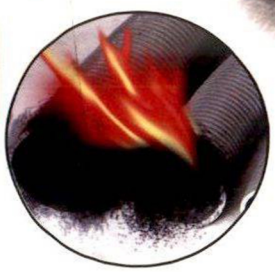
POLLUTION

Persistent Organic Pollutants (POPs) Project

Ministry of Environment
Sri Lanka

Preliminary Inventory of Dioxins and Furans







JUNE 2006

UNEP GEF

Preliminary Inventory of Dioxins and Furans

JUNE 2006

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POLLUTION 07

Persistent Organic
Pollutants (POPs) Project

MINISTRY OF ENVIRONMENT

Preliminary Inventory of Dioxins and Furans in Sri Lanka

MAR 2007

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Preliminary Inventory of Dioxins and Furans in Sri Lanka

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Preface

This preliminary inventory on Dioxins and Furans has been prepared for the purpose of developing a National Implementation Plan (NIP) for the Stockholm Convention on Persistent Organic Pollutants (POPs). Sri Lanka became a signatory on 5th September 2001 and ratified the Convention on 22nd December 2005.

The twelve (12) chemicals designated for action under the Convention consist of, eight (8) Pesticides (Aldrin, Chlordane, DDT, Dieldrin, Endrin, Heptachlor, Mirex and Toxaphene), two (2) Industrial Chemicals (PCB and Hexachlorobenzene, which is also a pesticide), and two (2) Unintentionally Produced Chemicals (Dioxins and Furans).

Dioxins and Furans are unintentionally formed and released from thermal processes involving organic matter and chlorine as a result of incomplete combustion or chemical reactions. The Convention requires taking preventive measures and introducing safe alternative products and technologies, with the goal of reducing and eliminating the formation of these unintentional byproducts.

A project for the formulation of the National Implementation Plan for POPs is executed by the Ministry of Environment, in collaboration with the relevant stakeholder institutions in the country. Financial and technical assistance for the project is provided by the Global Environmental Facility (GEF) through the United Nations Environment Programme (UNEP).

Prior to the formulation of the NIP, it is necessary to compile preliminary inventories that will help determine the scope of the POPs issue in Sri Lanka. Out of six (6) Task Teams set up to formulate the NIP, three (3) teams were assigned the tasks of compiling the three inventories on Pesticides, on Polychlorinated Biphenyls (PCBs), and on Dioxins and Furans. All the Task Team members were selected from relevant stakeholder institutions in order to build their capacity to ensure the effective implementation of the National Plan. The Task Teams were assisted by international consultants. The inventory was also subjected to a review by UNEP.

The methodology adopted and statistical interpretation of the data was made possible through technical assistance provided through UNEP. A toolkit developed by UNEP was used to estimate releases of Dioxins and Furans. The collection of data was possible due to the valuable information provided by various institutions and industries as well as from publications. The inventory was also subjected to a review by UNEP.

This preliminary inventory gives the general status of the issue of unintentionally produced Dioxins and Furans in Sri Lanka enabling the policy formulating and implementing agencies in decision making for the control of Dioxins and Furans in accordance with the requirements of the Stockholm Convention.

The Ministry of Environment wishes to extend its sincere thanks to the Task Team, the International Consultants, the Technical Advisory Panel, Central Environmental Authority, Industrial Technology Institute, Board of Investment and all other stakeholders who contributed to the production of this preliminary inventory. Financial and technical assistance provided by UNEP/GEF is very much appreciated.

L.P.Batuwitage
Project Director/POPs Project
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Acknowledgements

This preliminary inventory on Dioxins and Furans was compiled by a Task Team which comprised Mr.J.K.A.B.Wijegunasekera -Task Team Leader (Industrial Technology Institute), Mr. A.Rajaratnam (Central Environmental Authority), and Mrs. A. Beling (Board of Investment) who were assisted by Mr. Patrick H. Dyke, international consultant on Dioxins and Furans. Expert technical advice was also provided by Dr. A. M. Mubarak, Director, Industrial Technology Institute.

Subsequently it was reviewed by Dr. David Piper, Task Manager, POPs Enabling Activities of UNEP. Final editorial corrections were suggested by Prof. D.C.H.Senerath of the University of Moratuwa and we thank them for their contributions towards the production of this preliminary inventory. We wish to extend sincere thanks to the Task Team, the International Consultants, the Technical Advisory Panel, the National Coordinating Committee and all stakeholders who contributed to the production of this preliminary inventory. Valuable assistance and guidance was provided by former secretaries of the Ministry of Environment Mr. Thosapala Hewage, Mr. D. Dissanayake, Mr. P.M.Leelaratne and to the current secretary Mr. J.R.W.Dissanayake to whom we offer our grateful appreciation. Special thanks are due to Mr. W.R.M.S.Wickremasinghe, Additional Secretary, who has been assisting the project team from the inception in various ways and providing advice and guidance as well as reviewing project reports and publications.

Dr. Rupa Wickremaratne, former National Project Coordinator of the POPs project has done a lot of work during the beginning of the project assisted by Mr. Lal Induruwage and Mr. Champika Somatileka, former Project Assistants and Ms. Menaka Dilrukshi former office assistant. Our thanks are due to them. Our heartfelt thanks are due to Ms. Fatoumata Ouane former Task Manager of UNEP and Dr. David Piper, Task Manager who provided valuable guidance throughout the project and to Mr. Victor Ogbuneke, Financial Officer of UNEP.

The Project Director, Ms. L.P Batuwitage has been a source of inspiration for the project staff and has been keenly involved in the administration of the project and provided valuable advice on project implementation and reporting of progress and in preparation and review of reports. Mr. Desmond de Silva, Financial Assistant has been a valuable asset and has been very helpful in attending to financial matters promptly and with diligence. Ms. Dilani Sooriyarachchi, Project Assistant who has been assisting in administrative matters has been a cheerful and hardworking staff member who helped to translate a few of our awareness materials as well. Mr. Lalith Perera, Information Technology Assistant has, apart from attending to all IT related matters helped in many other ways to keep the office functioning smoothly. We wish to extend our sincere thanks to all of them.

The Global Environmental Facility (GEF) provided the financial assistance for this project while United Nations Environment Programme (UNEP) provided technical advice and guidance. The contributions of these organizations are gratefully acknowledged.

Finally, we wish to record our appreciation of numerous other ministries, departments, institutions and individuals who have assisted us in various ways in ensuring that the project activities could be successfully completed.

S.A.M.Azmy
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Abbreviations and Acronyms

2,4,5-T	2,4,5-Trichlorophenoxyacetic acid
[1]	For the purpose of the Toolkit, there is no difference if concentrations or emission factors are reported in I-TEQ or N-TEQ
°C	Degrees Celsius
a	Year (annum), 365 days
ADt	Air-dried ton (of pulp)
APC(S)	Air pollution control (system)
BAT	Best available techniques/technologies
BOI	Board of Investment of Sri Lanka
C	Chlorination bleaching stage using molecular chlorine dispersed dissolved in water (pulp and paper production)
CEA	Central Environmental Authority
CEB	Ceylon Electricity Board
CMC	Colombo Municipal Council
CNP	2,4,6-Trichlorophenyl-4'-nitrophenyl ether
CTC	Ceylon Tobacco Company
CTMP	Chemo-thermo-mechanical pulp
D	Chlorine dioxide bleaching stage using a water solution of chlorine dioxide (ClO_2) (pulp and paper production)
d.m.	Dry matter
DL	Detection limit
E	Extraction bleaching stage using sodium hydroxide (NaOH)
ECF	Elemental chlorine free (bleaching)
ECVM	European Council of Vinyl Manufacturers
EDC	1,2-Dichloroethane
EPA	Environmental Protection Agency
EPL	Environmental Protection Licence
EPZZ	Export processing Zones
ESP	Electrostatic precipitator
EU	European Union (15 Member States: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, United Kingdom)
FTA	Free Trade Agreement
GEF	Global Environment Facility
GSMB	Geological Survey and Mines Bureau
h	Hour(s)
HCB.	Hexa chloro benzene
HCE	Hexa chloro ethylene
HEPZ	Horana Export Processing Zone
HW	Hazardous waste
IDB	Industrial Development Board
IPHTR&DC	Institute of Post Harvest Technology Research and Development Centre
ISO	International Standardization Organization
I-TEF	International Toxicity Equivalency Factor
I-TEQ	International Toxic Equivalent
K	(Degree) Kelvin
kPa	Kilo Pascal (= one thousand Pascal)
L	Liter

