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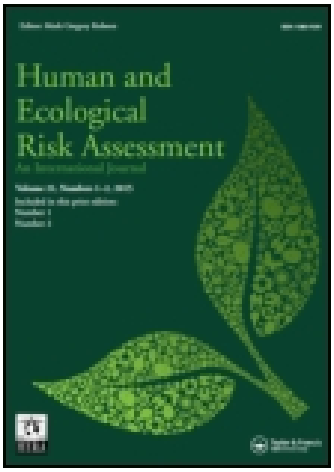

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Distribution Characteristics and Risk Assessments of PAHs in Fish from Lake Taihu, China

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ABSTRACT

The concentrations of PAHs in four species of fish (Common carp, Crucian carp, Bighead carp, and Topmouth culter) from Lake Taihu were tested, and the human health risks of PAHs by fish consumption were evaluated. Results showed that concentrations of PAHs in fish from Lake Taihu were 52.5–247.6 ng/g wet weight (ww), and the BaP equivalent concentrations of total PAHs ($B[a]P_{eq}$) were 0.2–0.6 ng/g ww, which were less than the screening value of 2.6 ng/g wet for human consumption. The concentration sequences of PAHs in fish from Lake Taihu from high to low were Bighead carp > Crucian carp > Common carp > Topmouth culter. The human health risk level of PAHs by fish consumption was $5.8 \pm 2.5 \times 10^{-6}$, which was less than the maximum acceptable risk level of 1×10^{-5} for human health set by the U.S. Environmental Protection Agency. The tissue residue guideline (TRG) of PAHs for protecting aquatic wildlife was 1.3 mg/kg diet ww, which was higher than the concentrations of PAHs in fish from Lake Taihu. The results indicated that fish consumption from Lake Taihu would not cause health risk or harmful effects on wildlife that consume aquatic biota.

Key Words: PAHs, Lake Taihu, health risk assessment, TRG.

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INTRODUCTION

Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous typical persistent organic pollutants (POPs) in the global environment (Guo *et al.* 2011a; Zhao *et al.* 2008), and have strong carcinogenic impacts on both humans and wildlife (Menzie *et al.* 1992; Guo *et al.* 2007; Hinck *et al.* 2009). Sixteen kinds of PAHs have been listed as priority pollutants by the U.S. Environmental Protection Agency (USEPA 1993b). The main sources of PAHs in the environment are from human activities including incomplete combustion of fossil fuels, biomass combustion, and oil leakage, and natural processes such as forest fires, volcanic activity, and endogenous synthesis in plants. The primary means of PAHs in the water compartment are oil pollution, air pollution deposition, and surface runoff (Leung *et al.* 2010; Yang 2000).

There have been studies on PAHs in air, water, sediment and soil, but only a few of the aquatic organisms. PAHs in organisms are direct evidence of their environmental pollution and direct characterization for their ecological risk (Cheng *et al.* 2007). The health risks caused by exposure to pollutants have increasingly attracted worldwide attention, and food intake is one of the most important routes for human body exposure to many pollutants (Brustad *et al.* 2008; Dovydaitis 2008; Genuis 2008). The pollutants into a water body make the fish consumption the main source of human exposure to many toxic substances (Li *et al.* 2010; Meng *et al.* 2007). Besides the harmful effects on human health, PAHs can also adversely affect aquatic ecosystems and wildlife (Meador *et al.* 1995; Eisler 1986). Studies have shown that exposure to PAHs could cause toxic effects on both laboratory mammals and wild species (Malcolm and Shore 2003), such health effects in birds (Briggs *et al.* 1997) and toxicological effects in mammals (Kannan and Perrotta 2008; Moon *et al.* 2012; Swart *et al.* 1994). At high trophic positions, ingestion of contaminated food is the main exposure route for predatory birds and mammals to accumulate bioaccumulative chemicals such as PAHs (Nakata *et al.* 2003; Payne *et al.* 2003; Braune 2007).

