Construction of polycyclic aromatic hydrocarbon emission inventories in major cities in Jiangsu Province

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Research Article

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Abstract

The sources of 16 polycyclic aromatic hydrocarbons (PAHs) in Nanjing were studied. The overall amount for these 16 PAHs in 2019 in Nanjing was 293.54t, with 13.70t identified as carcinogenic PAHs. Most of the PAHs were generated from the combustion of Petrol, Diesel, and coke-production coal, accounting for 82.71% of the total emission amount. Among the emissions of these 16 PAHs, two- and three- ring PAHs made up the majority (81.09%). In the different areas (11 in total) of Nanjing, the PAH emissions ranged from 45.056t in Jiangning County to 10.258t in Yuhuatai County. The estimated 16 PAH emissions in Nanjing from 2005 to 2019 based on historical energy consumption data showed that the amount of PAH emission has been gradually increasing.

Introduction

Polycyclic aromatic hydrocarbons (PAHs) are widespread pollutants, mainly from incomplete combustion of organic matter and oil seepage, and are produced during thermal cracking and combustion processes (Nisbet and LaGoy, 1992). PAHs are mainly derived from anthropogenic processes, including biomass burning, coal and petroleum combustion, and coke and metal production (Zainal et al., 2020). Natural processes such as forest fires and volcanic eruptions also produce PAHs. In recent years, polycyclic aromatic hydrocarbons (PAHs) have attracted widespread attention because of their long-range transport and toxicity potential, as well as their carcinogenic, teratogenic and mutagenic properties (Menzie et al., 1992). Among the 94 compounds listed by the International Agency for Research on Cancer as carcinogenic to experimental animals, 15 of them are PAHs. Meanwhile, 16 of the PAHs are listed by the U.S. Environmental Protection Agency (USEPA) among the priority pollution controls (Weiya, 2015; Zhang et al., 2020).

The establishment of a PAH emission inventory is very important for assessing their health impact and reducing PAH emission. As of 2020, many countries have been developed multiple PAH emission inventories. Huizhong Shen et al. estimated the total global atmospheric emissions of the 16 PAHs were 504Gg in 2007. Residential/commercial biomass combustion, open field biomass combustion, oil consumption as the most significant source. South China (87 Gg), East China (111 Gg) and Southeast Asia (52 Gg) are the regions with the highest PAH emission intensity, accounting for half of the global emissions. High molecular weight carcinogenic compounds account for 56.19% of total global PAHs, and the proportion of PAHs causing cancer is higher in developing countries (6.22%) than in developed countries (5.73%), and the difference arises due to energy structure and technology (Shen et al., 2013). For the current situation of PAHs in China, Mu Xilong in "China's PAH Emission Inventory" predicts that the total amount of PAHs emitted from anthropogenic sources in China will be 81,179 tons in 2012, among which diesel vehicles contribute the largest proportion of emissions (28.6%), followed by straw burning (24.5%) and civil coal burning (10.9%). The largest PAH monomer emitted is Nap (30%), and the emissions of six strong carcinogenic PAHs account for 26% of the total emissions, which is a high proportion. The spatial distribution shows that PAH emissions in China are concentrated in regions with high economic development and dense population, such as the Bohai Rim, the Yangtze River Delta, the Sichuan Basin and the Northeast (Long, 2016). As an important gateway city of the Yangtze River Delta, Nanjing is experiencing increasingly serious air quality problems due to its economic and industrial development. Although many investigations and analyses have been done on the atmospheric air quality environment in Nanjing, there are few studies on PAHs. Therefore, it is necessary to obtain the current status, emission trends and distribution characteristics of PAHs in Nanjing, and timely analysis, to provide a basis for comprehensive improvement of environmental quality.

The purpose of this study was to estimate individual PAH emissions, as well as the total for 16 PAHs in Nanjing, and depict their distribution characteristics. The 16 PAHs included in the inventory were naphthalene (NAP), acenaphthylene (ACY), acenaphthene (ACE), fluorine (PHE), anthracene (ANT), fluoranthene (FLA), pyrene (PYP), 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). Table 1. shows the emission factors of different emission sources (Yingjun et al., 2005; Xu et al., 2006; Shen et al., 2013; Wang et al., 2013; Liu et al., 2015).

