AN INTEGRATED PCDD/DFs INVENTORY FOR EAST ASIAN COUNTRIES

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Introduction

To control the unintentional formation of persistent organic pollutants (POPs), we need to compile emission inventories of the types of release sources, the emission amounts, and the environmental media through which exposure to POPs occurs. In accordance with the Stockholm Convention on Persistent Organic Pollutants, the United Nations Environment Program (UNEP) Chemicals has been compiling emission inventory data on polychlorinated dibenzodioxins and polychlorinated dibenzofurans (PCDD/DFs) on a global scale, and some of the results of an analysis of these data have been reported by Fiedler[1]. The industrial structure in East Asia has been changing as a result of recent remarkable economic growth, and the amounts of waste are therefore increasing. Compilation of an integrated inventory of unintentional POPs in East Asian countries is therefore important for a better understanding of the sources of emission of these compounds in each country within the region. Additionally, such an inventory is likely to be an important tool for evaluating the availability of best available techniques and best environmental practices (BAT/BEP), as well as in effective BAT/BEP application. Since 2006, the Japanese government has hosted the Workshop on Reduction of Unintentional POPs in East Asian Countries. The 1st workshop was an opportunity for representatives from East Asian countries to meet and share information on the implementation of an emission inventory for East Asia and on BAT/BEP in order to promote continuing efforts to reduce the emissions of unintentional POPs in each country[2].

Materials and methods

The process used to compile the data for the POP inventory was as follows.

First, at the 2nd Workshop on Reduction of Unintentional POPs in East Asian Countries (9 to 10 March 2010), hosted by the Ministry of the Environment, Japan, the Ministry proposed to organize and compile data for a POP inventory of the East Asian region, and the Ministry obtained agreement from each country. Then, a draft POP inventory for the region began to be drawn up on the basis of each country's National Implementation Plan (NIP) and presentations at the workshops. Materials cited in the NIPs and others are shown in references[3-16]. We chose PCDD/DFs as targeted unintentional POPs, because data on PCDD/DFs have been accumulated across East Asia. Data on HCBs and PCBs will be compiled later, when enough data on each country become available. The data on the air emissions of PCDD/DFs and the amounts released to all vectors of air, water, land, products, and residues have been examined and compiled. From the statistical data that have been released, authors have also collected and carefully examined the data related to PCDD/DF active masses, waste disposal amounts in the case of waste incineration, and we have calculated emission factors. The emission factor for release source *i* was calculated by the following formula:

$$K_{PCDD/DFs,i} = \frac{C_{PCDD/DFs,i} \times E_i}{A_i} \quad \cdots\cdots (1)$$

where:
C is concentration, A is activity rate, *E* is release flow, and *K* is the emission factor.

The 3rd Workshop on Reduction of Unintentional POPs in East Asian Countries was held, on 1 and 2 October 2009. Before the workshop, a draft of integrated PCDD/DF inventory was sent to the attendees and policymakers of each country to solicit their comments. The draft and relevant information were released at the

workshop, and in-depth discussions were held. In addition, new data from each country were reported at the 4th workshop, held on 14 and 15 December 2010.

Results and discussion

An integrated inventory for East Asia was compiled from each country's NIP and from related information. Thanks to each country's cooperation, we were able to accelerate this work. Examination of the inventory allowed us to specify the categories of emission sources that are important in the East Asian region. These categories are the metals industry, uncontrolled combustion, and waste incineration. By comparing the emission amounts estimated from the active masses obtained statistically, the emission inventories obtained can be verified. The characteristics of the release sources can be examined in the light of each country's experience, and effective measures for reducing unintentional POP emissions can be formulated.

