

Supporting Information for

Non-agricultural ammonia emissions in urban China

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(Modified and updated from Liu et al., 2011)

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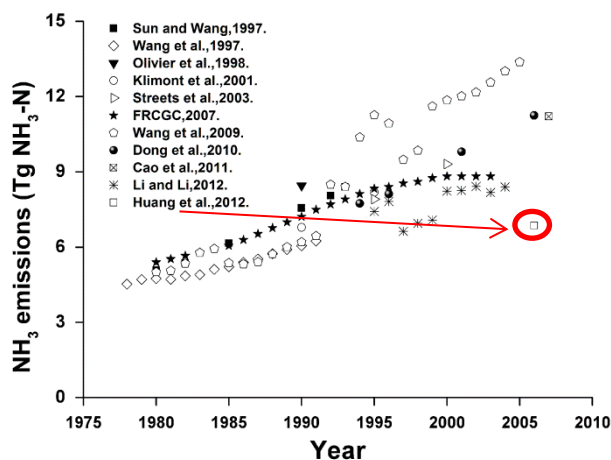


Fig. S1 A collection of studies on national NH₃ emission inventory in China (Modified and updated from Liu et al., 2011)

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Tables

Table S1. The social and economic index for the 113 key cities

City code	City name	Administrative areas (km ²)	Municipal area (km ²)	Registered population (ten thousand)	City GDP (ten thousand RMB)	Municipal GDP (ten thousand RMB)
1	Beijing	16411	7674	1174.63	121530000	119720000
2	Tianjin	11760	5150	802.9	75218500	70302455
3	Shijiazhuang	15848	2817	242.78	30012797	10821265
4	Tangshan	13472	3594	307	38127192	19193652
5	Qinhuangdao	7523	894.1	82.63	8045421	4668602
6	Handan	12062	642	147.4	20152800	4836098
7	Baoding	20584	1002	106.25	17300023	4808775
8	Taiyuan	6963	1460	285.16	15452409	14224531
9	Datong	14127	2080	154.69	5962587	2136306
10	Yangquan	4570	652	68.76	3487100	2354969
11	Changzhi	13896	345	69.8	7752901	2206691
12	Linfen	20275	1316	83.3	7668659	1733438
13	Hohhot	17224	2054	118.79	16439925	11813350
14	Baotou	27768	2591	141.48	21687980	18063073
15	Chifeng	90021	7077	121.44	9128888	3779292
16	Shenyang	12980	3471	512.23	42685137	36672242
17	Dalian	12574	2415	302.01	43495050	30204529
18	Anshan	9252	624	147.24	17304740	10779539
19	Fushun	11272	714	139.05	6986395	5173997
20	Benxi	8411	1518	95.54	6883947	5081110
21	Jinzhou	9891	436	93.38	7272951	3607359
22	Changchun	20604	4789	362.32	28485627	20533771
23	Jilin	27126	3636	185.07	15004776	8316415
24	Harbin	53068	7086	474.7	31755391	22722616
25	Qiqihar	42469	4365	141.99	6905169	3412886
26	Mudanjiang	40583	2464	79.91	6292848	2012961
27	Shanghai	6340	5155	1331.68	150464500	148758036
28	Nanjing	6582	4723	545.97	42302608	38257570
29	Wuxi	4788	1623	238.12	49917200	27406100
30	Xuzhou	11258	1160	186.22	23901600	11433600
31	Changzhou	4385	1872	226.67	25199300	19194200
32	Suzhou	8488	1650	240.21	77402000	29923300
33	Nantong	8001	1521	211.54	28728038	11449000
34	Lianyungang	7500	1156	88.69	9411300	3695386
35	Yangzhou	6634	1024	121.99	18563943	8308748
36	Zhenjiang	3847	1082	103.45	16720765	7412628

