C-1.1.2 Studies on the Current Emission Distribution of Acid Precipitation Precursor and Development of Emission Distribution Projection

Contact Person Kentaro Murano
Senior Research Scientist,
Global Environment Research Division
National Institute for Environmental Studies, Environment Agency
Onogawa 16-2, Tsukuba, Ibaraki, 305-0053 Japan
Tel:+81-298-50-2537 Fax:+81-298-50-2579
E-mail: murano@nies.go.jp

Total Budget for FY1996-FY1998 35,396,000 Yen (FY1998; 9,693,000 Yen)

Abstract In East Asia, China's economy is growing rapidly and consequently emission of air pollutants are increasing rapidly. A large amount of Non methane volatile organic compounds(NMVOCs) emission is accompanied by NOx emission will increase the oxidation potential in the atmosphere to promote sulfuric acid and nitric acid production from SOx and NOx, respectively. NMVOCs emission amounts were compiled for China, Korea, Japan and Taiwan. NMVOCs emission amount from all artificial sources is 14815Gg/y. Combustion source is the major contributor(13201Gg/y, (89.1%)) followed by evaporative source including gasoline vehicles(1614Gg/y, 10.9%). East Asian emission including China, Japan, South Korea and Taiwan is estimated as 18.5Tg/y and China's emission account for around 80%.

Key Words Emission Inventory, China, Volatile Organic Compound, Fossil Fuel Combustion

1. Introduction

For abatement of damages from acid deposition in East Asia, it is important to clarify the emission state and future projection of the precursors of acidification. To develop a comprehensive process model of acidification in East Asia, emission inventories of precursors of acidification are requested, but there had not been reliable and high resolution inventory of the Non methane volatile organic compounds (NMVOCs) emission in East Asia area. Therefore in this study emission amount of NMVOCs, which affect the transformation of SOx and NOx to sulfuric acid and nitric acid, respectively, is estimated on East Asia. The main part of the research work is estimation of emissions from artificial sources in China, so here we describe on the methodology and result of the estimation of emission in China and show the recent state of NMVOC emissions in East Asia..

2. Research Objectives

The emission inventory for the acidification modeling is required to have high spatial and time resolution. For such purposes, the objective of this emission inventory research is, detailed sectoring of the sources and fuel types, which simultaneously provide the possibility of accurate estimation, for example by application of detailed sectored emission factors. The final process of the inventory is preparing grid data all over the East Asia area, though in this study country total emission of China is estimated as the first step.

3. Research Method, Results and Discussion

NMVOCs emission from artificial sources in China is estimated based on the fundamental activities data from China government statistics and application of emission factors for Europe, US and Japan. Main data sources of emission factors are CORINAIR(1996) in European Union, AP-42, 5th edition of US.EPA, and Japan Environment Agency(JEA). Emission factors observed in China are not applicable because of lacking of observation data in China, so these emission factors data from any other areas must be applied to China by assumption of combustion and emission control technology levels in China.

(1) Stationary Evaporative Emission Sources

Emission from petroleum oil supply systems such as petroleum, refinery plant including lubricant production and gasoline service station are estimated, total in China is 258Gg/y. Emission from petro-chemical production process is estimated only 21Gg/y, using emission factors of the plant in Japan. Solvent use for painting is 1017Gg/y based on the assumption of solvent fraction in paint products and thinner fraction by paint type. Chlorous, rubber solvent and so on, 84Gg/y of the other industrial solvent is used. Totally emission from stationary evaporative emission sources in China is estimated, 1216Gg/y as shown in Fig. 1. The dominant source of the stationary evaporative sources is patenting, which is 75% of all the stationary evaporative sources.

(2) Stationary Combustion Sources

NMVOCs emission amount is estimated from energy matrix of China by energy demand sector and fuel type. In application of emission factors, facility size of boilers and furnaces are considered, by which combustion state for coal is different. In small size stoker boilers, much NMVOCs can be generated at reducing flame, so the emission factor for small size coal combustion boilers is given higher than those of large boilers. In same reason, emission factors for biomes burning also assumed high, consequently emission amount from coal and biomes burning are large, are dominant sources of NMVOCs in China. On the contrary emission from oil and gas combustion is small, 33Gg/y which is only 0.22% of the total emission of all the artificial sources, because fuel consumption and emission factors, both are small.

