Supplement of Atmos. Chem. Phys., 24, 11521–11544, 2024
https://doi.org/10.5194/acp-24-11521-2024-supplement

Atmospheric Chemistry and Physics
Open Access
EGU

Supplement of

ACEIC: a comprehensive anthropogenic chlorine emission inventory for China

Siting Li et al.

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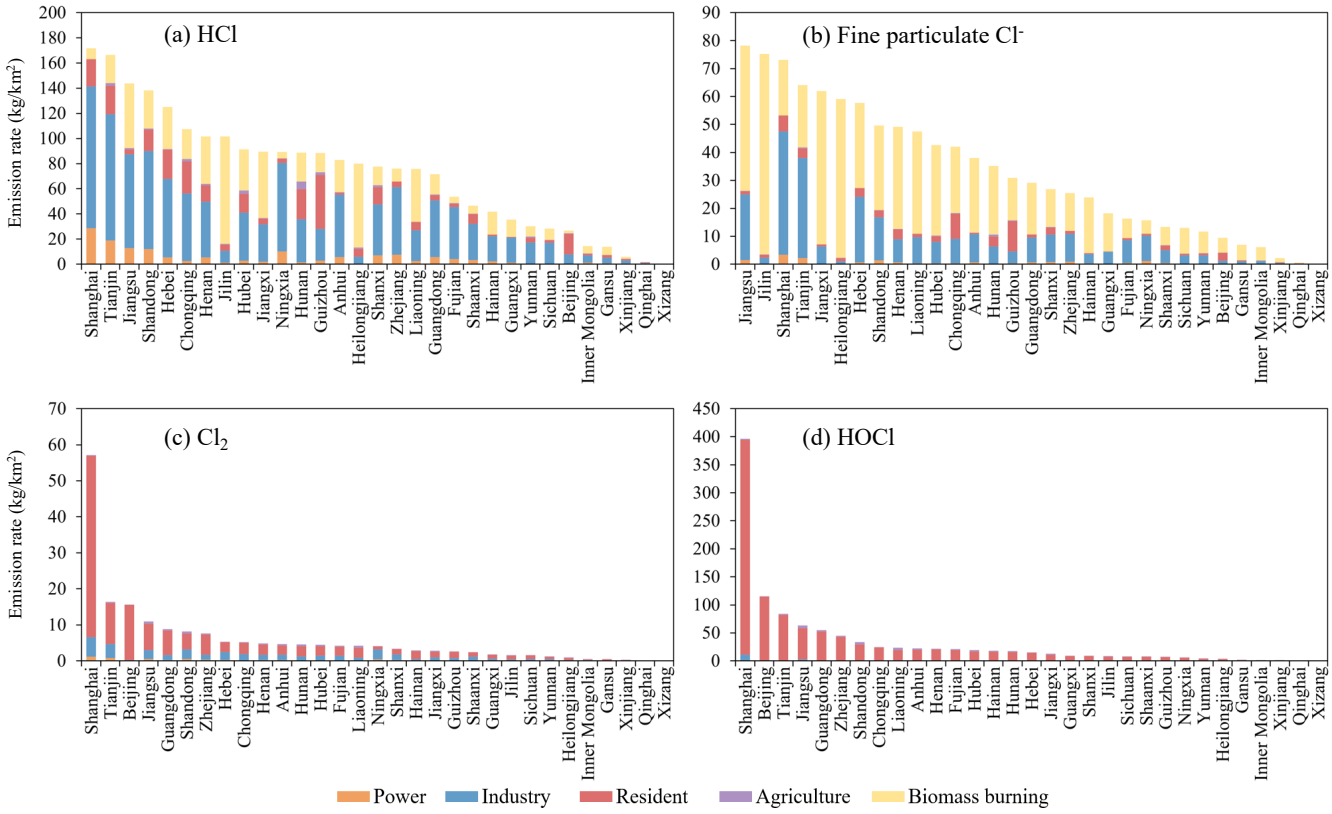

Figure S1 Per-unit-area emissions of HCl (a), fine particulate Cl^- (b), Cl_2 (c) and HOCl (d) by province.

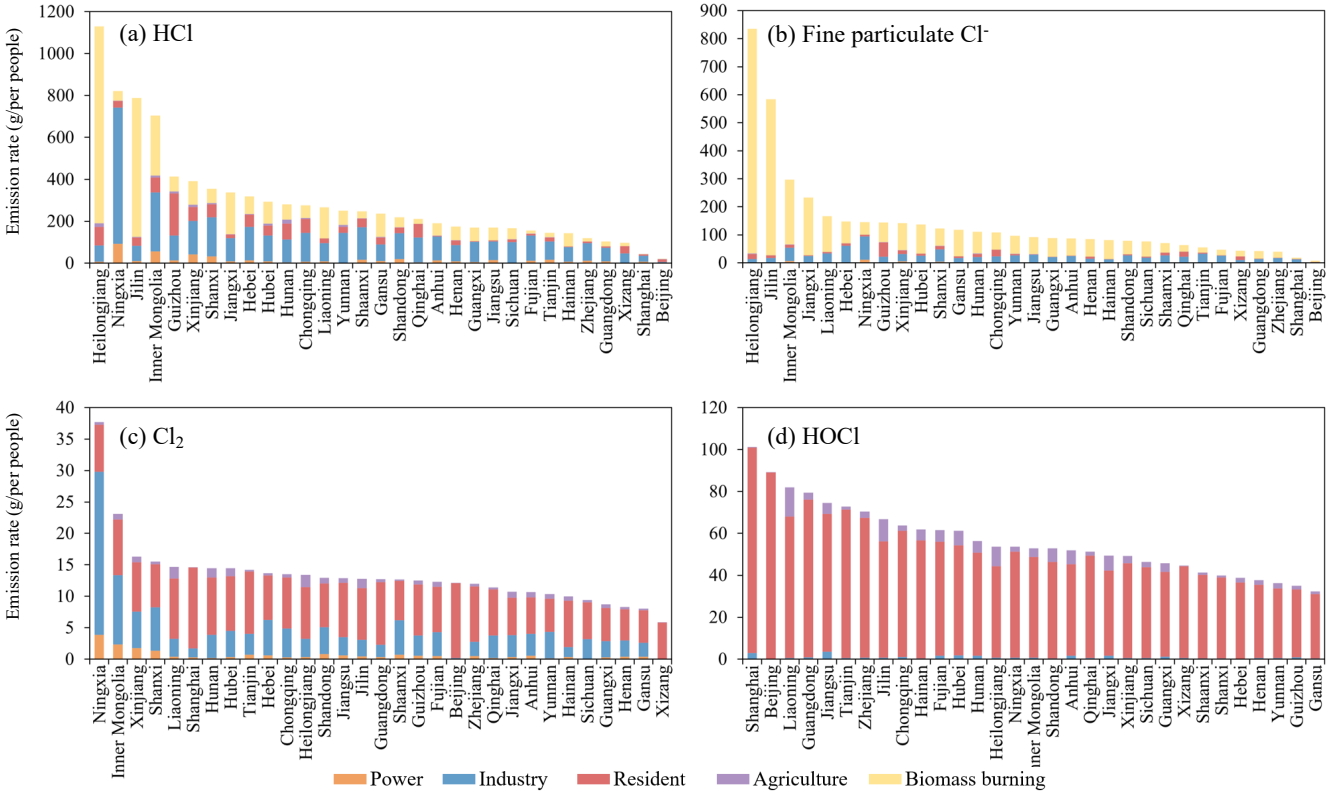

Figure S2 Per-capita emissions of HCl (a), fine particulate Cl^- (b), Cl_2 (c) and HOCl (d) by province.