Material And Methods

Nanjing is situated in the southwestern part of Jiangsu Province, China (See Fig1). By 2020, the city will have 11 districts with a total area of 6,587 square kilometers, a built-up area of 823 square kilometers, a resident population of 8.5 million, including 7.072 million urban residents, with an urbanization rate of 83.2%. Nanjing is a Ningzhen-Yang hilly area, dominated by low hills and gentle hills, with a humid north subtropical climate and a water area of more than 11%. Nanjing is a relatively fast-growing city, with a large number of cars per capita, a concentration of heavy industrial enterprises, and a relatively obvious coal- and energy-driven economy (Xinxie et al., 2020). These cause serious pollution by PAHs, which pose a severe threat to human health.

Emission inventory establishment

The local emission inventories of 16 priority PAHs were derived from the emission factors, as well as the energy consumption structure and composition. Nanjing city to coal as the main energy consumption, heavy industrial enterprises, high per capita ownership of vehicles, rice, wheat, corn open burning situation in Nanjing in 2012 since the full establishment of the project has been reduced to a certain extent, but not completely eliminated, urban and rural households have been used by most of the energy for natural gas. For these reasons, the emission source classification in Table 2 was developed in this study.:

Among these, the amounts of domestic coal, industrial coal, and coking coal, and natural gas consumed in 2019 and 2016 were derived from the Nanjing Statistical Yearbook(Bureau, 2021)

The amounts of indoor biomass (rice, wheat, corn), coking, traffic petroleum, and industrial petroleum consumed were estimated using a regression model with the latest parameters, including the total and rural populations and total firstly, secondary, and tertiary GDPs(Zhang et al., 2007). The emissions from open crop residue burning were estimated by the yield of the staple crops, including rice, wheat, corn. According to the Global Fire Emissions Database (2019,2016), there were no forest fires in 2019,2016.

The PAH emissions were calculated as follows:

$$E = EA_{i,j} * EF_{i,j} \quad (1)$$

$$E = M_t * EF_t \quad (2)$$

$$M = N * R * D * \epsilon \quad (3)$$

where E is the emission of PAHs; EA is the activity level of emission sources, such as average annual mileage, fuel consumption, etc.; EF is the emission factor of each emission source; i is the type of PAHs; and j is the type of pollution source, M is the amount of the I biomass burned, t: EF is the emission factor. n is the crop yield, t: R is the seed to straw volume ratio of the crop, and D is the percentage of outdoor burning, %. ϵ represents the straw burning rate. According to the 2012 statistics of Nanjing Municipal Agriculture Committee, the percentage of straw burning is taken as 10%, the crop straw burning rate is 0.9, and the seed/straw ratio of rice, wheat and corn are 0.9, 1.1 and 1.2 respectively(Chunlei and Feng, 2017). Table 3 shows the calculation results

Results And Discussion

Energy consumption data

Table 4 shows the use of each emission source in Nanjing from 2005-2019. Combining the trends in Table 4 and the line graph in Figure 2, it can be seen that the growth of biomass burning is in a flat pattern during the period 2005-2019, and the stability of straw burning under the trend of rising crop production indicates that Nanjing has achieved better results in controlling open burning of straw. As a city with coal as the main energy consumption, the small change in coal use and the faster growth in oil and natural gas during the 15-year period show that Nanjing has shown a trend of replacing traditional energy sources by new sustainable energy sources in the process of environmental protection

For 2019, the total consumption of biomass is 8.078 million tons. Due to the popularity of natural gas, traditional energy sources such as home heating are no longer used in daily life and are almost completely replaced by natural gas. Nanjing heavy industry enterprises are more concentrated, chemical raw materials and chemical manufacturing, ferrous metal smelting, non-metallic mineral products and other five categories of high consumption total annual consumption of 2930 million tons of standard coal, the energy-driven economy is more obvious(Changchun et al., 2018). Petrol (422.062 million ton), diesel (209.994 million ton) accounted for 19.20% and 9.55% of the total oil consumption, respectively. Other energy consumption values were negligible.

Total emission and source profile

Table 5 lists the estimated emission inventory of PAHs from different sources in Nanjing city in 2019.which were calculated using Eqs. (1)-(3). In 2019, the total annual atmospheric emissions of the 16 PAHs in Nanjing were 293.54t, equivalent to 34.535g per capita per year. The data was estimated based on the 2020 Statistical Yearbook published by the Nanjing Bureau of Statistics and the emission

factor data. Compared with the PAH emissions from Taiyuan and Linfen in previous studies, Nanjing has more serious pollution although the dye emissions are not the largest(Qiujing et al., 2013; Liu et al., 2017)

Table 6 was the estimated emission inventory of PAHs from different sources in Nanjing city in 2016. The total annual atmospheric emissions of the 16 PAHs in Nanjing were 251.56 t, which is not significantly different from the 2019 emission trend.

