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Characterization of ambient volatile organic compounds, source apportionment, and the ozone–NO_x–VOC sensitivities in a heavily polluted megacity of central China: effect of sporting events and emission reductions

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Table S1 Air quality control measures for NMG China 2019

Emission sources	Description of control measures
Industrial source controls	(1) Industries failed to meet related standards must halt or reduce production; (2) High VOCs emissions factories and power plants: halted from production or cut their productions
Vehicles controls	(1) Cargo trucks (~136 thousand vehicles) were banned whole day (2) 20% of vehicles (excluding taxies and buses) (~800 thousand vehicles) were not allowed to drive inside the third ring during 07:00–21:00
Oil evaporation controls	(1) Fuel tank trucks, oil storages and gas stations failed to meet related standards must stop offering service during 8:00 to 18:00
Solvent source controls	(1) Required to operate under sealed conditions, or totally halted from operating in Zhengzhou

Table S2 Results of monitored 106 VOCs species monitored: MDLs, concentrations with statistical analysis (Mean±SD) during the three periods (unit: μg/m^3).

Groups	VOC species	MDL	pre-NMG	NMG	post-NMG
Alkanes					
	Ethane	0.04	4.2±2.8	5.7±2.3	4.3±3.9
	Propane	0.07	3.8±2.2	4.2±1.8	5.1±10
	Isobutane	0.1	2.2±1.3	1.9±1	2.5±2.6
	n-Butane	0.11	2.5±1.6	2.1±1	2.8±3.4
	Cyclopentane	0.09	BDL	BDL	BDL
	Isopentane	0.08	4.6±3.2	3.7±2.3	5±2.9
	n-Pentane	0.08	2±1.6	1.9±1.3	2.5±3.5
	2,2-Dimethyl butane	0.02	BDL	BDL	BDL
	2,3-Dimethylbutane	0.02	1.2±0.8	0.8±0.4	1.2±0.8
	2-Methylpentane	0.04	1.1±0.9	0.8±0.4	0.8±0.4
	3-Methylpentane	0.02	0.9±0.4	0.9±0.4	1.1±0.4
	n-Hexane	0.02	16.5±23.1	9.6±8.1	8.1±5.4
	2,4-Dimethylpentane	0.02	BDL	BDL	BDL
	Methyl cyclopentane	0.02	0.6±0.4	0.5±0.4	0.7±0.4
	2-Methylhexane	0.02	0.3±0	0.3±0	0.4±0
	Cyclohexane	0.02	0.4±0.4	0.3±0.4	0.4±0.8
	2,3-Dimethylpentane	0.02	0.3±0.4	BDL	BDL
	3-Methylhexane	0.01	0.4±0.4	0.3±0	0.4±0.4
	2,2,4-Trimethylpentane	0.02	0.3±0	0.3±0	0.5±0.5
	n-Heptane	0.03	0.5±0.4	0.4±0.4	0.6±0.9
	Methyl cyclohexane	0.02	0.3±0.4	BDL	0.3±0.4
	2,3,4-Trimethylpentane	0.03	BDL	BDL	BDL
	2-Methylheptane	0.02	BDL	BDL	BDL

	3-Methylheptane	0.03	BDL	BDL	BDL
	n-Octane	0.02	0.4±0.5	0.3±0	0.4±0
	n-Nonane	0.02	0.4±0	0.3±0	0.4±0
	n-Decane	0.03	0.5±0.6	0.5±0.6	0.6±0.6
	n-Undecane	0.04	BDL	BDL	BDL
	n-Dodecane	0.36	BDL	BDL	BDL
Alkenes					
	Ethene	0.05	1.5±0.9	1.7±1.1	2.5±2
	Propene	0.06	0.3±0.2	0.3±0.2	0.6±2.3
	Trans-2-butene	0.06	BDL	BDL	BDL
	1-Butene	0.07	0.2±0.3	BDL	0.1±0.3
	Cis-2-butene	0.06	0.3±0.3	0.2±0.3	0.3±0.3
	1-Pentene	0.03	0.3±0.3	0.2±0.3	0.3±0.3
	1,3-Butadiene	0.01	BDL	BDL	BDL
	Trans-2-pentene	0.03	0.8±1.3	0.7±0.3	0.6±0.6
	Isoprene	0.02	1.1±1.5	0.6±0.9	0.5±0.6
	Cis-2-pentene	0.03	BDL	BDL	BDL
	1-Hexene	0.02	BDL	BDL	BDL
Alkynes					
	Acetylene	0.04	3.1±1.7	1.4±0.9	2.9±6.7
Aromatics					
	Benzene	0.01	3.6±2.4	3.6±2.1	4.3±2.4
	Toluene	0.02	4.9±4.1	4.5±3.7	6.3±4.5
	Ethylbenzene	0.04	1.5±0.9	1.2±0.9	1.7±1.4
	m/p-xylene	0.04	4.7±3.8	4.3±4.3	5.8±4.3
	O-xylene	0.02	1.4±0.9	1.2±1.4	1.6±1.4
	Styrene	0.02	0.3±0.5	0.2±0.5	0.3±0.5

	Isopropyl benzene	0.03	0.1±0	0.1±0	0.1±0
	n-Propyl benzene	0.03	0.2±0	0.3±0	0.2±0
	3-Ethyltoluene	0.03	0.4±0.5	0.4±0.5	0.5±0.5
	4-Ethyltoluene	0.03	0.4±0	0.4±0	0.4±0.5
	1,3,5-Trimethylbenzene	0.03	0.3±0	0.3±0	0.4±0.5
	2-Ethyltoluene	0.02	BDL	BDL	BDL
	1,2,4-Trimethylbenzene	0.02	0.7±0.5	0.6±0.5	0.9±0.5
	1,2,3-Trimethylbenzene	0.03	BDL	BDL	BDL
	1,3-Diethylbenzene	0.03	BDL	BDL	BDL
	1,4-Diethylbenzene	0.03	BDL	BDL	BDL
	Naphthalene	0.03	BDL	0.3±0	1.2±1.7
Halohydrocarbons					
	Freon 12	0.04	BDL	BDL	BDL
	Freon 114	0.05	BDL	BDL	BDL
	Freon 11	0.04	2±0.6	2±0.6	1.8±0.6
	Freon 113	0.04	0.7±0	0.7±0	0.7±0
	Chloromethane	0.04	0.3±0.2	1.3±0.9	1.9±0.9
	Bromomethane	0.03	BDL	BDL	BDL
	Chloroethane	0.01	BDL	BDL	BDL
	Dichloromethane	0.02	12.6±28.8	6.7±4.2	8.1±4.9
	1,1-Dichloroethane	0.02	BDL	0.3±0	0.4±0.4
	Trichloromethane	0.03	4.8±3.2	3.5±1.6	3.1±1.6
	1,1,2-Trichloroethane	0.03	BDL	BDL	0.3±0
	Carbon tetrachloride	0.03	3.9±2.7	4.1±3.4	3.6±2.7
	1,2-Dichloroethane	0.02	5±3.1	4.6±3.1	6.1±5.7
	1,2-Dichloropropane	0.03	1.1±0.5	1.1±1	1.4±1
	Dibromochloromethane	0.05	BDL	BDL	BDL

