Polymeric Aromatic Hydrocarbons in Sediments and Mussel Tissue from the Lower Tennessee River and Kentucky Lake

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ABSTRACT
Sediment and freshwater mussel tissues were used to evaluate distribution and bioaccumulation of polynuclear (polyaromatic) hydrocarbon (PAH) compounds in the lowermost Tennessee River and Kentucky Lake. The target analytes included napthenols, phenanthrenes, anthracene, benz(a)pyrenes, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, benzo(b)chrysene, benzo(j)fluoranthene, and benzo(a)pyrene. Surface sediments (0-5 cm depth) from four locations in the lowermost Tennessee River and five locations in Kentucky Lake were analyzed for target PAH compounds to determine spatial distributions. A sediment core from Ledbetter embayment in Kentucky Lake was analyzed to describe vertical distribution of the compounds. Freshwater mussels (Unio fabula) collected from the lowermost Tennessee River and Kentucky Lake were analyzed and examined for bioaccumulation. PAH compounds were detected in all sediments and mussel tissues. PAH concentrations ranged from 0.01 (detection limit) to 90.4 ng/g dry wt in sediments and 0.02 (detection limit) to 253 ng/g dry wt in mussel tissue. Considering spatial distributions of PAHs in the sampling sites, there was no clear difference found between Kentucky Lake and the lowermost Tennessee River. Accumulation patterns of PAH species in sediment and mussel tissues exhibited the following order: Naphthalene > Phenanthrene > Fluoranthene > Pyrene > Acenaphthylene > Benzo(a)pyrene > Benzo(b)fluoranthene > Benzo(k)fluoranthene > Benzo(j)fluoranthene. The results revealed that 68.2% (m/m) were non-carcinogenic PAHs, whereas 31.8% (m/m) were carcinogenic in Kentucky Lake and the lowermost Tennessee River. In comparison with other freshwater ecosystems, PAH concentrations in Kentucky Lake and the lowermost Tennessee River were low.

KEY WORDS: PAHs, sediments, mussels, lower Tennessee River, Kentucky Lake

INTRODUCTION
Polyaromatic hydrocarbons (PAHs) are hydrophobic organic contaminants and identified by the United States Environmental Protection Agency (USEPA) as priority environmental pollutants (EMAP, 1992; Montzka and George, 1995). PAHs are formed from the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances and result from both anthropogenic and natural activities (Buchheit and Christensen, 2004; Lee et al., 2004; Olivar et al., 2004a, 2004b). The release of PAHs into the environment through human activities continues to increase (Brenner et al., 2002; Hooij et al., 2003; Fernandez et al., 2003; Hufner et al., 2003). PAHs can enter surface water through deposition of airborne PAHs, discharge of municipal waste water, runoff from urban storm water and coal storage areas, wood treatment plants and other industries, oil spills, and petroleum processing (Buchheit and Christensen, 2004; Olivar et al., 2005; Chen et al., 2006). Because PAHs are non-polar, hydrophobic, and relatively stable, they tend to accumulate in environmental and biological matrices and exert toxic effects (Carpenter et al., 2002; Cornellissen et al., 2006).

Environmental contamination by PAHs has become a great concern due to their distribution in water and sediment and bioaccumulation in terrestrial environments as well as in aquatic plants, fish, and invertebrates (Farmer et al., 2003; Mette and Mahler 2004; Nakata et al., 2003; Zabaria et al., 2003). Although a large volume of literature is available on the levels of PAHs in sediments and aquatic organisms from natural lakes, coastal, and eutrophic environments, very limited information is available on the PAH levels in man-made reservoirs or lakes. Maruya et al. (1997), Mette and Mahler (2004), Nascimento (2002), Vintzileou et al. (2004), Zhang et al. (2005).

Kentucky Lake is the largest man-made lake in the southeastern United States (Fig.158)
It was created and used for multiple purposes, including generation of hydroelectric power, flood control, water supply, recreation, and transportation. Very limited information is available on the contamination levels and bioaccumulation of organic contaminants including PAHs in this Kentucky Lake ecosystem. The present study was conducted to describe the levels and accumulation pattern of PAHs in sediment and mussel tissues collected from Kentucky Lake and the lowermost Tennessee River.