37	Hangzhou	16596	3068	429.44	50875530	40698686
38	Ningbo	9817	2462	221.83	43293025	25490039
39	Wenzhou	11788	1187	144.77	25273448	10543477
40	Huzhou	5818	1567	108.56	11018263	5061124
41	Shaoxing	8256	1489	64.9	23757754	4075819
42	Hefei	7047	956	208.58	21021200	15914706
43	Wuhu	3317	764	104.92	9019997	6523380
44	Maanshan	1686	696	63.61	6658905	5206912
45	Fuzhou	13066	1043	187.33	26040448	13279794
46	Xiamen	1573	1573	177	17372349	17372349
47	Quanzhou	11015	892	102.94	30695003	7035714
48	Nanchang	7402	617	222.5	18375008	12464689
49	Jiujiang	18823	598	63.8	8313636	3903166
50	Ji'nan	8177	3277	348.24	33513645	25126262
51	Qingdao	10978	1471	275.47	48538672	27887651
52	Zibo	5965	2970	278.77	24452800	18878253
53	Zaozhuang	4563	3069	219.59	11960414	6537696
54	Yantai	13746	2722	179.24	37017900	15530089
55	Weifang	16143	2650	181.25	27072300	6899480
56	Jining	11194	1043	119.61	22381300	5389800
57	Taian	7762	2087	159.25	17156630	5873477
58	Rizhao	5348	1915	122.83	8646600	6704300
59	Zhengzhou	7446	1010	285.01	33085053	14317914
60	Kaifeng	6444	362	85.38	7787245	1894876
61	Luoyang	15200	1121.5	160.07	20014846	6663681
62	Pingdingshan	7882	459	101.86	11278100	4078726
63	Anyang	7413	544	107.53	11248807	3118570
64	Jiaozuo	4071	424	83.52	10714238	2215501
65	Sanmenxia	10496	198	29.2	7027459	994387
66	Wuhan	8494	2718	514.97	46208600	38888522
67	Yichang	21048	4248	124.79	12723300	6499300
68	Jingzhou	14205	1576	116.85	7095800	2490642
69	Changsha	11819	1938	240.95	37447641	22501417
70	Zhuzhou	11276	537	100.21	10248939	5210416
71	Xiangtan	5015	657	87.75	7393818	4301607
72	Yueyang	15087	1246	87.51	12721499	5504648
73	Changde	17950	2510	140.56	12392306	5598953
74	Zhangjiajie	9516	2735	49.88	2030965	1039170
75	Guangzhou	7434	3843	654.68	91382135	84097486
76	Shaoguan	18463	2870	92.09	5787525	2932298
77	Shenzhen	1992	1992	245.96	82013176	82013176
78	Zhuhai	1701	1701	102.65	10386627	10386627
79	Shantou	2064	1956	503.43	10358687	10278497
80	Zhanjiang	12471	1460	151.81	11566678	6239425

81	Nanning	22099	6447	267.14	15247144	11042774
82	Liuzhou	18617	658	103.83	10460537	7088329
83	Guilin	27809	565	75.79	9405425	3035814
84	Beihai	3337	957	60.42	3177113	2063680
85	Haikou	2305	2305	158.24	4895519	4895519
86	Chongqing	82826	5403	1542.77	65300100	48915782
87	Chengdu	12121	2172	520.86	45026032	31398618
88	Zigong	4373	1438	150.58	5410487	3520831
89	Panzhuhua	7440	2018	69.2	4240750	3294848
90	Luzhou	12229	2133	145.53	5876030	3017560
91	Deyang	5911	648	65.9	7798930	2195751
92	Mianyang	20249	1570	122.31	8201664	3874634
93	Nanchong	12479	2527	193.35	6862762	2466740
94	Yibin	13271	1131	80.03	7207800	2839800
95	Guiyang	8034	2404	218.79	9719382	7259529
96	Zunyi	30762	1316	85.3	7776409	2392289
97	Kunming	21015	4105	250.24	18086467	13484922
98	Qijiang	28906	1553	69.47	8709446	2715210
99	Yuxi	15285	1004	42.06	6444042	3818111
100	Lhasa	31662	554	21.67	1632777	306843
101	Xi'an	10108	3582	561.58	27240800	23150600
102	Tongchuan	3882	2406	75.72	1558600	1453810
103	Baoji	18131	3574	141.37	8065640	4678400
104	Xianyang	10196	527	89.7	8732000	3220170
105	Weinan	13134	1221	96.8	6554980	1418320
106	Yan'an	37037	3556	44.87	7282600	1251790
107	Lanzhou	13086	1632	210.47	9259821	8048843
108	Jinchang	8896	3019	21.53	1947494	1603038
109	Xining	7665	498	114.13	5010743	3549435
110	Yinchuan	9555	2311	91.42	5781483	4398196
111	Shizuishan	5310	2268	45.42	2707801	2028609
112	Urumqi	13788	9527	231.88	10945200	10794352
113	Karamay	9548	9548	39.35	4802909	4802909