	Bromodichloromethane	0.04	BDL	BDL	BDL
	1,1,2-Trichloroethane	0.03	BDL	BDL	0.3±0
	1,1-Dichloroethylene	0.02	BDL	BDL	BDL
	Hexachloro-1,3-butadiene	0.06	BDL	BDL	BDL
	1,2,4-Trichlorobenzene	0.04	BDL	BDL	BDL
	1,2-Dibromoethane	0.04	BDL	BDL	BDL
	Bromoform	0.06	BDL	BDL	BDL
	1,1,2,2-Tetrachloroethane	0.04	BDL	BDL	BDL
	Vinyl chloride	0.02	BDL	BDL	0.1±0.3
	Cis-1,2-dichloroethylene	0.01	0.9±0.9	1±0.9	1.7±2.2
	trans-1,2-Dichloroethylene	0.01	BDL	BDL	BDL
	Trichlorethylene	0.02	BDL	BDL	BDL
	Trans-1,3-dichloropropene	0.02	BDL	BDL	BDL
	Cis-1,3-dichloropropene	0.02	BDL	BDL	BDL
	Tetrachloroethylene	0.04	6.6±4.4	5.3±3.7	4.1±2.2
	Chlorobenzene	0.03	BDL	BDL	BDL
	1,3-Dichlorobenzene	0.03	BDL	BDL	BDL
	1,4-Dichlorobenzene	0.04	0.6±0	0.6±0	0.5±0.7
	Benzyl chloride	0.02	BDL	BDL	BDL
	1,2-Dichlorobenzene	0.04	BDL	BDL	BDL
OVOC					
	Acrolein	0.007	0.1±0	0.1±0	0.1±0.1
	4-Methyl-2-pentanone	0.006	BDL	BDL	0.1±0
	2-Hexanone	0.007	0.2±0.1	0.1±0.1	0.2±0.1
	Isopropanol	0.004	0.2±0.2	0.2±0.2	0.3±0.3
	Vinyl acetate	0.012	2.2±3	1.3±1.1	1±0.7
	Acetone	0.007	2.9±4.5	2.5±1.2	2.7±0.5

	Ethyl acetate	0.005	0.2±0.1	0.2±0.1	0.2±0.1
	2-Butanone	0.005	0.4±0.2	0.4±0.2	0.5±0.1
	Methyl methacrylate	0.01	0.2±1.4	BDL	BDL
	Tetrahydrofuran	0.009	0.3±0.2	0.4±0.3	0.3±0.2
	Methyl tert-butyl ether	0.006	0.2±0.1	0.1±0.1	0.1±0.1
	1,4-Dioxane	0.01	BDL	BDL	BDL
Sulfide					
	Carbon disulfide	0.005	0.1±0.1	0.2±0.7	0.3±0.4

Table S3 Non-carcinogenic and carcinogenic risk assessment results of VOCs in this paper and of other cities in China.

Species	RFC ($mg\ m^{-3}$)	IUR ($\mu g\ m^{-3}$)	This study		Zhengzhou (2018)		Langfang		Beijing	
			HQ	Risk	HQ	Risk	HQ	Risk	HQ	Risk
1,1,1-Trichloroethane	5.00E+00	-	1.30E-06	-	6.30E-09	-	4.60E-07	-	2.40E-07	-
1,1,2-Trichloroethane	4.00E-01	1.60E-05	1.00E-04	6.60E-07	5.20E-05	3.30E-07	-	2.30E-07	-	-
1,1-Dichloroethane	5.00E-01	1.60E-06	6.90E-05	5.50E-08	3.70E-05	2.90E-08	-	-	-	-
1,1-Dichloroethylene	2.00E-01	-	1.60E-05	-	2.20E-04	-	-	-	-	-
1,2,3-Trimethylbenzene	6.00E-02	-	5.80E-04	-	4.30E-04	-	5.70E-04	-	-	-
1,2,4-Trichlorobenzene	2.00E-01	-	2.10E-05	-	1.40E-04	-	-	-	-	-
1,2,4-Trimethylbenzene	6.00E-02	-	1.70E-03	-	5.70E-04	-	1.70E-03	-	-	-
1,2-Dibromoethane	9.00E-03	6.00E-04	1.40E-03	7.40E-06	1.70E-04	8.90E-07	2.60E-04	7.10E-07	4.90E-05	2.70E-07
1,2-Dichloroethane	2.40E+00	2.60E-05	3.10E-04	1.90E-05	2.30E-04	1.40E-05	-	-	-	-
1,2-Dichloropropane	4.00E-03	-	4.30E-02	-	5.90E-02	-	1.20E-01	-	8.00E-02	-
1,3,5-Trimethylbenzene	6.00E-02	-	8.40E-04	-	2.00E-04	-	7.90E-04	-	-	-
1,3-Butadiene	2.00E-03	3.00E-05	1.60E-03	9.40E-08	3.30E-03	2.00E-07	4.40E-02	2.60E-06	8.10E-03	4.90E-07
1,4-Dichlorobenzene	8.00E-01	1.10E-05	1.10E-04	9.30E-07	1.40E-05	1.20E-07	1.40E-05	-	5.90E-05	-
1,4-Dioxane	3.00E-02	5.00E-06	5.50E-05	8.20E-09	1.40E-03	2.20E-07	-	-	-	-
2-Butanone	5.00E+00	-	3.90E-05	-	4.90E-05	-	-	-	-	-
2-Hexanone	5.00E+00	-	2.00E-05	-	4.40E-05	-	-	-	-	-
4-Methyl-2-pentanone	3.00E+00	-	1.00E-05	-	9.80E-06	-	-	-	-	-
Acrolein	2.00E-05	-	1.60E+00	-	7.80E-01	-	4.90E+00	-	-	-
Benzene	3.00E-02	7.80E-06	1.80E-02	4.10E-06	4.30E-03	1.00E-06	3.50E-02	8.30E-06	3.60E-02	8.40E-06
Bromoform	-	1.10E-06	-	2.70E-08	-	7.90E-09	-	3.20E-09	-	-
Bromomethane	5.00E-03	-	1.80E-03	-	2.00E-03	-	1.30E-03	-	5.40E-03	-
Carbon disulfide	7.00E-01	-	1.40E-04	-	2.40E-04	-	-	-	-	-

