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RESEARCH ARTICLE

Spatial and temporal distribution and sources of polycyclic aromatic hydrocarbons in sediments of Taihu Lake, eastern China

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Abstract Spatial and temporal distributions of concentrations of polycyclic aromatic hydrocarbons (PAHs) in surface sediments and dated sediment core from Taihu Lake in eastern China were determined. The sum of concentrations of PAHs (sum of total 16 USEPA priority PAH (∑PAHs)) of the entire Taihu Lake ranged from 2.9×10^2 to 8.4×10^2 ng/g dry mass (dm). Concentrations of ∑PAHs in surface sediments near more urbanized regions of the lake shore were greater than those in areas more remote from the urban centers. Temporal trends in concentrations of ∑PAHs ranged from 5.1×10^2 to 1.5×10^3 ng/g dm, increasing from deeper layers to surface sediments with some fluctuations, especially in the past three decades after the inception of China's Reform and Opening Up Policy, in which China's economy and urbanization underwent rapid development. Forensic analysis of surface sediments indicates that PAHs originated primarily from combustion of grass/wood/coal except for the special function water area, which was most likely influenced by petroleum products of traveling vessels. Vertical profiles of relative concentrations of PAHs suggested that the contribution of lesser-molecular-weight PAHs was gradually decreasing, while due to the heavier consumption of petroleum products, the proportion of greater-molecular-weight PAHs was increasing. When assessed by use of the rather conservative, apparent effect threshold method, concentrations of ∑PAHs in sediments from most locations in Taihu Lake are predicted to pose little risk of harm to benthic invertebrates.

Keywords Polycyclic aromatic hydrocarbons · Sediment · Distribution · Source · Combustion · Risk · Asia

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Introduction

Polycyclic aromatic hydrocarbons (PAHs) are a class of complex organic priority pollutants that are ubiquitous in the environment. PAHs can originate from both anthropogenic and natural sources, such as production and combustion of petroleum, fossil fuels, and biomass (Guo et al. 2010; Ravindra et al. 2008). Due to their persistence, long-range transport properties, toxicity, carcinogenicity, and mutagenicity, PAHs are considered to be of concern as pollutant (Shi et al. 2007). PAHs have been studied in various environmental media, such as the atmosphere (Tsapakis and Stephanou 2005), surface water (Javier et al. 2012), soils (Wang et al. 2010), and sediments (Guo et al. 2013; Lin et al. 2011).

A body of water can act as a major sink (Lohmann et al. 2006) for PAHs in the environment. It can be significantly affected by the atmospheric PAHs through wet deposition, dry deposition, and gas exchange across the air–water interface (Qin et al. 2013). In aquatic environments, PAHs can be transported by the water column and accumulate in sediments, especially via association with sinking particles (Gogou et al. 2000), and accumulation phenomena dominate the degradation processes in sediments (Magi et al. 2002; Soclo et al. 2000). Meanwhile, PAHs in sediments can reenter the water column through physical, chemical, and biological processes (Wu et al. 1996; Yan et al. 2009; Zeng and Venkatesan 1999). As a result, sediments are not always the final destination but maybe a secondary source of PAHs in aquatic environments (Baumard et al. 1998; De Luca et al. 2004, 2005; Laflamme and Hites. 1978). Absolute and relative concentrations of PAHs in sediment cores can be useful in determining the status and trends of contamination as well as sources and efficacy of various treatment and remediation activities (Kannan et al. 2005; Soclo et al. 2000).

The Taihu Lake region located in eastern China, represents one of China's major economic and industrial developed areas coupled with a high population density. Over the last three decades, contamination of the Taihu Lake region has increased due to rapid economic development. Eutrophication has caused severe algal blooms, affecting the lives of nearby residents and restricting industrial production. Concentrations of PAHs have increased rapidly. Previous studies have been conducted in the northern part of Taihu Lake and collected both surface sediments and cores to determine the status and historical trends of loading of PAHs to the lake. Results of these studies indicated that PAHs originated largely from high-temperature pyrolysis (Qiao et al. 2006) and that concentrations of PAHs were positively associated with economic development (Liu et al. 2009). However, Taihu Lake, as one of the five largest freshwater lakes in China, and with a land area of 2,338 km^2, contains different water bodies classified for different functions, and development is not evenly distributed around the lake. Thus, previous studies assessed in only a limited area are cannot be used to describe the sources and distributions of PAHs both temporally and spatially across the entirety of Taihu Lake (Qiao et al. 2006) (Wenchuan et al. 2002).

The aim of this study was to provide overall understanding of concentrations and sources of PAHs in surface sediments of Taihu Lake, China. Another aim of this work was to construct the history of loadings and potential sources of PAHs, in order to put temporal trends into perspective and identify the possible sources. In addition, the relationships between concentrations of ∑PAHs and indices of regional economic development were investigated. A preliminary assessment of potential effects of concentrations of ∑PAHs on benthic invertebrates was also conducted by comparison to apparent effects thresholds.

