

Article

Pollution Characteristics and Carcinogenic Risk Assessment of PAHs in Car Dust Collected from Commercial Car Wash in Changchun, Northeast China

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Abstract: In the collection of dust, vacuum cleaners are used to clean everything inside the car, including floor/carpet, seat, console, etc. To investigate the characteristics, possible sources and carcinogenic risks of polycyclic aromatic hydrocarbons (PAHs) contamination in car dust, fourteen car dust samples were collected from commercial car washes in Changchun, Northeast China. The 16 priority PAHs were all detected in 100%, and PAHs were predominantly tetracyclic. The mean $\Sigma 16\text{PAHs}$ content was $9297.79 \pm 5855.89 \text{ ng g}^{-1}$, ranging from 2940.03 to 23,174.51 ng g^{-1} . Black carbon, total carbon and PAHs were weakly correlated. The results of positive matrix factorization indicated that coal combustion contributed 30.03% of PAHs and biomass combustion contributed 24.70%. Vehicle exhaust from traffic emissions, mainly incomplete combustion of gasoline and diesel, contributed 45.27% of PAHs. The mean incremental lifetime cancer risk (ILCR) values for children and adults were 4.94×10^{-3} and 4.37×10^{-3} , respectively, both above the threshold value of 10^{-4} . This indicates that PAHs from car dust put both adults and children at high carcinogenic risk, and that children are exposed to a higher carcinogenic risk than adults. This study provides a basis for proposing targeted measures to control PAHs' contamination from car dust.

Keywords: car dusts; PAHs; source identify; positive matrix factorization; carcinogenic risk



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1. Introduction

The private car has become one of the most important modes of travel in modern society [1,2]. The enclosed, small space of the car is likely to result in high levels of polycyclic aromatic hydrocarbons (PAHs) in car dust [3,4]. This is because dust is a good carrier of PAHs [4–6]. During opening and closing of windows and getting in and out of cars, PAHs are easily and adsorbed on the dust [7]. Therefore, it is necessary to study the PAHs' sources in car dust in order to reduce the health risk to humans [3,8]. There are many studies on the sources of PAHs in indoor dust and road/street dust [5,9,10]. However, at present, there are basically no studies on the characteristics and sources of PAHs' contamination in car dust. Cars are largely used for school (children) or work (adults) [11]. Traffic congestion in Chinese cities is severe, making the time spent in cars increasingly long. PAHs are known to have strong carcinogenic, teratogenic and mutagenic effects [12–16]. However, there are many previous studies on flame retardants such as Polybrominated diphenyl ethers (PBDEs), Brominated flame retardants (BFRs) and Organophosphorus flame retardants (PFRs) in car dust [1–3,17]. Unfortunately, there is little research on the carcinogenic risk of car dust PAHs in adults and children.

Changchun city (125°19' E, 43°43' N) is the capital of Jilin Province, located in North-east China [13]. In 2019, Changchun had a population of 4.45 million, with an area of 543 km². In 2019, there were 1.63 million non-operating cars in Changchun, including 1.53 million individual cars. Due to the limitation of collection cost, it is not possible for us to collect car dust in large quantities by hundreds or thousands [18]. However, if too few samples are collected, representation is likely to be inadequate [16,19]. Our investigation

revealed that all commercial car washes in China offer dust collection services during the car wash process. Each commercial car wash owns a large vacuum cleaner. In this study, we attempted to ensure the representativeness of the samples and also reduce the collection and analyzing costs by collecting the car dust provided by the commercial car wash.

The objectives of this paper are (1) to characterize PAHs' contamination in car dust, (2) to identify the possible sources of PAHs through principal component analysis (PCA) and positive matrix factorization (PMF) and (3) assesses the carcinogenic risk of children and adults posed by PAHs. This study will provide a basis for mitigating the hazard of PAHs' contamination in artificial micro-environmental automotive dust.

2. Methods and Materials

2.1. Sampling and Pretreatment

We randomly selected fourteen commercial car washes in Changchun, China. We signed an information letter with the operators and asked them carefully for relevant information. This study was conducted to find out about PAHs pollution from private car dust, so these commercial car washes had to meet the following conditions at the same time: (1) they must have been in service for at least one year, which avoids the effect of seasonal differences, (2) the number of vehicles washed is at least 1000 per year, (3) the type of car is mainly a family car with 2 to 7 passengers (including the driver) and driven by the owner himself, specifically including smaller cars (engine working volume of 1 L or less), medium cars (engine working volume of 1.0~1.6 L) and large cars (engine working volume of 1.6~2.5 L), and (4) car types excluding heavy, medium and light trucks and trailers for cargo.

