Establishment of VOCs Emission Inventory in Thailand: A Report on Methods and Early Results

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Abstract

A study of emission inventory of volatile organic compounds was conducted in order to elucidate important of establishing environment and emission standards of VOCs in Thailand. Macro level data related to amount of 47 VOCs compounds used nationwide were collected and emission inventories were carried out by top down approach. Twenty VOCs compounds were prioritized and selected taking into account their toxicity and exposure assessment including inhalation chronic toxicity and their existing in the environment. Evaluation of potential emission sources were performed by considering availability of data, experience of the PRTR system in Japan, and locating and estimating (L&E) report series of US.EPA. Emission amount of each compounds were calculated using US.EPA FIRE emission database.

Introduction

VOCs (Volatile Organic Compounds: VOCs) are defined by WHO (World Health Organization) as organic compounds having boiling point below 240 – 260 degree Celsius; under this definition, numerous organic compounds fall into this category. VOCs are released easily from a source to the ambient air and cause air pollution. In recent years, Thailand has faced environmental problems suspected to be caused by VOCs. Hence, understanding the current situation and taking appropriate measures are crucial. Two distinctive characteristics of VOCs should be noted; one being the harmful nature of inhaling the substances (called HAP: Hazardous Air Pollutants) and another being property of being a precursor to particulates and photochemical oxidants from photochemical reaction. Hence, a comprehensive and multiple views supported by accumulation of scientific data gathered by monitoring are necessary to establish environmental emission standards and develop measures against VOCs.

VOCs emitted from the industry and vehicles are considered as one of the sources for suspended particulate matters (secondary formation), which exceed the standard and requires immediate countermeasure and also triggers photo-oxidant. Furthermore VOCs are hazardous air pollutants, which cause various acute health problem as well as carcinogenic risk. Under this situation, the Thai government considers VOCs as an important issue in ambient environmental matters.

The Pollution Control Department (PCD) initiated a project aiming to establish appropriate ambient and emission standards for VOCs in Thailand. This project has been supported by Japan International Cooperation Agency (JICA) through its technical cooperation scheme. Establishment of VOCs emission inventory is crucial tool for implementation of policy formulation, monitoring of VOCs, and

setting up the control strategy and countermeasures for abatement of VOCs problem in the future.

Methodology

This study consists of 3 phases. In the 1st phase study, emission inventory of 44 VOCs compound, listed in US.EPA TO14 method together with 3 additional compounds namely formaldehyde, acetaldehyde and ethylene oxide are prepared using top down inventory approach. The macro level analysis provides overall picture of VOCs utilization in the country that will illustrate significance of each selected VOCs in supply chains of the country. General framework of demand-supply analysis is based on the macro data of VOCs production, import and export in order to identify consumption of VOCs in the country. Data on energy consumption such as types and quantity of fuel are also collected in the study.

Twenty VOCs species are prioritized and selected for the 2nd phase study. Selection criteria of target VOCs are set up based on toxicity of individual VOCs species as defined by several international agencies and organization such as IARC (International Agency for Research on Cancer), IRIS (Integrated Risk Information System; US.EPA), ACGIH (The American Conference of Governmental Industrial Hygienist), and JSOH (Japan Society of Occupational Health). Target VOCs are also prioritized according to possibility of exposure taking into consideration the fact that a compound may also pose threat to the human health and/or surrounding environment if it is released to the environment in large quantity or present in high concentration in the environment even if it has low toxicity. Evaluation of exposure is performed using amount of consumption. These data will assist in elucidating spatial distribution and degree of the problem which might be potentially occurred from each VOCs compounds. Data, collected in this phase are industry and source specific information taking into consideration potential emission sources and activities of each compounds as listed in the Factor Information Retrieval Data System (FIRE) of US.EPA which includes information about industries and emitting processes, the chemical emitted, and the emission factors themselves. Collected data are calculated with emission factor to evaluate emission amount of each VOCs species. Results are categorized by types of emission source and industry to elucidate contribution of each emission sources.

