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Table S1. Emission source categorization used in this study

Category	Sector	Activity level data	Data sources
Electricity and thermal power	Thermal power generation	Coal, natural gas, biomass, waste, diesel, other fuels	Field Survey
	Other electricity generation		
	Combined heat and power		
	Heat production and supply		
	Biomass power generation		
Industry	Industrial combustion	Coal, fuel oil, LPG, LNG, natural gas, coke, diesel, other fuels	Field Survey
	Non-metallic product industry	Cement, ceramic, refractory, bricks, graphite, glass, lime gypsum production	Field Survey
	Ferrous metal industry	Cast iron, iron making, sintered ore	Field Survey
	Nonferrous metal industry	Aluminum oxide, electrolytic aluminum, aluminum foil	Field Survey
	Chemical raw material industry	Chemical fertilizer, coating production, pigment	Field Survey
	Alcohol	Beer, liquor	Field Survey
	Papermaking	Papermaking	Field Survey
	Chemical fiber production	Chemical fiber production	Field Survey
	Rubber and plastic production	Rubber and plastic production	Field Survey
	Food industry	Meat product, soya bean oil, peanut oil, other edible oils	Field Survey
	Industrial solvent use	Quantity of the products	Field Survey
	On-road mobile	Gasoline, diesel, new energy, other fuel	Field Survey
Mobile source and oil storage and transportation	Non-road mobile	Airport, railway locomotive, agriculture machinery, construction machinery	Field Survey
	Oil storage and transportation	Gasoline, diesel, natural gas	Field Survey
	Road dust	High speed, national road, provincial road, county road, rural road, urban road	Field Survey
Fugitive dust	Construction dust	Construction area	Field Survey
	Soil dust	Farmland area, wasteland area	Field Survey
	Yard dust	Yard material, yard area type, floor space of yard, maximum height of yard	Field Survey
	Residential combustion	Coal, natural gas	Field Survey
Resident	Interior straw burning	Wheat, corn, soybean, sweet potato, other straw	Henan Statistical Yearbook
	Interior wood burning	Firewood consumption	Henan Statistical Yearbook
	Residential solvent use	Population and the consumption of solvent	Henan Statistical Yearbook
	Building surface coating	Consumption of coating	Field Survey
	Road asphalt paving	Consumption for road asphalt	Field Survey
	Catering	Amount of cooker, total annual operating hours	Field Survey
Agriculture	Livestock	Cattle, cow, goat, sheep, sow, hog, house, donkey, mule, rabbit, poultry	Henan Statistical Yearbook
	Fertilizer application	Urea, ABC, AS, AN,	China Rural Statistical Yearbook
	Natural ammonia sources	Amount of straw composted, crop sown area	Henan Statistical Yearbook
	Open straw burning	Wheat, corn, soybean, sweet potato, other straw	Henan Statistical Yearbook
Waste treatment	Sewage treatment	Amount of sewage	Henan Statistical Yearbook
	Waste treatment	Amount of waste	Henan Statistical Yearbook

Table S2. Emission factors of power and heat industry

Source	Fuel type	Emission factors (kg/t-fuel)							
		SO ₂	NO _x	CO	PM ₁₀	PM _{2.5}	VOCs	NH ₃	N ₂ O
Electricity and thermal power	Coal	16*S	7.21/8.19/8.96 ^a	8 ^a	46 ^b	12 ^b	0.04 ^a	0.02 ^c	1.4/6.1 ^d
	Natural gas	0.071 ^b	4.1 ^a	1.3 ^a	0.24 ^b	0.17 ^b	0.02 ^a	0.513 ^b	1 ^d
	Biomass	2.67 ^c	1.54 ^c	3.6 ^f	10.28 ^c	5.88 ^f	5.3 ^b	0.04 ^g	
	Waste	2.67 ^c	1.54 ^c	3.6 ^f	10.28 ^c	5.88 ^f	5.3 ^b		
	Diesel	3 ^a	7.4 ^a	0.6 ^a	0.5 ^a	0.5 ^a	0.13 ^a		0.4 ^d
	Other gas		1.35 ^a	1.3 ^a	0.03 ^a	0.03 ^a	0.02 ^a		

Note: The N₂O emission factor (kg/TJ) needs to be multiplied by the NCV of fuel (see Table S3).

