

Supplementary Materials:

Spatial Distribution, Source Apportionment, Ozone Formation Potential, and Health Risks of Volatile Organic Compounds over a Typical Central Plain City in China

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Table S1. Description of sampling sites.

Sampling Name	Logogram	Longitude	Latitude	Description
Jianxi District Experimental Primary School	JX	112.370209	34.668301	The surrounding area is a residential area, there is a subway construction site in the annex, and large vehicles are running throughout the day
Yuxi Hotel	YX	112.526962	34.706928	There are no obvious industrial sources in the surrounding area, mainly residential areas, and there are night market gathering areas within 1-2 km, which may affect the concentration level of VOCs at night
Luoyang Institute of Technology	LG	112.413567	34.649601	The point is located at the edge of the urban area, no more than 2km from the national control station-shooting hall station
Municipal Party School	DX	112.400177	34.65078	The site is located at the top of the hotel building next to the Party School of the Municipal Party Committee, next to the residential building. The kitchen smoke of the residential building has a unified purification flue, there is a subway construction site within 1km, and large vehicles are running.
Huaxia Road Community	HX	112.391319	34.622326	The site is located in the development zone, far away from the urban area, nearby the King Zhou tomb, rich in vegetation, no obvious industrial sources and residential areas around.
Yiyang County Provincial Control Station	YY	112.179189	34.514672	The site is located in the riverside park, on the roof of the police station, with rich vegetation and close to the Luohe River. The location is relatively remote and there are no industrial sources or residential areas nearby.

Xin'an County Provincial Control Station	XA	112.13242	34.72818	The site is located in the park and is rich in vegetation. The location is relatively remote, with no industrial sources or residential areas nearby
Yichuan County Experimental Primary School	YC	112.427498	34.429958	Located in the city, convenient transportation
Jili District Environmental Protection Agency	JL	112.579292	34.89893	The site is located on the top of the building of the Environmental Protection Bureau of Geely District, and there are petrochemical enterprises nearby.

Table S2. County overview.

County	Location	Population	GDP(¥)	Industry Overview
YY	Longitude 111°45'-112°26'E Latitude 34°16'-34°42'N	702800 (2017)	30.17 billion (2018)	Mainly manufacturing, such as rubber and plastic products, printing, metal products, automobiles and food
XA	Longitude 111°53'E to 112°19'E Latitude 34°36'N to 35°05'N,	520000 (2016)	51.46 billion (2018)	Mainly agriculture and heavy industry
YC	Longitude 112°42'E Latitude 34°.42'N	844000 (2018)	419.6 Billion (2019)	Mainly coal, electricity, aluminum, abrasives, machinery manufacturing, winemaking
JL	Longitude 112°59'E Latitude 34°90'N	69076 (2011)	-	Dominated by petrochemical industry

Table S3. Minimum detection limit (MDL) for each VOCs species (ppbv).

VOCs	MDL	VOCs	MDL
Ethane	0.06	Ethylene	0.008
Propane	0.081	Propylene	0.032
Isobutane	0.035	trans-2-Butene	0.02
n-Butane	0.046	1-Butene	0.04
iso-Pentane	0.075	cis-2-Butene	0.02
n-Pentane	0.037	Isoprene	0.02
Cyclopentane	0.029	Benzene	0.017
2-Methylpentane	0.026	Toluene	0.024
3-Methylpentane	0.026	Ethylbenzene	0.023
n-Hexane	0.042	m-/p-Xylene	0.019
2,3-Dimethylpentane	0.013	o-Xylene	0.008
n-Heptane	0.004	Styrene	0.017
n-Nonane	0.014	p-Ethyltoluene	0.007
n-Decane	0.014	1,2,4-Trimethylbenzene	0.021
Undecane	0.02	p-Diethylbenzene	0.013
Dodecane	0.025	Acetylene	0.026

Table S4. The maximum incremental reactivity (MIR) for each VOCs species.