Chlorobenzene	1.00E+00	-	2.90E-05	-	2.70E-04	-	-	-	-	-
Chloroethane	1.00E+01	-	1.40E-06	-	9.25E-07	-	-	-	-	-
Chloroform	9.80E-02	2.30E-05	5.80E-03	1.30E-05	2.60E-03	5.90E-06	-	1.30E-05	-	-
Chloromethane	9.00E-02	-	1.70E-03	-	3.70E-03	-	-	-	-	-
Cyclohexane	6.00E+00	-	9.10E-06	-	8.30E-06	-	1.20E-04	-	5.20E-05	-
Dichloromethane	6.00E-01	1.00E-08	1.90E-03	1.20E-08	1.40E-03	8.20E-09	-	-	-	-
Ethylbenzene	1.00E+00	2.50E-06	2.10E-04	5.30E-07	9.80E-05	2.50E-07	5.40E-04	-	4.20E-04	-
Hexachloro-1,3-butadiene	9.00E-02	2.20E-05	2.90E-04	5.70E-07	6.50E-04	1.30E-06	-	-	-	-
Isopropyl benzene	4.00E-01	-	4.40E-05	-	4.30E-05	-	9.10E-05	-	1.50E-05	-
m/p-Xylene	1.00E-01	-	2.00E-03	-	1.30E-03	-	1.50E-02	-	1.30E-03	-
Methyl methacrylate	7.00E-01	-	8.40E-05	-	1.80E-05	-	2.60E-03	1.60E-08	5.40E-03	3.20E-10
MTBE	3.00E+00	2.60E-07	2.80E-05	2.20E-08	1.40E-04	1.10E-07	2.90E-05	-	-	-
Naphthalene	3.00E-03	3.40E-05	2.40E-02	2.40E-06	3.10E-02	3.20E-06	-	-	-	-
n-Hexane	7.00E-01	-	2.40E-03	-	9.00E-04	-	4.20E-04	-	3.40E-04	-
o-Xylene	1.00E-01	-	7.00E-03	-	1.10E-03	-	4.90E-03	-	1.00E-02	-
Propylene	3.00E+00	-	1.90E-05	-	-	-	-	-	-	-
Styrene	1.00E+00	-	4.20E-05	-	3.20E-05	-	2.90E-04	-	6.50E-05	-
Tetrachloroethylene	4.00E-02	2.60E-07	2.10E-02	2.20E-07	6.30E-04	6.60E-09	2.50E-02	2.60E-08	2.00E-02	1.90E-07
Tetrachloromethane	1.00E-01	6.00E-06	5.90E-03	3.50E-06	1.20E-03	7.30E-07	-	-	-	-
Toluene	5.00E+00	-	1.50E-04	-	6.50E-05	-	2.40E-04	-	1.50E-04	-
trans-1,3-Dichloropropene	2.00E-02	4.00E-06	6.90E-04	5.60E-08	1.10E-03	8.70E-08	-	-	-	-
Trichloroethylene	2.00E-03	4.10E-06	1.00E-02	8.40E-08	3.30E-03	2.70E-08	2.00E-02	1.70E-07	2.10E-01	1.70E-06
Vinyl acetate	2.00E-01	-	4.30E-03	-	5.80E-04	-	-	-	-	-
Vinyl chloride	1.00E-01	8.80E-06	1.30E-04	1.20E-07	1.80E-04	1.60E-07	3.70E-04	3.30E-07	-	4.70E-06

Table S4 Noncarcinogenic and carcinogenic risk assessment results of VOCs during the three periods.

Species	HQ			
	pre-NMG	**NMG**	**post-NMG**	**Average**
Propylene	1.5E-05	1.8E-05	3.0E-05	2.0E-05
1,3-Butadiene	2.0E-03	1.1E-03	1.6E-03	1.6E-03
Cyclohexane	1.1E-05	8.1E-06	1.1E-05	9.5E-06
n-Hexane	3.6E-03	2.1E-03	1.8E-03	2.6E-03
Benzene	1.9E-02	1.8E-02	2.2E-02	1.9E-02
Toluene	1.5E-04	1.4E-04	1.9E-04	1.5E-04
Ethylbenzene	2.3E-04	1.9E-04	2.6E-04	2.2E-04
m/p-Xylene	2.2E-03	1.8E-03	2.5E-03	2.1E-03
o-Xylene	7.2E-03	6.7E-03	9.0E-03	7.3E-03
Styrene	4.9E-05	3.7E-05	4.8E-05	4.4E-05
Isopropyl benzene	5.1E-05	4.5E-05	4.2E-05	4.6E-05
1,3,5-Trimethylbenzene	8.3E-04	8.9E-04	1.0E-03	8.9E-04
1,2,4-Trimethylbenzene	1.8E-03	1.7E-03	2.3E-03	1.8E-03
1,2,3-Trimethylbenzene	6.0E-04	5.8E-04	6.9E-04	6.1E-04
Naphthalene	1.4E-02	1.8E-02	6.3E-02	2.6E-02
Carbon disulfide	9.1E-05	1.8E-04	1.9E-04	1.5E-04
Acrolein	1.5E+00	1.9E+00	1.9E+00	1.8E+00
2-Butanone	3.8E-05	4.1E-05	4.8E-05	4.1E-05
4-Methyl-2-pentanone	1.1E-05	1.0E-05	1.2E-05	1.1E-05
2-Hexanone	2.3E-05	2.0E-05	2.4E-05	2.2E-05
Vinyl acetate	6.5E-03	3.8E-03	3.1E-03	4.5E-03
Methyl methacrylate	2.4E-04	1.6E-05	1.9E-05	9.4E-05
MTBE	3.3E-05	2.7E-05	3.0E-05	2.9E-05

1,4-Dioxane	6.5E-05	4.1E-05	8.9E-05	5.8E-05
Tetrachloromethane	6.0E-03	6.4E-03	5.5E-03	6.0E-03
Dichloromethane	3.2E-03	1.7E-03	2.1E-03	2.3E-03
Bromomethane	1.7E-03	2.0E-03	2.0E-03	1.9E-03
Chloromethane	5.2E-04	2.3E-03	3.3E-03	1.9E-03
Chloroform	7.5E-03	5.4E-03	4.8E-03	5.9E-03
1,1,2-Trichloroethane	1.1E-04	1.0E-04	1.3E-04	1.1E-04
1,1,1-Trichloroethane	1.4E-06	1.3E-06	1.3E-06	1.3E-06
1,2-Dibromoethane	1.6E-03	1.3E-03	1.5E-03	1.4E-03
1,2-Dichloroethane	3.2E-04	3.0E-04	3.9E-04	3.2E-04
1,1-Dichloroethane	4.2E-05	8.1E-05	1.2E-04	7.5E-05
Chloroethane	1.5E-06	1.5E-06	1.5E-06	1.5E-06
1,2-Dichloropropane	4.3E-02	4.2E-02	5.5E-02	4.5E-02
Tetrachloroethylene	2.5E-02	2.0E-02	1.6E-02	2.1E-02
1,1-Dichloroethylene	1.7E-05	1.7E-05	1.7E-05	1.7E-05
Vinyl chloride	3.9E-05	2.0E-04	2.2E-04	1.5E-04
Trichloroethylene	1.2E-02	8.9E-03	1.3E-02	1.1E-02
trans-1,3-Dichloropropene	7.8E-04	6.2E-04	8.6E-04	7.3E-04
Hexachloro-1,3-butadiene	2.5E-04	2.7E-04	5.1E-04	3.1E-04
1,2,4-Trichlorobenzene	2.3E-05	1.2E-05	4.2E-05	2.2E-05
1,4-Dichlorobenzene	1.1E-04	1.1E-04	9.8E-05	1.1E-04
Chlorobenzene	3.1E-05	2.9E-05	3.5E-05	3.0E-05
	Carcinogenic risk			
	pre-NMG	**Dduging-NMG**	**post-NMG**	**Average**
1,3-Butadiene	1.2E-07	6.5E-08	9.5E-08	9.4E-08
Benzene	4.3E-06	4.3E-06	5.2E-06	4.4E-06

Ethylbenzene	5.8E-07	4.8E-07	6.6E-07	5.5E-07
Naphthalene	1.4E-06	1.8E-06	6.4E-06	2.6E-06
MTBE	2.5E-08	2.1E-08	2.3E-08	2.3E-08
1,4-Dioxane	9.8E-09	6.1E-09	1.3E-08	8.8E-09
Tetrachloromethane	3.6E-06	3.8E-06	3.3E-06	3.6E-06
Dichloromethane	1.9E-08	1.0E-08	1.3E-08	1.4E-08
Bromoform	3.1E-08	2.6E-08	3.0E-08	2.8E-08
Chloroform	1.7E-05	1.2E-05	1.1E-05	1.3E-05
1,1,2-Trichloroethane	6.9E-07	6.4E-07	8.2E-07	6.9E-07
1,2-Dibromoethane	8.6E-06	6.9E-06	8.1E-06	7.7E-06
1,2-Dichloroethane	2.0E-05	1.8E-05	2.5E-05	2.0E-05
1,1-Dichloroethane	3.4E-08	6.5E-08	9.7E-08	6.0E-08
Tetrachloroethylene	2.6E-07	2.1E-07	1.6E-07	2.2E-07
Vinyl chloride	3.4E-08	1.8E-07	2.0E-07	1.3E-07
Trichloroethylene	9.6E-08	7.3E-08	1.1E-07	8.7E-08
trans-1,3-Dichloropropene	6.2E-08	5.0E-08	6.9E-08	5.8E-08
Hexachloro-1,3-butadiene	4.9E-07	5.4E-07	1.0E-06	6.1E-07
1,4-Dichlorobenzene	9.5E-07	1.0E-06	8.6E-07	9.5E-07

Table S5 Meteorological conditions for the three sampling periods in Zhengzhou.