LOI	Loss on ignition (a measure for residual carbon content)
LP	Liquefied petroleum
ME&F	Ministry of Environment and Forestry
ME.	Ministry of Environment
MEPZ	Meerigama Export Processing Zone
Mg	Magnesium
MSW	Municipal solid waste
NA	Not applicable (not a relevant release vector)
Na2S	Sodium sulfide
NaOH	Sodium hydroxide
NCASI	National Council (of the Paper Industry) for Air and Steam Improvement, Inc.
NCS	National Conservation Strategy
ND	Not determined/no data (in other words: so far, no measurements)
NEA	National Environmental Act.
NERDC	National Engineering Research and Development Centre
NIP	National Implementation Programme
Nm^3	Normalized (standard) cubic meter; the volume a gas occupies at atmospheric pressure (1,013 mbar) and 273.15 K (0 °C)
NTEQ	Toxic equivalent using the Nordic scheme (commonly used in the Scandinavian countries)[1]
NWPEA	North Western Province Environmental Authority
O	Oxygen bleaching stage (pulp and paper production)
PAH	Poly aromatic hydrocarbon
PARCOM	Paris-Oslo Commission
PCB	Polychlorinated biphenyls
PCDD	Polychlorinated dibenzo-*para*-dioxins
PCDF	Polychlorinated dibenzofurans
PCP	Pentachlorophenol
PCP-Na	Sodium pentachlorophenate
POP	Persistent organic Pollutant
POPs	Persistent organic pollutants
PTS	Persistent toxic substances
PVC	Polyvinylchloride
RDA	Road Development Authority
RDF	Refuse derived fuel
RSS	Ribbed smoked sheet
t	Ton (metric)
TCF	Totally chlorine free (bleaching)
TEF	Toxicity Equivalency Factor
TEQ	Toxic Equivalent
UN	United Nations
UNEP	United Nations Environment Programme
UV	Ultra-violet
VCM	Vinyl chloride monomer
WHO	World Health Organization

UNITS

gal	1 Gallon	= 0.1337 ft^3	= 0.0038 m^3
in	1 inch	= 2.54 cm	= 0.0254 m
lb	1 pound	= 0.4536 kg	
	1 US short ton	= 0.90718 (metric) tons	
kt	kilo ton	= 1000 t	
t	ton	= 10^6 g (1,000 kg)	= 1 Mg Megagrams (a million grams)
kg	kilogram	= 10^3 g	
g	gram	= 10^0 g	
mg	milligram	= 10^{-3} g	
µg	microgram	= 10^{-6} g	
ng	nanogram	= 10^{-9} g	
pg	picogram	= 10^{-12} g	
kJ	Kilojoule		
MJ	Megajoule		
GJ	Gigajoule		
TJ	Terajoule		
Pa	Pascal		
KPa	kilopascal		

EXECUTIVE SUMMARY

An inventory of release of polychlorinated dibenzodioxins (PCDD) and polychlorinated dibenzofurans (PCDF) has been assembled for Sri Lanka. The process of developing an inventory has been successful and it was possible to make estimates for all main source categories which are suitable to identify the major sources of releases of PCDD/F in Sri Lanka. A summary of releases is presented in the table.

The Toolkit provided a valuable guide to facilitate the development of the inventory. Local emissions data was almost entirely absent and generating more appropriate emissions factors based on local conditions, processes and materials would significantly strengthen elements of the inventory.

In general good statistical information is available on those industries that are regulated by the Central Environment Authority and operated under the Board of Investment systems. Information on other processes was harder to gather in some cases.

The main sources of releases of PCDD/F in Sri Lanka were identified as:

- *The uncontrolled combustion of wastes, primarily in dumps and in the open;*
- *The processing of metals, in particular scrap copper where a significant amount of PCDD/F is likely to be associated with the residues from gas cleaning systems;*
- *The incineration of medical wastes which is largely carried out under very poorly controlled conditions;*
- *Burning of biomass in homes for cooking, industry and for disposal of agricultural residues.*

Estimates of releases to air and residues were far greater than for releases to water, land or in products. This reflects both the nature of the main sources (thermal processes giving air emissions and residues from gas cleaning and combustion) and a lack of data to estimate releases to other media.

The process of assembling the inventory has allowed a valuable and extensive database of knowledge on a wide range of processes and activities to be assembled. This knowledge should be reviewed, stored and used as a basis for updating the inventory with any necessary additions, changes and corrections. It will also be of considerable use in assessing other pollutant sources to the environment in Sri Lanka.

The inventory and supporting information forms a sound basis to be used to develop country priorities (related to the inventory), suitable action plans and options to meet the obligations of the Stockholm Convention.

Actions related to the inventory of sources are likely to include:

- *Work to improve release estimates – for example to refine estimates of releases from uncontrolled combustion of wastes;*
- *Work to fill identified gaps – for example releases from the incineration of textile wastes;*
- *Longer term projects to improve estimates based on new and improved data - for example to generate appropriate emissions factors for key processes in Sri Lanka, such as emissions from local waste and biomass under conditions found here;*
- *The development and assessment of a series of options to reduce and control releases and to reduce the likelihood of human exposure to releases (for example by ensuring proper management of residue streams).*

In addition inventories of other unintentionally produced POPs will be developed and strengthened in the future. At this stage only initial and partial estimates have been made for releases of HCB and PCB as detailed below. Hence, this a preliminary inventory. It should be noted that the Toolkit was specific for Dioxins and Furans, while unintended releases of HCB and PCBs have not been determined as the available technology for their estimation is limited and the releases of HCB and PCB in Sri Lanka as unintentionally produced POPs were considered to be insignificant.

	Category	**Releases, grams International Toxicity Equivalent (g I-TEQ) per year**				
		Air	*Water*	*Land*	*Products*	*Residues*
1	*Waste Incineration*	*20.3*	*0.055*	*NA**	*NA*	*0.133*
2	*Ferrous and non-ferrous metal production and processing*	*5.52*	*ND**	*NA*	*NA*	*49.8*
3	*Power generation, heat and cooking*	*19.3*	*ND*	*ND*	*NA*	*0.096*
4	*Mineral products*	*1.37*	*NA*	*ND*	*ND*	*0.002*
5	*Transport*	*0.54*	*NA*	*NA*	*NA*	*ND*
6	*Uncontrolled combustion*	*121*	*ND*	*ND*	*NA*	*29.4*
7	*Chemical and consumer products production and use*	*ND*	*ND*	*ND*	*0.446*	*ND*
8	*Miscellaneous*	*3.46*	*ND*	*ND*	*ND*	*0.074*
9	*Disposal/landfill*	*ND*	*0.024*	*ND*	*6.00*	*0.022*
10	*"Hot spots"*	*Site of chlorine production. Residues from chlorine bleaching of pulp*				
	Total	***171***	***0.079***	***ND***	***6.45***	***79.5***

**ND- Not Determined or No Data*

**NA- Not Applicable*

Chapter
1

1. INTRODUCTION

Sri Lanka became a signatory to the Stockholm Convention on Persistent Organic Pollutants in September 2001 and ratified the convention on December 22, 2005 and hence is a party to the Stockholm Convention. To meet her obligations under the Convention, Sri Lanka has to prepare a National Implementation Plan (NIP) that will outline the situation relating to POPs in Sri Lanka and develop a plan to meet the requirements of the Convention.

The NIP development project is being managed by the Ministry of Environment, the executing agency is the United Nations Environment Programme (UNEP) and is funded by the GEF.

The project is in five phases:

1. Establishment of Coordinating Mechanism and Process Organisation;
2. Establishment of POPs Inventories and Assessment of National Infrastructure and Capacity;
3. Priority Assessment and Objective Setting;
4. Formulation of National Implementation Plan; and
5. Endorsement and Submission of NIP.

As part of phase 2 inventories of unintentionally produced POPs were established. This report presents the results of this exercise. . It should be noted that the Toolkit used for estimation of Dioxins and Furans was specific for Dioxins and Furans, while unintended releases of HCB and PCBs have not been determined as the available technology for their estimation is limited and the releases of HCB and PCB in Sri Lanka as unintentionally produced POPs were considered to be insignificant.

1.1 Country Profile

Sri Lanka is an island located in the Indian Ocean. It is 60,000 km^2 in extent. The country is divided into nine administrative provinces. These provinces are further sub-divided into 25 administrative districts as shown in Figure 1. As per the Central Bank report, population in Sri Lanka in year 2002 was 19,007,007. The capital of the country is Sri Jayawardenapura located within the Colombo district of the Western province.