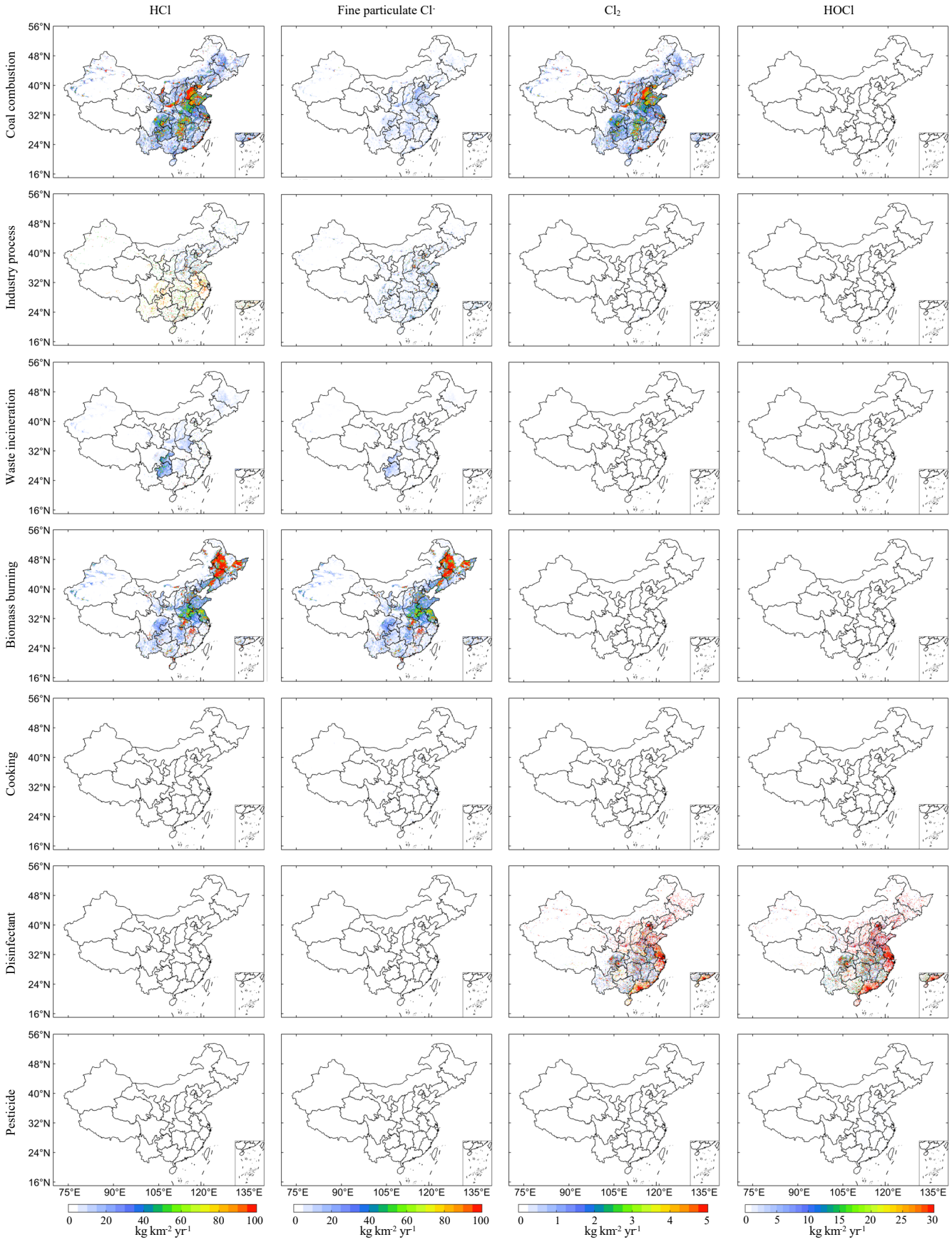

Figure S3 Spatial distribution of anthropogenic chlorine emissions by source category in 2019 at a 0.1° × 0.1° resolution.