Periods	**ppt**	**T**	**RH**	**Pressure**	**Visibility**	**WS**
Unit.	mm	℃	%	hPa	km	m/s
pre-NMG period	236.9	27.4±1.2	71±11	993±4	16.7±5.5	1.7±0.3
during-NMG period	39.8	24.2±3.3	65±14	1000±4	14.1±7.0	1.7±0.4
post-NMG period	1.6	22.3±1.5	60±7	1007±2	13.0±2.7	1.5±0.3

Table S6 The concentrations of VOCs groups to the total OFP (μg/m^3)

	Alkanes	Alkenes	Aromatics	Halohydrocarbons	OVOCs	Sulfide	Alkyne
pre-NMG	48.5	30.5	98.7	2.8	56.2	0.1	2.9
during-NMG	36	21.9	91.2	2.8	30	0.2	1.3
post-NMG	41.5	21.4	124.6	3.5	27.7	0.2	2.7

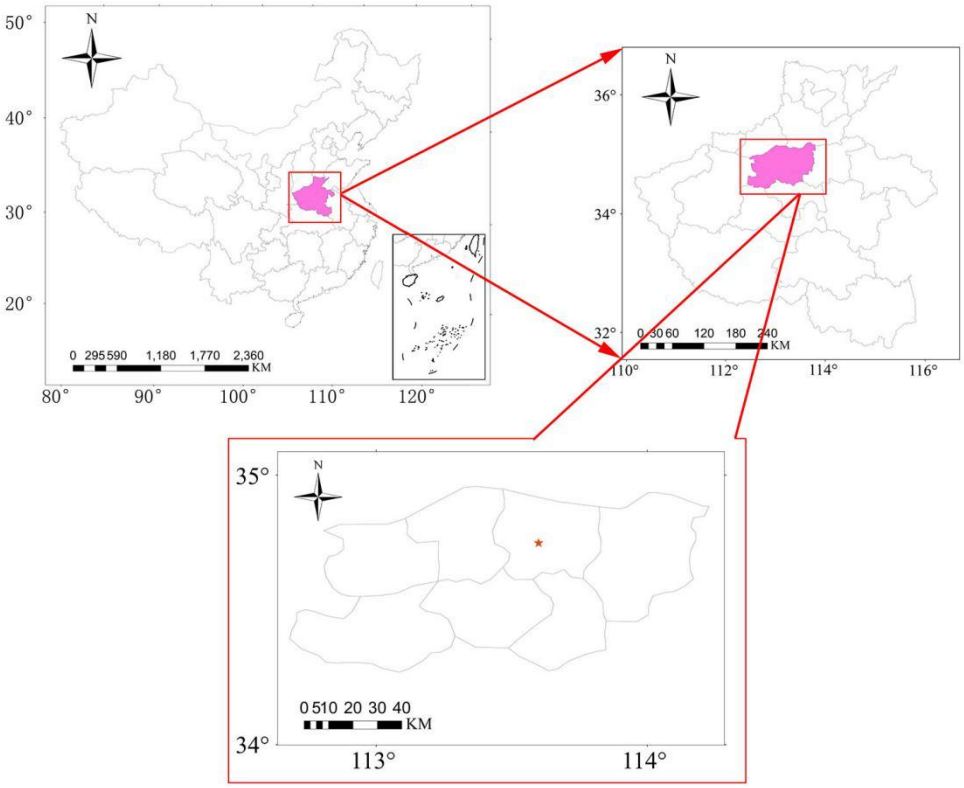


Fig. S1 Locations of the sampling stations in Zhengzhou.

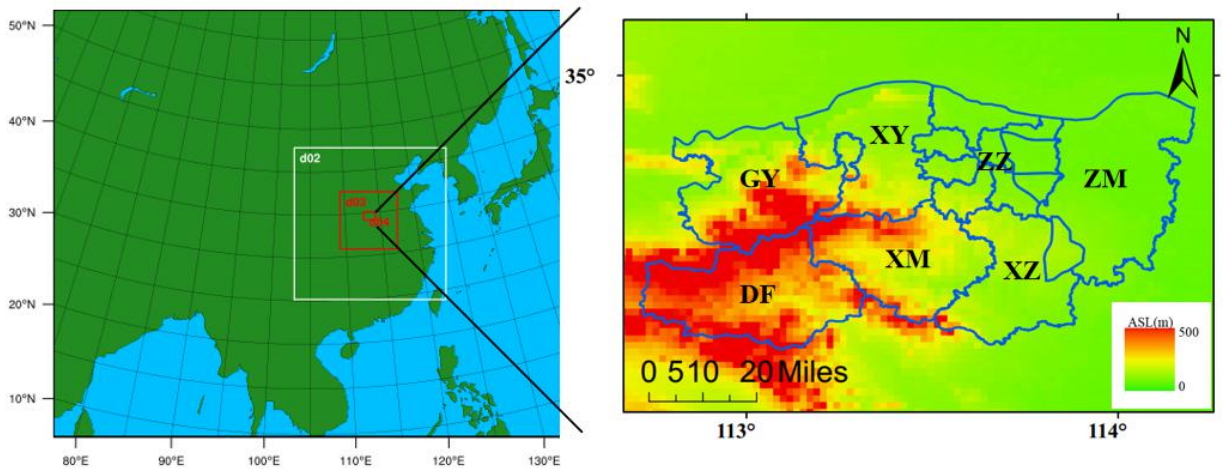


Fig. S2 Four-level nested domains used in the WRF/CMAQ simulations. d01, d02, d03 and d04 have horizontal resolutions of 36, 12, 4 and 1 km, respectively. ZZ: Zhengzhou main city; ZM: Zhongmu; XZ: Xinzheng; XM: Xinmi; DF: Dengfeng; GY: Gongyi; XY: Xingyang.