As per the development pattern, urbanized areas are mainly confined to the Western, North Western, Southern and Central parts of the island as a result of rapid development in these regions. This situation has resulted in migration of population into these parts resulting into high population densities. Hence, the development pattern in Sri Lanka correlates well with her population distribution pattern. The population distribution pattern is shown in Table 1.1. This in turn will correlate well with the vehicle distribution pattern in the country.

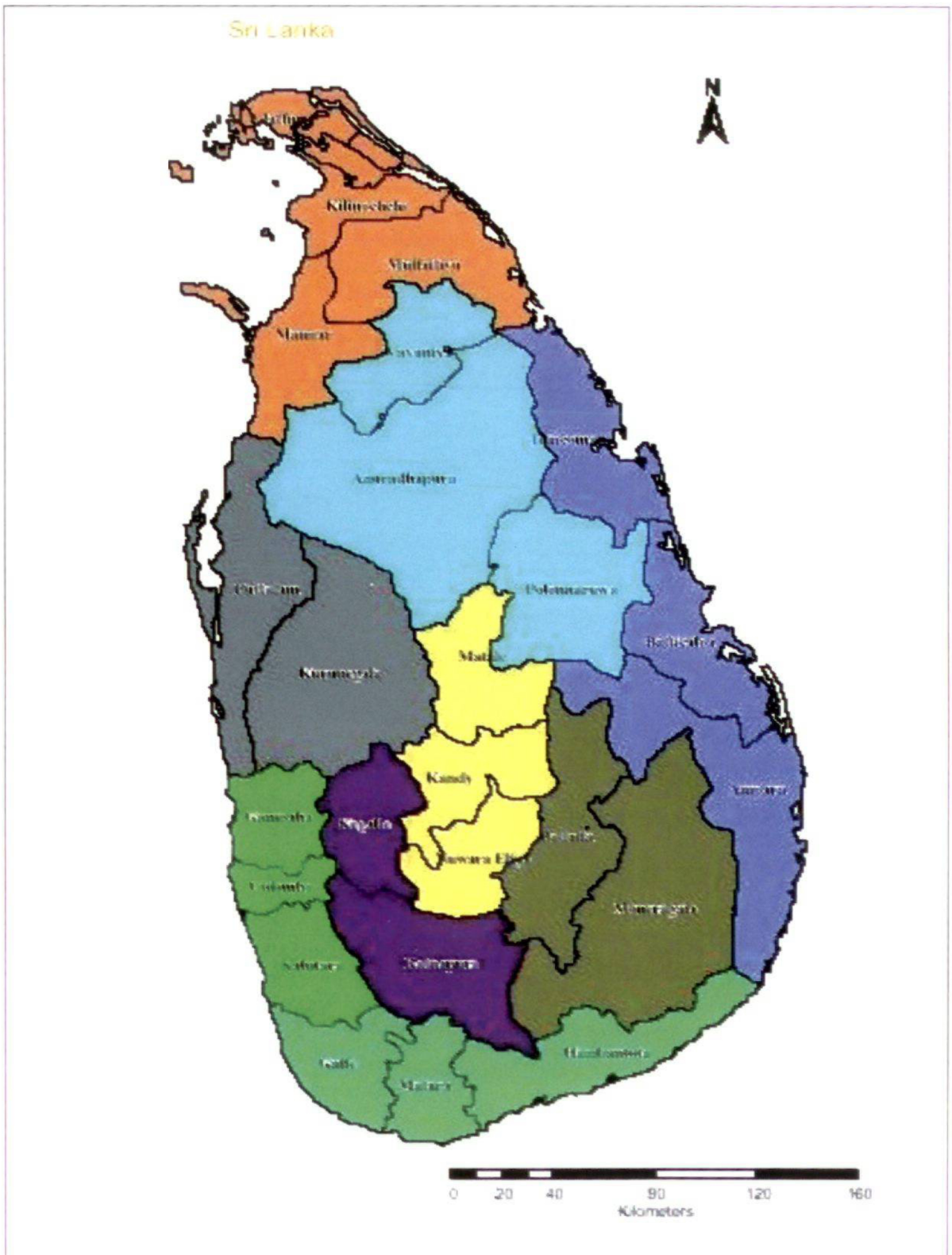


Figure 1 : Administrative districts of Sri Lanka

Table 1.1 : Distribution of Population in Sri Lanka

Population By District		
		'000 Persons
District	**Year 2001**	**Year 2002**
Colombo	2234	2266
Gampaha	2066	2077
Kalutara	1061	1069
Galle	991	1000
Matara	761	770
Hambantota	525	529
Badulla	775	787
Moneragala	396	401
Kandy	1273	1288
Matale	442	448
Nuwara Eliya	700	707
Kegalle	780	784
Ratnapura	1008	1020
Kurunegala	1452	1461
Puttalam	705	713
Anuradhapura	747	754
Polonnnaruwa	359	363
Ampara	589	596
Batticaloa	486	522
Trincomalee	340	358
Jaffna	491	532
Kilinochchi	127	154
Mannar	152	98
Mulaitivu	122	164
Vavuniya	150	146
Total	**18,732**	**19,007**

Source: Dept of Census and Statistics, Mid Year Estimates.

Out of the developed areas, Colombo District located in the Western Province shows the highest development and hence with the highest population density. The majority of industries are also located within the Western Province and in the North Western Province which is the adjoining Province. As a result, transport activities are highest within these areas.

With regard to the present laws in Sri Lanka for controlling POPs, legislation is in place only with respect of eight pesticides. All these are banned in Sri Lanka under the Control of Pesticides Act of 1980. Presently, there is no legislation in Sri Lanka for the controlling of the remaining four POPs.

out of these four POPs, two are considered as industrial chemicals (polpolychlorinated biphenyls (PCB) and hexachlorobenzene (HCB)) and the other two are considered as unintended by-products (dioxins and furans).

Out of the above four POPs, PCB is directly addressed in the list A (A3180) of the Basel Convention for which Sri Lanka is a signatory. Although there is no legislation in the country at present with respect to the controlling of list A wastes, policy decision has been taken by the Government to prohibit importation of material identified in list A. Further, presently Sri Lanka is in the process of drafting hazardous waste Regulations and under these Regulations PCB containing material (waste) will be

considered as a hazardous type of waste which requires special handling/transport/disposal practices. There is no legislation (present/proposed) for the direct control of HCB.

Dioxins and furans are considered as unintended by-products. In Sri Lanka there are several activities that could lead to these by-products especially in case of open air burning. At present there is no comprehensive mechanism for controlling of such activities though open burning within industries can be controlled by the National Environment Act. The releases of Dioxins and Furans can be controlled by temperature controls during incineration.

However, with regard to imports, a control mechanism is in place under the Basel Convention. Under this Convention, processing of some wastes in list B can lead to the emissions of dioxins and furans. Hence, if there is any project proposal involving such waste processing activities, the proposal is closely scrutinised by a National Committee formulated for the implementation of the requirements of the Convention. This Committee studies the project proposal in detail and if there is no risk of dioxins and furans emissions from the project activity, approval for the project is granted subject to the implementation of relevant precautionary measures.

Dioxins and furans can exert their toxicity at very low levels (Micro gram levels). Hence detection of dioxins and furans at such very low levels is essential and this requires use of highly sophisticated equipment/techniques. Sri Lanka does not have such sophisticated equipment.

In Sri Lanka, testing for dioxins and furans have not been carried out so far except for the recent sampling programme initiated by Holcim Lanka (pvt) Ltd. (only clinker Manufacturer in Sri Lanka) at Puttlam in February 2004. The samples collected were sent to Singapore for dioxins and furans analysis and the results are awaited.

1.2 Methodology

The task team used the Standardised Toolkit for Estimating Releases of Dioxins and Furans developed by UNEP as a guide for establishing the inventory. However, the Toolkit currently addresses releases of dioxins and furans but does not address releases of hexachlorobenzene (HCB) or polychlorinated biphenyls, where these are released as a result of unintentional production.

The Ministry of Environment engaged Mr. Patrick Dyke to assist the task team with the development of the inventory as well as with other tasks related to the NIP project. Mr Dyke worked with the task team and visited a number of sites of potential sources of unintentionally produced POPs while in Sri Lanka.

1.2.1 Study Background

Dioxins and Furans as well as other unintentionally produced POPs are not well known in Sri Lanka and this project represents the first assessment of potential releases in the country.

Two members of the team had taken part in a UNEP training course in Kuala Lumpur, Malaysia in August 2003 which served as a valuable introduction to the pollutants and the application of the Toolkit for dioxins and furans.