Materials and methods

Description of sites and sampling

Both surface sediment samples and cores of sediments were collected. To minimize the disturbance of the surface sediment layer, 15 samples of surface sediments were collected from Taihu Lake by a grab sampler (Fig. 1), and cores of sediments were collected in Meiliang Bay by a plastic, static gravity corer (8 cm in diameter). The core were extruded and sectioned by the method of common vertical-type extruder used primarily for high-water content sediments (Glew 1988). Cores were sectioned at 1-cm intervals and samples wrapped in pre-cleaned aluminum foil, then transported on ice to the laboratory, where they were stored at −20 °C until further treatment.

Extraction and instrument analysis

Procedures for extraction of PAHs from sediments have been described previously (Guo et al. 2010; Mai et al. 2002). In brief, an aliquot (5–10 ng/g dry mass) of a freeze-dried, homogenized sample, spiked with a mixture naphthalene-d_8, acenaphthene-d_{10}, phenanthrene-d_{10}, chrysene-d_{12}, and perylene-d_{12} (0.2 μg/mL, J&K Chemical, Beijing, China) as recovery surrogates, were Soxhlet extracted with a 200-mL mixture of hexane and acetone (1:1, *v*/*v*) for 48 h. Approximately 2 g of activated copper was added for desulfurization. Extracts were filtered, concentrated, and solvent-exchanged to hexane. Cleanup and fractionation were performed on an alumina/silica gel chromatography column. The aliphatic and aromatic fractions were successively eluted with 15 mL hexane and 70 mL dichloromethane/hexane (3:7, *v*/*v*), respectively. The second fraction was concentrated under a gentle flow of high-purity nitrogen to 200 μL. Internal standards, fluorobiphenyl and terphenyl-d_{14} (2.0 μg/mL, J&K Chemical, Beijing, China) were added prior to quantification by instrumental analysis.

Separation, identification, and quantification of the PAHs were performed on an Agilent 6890 gas chromatograph system equipped with an Agilent 5975B mass selective detector operating in selective ion monitoring mode with a DB-5 capillary column (60-m length × 0.25-mm diameter × 0.25-μm film thickness). Splitless injection of 1.0 μL of the samples was conducted with an auto-sampler. The GC oven temperatures were programmed from 90 to 180 °C at a rate of 8 °C/min (held for 30 min). The quantified compounds are listed in Table 1.