(3) Gasoline Vehicles

Emissions of NMVOCs from gasoline vehicles in China is estimated as 1477Gg/y in 1994CY, in which 1080 Gg/y is from engine exhaust gases, 397Gg/y is from evaporative emission. For this estimation, emission factors for European vehicles, 928g/GJ for engines, 342g/GJ for evaporative emissions, are applied from CORINAIR(1996). This emission level is rather high and equivalent to 3.75g/km for engines, 1.38g/km for evaporation.

(4) Diesel powered trucks and buses

For diesel powered buses, 170g/GJ is given the case of bigger than 16t class heavy duty diesel vehicles in rural area from CORINAIR(1996). For diesel powered trucks 190g/GJ for same size vehicles in general area from CORINAIR is applied. Estimation result is only 40Gg/y, occupied very small share, because of undeveloped condition of vehicle transportation in China.

(5) Railways and vessels

For railways and vessels, there are several levels of emission factors , but here in this study on China case, high level emissions factors are assumed, which from AP-42 of the old observation data by US.EPA. Estimation result is total 51Gg/y, same revel as diesel powered vehicles.

(6) Total Mobile Sources

Emission of NMVOCs form mobile sources in China is estimated 1612Gg/y, which is 10.8% of all artificial sources, in which the dominant source is gasoline vehicles.

