Research Article

Distribution and Health Risk Assessment on Dietary Exposure of Polycyclic Aromatic Hydrocarbons in Vegetables in Nanjing, China

Minmin Wu,^{1,2} Zhonghuan Xia,^{1,2,3,4} Qianqian Zhang,^{1,2} Jing Yin,^{1,2} Yanchi Zhou,^{1,2} and Hao Yang^{2,3,4}

¹Jiangsu Provincial Key Laboratory of Materials Cycling and Pollution Control, School of Environment, Nanjing Normal University, Nanjing 210023, China

²Key Laboratory of Virtual Geographic Environment, Ministry of Education, Nanjing Normal University, Nanjing 210023, China

³Jiangsu Center for Collaborative Innovation in Geographical Information Resource Development and Application, Nanjing 210023, China

⁴State Key Laboratory Cultivation Base of Geographical Environment Evolution in Jiangsu Province, Nanjing 210023, China

Correspondence should be addressed to Zhonghuan Xia; zhxia@njnu.edu.cn

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In a market basket study made in Nanjing, China, in which the most common consumed nine kinds of vegetables foodstuffs were sampled, the contents of 16 polycyclic aromatic hydrocarbons (PAHs) were analyzed using gas chromatography with mass spectrometer detector (GC-MS). The results showed that the total amount of 16 PAHs was within the range of 60.5~312 ng g⁻¹ (wet weight). The ranking of total concentrations for different types of vegetables in decreasing order was leafy vegetable, fruit vegetable, and rhizome vegetable. Source analysis suggested that coal, oil, or other incomplete combustion of biomass mainly contributed to the concentration of PAHs. The margin of exposure (MOE) approach with age/gender group-specific daily dietary exposure level was used to estimate the carcinogenic risk. The calculated total mean MOE in the case of BaP and PAH4 (sum of BaA, CHR, BbF, and BaP) was 14960 and 7723, respectively, for local residents. In addition, the MOEs in PAH4 for some groups of both male and female were below the critical limit of 10 000 proposed by EFSA. Therefore, health effect owing to the consumption of vegetables on local residents needs high concern.

1. Introduction

Polycyclic aromatic hydrocarbons (PAHs) are a large group of organic compounds containing two or more aromatic rings and belonging to the food and environment contaminants. They are produced by natural and anthropogenic processes.

Dietary intake of PAHs was the major source of human exposure [1, 2]. PAHs were found as contaminants in various food categories such as vegetables, fruits, meats, cereals, oils, and milk [3]. Epidemiological studies indicate that dietary exposure to PAHs is associated with some human cancers [4, 5]. In recent years, environmental PAH concentrations have increased in many industrialized and developing countries, leading to high levels of PAHs in foodstuffs [6]. The

occurrences of PAHs in vegetables in the literatures published during the last 15 years were summarized and the subsequent dietary exposures to Benzo[a]pyrene equivalents (BaP_{eq}) were calculated and then compared [7]. However, reports concerning cancer risk assessment of PAHs using the margin of exposure (MOE) approach [8] are quite limited.

Nanjing is a major city in southeastern China. It has more than 800 million inhabitants and is surrounded by mountains, with petrochemical, steel, and heavy industry as its economic pillars. Large amounts of pollutants have been poured into soil, water, and air owing to the combustion of fossil fuels and might seriously affected local environmental quality. Thus, obtaining the health risk level of citizens in Nanjing associated with the dietary intake of PAHs is

essential for effective environmental management. However, such information is not available currently, leaving a great information gap. The objective of this study is to quantify the daily dietary PAH exposure level for different population groups in Nanjing and to estimate the cancer risk using MOEs.

2. Material and Methods

2.1. Sampling. In May 2015, nine kinds of vegetables, including Chinese cabbage, green vegetables, cauliflower, cucumber, tomato, eggplant, rhizoma dioscoreae, potato, and lotus root, which have been surveyed as the primary vegetables consumed by local residents, were purchased in representative supermarkets, wholesale markets in Nanjing, China. We collected five samples for each kind of vegetable and each sample was mixed with five subsamples. Only edible parts of each foodstuff were surveyed in this study. All collected samples were transported to laboratory as soon as possible and preserved at -15°C before experimental analysis.