Fig.3. shows the relative contributions of various sources to the total emissions in Nanjing in 2019. Oil, including petrol, diesel, and industrial oil, was undoubtedly the major PAH emission source, contributing 73.50% of the total PAH emissions. Industrial coal and Industrial coal were also important PAH emission sources. coal contributed 24.4% of the total emissions. In addition, Outdoor biomass burning, including Rice, Wheat, Corn, contributed 2% of the total.

Fig. 4. was the relative contributions of various sources to the total emissions in Nanjing city in 2016. About the same percentage as in 2019.

Fig. 5. shows the PAH emission composition profiles of Nanjing City in 2019. Phe was the highest emission of the 16 PAHs. The emissions were 74.130 t, accounting for 25.25% of the total, followed by Nap (66.716t, 22.73%). The Carcinogenic PAHs (BaA, CHR, BbF, BkF, BaP, DahA, IcdP) emissions were 133.697t, accounting for 4.67%. The low molecular weight compounds (two-and three-ring PAHs) accounted for the majority of the total emissions (81.09%), followed by the middle molecular(four-ring) (15.12%) and high molecular (five-and six-ring) compounds (3.79%)

Different PAH contributions have been found among the various sources. As can be seen from Fig. 6., Among the different ring numbers, diesel, gasoline, and coking coal emissions all occupy the top three in total emissions. Among them, in the low molecular weight, the three occupy a total of 81.66% of emissions (of which gasoline 38.62%, diesel 26.76%, coking 16.29%) medium molecular weight 86.96% (40.51%, 29.24%, 17.20%), high molecular weight 88.08% (34.54%, 24.55%, 28.99%). To control the discharge of carcinogens in coking and industrial coal, we should focus on optimizing the management and technology of coking process and improving the dust treatment technology. At the same time, new and clean energy must be developed, and it must be encouraged to improve the combustion efficiency. New energy vehicles and trams should also be promoted to replace gasoline and diesel vehicles and reduce traffic emissions.

By calculating the emission mass of BAPeq/u and total PAHs, the potential impact of different pollutants on human health can be obtained. For example, the main toxicity of PAHs in Nanjing in 2019 originated from motor vehicle emissions (64.3% of total emissions, including 41.8% from gasoline vehicles and 22.5% from diesel vehicles) and coking (33.9%) in the city. This is followed by industrial coal combustion, which accounts for 1% of the total emissions.

Spatial distribution

Because of differences in economic development and population density, the counties in Nanjing had different emissions rates and patterns. Since the officially published data are not sufficient to support the regional analysis for 2019, and the comparison of the emission status between 2019 and 2016 above shows that the emission status of both is approximately the same, this paper uses 2016 data to analyze the emission status of PAHs in each district of Nanjing. Analysis with 2016 emission data, the annual emissions for the 16 PAHs ranged from 45.056 t in Jiangning County to 10.258t in Yuhuatai County. From the data of primary and secondary industries given by Nanjing Bureau of Statistics, it can be seen that the districts with more industrial output value are Jiangning (22.12%) Qixia (21.46%), Liuhe (16.59%), and from the above analysis it can be obtained that petrol and coking also occupy a larger proportion in the source analysis of PAHs(See Fig.8.)

Historical time trends

From the data given by Nanjing Bureau of Statistics and from the economic data of the secondary industry to launch the use of PAH emission sources in Nanjing, combined with the data of PAH emission factors to calculate the PAH emissions in Nanjing from 2005 to 2019, and make the time change trend. During the period from 2005 (total emissions was 111.306t) to 2019 (total emissions was 293.544t), the total emissions increased 163.73%, primarily as a result of the increasing consumption of Coking coal, Industrial coal, as well as the rapid increase in motor vehicles and crop yields. A comparison with the results of Shen et al. (2013) shows that even though the annual total emissions in developing countries have declined since 2000, the emission amounts in some cities are still on the rise(See Fig.9.)

Coal consumption in Nanjing has been high in the past fifteen years, and although domestic energy consumption has been replaced by natural gas, coal consumption in industrial enterprises has been growing. Obviously, the emission of PAHs from the coke industry will

remain high if no measures are taken to reduce either the production or emissions during manufacturing. The imposition of PAH emission fees on coke users could be a potential measure in this regard. With the investigation, it was found that the restructuring of the energy industry and the reduction of the rural population would have some biomass combustion. There would be room for further improvement in emissions if there were appropriate financial incentives or compensation for the rural use of new energy sources or replacement of obsolete equipment. At the same time, increased promotion of new energy vehicles and subsidy policies may make more and more people willing to drive new energy vehicles as a way to reduce oil emissions.