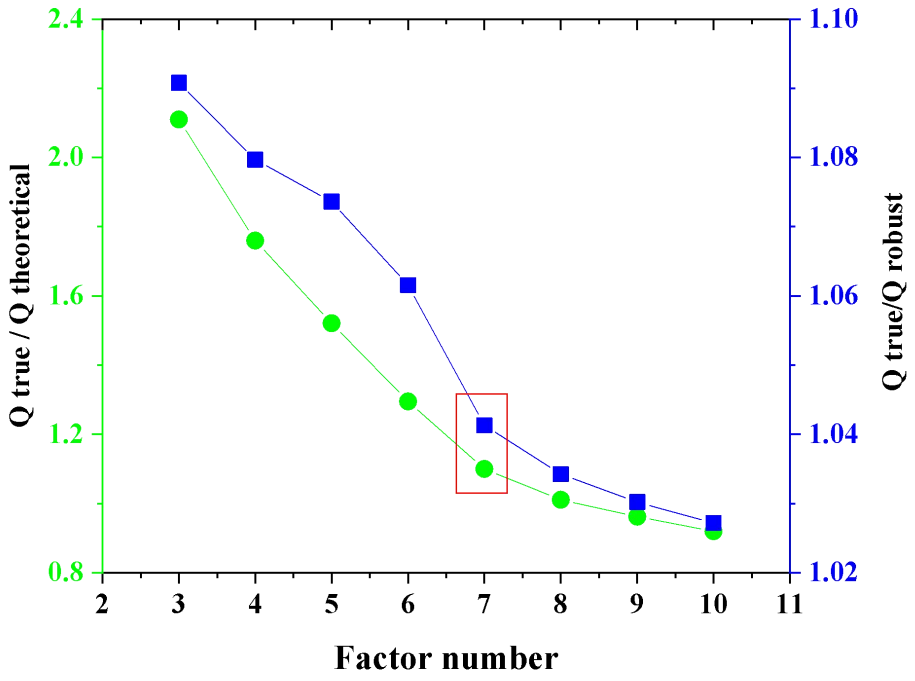


Fig. S3 The ratios of Qtrue/Qrobust and Qtrue/Qexp at factor size ranged from 3–10.

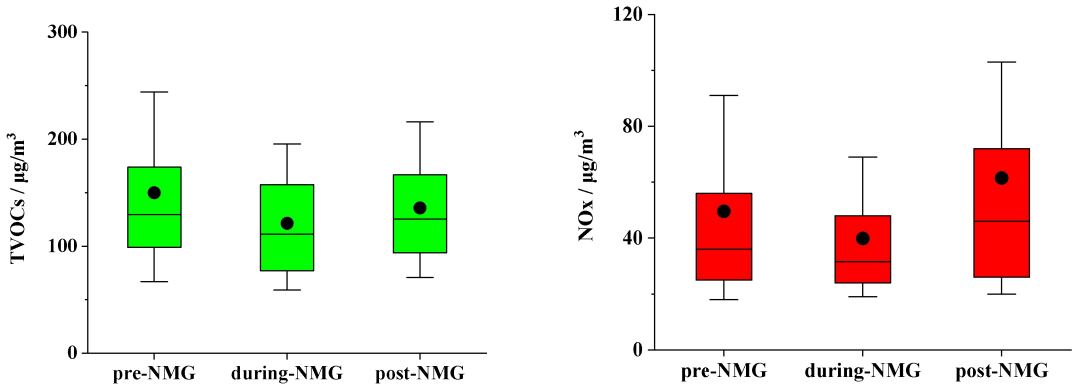


Fig. S4 The box plots for NO_x and TVOCs in Zhengzhou during the three periods.

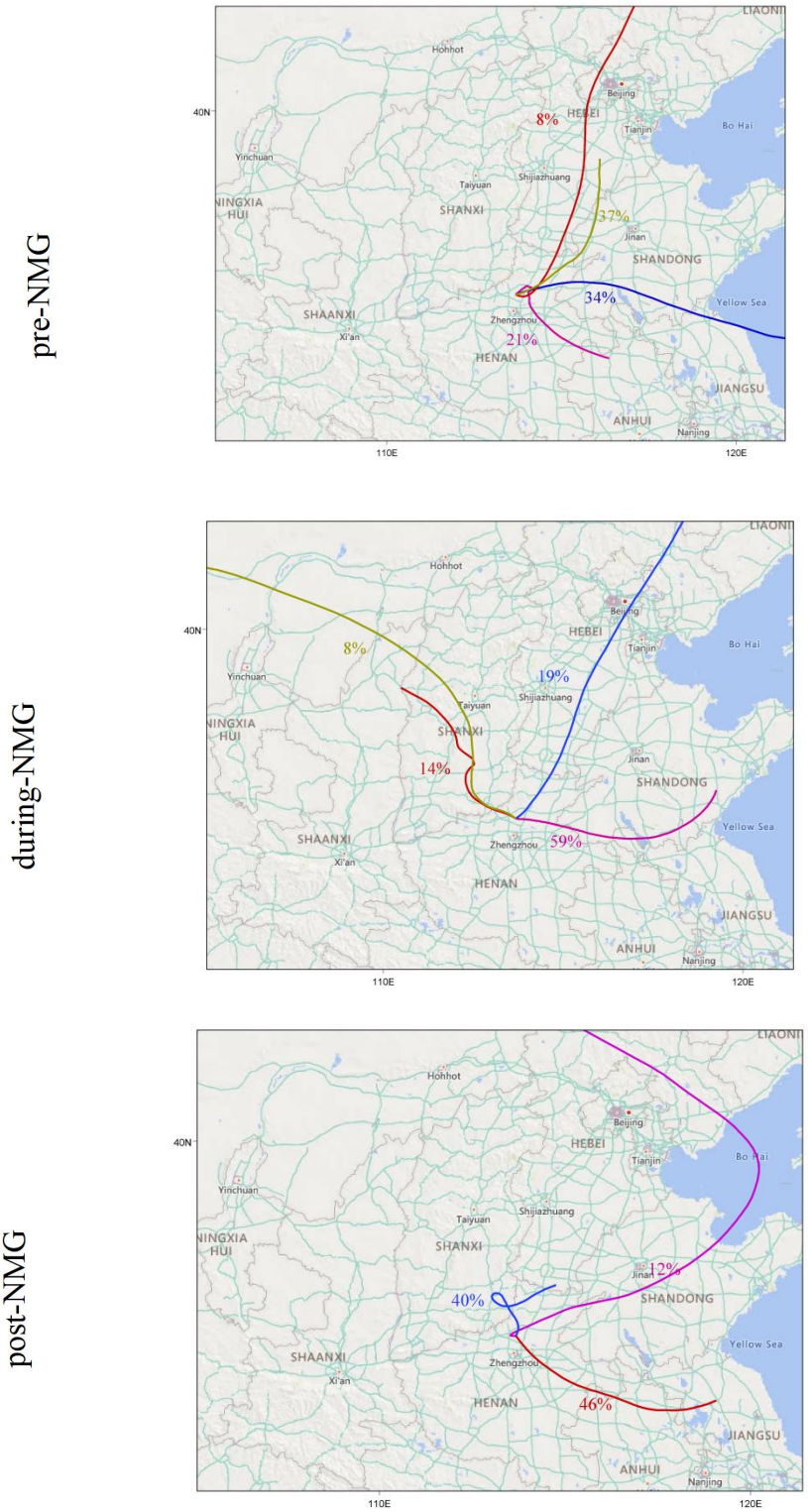


Fig. S5 The 48-h backward trajectories from Zhengzhou during the three periods.