Results and Discussions

Phase 1 study:

Macro data on demand-supply analysis of each VOCs compound from 2001-2005 is as indicated in Table 1. There are insufficient data for some VOCs compounds due to limitation in data availability. Since some chemicals share similar harmonized code, thus, import-export data of individual compound cannot be distinguished. As for dichloromethane and tetrachloroethylene, there have neither import-export data nor production data available. However, there are 34 VOCs species in which sufficient data are collected. Generally, these VOCs are major chemicals with significant demand for several applications. Thus, their supply sources from either import or domestic production are usually recorded, systematically.

Table 3-2: Demand-supply data of the selected VOCs from 2001 to 2005

NO.	Target VOCs	CAS No.	H-S code	2005				2004				2003				2002				2001			
				export (Tonnes)	import (Tonnes)	production (Tonnes)	consumption (Tonnes)	export (Tonnes)	import (Tonnes)	production (Tonnes)	consumption (Tonnes)	export (Tonnes)	import (Tonnes)	production (Tonnes)	consumption (Tonnes)	export (Tonnes)	import (Tonnes)	production (Tonnes)	consumption (Tonnes)	export (Tonnes)	import (Tonnes)	production (Tonnes)	consumption (Tonnes)
1	Vinyl chloride	75-01-4	2903210002	5,678	98,626	697,000	789,948	7,505	136,235	630,000	758,730	-	96,074	604,000	700,074	-	94,747	567,000	661,747	2,676	108,961	n.a.	n.a.
2	Vinylidene Chloride(Dichloroethylene)	75-35-4	3904500009	-	58	-	58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	Freon 113 (Trichlorotrifluoroethane)	76-13-1	2903430000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	Chloroform	67-66-3	2903130002	24	142	n.a.	n.a.	18	115	50	147	16	123	n.a.	n.a.	8	167	n.a.	n.a.	23	229	n.a.	n.a.
5	1,2-Dichloroethane	107-06-2	2903150004	-	336,126	-	336,126	-	223,300	-	223,300	1	247,100	-	247,099	-	221,930	-	221,930	-	216,216	-	216,216
6	Benzene	71-43-2	2902200006	398,019	3,150	742,000	347,131	331,688	12,212	706,000	386,524	218,549	2	580,000	361,453	214,499	14,558	502,000	302,059	190,187	2,139		
7	Toluene	108-88-3	2902300008	32,896	27,407	179,000	173,511	77,794	40,091	217,000	179,297	216,449	79	339,000	122,630	178,357	207	288,000	109,850	137,514	4,016		
8	Methyl Chloroform	71-55-6	2903190001	-	-	-	-	-	-	-	-	-	24	-	24	-	34	-	34	-	-	-	-