Grateful acknowledgement is made of the help and assistance from numerous individuals and organisations in the assembly of this inventory without whom it would not have been so comprehensive.

1.2.2 Research Undertaken

A combination of methods was applied to find the necessary data and information to compile the inventory. The basic approach and outline was based on the guidelines provided in the Standardised Toolkit for Identification and Quantification of Dioxin and Furan Releases (UNEP, draft 2001 and 2003).

The task team together the other task team members undertook visits to identified sites and processes and interviewed process operators as well as accessing statistics and official reports. Where precise information in the form needed was not available estimates were made using expert judgement.

No information on emissions from processes carried out in Sri Lanka is available[1]. Consequently the work relied on default emission factors. The team recognised that there may be significant differences between processes which are carried out in Sri Lanka and those processes for which emissions data are available and from which emissions factors have been developed so that some emission factors may not be representative of these emission sources.

Main data sources included databases of both the CEA and the BOI.

In the toolkit many industrial activities have been identified as unintended POPs producing sources. The Central Environmental Authority (CEA) is the main enforcement authority empowered for ensuring that the Industrialists carry out their operations as per the environmental regulations. These regulations are executed by way of a Licensing scheme where Industrialists are required to obtain an Environmental Protection Licence (EPL) from the CEA. As per the NEA, CEA is empowered with enacting the EPL Regulations throughout the country except for projects located within the purview of the North-Western province of the country. This province has formulated their own EPL scheme similar to the CEA scheme and it is being enforced by the North Western Provincial Environmental Authority (NWPEA).

The activities requiring EPL are prescribed in the Regulations of the NEA. There are 80 high polluting industrial activities prescribed in "Part A" and 45 low polluting industrial activities are in "Part B" of schedule of the National Environmental Regulation CEA issues the EPL for the activities in the "Part A". Basic information on such industries is available in the form of a simple data base. Even though there are about 1500 registered industries at the CEA data base, only around 100 industries which are more relevant to this study were considered. Power is delegated by the CEA to the relevant Local Authorities to issue the EPL to the activities in "Part B".

The Board of Investment of Sri Lanka (BOI) is the main statutory body in Sri Lanka for foreign investment promotion and facilitation. Hence, many industrial projects with foreign investment were established in Sri Lanka under the BOI authority. The environmental matters pertaining to these projects are handled by the BOI itself as this organisation has a separate Environmental Management Unit comprising staff with the necessary expertise on environmental issues. Further, the organisation has its own Laboratory capable of testing all parameters stipulated in the EPL Regulations. Therefore, the CEA has delegated their EPL process implementing powers to the BOI in case of BOI projects and issuing of EPL for these projects is carried out by the BOI with the concurrence of the CEA..

Hence, the main data source is the EPL databases at the CEA, BOI and the NWPEA.. Basic information on industries for which the EPL is issued is available in individual files maintained for each industry and also in the form of a simple data base

Information relevant to the Governmental and Private Institutions were colleted by visits, through letters and by phone calls.

1.3 Notes and Limitations

The report follows closely the structure laid out in the Toolkit and while the Toolkit proved to be a very valuable guide, experience has shown that some processes and activities found in Sri Lanka, and believed to be relevant, were either not well described or not easy to place into a category. The team appreciated the importance of describing the processes found and attempted to account for possible releases. This limitation relates to the fact that most data and descriptions used in the Toolkit primarily relate to processes found in developed countries and do not, in some instances, reflect processes carried out in less developed countries.

[1] Note that plans are underway to sample the flue gases from the cement works in January 2004

Detailed statistical data is not available for many of the processes considered, nor are accurate records kept in the form that is required for compiling an inventory. The lack of comprehensive records adds uncertainty to some of the estimates.

Chapter
2

2. Estimating Annual Releases of Dioxins and Furans from the Main Source Categories

The sections which follow describe the findings of the inventory project. The order follows that laid out in the Toolkit.

In order to provide as complete a picture as possible all the sections and categories outlined in the Toolkit are covered even if the practice or process was not identified in Sri Lanka. In this way it is clear to a reader what the status of each processes is believed to be and this will assist future planning and also periodic updating of the inventory.

2.1 Waste Incineration

Incineration is not well developed or widely practiced in Sri Lanka.

2.1.1 Municipal Solid Waste Incineration

No technical facilities for the incineration of municipal (or similar wastes) exist in Sri Lanka.

It is known that a number of industries in the textile sector incinerate textiles and other wastes arising in the process. The combustion facilities vary from basic technological incinerators to brick-built chambers or open burning. No information was available to estimate the total amount of material that was burned and no estimate of releases can be made at this time.

Wastes that are burned in the open or at dump sites are covered in Section 2.6

2.1.2 Hazardous Waste Incineration

No dedicated hazardous waste incinerators exist in Sri Lanka.

It is estimated that about 40,000 t and 54,300 t of hazardous wastes was generated in 1997 and 2002 respectively in Sri Lanka. Work is underway in Sri Lanka to assess the generation and disposal of hazardous wastes in a project linked to the implementation of the Basel Convention Oil sludge arising from the separation of water from heavy fuel. Oil is burned in a purpose built incinerator at Sapugaskanda power station. The inclusion of the sludge in this section does not imply that it is necessarily hazardous but is merely to enable an estimate of possible releases to be made. The quantity of sludge generated is reported to be 500 barrels per month of which most is recycled, a total 6 barrels per day are incinerated. Total sludge combusted was reported as 1400 m^3 in 2002 (assumed equivalent to 1400 t) An emission factor of 350 µg I-TEQ/t is selected since the material is likely to be contaminated with salt water but there is no directly comparable data. No estimate is made for residues since there is no gas cleaning system.

2.1.3 Medical Waste Incineration

Medical wastes are produced at hospitals, clinics and other health-care facilities throughout Sri Lanka.

Advanced technological incinerators are not used at the present time for waste disposal. In general waste may be burned on-site in a range of conditions such as pits in the open, enclosed walled areas and rudimentary incinerators. At other facilities no disposal is carried out and wastes may be added to the general waste collection and dumped at local dumpsites.

A total production of 6600 t has been estimated (ERM 1994). For the purposes of making an initial estimate of releases (as upper bound) we assume all of this material is burned in low-technology incinerators or burn pits. Emission factors for plants with no air pollution controls are applied to estimate releases (type 2 factors, the factors for type 1 are judged too high to be realistic).

The Apollo hospital in Colombo is privately owned and operated and has a more modern incinerator consisting of a two chamber unit fitted with a wet scrubber. Temperatures are controlled and the plant operated on a shift basis and cooled and de-ashed between shifts. The wet scrubber system releases a liquid effluent direct to sewer with no apparent treatment which will result in a potentially significant release of PCDD/F to water. For the purposes of making an initial estimate of releases we apply the emission factors for a controlled batch type incinerator but in recognition of the fact that no solid residue is collected from the wet scrubber (but instead all flushed to sewer) we proportion the residue factors to reflect this. Throughput data are reported to be 61 t for 2002 (the plant commissioned on May 1st, 2002).

The future waste throughput can be expected to be approximately doubled.

2.1.4 Light-fraction Shredder Waste Incineration

There are no shredder plants and no incineration of shredder residues in Sri Lanka.

Scrap vehicles tend to be exported.

2.1.5 Sewage Sludge Incineration

There are no dedicated sewage sludge incinerators in Sri Lanka

Water treatment is described in Section 2.9.

2.1.6 Waste Wood and Waste Biomass Incineration

There are a few installations in Sri Lanka specifically for the incineration of waste wood. All Timber Depots registered with the Forest Department should have incinerators for waste wood, saw dust, shavings etc. Wood is used to fire various industrial boilers and other biomass fuels are used for industrial heat and steam generation. These are covered in Section 2.3.

2.1.7 Animal Carcass Burning

There is no widespread practice of burning animal carcasses but from time to time large animals might be burned, such as cattle. No estimate of releases can be made but it is not thought to be significant.