**EXPERIMENTAL METHODS**

**Field Sampling**

The sampling sites included Kentucky Lake: Lake mooring site (TRM 23.1), И.3 Bridge (TRM 20.8), near the Air Products outfall (TRM 17.7), near the Atolna outfall (TRM 15.2), Cypress Creek mouth (TRM 10.1), and Ledbetter Embayment (Figure 1, Tables 1, 2). The Kentucky Lake mooring site is used for parking large barges. The Ledbetter Embayment site was located away from the mainstream of Kentucky Lake; therefore, the sediments in the embayment were expected to be less disturbed. The sediments of these sites were analyzed to describe vertical distributions of PAHs and to reveal the historical record of the accumulation of these compounds. The surface sediments (top 0.5 cm section) from the above sites were expected to represent recent inputs of PAHs at each site. PAHs data from these sites were used to describe spatial variation of PAHs in Kentucky Lake and the lowermost Tennessee River (Kentucky Dam Tailwater).

Surface sediments (0.5-5 cm) and mussel samples (grab samples) were collected by SCUBA diving. Four sediment samples from Ledbetter Embayment and five sediment samples from the lowermost Tennessee River were collected. Sediments were stored in pre-cleaned 1-Lm glass bottles and kept at -20°C until further analysis. The mussel samples were identified to species. The ages of the mussels were determined by counting shell growth rings. The mussel tissues were separated from shells, and tissues of the same species that were collected from the same sampling site were pooled and transferred into pre-cleaned 1-Lm bottles. A 40 cm long sediment core was collected at Ledbetter (LE) site using a custom-made iron core sampler equipped with a stainless steel inner liner (length: 90 cm, internal diameter: 7.5 cm). The core was cut into 2.5 cm sections using pre-cleaned stainless steel knife and each section was transfer to a pre-cleaned wide-mouth 1-Lm glass bottles and kept at -20°C until further analysis. All samples were...
freeze-dried for 60 h using a FreezeDry System (Model: 78555) and stored at 4°C until analysis.

**ANALYTICAL PROCEDURE**

PAHs were analyzed following the procedure described by EMPA (Environmental Monitoring and Assessment Program; 1982) and Maruya et al. (1987). About 20 g of freeze-dried sediment samples were Soxhlet extracted using 225 mL of a 5:1 v/v ratio of dichloromethane/hexane (pesticide grade, Fisher Scientific® optima, Fisher Scientific®) mixture for 16 hours. The extract was concentrated to 10 mL using a Rapid Vap Evaporation system (Labconco Model 7610000). Analytes were transferred to hexane by repeating Rapid Vap concentrations twice after adding 100 mL of hexane (optima, Fisher Scientific®) each time. The sample extract was further concentrated to 5 mL using a stream of ultra high purity nitrogen gas to evaporate the solvent. To separate the PAH compounds, silica-gel column chromatography was carried out to remove interfering organic and polar species. 1.5 g of silica gel (Wako Pure Chemicals Industries, Japan) was activated by heating at 130°C in an oven for 3 h. The silica gel was immediately added to 20 mL of ultra pure hexane (BD® GC®, Burdick & Jackson, USA) and packed in a 10 mm i.d. glass column. About 3 g of anhydrous sodium sulfate (certified A.C.S., 10-60 mesh, Fisher Scientific®) was then added on top of the silica gel to remove any water that might have been in the sample. The sample extract was loaded on the column and eluted with solvents: two different fractions, F1 and F2, were taken from the column. The first fraction (F1) containing low molecular weight PAHs was eluted with 120 mL of ultra pure hexane. The second fraction (F2) containing most of the high molecular weight PAH compounds was eluted with 130 mL (50% v/v) dichloromethane/hexane. F1 was concentrated using a Rapid Vap concentration apparatus to 10 mL followed by nitrogen gas evaporation to 0.1 mL and then analyzed by High Performance Liquid Chromatography with Fluorescence Detector (HPLC-FD). F2 also was concentrated to 0.1 mL similar to F1. Freshly activated copper (granular, 99%, Lancaster) was used to remove elemental sulfur in the sample extract. The extract was analyzed using HPLC-FD. To analyze PAH compounds in residual tissue, 5 g of freeze-dried sample was extracted and purified in the same manner as for sediment samples. However, after Soxhlet extraction, lipids were removed from the freeze-dried residue.

<table>
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<tr>
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</table>

* Values in parentheses indicate number of specimens pooled for analysis.