Table 1 shows PCDD/DFs emissions to the atmosphere by source category in East Asian countries. The total amount from the 12 countries in 2010 was 9.1 kg TEQ/year, whereas that from 82 countries across the world was 37.4 kg TEQ/year, as determined by Fiedler[17]. The contribution of East Asian countries was therefore about 25% of the global emission. The main release sources were metal production, uncontrolled combustion, power generation and heating/cooking, and waste incineration. Over all 12 countries, Category 1 (Waste Incineration) accounted for only about 16% of all PCDD/DFs air emissions, whereas in Japan, Malaysia, Korea, and Vietnam, where waste incineration is the main waste disposal method, it accounted for 50% to 60%.

Table 1 Annual PCDD/DFs air emissions (g TEQ/year) by source category in East Asian countries

Sector	Cambodia −2004	China −2004	Indonesia −2000	Japan −2008	Laos −2002	Malaysia	Mongolia −2004	Philippine −1999	Korea −2007	Singapore −2008	Thailand −2005	Viet Nam	Total	Ratio (%)
Cat.1 Waste Incineration	40.73	610.47	14.757	136	0.448	72.2	0.124	37.832	92.6	13.76	42.37	329.76	1391.05	15.5
Cat.2 Ferrous and Nonferrous Metal Production	0.41	2486.2	379.054	55.5	1.324	41.75	0.6	8.664	74.8	4.7	20.2	19.98	3093.18	34.5
Cat.3 Power Generating and Heating/Cooking	10.275	1304.4	153.047	1.3	5.116	0.084	4.337	142.8408	9.2	0.154	33.33	158.54	1822.62	20.3
Cat.4 Production of Mineral Products	0.099	413.61	46.255	14.4	1.339	4.62	0.113	2.5345	8.4	0.03	11.14	9.34	511.88	5.7
Cat.5 Transportation	0.005	119.7	31.223	1.1	0.047	15.44	5.683	0.1158	*	0.419	11.69	2.2	187.62	2.1
Cat.6 Uncontrolled Combustion Processes	217.871	64	1204.272	*	35.99	ND	17.483	135.4576	*	1.874	144.24	15.5	1836.69	20.5
Cat.7 Production of Chemicals and Consumer Goods	0	0.68	4.352	9.1	*	6.57	*	0	0.5	0.117	1.52	0.01	22.85	0.3
Cat.8 Miscellaneous	3.641	44.2	13.641	4.9	2.162	ND	0.001	0.2301	2.5	0.016	21.81	2.16	95.26	1.1
Cat.9 Disposal/Land filling	0	*	0.647	*	*	ND	*	0	*	0	*	*	0.65	0.0
Cat.10 Identification of Potential Hot-Spots	0	*	*	*	*	*	*	*	*	*	*	*	0.00	0.0
	273.031	5042.2	1847.248	221	46.426	140.664	28.341	327.6748	188	21.07	286.3	537.5	8959.45	100.0

*: Not estimated and/or No information, **: zero and/or Not estimated, ND: No Data Available

The following method can be used to calculate the dioxin emissions generated by the incineration of municipal solid waste (MSW):

amount of MSW in each country × emission factor (0.5–3500 μg TEQ/t) for Category 1 (Waste Incineration) shown in toolkit2005.

If 5000 Nm^3 of emission gas is produced per tonne of waste, then an emission factor of 0.5 μg TEQ/t will be equivalent to an emission gas concentration of 0.1 ng TEQ/Nm^3—the figure recommended by the BAT/BEP

guideline. The inventory data for Category 1 (Air) are shown in Figure 1, together with the estimates of PCDD/DFs emissions to air from waste incineration in each country. The emission inventory for Japan is based on the emission amounts generated by MSW incineration facilities (5000gTEQ/year in 1997→42 g TEQ/year in 2008). The amount of MSW was used as the active mass in the estimation, but the incineration ratio was not taken into consideration. Therefore, this result is a prediction of the amount of dioxins emitted during the treatment of MSW at different waste incinerators with different efficiencies, and the results are affected by the efficiency of each incinerator. The inventoried emissions in many of the countries are in the low levels of the estimated range; however, this is not because all the countries have high-performance incineration plants but because some countries have small amounts of MSW. In contrast, the inventoried emissions in Cambodia, Indonesia, and Vietnam are in the middle to high levels of the estimated range. Presumably, some of the MSW in these countries is treated by low-performance incinerators, because the incineration rates in these countries are not high. To promote the sanitary disposal of domestic waste or incineration treatment aimed at thermal recovery, two methods can be considered: 1) constructing high-performance incineration facilities with low emission factors or 2) decreasing the active mass by 3R (reduce, reuse, recycle) application—that is, promoting a reduction in the amount of waste.