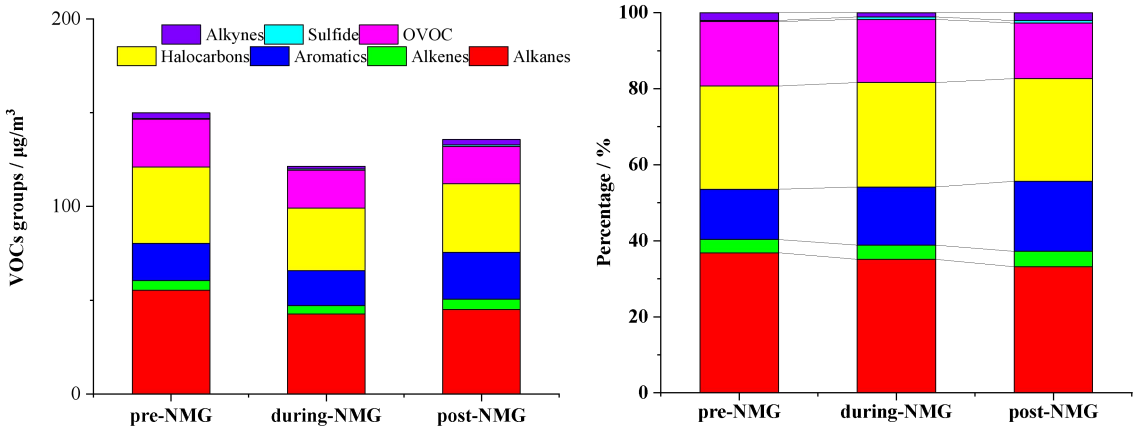


Fig. S6 Average concentrations and percentage of each group of VOCs.

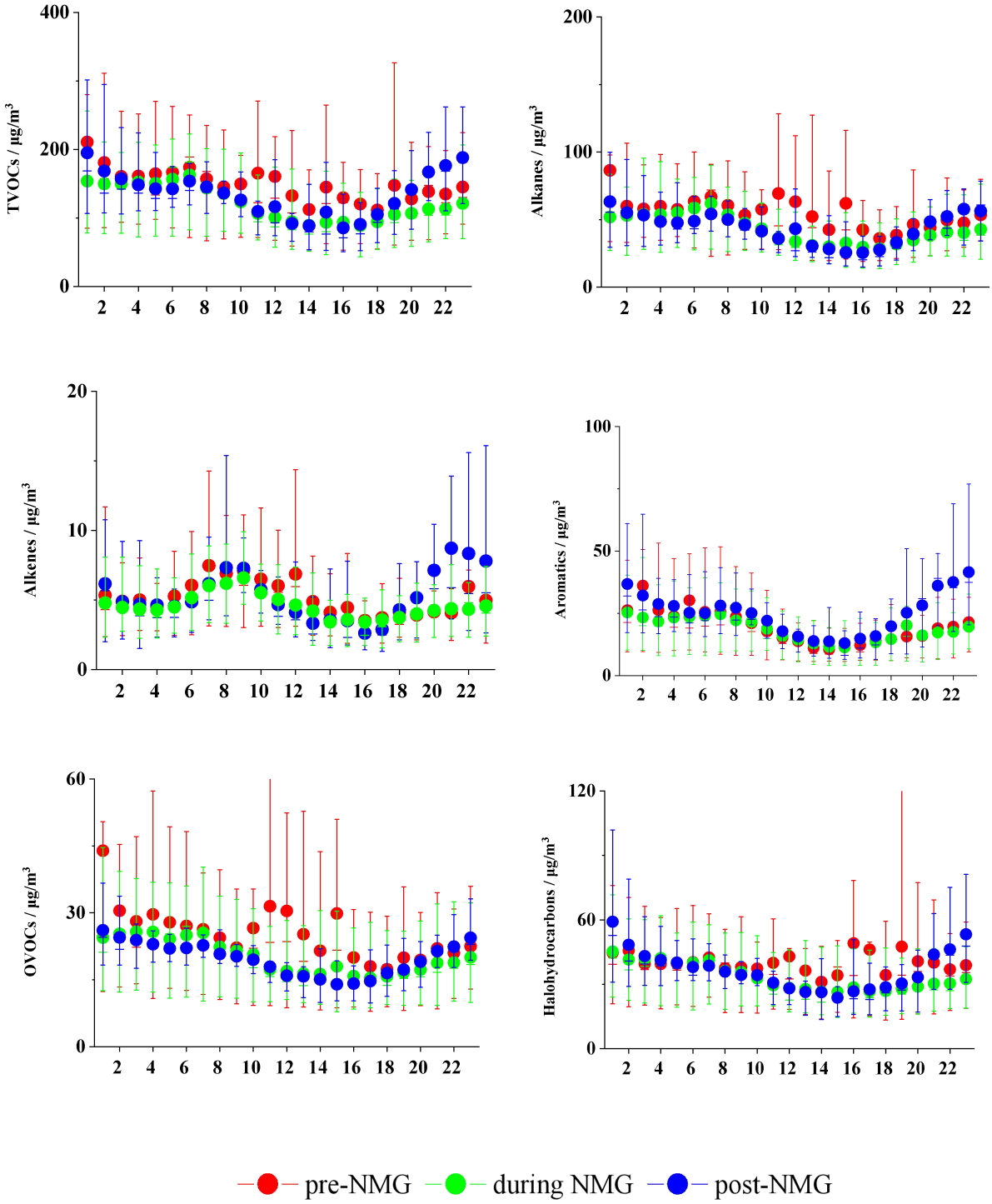


Fig. S7 Diurnal variations in concentrations of TVOC and its compounds in Zhengzhou.