2.1.8 Estimated Releases – Category 1, Waste incineration

Table 2.1 : Estimated releases from waste incineration

		Activity statistic	Emission factor			Estimated annual release, g I-TEQ		
			Air	Water	Residues	Air	Water	Residue
Industrial waste incineration	Cloth off-cuts and similar wastes	No data						
	Oil sludge	1400 t	350 µg I-TEQ/t	ND	ND	0.49	ND	ND
Medical	In technological	61.0 t	525 µg I-	900 µg	20 µg I-	0.032	0.055	0.001

		Activity statistic	Emission factor			Estimated annual release, g I-TEQ		
			Air	Water	Residues	Air	Water	Residue
waste incineration	incinerator		TEQ/t	I-TEQ/t	TEQ/t			
	In open pits or crude incinerators	6600 t	3000 µg I-TEQ/t	NA	20 µg I-TEQ/t	19.8	NA	0.132
Total						**20.3**	**0.055**	**0.133**

Notes: Medical waste incinerator discharges untreated effluent to sewer
Oil sludge incinerator classified as hazardous for purposes of making estimates only.

2.2 Ferrous and Non Ferrous Metal Production

There are no metal ore processing operations in Sri Lanka. Hence, all metal processing industries in Sri Lanka are secondary smelting, processing and recovery industries. Until the Indo- Sri Lanka Free Trade Agreement (FTA) came into being only a few large-scale industries were involved in the metal processing activities. After the FTA and Tax Holidays provided by the BOI, several Indian investors established smelting facilities in Sri Lanka particularly in the Export Processing Zones (EPZZ) with the concurrence of the National Committee formed for the implementation of the requirements of the Basel Convention as stated in Section 1.1.

Sri Lanka is one of the signatory countries to the Basel Convention on the Trans-boundary Movement of Hazardous Waste. All scrap metals such as Brass, Copper, Aluminium and Zinc imported to the country should get prior approval from the "Technical Woking Committee" for the Basel Convention on the Trans-boundary Movement of Hazardous Waste. Wastes defined in the "Schedule A" of the Convention are not permitted for importation into the country. Wastes define in the "Schedule B" of the Convention are permitted to import after the consideration of the constituents in the wastes.

With regard to importation of metal scrap, the committee ensures that only scrap with at least 95% metal content is imported to Sri Lanka. To ensure conformity to this requirement, the importers are required to forward a certificate from a recognised laboratory regarding the purity levels of scrap. Only if the laboratory certificate reveals conformity to the above purity requirement, unloading of consignment from the container is allowed.

Metal scrap importation is carried out by medium and large scale industries. Fairly, good pollution control systems are in place in these industrial sectors. In such industries diesel is used and no waste oil is used. Therefore, the possibility of PCDD/PCDF emission into the environment is reduced. The residue (slag and gas cleaning residues) generated from the melting operations should be re-exported to the country of origin as agreed at the time of approval. Therefore, the PCDD/PCDF contamination via residue should not be a major issue. However, before reaching a final judgment it is advisable to carry out testing for dioxins and furans in different environmental compartments of at least a few large scale metal processing industries. As indicated in the Toolkit, PCDD/F are expected to be present at much higher levels in the residues from gas cleaning operations compared to slag from the furnace. Therefore special measures may be required and it may be better to keep the two streams separate. Elevated levels of PCDD/F are often associated with flue gas cleaning residues because the compounds are often formed downstream of furnaces in cooling zones and tend to associate with fine particulate material. Decisions about appropriate waste management, handling and occupational exposure should be made taking account of all relevant properties and the presence of other pollutants.

2.2.1 Iron Ore Sintering

There is no iron ore sintering in Sri Lanka.

2.2.2 Coke Production

Coke is not produced from coal in Sri Lanka. Some coke is imported from India for metal production.

An estimated 29 kt (522 TJ) of charcoal is produced from coconut shells (Initial National Communication under the UN Framework Convention on Climate Change, Ministry of Forestry and Environment, 2000). A large part of the production is converted into activated carbon and exported. Many examples of coconut shell burning can be found in certain areas of Sri Lanka particularly the North Western Provincial Council area. These process coconut shells in open pits by controlled partial burning. The operators maintain the desired partial combustion by adding water as needed. The process leads to high amounts of smoke and steam release. Potential for production of PCDD/F is not known and to date there is no data on the potential releases. Worker exposure to smoke, particulate and polycyclic aromatic hydrocarbons (PAH) is likely to be high.

For the purposes of making an initial estimate we take the emission factors provided for coke production in the Toolkit. Note that this may well underestimate releases from this potentially highly polluting process.

2.2.3 Iron and Steel Production

2.2.3.1 Steel production

With regard to steel production, raw materials are mainly imported pellets (billets), scrap and locally collected scrap. The first large scale metal related Government owned industry established in Sri Lanka, "Ceylon Steel Corporation" was in 1967 at Oruwela, Athurugiriya. This manufactures steel, steel products and carries out lead soldering. It was privatised in 1997 and renamed as "Ceylon Heavy Industries and Constructions Co Ltd.". At present the total casting capacity is 550 t per year.

There are 10 steel plants in Sri Lanka. Out of these, eight plants are located in the Gampaha district and the finished products are marketed locally. Based on the information provided in the EPL applications the maximum output of these 10 industries is 50,172 tons per year.

Very little information is available on pollution control systems at theses plants. Comprehensive controls are not fitted and most plants have simple dust control.

For the purposes of estimating releases, the steel production was divided into plants using electric arc furnaces (classified depending on their pollution controls) and those using other furnace types for steel melting. For these the emission factors for foundries were applied.

2.2.3.2 Iron Foundries

Foundry or the cast iron industries are becoming a non profitable business due to the imports of such goods from India at cheaper prices. Relatively clean locally available scrap is the raw material for this industry. Crucible furnaces are mainly used in the foundries. Used oil is utilised as fuel for furnaces and generally there are no pollution controls incorporated into the furnaces. The clean scrap tends to lower the emissions. The lack of pollution controls is a concern and the use of waste oil may increase the release of pollutants.

A survey on foundries in Sri Lanka conducted by the Engineering Division of the Industrial Development Board reported that there are 22 cast iron foundries. In Sri Lanka, 20 out of 22 surveyed are located in the Colombo district. According to a GSMB report 115 and 98 tonnes of foundry products were manufactured in the years 2001 and 2002 respectively. Increases in the cost of the manufacture and importation of cast products from various countries have lead to a decrease in the demand for the local products and the closing of several local foundries.

Under BOI, there is one iron scrap processing plant and it is located in the Puttlam district. Locally collected scrap is smelted in an induction furnace. This induction furnace is equipped with bag filters to arrest emission of particulate matter into the environment. The collected particulate matter is mixed with cement and stored within the site until a suitable site is found for disposal.

To estimate releases the production was split according to the technology type.

2.2.4 Copper Production

Until the inception of the FTA, copper products were imported from other countries. The used copper products are reused as scrap material for new products.

After FTA and Tax Holidays provided by the BOI, several Indian investors established copper melting facilities in Sri Lanka particularly, in the EPZZ. Seven such industries are located in the HEPZ and two are located in the MEPZ. Three are located out side the EPZZ. All these industries are manufacturing copper ingots by smelting of imported copper scrap for the export market especially to India.

In accordance with the requirements under the Basel Convention, a certificate must accompany each consignment of copper scrap imported on purity levels of the scrap. If the purity testing reveals more than 95% copper the consignment is released for processing. This practice has enabled to prevent contaminated scrap entering into the country.

Gas cleaning systems are installed on all the copper melting plants located within the BOI EPZZ. These gas-cleaning systems consist of canopy-type extraction hoods, a venturi scrubber, demister chamber, blower and a chimney. No afterburners are included in the gas cleaning system. The Assessment Reports on the gas cleaning systems from the ITI has indicated that the gas cleaning system operated at theses industries are in a satisfactory condition.

Ambient air quality checks are being carried out and if breaches are found, measures are taken to correct them.

Following public complaints, all these industries are using diesel oil for the furnaces rather than heavy fuel oils to reduce pollution.

As per the agreement among the Industrialist, the CEA and the BOI all residues generated from the operation of these melting plants should be re-exported to the country of origin. However, this re-exportation procedure requires close monitoring by the Authorities by way of mass balance calculation method as the quantity of imports are known. This will also avoid any residue accumulating in the country. For the purposes of estimating releases, the residues are included even though the ultimate fate should be export.

76,658 tons of copper ingots were produced per year by the above 12 industries and exported to India.

Releases of PCDD/F may be high from copper processing since copper is a very effective catalyst. The Toolkit has a range of emission factors and for the purposes of estimating releases the plants were classified as well controlled secondary copper plants. Given the absence of afterburners and the fact that controls were not optimised for control of PCDD/F it is hard to say if releases are overestimated or underestimated. Further work is required to assess releases, environmental impacts, cost and benefit of control options and any changes that may be required.

