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Sedimentary record of hydrophobic organic compounds in relation to regional economic development: A study of Taihu Lake, East China

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PAHs, DDTs and PBDEs are still increasing in the Taihu Lake sediment.

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ABSTRACT

Sediment cores taken from Taihu Lake, East China were analyzed for polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides (OCPs) and polybrominated biphenyl ethers (PBDEs). The results showed a general sharp increase of HCH, DDT, PAH and PBDE concentrations in the surface layers, corresponding to a sedimentation time of 1980 and 1990 onward in the Meiliang Bay and Xukou Bay, respectively. The source of PAHs has largely transferred from petrogenic to pyrogenic origin, and good relationships were observed between sediment PAH concentrations and the regional gross domestic product. The sharp increase of DDTs in recent years may be related to the mobilization and migration of these chemicals from surface soil to lake sediment, as a result of enhanced soil run-off due to large scale land transform, as well as the contribution of current usage of dicofol and DDT-containing anti-fouling paints.

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1. Introduction

Lake sediments are recognized as a major sink for hydrophobic organic compounds (HOCs), such as polycyclic aromatic hydrocarbons (PAHs), organochlorine pesticides (OCPs) and polybrominated biphenyl ethers (PBDEs). These and other chemicals may enter aquatic systems through direct/indirect discharge, surface run-off and atmospheric deposition. Contaminated sediments can directly affect bottom-dwelling organisms and represent a continuing source for toxic substances in aquatic environments that may affect wildlife and humans *via* food chains (Kannan et al., 2005). Therefore, an understanding of the time trends of HOC accumulation in sediment is vital if we are to assess the current status of surface water quality and to enact management strategies. It is possible, however, to construct the chronological pollutant trends through the investigation of sediment cores, and also provides a useful way to elucidate the relationship between regional economic development and environmental pollution.

The use of sediment cores to reconstruct historical input of contaminants has been well documented in numerous studies (Hites et al., 1997; Hites and Zhu, 2005; Mai et al., 2005; Van Metre et al., 1997). On a global scale, sedimentary PAH displayed decreasing trends in the 1970s and 1980s (Hites et al., 1997; Simcik et al., 1996; Yamashita et al., 2000), owing to the transition from home heating with coal to the use of oil and natural gas, as well as the improved combustion efficiencies in power generation. However, sedimentary PAHs have actually increased in some fast developing regions, due to rapid urbanization and increasing demand for energy consumption (Lima et al., 2003; Liu et al., 2005; Van Metre et al., 2000).

OCPs are a class of persistent organic pollutants (POPs) that have aroused global concern due to their negative effect on human and wildlife. To date, OCPs application has been restricted or banned in most countries. Earlier studies on OCPs in dated sediment cores from a number of locations revealed a gradual decrease in overall concentrations in the 1970s and 1980s (Chen et al., 2002; Van Metre et al., 1997; Wong et al., 1995), obtained sedimentary profiles similar to their production and usage history. In those regions with large scale land transform, however, the accumulation flux of DDTs showed abnormal peaks around the 1990s, and wash-out DDTs from soil was considered to be a possible cause. Specific examples include the North Africa wetlands (Peters et al., 2001), the Pearl River Delta in China (Zhang et al., 2002) and the Mississippi River Delta in the

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United States (Santschi et al., 2001). PBDEs are a group of brominated compounds that widely used as flame-retardants in furniture and consumer products. The concentration of PBDEs in sediments have increased from the 1960s or 1970s to the 1990s in Europe, North America and Asia (Binelli et al., 2007; Chen et al., 2007; Hites and Zhu, 2005; Sakai et al., 2002; Song et al., 2005; Zegers et al., 2003). Although the use of penta- and octa-BDEs has been restricted in the European Union and in certain parts of the United States (Renner, 2004), a vast number of products containing PBDEs still remain in use. The distribution pattern, potential sources and fate of these pollutants in the environment are still of great concern.

The Yangtze River Delta is one of the most important economic engines of China, characteristic of fast urbanization and industrialization. The Taihu Lake basin, which is the heart of the Yangtze River Delta, is also an important grain production base in China and has a record of the highest pesticide application in the country. The basin covers only 0.4% of the total territory of the country, but contributes 3.1% of the national food production and 10% of the gross domestic product (GDP). With rapid economic development and population increase, man-made pollutants derived from household, agricultural and industrial activities have been discharged into the water, resulting in serious pollution and eutrophication in Taihu Lake.

In this study, two lacustrine sediment cores collected from Taihu Lake were analyzed for PAHs, OCPs and PBDEs. The regional HOCs pollution history was reconstructed based on the core analyse, and the relationship between HOCs pollution and regional economic development indexes was further investigated.