VOCs	MIR	VOCs	MIR
Ethane	0.26	Dodecane	0.5
Propane	0.46	Ethylene	8.76
Isobutane	1.17	Propylene	11.37
n-Butane	1.08	trans-2-Butene	14.79
iso-Pentane	1.36	1-Butene	9.42
n-Pentane	1.23	cis-2-Butene	13.89
Cyclopentane	2.25	1-Pentene	6.97
2,2-Dimethylbutane	1.11	trans-2-Pentene	10.25
2,3-Dimethylbutane	0.91	cis-2-Pentene	10.07
2-Methylpentane	1.41	1-Hexene	5.28
3-Methylpentane	1.7	Isoprene	10.28
n-Hexane	1.15	Benzene	0.69
2,4-Dimethylpentane	1.46	Toluene	3.88
Methylcyclopentane	2.06	Ethylbenzene	2.93
2-Methylhexane	1.1	m-/p-Xylene	9.52
2,3-Dimethylpentane	0.91	o-Xylene	7.44
Cyclohexane	1.16	Styrene	1.65
3-Methylhexane	1.51	Isopropylbenzene	2.43
n-Heptane	0.99	n-Propylbenzene	1.95
Methylcyclohexane	1.58	m-Ethyltoluene	7.21
2,3,4-Trimethylpentane	0.96	p-Ethyltoluene	4.32
2,2,4-Trimethylpentane	1.2	1,3,5-Trimethylbenzene	11.44
2-Methylheptane	0.99	o-Ethyltoluene	5.43
3-Methylheptane	1.15	1,2,4-Trimethylbenzene	8.64
n-Octane	0.82	1,2,3-Trimethylbenzene	11.66
n-Nonane	0.71	m-Diethylbenzene	6.92
n-Decane	0.62	p-Diethylbenzene	4.31
Undecane	0.55	Acetylene	0.93

Table S5. Slope factors ($\text{kg}\cdot\text{d}\cdot\text{mg}^{-1}$) and RfD [$\text{mg}\cdot(\text{kg}\cdot\text{day})^{-1}$] values of selected VOCs according to the IRIS system.

VOCs	SF	Rfd
Benzene	0.029	0.004
Toluene	-	0.08
Ethylbenzene	0.0087	0.1
m-/p-Xylene	-	0.2
o-Xylene	-	0.2
Styrene	0.00057	0.2

Table S6. Related parameters of health risk assessment.

Parameter	Adult male
IR with medium intensity activity	$2.8 \text{ m}^3\cdot\text{h}^{-1}$
Average lifetime	70 years
EFthe exposure time	$14 \text{ h}\cdot\text{day}^{-1}$
total number of exposure days	$300 \text{ day}\cdot\text{year}^{-1}$
the total number of days in 1 year	$365 \text{ day}\cdot\text{year}^{-1}$
the body weight	70 kg

Table S7. The concentration of four categories (alkanes, alkenes, aromatics, and acetylene) among nine sampling sites (ppbv).

	Sites	Alkanes	Alkenes	Aromatics	Acetylene
Urban Sites	JX	14.00	3.40	8.62	1.80
	YX	16.85	4.57	5.99	1.81
	LG	6.74	1.71	4.94	1.10
	DX	7.10	2.43	5.81	1.03
	HX	10.23	2.90	6.09	1.18
	U-AVG ^a	10.98	3.00	6.29	1.38
Suburban Sites	YY	8.37	1.98	8.72	2.15
	XA	6.68	1.62	3.40	0.32
	YC	6.29	1.68	2.09	0.06
	S-AVG ^b	7.11	1.76	4.74	0.85
Industrial Sites	JL	17.99	6.11	11.15	2.33
	TAVG ^c	10.47	2.93	6.31	1.31

a is the total average concentration of one type VOCs (alkanes, alkenes, aromatics, and acetylene) among urban sites.

b is the total average concentration of one type VOCs (alkanes, alkenes, aromatics, and acetylene) among suburban sites.

c is the total average concentration of one type VOCs (alkanes, alkenes, aromatics, and acetylene) among all sites.

Table S8. The OFP of four categories (alkanes, alkenes, aromatics, and acetylene) among nine sampling sites (ppbv).