**Table 2.** Details of animal samples collected from the lowermost Tennessee River and Kentucky Lake.
using Floridol column chromatography. For each sample, 200 g (± 5 g) of Floridol (σ,σ,σ-trichlorobenzene, Fisher Scientific, PA, USA) was packed into a 25 mm i.d. glass column. The extracted sample was then added into the column. A gentle stream of nitrogen gas was passed through the column to remove hexane. Then, 150 mL of a 4:1 v/v ratio of methanol/nanopure water (pesticide grade, Fisher Scientific)/deionized water washed with hexane/methanol mixture was passed through the column. The eluate was collected on 100 mL of hexane (Optima, Fisher Scientific) in 900 mL of nanopure water in a separatory funnel. The mixture was shaken for 15 min. After removing all lower water layer the sample extract was washed twice with 100 mL of nanopure water for 15 minutes. The organic layer was separated and then reduced to a 5 mL volume using Rapid Vap system. After lyophil removal, the extract was further cleaned using silica gel column chromatography in the same manner as sediment samples. PAH compounds were analyzed using a Shimadzu HPLC (Model: SCL-10A VP) system interfaced with a Shimadzu auto-injector (Model: SIL-10AD VP). The HPLC was equipped with a fluorescence detector (Model: RF-10AXL). The column (Prep@ (18 x 5 mm, 150 x 4.6 mm) condition program began isocratic elution for 4 min using methanol/water (4:6) (v/v) at 1.5 mL/min flow rate, then linear gradient elution to 100% acetone over 27 min at 0.4 mL/min flow rate. Seven different PAHs (Naphthalene, Phenanthrene, Anthracene, Benzo[b]fluoranthene, Benzo[a]anthracene, Benzo(a)pyrene) were quantified in the samples. To determine retention times of the individual PAHs, pure standards were injected into the HPLC-FTD. The retention times obtained were used to identify the PAHs in the standard mixture. Five different concentrations of the standard mixture were injected in order to obtain calibration curves of the target PAHs. The mean slope (response factors) and r² values were calculated for individual PAHs. The PAHs were identified in the sample extract by comparing the retention time from the standard mixture and quantified using the response factors.

Quality assurance and quality control protocols were followed to evaluate the reliability of the data. The approach method was used to calculate the detection limits. The area of baseline noise at 3 times the standard deviation of the baseline noise was divided by the slope of the calibration curve. Reagent blank was used to check laboratory contamination. The concentration of analytes detected in the reagent blank was less than the method detection limit. Also the relative accuracy of the method was determined using Standard Reference Material-1941b and 1974a in which 100 ± 30% of the known certified material was obtained. Calibration and calibration verification (five-point calibration with r² = 0.995) were checked routinely.

RESULTS
Spatial Distribution of PAHs in the lowermost Tennessee River and Kentucky Lake

Total PAHs data presented in this study is the sum of seven PAHs measured. Among the surface sediment samples (Figure 2), the samples from the rooting site in Kentucky Lake (TRM 231) exhibited the highest total PAH concentration (265 ng/g dry wt.). Followed by samples collected near L-24 bridge or TRM 10.1 (995 ng/g dry wt). The lowest total PAH concentration (150 ng/g dry wt) was found in samples from the Ledbetter site L1.

Among the various PAHs measured, naphthalene and phenanthrene were found in most of the surface sediment samples from the lowermost Tennessee River and Kentucky Lake (Figure 2). However, benzo(a)pyrene was found to have the highest concentration at Ledbetter site L4 in Kentucky Lake (Figure 7). Naphthalene concentrations ranged from below detection limit (BDL) (<1.72 ng/g dry wt) to 387 ng/g dry wt. Naphthalene was also found to have the highest concentration at the rooting site in Kentucky Lake followed by sediments collected from the area around the Air Product outfall (TRM 117). Phenanthrene concentra-
tion ranged from 3.21 to 90.4 ng/g dry wt. The highest concentration (100.4 ng/g dry wt.) of phenanthrene was found in sediments collected at the mooring site in Kentucky Lake, followed by a sample collected near the 124 Bridge in the lowermost Tennessee River (11.4 ng/g dry wt). Anthracene was found in relatively low concentrations compared with phenanthrene. Anthracene concentrations ranged from below detection limit (<0.34 ng/g dry wt) to 6.84 ng/g dry wt. The highest anthracene concentration was found in sediments collected at the mooring site (Site 2 on Figure 1) in Kentucky Lake. Anthracene made up about 2% (w/w) of total PAHs in surface sediments, while benzo[a]fluoranthene, benzo[b]fluoranthene, benzo[a]pyrene and benzo[k]pyrene made up about 17%, 5%, 11% and 14% (w/w), respectively, of the samples. Benzo[a]pyrene was BDL in sediments from the Ludbetter site 2. The highest concentration of all individual PAHs was found in samples from the mooring site (Figure 3) in Kentucky Lake. Surface sediments from the mouth of Cypress Creek also were found to contain relatively higher levels of PAHs than samples from other sites in the lowermost Tennessee River.