2.2. Analytical Procedure. The extraction and cleanup procedures of PAHs were similar to those of organochlorine pesticides in previous research [9]. Each samples of 10.0 g wet weight were mixed with 20 mL acetonitrile solvent and then were subjected to microwave extraction system (MES) (MARS2Xpress, CEM, USA). The vessels were heated in the microwave oven to 100°C at $10^{\circ}\text{C}/\text{min}$ and held for 10 min. After extraction, the contents in the vessels were transferred to the centrifugal and were centrifuged 3 times. Then 100 mL 4% sodium sulfate solution was added into a separating funnel with the eluent and the mixture was extracted twice with 30 mL n-hexane. After extraction, total extracts were concentrated to 1 mL using a vacuum rotary evaporator and were transferred to the alumina silica gel column which were eluted with n-hexane (20 mL) and dichloromethane (70 mL) for purification before being transferred with 1 mL of n-hexane to a chromatography column. The samples were stored at -4°C before analysis.

The concentrations of PAHs were determined by using gas chromatography-mass spectrometry (QP2010, Shimadzu, Japan) with a $30\text{ m} \times 0.25\text{ mm i.d.} \times 0.25\text{ }\mu\text{m}$ film thickness HP-5MS capillary column. GC temperature was programmed from an initial 60°C before commencing at $5^{\circ}\text{C}/\text{min}$ up to 280°C , with a final holding time of 20 min. Helium was used as the carrier gas and operated in splitless mode at a flow rate of 1 mL/min. The head column pressure was 30 kPa. The mass spectrometer was operated in scan mode with an electron impact ionization of 70 eV, an electron multiplier voltage of 1288 V, and an ion source of 230°C . Concentrations were determined for 16 PAHs in all samples. They were naphthalene (NAP), acenaphthene (ACE), acenaphthylene (ACY), fluorine (FLO), phenanthrene (PHE), anthracene (ANT), fluoranthene (FLA), pyrene (PYR), benz(a)anthracene (BaA), chrysene (CHR), benzo(b)fluoranthene (BbF), benzo(k)fluoranthene (BkF), benzo(a)pyrene (BaP), dibenz(a,h)anthracene (DahA), indeno(1,2,3-cd)pyrene (IcdP), and benzo(g,h,i)perylene (BghiP).

2.3. Quality Control. All solvents used were chromatography purity. Alumina and silica gel (80–200 mesh; Dikma, China) were heated at 650°C in a muffle furnace (DLII-9, Beijing, China) for 10 h, kept in a sealed desiccator, and reactivated at 130°C for 4 h immediately prior to use. All glassware was cleaned using an ultrasonic cleaner (KQ-500B, Kunshan, China) and heated to 400°C for 6 h. Quantification was performed by the use of external calibrations which were obtained with PAH solutions at five concentration levels. The procedural blank was determined by going through the extraction and cleanup procedures using glass beads and all the results of food samples were laboratory procedure blank corrected. Recovery of individual PAHs ranged from $71.0\% \pm 3.3\%$ to $122\% \pm 6.1\%$ with a mean value of $103\% \pm 4.5\%$ for the 16 PAHs. Data analyzed in the paper were not corrected for recoveries. The detection limit for different food samples was in the range of 0.0018–0.014 ng/g wet weight.

2.4. Dietary Exposure Assessment. The population of Nanjing was divided into eight groups according to age and gender: children (4–10 years), adolescents (11–17 years), adults (18–60 years), and seniors (61–70 years) of male as well as the above groups of female. Daily dietary BaP or PAH4 (sum of BaA, CHR, BbF, and BaP) exposure level (E) for each population group was calculated as follows:

$$E = C \times \text{IR}, \quad (1)$$

where E is daily dietary BaP or PAH4 exposure level (ng/day); C is BaP or PAH4 concentration in vegetables (ng/g); IR is ingestion amount of vegetables per day (g/day) [10–12].

2.5. Cancer Risk Assessment. The scientific opinion of European Food Safety Authority (EFSA) on a harmonized approach for risk assessment of substances which are both genotoxic and carcinogenic [13] was used to characterize the risk related to consumption of vegetables. In general, it was assumed that the margin of exposure (MOE) of 10000 or higher would be of low concern from the viewpoint of public health and might be considered low priority for risk management actions [14]. The BMDL_{10} (benchmark dose lower confidence limit 10%), an estimate of the lowest dose which is 95% certain to cause no more than a 10% cancer incidence in rodents, was used to obtain the MOE. MOE for each population group was calculated as follows:

$$\text{MOE} = \frac{\text{BMDL}_{10} \times \text{BW}}{E}, \quad (2)$$

where MOE is the margin of exposure for BaP or PAH4 (dimensionless); E is daily dietary BaP or PAH4 exposure level (ng/day); BW is body weight of each population group (kg) [10–12]; $\text{BMDL}_{10} = 70\text{ }\mu\text{g}/\text{kg bw}/\text{day}$ (for BaP) or $340\text{ }\mu\text{g}/\text{kg bw}/\text{day}$ (for PAH4) [15].