2.2.5 Aluminium Production

Aluminium melting takes place at an industrial scale and also as a cottage industry. Until the FTA, only the cottage type industries were operating. These industries are scattered over the country. In some areas several industries are located in a particular place. Malabe, Kelaniya and Biyagama are the areas where several aluminium melting industries are located within a defined area. There are 18 aluminium utensils manufacturing industries in Malabe. These use waste oil-fired crucible furnaces with

no pollution controls, to melt collected scrap. The absence of pollution controls, the variety of sources of scrap and the use of waste oil all give rise to concern about polluting emissions including PCDD/F.

A survey conducted by the Engineering Division of the IDB, reveals that there are 65 cottage type aluminium melting industries in the Colombo District. All these industries are using used oil to fire crucible furnaces and no pollution controls are available for these industries. The manufacturing capacity varies from 50 to 100 kg per day. Therefore, 75 kg of capacity was considered for the purpose of calculating the potential PCDD/F releases. Total estimated production is 1755 t per year. Releases are essentially uncontrolled and the highest emission factors are applied (these may underestimate emissions from these small-scale processes).

There are two industrial aluminium melting plants. A licensed aluminium melting plant is in operation at the HEPZ (production started in 2003). This plant processes scrap imported from Dubai into aluminium ingots (2400 t/annum) for export. Scrap is sorted by hand prior to processing. The rotary furnace is fitted with a wet scrubbing system using caustic soda. Effluent from the scrubber is released to the environment after settlement. Sludge is periodically collected and is stored awaiting export for further processing. The sludge is likely to contain dioxins and furans removed from the flue gases.

Another aluminium melting plant is located in the Gampha District. This plant manufactures extruder products in which the scrap metal is melted and the melted aluminium is subjected to extrusions under high pressure. No information is available on the pollution controls in place.

Metal refining is carried out using tablets which may be hexachloroethane (HCE) which has been associated with elevated levels of PCDD/F in aluminium processing.

Only imported aluminium ingots and clean aluminium were used for industrial scale processing.

To estimate releases we applied emission factors for aluminium production with scrap pre-treatment and pollution controls.

Note that from 2003 additional production commenced as described above which will increase estimated releases.

2.2.6 Lead Production

Two industries are licensed for vehicle battery manufacture. One industry has been licensed for lead recovery from lead battery scraps.

A lead acid manufacturing industry located at Ratmalana produces 200,000 batteries per year. The manufacturing process mainly consists of manufacturing of lead battery plates. This industry melts about 5 t of lead per day and produces 1000 batteries per day

Lead plates from used batteries are melted in two melting pots. (One ton capacity each) at 800- 900 ^{0}C for 2 ½ hrs. Emissions arising during the melting operations are first passed through a cooling chamber, then bag filters and finally sent out via 50m stack. Condensed powder particles collected in cooling chamber and filter bags are recycled back into the melting pot.

New lead frames are cast from the molten lead. Heat energy for this operation is derived from LP gas and any emissions arising from this operation is directed through the roof.

One lead battery processing industry is located at Mirigama export processing zone. This industry produces lead ingots by smelting lead separated from batteries. Therefore, the basic raw material – lead scrap is obtained from used battery plates or shells in the local market. These batteries are opened up manually in a separate yard within the factory premises and the plates (lead grids) are taken out. These plates mainly contained lead and lead oxide accumulated on its structure. The factory has two blast furnaces, one rotary furnace and a melting pot. The two blast furnaces in the factory can melt 1.5 t/shift. Battery plates are charged into the blast furnace manually at every ½ hour and the product (molten lead) is discharged continuously from the bottom of the furnace. During the process 20 – 27%

of charcoal per unit weight of finished lead is added as the fuel and as a reducing agent and the temperature of the furnace is maintained at 750 – 800 ^{0}C. Molten lead is allowed to flow into an underground pit and is poured into moulds to produce 25 kg lead ingots thereafter. Usually 50% of pure lead and 50% sinter are produced.

The flue gases of the blast furnaces are directed into an air pollution controlling system that consists of eight cooling chambers in series, bag filter and induced draft fan. The exhaust gases are then emitted to the atmosphere through 94 ft high stack.

A rotary furnace operates batch wise at a capacity of 2000- 2500 kg/batch using the sinter, which is a by-product of the blast furnaces. This furnace is fired by diesel oil and it is heated up to 900-950 ^{0}C. In addition to the sinter, soda ash (2%), iron scrap turnings (1.5% wt) and charcoal (8-10 % wt max. normally 5% wt) are also charged into the rotary furnace. The slag formed in the furnace is removed by adding iron and soda ash to the rotary furnace. Generally de-slagging is carried out after 3-4 batches. During the de-slagging the furnace temperature is raised further up to about 1000 ^{0}C.

The flue gases of the rotary furnace are directed into an air pollution control system consisting of two dust collector chambers, two cyclones and two bag filters and two scrubbers. Flue gases coming out from the cyclone separator enter into the two bag houses, which are connected in parallel. The outlet air stream of the bag houses is directed into wet scrubbers. The outlet gases from scrubbers are directed to the chimney via an underground duct line.

A further battery processing plant is located in the North Western Province with an estimated capacity of 20,000 t per year. For the purpose of estimating releases it is assumed that the same factors such as types of scrap, mode of melting and design of APC can be applied.

Emission factors relevant for lead production where PVC is removed and air pollution controls are presently applied to estimate releases.

2.2.7 Zinc Production

Zinc is mainly used for metal finishing industry in Sri Lanka. Galvanising and electro plating are the two industrial activities that use zinc as raw materials. Zinc is not used for domestic purposes and only a few cottage industries exist in Sri Lanka. No estimate is made for these processes.

Large scale Zn melting industries came after the FTA, with Indian companies which invested in zinc melting activity.

According to the Basel Convention on Trans- boundary Movements of Hazardous waste, under B1100 the following metal-bearing wastes arising from melting, smelting and refining of metals are permitted to import into the country.

- Hard zinc spelter,
- Zinc-containing drosses:
  - Galvanizing slab zinc top dross (>90% Zn)
  - Galvanizing slab zinc bottom dross (>92% Zn)
  - Zinc die casting dross (>85% Zn)
  - Hot dip galvanizers slab zinc dross (batch)(>92% Zn)
  - Zinc skimmings

Therefore, raw materials are believed to be comparatively clean.

There are two licensed zinc melting industries located in the BOI-managed HEPZ with a total output of 6005.8 t per annum. The furnaces are operated with diesel oil.

Both industries are equipped with gas cleaning systems. The gas cleaning systems consist of canopy type extraction hoods, a venturi scrubber, demister chamber, blower and the chimney. No afterburners are included in the gas cleaning systems. Either water or caustic soda is used in the scrubber . The wastewater is treated by sedimentation prior to release.

Slag and sludge generated from the furnaces are stored for export.

To estimate releases the factors given for class 2 are applied. Further study would be required to completely assess possible releases from this activity.

2.2.8 Brass /Bronze Production

Brass/ Bronzes casting is a well established cottage industry in Sri Lanka. A large number of brass industries are located in the Kandy district.

There is one licensed large scale brass manufacturing plant in Sri Lanka located at Horana (HEPZ). This plant is fitted with a wet scrubber (similar to the other non-ferrous metal plants). An electrical furnace is used. For this unit emissions at the low end of the data provided are assumed.

A survey on foundries in Sri Lanka conducted by the Engineering Division of the Industrial Development Board reported that there are 137 cottage scale brass and bronze foundries in Sri Lanka. The distribution of the brass and bronze melting industries are given in the Figure 2.1.