Vertical Distribution of PAHs in Kentucky Lake and the lowermost Tennessee River

Total PAH concentrations ranged from 5.62 ng/g to 57.5 ng/g dry wt (Figure 4). PAH concentrations showed relatively higher concentrations of PAHs at the 0 to 5.0 cm depth. Comparatively higher levels of total PAHs were found to surface sediments with a gradual decreasing concentration with depth up to 7.5 cm, then in gradually increasing concentrations from 7.5 to 12.5 cm. Relatively low and stable concentrations of total PAHs were found at 12.5 to 22.5 cm and then no clear trend was observed for deeper sediments. Naphthalene and phenanthrene were the predominant species among the PAH compounds. Anthracene was found throughout the core with relatively low concentrations at depths of 7.5 to 10 cm, 22.5 to 25 cm, 27.5 to 35 cm and 37.5 to 42.5 cm. Anthracene also was found in the core with below detection limits on the surface and at 10 to 22.5 cm and 35 to 37.5 cm deep. The highest PAH concentration of 57.5 ng/g dry wt was found at 40 to 42.5 cm. Anthracene and benzo[a]fluoranthene concentrations were below detection limits in more than 50% of the samples. Benz[a]anthracene, benz[a]-
pyrene and benzo[a]pyrene compounds were detected in the highest concentrations in the 40 to 42.5 cm section of the core sediment and contained 4.37 ng/g, 3.36 ng/g, and 10.2 ng/g dry wt respectively.

Total PAH concentrations found in mussel samples ranged from 90.1 to 340.9 ng/g dry wt (Figure 5). Total PAH concentrations (340.9 ng/g dry wt) were highest in the pink shellsplatter (Potamilus alatus) and yellow

![Figure 3. PAH concentrations in surface sediments from the lowermost Tennessee River and Kentucky Lake.](image)

![Figure 4. Total PAH concentrations (ng/g dry wt) in various sections of a sediment core collected from Ldrbetter Enshagement in Kentucky Lake.](image)
sandshell (Lampsilis tertes) collected from mouth of Cypress Creek in the lowermost Tennessee River, followed by purple warbyback (Cydnobatidea tuberculata) collected near the 1-24 Bridge and Autumn clown (Corbicula fluminea) collected at the mouth site in Kentucky Lake. Total PAH concentrations were 126.3 ng/g dry wt and 171.8 ng/g dry wt respectively. Naphthalene concentrations were relatively higher than other target compounds. Naphthalene concentrations ranged from 10.9 ng/g dry wt to 86.4 ng/g dry wt. The highest naphthalene concentration was found in a 15 year old pink heelpicker collected from mouth of Cypress Creek in the lowermost Tennessee River. Benzo[a]pyrene was found below the detection limit (<0.02 ng/g dry wt) or barely detected, with the exception of a purple warbyback collected from the area of the 1-24 Bridge with 1.91 ng/g dry wt.

**DISCUSSION**

Spatial Distribution

Because of the large amount of PAHs released into the environment, determining concentrations of PAHs in the environmental and biological media is essential for understanding sources, methods of transport, and potential negative health effects. PAHs in the atmosphere are transported by wet and dry deposition into soil, water, and vegetation. When PAHs are released into soil, they can volatilize, photolyze, oxidize, biodegrade, accumulate in plants, or enter groundwater (Wick et al. 2004; Zimmerman et al. 2004). Similarly, various chemical processes can occur with PAHs in surface water including volatilization, photolysis, oxidation, biodegradation, binding to suspended particles or sediments, and bioaccumulation in aquatic organisms (Zakaria et al. 2002; Braun et al. 2004; Marc et al. 2004).

