THAILAND'S DIOXIN INVENTORY AND APPLICATION OF UNEP TOOLKIT FOR ESTIMATING DIOXINS/FURANS RELEASE TO ENVIRONMENT

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Abstract
The inventory for dioxins/furans releases to air, water, land, product and residue were studied from 9 source categories including waste incineration (S1), ferrous and non-ferrous metal production (S2), power generation and heating (S3), production of mineral products (S4), transportation (S5), uncontrolled combustion processes (S6), production of chemicals and consumer goods (S7), miscellaneous (S8), and disposal/landfilling (S9). The amount of production per year from these source categories was collected and further calculated to dioxins/furans releases to environment by using the UNEP standardized toolkit for identification and quantification of dioxin and furan releases. The emission to residue was found to be the first potential source of concerns. The emission from S7, S6, S2, S1 and S3 was 384.16, 236.10, 99.64, 32.45 and 14.28 g I-TEQ/a, respectively. The emission to air was the second source of concerns especially from S6 at the amount of 231.76 g I-TEQ/a and others including S1, S3, S8 and S2 at the amount of 42.37, 33.33, 21.81 and 20.20 g I-TEQ/a, respectively. However, emission to land was found only from S6 at 6.64 g I-TEQ/a while emissions to water and product were found only from S7 at 1.33 and 8.31 g I-TEQ/a, respectively.

Introduction
Dioxins/Furans (PCDDs/PCDFs) inventory in Thailand was prepared upon Thailand's ratification on the Stockholm Convention on Persistent Organic Pollutants (POPs) on January 30, 2005 to protect human health and environment from POPs[1]. According to Article 5 on "Measures to Reduce or Eliminate Releases from Unintentional Production", each party shall develop an action plan within two years of the date of entry into force of this Convention. Thai government is obliged to submit the action plan including the development and maintenance of source inventories and release estimates of source categories identified in Annex C of the Stockholm Convention on POPs[1]. Therefore, the objective of this study is to compile data from PCDDs/PCDFs emission releases to air, water, land, product and residue from all relevant source categories.

Materials and Methods
Nine source categories including waste incineration (S1), ferrous and non-ferrous metal production (S2), power generation and heating (S3), production of mineral products (S4), transportation (S5), uncontrolled combustion processes (S6), production of chemicals and consumer goods (S7), miscellaneous (S8), and disposal/landfilling (S9) were identified according to UNEP: Standardized Toolkit for Identification and Quantification of Dioxins/ Furan Releases[2]. Questionnaires were sent out to industries and enterprises that have relevant sources of dioxins/furans emission. Field visits were scheduled for incinerator plants and industries to investigate types of incineration and boilers, operation procedures and conditions as well as air pollution control device. Data were extracted from the questionnaires to calculate for the amount of production per annual and identify source category, subcategory and class as guided by the UNEP Toolkit[2], then the annual PCDDs/PCDFs emission was calculated by multiplying with the default emission factor for potential release route to air, water, land, products and residue according to source categories, sub categories and class as indicated in UNEP Toolkit[2] to obtain an annual release of PCDDs/PCDFs emission to air, water, land, product and residue in "g I-TEQ/a" unit.

Results and Discussion
The inventory matrix of PCDDs/PCDFs emission from 9 source categories to air, water, land, product and residue was shown on Table 1. The current study found that PCDDs/PCDFs emission to residues at the amount of 773.28 g I-TEQ/a was the highest when compared to the emission to air, product, land and water at the amount of 286.30, 8.31, 6.64 and 1.33 g I-TEQ/a, respectively. Therefore, PCDDs/PCDFs emission released to residue and air would be the first and second source of concern. The amount of emission to residue in all source categories was ranked from high to low amount of release as followings: S7, S6, S2, S1 and S3 for 384.16, 236.10, 99.64, 32.45 and 14.28 g I-TEQ/a, respectively. The study suggested that PCDDs/PCDFs emission to residue should be emphasized for S7 from black liquor boiler and burning of sludge, S6 from

Table 1 PCDDs/PCDFs emission from 9 source categories to environmental media and product

Source	Subcat.	Source Categories	Annual Release (g I-TEQ/a)				
			Air	Water	Land	Product	Residues
1		**Waste incineration**					
	a	Municipal solid waste incineration	4.073	0.000	NA	NA	25.730
	b	Hazardous waste incineration					
	c	Medical/hospital waste incineration	38.289	0.000	NA	NA	6.718
	d	Light fraction shredder waste incineration					
	e	Sewage sludge incineration					
	f	Waste wood & waste biomass incineration					
	g	Animal carcasses burning	0.005	0.000	NA	NA	NA
Total for Category 1			**42.37**	**0.00**	**0.00**	**0.00**	**32.45**
2		**Ferrous and non-ferrous metal production**					
	a	Iron ore sintering					
	b	Coke production					
	c	Iron and steel production & foundries	19.938	ND	ND	ND	98.777
	d	Copper production	0.060	ND	ND	ND	0.756
	e	Aluminum production	0.009	ND	ND	ND	0.103
	f	Lead production	0.193	ND	ND	ND	ND
	g	Zinc production					
	h	Brass and bronze production	0.0005	ND	ND	ND	ND
	i	Magnesium production					
	j	Other non-ferrous metal production					
	l	Shredders					
	m	Thermal wire reclamation					
Total for Category 2			**20.20**	**0.00**	**0.00**	**0.00**	**99.64**
3		**Power Generation and Heating**					
	a	Fossil fuel power plants	4.537	NA	NA	NA	5.790
	b	Biomass power plants	27.900	NA	NA	NA	8.370
	c	Landfill, biogas combustion					
	d	Household heating and cooking (biomass)	0.480	NA	NA	NA	0.096
	e	Household heating and cooking (fossil fuels)	0.417	NA	NA	NA	0.028
Total for Category 3			**33.33**	**0.00**	**0.00**	**0.00**	**14.28**
4		**Production of mineral products**					
	a	Cement kilns	8.278	NA	ND	ND	0.166
	b	Lime	1.731	ND	ND	ND	ND
	c	Brick	0.900	NA	ND	ND	ND
	d	Glass	0.012	NA	ND	ND	ND
	e	Ceramics	0.170	NA	ND	ND	ND
	f	Asphalt mixing	0.046	NA	ND	ND	ND
Total for Category 4			**11.14**	**0.00**	**0.00**	**0.00**	**0.17**
5		**Transportations**					
	a	4-Stroke engines	0.229	NA	NA	NA	ND
	b	2-Stroke engines	2.636	NA	NA	NA	ND
	c	Diesel engines	8.279	NA	NA	NA	ND
	d	Heavy oil fired engines	0.544	NA	NA	NA	ND
Total for Category 5			**11.69**	**0.00**	**0.00**	**0.00**	**0.00**