Each car wash has its own vacuum cleaner to collect the dust from the interior car for cleaning. The vacuum cleaners are used to clean everything inside the car, including floor/carpet, seat, console, etc. We collected a total of 14 dust samples of 120 g each in December 2019. The sampling process was as follows. We gently turned on the vacuum cleaner and very carefully cleaned the filter of the Hoover with a separate brush and dustpan. Because the dust sample deposited on these filters is very small in size and can be easily re-suspended, the whole dust collection process had to be very slow and careful. Each dust sample was wrapped in tin foil and stored in plastic bag so that there was no cross contamination at all. After the dust samples had air-dried, foreign matter such as hair, grass clippings and plastic particles were removed manually and passed through a 200 mesh sieve (not grinding).

2.2. Chemical Analysis

The test for PAHs in dust was modified from the Chinese standard methods (Soil and sediment—Determination of polycyclic aromatic hydrocarbon by Gas chromatography–Mass spectrometry method, HJ 85-2016). Briefly, 1.000 g of the dust sample was accurately weighed and 50 mL of a mixture of acetone and hexane (V:V = 1:1) was added. The sample was extracted repeatedly with Soxhlet for 18 h and concentrated by rotary evaporation to approximately 2 mL at 38 °C. The extract solution was cleaned up with a silica gel SPE column (CNW, SBEQ-CA1355, 1 g, 6 mL). An amount of 1.00 g of copper powder (to remove sulphur) was added manually to the SPE column and the SPE was activated with 4 mL of dichloromethane and equilibrated twice with 5 mL of hexane before use. The flow rate was controlled to sample onto the SPE, then 2 mL of hexane was added to brush the bottle and added to the SPE column together. The SPE column was eluted with 5 mL of dichloromethane and hexane mixture (V:V = 1:9) followed by 5 mL of dichloromethane and hexane mixture (V:V = 1:9). Then, 15 mL centrifuge tubes were used to receive all the supernatant, rinsate and eluate, and nitrogen was blown to 5 mL and transferred to 10 mL volumetric tubes, fixed to 1 mL and stored at −20 °C for measurement.

The PAHs content was determined by GC-MS (7000C, Agilent, Palo Alto, CA, USA). The chromatographic column was a CD-5 MS (30 m × 0.25 mm × 0.25 µm, CNW, Shanghai, China). The ramp-up procedure was set as follows: initial temperature is 80 °C, hold for

2 min, ramp-up to 180 °C at 20 °C min^{−1}, hold for 5 min, ramp-up to 290 °C at 10 °C min^{−1}, hold for 5 min. The temperature of the injection port, transfer line and ion source were all 280 °C. The carrier gas was helium and the injection volume was 1.0 µL with no split injection. PAHs content was quantified using deuterated substitutes of five PAHs, including d₈-Nap, d₁₀-Ace, d₁₀-Phe, d₁₂-Chr and d₁₂-Pyr, as internal standard method. The PAHs recoveries, MDL and RSD of dust samples are shown in Table S1. The PAHs content in this paper was not corrected for recovery.

2.3. Carcinogenic Risk Assessment of PAHs through Dusts Exposure

The toxicity equivalency factor (TEF) approach was used to assess the carcinogenic risk posed by PAHs in car dust. Due to the strong carcinogenic effect of BaP, it is possible to quantitatively assess the carcinogenicity of PAHs to humans by using BaP as reference compound. It is calculated using the following Equation (1).

$$BaP_{eq} = \sum C_i \times TEF_i \quad (1)$$

where C_i and TEF_i are the concentration and the TEF value of PAHs, respectively, which are provided in Table S1.