3. Results and Discussion

3.1. Concentrations of PAHs in Vegetables. Vegetable samples were divided into three groups—leafy vegetable, melon

FIGURE 1: Percentage distribution of PAH16 in different groups of vegetables.

FIGURE 2: Relative contribution of individual PAH to PAH16 in the vegetables.

and fruit vegetable, and rhizome vegetable. The mean and standard deviation values of single PAH compound, as well as the total content of PAHs, are shown in Table 1. The concentrations of 16 PAHs ranged from 60.5 to 312 ng g^{-1} (wet weight). The observed PAH16 concentrations in this study were much lower than those in vegetables growing near an iron and steel industrial area in Nanjing in 2007 (227~1533 ng g^{-1}) [16], but higher than 25.0~290 ng g^{-1} in vegetables grown in an industrial Greek area [17]. According to Figure 1, the three groups of vegetable samples in PAH16 ranked in the order: leafy vegetable > melon and fruit vegetable > rhizome vegetable. The highest level of PAH16 was detected in Chinese cabbage (312 ng g^{-1}) followed by cauliflower (198 ng g^{-1}) and tomato (105 ng g^{-1}) whereas cucumber (60.5 ng g^{-1}) accumulated the lowest amount. Due to the difference of surface/mass ratio, the leafy vegetable such as green vegetables and Chinese cabbage, which have large surface area, showed high values of PAHs contents [14, 18]. Another study also found that the highest concentration was in the leafy vegetable, followed by melon and fruit vegetable, while the lowest concentration was found in the rhizome vegetable [16]. Relative contribution of individual PAH to PAH16 in vegetables is shown in Figure 2. The 16 PAHs in all kinds of vegetables ranked in the order PYR > FLA > PHE > NAP > FLO > ANT > BbF > ACY > ACE > BaA > BkF > BaP > CHR > BghiP > IcdP > DahA.

FIGURE 3: General distribution of PAH4 analytes (%).

Low-molecular-weight compounds, such as NAP, FLO, ANT, PHE, FLA, and PYR, took the dominant place in PAHs while higher-molecular-weight PAHs showed relatively low levels.

The highest level of PAH4 for individual samples was found in green vegetables (19.6 ng g^{-1}) (Table 1), owing to the high concentration of BbF (Figure 3). The concentrations of PAH4 in Chinese cabbage, green vegetables, and tomato exceeded the maximum level (ML) of 12 ng g^{-1} for PAH4 (Commission Regulation (EC) number 1881/2006 amended by Commission Regulation (EU) number 835/2011) [19]. The PAH4 values observed in eggplant and cucumber were higher than those reported for Pakistan [20] and Wuhan, China [21]. The mean BaP content was 1.05 ng g^{-1} in vegetables, which was significantly below the ML of 5 ng g^{-1} in China (GB2762-2012) and was lower than ML for BaP in 2011 (2 ng g^{-1}) [19]. However, concentrations of BaP in some kinds of samples, such as Chinese cabbage, rhizoma dioscoreae, and lotus root, exceeded 2 ng g^{-1} .

3.2. Identification of PAH Sources. PAHs molecular diagnostic ratios have long been used as a tool for PAHs source identification purposes [22–29] whereas some molecular diagnostic ratios were suggested to be of limited use as a source identification tool [30, 31]. In this study, relatively more stable ratios of BaA/(BaA + Chr) [30] and IcdP/(IcdP + BghiP) [31] were calculated to identify the sources of PAHs in the vegetables (Table 2). It was found that the above ratios were 0.83 and 0.34, respectively, which exceeded 0.35 and ranged from 0.20 to 0.50, respectively, indicating that sources of PAHs might be combustion and petroleum.

By importing the concentrations of samples into SPSS 20 with the method of R cluster analysis, it was found that the data were divided into six groups (Figure 4). The first group consisted of IcdP, BghiP, BkF, and BaP, and the second group included BaA, CHR. DahA belonged to the third group whereas NAP, BbF, and ACY were part of the fourth group. The fifth group included ANT and the sixth group consisted of ACE, PHE, FLO, PYR, and FLA. Some studies found that PHE, ANT, ACE, FLO, and PYR are considered to be the emission of coal combustion [32, 33] whereas BghiP and IcdP are tracers for vehicular fuels [28].