2. Experiment section

2.1. Site descriptions and sampling

Located in the southern part of the Yangtze River Delta, Taihu Lake (Fig. 1) is the third largest freshwater lake in China. The lake has a catchment area of 2340 km^2 and an average water depth of 1.9 m. Sediment cores were collected in Meiliang (ML) Bay, a typical algae zone, and Xukou (XK) Bay, a typical macrophyte zone. A plastic static gravity corer (8 cm i.d.) was employed to minimize the disturbance of the surface sediment layer. The core samples were sectioned at 1-cm intervals and immediately stored at −20 °C until analysis.

2.2. Sediment dating

Sedimentation rates were calculated from the unsupported ^{210}Pb activity and used to determine the year of deposition of each sediment layer. The procedure of sediment dating was described in detail elsewhere (Zhang et al., 2002). In summary, the ^{210}Pb activity concentrations in sediment samples were determined by analysis of the α-radioactivity of its decay product ^{210}Po, on the assumption that both are at equilibrium. The Po was extracted, purified, and self-plated onto Ag discs at 75–80 °C in 0.5 mol/L HCl, with ^{209}Po used as yield monitor and tracer in quantification. Counting was done by computerized multi-channel α-spectrometry with Au–Si surface barrier detectors. Supported ^{210}Pb was obtained by indirectly determining the α-activity concentration of the supporting parent ^{226}Ra, which was carried by co-precipitated $BaSO_4$. In this study, dates were calculated using a constant rate of supply (CRS) dating model, obtained an average sedimentation rate of 0.21 cm/yr and 0.31 cm/yr in the XK core and ML core, respectively.

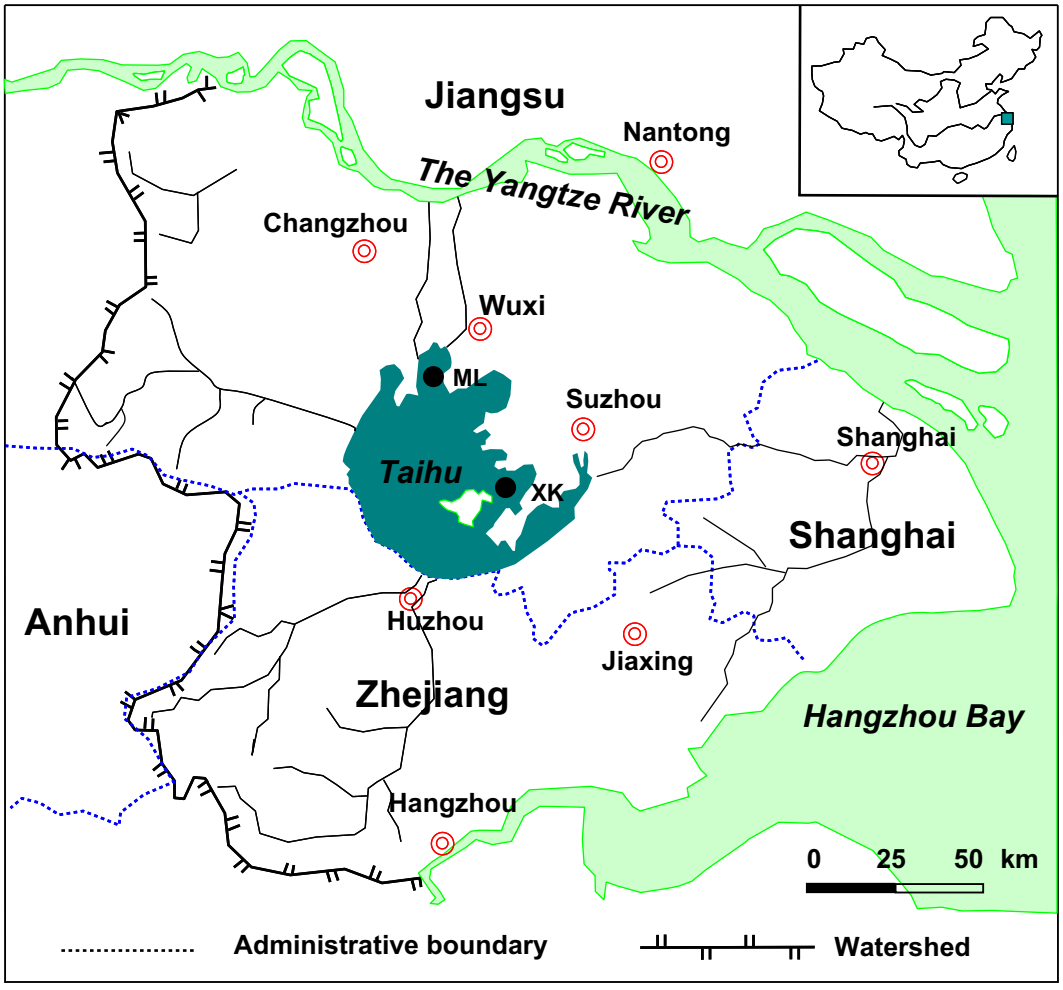

Fig. 1. Sketch map of Taihu Lake region with the sampling locations.

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