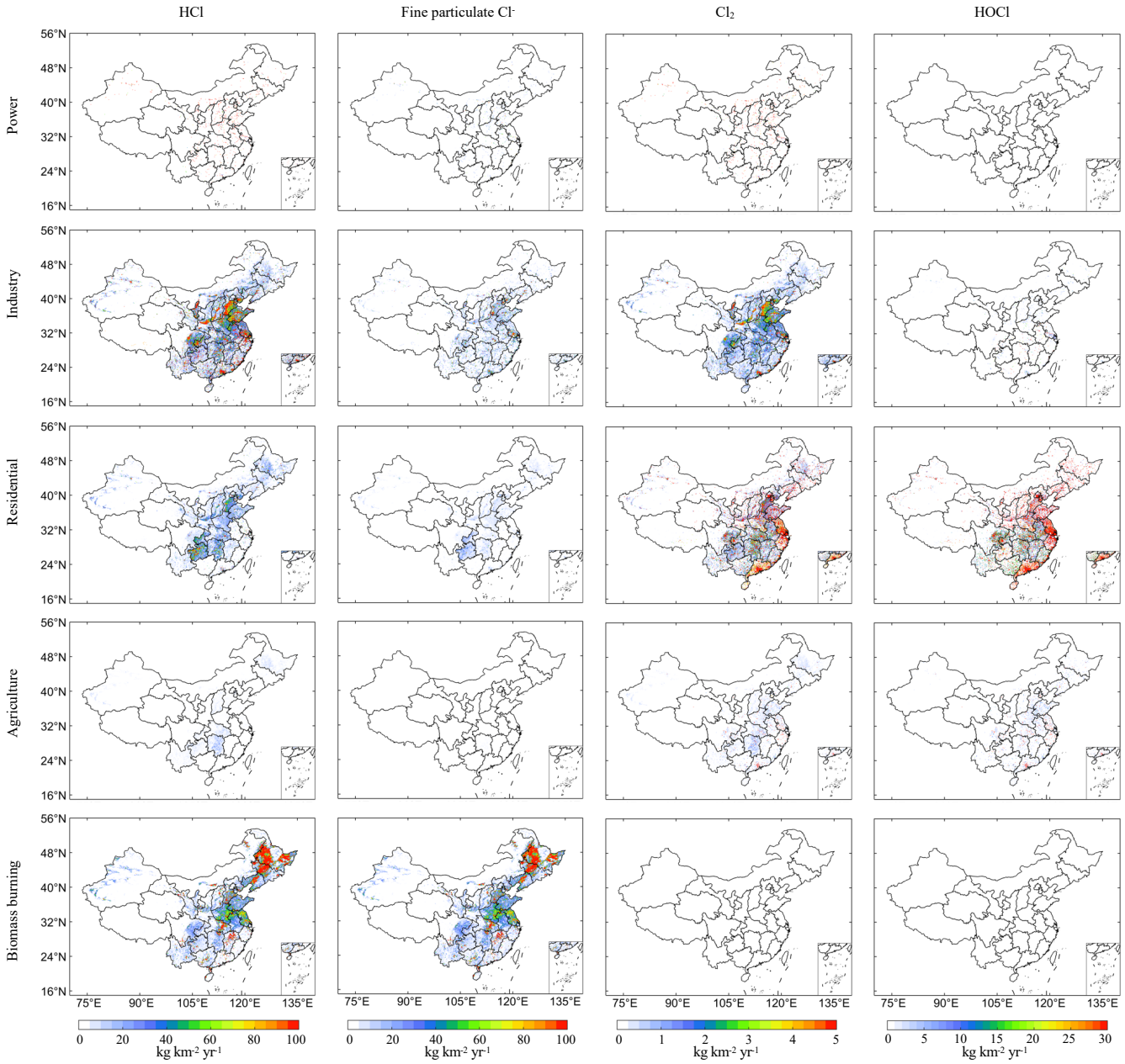

Figure S4 Spatial distribution of anthropogenic chlorine emissions by economic sector in 2019 at a 0.1° × 0.1° resolution.

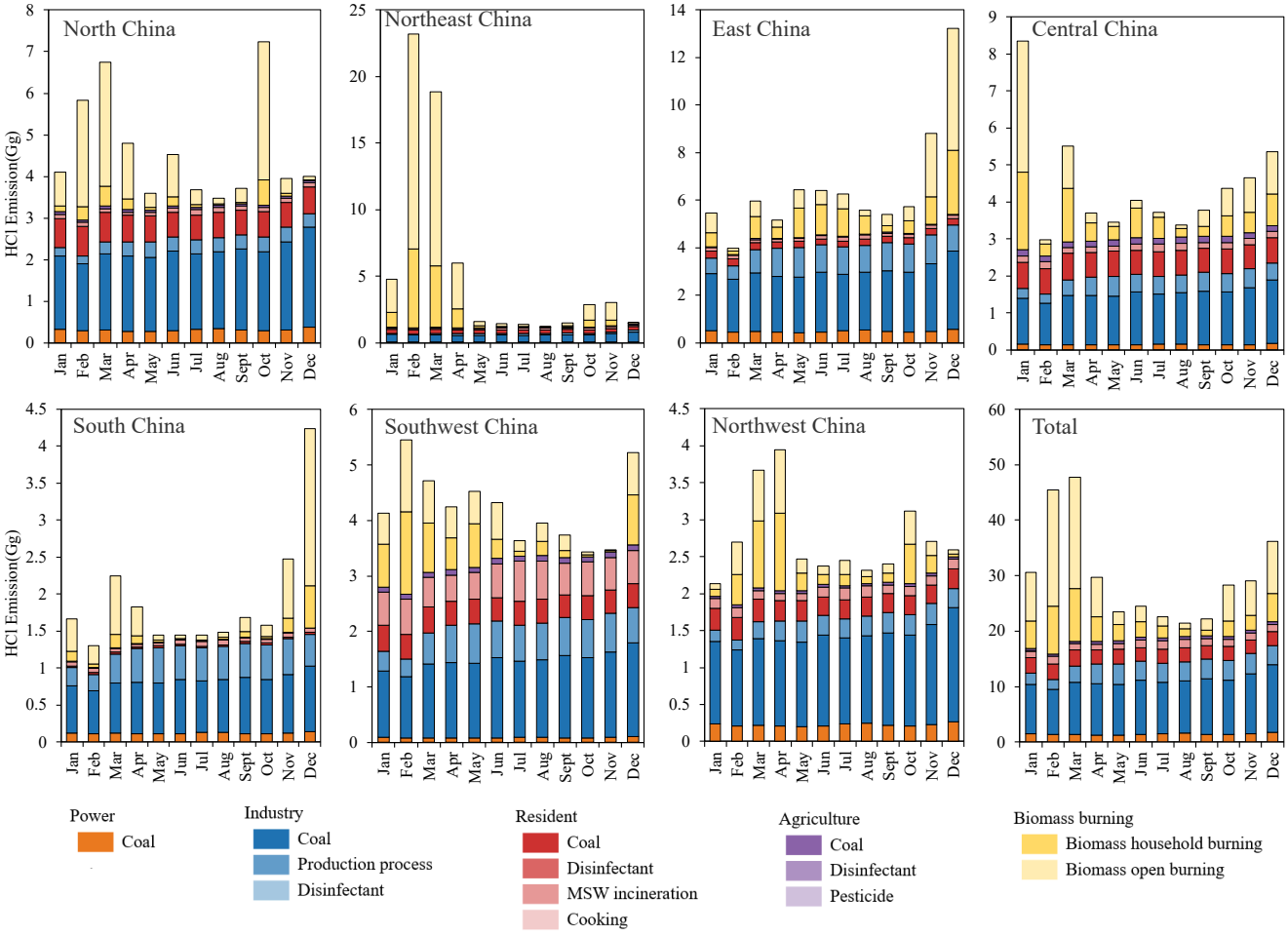

Figure S5 Monthly distribution of HCl emission in different regions in 2019. (North China: Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia. Northeast region: Liaoning, Jilin, Heilongjiang. East China: Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong. Central China: Henan, Hubei, Hunan. South China: Guangdong, Guangxi, Hainan. Southwest China: Chongqing, Sichuan, Guizhou, Yunnan, Xizang. Northwest region: Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang)