	Sites	Alkane	Alkene	Aromatic	Acetylene	SUM
Urban sites	JX	10.01	32.68	34.79	1.67	79.16
	YX	12.14	44.94	26.41	1.68	85.16
	LG	4.92	15.99	18.99	1.02	40.92
	DX	4.96	22.33	22.48	0.96	50.73
	HX	7.01	26.88	23.14	1.09	58.13
	U-AVG ^a	7.81	28.56	25.16	1.29	62.82
Suburban sites	YY	5.95	18.25	31.38	2.00	57.58
	XA	4.99	15.07	13.97	0.30	34.34
	YC	4.78	15.60	9.87	0.06	30.30
	S-AVG ^b	5.24	16.31	18.41	0.79	40.74
Industrial site	JL	13.22	59.31	40.05	2.17	114.74
	TAVG ^c	7.55	27.89	24.56	1.22	61.23

a is the total average OFP of one type VOCs (alkanes, alkenes, aromatics, and acetylene) among urban sites.

b is the total average OFP of one type VOCs (alkanes, alkenes, aromatics, and acetylene) among suburban sites.

c is the total average OFP of one type VOCs (alkanes, alkenes, aromatics, and acetylene) among all sites.

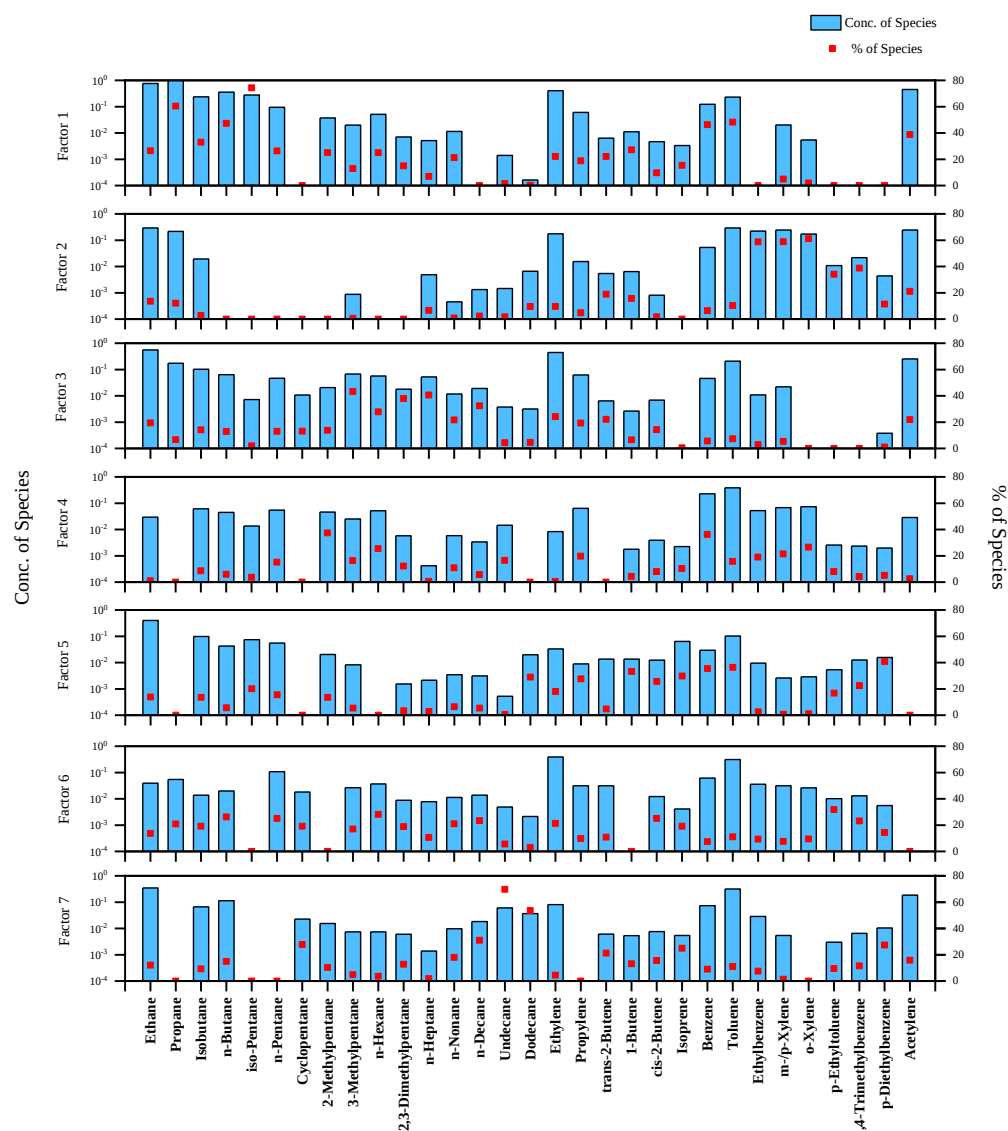


Figure S1. Characters of 7 factors analyzed by PMF in urban regions.

