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Core Sampling with VCS and Implications of Cultural Eutrophication in Taihu Lake: A Preliminary Report*

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Abstract : *The lake sediments, especially in recent years, genuinely record human being ' s activities upon the lake environment. The top 30cm sections are of significance in the process of advanced cultural eutrophication and water quality deterioration. Based on the data of 4 core samples obtained in June 19-22, 1997, with VCS in northern, western and southern Taihu Lake, some preliminary results are reported. Further analyses on the physico-chemical items as well as element content may reveal more information of the accelerating cultural eutrophication.*
Keywords: *Lake sediment, cultural eutrophication, core sampling, Taihu Lake*

Taihu Lake, the third largest freshwater lake in China, is situated in the center of the 35000km^2 Changjiang River Delta. It covers an area of 2 350 km^2 with a mean depth of 1.86 m, a volume of 4.4×10^9 m^3. It is a polymictic lake with no seasonal stratification and no sustained hypolimnetic oxygen deficit (more than 24 hrs). The flushing rate is 309 days. Because of wind-driven circulation, the lake basin has a circular outline with a hard bottom and steep shore. Areas with sediments are usually found in the depositional zone on the eastern bank of the lake, the river convergence or in ancient creekbeds.

The Changjiang River delta is one of the developed regions in China. In recent years, with the development of economy around the Taihu Lake, human activities have had significant impacts on the ecology of the lake. Increased anthopogenic loading of untreated effluents from expansion in industry, agriculture and urbanization in the lake basin contribute to the accelerated eutrophication. Three major types of activities have remarkable impact on the ecology and trophic dynamics of the lake, i.e.: (1) the construction of dams and weirs in the waterways connecting the lake, (2) in-

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creased use of wetland and littoral zones, (3) booming pen-fish culture esp. in East Taihu Lake.

Taihu Lake is a multi-use water body. It currently serves more than 33 million people for drinking water, flood control, transportation, waste disposal, fishery, farming and tourism. The lake was once clear to the bottom in the 1950s, but dam construction, littoral conversion, reclamation, and overfishing resulted in the following changes in the ecology of the lake. The lake was oligotrophic in the 1950s to 1960s. Signs of advanced cultural eutrophication and deteriorated water quality have developed in recent years in many parts of the lake, esp. in Meiliang Bay, Wuli Lake where rivers and non-point sources carry large amounts of untreated effluent into the lake. Eutrophication conditions are serious particularly during the peak of the low water period in March. The "water bloom" occurrences often make water plants stop working. The purpose of this study is to report the nature of changes in the lake sediments, to discuss the mechanisms which the sediment contribute to the process of cultural eutrophication, to make feasibility analysis on the dredging engineering in certain areas.

1. Core Sampling

Sediment cores were collected from Taihu Lake in June 19-22, 1997 from four selected stations (see Fig.1). Core N_1(31°25′34″ N, 120°12′07″ E) and N_2(31°23′50″ N, 120°07′54″ E) are in the northern part of the lake. Core W_3(31°18′58″ N, 119°57′26″ E) is near the mouth of Dapu River, and Core S_4(30°58′46″ N,120°24′51″ E) at the juncture of East and West Taihu Lake.