Uncertainty analysis

The uncertainty of the PAH emission estimates mainly lies in the accuracy of the data for the energy consumption and emission factors. The energy consumption data of open crop straw burning, coal, oil, natural gas, etc. are mainly calculated by using the statistical yearbook data from Nanjing Bureau of Statistics. In addition, the burning of Biomass straw burning rate, Industrial coal, traffic oil is estimated using a fitting method function derived from a statistical analysis and mass balance under the reasonable assumption, which may have caused some uncertainty. There are differences in the annual mileage and oil consumption values. The emission factors collected by different laboratories has certain uncertainties. Thus, in the future, it is necessary to obtain more accurate emission factors for different sources by making precise measurements.

Conclusion

The emission concentration of PAHs in Nanjing was lower than the average concentration in China. The PAH emissions were dominated by low molecular weight compounds, with Phe being the largest among the 16 PAHs. The largest contribution to the total emissions of 16 PAHS comes from vehicle emissions (gasoline, diesel), and domestic vehicle emissions pollutants and coking contribute much more to human health impact potential than other sources. The quantity of PAHs emitted from Jiangning Country was the largest among the various areas in Nanjing, followed by Yuhuatai Country and Xuanwu Country. From 2005 to 2019, the annual PAHs emissions in Nanjing showed a trend of gradual increase.

Declarations

Author contributions:

All authors contributed to the conception and design of the study. Material preparation, data collection, and analysis were performed by [Pei zhang], [Ying Zhou], [Ying Chen],and [Miaotong Yu]. The first draft of the manuscript was written by [Pei zhang], and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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3:The authors declare they have no financial interests

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Tables

Table 1. Emission factors for different sources (unit: mg/kg)

Component	Biomass burning			Coal			Oil			Natural gas
	Rice	Wheat	Corn	Domestic	Industrial	Coking	Transport		Industrial	
							Petrol	Diesel		
Nap	37.00	44.00	1.50	10.9	0.52	4.9	3.63	1.26	0.51	52000
Acy	0.04	0.33	0.63	25.6	0.02	0.75	6.86	7.82	0.00	4010
Ace	0.58	0.70	0.50	10	0.1	0.13	1.62	0.43	0.00	72400
Flu	0.29	0.25	0.06	16.1	0.02	0.44	4.67	2.39	0.00	225
Phe	1.29	4.80	1.80	44.2	0.04	1.47	4	16.97	0.84	639
Ant	0.21	1.50	0.27	10.5	0.01	0.13	1	1.46	0.00	19.6
Flt	0.39	6.70	0.76	14.1	0.14	0.7	1.74	2.57	0.04	390
Pyr	0.30	3.30	0.79	10.6	0.01	0.54	2.16	2.69	0.06	1540
BaA	0.09	2.30	0.08	9.61	0	0.17	0.16	0.45	0.01	626
Chr	0.11	2.30	0.15	14	0	0.13	0.2	0.47	0.00	22.8
BbF	0.10	0.99	0.03	18.4	0.01	0.13	0.11	0.29	0.00	211
BkF	0.04	0.53	0.18	11.7	0.01	0.07	0.14	0.36	0.00	523
BaP	0.04	0.28	0.02	7.98	0	0.24	0.22	0.21	0.00	144
DahA	0.03	0.67	0.00	6.21	0.01	0.02	0.03	0.09	0.00	37.7
lcdP	0.00	0.00	0.00	9.04	0	0.08	0.14	0.14	0.00	111
BghiP	0.03	1.00	0.00	11.5	0.02	0.11	0.27	0.21	0.00	159

Note: Natural gas: g/10⁸ m³.