^a He et al. (2018)

^b MEPPRC (2014)

^c Yin et al. (2010)

^d NDRC (2011)

^e Qi et al. (2017)

^f U.S. EPA.

^g Pham et al. (2008)

Table S3. Net calorific value, carbon content and carbon oxidation rate of energy

Fuel category	Net calorific value	Carbon content	Carbon oxidation rate
Coal	223.1/230.9/174.6 ^a	27.5/22.0/33.6 ^b	95/85/89.5 ^a
Gasoline	448 ^a	18.5 ^b	98 ^a
Diesel	433.3 ^a	19.8 ^a	98 ^a
LPG	473.1 ^a	16.9 ^b	98 ^a
Natural gas	3893.1 ^a	15.2 ^b	99 ^a
fuel oil	401.9 ^a	20.7 ^b	98 ^a
Coke	325 ^a	26.6 ^b	93 ^a
Other coking	439.6 ^a	27.4 ^b	93 ^a
Other coal gas	1575.8 ^a	12.2 ^b	99 ^a
LNG	515.0 ^a	15.0 ^b	98 ^a
Biogas	2100/2090.8		

Unit: NCV, TJ/10⁴t or TJ/10⁸ m³; CC, tons C/TJ; COF, %.

^a DEEGP (2020)

^b NDRC (2011)

Table S4. Emission factors of industry

Sources	SO ₂	NO _x	CO	PM ₁₀	PM _{2.5}	VOCs	NH ₃	CO ₂
Industrial combustion (Coal)	16*S	4 ^a	15 ^a	5.4 ^d	1.89 ^d	0.39 ^d	0.02 ^f	
Industrial combustion (Fuel oil)	20*S	7.65 ^c	0.6 ⁱ	0.85 ^d	0.67 ^d	0.35 ^d	0.13 ^f	
Industrial combustion (LPG)		2.63 ^a	0.36 ^a	0.17 ^a	0.17 ^a	33 ^a		
Industrial combustion (LNG)		2.63 ^a	0.36 ^a	0.17 ^a	0.17 ^a	33 ^a		
Industrial combustion (Natural gas)	0.18 ^a	1.76 ^a	1.3 ^a	0.24 ^a	0.17 ^a	0.18 ^a	0.513 ^a	
Industrial combustion (Coke)	16*S	9 ^j	6.6 ⁱ	0.29 ⁱ	0.14 ⁱ	0.04 ⁱ	0.02 ^f	
Industrial combustion (Diesel)	3 ^a	9.62 ^a	0.6 ^a	0.5 ^a	0.5 ^a	0.12 ^a	0.132 ^a	
Industrial combustion (Other coking)		10.06 ^a	2 ^a			0.04 ^a		
Industrial combustion (Other coal gas)		0.13 ^a	1.3 ^a	0.03 ^a	0.03 ^a	0.05 ^a		
Industrial combustion (Other gas)		0.13 ^a	1.3 ^a	0.03 ^a	0.03 ^a	0.02 ^a		
Industrial combustion (Other liquid)		10.06 ^a	0.6 ^a	0.62 ^a	0.85 ^a	0.13 ^a		
Glass productions				3.07 ^a	2.94 ^a	0.4 ^a		
Refractory	5.8 ^b	4.7 ^c		0.26 ^d	0.11 ^d	0.18 ^c	0.02 ^f	
Cement	3.71 ^a	1.88 ^a	3.71 ^a	77.43 ^d	28.46 ^d	0.33 ^a		538 ^g
Graphite	18.87 ^a	1.04 ^a	2.83 ^a	1.6 ^a	2.48 ^a	0.38 ^a		
Ceramic	2.25 ^a	5 ^a		2.43 ^a	0.67 ^a	29.22 ^a		
Bricks	0.6 ^a	0.05 ^a	4.04 ^a	0.71 ^a	0.27 ^a	0.13 ^a		
lime gypsum production								683 ^g
Cast iron	0.14 ^a	0.17 ^a	15.29 ^a	8.43 ^a	5.27 ^a			
Iron making	0.18 ^a	0.21 ^a		2.82 ^a	1.38 ^a			
Sintered ore	0.34 ^a	0.55 ^a	16 ^a	5.81 ^a	2.52 ^a	0.25 ^a		
Aluminum oxide				396.17 ^a	297.13 ^a			
Electrolytic aluminum				18.28 ^a	26.51 ^a			
Aluminum foil						54.5		
Chemical fertilizer				2.12 ^a	1.86 ^a		1 ^a	
Coating production						15 ^a		
Pigment						81.4 ^a		
Drink wine						0.25 ^a		
Papermaking						3.1 ^a		
Chemical fiber production						10 ^h		
Rubber and plastic						10 ^h		
Meat products						0.143 ^a		
Soya bean oil Products						2.45 ^a		
Peanut oil Production						10.35 ^a		
Other edible oil production						9.26 ^a		
Wood-based panel						0.5 ^d		
Printing and dyeing cloth						10 ^d		
Furniture surface coating						640 ^a		
Motor vehicle surface coating						77.25 ^k		
Equipment manufacturing						77.25 ^k		
Shoemaking						479 ^k		
Printing						100/750 ^a		