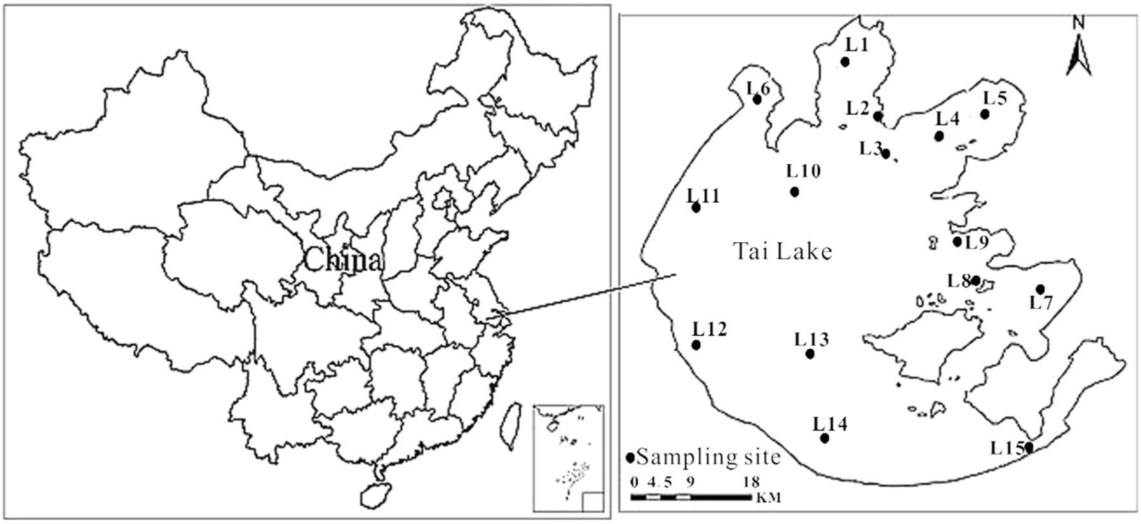

Fig. 1 Map of Taihu Lake and locations where the samples were taken

Quality control and quality assurance

Recoveries of surrogates from samples were as follows: 73.1±8.3 % for naphthalene-d_8, 85.6±8.2 % for acenaphthene-d_{10}, 82.7±10.4 % for phenanthrene-d_{10}, 87.0±12.2 % for chrysene-d_{12}, and 79.6±12.6 % for perylene-d_{12}. For method quality control, the field and laboratory blanks were analyzed. Mean recoveries of 16 target PAHs ranged from 75.8±4.6 to 112.2±8.1 % in the triplicate spiked blanks and from 61.1±1.1 to 116.9±8.5 % in the triplicate spiked matrices. Only trace levels of target PAH were detected in blanks and were subtracted from those in the sediment samples. Limits of detection (LOD) (defined as S/N >3), of individual PAHs were 0.01–0.02 ng/g dry mass (dm). All results were expressed on a dry weight basis and corrected for surrogate recoveries.

Table 1 Standard pollution criteria of ∑PAH components for sediment matrix (ng/g)

Compound	ERL (ng/g)	ERM (ng/g)	This study		
			Average (ng/g)	Maximum (ng/g)	Standard deviation
Naphthalene (Nap)	160.0	2,100.0	120.2	191.3	22.4
Acenaphthylene (Ace)	44.0	640.0	8.3	17.5	4.3
Acenaphthene (Ac)	16.0	500.0	7.9	14.9	2.3
Fluorine (Flu)	19.0	540.0	6.9	11.9	1.8
Phenanthrene (Phen)	240.0	1,500.0	40.3	63.8	10.4
Anthracene (Ant)	85.3	1,100.0	6.9	41.0	9.3
Fluoranthene (Fluo)	600.0	5,100.0	46.7	108.2	25.2
Pyrene (Pyr)	665.0	2,600.0	31.4	70.7	16.6
Benzo[a]anthracene (BaA)	261.0	1,600.0	ND	ND	ND
Chrysene (Chry)	384.0	2,800.0	22.2	63.1	14.2
Benzo[b]fluoranthene (BbF)	NA	NA	55.7	104.9	24.9
Benzo[k]fluoranthene (BkF)	NA	NA	16.7	28.4	7.1
Benzo[a]pyrene (BaP)	430.0	1,600.0	22.0	42.0	10.8
Indeno[1,2,3-c,d]pyrene (INP)	NA	NA	37.2	73.4	18.3
Dibenzo[a,h]anthracene (DBA)	63.4	260.0	6.6	12.7	3.1
Benzo[g,h,i]perylene (BghiP)	NA	NA	32.5	72.5	17.6
∑PAHs	4,022.0	44,792.0	461.3	841.8	148.8

NA not available, *ND* not detected

Statistical methods

Normality was confirmed by the Kolmogorov–Smirnov test; data were applied as required to fulfill ANOVA assumptions; and homogeneity of variance was confirmed by use of Levene's test. Descriptive statistics were estimated using the SPSS for Windows statistical package, version 15.0.

Results and discussion

Spatial distributions of concentrations of PAHs in surface sediment

Concentrations of PAHs in surface sediments can be used as an indicator of contemporary loadings of PAHs while concentrations in dated sediment cores can be used to assess historical inputs. Total concentrations of the 16 US EPA priority PAHs (∑PAHs) in surface sediments ranged from 2.8×10^2 to 8.4×10^2 ng/g dm, with a mean concentration of 4.6×10^2 ng/g dm.

Much work has been done on the PAH residual levels in lake sediment from China. The PAHs 16 content in the Taihu Lake sediment is lower than data reported in Lake Chaohu (908.5±1,878.1 ng/g) (Qin et al. 2014), Lake Dianchi (210.0–11,070.0 ng/g) (Zhao et al. 2014), and Lake Erhai (31.9–269.0 μg/g) (Guo et al. 2011), but higher than research in Lake Baiyangdian (189.9 ng/g) (Hu et al. 2010) and Lake Poyang (157.0±63.2 ng/g) (Lu et al. 2012).

The spatial distribution of ∑PAHs is illustrated in Fig. 2. The greatest concentration was found at location 6, which is located in the north area of Taihu Lake, followed by location 8 (7.0×10^2 ng/g dm) belonging to the eastern region and northeast region, respectively. The lowest concentration was found at location 13 (2.8×10^2 ng/g dm) in the center of the lake. It can be seen that the ∑PAH contents were much higher in the northeast region of the lake than the contents in the southwest. Moreover, ∑PAHs were higher in the areas around the lake than ∑PAHs in the center of the lake. There may be two reasons accounting for the spatial variation. First, sampling sites near the bank are easily affected by the urban runoffs from the cities nearby. Concentrations of PAHs are related to urban runoffs and sewage discharges, which has been proved in the previous studies (McDonough et al. 2014; Yan et al. 2009). Locations 6 and 8 are located near two cities, Wuxi and Suzhou, which are the most developed and urbanized areas of the region. Both industrial and municipal waste water is known to enter the lake from these locations; thus, the extreme ∑PAHs value can be found in sampling sites nearby. Second, sampling sites in the northeast lake may be influenced by atmospheric input. Water and sediment can be significantly affected by the atmospheric PAHs through wet deposition, dry deposition, and gas exchange across the air–water interface (Qin et al. 2013). Urban centers played an important role in determining spatial distributions of gaseous PAHs, and strong correlations had been reported between gaseous PAH concentrations with population (McDonough et al. 2014). It can be inferred that the atmospheric PAHs content is higher around Wuxi and Suzhou in the northeast of the lake. Therefore, sediments in locations 6 and 8 may suffer much heavier PAH deposition flux than the other sites in the lake.