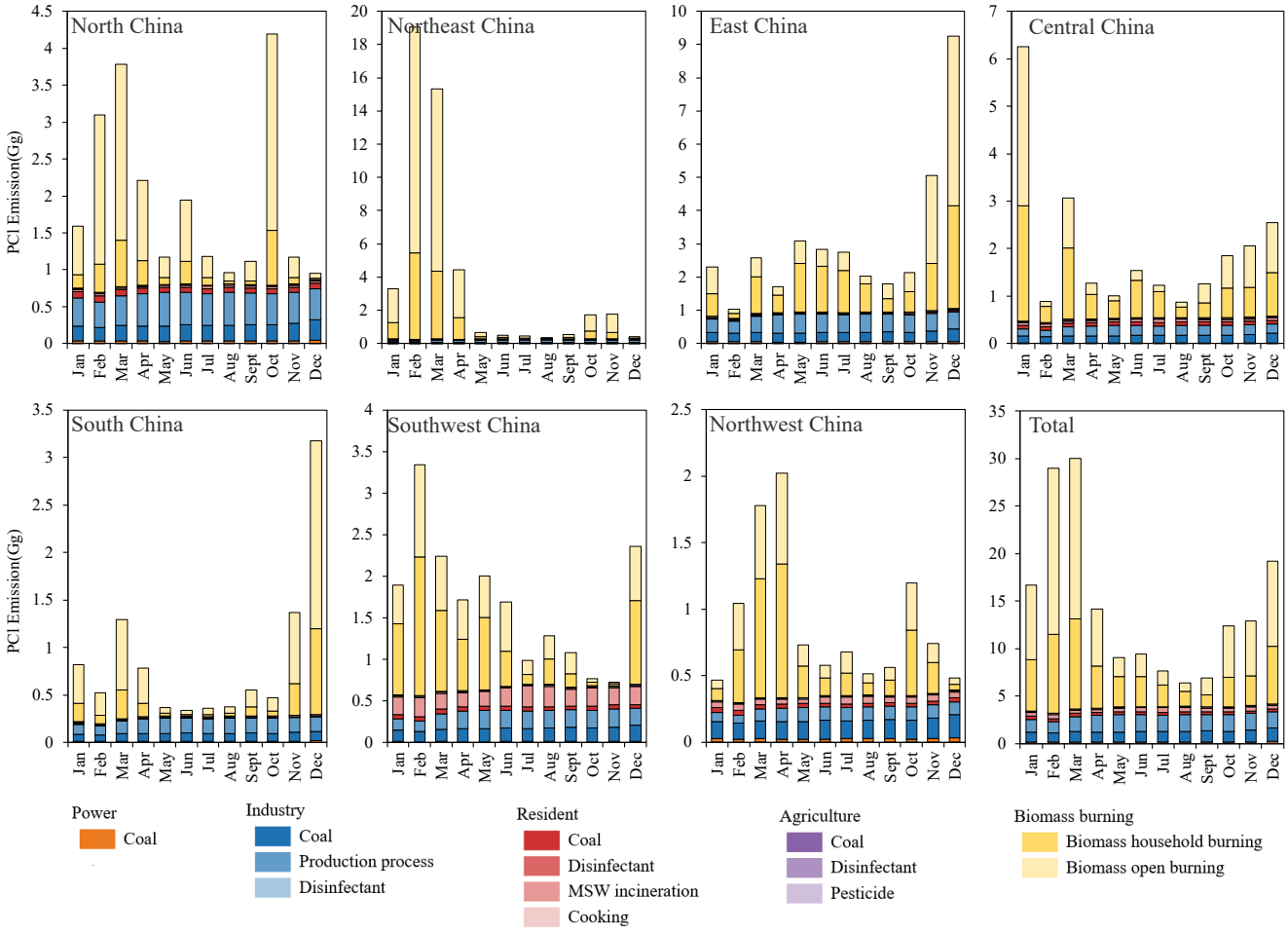

Figure S6 Monthly distribution of pCl emission in different regions in 2019. (North China: Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia. Northeast region: Liaoning, Jilin, Heilongjiang. East China: Shanghai, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong. Central China: Henan, Hubei, Hunan. South China: Guangdong, Guangxi, Hainan. Southwest China: Chongqing, Sichuan, Guizhou, Yunnan, Xizang. Northwest region: Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang)

Table S1 The aggregation of 7 source categories from 41 specific sources.

Source	Sub-source	Thi-source
coal combustion	Power coal combustion	Power plant
	Industrial coal combustion	Heat supply
		Industry
		Construction industry
	Residential coal combustion	Residents
		Traffic
		Business
		Other
	Agricultural coal combustion	
Industrial production process	Cement production	
	Iron production	
	Steel production	
	HCl production	
	Flat glass production	
Waste incineration	MSW (municipal solid waste) incineration station	
	MSW open burning	
	Medical waste incineration	
Biomass burning	Biomass household burning	Crop
		Firewood
	Biomass open burning	
Cooking	Household	
	Restaurant	
	Canteen	School
		Unit
Disinfectant	Cooling tower	
	Water treatment	
	Waste water treatment	Domestic sewage
		Medical sewage
	Swimming pool	Public swimming pool
	Environmental disinfection	Hospital
		Toilet-Public toilet
		Toilet-Domestic toilet
		Breeding-Pig farming
		Breeding-Poultry farming
		Breeding-Aquaculture
	Tap water use	Car washing
		Lawn watering
		Road watering
		Water leakage
Pesticide	Insecticide	
	Herbicide	

Table S2 The aggregation of 5 economic sectors from 41 specific sources.

Sector	Sub-sector	Thi-sector	Four-sector
Power	Power coal combustion	Power plant	
Industry	Industrial coal combustion	Heat supply	
		Industry	
		Construction industry	
	Industrial production process	Cement production	
		Iron production	
		Steel production	
		HCl production	
		Flat glass production	
	Industrial usage of disinfectant	Cooling tower	
Residential	Residential coal combustion	Residents	
		Traffic	
		Business	
		Other	
	Residential usage of disinfectant	Water treatment	
		Waste water treatment	Domestic sewage
			Medical sewage
		Swimming pool	Public swimming pool
		Environmental disinfection	Hospital
			Toilet-Public toilet
			Toilet-Domestic toilet
		Tap water use	Car washing
			Lawn watering
			Road watering
			Water leakage
	Waste incineration	MSW incineration station	
		MSW open burning	

		Medical waste incineration	
	Cooking	Household	
		Restaurant	
		Canteen	School
			Unit
Agriculture	Agricultural coal combustion		
	Agricultural usage of disinfectant	Pig	
		Poultry	
		Aquaculture	
	Agricultural usage of pesticide	Insecticide	
		Herbicide	
Biomass burning	Biomass household burning	Crop	
		Firewood	
	Biomass open burning		

Table S3 Sources of activity data.

Source category	Sub-category	Activity level data	Source
Coal combustion	Power	Coal consumption of power plant	China Energy Statistical Yearbook 2020 (National Bureau of Statistics, 2020a)
	Industrial	Coal consumption for heat supply	
		Coal consumption of industry	
		Coal consumption of construction industry	
	Residential	Coal consumption of residents	
		Coal consumption of traffic	
		Coal consumption of business	
		Coal consumption of other	
	Agriculture	Coal consumption of agriculture	
Industrial production process	Cement production	Production of cement	China Industrial Statistics Yearbook 2020 (National Bureau of Statistics, 2020f)
	Iron production	Production of iron	
	Steel production	Production of steel	
	Flat glass production	Production of flat glass	
	HCl production	Production of hydrochloric acid	National Bureau of Statistics (https://m.sohu.com/a/335035620_775892/?pvid=000115_3w_a)
Waste incineration	MSW incineration station	Waste incineration amount	China Urban–Rural Construction Statistical Yearbook 2020 (National Bureau of Statistics, 2020h)
	MSW open burning	Population	
		Waste disposal rate	
	Medical waste incineration	Medical waste incineration amount	Ministry of Health (https://www.reportrc.com/article/20200506/6615.html)
Biomass burning	Household burning-Firewood	Rural population	China Population and Employment Statistical Yearbook 2020 (National Bureau of Statistics, 2020c)
		Rural household size	
	Household burning-Crop	Crop yield	China Rural Statistical Yearbook 2020 (National Bureau of Statistics, 2020g)
	Open burning	Crop yield	
Cooking	Household	Population	China Population and Employment Statistical Yearbook 2020 (National Bureau of Statistics, 2020c)
		Household size	
	Restaurant	Number of restaurants	Gaode' POI (point of interest) data