Fung *et al.* (2004) studied PAHs in bivalves from Dalian, Qingdao, Shanghai, and Ningbo, and found that concentrations of PAHs in shellfish from Chinese coastal areas were significantly low. Kong and Cheung studied the PAHs concentrations in fish from the Chinese mainland, Hong Kong, and the Pearl River Delta, and found that PAHs caused no significant risks to human health through fish consumption (Kong *et al.* 2005a,b; Cheung *et al.* 2007). Xia *et al.* (2010) characterized the health risk of PAHs via diet exposure in Taiyuan, and found that fish consumption was the main pathway of human exposure to PAHs. The residues and health risk of PAHs in aquatic products from Lake Chaohu were studied, and results showed that aquatic products' consumption was the primary pathway of exposure to PAHs in the Lake Chaohu region (Qin *et al.* 2013). The toxicity reference value (TRV) of 0.615 mg PAHs/kg bw/day for mammalian species was derived to calculate mammalian Ecological Soil Screening Levels for PAHs (USEPA 2007).

Lake Taihu, as one of the five largest freshwater lakes in China, is a significant water source for the cities Wuxi, Suzhou, and Shanghai, with important ecosystem services and a wealth of biological species resources. With the rapid development of urbanization and industrialization in the Taihu lake basin, pollution in Lake Taihu has been gradually attracting public attention, in addition to problems of eutrophication and POPs (Ta *et al.* 2006; Zhong *et al.* 2010). The health and

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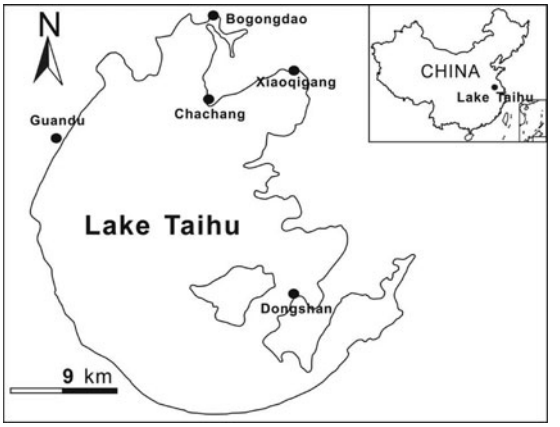

Figure 1. The distribution of sampling sites (Guo *et al.* 2012).

ecological risks of PAHs in sediments of Meiliang Bay were evaluated (Qiao *et al.* 2006, 2007). The ecological risk of PAHs in Lake Taihu were accessed (Guo *et al.* 2011a,b).

To date, there have been few studies on concentrations of PAHs in fish from Lake Taihu and their risk assessments. Concentrations of PAHs in fish may affect the health of wildlife and humans that consume them. The concentrations of PAHs in four species of fish taken from Lake Taihu were tested, and the risks of PAHs through fish consumption were assessed for human health and wildlife based on the human health screening value and wildlife criteria calculated in this study. The results could provide scientific-based guidance for risk management of PAHs in the Lake Taihu region.

METHODS AND MATERIALS

Collection of Samples

In September 2009, 82 fish samples of four fish species (Crucian carp, Common carp, Bighead carp, and Topmouth culter) from five sampling sites (Xiaoqigang, Bogongdao, Chachang, Guandu, and Dongshan) in the Lake Taihu area were collected. The sampling duration was 1 week and the fish samples were collected once at each sampling site. The distribution of sampling sites is shown in Figure 1, and the data on fish sampled is provided in Table 1. The four species of fish collected are representative fish and main catch from Lake Taihu (Liu 2005; Su *et al.* 2011), suitable for the monitoring of POPs in Lake Taihu and the evaluation of health risks. Upon collection, all samples were wrapped with aluminum foil and kept in clean polyethylene bags with ice immediately after sampling. They were then brought to the laboratory and stored at –20°C until analyzed.

For risk assessment of PAHs in fish to wildlife, representative wildlife species need to be selected in order to derive the wildlife criteria. The risk of PAHs to wildlife was assessed by comparing PAH concentrations in fish with wildlife criteria. The primary basis for selection of representative wildlife species is exposure to pollutants

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Table 1. The information on fish species sampled from Lake Taihu.

Common name	Scientific name	Number	Body mass (kg)	Length (cm)
Crucian carp	*Carassius auratus*	20	0.3 ± 0.1	21.6 ± 3.3
Topmouth culter	*Erythroculter ilishaeformis*	21	0.3 ± 0.2	29.1 ± 7.8
Common carp	*Cyprinus carpio*	20	0.6 ± 0.3	29.4 ± 3.1
Bighead carp	*Aristichths nobilis idellus*	21	1.0 ± 0.33	36.5 ± 5.1

The body mass and length were expressed as mean ± standard deviation.