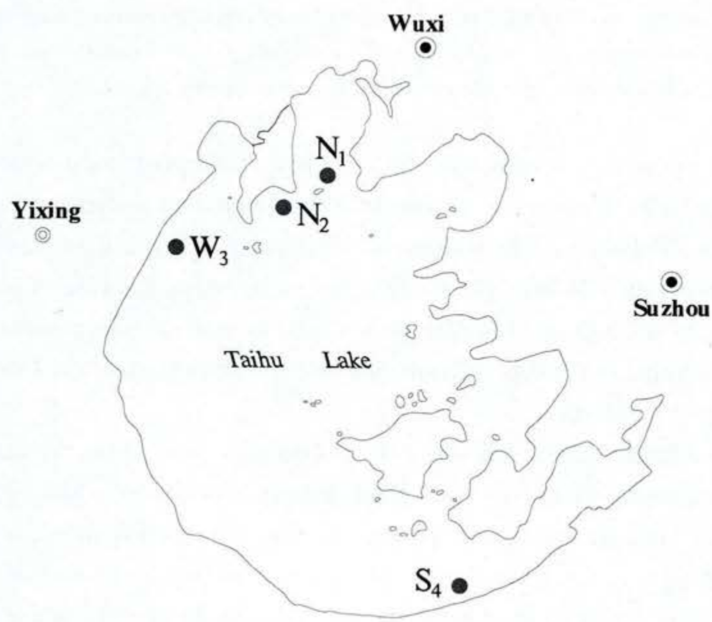

Fig.1 Core locations in Taihu Lake

Vibration Core Sampler (VCS) is used for the first time in Taihu Lake. It is a sampling machine for sandy/muddy soil or sediments investigation. Handy, convenient, and functional, it enables the efficient sampling in field works. The VCS system consists of air vibrator, clamps, sampling pipes of 4 m, N_2 gas cylinders and so on. For sampling in certain deep areas in Taihu Lake, divers were needed for better operation.

The SJ-1 Multifunction Soil Fertility Meter was used to determine some physico-chemical properties of sediments, such as pH, Eh, Conductance, and the contents of K^+,Cl^-,NO_3-N, NH_3-N, Phosphate, etc. The instrument uses various ion selective electrodes and chemical sensors developed by Institute of Soil Science, Chinese Academy of Sciences to quickly detect the ion concentration and contents of different properties of the samples(Institute of Soil Science, 1978).

2. Core Description

Subsamples of Core N_1, N_2 and S_4 were acquired by drilling at certain positions of the sampling pipes. The top 30cm column of Core W_3 was sectioned at 1cm intervals by extruding the sediment vertically.

Core N_1: 0 cm-22 cm, dark blue in colour, with macrophyte root remnants as well as micrbiota can be seen in the column; 22 cm—61cm, loess deposit in general.

Core W_3 section can be divided into 4 beds: Bed A, olive black, 15-20 cm , deposits resulting from wind/wave disturbance; Bed B, dark olive grey, 140 cm, silty fine sand; Bed C, greyish black, 200 cm, silty mud; Bed D, dark greenish grey, 35-40 cm, fine silt.

Core S_4: 0cm—46cm, dark blue, silty mud, with blackened remnants of macrophyte roots and stems.46cm-90cm, loess deposit.

3. Results and Discussions

Tab.1 Grain size distribution in different sections

Core No.	Percentage(%)				MS		SD		SK		KU		Mode
	3-4 φ	4-6 φ	6-8 φ	>8 φ	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	
N_1-1	0.04	37.76	31.70	30.50	7.045	6.984	2.173	1.906	0.255	0.321	0.796	1.811	4.500
N_1-2	0.01	34.25	33.44	32.30	7.237	7.148	2.198	1.874	0.240	0.272	0.820	1.780	4.500
N_2-1	0.00	25.60	55.48	18.90	6.911	6.929	1.375	1.356	0.184	0.458	1.154	2.802	4.500
N_2-2	0.00	13.08	41.87	45.05	7.962	7.883	1.750	1.572	0.129	0.069	0.810	1.929	4.500
N_2-3	0.01	39.13	38.64	22.22	6.741	6.768	1.775	1.647	0.337	0.634	1.011	2.384	4.500
N_2-4	0.03	61.69	27.17	11.11	5.931	6.061	1.345	1.401	0.493	1.401	1.476	4.388	5.250
S_4-1	0.01	34.28	40.19	25.52	6.887	6.928	1.756	1.634	0.202	0.408	0.931	2.171	5.250
S_4-2	0.01	34.14	37.93	27.91	7.003	7.007	1.986	1.755	0.287	0.414	0.952	2.032	5.250

(1) Results from graph calculation; (2) results by matrix method calculation.