	Canteen-School	Number of students	China Education Statistics Yearbook 2020 (National Bureau of Statistics, 2020b)
		Number of teaching staff	
	Canteen-Unit	Number of public institutions	National Bureau of Statistics (https://data.stats.gov.cn/easyquery.htm?cn=E0103)
		Number of organizations	
Cooling tower	Cooling tower	Industrial water consumption	China Environmental Statistics Yearbook 2020 (National Bureau of Statistics, 2020e)
Water treatment	Water treatment	Tap water supply	China Urban–Rural Construction Statistical Yearbook 2020 (National Bureau of Statistics, 2020h)
Waste water treatment	Medical sewage	Number of hospital beds	China Health Statistics Yearbook 2020 (National Health Commission of the People's Republic of China, 2020)
	Domestic sewage	Sewage treatment capacity	China Urban–Rural Construction Statistical Yearbook 2020 (National Bureau of Statistics, 2020h)
Swimming pool	Public Swimming pool	Number of swimming pools	General Administration of Sport of China
Tap water use	Car washing	Number of cars	China Statistical Yearbook 2020 (National Bureau of Statistics, 2020d)
	Lawn watering	Afforested area	China Urban–Rural Construction Statistical Yearbook 2020 (National Bureau of Statistics, 2020h)
	Road watering	Road area	
	Water leakage	Leakage water volume	
Environmental disinfection	Hospital	Number of hospitals	China Health Statistics Yearbook 2020 (National Health Commission of the People's Republic of China, 2020)
		Total health expenditure in 2018	
		Total health expenditure in 2007	China Health Statistics Yearbook 2008 (National Health Commission of the People's Republic of China, 2008)
	Breeding	Number on hand at the end of the pig year	China Rural Statistical Yearbook 2020 (National Bureau of Statistics, 2020g)
		Number of poultry on hand at the end of the year	
		Aquaculture area	
	Toilet	Number of public toilets	China Urban–Rural Construction Statistical Yearbook 2020 (National Bureau of Statistics, 2020h)
Pesticide	Insecticide	Pesticide usage	China Rural Statistical Yearbook 2020 (National Bureau of Statistics, 2020g)
	Herbicide	Pesticide usage	

Table S4 Emission factor of HCl from different sources

Source category	Sub-category	Emission factor	Reference
Industrial production process	Cement production (g/t)	15.49	Yi et al. (2020); Zheng et al. (2018)
	Iron production (g/t)	0.57	Yi et al. (2020); Zheng et al. (2018)
	Steel production (g/t)	0.76	Yi et al. (2020); Zheng et al. (2018)
	HCl production (g/kg)	0.08	Yi et al. (2020); Zheng et al. (2018)
	Flat glass production (g/t)	11.87	Sepa (2011); Wang et al. (2014); Zheng et al. (2018)
Waste incineration	MSW incineration station (g/kg)	0.0192	Fu et al. (2022)
	MSW open burning (g/kg)	3.58	Fu et al. (2018)
Biomass burning	Rice straw (g/kg)	0.44	Stockwell et al. (2014)
	Wheat straw (g/kg)	0.60	Stockwell et al. (2014)
	Other crop straw (g/kg)	0.52	Yi et al. (2021)
	Firewood (g/kg)	0.06	Yi et al. (2021)

Table S5 Emission factor of fine particulate Cl^- from different sources

Source category	Sub-category	Emission factor (g/kg)	Reference	Cl^- in $PM_{2.5}$ (%)	Reference
Industrial production process	Cement production	0.48	Yi et al. (2020); Zheng et al. (2018)	0.73	Yi et al. (2020)
	Iron production	0.16	Yi et al. (2020); Zheng et al. (2018)	3.54	Yi et al. (2020)
	Steel production	0.19	Yi et al. (2020); Zheng et al. (2018)	3.54	Yi et al. (2020)
	Flat glass production	0.523	Pan et al. (2015); Zheng et al. (2018)	2	Wen et al. (2019)
Waste incineration	MSW incineration station	0.0109	Fu et al. (2022)	13.8	Wiedinmyer et al. (2014)
	MSW open burning	9.8	Wiedinmyer et al. (2014)	13.8	Wiedinmyer et al. (2014)

Table S6 The proportion of medical waste components and HCl release rate

	Plastics	Glass	Organic waste	Rubber	Wood	Fabric	Metal	Reference
Component (%)	57.11	17.79	10.21	4	3.21	1.28	0.51	Zhang (2018)
HCl release rate (g/kg)	28.3	0.081	3.6	21.9	0.5	4.82	0	Zhang et al. (2022)

Table S7 Straw-to-product ratio, dry matter fraction, and combustion efficiency for biomass burning (Zhou et al., 2017).

Crop type	Straw-to-product ratio (R)	dry matter fraction (D)	combustion efficiency (C)
Rice	1.323	0.89	0.93
Wheat	1.3	0.89	0.83
Corn	1.269	0.87	0.92
Bean	1.6	0.91	0.68
Potato	0.5	0.45	0.68
Cotton	3	0.83	0.9
Peanut	1.5	0.94	0.82
Rapeseed	1.5	0.83	0.9
Sesame	2.2	0.83	0.9
Hemp	1.7	0.83	0.9
Sugar cane	0.3	0.45	0.68
Sugar beet	0.1	0.45	0.9

Table S8 Percentage of biomass domestic burning and open burning by province

Province	Percentage of domestic burning (Zhou et al., 2017; Liu et al., 2022)	Percentage of open burning (Zhou et al., 2017)
Beijing	0.0063	0.0190
Tianjin	0.0061	0.2003
Hebei	0.0424	0.2547
Shanxi	0.0605	0.2794
Inner Mongolia	0.0265	0.3542
Liaoning	0.2068	0.2781
Jilin	0.1602	0.6398
Heilongjiang	0.2194	0.5806
Shanghai	0.0089	0.0173
Jiangsu	0.2263	0.0237
Zhejiang	0.0171	0.2579
Anhui	0.1152	0.0334
Fujian	0.0118	0.1955
Jiangxi	0.0876	0.7124
Shandong	0.0548	0.0883
Henan	0.1210	0.0276
Hubei	0.0670	0.3252
Hunan	0.1105	0.1820
Guangdong	0.0143	0.3626
Guangxi	0.0718	0.2236
Hainan	0.0390	0.7610
Chongqing	0.1048	0.2988
Sichuan	0.1228	0.1057
Guizhou	0.2392	0.3480
Yunnan	0.1742	0.1315
Xizang	0.1071	0.1537
Shaanxi	0.0453	0.1421
Gansu	0.1334	0.3633
Qinghai	0.0733	0.1616
Ningxia	0.1400	0.0393
Xinjiang	0.1641	0.0325

Table S9 Emission factors for biomass burning (Yi et al., 2021).