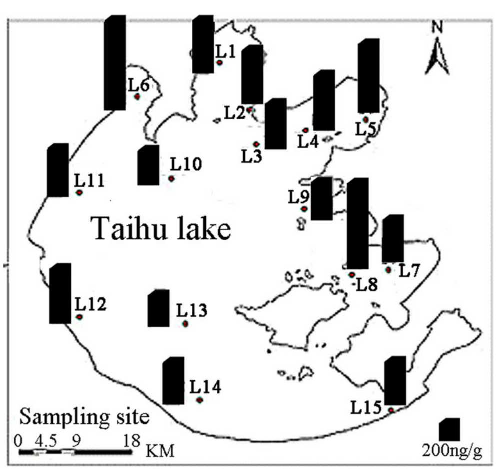

Fig. 2 ∑PAH concentrations in the surface sediment

Relative concentrations and sources of PAHs in surface sediments

PAHs are mainly formed during combustion processes or discharge of petroleum-related materials (Marchand et al. 2004; Ravindra et al. 2008). Lesser-molecular-weight (LMW) PAHs and alkylated PAHs are released both from discharge of petroleum and combustion, whereas greater-molecular-weight (GMW) PAHs are formed predominantly pyrolytically (Mai et al. 2002; Yan et al. 2009). Therefore, comparing patterns of relative concentrations of PAHs' classified by the number of rings they contain is a preliminary mean to determine potential sources of the PAHs. As shown in Fig. 3, the percentage of GMW (4-6 ring) PAHs was greater than those of the LMW (2-3 ring) PAHs in most locations, with the exceptions of locations 10, 13, and 14. The least percentage was found at location 8 (28.7 %), and the greatest was found at location 10 (87.1 %). In the north part of Taihu Lake, the percentage of concentrations of LMW PAHs in proportion to the ∑PAHs at locations 1, 2, 3, 4, 5, and 6 were similar, ranging from 31.5 to 39.9 %. In the east and west areas of the lake, the percentage of locations 7, 9, 11, 12, and 15 were within the range of 39.4–50.0 %. At locations 13 and 14, LMW PAHs, respectively, accounted for 53.3 and 54.6 %. Therefore, LMW PAHs were dominant only at locations 10, 13, and 14. These three locations are all located near the waterway, where there are large numbers of diesel vessels

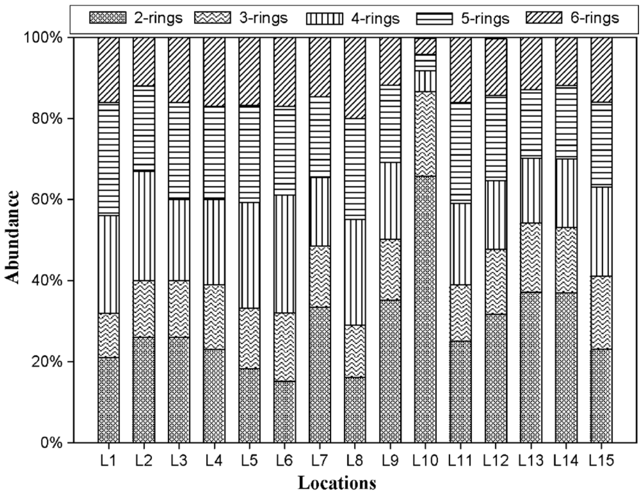

Fig. 3 Distribution of 2-, 3-, 4-, 5-, 6-ring in the surface sediment

traveling from south to north. Therefore, the LMW PAHs dominating in surface sediment were strongly influenced by waterway transport.