Incremental lifetime cancer risk (ILCR) is widely used to assess the toxicity evaluation of PAHs in indoor, road/street and car dust. Typically, humans can be exposed to PAHs through ingestion of dust, dermal absorption and inhalation. To estimate the ILCR, the Equations (2)–(5) for these exposure pathways are given below.

$$ILCR_{ing} = CSF_{ing} \times \sqrt[3]{\frac{BW}{70}} \times \frac{CS \times IR_{ing} \times EF \times ED \times 10^{-6}}{BW \times AT} \quad (2)$$

$$ILCR_{derm} = CSF_{derm} \times \sqrt[3]{\frac{BW}{70}} \times \frac{CS \times SA \times AF \times EF \times ED \times 10^{-6} \times ABS}{BW \times AT} \quad (3)$$

$$ILCR_{inh} = CSF_{inh} \times \sqrt[3]{\frac{BW}{70}} \times \frac{CS \times \left(\frac{IR_{inh}}{PEF}\right) \times EF \times ED}{BW \times AT} \quad (4)$$

$$ILCRs = \sum (ILCR_{ing} + ILCR_{derm} + ILCR_{inh}) \quad (5)$$

where IR_{ing} and IR_{inh} are the ingestion and inhalation rates of dust, respectively; BW represents body weight; EF is the exposure frequency; ED is the exposure duration; AT is the average time during exposure; SA is the dermal exposure area; AF is the dermal adherence factor; ABS is the adsorption factor of BaP; PEF is the particle emission factor; CSF_{ing} , CSF_{derm} and CSF_{inh} are the carcinogenic slope factor for ingestion, dermal contact and inhalation, respectively. The corresponding parameter values are given in Table S2. All parameters used in ILCR models for children and adults are based on US EPA risk assessment guidelines and related publications. Carcinogenic risks exceeding 1×10^{-4} are regarded as unacceptable, whereas risks below 1×10^{-6} are considered to pose no significant health effects and risks lying in the range of 10^{-6} – 10^{-4} are generally considered as a chance that carcinogenic health effects may occur.

2.4. Statistical Analysis

The positive matrix factorization (PMF) model (version 5.0) can be downloaded from the website (<https://www.epa.gov/air-research/positive-matrix-factorization-model-environmental-data-analyses>), and is referred to the PMF 5.0 fundamentals and user guide, for details see Text S1. For correlation analysis and principal component analysis, SPSS was used (version 17.0, Chicago, IL, USA). All plots were made using origin (version 8.0, Northampton, MA, USA).

3. Results and Discussion

3.1. PAHs Content in Car Dust and Compared to Other Studies

The concentrations of 16 priority PAHs in car dust ranged from 2940.03–23,174.51 ng g^{−1}, with a mean value of 9297.79 ± 5855.89 ng g^{−1} (Table 1 and Table S3). Seven cancerogenic PAHs (Σ 7carPAHs) comprised the total content of BaA, Chr, BbF, BkF, BaP, DBA and InP. The mean value of Σ 7carPAHs was 4016.35 ± 2656.95 ng g^{−1}, with a range of 1210.59–10,945.87 ng g^{−1} (Table 1). The proportion of PAHs to the 16 PAHs was ranked according to the number of PAHs aromatic rings: four rings (35.6%) > three rings (21.1%) > five rings (20.8%) > three rings (18.4%) > two rings (4.2%). The highest content of four-aromatic-ring PAHs as a percentage of 16 PAHs is due to the fact that LMW PAHs have a high vapor pressure and are more likely to be present in the gas phase [7,20], whereas HMW PAHs are more likely to be present in the solid phase like dust particles [21,22].

Table 1. The PAHs content (ng g^{−1}) in car dusts collected from commercial car washes.