Crop type	pCl Emission Factors (g/kg)
Rice straw	0.4635
Wheat straw	0.5271
Corn straw	0.4146
Bean straw	0.233
Rapeseed straw	0.246
Other straw	0.37684
Firewood	0.16

Table S10 Parameters of emission factors for cooking.

Source category			Number of heats [a]	Smoke discharge (m^3/h) [b]	Cooking time (h/d) [b]	Day (d) [b]	$PM_{2.5}$ Emission Factors (mg/m^3) [b]	Removal rate (%) [b]	Percentage of domestic burning (%) [c]
Household			1	600	0.5	360	1.32	30	1.545
Restaurant	Small and medium-sized (80%)		4	2000	4	360	0.68	30	1.545
	Large-sized (20%)		6	2000	4	360	0.68	30	1.545
Canteen	Middle school	Student	-	2000/150 (people)	6	300	1.32	30	1.545
		Teaching staff	-	2000/150 (people)	1.5	300	1.32	30	1.545
	University	Student	-	2000/150 (people)	6	200	1.32	30	1.545
		Teaching staff	-	2000/150 (people)	1.5	200	1.32	30	1.545
	Unit		1	2000	1.5	240	1.32	30	1.545

a Wu et al. (2018) and Sepa (2001); b Wu et al. (2018); c Li et al. (2018).

Table S11 Emission factors of Cl_2 and HOCl.

Sub-category	Thi-category	Chlorine dose (mg/L)	Free chlorine (mg/L)	Cl volatilization rate	Reference
Cooling tower		1	0	1	Wong et al. (2017); Wang et al. (2002)
Water treatment		2.30	--	0.2	Li et al. (2020); Wong et al. (2017)
Waste water treatment	Medical sewage	10.48	0	0.2	Li et al. (2020); Wong et al. (2017)
	Domestic sewage	2.93	0	0.2	Li et al. (2020); Wong et al. (2017)
Swimming pool	Indoor swimming pool	1.89	0	0.2	Wong et al. (2017); (Wang et al., 2002)
	Outdoor swimming pool	1.19	0	0.2	Wong et al. (2017); (Wang et al., 2002)
Tap water use	Car washing	--	0	1	Li et al. (2020); Wong et al. (2017)
	Lawn watering	--	0	1	Li et al. (2020); Wong et al. (2017)
	Road watering	--	0	1	Li et al. (2020); Wong et al. (2017)
	Water leakage	--	0	0.1	Li et al. (2020); Wong et al. (2017)

Table S12 Residual chlorine content in tap water. Data are collected from the website of water bureau for each province.

Province	Residual chlorine at the end of the pipeline network (mg/L)
Beijing	0.18
Tianjin	0.51
Hebei	0.31
Shanxi	0.24
Inner Mongolia	0.37
Liaoning	0.39
Jilin	0.06
Heilongjiang	0.24
Shanghai	0.77
Jiangsu	0.31
Zhejiang	0.46
Anhui	0.45
Fujian	0.33
Jiangxi	0.35
Shandong	0.19
Henan	0.28
Hubei	0.49
Hunan	0.30
Guangdong	0.44
Guangxi	0.51
Hainan	0.07
Chongqing	0.68
Sichuan	0.44
Guizhou	0.29
Yunnan	0.25
Xizang	0.51
Shaanxi	0.31
Gansu	0.37
Qinghai	0.16
Ningxia	0.06
Xinjiang	0.47

Table S13 Size of swimming pool (Li et al., 2020).

Size Type	Standard swimming pool	Semi standard and non-standard swimming pools
Length (m)	50	25
Width (m)	21	21
Depth (m)	1.8	1.8

Table S14 Parameters of breeding disinfection (Li et al., 2020).

Breeding type	Breeding density (m^2/per)	Disinfectant usage per unit area (g/m^2)	Disinfection frequency (times/year)	Chlorine volatilization rate
Livestock	1.2	1.05	52	0.3
Poultry	0.05	1.05	52	0.3
Aquaculture	-	0.31	18	0.2

Table S15 Water consumption and frequency of car washing.

Car type		Water consumption (m^3·(vehicle·time)$^{-1}$) [a]	Frequency (year^{-1})
Passenger vehicle	Micro and small scale	0.05	52
	Medium and large scale	0.1	365 [b]
Cargo vehicle	Micro and small scale	0.05	52
	Medium and large scale	0.1	52
Other vehicle		0.05	52

a Sun et al. (2018); b https://auto.ifeng.com/roll/20111209/727919.shtml;

Table S16 Sources of spatial allocation factors

Sector	Sub-sector	Thi-sector	Four-sector	Resolution	Space allocation factor
Power	Power coal combustion	Power plant		Point	Location of thermal power plants (WRI dataset https://datasets.wri.org/dataset/globalpowerplantdatabase)
Industry	Industrial coal combustion	Heat supply		Point	Location of heating enterprises (http://www.sz-w.com/hyqyml.php)
		Industry		Area (1km×1km)	Total population data (LandScan 2019)
		Construction industry		Area (1km×1km)	Total population data (LandScan 2019)
	Industrial production process	Cement production		Point	Location of cement enterprise (http://www.sz-w.com/hyqyml.php)
		Iron production		Point	Location of metallurgical enterprises (http://www.sz-w.com/hyqyml.php)
		Steel production		Point	Location of metallurgical enterprises (http://www.sz-w.com/hyqyml.php)
		HCl production		Point	Location of chemical enterprises (http://www.sz-w.com/hyqyml.php)
		Flat glass production		Point	Location of glass enterprises (http://www.sz-w.com/hyqyml.php)
	Industrial usage of disinfectant	Cooling tower		Point	Location of thermal power plants (WRI dataset https://datasets.wri.org/dataset/globalpowerplantdatabase) and chemical enterprises (http://www.sz-w.com/hyqyml.php)
Residential	Residential coal combustion	Residents		Area (1km×1km)	Total population data (LandScan 2019)
		Traffic		Area (1km×1km)	Total population data (LandScan 2019)
		Business		Area (1km×1km)	Total population data (LandScan 2019)
		Other		Area (1km×1km)	Total population data (LandScan 2019)
	Residential usage of disinfectant	Water treatment		Point	Location of water plants (http://www.sz-w.com/hyqyml.php)
		Waste water treatment	Domestic sewage	Point	Location of sewage-treatment plants (https://www.dowater.com)
			Medical sewage	Point	Location of hospitals (Gaode's 2019 POI data)
		Swimming pool	Public swimming pool	Point	Location of swimming pools (Gaode's 2019 POI data)
		Environmental disinfection	Hospital	Point	Location of hospitals (Gaode's 2019 POI data)
			Toilet-Public toilet	Point	Location of public toilets (Gaode's 2019 POI data)

