

Stakeholders' Meeting of the Malé Declaration 14th October 2005, Delhi

**Compilation of emissions inventories using the Malé
Declaration Emission inventory Manual.**

Harry Vallack, Stockholm Environment Institute



**Malé Declaration on Control and Prevention of Air Pollution
and Its Likely Transboundary Effects for South Asia**

The problem

Air pollution can have many adverse effects including:

- ❖ **Damage to human health**
- ❖ **Damage to crops, animals and ecosystems**
- ❖ **Damage and soiling of buildings and other structures**
- ❖ **Air quality degradation**
- ❖ **Global warming/climate change**
- ❖ **Stratospheric ozone depletion**



Why produce an emissions inventory?

- ❖ **provide input data for modelling the movement, deposition and effects of air pollutants**
- ❖ **help inform the policy makers and the public**
- ❖ **help define priorities and set objectives for reducing emissions**
- ❖ **assess the potential impacts of different reduction strategies**
- ❖ **forecast future emission levels to determine which emission sources might require further controls**

What is an emissions inventory?

An air pollutant emissions inventory details the amounts and types of air pollutants released into the air by source category.

Some consist of large point sources :

- ❖ electrical power plants
- ❖ metal smelters
- ❖ oil refineries
- ❖ large factories



What is an emissions inventory?

Other source categories are made up of many small, or diffuse (area or line) sources:

- ❖ domestic households
- ❖ small factories
- ❖ offices and public buildings
- ❖ cars and other vehicles
- ❖ vegetation fires (e.g. savannah burning)
- ❖ crop residue burning
- ❖ application of fertilizers



What is an emissions inventory?

Sometimes *natural* emissions are also inventoried:

- ❖ trees and other vegetation (VOCs & NH₃)
- ❖ Volcanoes (SO₂ & PM)



Photo by Celia Nyamweru

General approach for calculation of emissions

Unless measured directly, emissions are generally estimated as:

$$\text{Emission} = (\text{emission factor}) \times (\text{activity rate})$$

In practice the calculations are more complicated but the principle remains the same.

General approach for calculation of emissions

$$\text{Emission} = (\text{emission factor}) \times (\text{activity rate})$$

Emission factors are the rate of emission of a pollutant per unit of activity

Examples:

- ❖ In a power station - kg NO_x per tonne coal burnt
- ❖ In a copper smelter - kg SO₂ per tonne copper produced

General approach for calculation of emissions

$$\text{Emission} = (\text{emission factor}) \times (\text{activity rate})$$

Examples of activity rates:

- ❖ For *fuel combustion* - the annual rate of consumption of a fuel (e.g. kilotonnes coal burnt per year in a power station)
- ❖ For *industrial process emissions* - the annual rate of production of the commodity (e.g. kilotonnes copper produced per year at a copper smelter)

The Malé Declaration Air Pollutant Emissions Inventory Manual

Draft Version 1.2
September, 2005

Implementation of the Malé Declaration on Control and Prevention of
Air Pollution and its Likely Transboundary Effects for South Asia



Pollutants currently included in the Malé emission inventory manual

- ❖ **Sulphur dioxide (SO₂)**
- ❖ **Nitrogen oxides (NO_x)**
- ❖ **Ammonia (NH₃)**
- ❖ **Particulate matter (PM₁₀ and Total Suspended Particulate (TSP))**

Additions to be made to a new version of the Malé manual during Phase III

Two extra pollutants will be added to enable ozone modelling:

- ❖ Carbon monoxide (CO)**
- ❖ Non-methane volatile organic compounds (NMVOCs)**

Spatial allocation of emissions will be addressed

Improve and extend PM/dust emission coverage

Information required to compile the emissions inventory

Regional and national sources of activity data from:

- ❖ **government departments**
- ❖ **industries**
- ❖ **research institutes**
- ❖ **research publications**











Information required to compile the emissions inventory

International sources of activity data:

- ❖ International Energy Agency (IEA) Energy Statistics and Balances
- ❖ United Nations Industrial Commodity Statistics Yearbooks
- ❖ Food and Agriculture Organisation's (FAO) on-line database FOASTAT

The Malé emission inventory Excel workbook: main menu

MENU OVERVIEW

	Menu1	Sectors 1. to 4. Fuel combustion activities
	Menu2	Sector 5. Fugitive emissions (non-combustion) for fuels
	Menu3	Sector 3. Fuel combustion activities. Sub-sector: Transport (Detailed method)
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The Malé emission inventory Excel workbook: Menu 4

Sector 6. Industrial processes (non-combustion) emissions

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Sheet: 2.1 Process (non-combustion) emissions from the production of mineral products.

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Sheet: 2.2 Process (non-combustion) emissions from the production of chemicals.

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Sheet: 2.3 Process (non-combustion) emissions from metal production.

GO

Sheet: 2.4 Process (non-combustion) emissions of SO₂, NO_x from pulp and paper production.

GO

Sheet: 2.5 Fugitive emissions of particulate matter from major building construction activities.

Worksheet for *Process (non-combustion) emissions from metal production*

Sheet: 2.3 Process (non-combustion) emissions from metal production.

Sector: Industrial processes

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Sub-sector: Metals production (ISIC¹ Division 27)

Process	A Activity rate (kt product/ year)	B SO ₂ emission factor (kg SO ₂ /t)		C SO ₂ emissions (Tonnes) (A x B)	D NO _x emission factor (kg NO _x /t)		E NO _x emissions (Tonnes) (A x D)
			Default			Default	
Pig iron production			3 ^a	0		0.076 ^d	0
Aluminium production			15.1 ^e	0		2.15 ^e	0
Copper smelting (primary)			2120 ^f	0			
Lead smelting (primary)			320 ^g	0			
(secondary)			40 ^h	0			
Zinc smelting (primary)			1000 ^g	0			
Other (please specify)				0			0
Total emissions				0			0

Worksheet for *Process (non-combustion) emissions from metal production*

Sheet: 2.3 Process (non-combustion) emissions from metal production.

Sector: Industrial processes

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Sub-sector: Metals production (ISIC¹ Division 27)

Process	A Activity rate (kt product/ year)	B SO ₂ emission factor (kg SO ₂ /t)		C SO ₂ emissions (Tonnes) (A x B)	D NO _x emission factor (kg NO _x /t)		E NO _x emissions (Tonnes) (A x D)
			Default			Default	
Pig iron production	10000	3	3 ^a	30000	.076	0.076 ^d	760
Aluminium production	2000	15.1	15.1 ^e	30200	2.15	2.15 ^e	4300
Copper smelting (primary)	2000	2120	2120 ^f	4240000			
Lead smelting (primary)	1000	320	320 ^g	320000			
(secondary)	1000	40	40 ^h	40000			
Zinc smelting (primary)	1000	1000	1000 ^g	1000000			
Other (please specify)				0			0
Total emissions				5660200			5060