Statistic	Min	Max	Mean	SD	CV%
Black carbon (g kg ^{−1})	5.74	63.07	26.55	12.78	48.12
Total carbon (g kg ^{−1})	65.88	177.61	128.97	30.45	23.61
Naphthalene (ng g ^{−1})	68.94	1066.04	386.15	321.08	83.15
Acenaphthene (ng g ^{−1})	32.31	200.07	72.28	47.24	65.36
Acenaphthylene (ng g ^{−1})	66.34	163.83	93.92	33.16	35.31
Fluorene (ng g ^{−1})	140.81	461.07	250.37	124.81	49.85
Phenanthrene (ng g ^{−1})	469.92	3218.09	1311.79	875.10	66.71
Anthracene (ng g ^{−1})	107.01	435.25	232.66	114.91	49.39
Fluoranthene (ng g ^{−1})	254.43	2633.51	997.71	730.08	73.18
Pyrene (ng g ^{−1})	227.84	2404.42	906.20	609.46	67.25
Benzo[a]anthracene (ng g ^{−1})	135.61	1055.09	429.65	256.51	59.70
Chrysene (ng g ^{−1})	290.42	2729.97	972.96	654.09	67.23
Benzo[b]fluoranthene (ng g ^{−1})	180.07	2824.73	895.09	712.05	79.55
Benzo[k]fluoranthene (ng g ^{−1})	48.97	1096.48	412.49	319.92	77.56
Benzo[a]pyrene (ng g ^{−1})	151.81	1087.18	495.36	309.78	62.54
Dibenzo[ah]anthracene (ng g ^{−1})	39.04	454.84	129.45	121.10	93.56
Indeno[123-cd]pyrene (ng g ^{−1})	74.78	1794.49	681.34	490.78	72.03
Benzo[ghi]perylene (ng g ^{−1})	242.66	2307.03	1030.36	677.85	65.79
Σ 16PAHs (ng g ^{−1})	2940.03	23174.51	9297.79	5855.89	62.98
Σ 7carPAHs (ng g ^{−1})	1210.59	10,945.87	4016.35	2656.95	66.15
Σ LMW PAHs (ng g ^{−1})	935.32	4883.68	2347.18	1415.01	60.29
Σ HMW PAHs (ng g ^{−1})	2002.84	18,290.82	6950.61	4600.86	66.19
2 rings (ng g ^{−1})	68.94	1066.04	386.15	321.08	83.15
3 rings (ng g ^{−1})	839.72	4384.08	1961.03	1158.53	59.08
4 rings (ng g ^{−1})	911.61	8822.99	3306.52	2214.93	66.99
5 rings (ng g ^{−1})	542.13	5366.32	1932.39	1314.07	68.00
6 rings (ng g ^{−1})	423.07	4101.52	1711.70	1146.38	66.97

SD indicates standard deviation. CV indicates coefficient of variation. Σ 16PAHs indicates the sum of 16 PAHs. Σ 7carPAHs indicates the sum of seven cancerogenic PAHs. LMW PAHs indicates light molecular weight PAHs (2–3 rings PAHs). HMW PAHs indicates heavy molecular weight PAHs (4–6 rings PAHs).

PAHs' concentrations in car dust in Changchun, China are significantly higher than those in Jeddah, Saudi Arabia [18] and Kuwait [23], but clearly lower than those in Barcelona [5] (Table 2). In this study, PAHs content in car dust is higher than those in public transport areas such as bus stop [7] and railway station dust [4], and also higher than those in indoor dust in Voivodina, Serbia [21]. The PAHs content in car dust is noticeably greater than in street/road dust/soil in Shenyang, China [24], Rafsanjan, Iran [25], and Lucknow, India [26]. The high PAHs content in car dust is, on the one hand, most likely due to the small particle size of the dust samples collected in this study [27]. On the other hand, it is due to the small space of private cars [11], where the ubiquitous PAHs in the environment are easily enriched in the dust [28].

Table 2. Comparison of PAHs' concentrations (ng g^{-1}) in dust with other studies worldwide.

City	Sample (n)	N of PAHs	Range	Mean	Reference
Changchun, China	Car dust (14)	16	2940.03–23,174.51	9297.79	This study
Jeddah, Saudi Arabia	Car dust (15)	16	–	2762	[18]
Barcelona	Car dust (14)	16	–	32,512 ^a	[5]
Kuwait	Non-smoking car dust (22)	16	516–1554	945	[23]
Kuwait	Smoking car dust (18)	16	1082–3086	1908	[23]
Qingyang, China	Bus stop dust (126)	16	800–18,300	4100	[7]
Wuhan, China	Railway station dust (12)	16	4170–10,400	5940	[4]
Wuchang, China	Railway station dust (8)	16	467–5740	2580	[4]
Voivodina, Serbia	Indoor dust (47)	16	140–8265	1825	[21]
Shenyang, China	Urban dust (30)	14	371.57–3300.04	1244.76	[24]
Rafsanjan, Iran	Street dust (70)	17	1380–1550	1443	[25]
Lucknow, India	Roadside soil (10)	15	478.94–8164.07	3748.23	[26]

^a: median value.