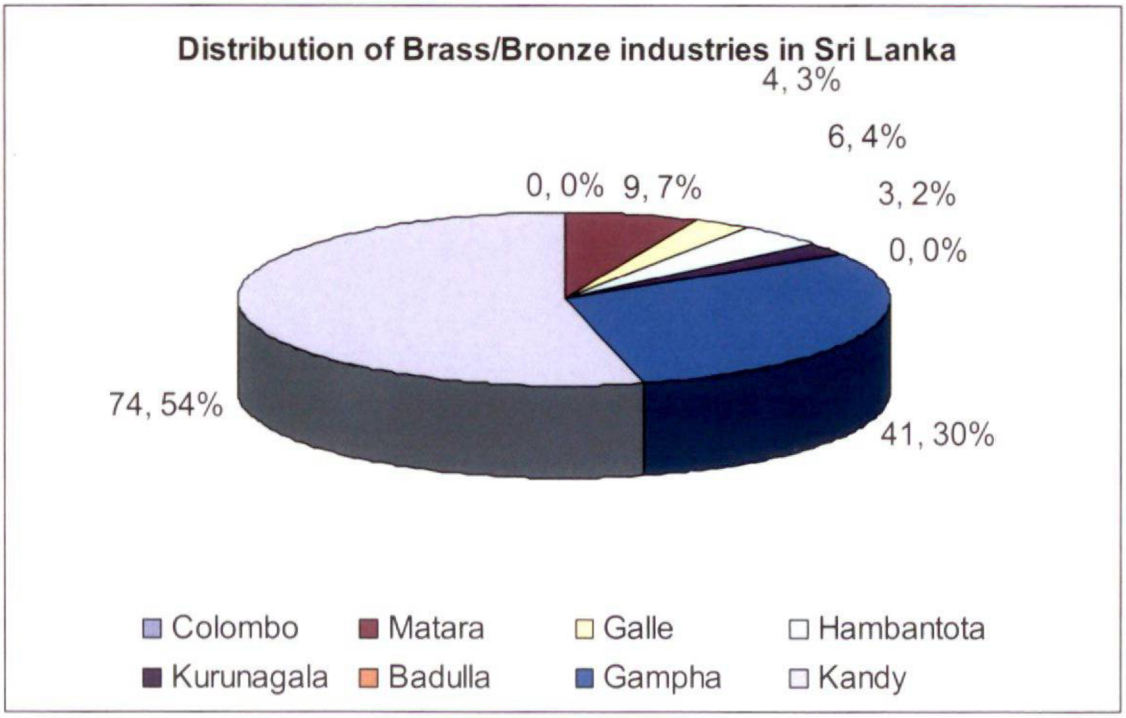


Figure 2.1Distribution of brass and bronze industries in Sri Lanka

Scrap brass / bronze is melted in a furnace constructed out of earth and the molten brass / bronze is poured into the moulds to get the desired products. No gas cleaning systems are available in this type of industry. The emissions arising from the furnaces are sent through either specially constructed chimney stacks or through chimney stacks constructed by using steel barrels. The production capacity of these industries varies from 50 to 100 kg /day. The average value of 75 kg has been taken to estimate the emission of PCDD/PCDF and it is also assumed that the melting operations are carried out for 6 days in a week. Based on the above assumptions it was estimated that 865.8 tons of brass / bronze are processed in a year.

About 50% of the industries uses diesel for the furnace and other 50% uses used oils.

To estimate emissions a higher factor than is given in the Toolkit is applied (the furnaces have no controls compared to the tested one) as noted in the table.

2.2.9 Magnesium Production

No production or melting of magnesium has been identified.

2.2.10 Other Non-ferrous Metal Production

No other significant metal production was identified.

2.2.11 Shredders

There are no shredding plants for vehicles or white goods in Sri Lanka. End-of-life vehicles and scrap white goods are generally cut into small pieces manually by using welding and exported to India, Singapore and other countries for recycling purposes.

2.2.12 Thermal Wire Reclamation

No thermal wire reclamation was identified although it may well occur to some degree.

2.2.13 Estimated Releases – Category 2, Metal production and processing

Table 2.2: Estimated releases from metal production and processing

Sub categories		Activity statistic	Emission factor		Estimated annual release, g I-TEQ	
			Air	Residues	Air	Residue
Charcoal production		29,000 t	3 µg I-TEQ/t	ND	0.087	ND
Steel production	EAF	17050 t	10 µg I-TEQ/t	15 µg I-TEQ/t	0.171	0.256
	Foundry type melting processes, few controls	8680 t	10 µg I-TEQ/t	ND	0.087	ND
Iron foundries	Small-scale	98 t	10 µg I-TEQ/t	ND	0.000098	ND
	Large scale (induction furnace)	24,000 t	0.03 µg I-TEQ/t	0.5µg TEQ/t	0.0007	0.012
Copper production		76,658 t	50 µg I-TEQ/t	630 µg I-TEQ/t	3.8329	48.3
Aluminium production	Industrial	1200 t	35 µg I-TEQ/t	400 µg I-TEQ/t	0.042	0.48

Sub categories		Activity statistic	Emission factor		Estimated annual release, g I-TEQ	
			Air	Residues	Air	Residue
	Cottage scale	1755 t	150 µg I-TEQ/t	400 µg I-TEQ/t	0.263	0.702
Zinc production		6005.8 t	100 µg I-TEQ/t	ND	0.601	ND
Lead production		44,000 t	8 µg I-TEQ/t	ND	0.352	ND
Brass/Bronze production	Industrial	402 t	0.1 µg I-TEQ/t	ND	0.00004	ND
	Cottage scale	866 t	100 µg I-TEQ/t	ND	0.087	ND
Total					5.52	49.8

2.3 Power Generation and Heating

The power sector is dependent on hydroelectric power with thermal power plants making up shortfalls in recent years due to reduced rainfall. Biomass use is high (c 50% of primary energy) mainly used in homes but also in industry.

2.3.1 Fossil fuelled power generation and industrial boiler plants

There are no fossil fuel/waste co-fired or coal fired power boilers in Sri Lanka.

Thermal power plants include gas turbines, steam cycles, combined cycle and reciprocating engine plants. Fuels used are reported to be diesel and heavy fuel oil (or furnace oil).

The Kelanitissa Power Station at Wellampitiya owned by the Ceylon Electricity Board is the largest thermal power plant in Sri Lanka with the Capacity of 285 MW for the year 2001. There are two steam turbines fired by the furnace oil with installed capacity 25 MW each and six gas turbine each with a capacity of 20 MW and one 115 MW Gas turbine fired by diesel operated at the site.

Two separate combined cycle power projects, namely Kelanitissa Combine Cycle Power Plant of 165 MW and Kelanitissa AES Combine Cycle Power Project of 165 MW are being carried out at the close proximity to the Kelanitissa Power Station under two different administrations.

Sapugaskanda Power Station owned by the CEB is generating 160 MW electricity using 12 Diesel / Heavy oil power plants. There are four engines of 20 MW and eight engines with 10 MW installed capacity. Twelve 60 m height generator stacks and one incinerator stack are arranged in a bundle to discharge exhaust emission from generators and incinerator. Operation of this the power plant was commenced in 1984 with four diesel fired engines each with an install capacity of 20 MW and then it was extended with four diesel fired engines in 1998 with install capacity of 10 each In addition, four more 10 MW diesel driven generators were installed in 1999.

Furnace oil used for the engines is purified before using for the plant. Oil Sludge with water is directed to an oil water separator plant where waste oil, water and sludge are separated and the sludge and waste oil separated are sent to an incinerator (see Section 2.1.2).

There are five heavy fuel (furnace oil) fired power plants (engines) with BOI status in Colombo and Gampaha and installed capacities of these are 80, 51, 24, 20 and 24 MW. The furnace oil is cleaned prior to burning and the resulting residue is sold to Suppliers that have been registered with the CEA.

There is also one diesel power plant with BOI status of 15 MW capacity. and it is located in the Jaffna District.

About 692 industries are using diesel and furnace oil for the purpose of generating their own electricity and for the generation of steam. Out of these, 340 (49%) industries are in the Colombo district and 172 (25%) are in the Gampaha district. The balance 26% is distributed in the other districts (NERDC).

For the purposes of estimating releases from the above category, the power generation processes using engines were assigned emission factors from the information on transport within the Toolkit (since these engines are closer to the situation found than thermal steam cycles for which data are provided in the power generation section). For the steam cycles, gas turbines and combined cycles the factors were based on those provided in the Toolkit for power generation.

Additional estimate is made for the potential releases from the combustion of oil in industry.

2.3.2 Biomass units

Energy supply in Sri Lanka is mainly based on three primary sources, hydroelectricity, biomass and petroleum. Biomass contributes around 50 % of the total energy consumed in the country. Biomass includes fuelwood (domestic), agro–waste as well as industrial wood combustion.

Fuelwood and other biomass such as coconut residues, paddy husk and saw dust are widely used for domestic cooking and account for three quarters of all biomass use. Small-scale/traditional manufacturing industries such as bakeries, tile, lime and brick making industries use mainly fuel wood. Rice husk is being increasingly used in rice mills and tobacco barns as a major energy sources.

There are four large scale industries using bio- mass for the boilers. Two sugar factories utilise an estimated 300,775 tonnes of bagasse for their boiler operations. No air pollution controls are in place to clean the flue gases.