Vegetables in this study were sampled in wholesale markets and supermarkets in Nanjing city, which implied that these vegetables were from a wide variety of producing areas in several provinces in China, not only from Nanjing. With the relatively more stable ratios of BaA/(BaA + Chr) and IcdP/(IcdP + BghiP) as well as the method of R cluster

TABLE 1: Concentrations of PAHs expressed in ng g^{-1} in vegetables.

PAHs	Leafy vegetable		Melon and fruit vegetable				Rhizome vegetable		
	Chinese cabbage	Green vegetables	Cauliflower	Cucumber	Tomato	Eggplant	Rhizoma dioscoreae	Potato	Lotus root
NAP	25.5 $\pm$ 7.44	8.43 $\pm$ 1.43	2.69 $\pm$ 0.59	3.01 $\pm$ 0.37	16.4 $\pm$ 8.59	10.1 $\pm$ 4.47	2.20 $\pm$ 0.65	3.59 $\pm$ 2.25	3.63 $\pm$ 1.25
ACE	7.17 $\pm$ 0.51	4.87 $\pm$ 0.61	6.15 $\pm$ 0.75	5.13 $\pm$ 1.10	5.83 $\pm$ 0.59	5.39 $\pm$ 2.05	5.20 $\pm$ 1.11	5.17 $\pm$ 1.10	5.14 $\pm$ 0.96
ACY	6.54 $\pm$ 0.67	4.51 $\pm$ 0.51	5.39 $\pm$ 0.41	4.98 $\pm$ 1.06	7.46 $\pm$ 1.64	5.30 $\pm$ 0.28	5.04 $\pm$ 0.70	5.12 $\pm$ 2.26	5.23 $\pm$ 0.41
FLO	13.6 $\pm$ 0.83	6.39 $\pm$ 0.50	9.09 $\pm$ 0.45	6.07 $\pm$ 1.20	8.53 $\pm$ 2.04	7.93 $\pm$ 0.73	6.26 $\pm$ 0.25	6.22 $\pm$ 0.60	6.09 $\pm$ 0.31
PHE	24.2 $\pm$ 0.42	8.27 $\pm$ 0.63	17.5 $\pm$ 0.78	8.31 $\pm$ 0.60	13.1 $\pm$ 4.25	12.3 $\pm$ 2.44	9.16 $\pm$ 2.08	9.86 $\pm$ 2.52	9.67 $\pm$ 1.42
ANT	709 $\pm$ 0.19	6.17 $\pm$ 0.03	8.18 $\pm$ 1.25	6.22 $\pm$ 0.01	6.24 $\pm$ 0.01	6.47 $\pm$ 1.06	6.32 $\pm$ 0.98	6.36 $\pm$ 0.16	6.34 $\pm$ 0.10
FLA	43.9 $\pm$ 7.86	10.4 $\pm$ 3.11	31.6 $\pm$ 0.64	7.59 $\pm$ 0.97	10.4 $\pm$ 3.83	8.27 $\pm$ 1.16	9.74 $\pm$ 1.70	8.69 $\pm$ 1.67	10.30 $\pm$ 2.99
PYR	162 $\pm$ 29.0	17.8 $\pm$ 17.8	110 $\pm$ 1.55	11.9 $\pm$ 5.10	22.4 $\pm$ 15.6	14.5 $\pm$ 2.27	21.8 $\pm$ 7.37	16.6 $\pm$ 7.45	22.4 $\pm$ 13.4
BaA	4.02 $\pm$ 3.80	7.24 $\pm$ 0.04	0.01 $\pm$ 0.01	7.12 $\pm$ 0.03	4.34 $\pm$ 2.85	0.05 $\pm$ 0.04	0.43 $\pm$ 0.10	0.02 $\pm$ 0.01	3.61 $\pm$ 3.61
CHR	0.23 $\pm$ 0.03	3.57 $\pm$ 3.57	0.05 $\pm$ 0.02	0.07 $\pm$ 0.02	0.43 $\pm$ 0.08	0.13 $\pm$ 0.06	0.54 $\pm$ 0.16	0.03 $\pm$ 0.01	0.42 $\pm$ 0.15
BbF	9.73 $\pm$ 0.11	8.81 $\pm$ 0.39	6.40 $\pm$ 0.57	0.06 $\pm$ 0.01	9.40 $\pm$ 0.21	9.32 $\pm$ 0.13	0.32 $\pm$ 0.15	0.01 $\pm$ 0.00	3.27 $\pm$ 3.27
BkF	3.56 $\pm$ 3.56	3.40 $\pm$ 3.40	ND	0.02 $\pm$ 0.01	ND	0.05 $\pm$ 0.05	3.40 $\pm$ 3.40	4.04 $\pm$ 4.04	6.79 $\pm$ 0.02
BaP	4.40 $\pm$ 0.35	0.03 $\pm$ 0.01	0.01 $\pm$ 0.01	ND	0.04 $\pm$ 0.01	0.02 $\pm$ 0.00	2.47 $\pm$ 2.47	0.04 $\pm$ 0.01	2.46 $\pm$ 2.46
IcdP	ND	ND	ND	ND	ND	ND	2.20 $\pm$ 2.20	ND	2.34 $\pm$ 2.34
DahA	ND	ND	ND	ND	ND	ND	ND	ND	ND
BghiP	ND	ND	ND	ND	ND	ND	4.28 $\pm$ 0.19	2.29 $\pm$ 2.29	2.29 $\pm$ 2.29
Σ PAH4	18.4 $\pm$ 4.30	19.6 $\pm$ 4.01	6.48 $\pm$ 0.61	7.25 $\pm$ 0.06	14.2 $\pm$ 3.14	9.52 $\pm$ 0.23	3.76 $\pm$ 2.89	0.09 $\pm$ 0.03	9.75 $\pm$ 9.48
Σ PAH16	312 $\pm$ 34.4	89.9 $\pm$ 17.9	198 $\pm$ 2.22	60.5 $\pm$ 7.56	105 $\pm$ 40.0	79.8 $\pm$ 1.63	79.4 $\pm$ 11.3	68.0 $\pm$ 1.50	90.0 $\pm$ 28.0