Sector	Subcat.	Source Categories	Annual Release (g I-TEQ/a)				
			Air	Water	Land	Product	Residues
6		**Uncontrolled combustion processes**					
	a	Fires/burnings - biomass	19.904	ND	6.631	NA	ND
		Forest fires	0.012	ND	0.010	NA	ND
		Grassland and moor fires	0.000	ND	0.000	NA	ND
		Agricultural residue burning (in field)	19.892	ND	6.631	NA	ND
	b	Fires: waste burning, landfill, industry, accident	124.332	ND	0.000	0.000	236.097
		Landfill fires	6.122	ND	NA	NA	ND
		Accidental fires in houses, factories (per event)	0.176	ND	see residue	NA	0.176
		Uncontrolled domestic waste burning	117.953	ND	see residue	NA	235.907
		Accidental fires in vehicles (per event)	0.008	ND	see residue	NA	0.002
		Open burning of wood (construction/demolition)	0.072	ND	ND	NA	0.012
Total for Category 6			**144.24**	**0.00**	**6.63**	**0.00**	**236.10**
7		**Production of chemicals, consumer goods**					
	a	Pulp and paper mills					
		Boilers (per ton of pulp)	0.027				381.000
		Sludges					19.944
		Water (in L)		1.328			
		Pulp and paper				8.248	
	b	Chemical industry					
		PCP					
		PCB					
		Chlorinated Pesticides					
		Chloranil					
		ECD/VCM/PVC	1.490	0.027	0.000	0.057	3.156
	c	Petroleum refineries					
	d	Textile plants					
	e	Leather plants					
Total for Category 7			**1.52**	**1.33**	**0.00**	**8.31**	**384.16**
8		**Miscellaneous**					
	a	Drying of biomass					
	b	Crematories	21.614	NA	ND	0.000	6.477
	c	Smoke houses					
	d	Dry cleaning residues					
	e	Tobacco smoking	0.194	NA	NA	NA	NA
Total for Category 8			**21.81**	**0.00**	**0.00**	**0.00**	**6.48**
9		**Disposal/Landfill**					
	a	Landfill leachate					
	b	Sewage/sewage treatment					
	c	Open water dumping					
	d	Composting					
	e	Waste oil disposal					
Total for Category 9							
Total for Category 1 - 8			**286.30**	**1.33**	**6.64**	**8.31**	**773.28**

Note: 1) Data for source category 9 – disposal/landfill is not available due to poor record of enterprises.
2) Blank data for few sub-categories in source categories 1, 2, 3, 7 and 8 are not available at the present.

uncontrolled domestic waste burning, S2 from iron and steel production that used electric arc furnace and fabric filter and S1 from municipal solid waste and medical waste incineration. The emission to air, especially from S6 at the amount of 144.24 g I-TEQ/a and others including S1, S3, S8 and S2 at the amount of 42.37, 33.33, 21.81 and 20.20 g I-TEQ/a, respectively. The emission to air should be emphasized for S6 from uncontrolled domestic waste burning. Though PCDDs/PCDFs emission to air from S1, S2, S3 and S8 were relative small when compared to that of S6. However, emission to land was found only from S6 at 6.64 g I-TEQ/a while emissions to water and product were found only from S7 at 1.33 and 8.31 g I-TEQ/a, respectively.

As shown in Table 1, the data for few sub-categories in S1, S2, S3, S7, S8 and S9 are not available at the present and may need at least a year to collect the data. Data for S9 are not obtained due to scarcity and insufficient data which need more time for enterprises to record and collect data. Therefore, identification of potential hot spots cannot be identified as well. In the past, there was no record for relevant data due to lack of knowledge and poor understanding on the operation procedure regarding the incineration temperature and thermal process. In addition, the enterprises are not aware of unintentional production of PCDDs/PCDFs from low temperature operation and uses of chlorinated compound in the manufacturing process.

The study found that the estimated PCDDs/PCDFs release to environment, which was obtained from the calculation of annual mass production with default emission factor characterized by source category, sub-category and class according to UNEP Toolkit, mostly reflected the real amount of PCDDs/PCDFs emission. However, some default emission factors relevant to S1, S2, S6, S7 and S8 need to be revised as appropriate. The UNEP Toolkit would be benefit for an application to estimate PCDDs/PCDFs emission releases to environment and product from each source categories. The cost of actual sampling analysis is considerably high and could be a burden for small and medium enterprises to conduct the measurement, especially those in the developing countries. Nevertheless, the actual sampling analysis and monitoring of PCDDs/PCDFs emission should be conducted and this would be the best clue in assessing hazardous health effect and environmental impact from PCDDs/PCDFs exposure.

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References

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