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via aquatic food webs (USEPA 1995), such as fish-eating birds and mammals. Three avian species, night heron (*Nycticorax nycticorax*), little egret (*Egretta garzetta*), and Eurasian spoonbill (*Platalea leucorodia*), and two mammalian species, indo-pacific humpback dolphin (*Sousa chinensis*) and finless porpoise (*Neophocaena phocaenoides*), were selected as representative wildlife species in China (Su *et al.* 2014; Zhang *et al.* 2013). These species are widely distributed in China's aquatic ecosystems and feed on aquatic prey. Body masses (BM) and rates of ingestion of food (FI) for these five species are shown in Table 2.

Preparation of Samples

Frozen samples were thawed and rinsed individually with purified water to remove possible impurities. Subsequently, about 20 g (wet weight) of skin-off fish muscle were taken, homogenized, freeze-dried, and ground into fine powders and stored at –20°C for chemical analysis. An aliquot of each sample was spiked with surrogate standards for PAHs, and was Soxhlet extracted for 48 h with 200 mL of acetone:n-hexane(1:1, v:v). Then the extract was concentrated to approximately 5 mL. A portion (1 mL) of the extract was taken for gravimetrical determination of lipid content, and the remaining 4 mL were subject to a gel permeation chromatograph, a glass column (50 cm length × 2.0 cm i.d.) packed with 40 g of SX-3 Bio-Beads (Bio-Rad). Then the column loaded with extract was eluted with 50% dichloromethane in *n*-hexane, and a fraction from 90 to 280 mL was collected and concentrated. The subsequent clean-up and fractionation were performed with a multilayer alumina/silica column packed, from the bottom to top, with neutral alumina (6 cm, 3% deactivated), neutral silica gel (12 cm, 3% deactivated), and anhydrous sodium sulfate (1 cm). The defatted sample was pre-washed with 5 mL of *n*-hexane and eluted slowly with 80 mL of *n*-hexane:dichloromethane (7:3, v:v), and only the latter portion was collected. The collected effluent was concentrated, quantitatively transferred into a 2-mL vial, and further concentrated to the final

Table 2. Body masses and food ingestion rates of representative wildlife.

Wildlife species	BM (kg)	FI (kg/d ww)	FI:BM	Reference
Dolphin	185	9	0.0486	Jefferson (2000)
Finless porpoise	60	3	0.05	Hung *et al.* (2007)
Night heron	0.706	0.239	0.34	Zhang *et al.* (2013); Su *et al.* (2014)
Little egret	0.342	0.148	0.43	Zhang *et al.* (2013); Su *et al.* (2014)
Eurasian spoonbill	2.232	0.514	0.23	Zhang *et al.* (2013); Su *et al.* (2014)

volume of 0.5 μL under a gentle nitrogen stream. An internal standard, PCB 82, was added to the extract prior to instrumental analysis.

Instrumental Analysis

Instrumental analyses were performed on a Hewlett-Packard (HP, Avondale, PA, USA) 6890 gas chromatograph and an 5975B mass selective detector (Agilent Technologies, Inc., Wilmington, DE, USA) operating in the selective ion monitoring mode. A DB-5 MS capillary column (60 m length $\times$ 0.25 mm i.d. $\times$ 0.25 μm film thickness) was used for chromatographic separation. The quantitative analysis was conducted using a multipoint internal calibration method. The chromatographic condition is carrier gas (high purity nitrogen, constant pressure at 10.0 psi), injector temperature (280°C), and electron energy (70eV). For each batch of 20 field samples, a procedural blank, a spiked blank, and a spiked matrix sample were processed.

For measurement of PAHs, the initial temperature 80°C was kept for 1 min and was programmed to 180°C at rate of 10°C/min, to 220°C at rate of 2°C/min, and then to 290°C at rate of 8°C/min. The temperature 290°C was kept for 30 min. Splitless injection of 1.0 μL of sample was conducted with an autosampler. The 16 PAHs in this study were acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, benzo[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[a]pyrene, indeno[1,2,3-cd]pyrene, dibenzo[a,h]anthracene, Naphthalene, and benzo[g,h,i]perylene. Total concentrations of PAHs were calculated by summing the 16 kinds of PAH concentrations.