ND: not detected.

TABLE 2: PAH isomer ratios commonly used in the identification of PAH sources.

Ratio	Petroleum (unburned)	Petroleum (combustion)	PAH source Petroleum and combustion (mixed)	Combustion	Biomass/coal combustion
BaA/(BaA + Chr)	<0.20		0.20–0.35	>0.35	
IcdP/(IcdP + BghiP)	<0.20	0.20–0.50			>0.50

TABLE 3: The mean values of daily dietary PAHs exposure for population groups in Nanjing (ng day⁻¹).

	Male				Female			
	Children	Adolescents	Adults	Seniors	Children	Adolescents	Adults	Seniors
BaP	173	249	272	270	160	223	254	246
PAH4 sum	1627	2339	2558	2541	1504	2099	2385	2315

FIGURE 4: Clustering tree of PAH concentration in vegetables.

analysis, the possible pollution sources of PAHs in vegetables in the producing areas might mainly be coal combustion and petroleum.

3.3. Dietary Exposure. The dietary exposure to PAHs for each population group in Nanjing is shown in Table 3. The mean BaP concentrations of dietary exposure in eight groups (boys, male adolescents, male adults, male seniors, girls, female adolescents, female adults, and female seniors) were 173, 249, 272, 270, 160, 223, 254, and 246 ng day⁻¹, respectively. The total dietary exposure of male (963 ng day⁻¹) was more than that of female (883 ng day⁻¹). Moreover, the ranking of population groups for dietary intake of BaP in decreasing order was male adults, male seniors, female adults, male adolescents, female seniors, female adolescents, boys, and girls. Daily dietary exposure to B[a]P_{eq} among above eight groups in Taiyuan, China, was 392, 511, 572, 533, 355, 441, 488, and 445 ng day⁻¹, respectively [3]. The dietary exposure in Nanjing was lower than that in Taiyuan. The first reason might be the more serious pollution level in Taiyuan. In addition, the dietary exposure of a variety of foods, which

included vegetables, fruits, rice, wheat, fish, pork, chicken, eggs, milk, oils, beef, and mutton, was assessed in Taiyuan whereas in Nanjing only that of vegetables was estimated. A third reason was that the toxicity equivalency factors (TEFs) were used to estimate the dietary exposure in Taiyuan and the TEFs in high rings of PAHs were large, which resulted in higher values of B[a]P_{eq}. Exposure dose among different population groups in Lanzhou, China, was female adult > male adult > girls > boys [34]. This result was not the same as our study due to the fact that the exposures in Lanzhou included not only dietary exposure, but inhalation exposure and skin exposure.