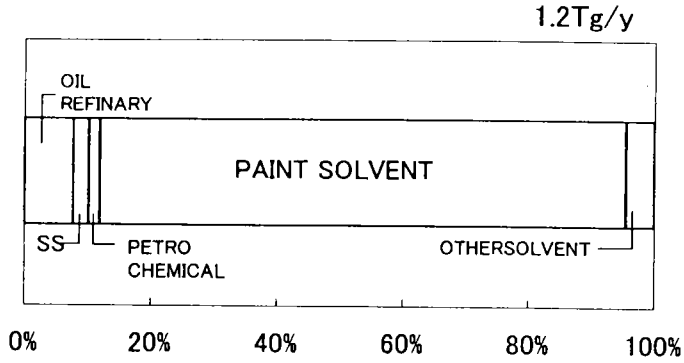

Fig. 1 NMVOCs emission from stationary evaporative sources in China 1994,95CY

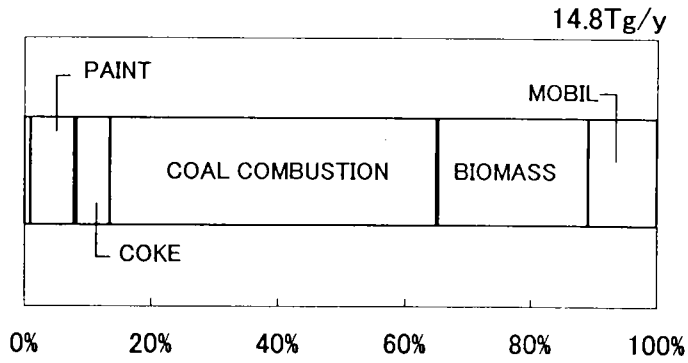

Fig. 2 NMVOCs emissions from artificial sources in China 1994,95CY

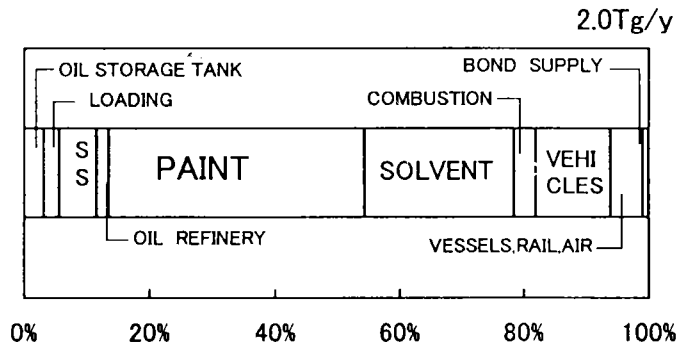

Fig. 3 NMVOCs emission from artificial sources in Japan 1993FY

Table 1 NMVOCs emissions from artificial aources in China 1994,95CY

Sources	Calender Year	NMVOCs Emission Gg/y	NMVOCs Emission %
Oil Refinary	1994	92	0.62%
lubricant	1995	2	0.01%
Filling Underground Tank	1994	13	0.09%
Refueling Dispracement Losses	1994	17	0.12%
Gasoline Service Station Total	1994	30	0.20%
Oil Supply Total	1994,95	124	0.84%
Petro Chemical Prducts	1994	21	0.14%
Paint Solvent Use	1995	1017	6.86%
Tri Chloro Ethilene	1994	16	0.11%
Per Chloro Ethilene	1994	13	0.09%
Chlorous Total	1994	29	0.20%
Rubber Solvent Use (Tyres Production)	1994	26	0.18%
SOLVENT Total	1994,95	1101	7.43%
STATIONARY EVAPORATIVE TOTAL	1994,95	1216	8.21%
Power Plant	1994	253	1.71%
Thermal Plant	1994	35	0.23%
Coke Production	1994	774	5.23%
Coke Consumption	1994	35	0.24%
Coal Gas Generation	1994	2	0.01%
Others(Industries)	1994	7322	49.42%
Coal Total	1994	8421	56.84%
Kerosene	1994	3	0.02%
Diesel	1994	12	0.08%
Heavy Oil	1994	15	0.10%
Natu.Gas	1994	3	0.02%
Oil,Gas Total	1994	33	0.22%
Crop Stalk	1995	2123	14.33%
Firewood	1995	1409	9.51%
Methane	1995	0.3	0.00%
Biomass Total	1995	3532	23.84%
Stationary Combustion Total	1994	11986	80.91%
Gasoline Vehicles Engine	1994	1080	7.29%
Gasoline Vehicles Evapo	1994	397	2.68%
Gasoline Vehicles	1994	1477	9.97%
Buses Diesel	1994	24	0.16%
Trucks Diesel	1994	16	0.11%
VehiclesTotal	1994	1517	10.24%
Agricultural; Trackter	1994	44	0.30%
Rail Ways Diesel	1994	24	0.16%
Vessels Diesel	1994	27	0.18%
Mobile Diesel Total	1994	135	0.91%
Mobile Sources Total	1994	1612	10.88%
EVAPOLATIVE TOTAL #1	1994,95	1614	10.89%
Fossil Fuel COMBUSTION TOTAL#2	1994	9669	65.27%
COMBUSTION TOTAL#2	1994,95	13201	89.11%
ARTIFICIAL TOTAL	1994,95	14815	100.00%

#1: STATIONARY EVAPO+ Gasoline Vehicle Evapo
#2: Excluding Gasoline Vehicle Evapo.

(7) Total Artificial Sources

Compiling above mentioned estimation result, as shown in Table 1, NMVOCs emission amount from all artificial sources is 14815Gg/y. Total emission from combustion source is 13201Gg/y, (89.1%),Evaporative source including gasoline vehicles is totally 1614Gg/y, 10.9%. Figure 2 shows emission source component of artificial NMVOCs in China. Evaporative emission share is relatively small, rather combustion sources emissions, coal and biomes fuel use are dominant. It is in remarkable contrast, evaporative emission is dominant in Japan as shown in Fig. 3.

(8) Comparison with other estimate on China

Shown in Table 2, our result is compared with the other estimate result. For example, RIVM estimated world NMVOCs emissions. By the Ver2. of EDGER Model, NMVOCs emission in China is 18.2Tg/y in 1990CY, 23% bigger than our estimation for 1994,95CY. When comparing by each source category, emission amount are very different from each other, evaporative and biomes burning of RIVM is bigger, but stationary combustion of our estimate is much bigger than RIVM work.