9	Freon12 (Dichlorodifluoromethane)	75-71-8	2903420000	18	1,157	-	1,139	1	1,164	-	1,163	9	1,395	-	1,386	57	4,247	-	4,190	-	2,779	-	2,779
10	Carbon Tetrachloride	56-23-5	2903140003	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11	Methly Chloride (Chloromethane)	74-87-3	2903110001	-	-	-	-	-	132	-	132	-	226	-	226	-	232	-	232	3	78	-	75
12	Trichloroethylene	79-01-6	2903220003	35	5,832	-	-	48	7,889	-	-	1	7,471	-	-	7	7,364	-	-	0	6,209	-	-
13	Freon114	76-14-2	2903440000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14	cis-1,3-Dichloropropene*	10061-01-5	2903290xxx	0	6	n.a.	n.a.	-	123	n.a.	n.a.	1	12	n.a.	n.a.	-	14	n.a.	n.a.	-	3	n.a.	n.a.
15	Methyl Bromide(Bromomethane)	74-83-9	2903300202	-	336	-	336	-	738	-	738	-	608	-	608	-	922	-	922	-	682	-	682
16	Trans-1,3-Dichloropropene*	10061-02-6	2903290xxx	0	6	n.a.	n.a.	-	123	n.a.	n.a.	1	0	n.a.	n.a.	-	14	n.a.	n.a.	-	3	n.a.	n.a.
17	Ethyl Chloride (Chloroethane)	75-00-3	2903110002	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18	Ethylbenzene	100-41-4	2902600003	-	105	-	105		177	-	177	-	136	-	136	-	124	-	124	-	92	-	92
19	Freon11	75-69-4	2903410000	-	102	-	102	-	218	-	218	1	476	-	475	0	797	-	797	7	1,509	-	1,502
20	o-Xylene	95-47-6	2902410000	37,034	549	71,185	34,700	24,549	884	65,010	41,345	36,309	3	64,967	28,661	14,807	4,037	43,518	32,748	1,960	1,025	32,236	31,301
21	Dichloromethane	75-09-2	2903120001	56	8,332	n.a.	n.a.	23	10,930	n.a.	n.a.	21	9,328	n.a.	n.a.	12	8,791	n.a.	n.a.	15	8,584	n.a.	n.a.
22	m-Xylene	108-38-3	2902420001	-	0	0	0	-	0	0	0	-	0	0	0	-	0	0	0	-	-	-	-
23	1,1-Dichloroethane**	75-34-3	2903190xxx	-	46	n.a.	n.a.	-	-	n.a.	n.a.	-	-	n.a.	n.a.	-	-	n.a.	n.a.	-	-	n.a.	n.a.
24	p-Xylene	106-42-3	2902430002	263,866	154,700	1,132,000	1,022,834	235,648	139,770	1,041,000	945,122	297,080	80,980	1,057,000	840,900	276,769	40,116	906,000	669,347	227,519	70,290		
25	cis-1,2-Dichloroethylene	156-59-2	2903290001	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	Styrene	100-42-5	2902500001	21,322	85,840	502,000	566,518	24,547	100,918	467,000	543,371	22,787	88,786	475,000	540,999	19,830	78,566	448,000	506,736	9,693	53,917		
27	1,2-Dichloropropane**	78-87-5	2903190xxx	-	46	n.a.	n.a.	-	-	n.a.	n.a.	-	-	n.a.	n.a.	-	-	n.a.	n.a.	-	-	n.a.	n.a.