The mean PAH4 concentrations of dietary exposure for the above eight groups in Nanjing were 1627, 2339, 2558, 2541, 1504, 2099, 2385, and 2315 ng day⁻¹, respectively. The total dietary exposure of male (9064 ng day⁻¹) was also more than that of female (8304 ng day⁻¹) in this case. Moreover, the ranking order of population groups for dietary intake of PAH4 was the same as that of BaP. The total PAH16 concentration of dietary exposure in Catalonia, Spain, was different from our study: male adolescents > male adults > boys > female adolescents > girls and male seniors > female adults > female seniors [35]. Part of the reason for the difference between the two studies may be well related to the fact that ingestion amounts of vegetables for population groups in Nanjing were different from that in Catalonia. Another reason might be that different kinds of PAHs were chosen to calculate the exposure.

3.4. Risk Assessment. The values of MOE indicators in case of BaP and PAH4 for all residents and different population groups in Nanjing were demonstrated in Table 4. It can be found that MOEs calculated for mean exposure using EFSA BMDL10 of 70 µg/kg bw/day, EFSA for BaP were more than 10000, whereas that using EFSA BMDL10 of 340 µg/kg bw/day, EFSA for PAH4 were far less than 10000. According to the calculation, it was found that higher dietary exposure resulted in lower MOE values. Compared with the eight groups, a relatively lower MOE is characteristic for children. It may be due to the fact that children were more sensitive and were easier to be exposed to the environmental pollutants.

TABLE 4: MOE indicators within different population groups in Nanjing.

(a)															
	Consumption of vegetables (g day ⁻¹)			Mean BaP/ Σ PAH4 (ng/g)	Population exposure (ng kg ⁻¹ b.w. day ⁻¹)			BMDL ₁₀ (μ g kg ⁻¹ b.w. day ⁻¹)	MOE						
	Mean	Median	75 %tile		Mean	Median	75 %tile		Mean	Median	75 %tile				
BaP	219	235	258	1.05	4.68	5.02	5.50	70	14960	13956	12728				
PAH4 sum	219	235	258	9.90	44.0	47.2	51.7	340	7723	7204	6571				
(b)															
Population groups	MOE (in case of mean BaP)						MOE (in case of mean PAH4)								
	Mean			Median			75 %tile			Mean		Median		75 %tile	
All residents	14960			13956			12728			7723		7204		6571	
Male															
Children	7857			7330			6685			4056		3784		3451	
Adolescents	15351			14320			13061			7924		7392		6742	
Adults	20357			20357			20357			10509		9803		8941	
Seniors	19780			18452			16829			10211		9525		8688	
Female															
Children	7493			6990			6375			3868		3609		3291	
Adolescents	14471			13499			12312			7470		6969		6356	
Adults	17384			16216			14790			8974		8371		7635	
Seniors	16989			15848			14454			8770		8181		7462	

The MOE values in the groups of both adults and seniors in case of BaP were more than the critical limit of 10000 proposed by EFSA, whereas the MOE values in most groups in case of PAH4 were less than 10000, indicating a certain cancer risk.

Rozentāle studied on smoked meat products produced in Latvia and concluded a relatively higher dietary exposure and a comparatively lower MOE [14] by comparison with that in Nanjing. Different MOEs between Nanjing and Latvia may be due to the different eating habits and customs in the two regions. Veyrand found MOEs calculated for mean exposure for PAH4 were 150,000 for children and 230,000 for adults in French total diet study [8]. The results in our study were lower than the MOEs values in France, owing to the higher pollution level in Nanjing.

4. Conclusions

The content of PAH16 sum in the analyzed vegetables in Nanjing, China, ranged from 60.5 to 312 ng g⁻¹. The mean of BaP content is lower than the maximum level of European Commission Regulation. Due to the differences in growth structure of vegetables, the order of the contents of PAHs in three edible vegetables was leafy vegetable > fruit vegetable > rhizome vegetable. Source analysis indicated that PAHs in vegetables mainly came from petroleum or other incomplete combustion biomass. The ranking of population groups for dietary intake of PAHs in decreasing order was male adults, male seniors, female adults, male adolescents, female seniors, female adolescents, boys, and girls. The calculated MOE values in the case of PAH4 sum for most population groups

were less than the critical limit of 10000 proposed by EFSA, indicating a certain cancer risk.

Additional Points

Submission Declaration. The authors declare that this work described has not been published previously and that it is not under consideration for publication elsewhere, and its publication is approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out, and also, if accepted, it will not be published elsewhere including electronically in the same form, in English or in any other language, without the written consent of the copyright holder.

Competing Interests

The authors declare that there is no conflict of interests.

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