			Toilet-Domestic toilet	Area (1km×1km)	Total population data (LandScan 2019)
		Tap water use	Car washing	Point	Location of car washing stations (Gaode's 2019 POI data)
			Lawn watering	Area (1km×1km)	Urban population data (LandScan 2019)
			Road watering	Area (1km×1km)	Urban population data (LandScan 2019)
			Water leakage	Area (1km×1km)	Total population data (LandScan 2019)
	Waste incineration	WSM incineration station		Point	Location of waste incineration stations (Information Platform for Municipal Solid Waste Incineration www.waste-cwin.org)
		WSM open burning		Area (1km×1km)	Rural population data (LandScan 2019)
		Medical waste incineration		Point	Location of hospitals (Gaode's 2019 POI data)
	Cooking	Household		Area (1km×1km)	Total population data (LandScan 2019)
		Restaurant		Area (1km×1km)	Total population data (LandScan 2019)
		Canteen	School	Area (1km×1km)	Total population data (LandScan 2019)
			Unit	Area (1km×1km)	Total population data (LandScan 2019)
Agriculture	Agricultural coal combustion			Area (1km×1km)	Rural population data (LandScan 2019)
	Agricultural usage of disinfectant	Livestock		Point	Location of poultry breeding bases (Gaode's 2019 POI data)
		Poultry		Point	Location of poultry breeding bases (Gaode's 2019 POI data)
		Aquaculture		Point	Location of fisheries (Gaode's 2019 POI data)
	Agricultural usage of pesticide	Insecticide		Area (1km×1km)	Rural population data (LandScan 2019)
		Herbicide		Area (1km×1km)	Rural population data (LandScan 2019)
Biomass burning	Biomass household burning	Crop		Area (1km×1km)	Rural population data (LandScan 2019)
		Firewood		Area (1km×1km)	Rural population data (LandScan 2019)
	Biomass open burning			Point	Fire location and fire radiation power over crop land from the MODIS satellite fire point data (https://modis.gsfc.nasa.gov)

Table S17 Monthly allocation factors.

Source category	Sub-category	Month											
		1	2	3	4	5	6	7	8	9	10	11	12
Coal combustion	Power plant	8.7%	7.8%	8.1%	7.6%	7.5%	7.9%	8.9%	9.2%	8.1%	7.8%	8.5%	9.9%
	Heat supply	25.8%	23.3%	12.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	12.5%	25.8%
	Industrial process [a]	7.1%	6.5%	7.9%	8.2%	8.1%	8.7%	8.2%	8.4%	8.9%	8.7%	9.2%	10.1%
	Residential coal combustion [a]	9.5%	10.1%	9.6%	8.5%	8.3%	7.5%	7.7%	7.7%	7.5%	7.8%	7.5%	8.3%
	Other coal combustion	8.5%	7.7%	8.5%	8.2%	8.5%	8.2%	8.5%	8.5%	8.2%	8.5%	8.2%	8.5%
Industrial	Cement production	4.8%	4.3%	7.7%	9.2%	9.8%	9.0%	9.0%	9.1%	9.4%	9.4%	9.7%	8.6%
production process	Iron production	8.2%	7.4%	8.2%	8.6%	8.9%	8.7%	8.4%	8.8%	8.3%	8.1%	8.0%	8.3%
	Steel production	7.9%	7.1%	8.1%	8.6%	9.0%	8.8%	8.6%	8.8%	8.3%	8.2%	8.1%	8.5%
	HCl production	7.1%	6.5%	7.9%	8.2%	8.1%	8.7%	8.2%	8.4%	8.9%	8.7%	9.2%	10.1%
	Flat glass production	8.0%	7.2%	8.2%	8.4%	8.4%	8.8%	8.4%	8.5%	8.6%	8.5%	8.3%	8.7%
Waste incineration [b]		8.4%	8.9%	7.5%	6.6%	6.8%	8.7%	10.1%	9.7%	8.0%	8.5%	8.3%	8.4%
Cooking	Restaurant	8.2%	7.4%	7.3%	7.0%	7.8%	8.0%	7.8%	8.3%	8.1%	9.3%	10.6%	10.3%
	Except restaurant [d]	9.2%	9.4%	8.5%	8.5%	8.5%	7.2%	6.6%	6.6%	8.5%	8.5%	8.5%	10.0%
Disinfectant	Cooling tower	8.7%	7.8%	8.1%	7.6%	7.5%	7.9%	8.9%	9.2%	8.1%	7.8%	8.5%	9.9%
	Water treatment [e]	7.5%	6.9%	8.0%	8.0%	8.4%	8.3%	9.0%	9.3%	8.8%	8.9%	8.4%	8.5%
	Waste water treatment [e]	7.5%	6.9%	8.0%	8.0%	8.4%	8.3%	9.0%	9.3%	8.8%	8.9%	8.4%	8.5%
	Swimming pool	3.4%	3.1%	3.4%	3.3%	10.8%	18.0%	18.6%	18.6%	10.7%	3.4%	3.3%	3.4%
	Environmental disinfection	8.5%	7.7%	8.5%	8.2%	8.5%	8.2%	8.5%	8.5%	8.2%	8.5%	8.2%	8.5%
	Tap water use [e]	7.5%	6.9%	8.0%	8.0%	8.4%	8.3%	9.0%	9.3%	8.8%	8.9%	8.4%	8.5%
Pesticide		7.8%	7.0%	9.4%	8.5%	8.7%	8.8%	8.3%	7.6%	7.8%	7.8%	8.2%	10.2%

[a] Hong et al. (2020); [b] Wang et al. (2021); [c] Wu (2009); [d] Wu et al. (2018); [e] Wang et al. (2007).

Table S18 Variation coefficient of activity data.

Source category		Distribution type	Variation coefficient	Reference
Coal combustion	Coal consumption of power plant	Normal	5%	Fu et al. (2018); Yi et al. (2021)
	Coal consumption for heat supply	Normal	5%	Fu et al. (2018); Yi et al. (2021)
	Coal consumption of industry	Normal	10%	Fu et al. (2018); Yi et al. (2021)
	Coal consumption of residents	Normal	20%	Fu et al. (2018); Yi et al. (2021)
	Coal consumption of traffic	Normal	30%	Fu et al. (2018); Yi et al. (2021)
	Coal consumption of business	Normal	30%	Fu et al. (2018); Yi et al. (2021)
	Coal consumption of construction industry	Normal	30%	Fu et al. (2018); Yi et al. (2021)
	Coal consumption of agriculture	Normal	30%	Fu et al. (2018); Yi et al. (2021)
	Coal consumption of other	Normal	30%	Fu et al. (2018); Yi et al. (2021)
Industrial production process	Production of cement	Normal	10%	Fu et al. (2018); Yi et al. (2021)
	Production of iron	Normal	10%	Yi et al. (2021)
	Production of steel	Normal	10%	Yi et al. (2021)
	Production of hydrochloric acid	Normal	20%	Fu et al. (2018); Yi et al. (2021)
	Production of flat glass	Normal	10%	Fu et al. (2018); Yi et al. (2021)
Waste incineration	Amount of MSW incineration station	Normal	10%	Fu et al. (2018); Yi et al. (2021)
	Amount of MSW open incineration	Normal	30%	Fu et al. (2018); Yi et al. (2021)
Biomass burning	Biomass combustion	Normal	20%	Fu et al. (2018); Yi et al. (2021)
Cooking	Household	Normal	20%	Zheng et al. (2022)
	Restaurant	Normal	30%	Zheng et al. (2022)
	Canteen	Normal	10%	Zheng et al. (2022)
Cooling tower	Supplementary water volume	Normal	30%	Yi et al. (2021); Li et al. (2020); Zheng et al. (2022)
Water treatment	Treatment water volume	Normal	10%	Yi et al. (2021)
Waste water treatment	Domestic sewage treatment volume	Normal	10%	Yi et al. (2021)
	medical wastewater treatment volume	Normal	30%	Yi et al. (2021)
Swimming pool	Number of swimming pools	Normal	30%	Li et al. (2020)
	Volume of pools	Normal	50%	Li et al. (2020)
Tap water use	Tap water consumption	Normal	50%	Li et al. (2020)
Environmental disinfection	Disinfectant usage	Normal	50%	Li et al. (2020)
Pesticide	Usage of disinfectants	Normal	40%	Yi et al. (2021)