3.2. PAHs' Source Identification

3.2.1. Correlation Analysis among PAHs, BC and TC

However, BC, TC and PAHs correlated weakly in this study (Table S3). It has been suggested that PAHs are highly susceptible to adsorption by BC, and BC becomes a carrier medium for PAHs [4]. This is due to the fact that BC itself has many pores and a large specific surface area [29,30]. However, the low BC content in car dust and the small number of dust samples likely contributed to the poor correlation between BC and PAHs. To date, several studies also showed that PAHs' accumulation in road/street dust was not clearly affected by TC or BC content, possibly due to the more complex composition of road/street dust in urban areas [6,31]. The results of our study are very similar to the above-mentioned studies.

3.2.2. Diagnostic Ratios

The PAHs sources in road and indoor dust are usually analyzed by diagnostic ratios methods [25,26]. ΣCOMB is the sum of combustion-specific compounds, including Fla, Pyr, BaA, Chr, BkF, BbF, BaP, InP and BghiP. The $\Sigma\text{LMW}/\Sigma\text{HMW}$ and $\text{COMB}/\Sigma 16\text{PAHs}$ ratios are both less than one (Figure 1), indicating that PAHs in car dust are mainly pyrogenic sources. This is similar to the results of many studies on the sources of PAHs in street/road dust and indoor dust (e.g., house, office, school) [6,7,18,29]. The corresponding Fla/(Fla + Pyr) and InP/(InP + BghiP) ratios in all car dusts ranged from 0.40 to 0.60 and 0.20 to 0.50, respectively. This indicates that PAHs were derived from petroleum combustion (liquid fossil fuels, crude oil). The BaA/(BaA + Chr) ratio indicates that PAHs present in 92.9% of car dust samples were from petroleum combustion (liquid fossil fuels, crude oil) and only 7.1% were emitted from coal and biomass combustion. This suggests that traffic emissions including vehicle exhaust from diesel combustion and petrol combustion are likely to be the main source of PAHs in car dust [32]. In addition, the Ant/(Ant + Phe) ratio was not used in this study as it may occasionally result in misinterpretation, being aware that these two compounds are less stable [21,33].

3.2.3. Principal Component Analysis

Based on the results of the initial eigenvalues, three principal components (PC) were considered [34–36], which accounted for more than 94.79% of the total variance (Table 3 and Table S5). According to the rotated component matrix (Table 3), Ace, Fla, Pyr, BaA, Chr, BbF, BkF, BaP and InP are closely related to PC1, which explains 45.81% of the total variance. PC 1 is likely to come from high temperature combustion mixtures, such as the combustion of fossil fuels, coal and petrol. PC 2 explains 36.64% of the total variance and includes Nap, Acy, Flu, Phe, Ant and BghiP. PC 2 consists mainly of light group PAHs and is likely to originate from volatile oils, coking and biomass burning. PC 3 explains

12.33% of the total variance, including DBA. DBA has been identified as a marker for motor vehicle emissions.