28	1,1,2,2-Tetrachloroethane	79-34-5	2903190003	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29	1,1,2-Trichloroethane	79-00-5	2903190002	0	19	-	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30	1,3,5-Trimethylbenzene***	108-67-8	2902900xxx	7,096	2,167	n.a.	n.a.	114,342	1,892	n.a.	n.a.	70,715	1,594	n.a.	n.a.	25,263	1,244	n.a.	n.a.	7,096	538	n.a.	n.a.
31	1,2-Dibromoethane(1,2-Ethylene dibromide)	106-93-4	2903300303	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32	1,2,4-Trimethylbenzene***	95-63-6	2902900xxx	7,096	2,167	n.a.	n.a.	114,342	1,892	n.a.	n.a.	70,715	1,594	n.a.	n.a.	25,263	1,244	n.a.	n.a.	7,096	538	n.a.	n.a.
33	Tetrachloroethylene	127-18-4	2903230004	2	1,117	n.a.	n.a.	-	1,388	n.a.	n.a.	-	1,069	n.a.	n.a.	-	1,370	n.a.	n.a.	-	1,463	n.a.	n.a.
34	m-Dichlorobenzene	541-73-1	2903610xxx	-	44	n.a.	n.a.	-	66	n.a.	n.a.	-	723	n.a.	n.a.	-	421	n.a.	n.a.	-	224	n.a.	n.a.
35	Monochlorobenzene	108-90-7	2903610101	1	102	-	101	0	80	-	80	1	104	-	103	9	370	-	361	1	361	-	360
36	o-Dichlorobenzene	95-50-1	2903610201	-	0	-	-	0	1	-	1	-	1	-	1	-	1	-	1	-	0	-	-
37	Benzyl Chloride	100-44-7	2903690002	10	324	-	314	-	259	-	259	-	271	-	271	-	280	-	280	-	92	-	92
38	p-Dichlorobenzene	106-46-7	2903610202	0	523	-	523	-	756	-	756	-	530	-	530	-	507	-	507	-	284	-	284
39	Hexachloro-1,3-butadiene	87-68-3	2901290xxx	3,262	3,194	n.a.	n.a.	12	2,001	n.a.	n.a.	0	5,323	n.a.	n.a.	1,461	1,937	n.a.	n.a.	11,413	14,011	n.a.	n.a.
40	1,2,4-Trichlorobenzene	120-82-1	2903690xxx	-	-	n.a.	n.a.	-	-	n.a.	n.a.	-	-	n.a.	n.a.	-	-	n.a.	n.a.	-	618	n.a.	n.a.
41	Acrylonitrile	107-13-1	2926100000	2	124,638	-	124,636	-	111,101	-	111,101	-	97,164	-	97,164	-	93,267	-	93,267	51	92,438	-	92,387
42	1,3 Butadiene	106-99-0	2901240004	26,872	14,708	192,200	180,036	27,892	18,337	188,000	178,445	31,703	11,789	173,400	153,486	33,133	9,899	n.a.	n.a.	29,271	4,858	n.a.	n.a.
43	3-Chloro-1-Propane**	107-05-1	2903190xxx	0	46	n.a.	n.a.	-	-	n.a.	n.a.	-	-	n.a.	n.a.	-	-	n.a.	n.a.	-	-	n.a.	n.a.
44	4-Ethyltoluene***	622-96-8	2902900xxx	7,096	2,167	n.a.	n.a.	114,342	1,892	n.a.	n.a.	70,715	1,594	n.a.	n.a.	25,263	1,244	n.a.	n.a.	7,096	538	n.a.	n.a.
45	Formaldehyde	50-00-0	2912110002	43	38	124	119	39	28	n.a.	n.a.	218	35	n.a.	n.a.	34	33	n.a.	n.a.	178	876	n.a.	n.a.
46	Acetaldehyde	75-07-0	2912120003	0	48	-	48	0	0	-	0	5	0	-	0	-	0	-	0	-	0	-	0
47	Ethylene oxide	75-21-8	2910100000	0	464	-	464	10	429	-	419	16	311	-	295	5	419	-	414	3	324	-	321