Table S19 Variation coefficient of emission factors.

Parameter		Distribution	Variation coefficient	Reference
Coal combustion				
Cl release ratio	Pulverized coal boiler	Uniform	78%, 98.5%	Fu et al. (2018); Yi et al. (2021)
	Stoker furnace	Uniform	75%, 99%	Fu et al. (2018); Yi et al. (2021)
	Circulating fluidized bed boiler	Uniform	86%, 99.6%	Fu et al. (2018); Yi et al. (2021)
	Traditional stove	Normal	50%	Yi et al. (2021)
	Strengthen stove	Normal	50%	Yi et al. (2021)
	Tea bath	Normal	50%	Zheng et al. (2022)
Removal efficiency	Wet scrubber	Uniform	40%, 60%	Fu et al. (2018); Yi et al. (2021)
	FF	Uniform	9.5%, 11.3%	Fu et al. (2018); Yi et al. (2021)
	ESP	Uniform	0.9%, 12%	Fu et al. (2018); Yi et al. (2021)
	Mechanical dedusting	Uniform	16.8%, 27.8%	Fu et al. (2018); Yi et al. (2021)
	Wet desulfurization	Uniform	93%, 99.4%	Fu et al. (2018); Yi et al. (2021)
	Other desulfurization	Uniform	85%, 94%	Fu et al. (2018); Yi et al. (2021)
Cl content in coal	Cl content in coal	Lognormal	50%	Fu et al. (2018)
Industrial production process				
HCl emission factor	Cement production	Lognormal	10%	Yi et al. (2021)
	Iron production	Lognormal	50%	Fu et al. (2018); Yi et al. (2021)
	Steel production	Lognormal	50%	Fu et al. (2018); Yi et al. (2021)
	HCl production	Lognormal	30%	Yi et al. (2021)
$PM_{2.5}$ emission factor	Cement production	Lognormal	50%	Zheng et al. (2022)
	Iron production	Lognormal	50%	Zheng et al. (2022)
	Steel production	Lognormal	50%	Zheng et al. (2022)
	Flat glass production	Lognormal	50%	Zheng et al. (2022)
Fine particle Cl^- percentage	Cement production	Uniform	0.3%, 1.92%	Yi et al. (2021)
	Iron production	Uniform	0.74%, 8.37%	Yi et al. (2021)
	Steel production	Uniform	0.74%, 8.37%	Yi et al. (2021)
	Flat glass production	Lognormal	50%	Zheng et al. (2022)
Flat glass production	Reference air displacement	Lognormal	50%	Zheng et al. (2022)
	HCl emission concentration	Lognormal	50%	Zheng et al. (2022)
	Cl_2 emission concentration	Lognormal	50%	Zheng et al. (2022)
Waste incineration				
HCl emission factor	Incineration station	Lognormal	50%	Zheng et al. (2022)
	Open burning	Lognormal	50%	Fu et al. (2018)
$PM_{2.5}$ emission factor	Incineration station	Lognormal	50%	Zheng et al. (2022)
	Open burning	Lognormal	50%	Zheng et al. (2022)
Fine particle Cl^- percentage	Incineration station	Lognormal	50%	Fu et al. (2018)
	Open burning	Lognormal	50%	Fu et al. (2018)
Biomass burning				
HCl emission factor	Rice straw (g/kg)	Uniform	0.0393, 0.8065	Yi et al. (2021)
	Wheat straw (g/kg)	Uniform	0.0201, 1.0034	Yi et al. (2021)
	Other crop straw	Lognormal	50%	Yi et al. (2021)
	Firewood (g/kg)	Uniform	0.0376, 0.087	Yi et al. (2021)
Cl^- emission factor	Rice straw (g/kg)	Uniform	0.187, 0.83	Yi et al. (2021)
	Wheat straw (g/kg)	Uniform	0.1317, 0.939	Yi et al. (2021)
	Corn straw (g/kg)	Uniform	0.059, 1.026	Yi et al. (2021)

	Bean straw (g/kg)	Uniform	0.068, 0.361	Yi et al. (2021)
	Rapeseed straw	Lognormal	50%	Yi et al. (2021)
	Other straw	Lognormal	50%	Yi et al. (2021)
	Firewood (g/kg)	Uniform	0.086, 0.276	Yi et al. (2021)
Cooking				
$PM_{2.5}$ emission factor	Cooking	Lognormal	50%	Zheng et al. (2022)
Fine particle Cl^- percentage	Cooking	Lognormal	20%	Yi et al. (2021)
Cooling tower				
Cl_2/HOCl emission factor	Cooling tower	Lognormal	50%	Yi et al. (2021)
Water treatment				
Cl_2/HOCl emission factor	Chlorine dose	Lognormal	50%	Yi et al. (2021); Li et al. (2020)
	Free chlorine	Lognormal	5%	Yi et al. (2021); Li et al. (2020)
	Emission factor	Uniform	10%, 30%	Yi et al. (2021)
Waste water treatment				
Cl_2/HOCl emission factor	Chlorine dose	Lognormal	50%	Yi et al. (2021); Li et al. (2020)
	Free chlorine	Lognormal	30%	Yi et al. (2021)
	Emission factor	Uniform	10%, 30%	Yi et al. (2021)
Swimming pool				
Cl_2/HOCl emission factor	Chlorine dose	Lognormal	50%	Li et al. (2020)
Tap water use				
Cl_2/HOCl emission factor	Free chlorine	Lognormal	10%	Yi et al. (2021)
	Emission factor	Uniform	5%, 15%	Yi et al. (2021); Li et al. (2020); Zheng et al. (2022)
Environment disinfectant				
Cl_2/HOCl emission factor	Emission factor	Uniform	20%, 40%	Yi et al. (2021); Li et al. (2020)
Pesticide				
Cl_2/HOCl emission factor	Pesticide	Lognormal	50%	Yi et al. (2021); Zheng et al. (2022)

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