Table S2. The annual NH₃ emission intensity for the 113 key cities in municipal urban areas

City code	City name	NH ₃ emission intensity (Mg km ⁻²)
1	Beijing	1.72
2	Tianjin	1.03
3	Shijiazhuang	0.95
4	Tangshan	1.12
5	Qinhuangdao	1.06
6	Handan	2.49
7	Baoding	1.38
8	Taiyuan	2.38
9	Datong	0.34
10	Yangquan	0.99
11	Changzhi	1.69
12	Linfen	0.41
13	Hohhot	1.42
14	Baotou	1.66
15	Chifeng	0.18
16	Shenyang	1.31
17	Dalian	1.65
18	Anshan	2.57
19	Fushun	1.18
20	Benxi	0.49
21	Jinzhou	1.62
22	Changchun	0.61
23	Jilin	0.39
24	Harbin	0.51
25	Qiqihar	0.19
26	Mudanjiang	0.24
27	Shanghai	2.08
28	Nanjing	0.89
29	Wuxi	1.59
30	Xuzhou	1.20
31	Changzhou	0.52
32	Suzhou	2.22
33	Nantong	1.02
34	Lianyungang	0.49
35	Yangzhou	0.97
36	Zhenjiang	0.83
37	Hangzhou	1.28
38	Ningbo	1.23
39	Wenzhou	1.43
40	Huzhou	0.53

41	Shaoxing	0.97
42	Hefei	2.32
43	Wuhu	1.24
44	Maanshan	1.00
45	Fuzhou	1.56
46	Xiamen	0.85
47	Quanzhou	1.69
48	Nanchang	2.44
49	Jiujiang	1.00
50	Ji'nan	0.90
51	Qingdao	2.50
52	Zibo	0.77
53	Zaozhuang	0.36
54	Yantai	0.95
55	Weifang	0.68
56	Jining	1.35
57	Taian	0.61
58	Rizhao	0.43
59	Zhengzhou	2.72
60	Kaifeng	1.67
61	Luoyang	1.33
62	Pingdingshan	1.89
63	Anyang	1.60
64	Jiaozuo	1.76
65	Sanmenxia	0.69
66	Wuhan	1.97
67	Yichang	0.27
68	Jingzhou	0.30
69	Changsha	1.36
70	Zhuzhou	1.66
71	Xiangtan	1.12
72	Yueyang	0.79
73	Changde	0.41
74	Zhangjiajie	0.08
75	Guangzhou	1.96
76	Shaoguan	0.17
77	Shenzhen	3.13
78	Zhuhai	0.51
79	Shantou	0.78
80	Zhanjiang	0.68
81	Nanning	0.25
82	Liuzhou	1.37
83	Guilin	1.16
84	Beihai	0.33

85	Haikou	0.30
86	Chongqing	0.97
87	Chengdu	1.77
88	Zigong	0.45
89	Panzhuhua	0.26
90	Luzhou	0.31
91	Deyang	0.97
92	Mianyang	0.49
93	Nanchong	0.30
94	Yibin	0.54
95	Guiyang	0.92
96	Zunyi	0.81
97	Kunming	0.61
98	Qujing	0.58
99	Yuxi	0.62
100	Lhasa	0.62
101	Xi'an	0.97
102	Tongchuan	0.11
103	Baoji	0.25
104	Xianyang	1.50
105	Weinan	0.47
106	Yan'an	0.15
107	Lanzhou	0.86
108	Jinchang	0.08
109	Xining	1.52
110	Yinchuan	0.41
111	Shizuishan	0.38
112	Urumqi	0.27
113	Karamay	0.09