Sheet 8 Summary sheet - Annual emissions of each pollutant by source sector

Sector	Sub-sector	Total emissions (kilotonnes pollutant per year (kt/yr))				
		SO ₂	NO _x	NH ₃	PM ₁₀	TSP
1. Combustion in the Energy Industries	Public Electricity and Heat	0.00	0.00	0.00	0.00	0.00
	Petroleum Refining	0.00	0.00	0.00	0.00	0.00
	Manufacture of Solid Fuels and Other Energy	0.00	0.00	0.00	0.00	0.00
2. Combustion in Manufacturing Industries and construction	Iron and Steel	0.00	0.00	0.00	0.00	0.00
	Non-ferrous metals	0.00	0.00	0.00	0.00	0.00
	Non-metallic minerals	0.00	0.00	0.00	0.00	0.00
	Chemicals	0.00	0.00	0.00	0.00	0.00
	Pulp, Paper and print	0.00	0.00	0.00	0.00	0.00
	Food, Beverages and Tobacco	0.00	0.00	0.00	0.00	0.00
	Textiles and leather	0.00	0.00	0.00	0.00	0.00
	Other (Please specify in sheet 1.1.1a, 1.1.1b or 1.1.1c)	0.00	0.00	0.00	0.00	0.00
	Remainder (Non-specified)	0.00	0.00	0.00	0.00	0.00
3. Transport	Civil Aviation (Simple--not used if Detailed used)	0.00	0.00	0.00	0.00	0.00
	Civil Aviation (Detailed)	0.00	0.00	0.00	0.00	0.00
	Road transport (Simple--not used if Detailed used)	0.00	0.00	0.00	0.00	0.00
	Road transport (Detailed)		0.00		0.00	0.00
	Railways	0.00	0.00	0.00	0.00	0.00
	Navigation	0.00	0.00	0.00	0.00	0.00
	Pipeline transport	0.00	0.00	0.00	0.00	0.00
	Non-specified transport	0.00	0.00	0.00	0.00	0.00
4. Combustion in Other Sectors	Commercial/Institutional	0.00	0.00	0.00	0.00	0.00
	Residential	0.00	0.00	0.00	0.00	0.00
	Agriculture/Forestry/Fishing	0.00	0.00	0.00	0.00	0.00
5. Fugitive emissions from fuels	Production of coke				0.00	0.00
	Oil refining	0.00	0.00			
	Flaring during oil and gas extraction		0.00			
6. Industrial processes	Mineral products	0.00	0.00		0.00	0.00
	Chemicals	0.00	0.00	0.00	0.00	0.00
	Metals	5660.20	5.06		872.50	1182.50
	Pulp and paper	0.00	0.00		0.00	0.00
	Major construction site activities (Fugitive PM only)				0.00	0.00
7. Agriculture	Manure management			0.00		
	Application of N-containing fertilizers		0.00	0.00		
	Burning of agricultural crop residues	0.00	0.00	0.00	0.00	0.00
8. Vegetation fires and Forestry	On-site burning of forests and grasslands	0.00	0.00		0.00	0.00
9. Waste	Waste incineration	0.00	0.00	0.00	0.00	0.00
	Latrines			0.00		
Total anthropogenic		5660.20	5.06	0.00	872.50	1182.50
10. Natural sources	Volcanoes	0.00			0.00	0.00
	Biogenic emissions from natural vegetation			0.00		
	Human breath and perspiration			0.00		
Total anthropogenic + natural		5660.20	5.06	0.00	872.50	1182.50

Making inventory output compatible with the Integrated Assessment Model (IAM)

- ❖ **For the IAM, the 8 countries of the Malé Declaration are divided into 19 emission regions.**
- ❖ **This division was arrived at using a method combining reported SO₂ emissions, land area and population. (With proviso that each country should comprise at least 1 emission region.)**
- ❖ **Only 3 countries have more than 1 emission region :**
 - Iran (2) India (10)**
 - Pakistan (2) [All other countries (1)]**

Division of India into 10 emission regions



Division of Pakistan into 2 emission regions



Division of Iran into 2 emission regions



Making inventory output compatible with the Integrated Assessment Model (IAM)

- ❖ **For *India, Pakistan and Iran*, if data are available at the provincial or state level, a separate inventory should be compiled for each emission region.**
- ❖ **Otherwise, national inventories will have to be compiled and the *area* emissions allocated to emission regions based on population density, economic activity statistics etc.**
- ❖ **(Allocation of *large point source* emissions will be straight forward as their locations will be known.)**

Training requirements

- ❖ **Over the next 3 years, a series of up to 4 emission inventory training workshops will be held in Asia.**
- ❖ **First training workshop will be in March 2006 with a follow-up workshop in October 2006 (dates to be confirmed).**
- ❖ **Subsequently workshops will probably be held in 2007 and 2008.**