source: Customs Department, PTIT Special Annual Issue 2005, Department of Agriculture, Department of Industrial Works, Aromatics Thai (Plc.), Thai Petrochemical Industries (Plc.), Bangkok Synthetics Co.,Ltd.

Remarks : '-' = 0 (zero) tonne

: '0' = the value is too small that is less than 1 tonne

: H-S code ended with xxx = chemical's data might be included within other derivatives in a family

: Chemicals No.14 ,16 (marked with *) share the same data as derived from the same group of 2903290xxx , No.23,27 (**) share the same data of 2903190xxx, and No. 30,32,44 (***) share the same data of 2902900xxx

: 'n.a.' = data is not available

The demand-supply analysis indicates that major VOCs utilization in Thailand is those related to petrochemical industry, such as benzene and *p*-xylene. Some VOCs are consumed in a small amount or discontinued for the import and use, domestically. These reductions might be caused by their high toxicity and banning of chemical or replacing to other chemical as results of international agreement such as those ozone depleting substances under the Montreal Protocol (Freon 113, Freon 114), etc. Examples of demand-supply analysis are given for vinyl chloride, benzene, toluene and *p*-xylene as illustrated in Figure 1-4.

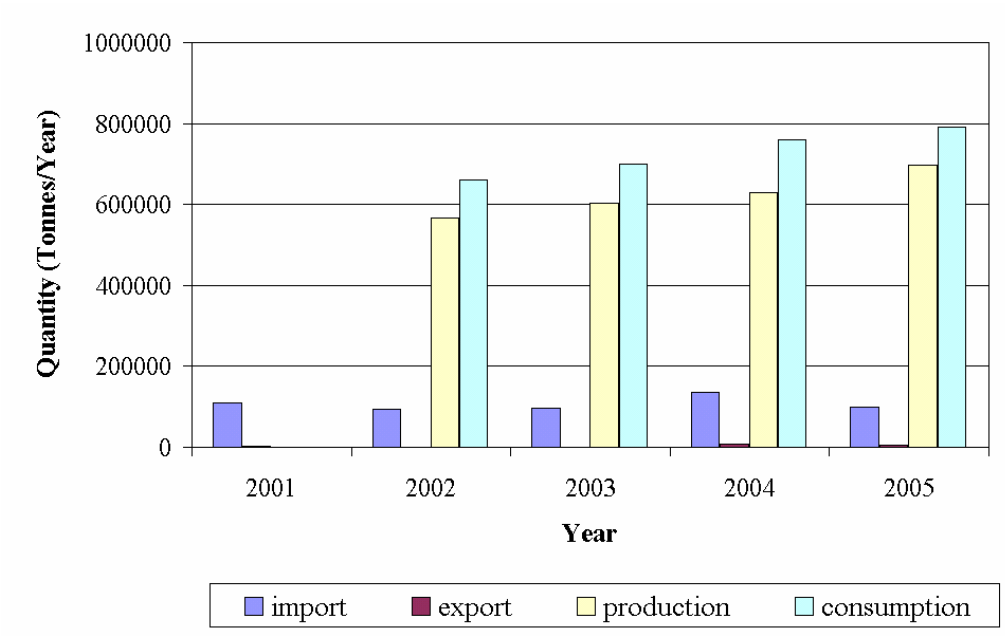

Figure 1: Demand-supply of vinyl chloride

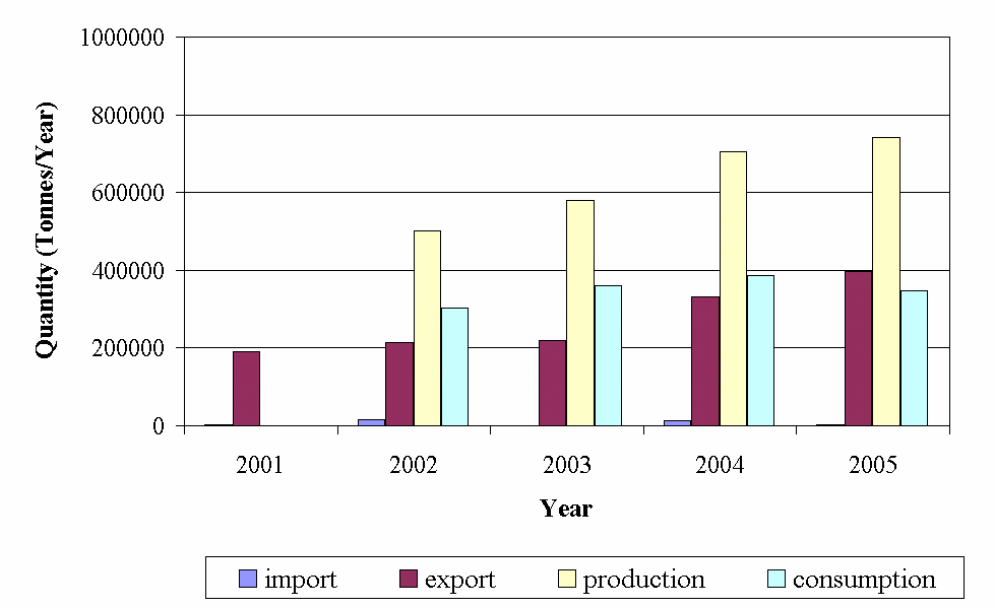

Figure 2: Demand-supply of benzene

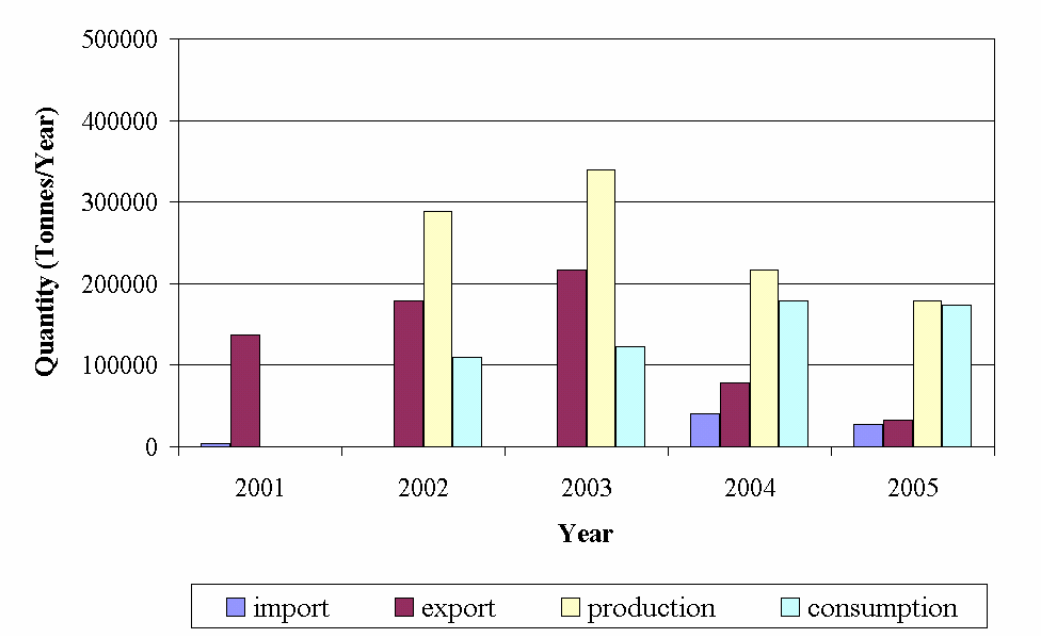

Figure 3: Demand-supply of toluene

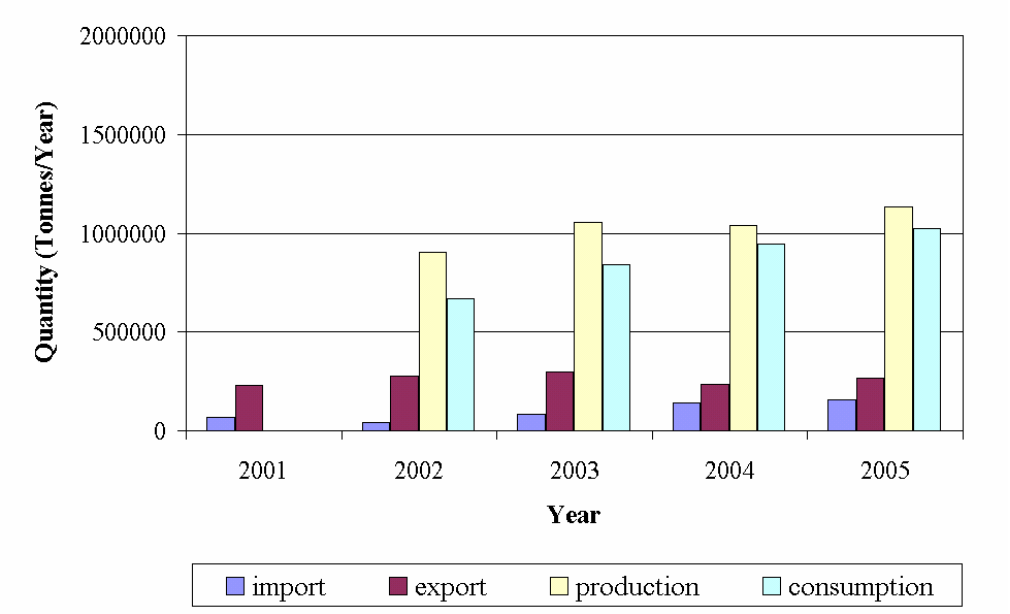

Figure 4: Demand-supply of *p*-xylene

Phase 2 study:

Selection criteria of target VOCs is set up based on toxicity of individual VOCs species and amount of its consumption in Thailand. Priority is given to carcinogenic substance and chemical having large amount of consumption which might lead to high possibility in environmental exposure. Matrix of selection of target VOCs is summarized in Table 2.