Quality Control and Quality Assurance

The recoveries of the 16 PAHs in spiked blanks and spiked matrix ranged from 75.8 $\pm$ 4.9% to 114.3 $\pm$ 8.2% and from 60.8 $\pm$ 1.1% to 120.9 $\pm$ 9.1%, respectively. The mean surrogate recoveries were 58.9% for NAP-d8, 78.9% for ACE-d10, 93.0% for PHEN-d10, 78.7% for CHRY-d12, and 88.7% for PERY-d12, respectively. The detection limits of 16 PAHs were the 0.01–0.02 ng/g wet weight. A little of the target compounds were found in the procedural blanks and the results were corrected by blank deduct and recoveries.

Statistical Analysis

Statistical analysis of the obtained results was performed using the Excel (2007) and Origin 8.0 software. The statistical results were presented as mean $\pm$ standard deviation. The normality of data was tested (Kolmogorov-Smirnov test) before analysis and results showed that these data fit Logarithmic normal distribution. Probability values less than 0.05 were considered as statistically significant. A *T*-test was performed to examine the differences of PAH concentration among the fish species and results showed that PAH concentration among the fish species have no statistically significant difference.

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Table 3. The values of parameters in Eq. (2).

Parameters	Values	References
RL	10^{-5}	USEPA (2000b)
SF	7.3 $(\mu g/g\ day)^{-1}$	USEPA (1993a)
BM	63.07 kg	Xiang *et al.* (2012)
CR	33.09 g/day	Wang *et al.* (2009); Xiang *et al.* (2012)

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Methods for Human Health Assessment and Wildlife Risk Assessment

According to the guideline of the USEPA (1993b), the potency equivalent concentration (PEC) of total PAHs was calculated for comparison with the screening value for benzo(a)pyrene. Equation (1) (Cheung *et al.* 2007; Nisbet and LaGoy 1992) was used for the calculation of the PEC of total PAHs:

$$PEC = \Sigma(TEF \times C) \tag{1}$$

where TEF is the toxicity equivalency factors of each PAH and C is the concentration of each PAH in fish (ng/g).

The screening values (SVs) of PAHs for human health were calculated using Eq. (2) (Fairey *et al.* 1997):

$$SV = [(RL/SF) \times BM]/CR \tag{2}$$

where SV is screening value ($\mu g/g$), RL is the maximum acceptable levels of risk (dimensionless), SF is oral slope factor $(\mu g/g\ day)^{-1}$, BM is body mass (kg), CR is consumption rate (g/day). The values of the parameters in Eq. (2) are listed in Table 3. Accordingly, the screening value calculated for PAHs was 2.6 ng/g wet weight.

The human health risk level was calculated by Eq. (3) (USEPA 2000a):

$$Risk = (Cm \times CR \times SF)/BM \tag{3}$$

where Cm is the concentration of pollutants in the fish body($\mu g/g$). The cumulative probability distributions of health risks for PAHs were simulated using Matlab 6.5 software.

The reference concentration (RC) was calculated by Eq. (4) used to derive tissue residue guideline (TRG), which means the maximum concentration of a substance in aquatic biota recommended to protect wildlife that consume them (CCME 1998):

$$RC = TDI/(FI/BM) \tag{4}$$

where TDI is tolerable daily intake (mg/kg body mass/day), FI is food injection rate (kg/day ww). RCs for representative species were calculated by Eq. (4). The geometric mean of RCs for representative mammals was taken as the TRG for mammals. The geometric mean of RCs for representative birds was taken as the TRG for birds. Then the TRGs for mammals and birds were compared and the smaller value was taken as the wildlife criteria for protecting aquatic wildlife from PAHs in fish.

Table 4. The concentrations of 16 PAHs in fish from Lake Taihu (ng/g wet weight).