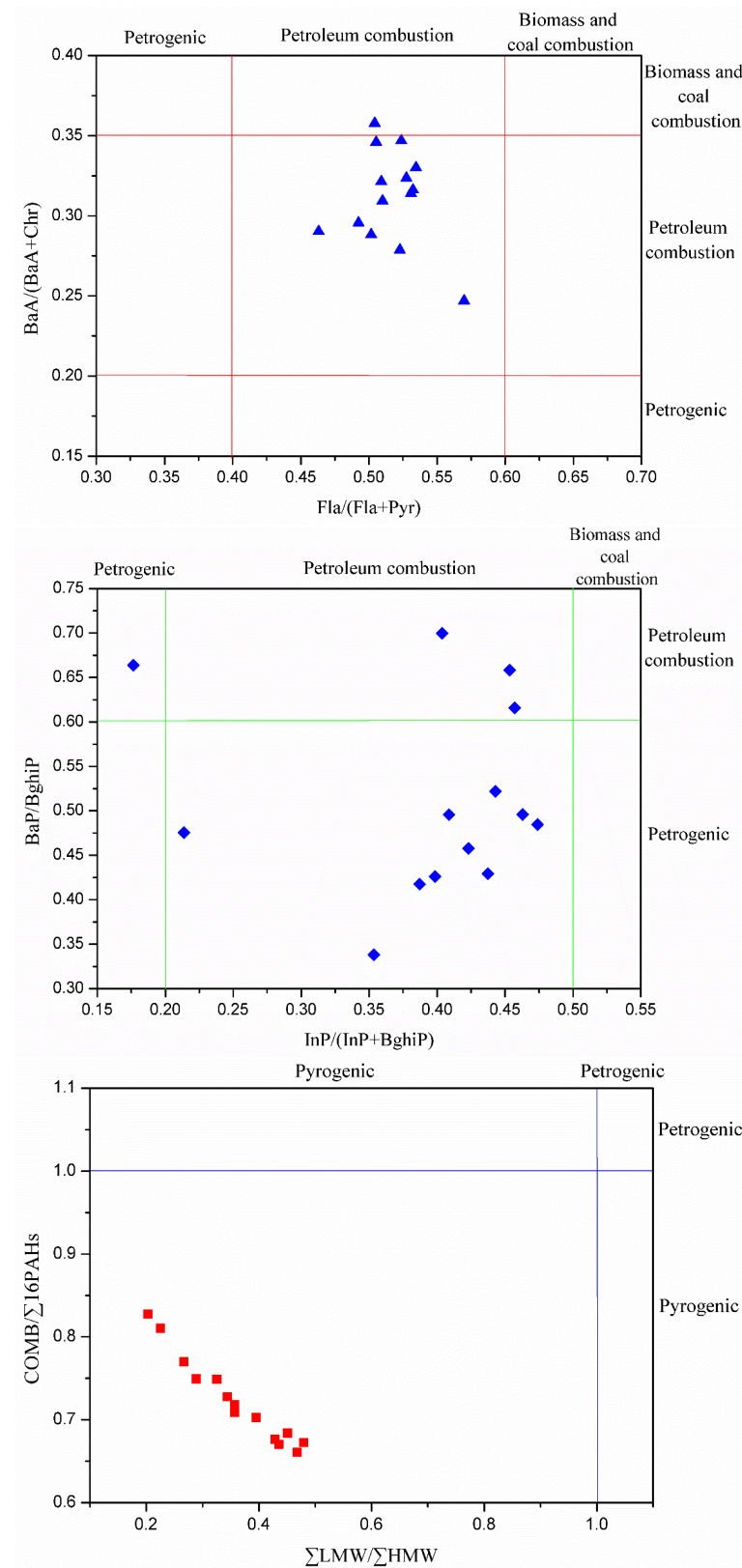


Figure 1. Bivariate scatter plot of diagnostic ratios.

Table 3. Principal component analysis and component matrixes for PAHs in car dust.

PAHs	Rotated Component Matrix ^a		
	PC 1	PC 2	PC 3
Nap	0.078	0.954	−0.044
Ace	0.944	0.193	−0.012
Acy	0.179	0.866	0.419
Flu	0.244	0.882	0.377
Phe	0.600	0.721	0.255
Ant	0.546	0.790	0.176
Fla	0.930	0.312	0.181
Pyr	0.872	0.390	0.284
BaA	0.663	0.614	0.363
Chr	0.790	0.455	0.394
BbF	0.749	0.436	0.426
BkF	0.880	−0.102	0.277
BaP	0.831	0.488	0.081
DBA	0.280	0.295	0.889
InP	0.685	0.610	0.211
BghiP	0.649	0.716	0.239
% variance	45.81	36.64	12.33

^a Rotation method: varimax with kaiser normalization. Bold values show the highest loading of a particular PAH.

3.2.4. Positive Matrix Factorization

In order to quantify the sources of PAHs, the PMF model was used to quantify the possible sources of PAHs in car dust samples and their contribution [8,37]. The results of the PMF analysis indicated that there are three identified factors that characterize the determined PAHs in car dust (Figure 2). F1 is mainly composed of light groups of PAHs such as Fla, Pyr and BkF. Coal combustion should be the likely source of F1 with a contribution of 30.03%. F2 is dominated by Acy, Flu and DBA and is likely to originate from domestic waste as well as biomass combustion such as wood with a contribution of 24.70%. F3 is mainly loaded by Nap, Ace, Phe, Ant, BaA, Chr, BbF, BaP, InP and BghiP with a contribution of 45.27%. F3 should be a typical traffic source, mainly vehicle exhaust from incomplete combustion of petrol and diesel [5,38].