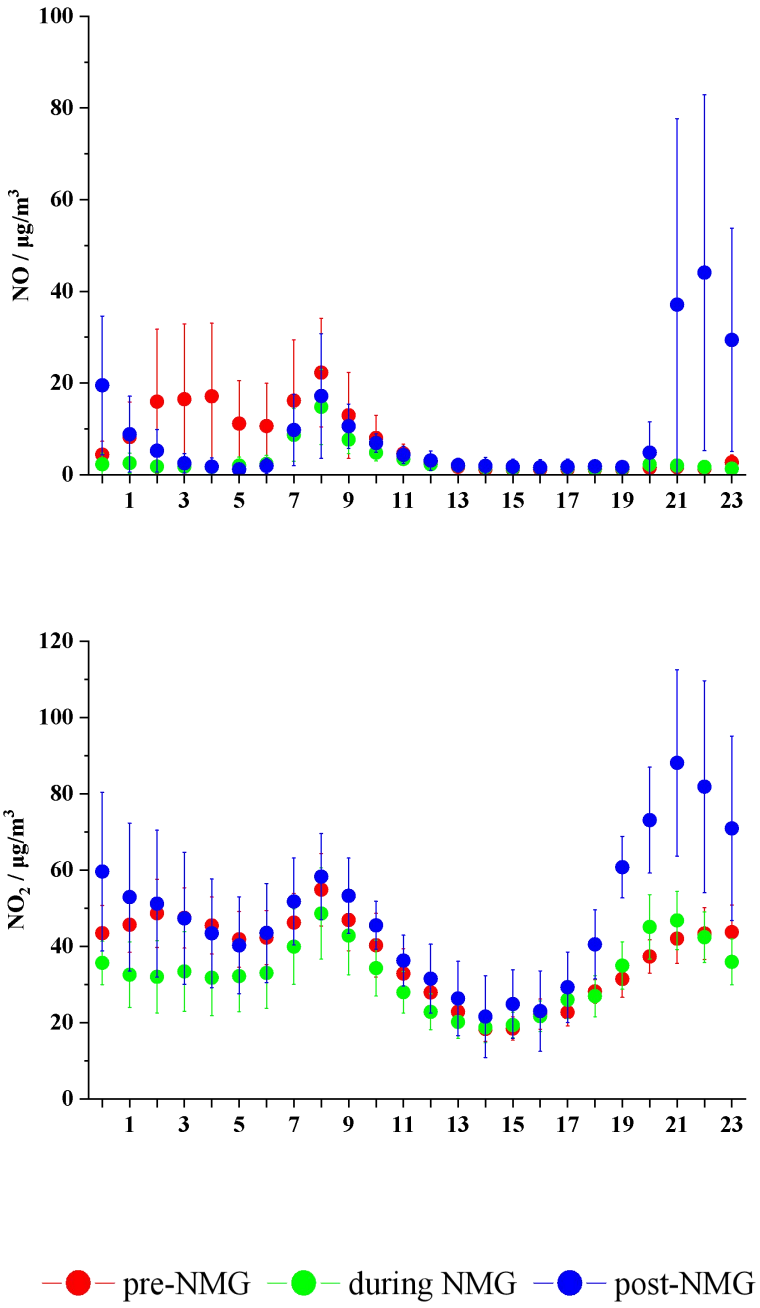


Fig. S8 Diurnal variations in concentrations of NO and NO_2 in Zhengzhou during the three periods.

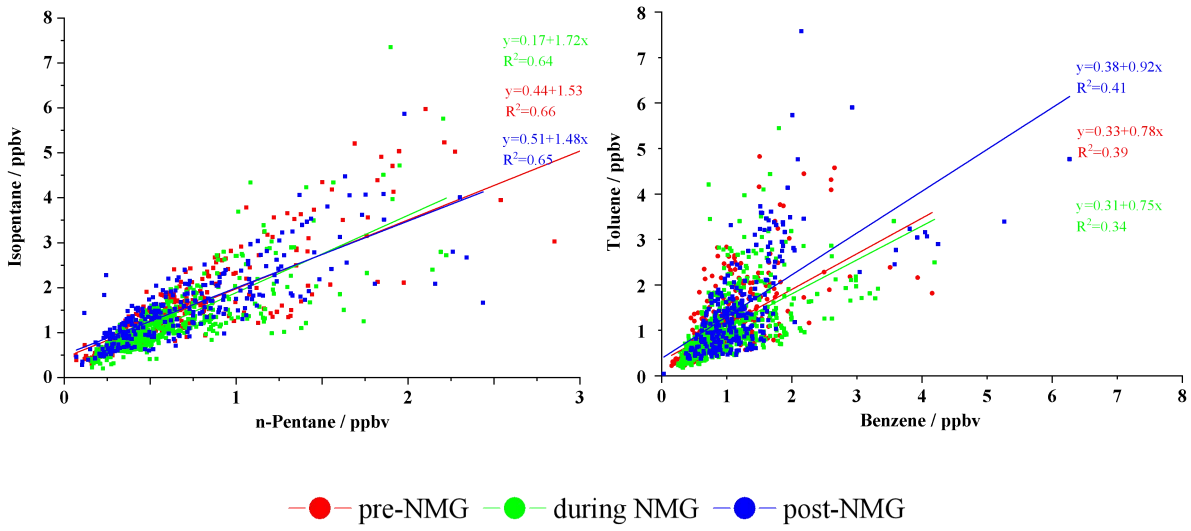


Fig. S9 Ratios of T/B and *i*/*n*-Pentane in Zhengzhou.

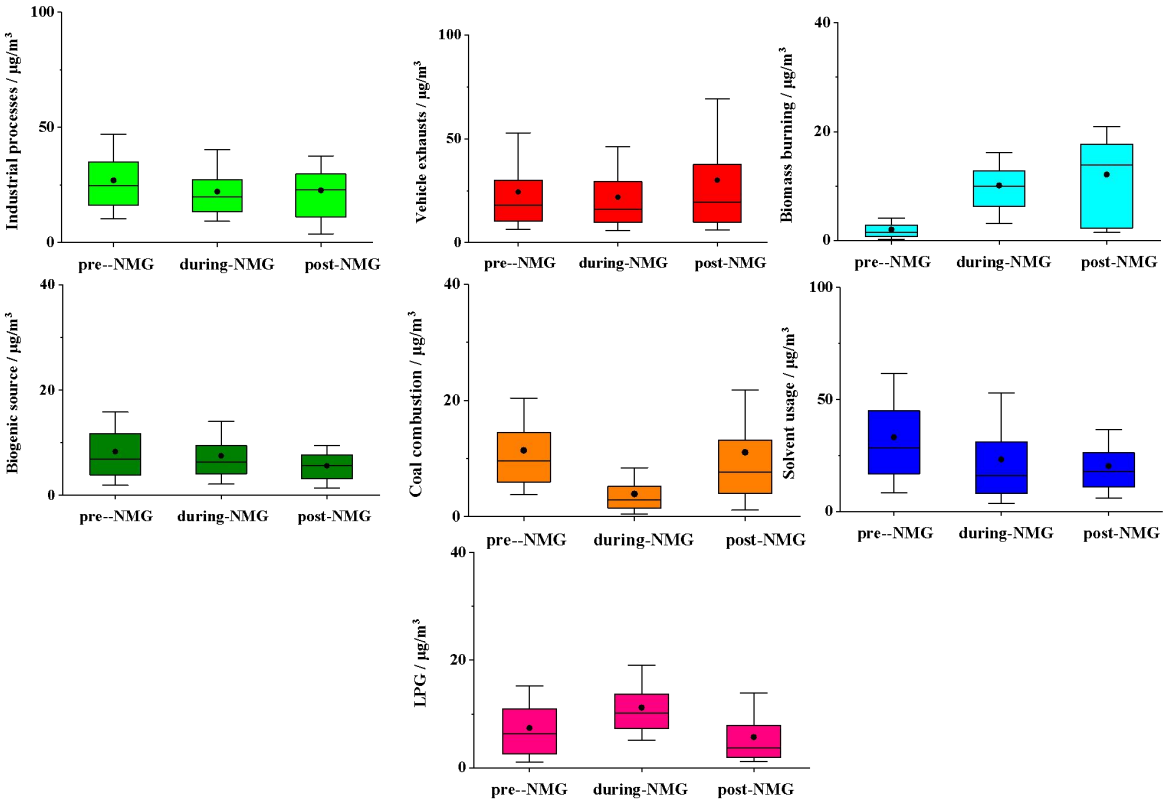
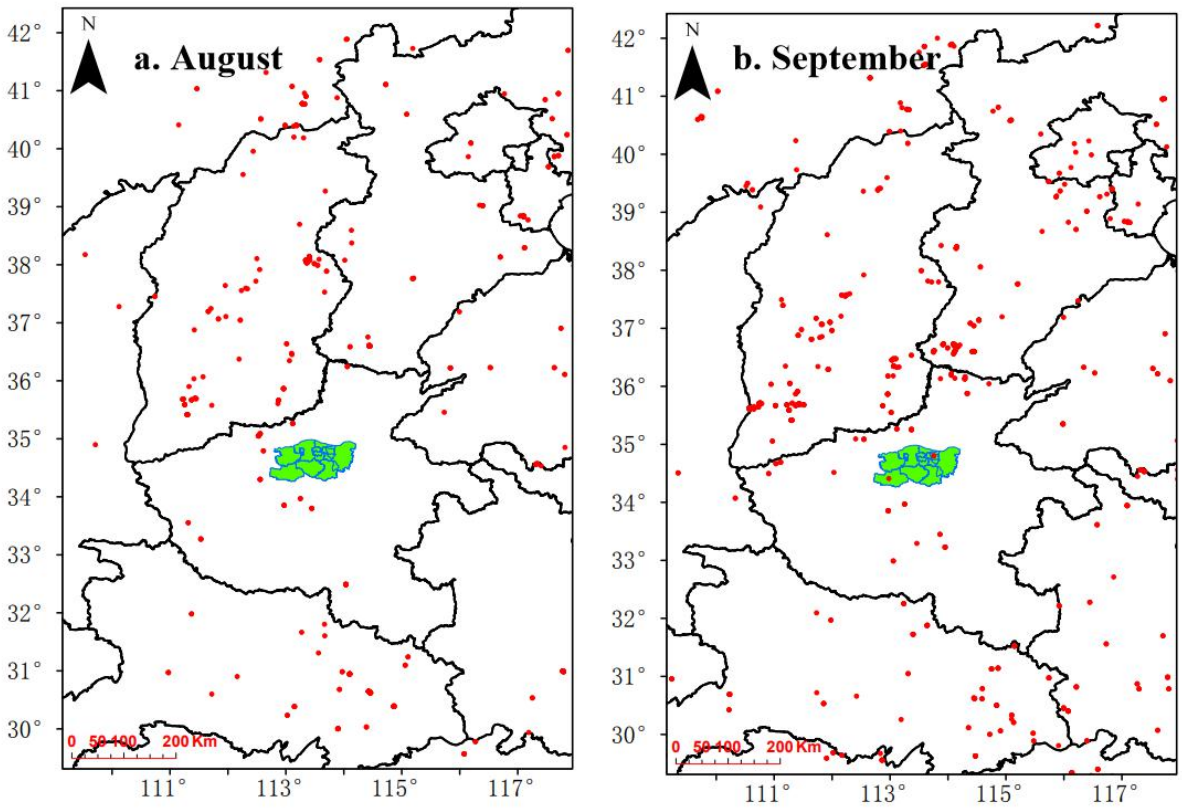