Analysis of PAHs in the lowermost Tennessee River and Kentucky Lake is helpful in determining the baseline concentrations of contamination, in order to understand the inputs, bioaccumulation in these freshwater ecosystems. Although PCBs and chlorinated pesticides have been reported in Kentucky Lake sediments and mussel tissue, very limited information is available on the PAH contamination in the sediment and biota (Loganathan et al. 2001). The present study revealed the presence of seven PAH compounds in all of the sediments collected. However, the spatial distribution showed no
clear concentration patterns. The concentration of total PAHs in Kentucky Lake monitoring sites was relatively higher than the PAH concentration found in the sediments from the lowermost Tennessee River. The monitoring site (TRM 23.1) in Kentucky Lake is located near the dam and used for parking large barges. This site has large amounts of sediment deposits, which has been found to have relatively high concentration of PAHs (993.3 ng/g dry wt) compared with other sampling sites in the lowermost Tennessee River (TRM 20.9, TRM 17.7, and TRM 15.5). Among the PAHs measured, phenanthrene was found to be the predominant analyte (Figure 3). Phenanthrene was found in all of the sediment samples. The lowest concentration of PAH species (fluoranthene) was found to range from below detection limit to 6.84 ng/g dry wt. The concentration of total PAHs in sediments in these study areas was comparatively lower than several other freshwater ecosystems. The reported concentration ranged from 15,000 to 120,000 ng/g dry wt in Central Park Lake in New York City and in upper Mystic Lake in the Boston area respectively (Mette and Mahler 2004; Yan et al. 2005). Those studies analyzed 11–16 different PAHs, whereas in the present study only 7 PAHs were measured.

Transverse and partitioning of PAHs in the environment also are correlated with their molecular weights (Hafner and Hites 2003). The target PAHs are divided into two categories, low molecular weight compounds (152–178 g/mol) and high molecular weight compounds (228–278 g/mol) (Jacobi 1996; Norriani et al. 2005). In this study, PAH concentrations have been detected as low molecular weight compounds containing two or three ringed PAHs (290.2 ng/g dry wt) and high molecular weight PAHs containing five or six ringle (353.7 ng/g dry wt). Our study revealed that the amount of low molecular weight PAHs were not significantly different compared with those of high molecular weight PAHs.

Several target PAH compounds are known as human carcinogens and are classified into two categories, depending on their carcinogenicity. The carcinogenic PAHs are benz[a]anthracene, benz[b]fluoranthene, and benzo[a]pyrene. Non-carcinogenic PAHs are naphthalene, acenaphthene, phenanthrene, and benzo[g,h,i]perylene. (Norriani et al. 2005). In this study, it was shown that 33.8% (w/w) of the total PAHs found in the study sites (both Kentucky Lake and lowermost Tennessee River) were carcinogenic PAHs, whereas 66.2% (w/w) were non-carcinogenic PAHs.

Vertical Distribution

A sediment core represents a record of contaminant inputs in a freshwater system reflecting a continuous sequence of sediment and an accumulation of PAHs over time. Therefore, sediment cores can be used to estimate the history of pollutant input to the aquatic ecosystem (Mette and Mahler 2004). In this study, the selected sampling site, Ledbetter Embayment in Kentucky Lake, which is located away from main channel was expected to best represent an accumulation of organic contaminants over time. PAH trends in sediment cores have been investigated in relatively undisturbed embayment areas that might favor preservation of PAHs (Alexander et al. 1999; Kansan et al. 2000). The differences with other sites in degree of persistence within the cores and suspended sediment may be due to hydrologic setting as well as grain size, geology, and climate (Hofmockel et al. 2004). Mette and Mahler (2004) have studied PAH trends in sediment cores collected from Lake Como, Echo Lake, and Pico Lake in Fort Worth, Texas, as well as Harris Pond and Upper Mystic Lake in Boston, Massachusetts. The total PAHs were found to be relatively high concentrations at the tops of cores from Echo Lake, Harris Pond, and Upper Mystic Lake. These profiles are similar to those found in cores collected from Ledbetter Embayment in Kentucky Lake. Additionally, there are differing trends. The PAH profiles showed the increasing concentration and then a decrease in the top section of sediment cores in Lake Como and Echo Lake (Mette and Mahler 2004). Accumulation in Mussel Samples

PAHs were found in all mussel samples collected from the lowermost Tennessee River and Kentucky Lake. This represents accumulation of PAHs in aquatic organisms in the freshwater ecosystems (Page et al. 2004). PAH
concentrations found in mussels are lower than the amounts reported by the National Oceanic and Atmospheric Administration (NOAA) Mussel Watch Project. The low molecular weight PAHs reported ranged from not detected or barely detected (detection limits 3.3 to 67 ng/g dry wt) to 4,200 ng/g dry wt. The mean concentrations of high molecular weight PAHs in that project were reported from below detection limit (detection limits 3.9-47 ng/g dry wt) to 11,000 ng/g dry wt (Duggs et al. 2004).