3.3. Potential Carcinogenic Risks of PAHs from Car Dust

The mean ILCR values for children and adults were 4.94×10^{-3} and 4.37×10^{-3} , respectively (Figure 3 and Table S6), both higher than 1×10^{-4} . This indicates that PAHs in car dust put both adults and children at a high health risk of cancer. Children have a higher carcinogenic risk than adults. This suggests that children are more susceptible to the effects of PAHs from car dust than adults. This may be due to the specific behavior of children, including higher breathing rates per body weight and hand-to-mouth sucking activities [4,33]. The contribution of children through ingestion and the dermal contact exposure route was 44.51% and 55.49%, respectively, while the contribution of adults through the ingestion and the dermal contact exposure route was 36.02% and 63.98%, respectively. Dermal contact was the main exposure route to PAHs in car dust. The contribution to carcinogenic risk from the inhalation route is close to zero for both children and adults and is almost negligible. It is important to note that, in practice, the bioavailable fraction of PAHs should be a key aspect in assessing the precise human health risk [15,39,40]. In the present study, the oral bioavailable fraction of PAHs in car dust was ignored and the actual human intake of PAHs should be much lower, resulting in an overestimation of the carcinogenic risk from PAHs' exposure to car dust [12,39]. However, some occupational groups such as taxi drivers and bus drivers who drive for long periods of time daily are likely to be exposed to higher than average amounts of dust, and their estimated daily dust intakes are likely to be correspondingly higher [16,41].

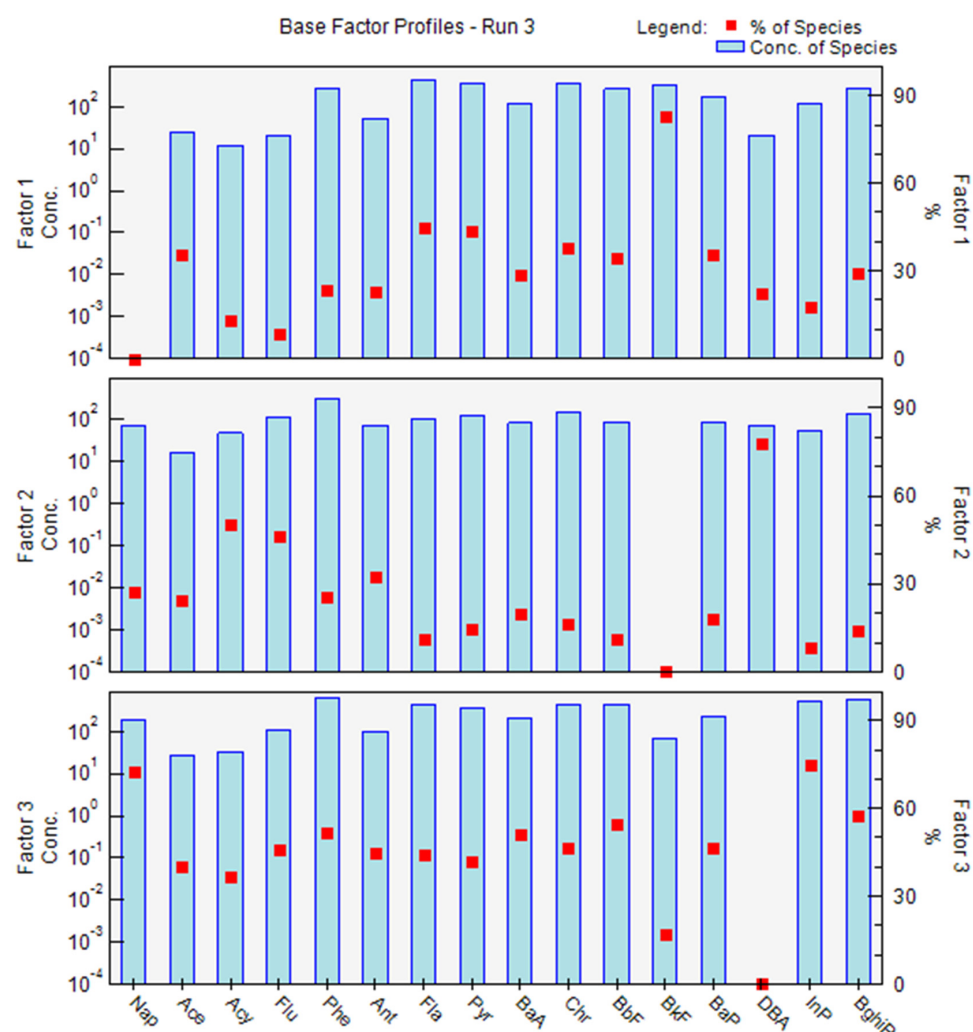


Figure 2. Source profiles and relative contribution of PAHs in car dusts obtained from PMF.