Fig. S10 The box plots for each identified source during the three periods.



Fg. S11 Hotspots diagram (https://firms.modaps.eosdis.nasa.gov/firemap/), (a) August and (b) September.

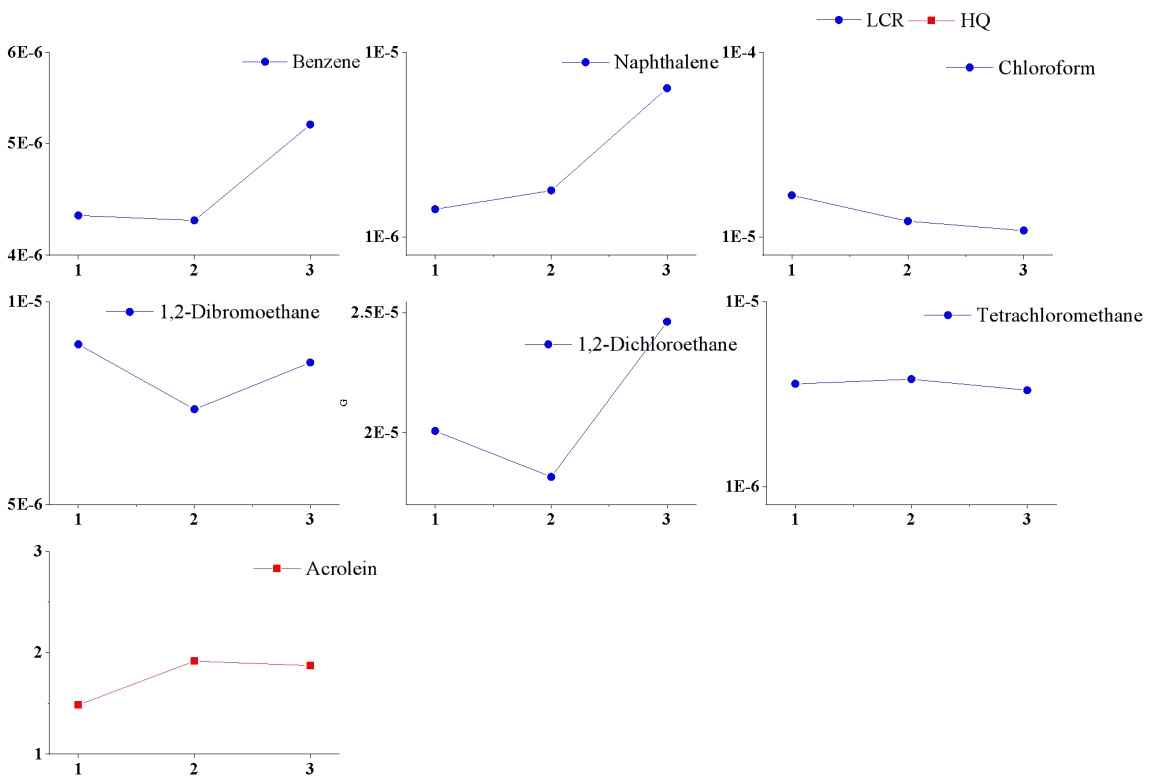


Fig. S12 The evolution of HQ and carcinogenic risks of hazardous VOC species during the three period. 1, 2, and 3 of x-axis represent pre-NMG, NMG and post-NMG periods, respectively.

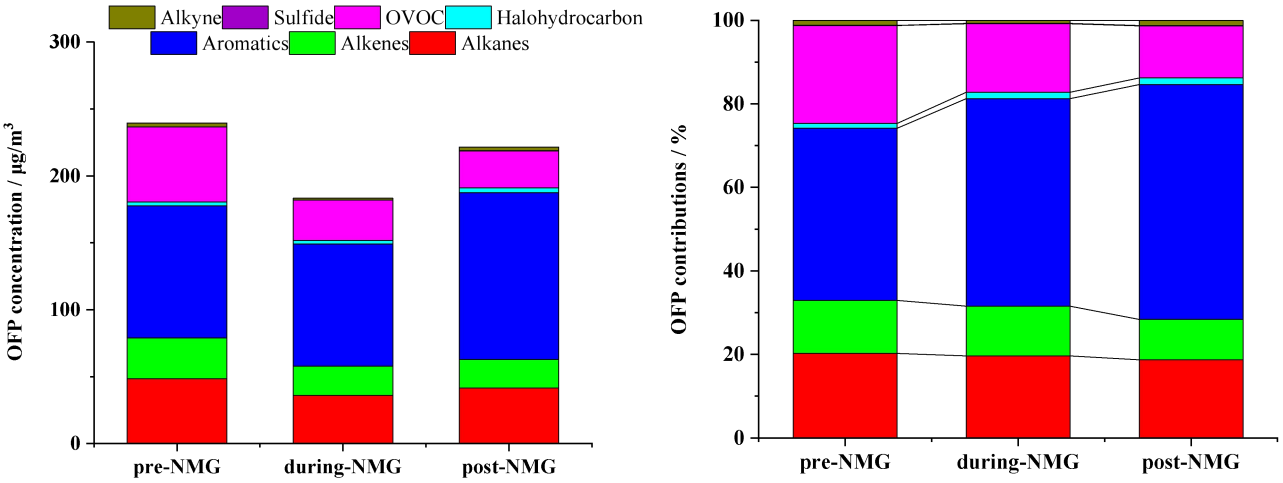


Fig. S13 The contributions and percentage of VOCs groups to the total OFP before, during, and after the control period during the NMG 2019.