In our study, naphthalene and phenanthrene were found predominantly in mussel samples from the lowermost Tennessee River and Kentucky Lake. Except for the sampling site at TRM 15.5 near the Atolino outfall and Cypress Creek mouth (TRM 10.1), the predominant PAHs found were phenanthrene, benzo[b]fluoranthene, naphthalene, anthracene and benzo[a]pyrene respectively. Total PAH concentrations ranged from 90.1 to 349.9 ng/g dry wt in a threeway mussel (Anodonta pisculata) at TRM 15.5 near the Atolino outfall and in a pink heebesplitter (Potamidus alatus) at the mouth of Cypress Creek (TRM 10.1).

Comparing PAH concentrations in mussel samples with PAHs measured in sediment from the same sampling site, there was no clear relationship (Figure 6). Due to high deposition of suspended sediment at the mouth of Cypress Creek (TRM 10.1) and the mooring site (TRM 23.1) in Kentucky Lake, the highest total concentration of PAHs were found in pink heebesplitter at the mouth of Cypress Creek (TRM 10.1) and in relatively high concentrations in the Asiatic clam (Corbicula fluminea, age 5 years) at the mooring site (TRM 23.1) in Kentucky Lake. Because the highest amount of total fat was found in the Asiatic clam at the mooring site in Kentucky Lake, total PAHs were found in relatively high concentrations with the youngest age of collected mussel samples. The low molecular weight PAHs are the predominant species found in the mussel.

Nakata et al. (2003) reported total PAH concentration in biota such as clams, oysters, lugworms, crabs, mudskippers (hetespinus), and other omnivore fish collected from a tidally flat in the Asiatic Sea. Japan. The highest PAH concentrations were reported in lugworms (24 ± 2.5 ng/g wet
PAHs in Kentucky Lake—Legzheimer and Loganathan

wt.), followed by cyprinids (6.3 ± 1.8 ng/g), clams (6.3 ± 3.0 ng/g), crabs (4.2 ± 1.4 ng/g), herbivore masu okamas (2.9 ± 1.5 ng/g), omnivore sand shads (0.37 ng/g), and other omnivore fishes (0.37 ng/g). The lowest mean Tennessee River and Kentucky Lake samples showed relatively higher accumulations compared with the amounts reported in the biological samples from marine environments (Kulka et al. 2000). Several authors reported that environmental (soil, sediment) and biological samples (freshwater mussels, fish) from freshwater environment contain higher PAHs concentration than marine environments (Metcalf and Makler 2004; Yan et al. 2005). Differences in the PAHs contamination level may attributable to sources of PAHs and distance from the source.

CONCLUSIONS
Polynuclear aromatic hydrocarbons (PAHs) measurements made in sediments and mussel tissues collected from the lowest Tennessee River and Kentucky Lake revealed several findings with respect to chemical characteristics governing the distribution and bioaccumulation of these pollutants. Based on limited number of samples analyzed and 7 target PAHs, the following observations were made:

- PAH concentrations were detected in all sediments and mussel tissues.
- Sediment collected from the mooring site (TRM 33.1) in Kentucky Lake was recorded the greatest concentration of total PAHs. Greater deposition of suspended sediment due to relatively low water current at this site and higher barge traffic might have contributed to relatively higher concentrations of PAHs. Phenanthrene, benz[a]anthracene, naphthalene were predominantly found at this sampling site.
- The lowest mean Tennessee River and Kentucky Lake are comparatively least polluted with total PAH compounds than other selected freshwater ecosystems in the United States.
- PAH profiles showed preferential accumulation of low molecular weight PAHs (naphthalene and phenanthrene) in the deeper cores. The profiles of sediment cores suggested that PAHs were relatively stable in deeper section of the core sediments.
- Accumulation pattern of PAH species in sediment and mussel tissues exhibited the following order: naphthalene > phenanthrene > benz[a]anthracene > benz[b]anthracene > benz[a]pyrene. The low molecular weight PAHs were predominant species accumulated in mussels at all sampling sites.
- Several PAHs have been considered human carcinogens that are classified into two categories depending on their properties: carcinogenic and non-carcinogenic PAHs. The composition of PAHs in sediments from the lowermost Tennessee River and Kentucky Lake revealed that 66.2% (w/w) of the total PAHs were noncarcinogenic PAHs, and 33.8% (w/w) were carcinogenic PAHs.

The present study provides evidence of the spatial and temporal distribution and bioaccumulation of selected PAH compounds in sediments and freshwater mussels from the lowermost Tennessee River and Kentucky Lake. Future monitoring studies including more number of samples and 16 priority PAHs are essential to identify the sources of contamination, and effects on environment and organisms.

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LITERATURE CITED
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