Table S3. Summary of recent published emission factors for non-agricultural NH₃ emission sources

Category	Subcategory	Roe et al., (2004) ^a	Sutton et al., (2000)	Yao et al., (2011)	Yang, (2011)	Unit (as NH ₃)
Traffic	Light-duty gasoline vehicles	63.20	85.36	63.00	26.64	mg km ⁻¹
	Heavy-duty gasoline vehicles	28.00	1.21	23.00	41.97	mg km ⁻¹
	Light-duty diesel vehicles	4.20	1.21	20.00	65.50	mg km ⁻¹
	Heavy-duty diesel vehicles	16.8	2.91	17.00	107.18	mg km ⁻¹
	Motorcycles	7.00	1.46	74.00		mg km ⁻¹
Waste treatment	Wastewater	Gu et al., (2012)	Coe et al., (1998)	Torres, (1995)		g m ⁻³
	Landfill	Yin et al., (2012)				kg t ⁻¹
	Compost	Roe et al., (2004)	SCAQMD, (1996)	SCAQMD, (2001a, b)		kg t ⁻¹
	Incineration	Yin et al., (2012)	Geadah, (1985)	Geadah, (1985)		kg t ⁻¹
		0.21	0.14 ^b	0.54 ^c		kg t ⁻¹
Humans	Human breath	Sutton et al., (2000)	Sutton et al., (2000)	Sutton et al., (2000)		g person ⁻¹ yr ⁻¹
	Human sweat	3.64	1.21	9.35		g person ⁻¹ yr ⁻¹
	Infants (0-3 yr)	17.00	2.55	90.95		g infant ⁻¹ yr ⁻¹
	Smoking	16.64	3.40	76.74		g smoker ⁻¹ yr ⁻¹
Fuel combustion	Industrial coal combustion	Roe et al., (2004)	Sutton et al., (2000)	Sutton et al., (2000)		kg t ⁻¹
	Domestic coal combustion	0.02	0.005			kg t ⁻¹
		0.90	0.50	2.00		kg t ⁻¹
	Roe et al., (2004)	Muzio and Arand, (1976)	Magill and Benoliel,			

		(1952)			
	Industrial oil combustion	0.10	0.023	0.007	kg (10 ³ l) ⁻¹
	Domestic oil combustion	0.12	0.18		kg (10 ³ l) ⁻¹
		Roe et al., (2004)			
	Industrial gas combustion	51.30			kg (10 ⁶ m ³) ⁻¹
		Sutton et al., (2000)	Roe et al., (2004)		
	Domestic gas combustion	320.51	300.00		kg (10 ⁶ m ³) ⁻¹
		Zhang, (2002); Sutton et al., (2000)	Battye et al., (2003)	Coe et al., (1998)	
Urban land cover	Green land	6.10	0.30	5.50	kg ha ⁻¹ yr ⁻¹
		Sutton et al. (2000)			
Pets	Dogs	0.74 (0.36-1.13)			kg animal ⁻¹ yr ⁻¹
	Cats	0.13 (0.06-0.19)			kg animal ⁻¹ yr ⁻¹
		Roe et al., (2004)	Sutton et al. (2000)	AAPFCO, (2002)	
Domestic activity	Household products	17.10	14.10	49.03	g person ⁻¹ yr ⁻¹
		Roe et al., (2004)	Terry, (2004)		
	Non-agricultural fertilizers	36.90	30.60		g person ⁻¹ yr ⁻¹

*Note: a: emission factors in this column are selected for the current non-agricultural NH₃ emission inventory study. b: commercial/institutional incineration. c: external combustion.