LMW PAHs and GMW PAHs are used to identify possible sources of pollution, in which a ratio of LMW/GMW <1 suggests a pyrolytic source, and LMW/GMW >1 suggests a petroleum source. In addition, isomer pair ratios are usually used to identify possible sources in sediment (Guo et al. 2011; Tang et al. 2011; Viñas et al. 2010; Yunker et al. 2002). The ratio of An/(An + Phen) <0.10 indicates the predominance of petroleum, and >0.10 indicates predominance of combustion; FlA/(FlA + Pyr) <0.40 is attributed to petroleum source, while >0.50 suggests grass/wood/coal combustion, and 0.40 < FlA/(FlA + Pyr) <0.50 suggests petroleum combustion. Finally, InP/(InP + BghiP) <0.20 suggests petroleum source, >0.50 suggests grass/wood/coal combustion, and 0.20 < InP/(InP + BghiP) <0.50 suggests petroleum combustion.

As shown in Fig. 4, pyrolytic sources were dominant in most locations, while fewer were the result of a combination of pyrolytic and petroleum sources, and locations 10, 13, and 14 were all largely influenced by petroleum. All the ratios of FlA/(FlA + Pyr) and InP/(InP + BghiP) were greater than or close to 0.5, indicating that the PAHS input into sediment originated from combustion of grass/wood/coal. In addition, the ratios of An/(An + Phe) indicated that PAHs in surface sediment were the result of a mixture of pyrolytic and petroleum sources, since pyrolytic sources are dominant in locations near the lake shore (locations 1, 2, 3, 4, 5, 6, 8, and 11). Especially on the north shore, these locations are near residential areas, and thus are largely influenced by human activities. Furthermore, the ratio of LMW/GMW >1 at locations 10, 13, and 14 indicated that petroleum sources are dominant at these three locations. The reason for this was that the three locations are near the waterway, where petroleum products sometimes leak during shipping.

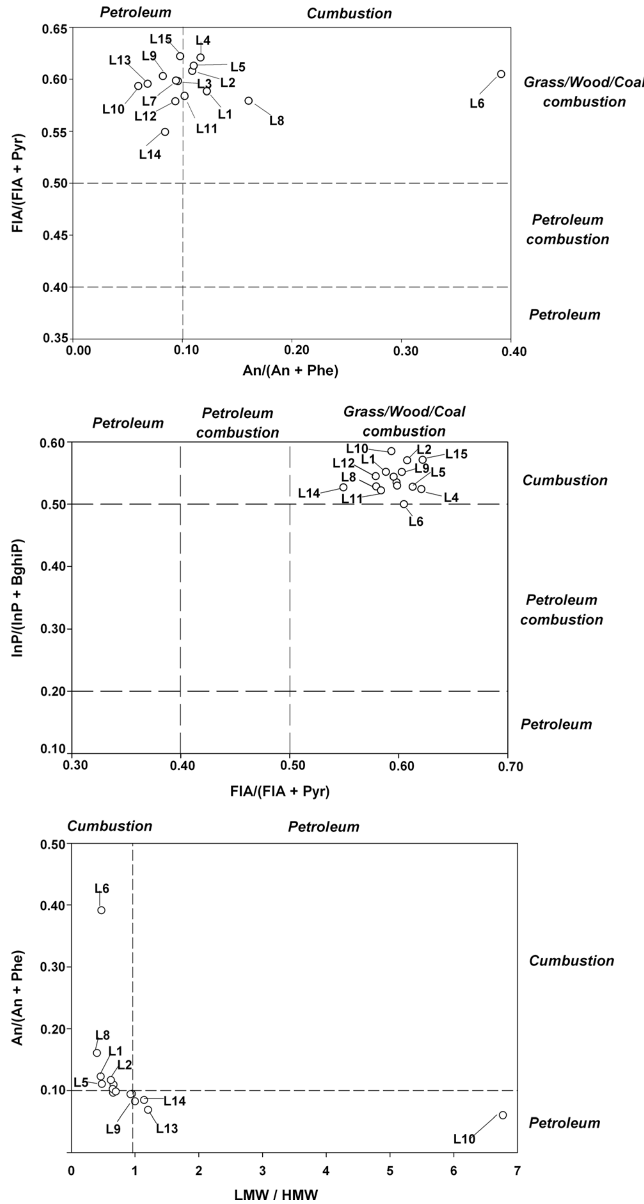

Fig. 4 PAH cross-plots for the ratio An/(An + Phen) versus FlA/(FlA + Pyr) (**a**), FlA/(FlA + Pyr) versus InP/(InP + BghiP) (**b**), and LMW/GMW versus An/(An + Phen) (**c**)

Sources of PAHs in surface sediment from Taihu Lake are mixed, which is consistent with results of previous studies, in which single sources do not always conform to the "ideal," and most environmental samples contain PAHs originating from mixed sources (Yunker et al. 2002). However, in Taihu Lake, sources of PAHs can be classified into two categories. First, grass/wood/coal combustion was dominant at most locations, which were located near the lake shore and thus influenced by local residents, and second, leaking of petroleum products was dominant at locations 10, 13, and 14, which were near waterways.