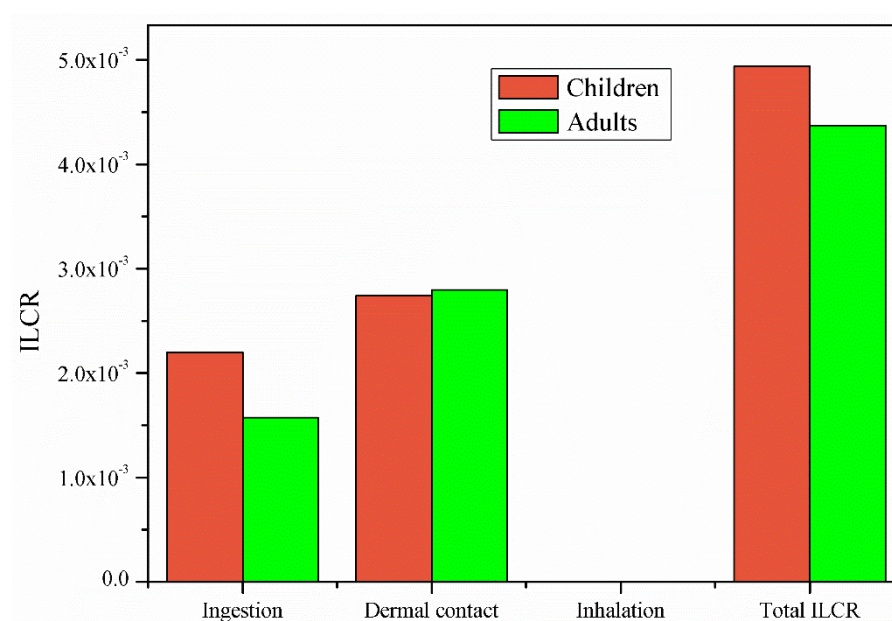


Figure 3. Carcinogenic risk posed by PAHs in car dust for adults and children.

The present study is the first report to clarify the characteristics, possible sources and carcinogenic risk of PAHs' contamination in car dust in Changchun, Northeast China. This provides fundamental data for mitigating PAHs' contamination in artificially created microenvironments [3,39]. We will consider the seasonal variation of PAHs in car dust and the effect of vehicle fuel types (e.g., electric, LPG, diesel, gasoline) on PAHs content in future studies [42,43].

4. Conclusions

Dust is a good carrier of PAHs. Cars have become an important artificially created microenvironment in modern society and PAHs' contamination in car dust will have a direct impact on human carcinogenic risk. All 16 priority PAHs were detected in car dust collected from commercial car washes in Changchun, Northeast China, and PAHs were predominantly tetracyclic. The levels of PAHs in car dust were generally higher than those in street/road dust. BC, TC and PAHs correlated poorly. Combining the diagnostic ratios method, PCA and PMF models, the contribution of coal combustion to PAHs was 30.03% and that of biomass combustion was 24.70%. Traffic emissions, mainly vehicle exhaust from the incomplete combustion of petrol and diesel, contributed 45.27% of PAHs. The mean ILCR for children and adults was 4.94×10^{-3} and 4.37×10^{-3} , respectively, both higher than 10^{-4} . This indicates that PAHs from car dust contribute to a potential carcinogenic risk for both adults and children. Children have a higher carcinogenic risk than adults. Dermal contact is the main route of exposure to PAHs in car dust. This study reports on the characteristics, possible sources and carcinogenic risks of PAHs' contamination in car dust. This provides a basis for controlling PAHs' contamination in car dusts to mitigate human health risk.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/su142215013/s1>, Text S1: Positive matrix factorization (PMF); Text S2: Black carbon (BC) and Total carbon (TC) analysis; Table S1: The names, abbreviations TEF, MDL, and Recovery of the PAHs analyzed in this research; Table S2: The values of incremental lifetime cancer risks (ILCRs) parameters to children and adults in car dust; Table S3: All data of BC (g kg^{-1}), TC (g kg^{-1}), PAHs (ng g^{-1}) contents in car dusts from commercial car wash; Table S4: Pearson correlation among BC, TC and PAHs; Table S5: Total variance explained and component matrixes (three principal components selected) for PAHs in car dust; Table S6: The BaPeq, and ILCR in all car dust sample.

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