In aggregation data from a number of countries, difference of the data quality should be recognized. In many countries, for example, the active masses at the release points were difficult to estimate because of factors such as uncontrolled combustion. Nevertheless, maintaining and sharing information on integrated inventories in the East Asian region is meaningful for examining ways to deal with unintentional POP emissions, and we can expect to develop more effective measures when this inventory information is combined with monitoring information. It is essential that we follow up and more accurately investigate the details surrounding emission sources, emission factors, and active mass. It is also important to reduce unintentional POP emissions by reducing emission factors and active mass. It is desirable to promote these further actions in line with approaches to the reduction of emissions of other environmental pollutants and greenhouse gases. Accumulation and exchange of BAT information are also desirable, along with the revision of region-based integrated inventories. As part of emission source monitoring, unintentional POP emissions need to be measured regularly; this should be done in addition to the use of alternative indicators and continuous monitoring.

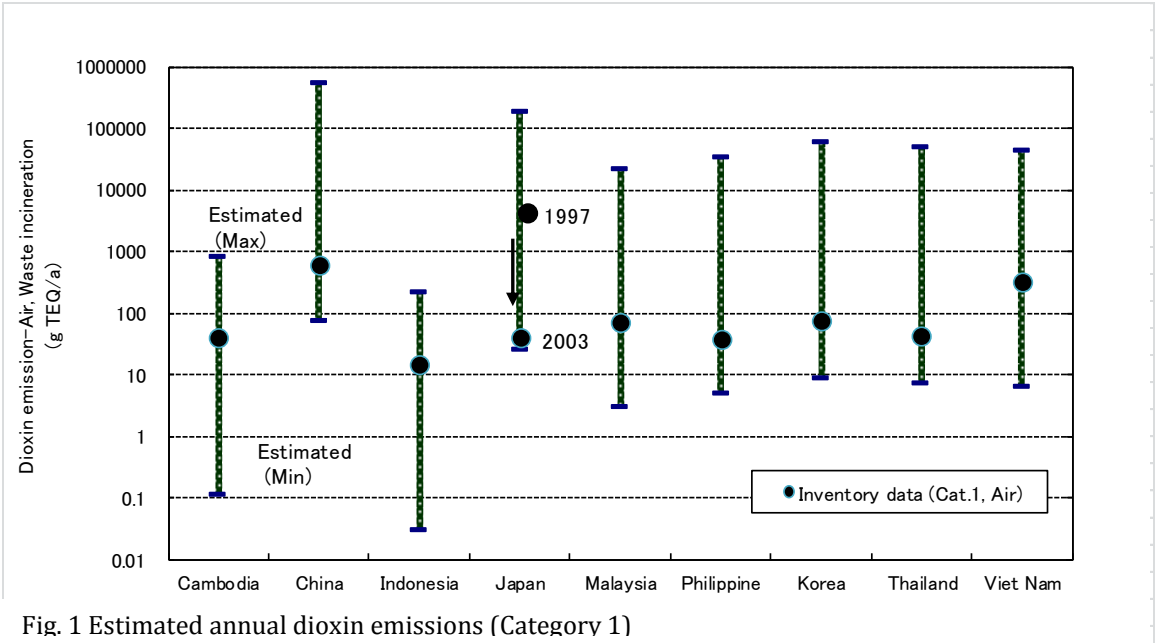

Fig. 1 Estimated annual dioxin emissions (Category 1)

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