A cluster analysis (CA) was conducted to further illustrate the dominance of each congener and the similarity of each sampling site as shown in Fig. 5. Four clusters were employed. The first cluster contained locations 7, 9, 13, and 14. The composition and quantity of congeners in this group were similar for all four sites. The second cluster included locations 1, 2, 3, 4, 11, 12, and 15. These sites were located in the south of the lake, and the composition and quantity of this group were similar for first cluster, and those sites were near bank of lake. The third cluster included locations 5, 6, and 8, and concentration of PAHs in this cluster was higher than other clusters. Another cluster contained only one sampling site, location 10, and this site was more near the central of the lake. So CA provided a useful approach for comprehensive classification. We could clearly distinguish which sampling sites belonged to one cluster, and the result of cluster analysis is consistent with above suggestion of forensic analysis of surface sediments.

Temporal trends of ∑PAHs in sediment core

For the sediment core collected from location 1 in Meiliang Bay, the average rate of sedimentation was 0.31 cm/year (Liu et al. 2009); thus, a 1-cm depth represented a period of 3 years. Temporal trends in concentrations of ∑PAHs were examined (Fig. 6). The concentration of ∑PAHs ranged from 5.1×10^2 to 1.5×10^3 ng/g dm, with a mean of 8.9×10^2 ng/g dm, and two clear peak-time periods are observed in the mid-1950s and 1980s, respectively, a fluctuation which is similar to previous studies performed in other regions of China (Liu et al. 2005; Yan et al. 2009).

The fluctuation of the temporal trend can be explained by local economic development. Since the founding of the People's Republic of China, China, has undergone a great economic development, especially since its economic reform in the late 1970s. Furthermore, PAHs are good indicators of human activities in general; thus, there is often a correlation between concentrations of ∑PAHs with economic development as determined by GDP. The first peak-time period in the 1950s might correspond to the rapid development of the quality of life (including economy and population) in the First Five-Year Plan (1951–1955) after the founding of the People's Republic of China (Fig. 6). Comparing this with the second peak-time period in the mid-1980s, the Taihu Lake region has undergone rapid economic development in the past three decades, especially in Jiangsu Province, which is one of the most developed provinces around the lake, has a flourishing economy, and the greatest urbanization in the region. Therefore, the second peak-time period is likely associated with rapid economic growth and urbanization since reforms to the economic system of China begun in the late 1970s.

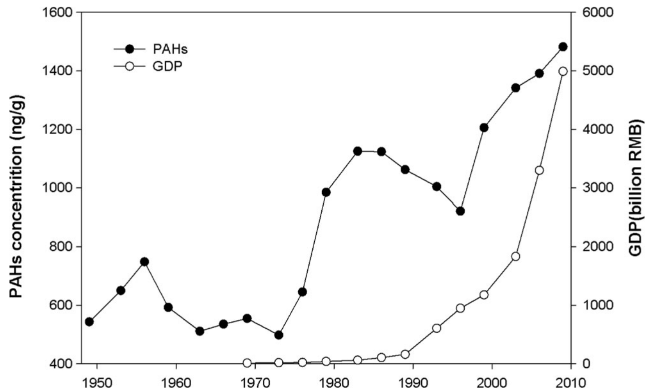

Fig. 6 Time trends of ∑PAH concentrations in the sediment core versus GDP (Wuxi Municipal Statistical Bureau 2013)

The temporal trends of the 2-3 and 4-6 ring PAH concentrations in the sediment core are shown in Fig. 7. The concentrations of three patterns all show an upward trend with a fluctuation. The 2-3 ring PAHs ranged from 3.3×10^2 to 7.3×10^2 ng/g dm, and 4-6 ring PAHs ranged from 0.9×10^2 to 7.8×10^2 ng/g dm. The trend of concentration variation of the 2-3 and 4-6 ring PAHs is similar to that of the ∑PAHs, especially in that the 2-3 ring PAHs showed an upward trend in volatility. However, the concentration of 4-6 ring PAHs was very small and did not undergo significant changes before the late 1980s and has risen sharply since the 1980s. In terms of the ∑PAHs, the percentage of 4-6 ring PAHs increased from 12.27 to 50.78 %, and the contribution of 2-3 ring PAHs gradually declined. As mentioned above, the high temperature combustion of fossil fuels is usually characterized by a dominance of PAHs with GMW (Magi et al. 2002; Soclo et al. 2000). For example, BbF is a product of high-temperature combustion, and INP and BghiP are tracers of vehicular emission (Harrison et al. 1996; Mai et al. 2003). The change of the PAH composition in the cores indicates that throughout a very long period of time, the PAHs flowing into Taihu Lake were dominated by the biomass burning and domestic coal combustion processes, and in recent years, the ever increasing