Table 2: Screening matrix of prospective priority VOCs

	1st Target VOCs	selection	Detected in existing monitoring results	Import and Export in 2005 (ton/year)			Production in 2005	Exposure (Import+production)	Inhalation chronic toxicity(mg/m3)		Carcinogenicity			
				Export Quantity	Import Quantity	Net	ton/year		WHO *1	IRIS *2	IARC *5	EPA *6	ACGIH *7	JSOH *8
1	Vinyl Chloride	○	○	5,677.8	98,626.0	92,948.2	697,000	795,626.0	0.01	0.0011	1	A	A1	1
2	Vinylidene Chloride			0.0	57.0	57.0		57.0		0.2				
3	Freon 114		○	0.0	0.0	0.0		0.0						
4	Chloroform	○	○	24.2	141.7	117.5		141.7	0.024	0.00043	2B	B	A3	2B
5	1,2-Dichloroethane	○	○	0.0	336,125.9	336,125.9		336,125.9	0.061	0.00038	2B	B	A3	2A
6	Benzene	○	○	398,019.0	3,150.1	-394,868.9	742,000	745,150.1	0.0017	0.0013	1	A	A1	1
7	Toluene	○	○	32,896.0	27,407.3	-5,488.7	179,000.0	206,407.3			3		A4	
8	Methyl Chloroform		○	0.0	0.0	0.0		0.0			3		A4	
9	Freon 12			17.5	1,157.4	1,139.9		1,157.4						
10	Carbon Tetrachloride	○	○	0.0	0.0	0.0		0.0		0.00067	2B	B	A2	2B
11	Methyl Chloride		○	0.0	0.0	0.0		0.0			3		A4	
12	Trichloroethylene	○	○	35.1	5,831.6	5,796.5		5,831.6	0.023		2A	B	A5	2B
13	Freon 11			0.0	0.0	0.0		0.0					A4	
14	cis-1,3-Dichloropropene		○	0.1	6.0	5.9		6.0		0.02				
15	Methyl Bromide			0.0	336.2	336.2		336.2			3		A4	
16	Trans-1,3-Dichloropropene			(0.1)	(6.0)	5.9		6.0		0.02				
17	Ethyl Chloride			0.0	0.0	0.0		0.0			3		A3	
18	Ethylbenzene	○	○	0.0	105.0	105.0		105.0	22		2B	B	A3	2B
19	Freon 11		○	0.0	102.5	102.5		102.5						
20	o-Xylene		○	37,034.3	549.4	-36,484.9		549.4						

	1st Target VOCs	selection	Detected in existing monitoring results	Import and Export in 2005 (ton/year)			Production in 2005	Exposure (Import+production)	Inhalation chronic toxicity(mg/m3)		Carcinogenicity			
				Export	Import	Net			WHO	IRIS	IARC	EPA	ACGIH	JSOH
				Quantity	Quantity		ton/year		*1	*2	*5	*6	*7	*8
21	Dichloromethane	○	○	0.056	8,332.5	8,332.4		8,332.5		2.1E-02	2B	B	A3	2B
22	m-Xylene		○	0.0	0.022	0.0		0.0						
23	1,1-Dicholoroethane			0.0	45.9	45.9		45.9					A4	
24	p-Xylene	○	○	263,866.3	154,700.1	-109,166.2	1,132,000	1,286,700.1						
25	cis-1,2-Dicholoroethylene		○	0.0	0.0	0.0		0.0						
26	Styrene	○	○	21,322.3	85,840.3	64,518.0	502,000	587,840.3			2B		A4	2B
27	1,2-Dichloropropane		○	(0.0)0	(45.9)	45.9		45.9		0.004				
28	1,1,2,2-Tetrachloroethane		○	2.5	0.0	-2.5		0.0						
29	1,1,2-Trichloroethane			0.0	18.9	18.9		18.9		0.0063	3		A3	
30	1,3,5-Trimethylbenzene		○	7,096.0	2,167.0	-4,929.0		2,167.0						
31	1,2-Dibromoethane	○	○	0.09	0.0	-0.1		0.0			2A	B	A3	2A
32	1,2,4-Trimethylbenzene		○	(7,096.0)	(2,167.0)	(-4,929)		2,167.0						
33	Tetrachloroethylene	○	○	2.1	1,116.7	1,114.6		1,116.7	0.2		2A	B	A3	2B
34	m-Dichlorobenzene		○	0.0	44.3	44.3		44.3						
35	Monochlorobenzene		○	1.1	102.5	101.4		102.5					A3	
36	o-Dichlorobenzene		○	0.0	20.0	20.0		20.0			3		A4	
37	Benzyl Chloride	○	○	10.1	324.0	313.9		324.0			2A		A3	2A
38	p-Dichlorobenzene	○	○	0.1	522.6	522.5		522.6			2B	B	A3	2B
39	Hexachloro-1,3-butadiene					0.0		0.0						
40	1,2,4-Trichlorobenzene		○	0.0	0.0	0.0		0.0						
41	Acrylonitrile	○		2.2	124,637.9	124,635.7		124,637.9	0.0005	0.00015	2B	B	A3	2A
42	1,3 Butadiene	○	○	26,871.9	14,708.6	-12,163.3		14,708.6		0.00033	2A	A	A2	1