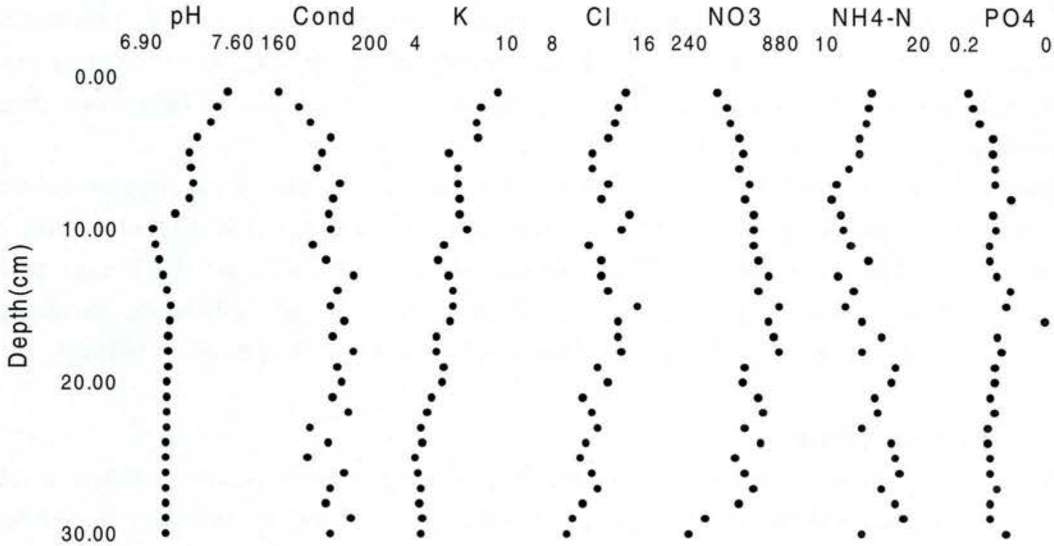

Fig.2 Some Physico-chemical indexes of sediments in the top 30cm of Core W_3

Increases in NO_4-N, Cl^-, K^+ and pH were found in the top 10 cm of surficial core W_3 samples (Fig. 2). The average depositional flux reported for the western Taihu lake is 0.08 $g \cdot cm^{-2} \cdot a^{-1}$ (Sun, *et al*, 1993). Because sediments resuspension and redistribution are significant in the open lake areas, the sedimentation rates may vary greatly within the lake depending on the location and physical environmental properties. From the *in situ* inspection, sediments from W_3 at the top 30cm may be divided into three sections: top 0-15 cm, olive black; 15-20cm, olive-black in color, resulting from mixing and redistribution from wind and storms; 20 cm below, silty fine sand with dark olive grey color.

Taihu Lake has undergone several major changes since its formation thousands of years ago. The lake size has shown an overall increase during the past 2 000 years (Sun, *et al.*, 1993), since the 1950s, the expansion was traversed as shallower areas being reclaimed for culturing purposes. Another primary factor that impacts the formation of the lake is the sea level transgression (William, 1996; Sun, *et al.*, 1993). Cultural influences, on the other hand, were generally in pace with the population increase in the lake area. At least three major types o human activities have had significant impact on the environmental change of the Lake: (1) engineering projects such as dam building and weir construction in the waterways to the lake; (2) reclamation and overfishing in the litteral zones and wetlands around the lake; (3) anthropogenic imputs, such as water from industrial and non-point sources from agricultural land areas. Needless to say, positive effects of flood control, GNP increase, were obvious. It was not until 1990s that mankind began to acknowledge the negatives, most of which have had far-reaching counter-effects and difficult to recover in a sense of ecological meanings.

The lake size has been reduced significantly since the 1950s due to the increased use of wetland

and littoral zones. It was not until the 1980s that the government took measures to stop such reclamation activities. Many small lakes were disappeared and the lake capacity for floodwater was severely reduced. Moreover, major ecological effects were becoming obvious. The aquatic vegetation coverage was reduced, many species depending on this environment have been declining. The combined effects of reclamation and dam & weirs building have significantly changed the tropic status and the fish population, species composition in Taihu Lake over the last 40 years.

The eutrophication questions, one of the major problems confronting Taihu Lake, were also becoming more and more serious with the increasing population and human activities, especially since the 1980s. During the 1960s and 1970s, the lake was generally oligotrophic and mesotrophic, observations from 1987-1988 revealed that a more eutrophic status was noted in the majority of lakes, as untreated effluents to the lake have increased substantially. It is likely that eutrophication in Taihu Lake is to be more severe than in other deep lakes receiving similar levels of enrichment because of its shallowness and strong nutrient resuspension. Unless integrated program be initialized, the lake's status would become more severely eutrophic. We are glad that the national government have taken measures to abate wastewater effluents to the lake in recent years, and some ecological measures such as sludge-dredging, aquatic vegetation restoration have going on. China now has taken sustainable development as basic principles for economic growth, we should be more optimistic that in the coming future a really clear Taihu Lake would return.

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