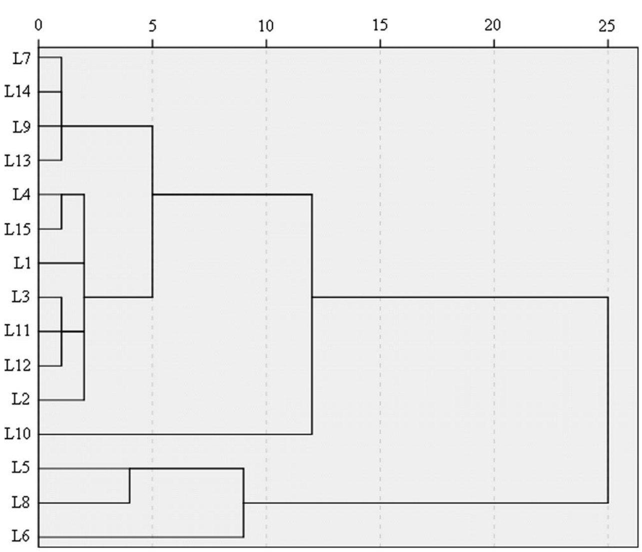

Fig. 5 Cluster analysis of sampling sites

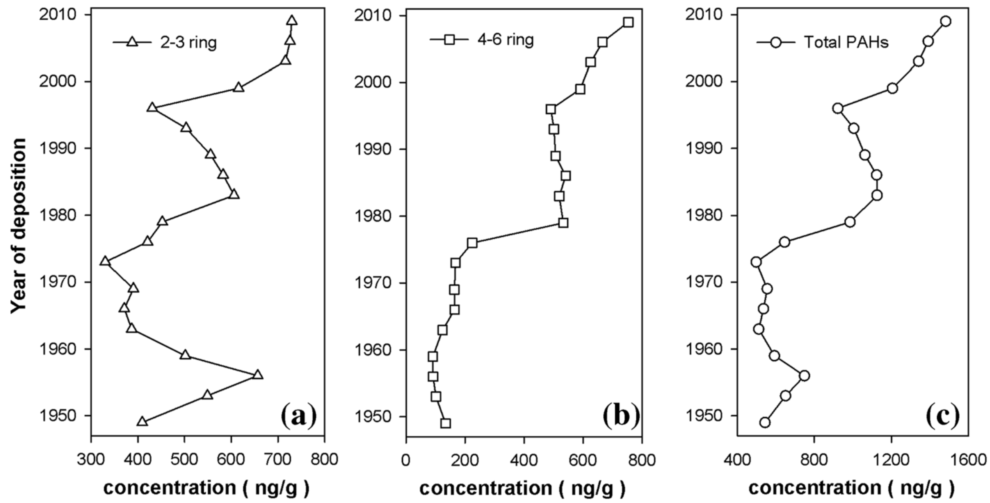

Fig. 7 Concentration variation of 2-3 ring (**a**), 4-6 ring (**b**), and ∑PAHs (**c**) in the sediment core

vehicular combustion emission has also contributed a portion of the PAH inputs, which is similar to the results of previous studies performed in other regions (Guo et al. 2010; Yunker et al. 2002).

With the rapid economic development, the Chinese people's lifestyle has undergone a large number of changes, especially the rapid increase in the amount of civilian vehicles and consequent consumption of petrochemical products beginning in the 1990s. Previous studies performed in other regions have confirmed that the PAHs deposited onto sediments are dominated by PAHs associated with biomass burning and domestic coal combustion. However, increasing vehicular and industrial coal combustion emissions also contributed a significant portion of the PAHs (Guo et al. 2010). Comparing the concentration of GMW PAHs with the amount of civilian vehicles may reflect the relation of contamination of PAHs and fossil fuels combusted by automobiles (Jiangsu Municipal Statistical Bureau 2013). As shown in Fig. 8, the GMW PAH concentrations increase rapidly in accord with the amount of automobiles since the 1990s. In more recent years, there has been a decrease in the rise rate of GMW PAH concentrations, which may be due to the fact that a series of automobile emission standards was later promulgated in China. Previous studies have proven that the production process of PAHs from gasoline automobiles depends on many factors, such as fuel type and quality and driving style (Ravindra et al. 2008; Westerholm and Li 1994). Thus, improvement of emission standards would contribute to the reduction of the GMW PAH concentrations but would need to be balanced against the number of vehicles in use.