Table 2. Classification of emission sources applicable to Nanjing

Level 1	Level 2	Level 3	Level 4
Biomass	Straw	Outdoor burning	Rice
			Wheat
			Corn
Coal	Domestic		
	Industrial		
	Coking		
Oil	Transport	Petrol	
		Diesel	
		Industrial	
Natural gas			

Table 3. Emissions of PAHs in Nanjing from 2015-2019(unit: tons)

Year	Biomass burning			coal			Oil			Natural gas	Total
	Rice	Wheat	Corn	Domestic	Industrial	Coking	Transport		Industrial		
							Petrol	Diesel			
2019	2.288	1.533	0.016	0.000	22.157	49.628	113.746	79.399	22.869	1.908	293.544
2018	2.451	1.799	0.023	0.002	22.906	49.230	106.439	68.894	20.883	1.841	274.470
2017	2.433	1.493	0.027	0.126	24.270	52.339	98.968	60.333	19.061	1.624	260.674
2016	2.523	1.618	0.030	2.575	25.342	58.592	89.374	52.893	17.061	1.549	251.556
2015	2.619	1.664	0.041	1.075	24.940	58.003	85.027	45.737	15.792	1.389	236.288
2014	2.666	1.641	0.040	1.580	25.009	61.564	74.866	44.655	14.325	1.266	227.610
2013	2.701	1.739	0.038	1.405	25.591	67.051	72.214	34.472	12.994	1.146	219.352
2012	2.726	1.682	0.041	1.903	26.031	65.484	65.050	30.772	11.678	1.097	206.463
2011	2.656	1.420	0.044	2.707	25.260	58.664	56.360	24.959	9.955	0.904	182.929
2010	2.599	1.454	0.042	31.532	20.020	56.596	46.419	19.583	8.106	0.770	187.122
2009	2.612	1.415	0.042	6.888	13.265	64.498	39.477	15.943	6.826	0.601	151.568
2008	2.703	1.470	0.041	7.611	13.319	59.158	35.686	14.204	6.150	0.571	140.913
2007	2.364	1.426	0.034	5.775	14.111	63.299	30.752	12.465	5.322	0.511	136.060
2006	2.608	1.243	0.031	9.904	14.339	57.505	25.891	10.493	4.480	0.419	126.913
2005	2.637	0.505	0.027	12.377	13.242	46.759	21.971	9.719	3.880	0.189	111.306

Table 4. Use of emission sources in different years (unit: million ton)

Year	Biomass burning			coal			Oil			Natural gas
	Rice	Wheat	Corn	Domestic	Industrial	Coking	Transport		Industrial	
							Petrol	Diesel		
2019	5.645	2.200	0.233	0.000	2434.809	495.789	422.062	209.994	1566.398	14.343
2018	6.047	2.583	0.341	0.001	2517.174	491.808	394.949	182.212	1430.356	13.836
2017	6.000	2.144	0.395	0.055	2667.037	522.869	367.227	159.569	1305.538	12.208
2016	6.224	2.323	0.442	1.117	2784.788	585.333	331.630	139.892	1168.555	11.639
2015	6.460	2.389	0.613	0.466	2740.674	579.447	315.499	120.966	1081.675	10.438
2014	6.575	2.355	0.586	0.686	2748.233	615.026	277.797	118.102	981.141	9.518
2013	6.662	2.496	0.560	0.610	2812.237	669.844	267.956	91.173	890.014	8.613
2012	6.724	2.415	0.605	0.826	2860.496	654.184	241.375	81.385	799.882	8.241
2011	6.553	2.039	0.644	1.175	2775.867	586.057	209.127	66.011	681.863	6.792
2010	6.410	2.088	0.621	13.683	2199.987	565.399	172.243	51.794	555.221	5.789
2009	6.443	2.032	0.617	2.989	1457.727	644.336	146.484	42.166	467.523	4.520
2008	6.667	2.110	0.599	3.303	1463.641	590.988	132.415	37.566	421.255	4.294
2007	5.832	2.048	0.505	2.506	1550.710	632.357	114.109	32.967	364.491	3.841
2006	6.433	1.785	0.451	4.298	1575.757	574.473	96.069	27.752	306.861	3.149
2005	6.506	0.724	0.405	5.371	1455.167	467.127	81.524	25.705	265.742	1.417

Note: Natural gas: Billion cubic meters

Table5. PAHs emissions in Nanjing in 2019 (unit: ton)

