71%) > humic acid (11-20%) > fulvic acid (8-15%) > lipid (3-12%). Composing the levels presented in Tables 2a and 2b, it is also apparent that in the West Lake were high.

CONCLUTION

1) West Lake is a high humic lake, based on the IG/TN value classification.
2) The humic acid in the West Lake sediment exhibited a typical infrared absorption band for lake sediment humus. Its E4/E6 ratio showd that the sediment had a high humification level.
3) Analysis of the humus composition suggested that the lotus growth increased the lipid and free HA and FA contents in sediment, therefore potentially increasing the release of nutrients. Results also indicated that the Qianjiang river diversion project has reduced the organic substances and changed the humus composition improving the eutrophication situation of the West Lake.

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