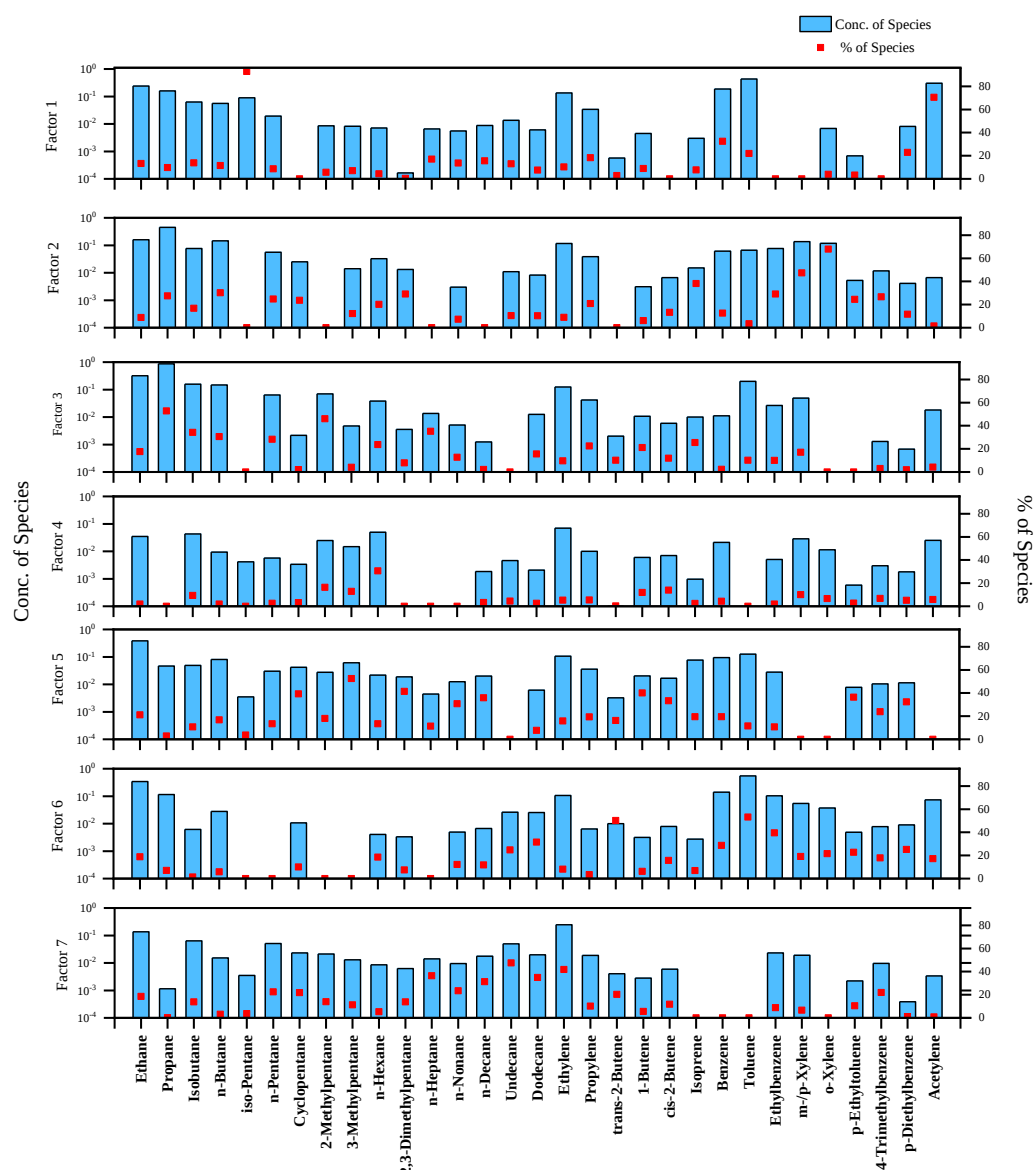


Figure S2. Characters of 7 factors analyzed by PMF in suburban regions.