RIVM estimation includes "Uncontrolled waste burning", 1.9Tg/y, "Deforestation", 0.4Tg/y "Savannah burning", 0.1Tg/y, however not estimated in our study. The detailed estimation methodology of RIVM is not reported, though these sources should be additionally estimated.

Table 2 Comparison of NMVOCs emission estimates

SOURCES unit : Pg/y	RIVM EDGER,Ver2	THIS WORK
ARTIFICIAL TOTAL	18.2	14.8
INDUSTRIAL SOURCES	2.4	0.02
OIL REFINARY & SUPPLY#1	1.2	0.9
SOLVENT	1.5	1.1
STATIONARY COMBUSTION	0.4	7.7
RESIDENTIALS etc.	0.9	0.0
TRANSPORTATION	1.4	1.6
BIOMASS BURNING	6.3	3.5
AGRI.WASTE..BURNING,etc	3.7	0.0
OTHERS	0.4	0.0

#1: INCL.. COKE PRODUCTION 0.7

(9) Emission State of NMVOCs in East Asia

NMVOCs emission amount from China is dominant as shown in Table 3. Emissions from North Korea and East Siberia are not estimated, but total of China, Japan, South Korea and Taiwan area is estimated as 18.5Tg/y in recent year, of which 80% is from China.

Table 3 NMVOCs Emissions in East Asia

Area	Evaporative Sources	Combustion Sources Sub Total	Stationary	Mobile	Aitificial Total	Data.Year	
China	1614	13201	11986	1215	14815	1994	*1
Taiwan.area#1		889	478	411	889	1991	*2
Korea	667	154	21	133	821	1997,96#2	*3
Japan	1551	405	67	338	1956	1993	*4
4.Araes.Total	3831	14649	12552	2097	18480		

#1 : Stationary,Mobile include evaporative sources, unseparatable evapo & comb.

#2 : NMVOCfrom.Evapo.sources,1997,HC.from.Comb.sources,1996

*1 : This work

*2 : Chang Ken-Hui ,Fu-TianJeng(1994)Emssions Inventory and DistributioninTaiwan,the 2nd International Workshop On the Harmonization of the Monitoring Techniques ofAcid Deposition and the Methodology of Emission Inventories of SO2 and NOx in East Asia,Tubuka

*3 : Korea Government(1999)Country Report on Expert Meeting on Emission Monitoring and Estimation,Niigata

*4 : IBS(1996)Inside Report for JEA

Reference
1) McInnes G.edt(1996)Atmospheric Emission Inventory Guidebook,EMEP/CORINAIR joint production, http://WWW.eea.dk/aegb/
2) CITEPA(1992)CORINAIR Inventory Default Emission Factors Handbook
3) IBS(1994) Emission Inventory of Stationary Evaporative Sources in Japan, Fundamental survey report on emission control options for JEA
4) State Statistical Bureau, P.R..China,edt(1998)Statistics Year book of China1998, China Statistics Printing Co.
5) JEA(1976)report on Air Pollutants Emission Factors for Stationary Combustion Source
6) Dept. of Industrial and Transportation Statistics, State Statistical Bureau, P.R..China(1998)China Statistical Yearbook1991-1996
7) US.EPA(1977)Compilation of Air Pollutant Emission Factors,AP-42
8) Olivier J.G.J et al(1996)Description of EDGER Version2.0,RIVM&TNO ftp//info.rivm.nl/pub/lae/EDGARV20/

Publication
1) Murano, K., Hatakeyama, S., Kuba, N., Lee, D. S. and Lee,.T-Y.
Gridded ammonia emission fluxes in Japan and Korea
Proceedings of the International Symposium on Acidic Deposition and its Impacts 134-140(1996)
2) Morita, T. (1997) An Economic Evaluation of Japan,s Response to Air Pollution. Japan,s Experience in the Battle against Air Pollution, pp76-93, The Pollution Related Health Damage Compensation and Prevention Association.
3) Tonooka, Y.,
Country report on emission estimation in Japan
Proceedings of the Expert Group Meeting on Emission Monitoring and Estimation, 85 -113(1999)