	1st Target VOCs	selection	Detected in existing monitoring results	Import and Export in 2005 (ton/year)			Production in 2005	Exposure (Import+production)	Inhalation chronic toxicity(mg/m3)		Carcinogenicity			
				Export Quantity	Import Quantity	Net	ton/year		WHO *1	IRIS *2	IARC *5	EPA *6	ACGIH *7	JSOH *8
43	3-Chloro-1-Propane			6.5	0.0	-6.5		0.0			3		A3	
44	4-Ethyltoluene					0.0		0.0						
45	Formaldehyde	○		43.2	38.4	-4.8	123,940.0	123,978.4		0.00077	1	B	A2	2A
46	Acetaldehyde	○	○	0.2	48.0	47.8		48.0	0.019	0.0045	2B	B	A3	2B
47	Ethylene oxide	○		0.2	464.4	464.2		464.4			1	A	A2	1
	Total	20												

Remarks:

*1: Guideline figure of environment standard

*2: IRIS: Integrated Risk Information System,VSD (Virtually Safe Dose, USEPA)

*3: ACGIH:The American Conference of Governmental Industrial Hygienist (working environment air standard)

*4: JSOH:Japan Society of Occupational Health (working environment air standard)

*5: IARC:The International Agency for Research on Cancer: Toxicity are classified into 5 classes as follows:

1:The agent is carcinogenic to humans; 2A:The agent is probably carcinogenic to humans.; 2B:The agent is possibly carcinogenic to humans.; 3:The agent is not classifiable as to its carcinogenicity in to humans, and 4:The agent is probably not carcinogenic to humans

*6: Evalution under USNTP of USEPA: Toxicity are divided as follows:

A: The agent is carcinogenic to humans with enough epidemiological evidences, and B: The agent is probably carcinogenic to humans but with limited epidemiological evidences

*7: Evaluation by ACGIH: Toxicity are classified into 5 classes as follows:

A1: The agent is carcinogenic to humans; A2: Carcinogenesis to humans is suspected with limited epidemiological evidences or animal study; A3: Carcinogenesis is perceived with animal study; A4:The agent is not classifiable as to its carcinogenesis into humans; A5:The agent is not suspected of carcinogenesis to humans

*8: Evaluation by JSOH: Toxicity are classified into 3 classes as follows:

1: The agent is carcinogenic to humans; 2A:The agent is probably carcinogenic to humans with enough evident., and 2B:The agent is possibly carcinogenic to humans without enough evident.

In total, 20 VOCs compounds prioritized and selected in this phase. They are vinyl chloride, chloroform, 1,2-dichloroethane, benzene, toluene, carbon tetrachloride, trichloroethylene, ethyl benzene, dichloromethane, *p*-xylene, styrene, 1,2-dibromoethane, tetrachloroethylene, benzyl chloride, *p*-dichlorobenzene, acrylonitrile, 1,3-butadiene, formaldehyde, acetaldehyde, and ethylene oxide.

Further step of study

Emission inventory of each selected compounds will be evaluated using appropriate emission factor. The Factor Information Retrieval Data System (FIRE) of US.EPA is used as reference and guideline for industry and source specific information. Emission factors are selected according to types of emission source (industry, wastewater treatment, waste treatment, vehicle, internal and external combustion, and fugitive emission), type of process, and type of emission control technology. Estimating of potentially emission sources is taken by reviewing of relevant literatures such as locating and estimating (L&E) report series of US.EPA, experience of the PRTR system in Japan, and availability of data. Selected emission factors are listed and sorted in order to determine magnitude of their contribution to total emission amount of each compounds. Questionnaire and door to door survey will be carried out, randomly. Expected outcome of the study is data, illustrated contribution of each major source in total emission of each compound. These data will be used to evaluate the policy formulation related to designation of environment and emission standards of VOCs as well as designation of appropriate countermeasures for reduction of such compounds.

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