Component	Biomass burning			coal			Oil			Natural gas	Total
	Rice	Wheat	Corn	Domestic	Industrial	Coking	Transport		Industrial		
							Petrol	Diesel			
Nap	2.088	0.968	0.003	0.000	12.661	24.294	15.321	2.646	7.989	0.746	66.716
Acy	0.002	0.007	0.001	0.000	0.487	3.718	28.953	16.422	0.000	0.058	49.649
Ace	0.033	0.015	0.001	0.000	2.435	0.645	6.837	0.903	0.000	1.038	11.907
Flu	0.016	0.006	0.000	0.000	0.487	2.181	19.710	5.019	0.000	0.003	27.423
Phe	0.073	0.106	0.004	0.000	0.974	7.288	16.882	35.636	13.158	0.009	74.130
Ant	0.012	0.033	0.001	0.000	0.243	0.645	4.221	3.066	0.000	0.000	8.220
Flt	0.022	0.147	0.002	0.000	3.409	3.471	7.344	5.397	0.627	0.006	20.423
Pyr	0.017	0.073	0.002	0.000	0.243	2.677	9.117	5.649	0.940	0.022	18.739
BaA	0.005	0.051	0.000	0.000	0.000	0.843	0.675	0.945	0.157	0.009	2.685
Chr	0.006	0.051	0.000	0.000	0.000	0.645	0.844	0.987	0.000	0.000	2.533
BbF	0.006	0.022	0.000	0.000	0.243	0.645	0.464	0.609	0.000	0.003	1.992
BkF	0.002	0.012	0.000	0.000	0.243	0.347	0.591	0.756	0.000	0.008	1.959
BaP	0.002	0.006	0.000	0.000	0.000	1.190	0.929	0.441	0.000	0.002	2.570
DahA	0.002	0.015	0.000	0.000	0.243	0.099	0.127	0.189	0.000	0.001	0.675
IcdP	0.000	0.000	0.000	0.000	0.000	0.397	0.591	0.294	0.000	0.002	1.283
BghiP	0.002	0.022	0.000	0.000	0.487	0.545	1.140	0.441	0.000	0.002	2.639

Table 6. PAHs emissions in Nanjing in 2016 (unit: ton)

Component	Biomass burning			coal			Oil			Natural gas	Total
	Rice	Wheat	Corn	Domestic	Industrial	Coking	Transport		Industrial		
							Petrol	Diesel			
Nap	2.303	1.022	0.007	0.122	14.481	28.681	12.038	1.763	5.960	0.605	66.981
Acy	0.002	0.008	0.003	0.286	0.557	4.390	22.750	10.940	0.000	0.047	38.982
Ace	0.036	0.016	0.002	0.112	2.785	0.761	5.372	0.602	0.000	0.843	10.529
Flu	0.018	0.006	0.000	0.180	0.557	2.575	15.487	3.343	0.000	0.003	22.170
Phe	0.080	0.111	0.008	0.494	1.114	8.604	13.265	23.740	9.816	0.007	57.240
Ant	0.013	0.035	0.001	0.117	0.278	0.761	3.316	2.042	0.000	0.000	6.565
Flt	0.024	0.156	0.003	0.158	3.899	4.097	5.770	3.595	0.467	0.005	18.174
Pyr	0.019	0.077	0.003	0.118	0.278	3.161	7.163	3.763	0.701	0.018	15.302
BaA	0.006	0.053	0.000	0.107	0.000	0.995	0.531	0.630	0.117	0.007	2.446
Chr	0.007	0.053	0.001	0.156	0.000	0.761	0.663	0.657	0.000	0.000	2.299
BbF	0.006	0.023	0.000	0.206	0.278	0.761	0.365	0.406	0.000	0.002	2.047
BkF	0.002	0.012	0.001	0.131	0.278	0.410	0.464	0.504	0.000	0.006	1.809
BaP	0.002	0.007	0.000	0.089	0.000	1.405	0.730	0.294	0.000	0.002	2.528
DahA	0.002	0.016	0.000	0.069	0.278	0.117	0.099	0.126	0.000	0.000	0.708
IcdP	0.000	0.000	0.000	0.101	0.000	0.468	0.464	0.196	0.000	0.001	1.231
BghiP	0.002	0.023	0.000	0.129	0.557	0.644	0.895	0.294	0.000	0.002	2.545

Figures

Figure 1

Location Map of Nanjing City

Figure 2

Variation trend of PAHs emission sources in Nanjing from 2005 to 2019

Figure 3

Overview of PAH emission sources in Nanjing in 2019

Figure 4

Overview of PAH emission sources in Nanjing in 2016

Figure 5

PAH emission profiles in Nanjing in 2019

Figure 6

Emissions of PAHs at different ring numbers in 2019

Figure 7

Source profiles of BaPeq emissions in Nanjing in 2019.

Figure 8

Emissions of PAHs in different County of Nanjing in 2016

Figure 9

Emissions of PAH in Nanjing from 2005 -2019