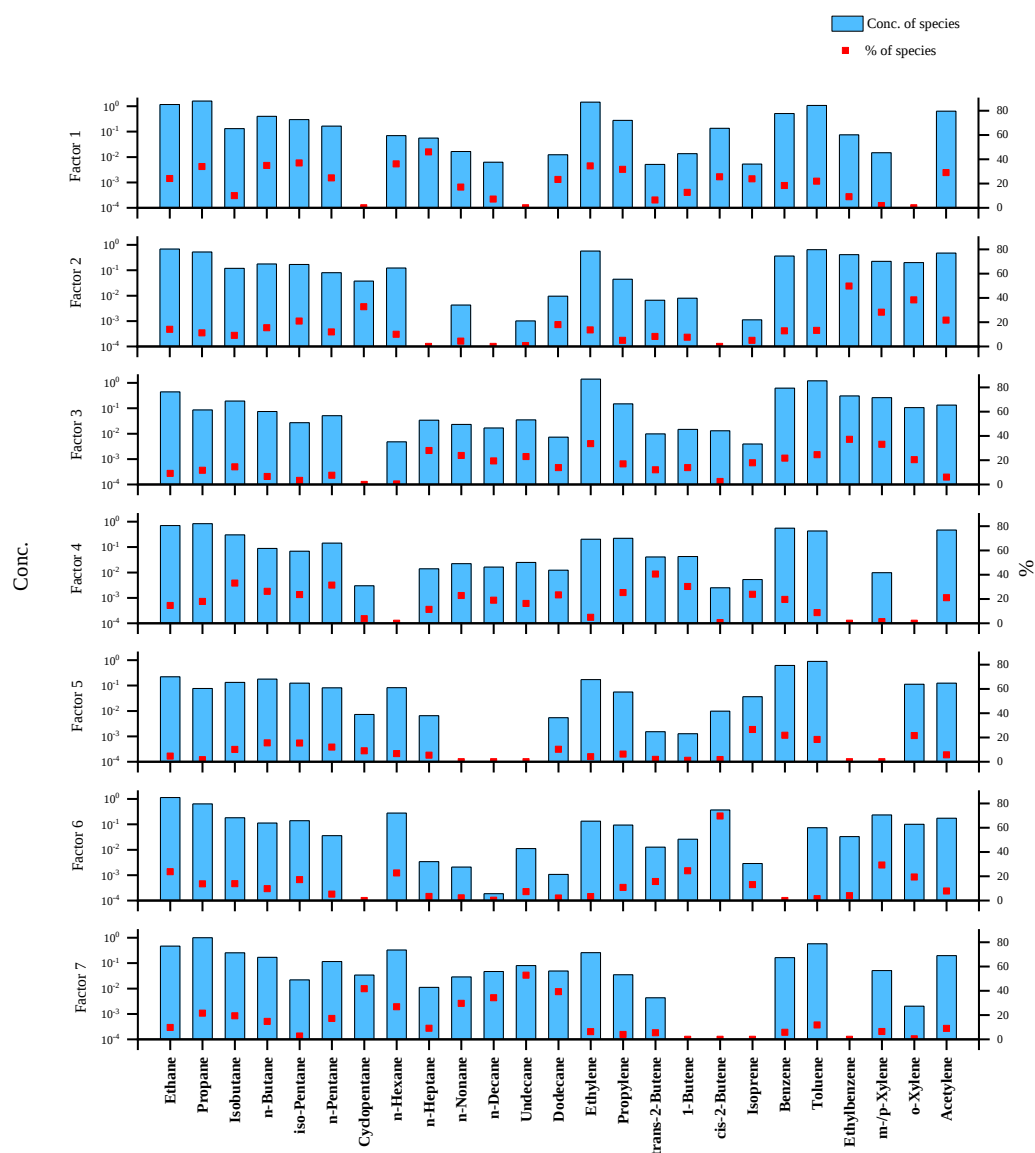


Figure S3. Characters of 7 factors analyzed by PMF in industrial region (JL).

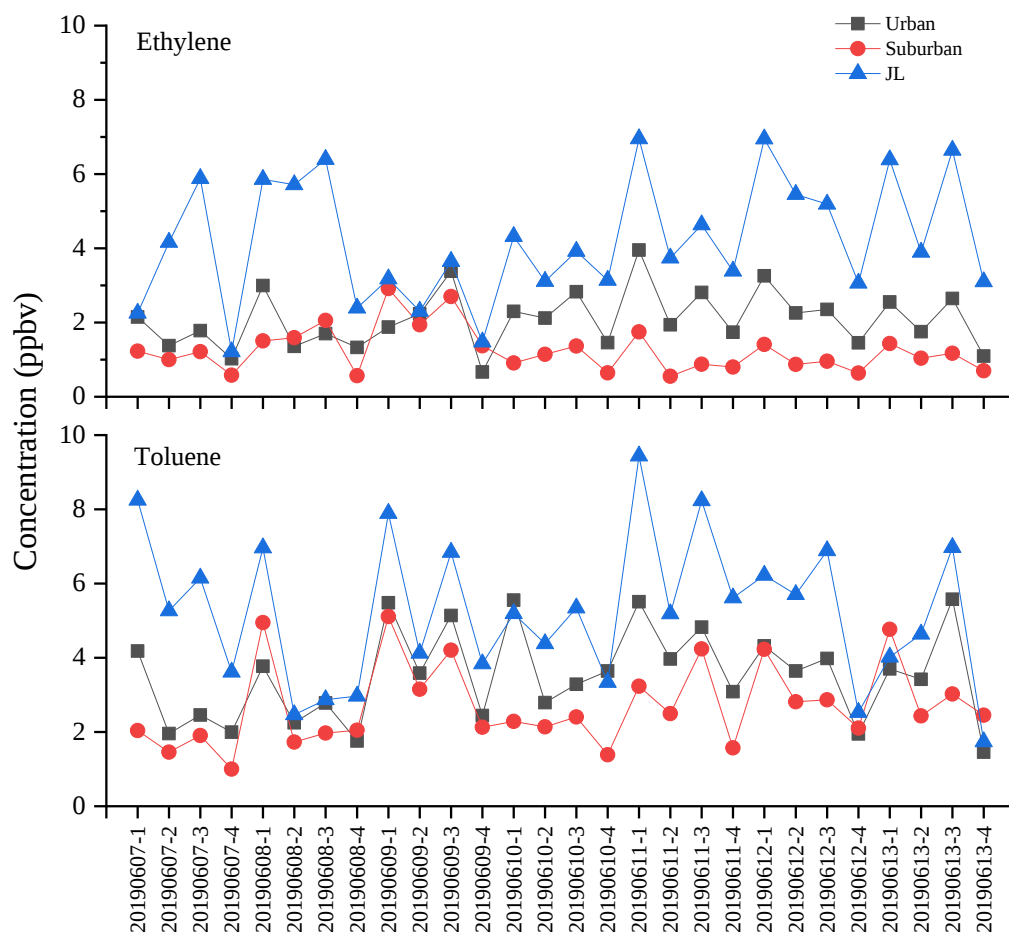


Figure 4. Daily variations of concentration in ethylene and toluene among urban, suburban and industrial areas (1,2,3,4 in x-axis denotes morning period 8:00-9:00, afternoon period 15:00-16:00, evening period 19:00-20:00, midnight period 23:00-24:00, respectively).