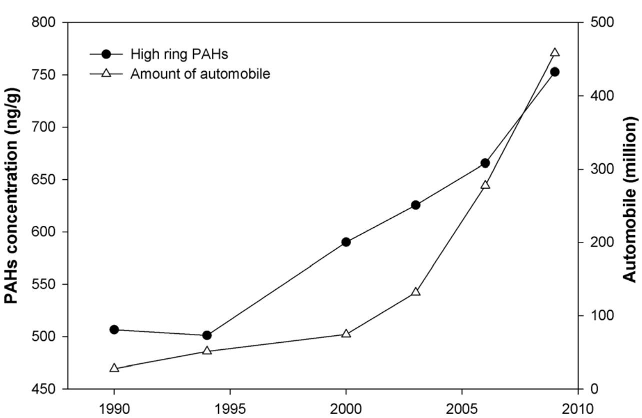

Fig. 8 The 4-6 ring PAH concentrations in the sediment core versus amount of automobiles (Jiangsu Municipal Statistical Bureau 2013)

Assessment of sediment quality using biological thresholds

The apparent effect threshold (AET) method was used to assess the hazard of PAHs in sediments to benthic invertebrates. In the AET method, the effects range low (ERL) and the effects range median (ERM) values were ranked from lesser to greater in terms of effects (Long and Macdonald 1992; Long et al. 1995; Long and Morgan 1990), and concentrations of PAHs measured in sediments were compared to the ERL and ERM (Table 1). In order to make the results more intuitive, hazard ratios (HRs) were used to assess the

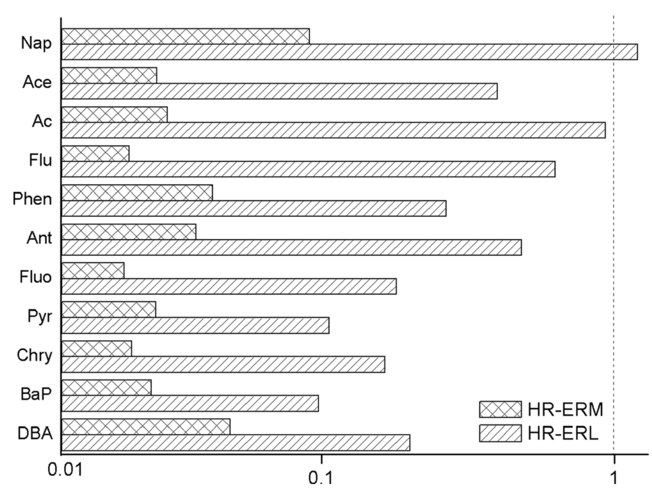

Fig. 9 Hazard ratio of individual PAHs on surface sediments

ecological risks of the PAHs. The HR-ERL and HR-ERM, respectively, correspond to HR of ERL and ERM, i.e., the ratio between concentration of contamination and effect range value. When the concentration of contamination was less than the ERL (HR-ERL <1), it was concluded that the sediments should not adverse effects to benthic invertebrates; when the concentration was greater than the ERL but less than the ERM (HR-ERL >1, HR-ERM <1), potential effects on benthic invertebrates would be indicated; and when concentrations of contaminants were greater than the ERM (HR-ERM >1), this would indicate potential for serious deleterious effects.

Concentrations of ∑PAHs at all sites were less than the ERL (Fig. 9). Also, the HR-ERM of individual PAHs did not exceed 1.0 at any of the sites, which indicates that PAHs in sediments at none of the locations would be expected to cause adverse effects on benthic invertebrates. However, the HR-ERL for naphthalene at location 10 exceeded 1, indicating that the naphthalene at that location might have some effects on benthic invertebrates. Location 10 was the site which was located near the waterway; thus, its potential biological impact may have been affected by the shipping industry. The AET approach suffers from many limitations. First, it does not account for the effects of co-occurring contaminants and thus probably overestimates the potential for effects associated with a single compound like an individual compound or a class of compounds like ∑PAHs (Baudo 1990; Giesy and Hoke 1990). Thus, due to the uncertainties of the AET approach, the true toxicity of the mixtures of contaminants in sediments of Taihu Lake could be greater or lesser, depending on the relative proportions of contaminants present in Taihu Lake relative to those present in sediments used to develop the AET. This uncertainty could be minimized by conducting some bioassays with sediments from various regions of Taihu Lake.

Conclusions

Results presented here suggest that concentrations of ∑PAHs in surface sediments of Taihu Lake were of the same order of magnitude as other regions of China, and concentrations near urbanized regions were greater than those in more remote areas. The sources of PAHs in most areas were dominated combustion of biomass and domestic coal, with few areas influenced by petroleum. Concentrations of ∑PAHs increased from deeper layers to the surface of sediments, with some fluctuations. Based on the association between concentrations of ∑PAHs and GDP of China, loading of PAHs to Taihu Lake coincided with economic development of the area around Taihu Lake. The proportion of GMW PAHs has been gradually increasing since the 1980s. Based on comparison to the apparent effects threshold current concentrations of PAHs in most areas should pose little harm to benthic invertebrates.

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