PAHs	Crucian carp	Topmouth culter	Common carp	Bighead carp
Naphthalene	14.2 ± 16.0	14.6 ± 11.2	24.1 ± 63.0	207.9 ± 679.9
Acenaphthylene	1.1 ± 0.7	0.8 ± 0.6	0.7 ± 0.3	0.6 ± 0.2
Acenaphthene	3.4 ± 2.4	2.8 ± 1.7	2.1 ± 0.9	1.8 ± 0.7
Fluorene	8.0 ± 3.6	6.5 ± 2.8	5.7 ± 1.6	5.0 ± 1.5
Phenanthrene	20.9 ± 9.4	18.9 ± 10.3	16.0 ± 7.0	16.8 ± 10.0
Anthracene	1.1 ± 0.8	1.2 ± 0.7	1.2 ± 0.5	6.1 ± 21.2
Fluoranthene	4.4 ± 2.7	3.4 ± 1.8	3.2 ± 1.8	3.6 ± 1.9
Pyrene	3.6 ± 2.9	3.8 ± 2.2	3.6 ± 2.2	4.5 ± 1.9
Benzo[a]anthracene	0.3 ± 0.6	0.2 ± 0.1	0.3 ± 0.1	0.3 ± 0.3
Chrysene	0.4 ± 0.5	0.2 ± 0.2	0.3 ± 0.3	0.4 ± 0.5
Benzo[b]fluoranthene	0.2 ± 0.2	0.2 ± 0.1	0.2 ± 0.2	0.3 ± 0.3
Benzo[k]fluoranthene	0.1 ± 0.3	0.0 ± 0.0	0.1 ± 0.0	0.1 ± 0.0
Benzo[a]pyrene	0.1 ± 0.1	0.0 ± 0.0	0.1 ± 0.0	0.1 ± 0.0
Indeno[1,2,3-cd]pyrene	0.1 ± 0.2	0.0 ± 0.0	0.1 ± 0.0	0.1 ± 0.0
Dibenzo[a,h]anthracene	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Benzo[g,h,i]perylene	0.1 ± 0.3	0.0 ± 0.0	0.1 ± 0.0	0.1 ± 0.0
∑PAHs	57.9 ± 31.0	52.5 ± 26.5	57.6 ± 67.2	247.6 ± 706.6
PEC (PAHs)	0.4	0.2	0.3	0.6

The results were presented as mean ± standard deviation.

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RESULTS AND DISCUSSION

Distribution of PAHs in Fish from Lake Taihu

The concentrations of PAHs and their PECs in the four different fish species in Lake Taihu are shown in Table 4. The concentrations of total PAHs in these four species of fish were 52.5–247.6 ng/g wet weight. The Bighead carp had the highest concentration of total PAHs, which was almost three times those in other fish species. The total PAHs in Crucian carp, Common carp, and Topmouth culter were similar. Besides, the PECs of total PAHs in the four species of fish in Lake Taihu were 0.2–0.6 ng/g wet weight, which were all below the screening value of 2.6 ng/g wet weight for human health. It can be concluded that PAHs in fish from Lake Taihu would not cause significant health risk to local residents through fish consumption.

The relative abundances of 16 kinds of PAHs in four species of fish are shown in Figure 2. The concentration of naphthalene in Bighead carp was 207.2 ng/g wet weight, which was much higher than for the other three fish species, causing the highest concentration of total PAHs in Bighead carp. The distributions of 16 PAHs in four species of fish were very similar. Concentrations of phenanthrene and naphthalene were clearly higher than the other 14 PAHs in these four fish species. The concentrations of several PAHs with higher TEFs (TEFs $\geq$ 0.1), such as benzo[k]fluoranthene, benzo[a]pyrene, and dibenzo[a,h]anthracene were very low, leading in the low PECs of total PAHs in fish species from Lake Taihu.

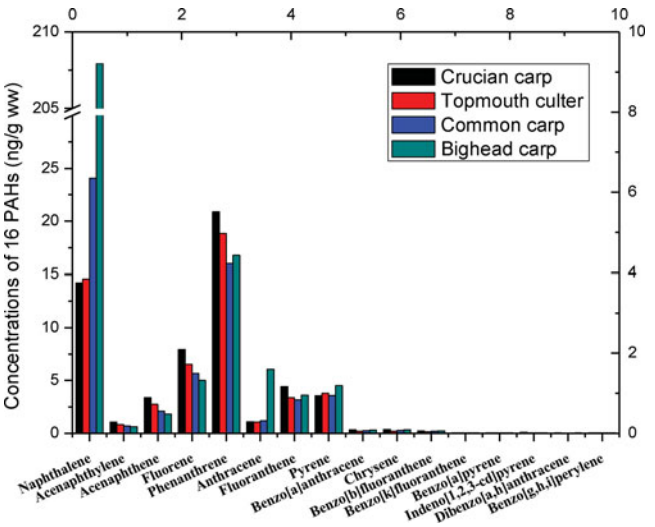

Figure 2. Distribution of 16 PAHs in four species of fish.