Unit: Emission factors are expressed per ton of fuel or product unless otherwise specified. VOCs may be reported in kg/t, g/kg, or g/m³ depending on the emission source type.

^a He et al. (2018)

^b He et al. (2013)

^c Tian et al. (2001)

^d MEPPRC (2014).

^e Bo et al. (2008)

^f Yin (2011)

^g NDRC (2011)

^h Pan et al. (2015)

ⁱ Lu (2014)

^j Qi et al. (2017)

^k Yan (2016)

Table S5. Emission factors for Oil storage and transportation

Sources	PM ₁₀	PM _{2.5}	VOCs	NH ₃	CO ₂
Mobile source and oil storage and transportation (Oil storage)					
Gasoline station					
Gasoline			3.24 ^a		
Diesel			0.08 ^a		
Oil storage					
Gasoline			0.16 ^a		
Diesel			0.05 ^a		
Mobile source and oil storage and transportation (Oil transportation)					
Gasoline			1.6 ^a		
Diesel			0.05 ^a		
Natural gas			2.6 ^a		

Unit: kg/t, g/m³, kg/year/people, t/MWh.

^a He et al. (2018)

Table S6. Emission factors of Resident source

Source type		Emission factor (kg/t)								
		SO ₂	NO _x	CO	PM ₁₀	PM _{2.5}	VOCs	NH ₃	CH ₄	N ₂ O
Residential combustion	Coal	18.5 ^h	1.88 ^h	75 ⁱ	9.52 ^h	7.35 ^h	1.8 ^h	0.9 ^h		
	Natural gas	0.18 ^f	1.76 ^j	1.3 ^a	0.24 ^k	0.1 ^k	0.18 ^h	0.32 ^h		
Interior straw burning	Rice	0.48 ^a	0.31 ^a	67 ^a	6.68 ^a	6.4 ^a	8.4 ^a	0.52 ^a	2.8 ^g	0.13 ^g
	Corn	1.33 ^a	1.86 ^d	56.60	7.39	6.87	7.34	0.37 ^b	2.8 ^g	0.13 ^g
	Wheat	0.04 ^b	1.19 ^d	171.70	8.86	8.24	13.74 ^c	1.3 ^c	2.8 ^g	0.13 ^g
	Others	0.27 ^d	2.49 ^d	85.20	7.69	7.15	7.97 ^f	1.3 ^b	2.8 ^g	0.13 ^g
Interior wood burning		0.40 ^a	1.19 ^c	75.93 ^f	6.16 ^b	3.24 ^a	3.13 ^a	1.3 ^a	2.4 ^g	0.08 ^g
Domesticate solvent (City)								0.5 ^l		
Domesticate solvent (Rura)								0.11		
Pesticide use								568/562/		
								576/382/		
								568/355.		
Cooking								8 ^a		
Building interior wall (waterborne coating)								3.5 ^m		
Building exterior wall (solvent coating)								120 ^a		
Road asphalt paving								360 ^a		
Catering					8 ^a	6.4 ^a	5.6 ^a	353 ^a		

Unit: g/kg.