Assessments of the Human Health Risks of PAHs via Fish Consumption

By use of Eq. (3), the human risk levels caused by PAHs in Crucian carp, Topmouth culter, Common carp, and Bighead carp were 1.5×10^{-6}, 0.9×10^{-6}, 1.2×10^{-6}, and 2.4×10^{-6}, respectively, with an average of $1.5 \pm 0.7 \times 10^{-6}$. These risk levels were all less than the maximum acceptable level of 1×10^{-5} for human health risk.

Human health risks of PAHs in fish from Lake Taihu through fish consumption were conducted by Monte-Carlo simulation. The cumulative probability distributions of health risks by PAHs though fish consumption are shown in Figure 3. The simulation results showed that health risks caused by PAHs in fish were 0.4×10^{-6} at 5%th, 1.5×10^{-6} at 50%th, and 2.5×10^{-6} at 95%th, respectively, indicating

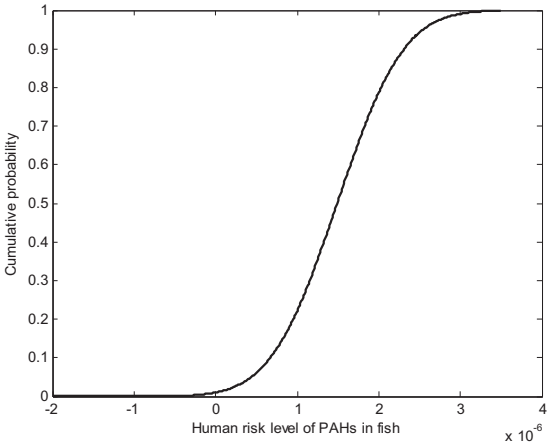

Figure 3. Cumulative probability distributions of health risks from PAHs via fish consumption.

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that PAHs in fish from Lake Taihu would not cause significant health risk to local residents through fish consumption.

Risk Assessments of PAHs to Wildlife via Fish Consumption

A toxicity reference value (TRV) of 0.615 mg PAHs/kg bw/day for mammalian species was derived to calculate mammalian Ecological Soil Screening Levels for PAHs (USEPA 2007). An uncertainty factor of 10 was used for the extrapolation to aquatic mammals, and the TDI for aquatic mammals was 0.0615 mg PAHs/kg bw/day. Using the FI/BW values of two mammalian species in Table 2 and Eq. (4), the RCs of these two species were calculated to be 1.27 and 1.23 mg/kg diet ww, respectively. The geometric mean of these two RCs was 1.3 mg/kg diet ww, which was the TRG of PAHs for mammals.

Although birds rapidly metabolize and readily excrete PAHs (Troisi *et al.* 2006), exposure to PAHs can cause acute and reproductive toxicity in birds (Malcolm and Shore 2003). The TRV was not derived for avian species because there was not enough data for PAHs in birds (USEPA 2007). Therefore, the TRG of 1.3 mg/kg diet ww for mammals was selected as the wildlife criteria for protecting wildlife from PAHs. The concentrations of PAHs in the four fish species from Lake Taihu were 52.5–247.6 ng/g ww, all of which were lower than the wildlife criteria of 1.3 mg/kg diet ww for PAHs. It was concluded that the PAHs in fish from Lake Taihu would not cause harmful effects to wildlife via fish consumption.

Comparisons of the Concentrations of PAHs in Fish and Their Health Risks from Different Regions in China

For the four fish species (Crucial carp, Topmouth culter, Common carp, and Bighead carp) in Lake Taihu, concentration of PAHs in Bighead carp was the highest, followed by Crucial carp, Common carp, and Topmouth culter. The concentration of total PAHs in Bighead carp was much higher than the other three types of fish, indicating that the Bighead carp had higher accumulating capacity for PAHs.