Note: In interior biogas burning, the CH₄ and N₂O emission factor (kg/TJ) needs to be multiplied by the NCV of fuel (see Table S3).

^a He et al. (2018)^b Li et al. (2007)^c Andreae and Merlet (2001)^d Cao et al. (2011)^e Wang et al. (2009)^f Lu (2014)^g NDRC (2011)^h MEPPRC (2014)

ⁱ Wang et al. (2005)

^j Yin et al. (2010)

^k He et al. (2013)

^l Wang (2006)

^m Pan et al. (2015)

Table S7. Emission factors for waste treatment source

Sources	PM ₁₀	PM _{2.5}	VOCs	NH ₃	CO ₂
Sewage treatment			0.0011 ^a	0.003 ^b	
Waste treatment					
Waste incineration			0.74 ^a	0.21 ^a	
Landfill			0.74 ^a	1.275 ^a	
Garbage composting			0.23 ^a	0.56 ^a	

Unit: kg/t, g/m³, kg/year/people, t/MWh.

^a MEPPRC (2014).

^b Wei (2009)

Table S8. Temporal allocation profile and reference for difference source

Category	Subcategory	Temporal allocation	profile reference
Electricity and thermal power	Power plant	Thermal power generation	National Bureau of Statistics of China
	Industrial combustion	Industrial Boiler Output	
	Non-metallic mineral industry		
	Ferrous metals industry		
	Nonferrous metals industry		
Industry	Chemical raw material industry	Product yield	National Bureau of Statistics of China
	Alcohol		
	Papermaking		
	Chemical fiber production		
	Rubber and plastic production		
Mobile source and oil storage and transportation	Food industry	Consumption of industrial solvent	Local investigation
	Industrial solvent use		
	On-road mobile sources		
	Non-road mobile source		
	Oil storage and transportation		
Fugitive dust	Road dust	Rainfall information, traffic flow	Henan Provincial Department of transportation, national Bureau of Statistics of China
	Construction dust	Construction area	
	Soil dust	Average	
	Yard dust	Yard area	
	Residential combustion	Natural gas variation	
Resident	Interior straw burning	Average	National Bureau of Statistics of China
	Interior wood burning	Average	
	Residential solvent use	Average	

Agriculture	Building surface coating	Completed area of residential	
	Road asphalt paving	Consumption of asphalt	
	Catering	Restaurant hours business hours	
	Livestock	Average	
	Fertilizer application	Consumption of fertilizer	
	Natural ammonia sources	Average	Local investigation
	Farming land	Consumption of fertilizer, farming time	
Waste treatment	Open straw burning	Monthly fire points	https://firms.modaps.eosdis.nasa.gov
	Sewage treatment	Average	
	Garbage disposal	Average	

Table S9. Spatial allocation profile and reference for difference source

Category	Subcategory	Spatial allocation	Profile reference
Electricity and thermal power	Power plant	Longitude and latitude	
	Industrial combustion	Longitude and latitude	
	Non-metallic mineral industry		
Industry	Ferrous metals industry		
	Nonferrous metals industry		
	Chemical raw material industry	The latitude and longitude of industrial plants	
	Alcohol		
	Papermaking		
	Chemical fiber production		
	Rubber and plastic production		
	Food industry		
	Industrial solvent use	The latitude and longitude of industrial plants	National Earth System Science Data Sharing Infrastructure,Google Maps
	On-road mobile sources	Road	
Mobile source and oil storage and transportation	Non-road mobile source	Cultivated fields, population, railway, longitude and latitude of airport	
	Oil storage and transportation	Latitude and longitude, Population	
	Road dust	Road	
	Construction dust	Construction area	
Fugitive dust	Soil dust	Soil area	
	Yard dust	Longitude and latitude	
	Residential combustion	Population	
	Interior straw burning	Rural residential	
Resident	Interior wood burning	Rural residential	
	Residential solvent use	Population	
	Building surface coating	Population	
	Road asphalt paving	Road	

Agriculture	Catering	Population, latitude and longitude
	Livestock	Rural residential
	Fertilizer application	Arable land
	Natural ammonia sources	Rural residential
	Farming land	Arable land
Waste treatment	Open straw burning	Arable land
	Sewage treatment	Latitude and longitude
	Garbage disposal	Latitude and longitude

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