The concentrations of PAHs in fish from different regions in China are shown in Table 5. In general, the fish from Taiyuan and Lake Taihu had higher concentrations of PAHs but had little difference with fish from other regions. Fish from Taiyuan had the highest PEC of total PAHs 5.7 ng/g wet weight, which was higher than

Table 5. The concentrations of PAHs in fish from different regions in China (ng/g wet weight).

Sampling sites	Sampling time	∑PAHs	PEC (PAHs)	References
Taiyuan (market)	2008	160.3	5.7	Xia *et al.* (2010)
Lake Taihu	2009	52.5–247.6	0.2–0.6	This study
Hong Kong(market)	2004	1.57–145	0–0.4	Cheung *et al.* (2007)
Hong Kong and Mainland China	2003	15.1–92.5	0–0.2	Kong *et al.* (2005b)
Pearl River Delta (fishpond)	2001–2002	25.8–77.1	0–0.1	Kong *et al.* (2005a)

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the screening value of 2.6 ng/g wet weight for human health, indicating that PAHs in this area might cause health risk to local residents through fish consumption. Apart from Taiyuan, the PECs of the total PAHs in fish from other regions of China were lower than the screening value of 2.6 ng/g wet weight, suggesting that fish consumption would not cause significant health risk.

Uncertainty Analysis

Uncertainties in this research mainly had the following several aspects. Firstly, artificial errors and system errors in the processes of measurement of PAHs inevitably brought uncertainty to measurement results. Secondly, in the calculation of PECs of total PAHs, the toxicity equivalent factors used would also introduce some uncertainty. Finally, the food intake rate and human bodyweight were important parameters in health risk assessment. The consumption rate of 33.09 g/day and bodyweight of 63.07 kg (Xiang *et al.* 2012) used in health risk assessment had certain differences with the actual exposure parameters for the local residents. Especially the consumption rate used was the intake rate of aquatic products for residents in the Lake Taihu region, which certainly had some differences with the fish intake rate. All these factors mentioned above would increase the uncertainty in health risk assessment. It would be needed to do more study in greater depth as much as possible to reduce the uncertainty of results.

The wildlife criteria values derived in this study can be used to evaluate the risk of PAHs to wildlife in China, and to provide indices that are more reasonable for protecting Chinese wildlife species. However, several sources of uncertainty exist when deriving TRG for the PAHs, such as lack of adequate toxicity data for birds and need to use uncertainty factors. Clearly, relevant work on PAHs and birds and mammals in China is needed in the future. For example, PAH toxicity data for resident avian and mammalian species in China are needed. In addition, different PAH compounds have different toxicity in wildlife, and relative toxic potency for PAH compounds need to be studied for more reasonable risk assessment.

CONCLUSIONS

1. The concentrations of total PAHs and their PECs in different fishes from Lake Taihu followed the order: Bighead carp > Crucial carp > Common carp > Topmouth culter. The concentration of PAHs in Bighead carp was much higher than in the other three fish species, which had similar concentrations of PAHs. The PECs of total PAHs in the four fish species were 0.2–0.6 ng/g wet weight, which were all below the screening value of PAHs calculated for local residents (2.6 ng/g wet weight).
2. The concentration of naphthalene in Bighead carp was far higher than the other three fish species, reaching 207.9 ng/g wet weight. The distributions of 16 PAHs in the four species of fish were very similar. The concentrations of phenanthrene and naphthalene were clearly higher than the other 14 PAHs.
3. Health risks caused by PAHs in the four fish species through fish consumption were 0.9×10^{-6}–2.4×10^{-6}, with an average of $1.5 \pm 0.6 \times 10^{-6}$. The health risk at 95%th by Monte-Carlo simulation was 2.5×10^{-6}, which was below the maximum acceptable health risk level of 1×10^{-5}. Results showed that PAHs

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in fish from Lake Taihu would not cause significant health risks to the local population through fish consumption.

4. The concentration of PAHs in four fish species in Lake Taihu were 52.5–247.6 ng/g ww, all of which were lower than the wildlife criteria of 1.3 mg/kg diet ww for PAHs. It was concluded that the PAHs in fish from Lake Taihu would not cause harmful effects to wildlife via fish consumption.

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