Two BOI glove industries are equipped with large rubber-wood fired boilers. These two industries are located in the Gampaha and Colombo districts respectively and capacities of these two boilers are reported to be 4.5 million kilocalories (15MW approximately) and 2x2.5 million Kilo calories respectively. According to the industry, each factory will utilise 15,000 t of rubber-wood per annum at maximum production. These boilers incorporate gravitational settling and cyclone separators for controlling of particulate emissions.

The drying of tea is a major use of wood fuel with a consumption of approximately 326 000 t in this sector firing indirect air heaters. Releases from this practice are addressed in Section 2.8.1, biomass drying.

A significant quantity of wood is also used to manufacture bricks and tiles in traditional furnaces. The potential releases from this process are addressed in Section 2.4.

Another significant use of biomass is in the tobacco industry where curing is carried out using biomass, believed to be entirely risk husk. Potential releases from this process are considered in Section 2.8.1. on biomass drying.

2.3.2.1 Paddy Par – boiling

Rice processing is the most wide spread and the largest agro- based industry in Sri Lanka. The rice processing industry is capable of producing more than 2.5 million t. of rice each year, the actual crop depends on the weather conditions and pests etc.

It is estimated that out of 1700 commercial mills about 400 adopt the direct steam injection system for par–boiling and rest are still using in the traditional Govia Tank System where par–boiling is done with steam at almost atmospheric pressure. Paddy husk is a major by-product in the rice milling industry and at present approximately between half a million and a million tons of husk are produced annually.

According to the Central Bank Report that 2,859,000 t of paddy was harvested in 2002 and one ton of paddy gives 0.7 t of rice giving 2,001,300 t of rice. (Central Bank Report 2002), it is estimated that about 70% of the rice produced in Sri Lanka are par-boiled. Therefore, 1,400,910 t of par-boiled rice was produced in 2002. A study carried out by the IPHTR&DC reveals that about 90-150 kg of paddy husk is used for one metric tonne of paddy in a steam boiler system. Using these data we estimate that 126,081 to 210,136 t of paddy husk has been used for the par - boiling process. To make an estimate of releases we take a central estimate of 168,011 t which is treated as mixed biomass for the purpose of making an estimate.

2.3.2.2 Raw Rubber Manufacturing Industry

The main raw rubber products manufactured in Sri Lanka are Ribbed Smoked Sheet (RSS) Rubber, Crepe Rubber and Centrifuge Latex Rubber. The RSS is the predominant product of raw rubber manufactured in Sri Lanka. Biomass is the main source of energy used for drying of RSS and Crepe Rubber (NERDC).

2.3.2.3 Ribbed Smoked Sheet (RSS) Rubber

Most RSS rubber is produced by small holders. The production process is simple in comparison to other types of rubber production processes. Rubber is coagulated from the latex in a flat aluminium tray. The coagulum is then pressed into a sheet by a roll mill and the sheets are dried in the smoke house (CEA).

Smoke houses are typically tall buildings with a capacity of producing 30–70 kg of rubber sheets per day. Fire wood is burnt at a pit located at the bottom of the smoke house or in a crude furnace located by the side of the smoke house. Incomplete combustion takes place and the resulting heated combustion air with smoke is passed through the rubber sheets. It is estimated that 1 kg of fuel wood (dry basis) is used for drying of 1 kg of RSS rubber. It is estimated that about 55,200 t of fuel wood is consumed per annum. Out of this 7,360 t is rubber wood and the remaining 47,840 t is forest wood.

2.3.2.4 Crepe Rubber

Around 95% of the state owned factories produce crepe rubber. Rubber is coagulated from latex in tanks. The coagulum is then passed through a series of rollers until thin rubber sheets or laces are formed. These laces are dried in drying towers. The dry laces are cut into a regular shapes and folded and then spindled into bundles of 50 Kg (CEA).

It is estimated that about 0.32 kg of fuel wood (dry basis) is consumed for the drying of one kg of crepe rubber (NERDC).

For rubber drying/smoking we consider releases in this section rather than Section 2.8.3 (smoke houses) since the product is not a food stuff and there is therefore not a direct exposure route.

2.3.3 Landfill Gas/Biogas Combustion

There is no collection and combustion of landfill or dumpsite gas in Sri Lanka.

Anaerobic digestion of mainly piggery waste is carried out on a small scale and the resulting gases are typically vented. No significant emissions of PCDD/F are expected from this practice.

2.3.4 Household heating and cooking (biomass)

Forestry products and agricultural by-products are the main biomass resources used in the domestic sector for their energy purposes. There is no entirely reliable means to estimate the amount of wood and other biomass used in the domestic sector. The consumption of various fuels used in the residential sector is given in table 2.3.

Table 2.3: Fuel consumption by the residential sector

Fuel Type	Appliance	Consumption (kt) 1994
Kerosene	Cooker	56.49
	Lamp	156.34
LPG	Cooker	53.0
Charcoal	Iron	.0448
Fuel wood	Stoves	8256

Source: Ministry of Forestry and Environment,

Consumption of LPG, Charcoal and Fuel wood in the commercial sector in 1994 was 11kt, 0.82kt and 276kt respectively (MEF&F). These data are for information and the commercial use is addressed in Section 2.3.2.

The total quantity of fuel wood used in the domestic sector has also been estimated in the Sri Lanka Energy Balance (2001) at 7949 kt with an additional 352 kt used in bakeries, hotels and eating houses. In addition to fuel wood various other sources of biomass are used for cooking. For example in the Moratuwa district 3000 t of sawdust are reported to be used for cooking. No separate estimates are made for releases from this process. For the purposes of making the first estimate of releases of PCDD/F a value of 8200 kt is used (123,000 TJ using a calorific value of 15 MJ/kg). The combustion equipment and conditions will vary widely. The biomass is considered clean although there may be some contamination and co-firing on a small-scale with other wastes.

2.3.5 Household heating and cooking (fossil fuel)

Sri Lanka is a tropical country and there is no appreciable need for household heating. In a few houses in the upcountry, household heating takes place in the cold season by electricity or by burning firewood. Emissions of PCDD/PCDF due to fire wood burning were considered in the Section 2.3.4.

LPG (53 kt, 2438 TJ) and kerosene (212.83 kt, 9364 TJ) are used for cooking and lighting.

The use of LPG is increasing.

2.3.6 Estimated Releases – Category 3, Power generation, industrial heat generation and the use of biomass and fossil fuels

Table 2.3 : Estimated emissions from power and heat generation and household heating and cooking

		Activity statistic	Emission factor		Estimated annual release, g I-TEQ	
			Air	Residue	Air	Residue
Power generation	**Heavy oil steam cycle**	4340 TJ	2.5 µg I-TEQ/ TJ	ND	0.011	ND

		Activity statistic	Emission factor		Estimated annual release, g I-TEQ	
			Air	Residue	Air	Residue
	Heavy oil fired engines	466,000 t	4 µg I-TEQ/ t	ND	1.86	ND
	Light oil/diesel gas turbines/combined cycle	30700 TJ	0.5 µg I-TEQ/ TJ	ND	0.015	ND
	Light oil engines (including back-up generators)	170,000 t	0.1 µg I-TEQ/ t	ND	0.017	ND
	Heavy oil used for industrial heat generation	6960 TJ	2.5 µg I-TEQ/ TJ	ND	0.017	ND
Biomass fired boilers	**bagasse**	2410 TJ	500 µg I-TEQ/TJ	15µg I-TEQ/TJ*	1.20	0.036
	Wood fired boilers (glove industry)	450 TJ	500 µg I-TEQ/TJ	15µg I-TEQ/TJ	2.25	0.007
	Paddy par-boiling (rice husk)	2350 TJ	500 µg I-TEQ/TJ	15µg I-TEQ/TJ	1.175	0.035
	Rubber smoking	773 TJ	500 µg I-TEQ/TJ	15µg I-TEQ/TJ	0.387	0.012
Household cooking	**Wood**	123,000 TJ	100µg I-TEQ/TJ	20 µg I-TEQ/TJ	12.3	0.006
	Kerosene	2440 TJ	10 µg I-TEQ/TJ	NA	0.024	NA
	LPG	9360 TJ	1.5 µg I-TEQ/TJ	NA	0.014	NA
Total					**19.3**	**0.096**

Notes: an emission factor for residues from biomass combustion was included based on the factor for wood that is given Other release vectors are not applicable for engines, and there is no data for land releases from cooking.

2.4 Production of Mineral Products

Sri Lanka is reasonably well endowed with industrial minerals but has no significant metallic and energy minerals. The production of tiles is a major export industry and there are several large-scale facilities. Other processes are often carried out at smaller-scale and using more traditional methods.

2.4.1 Cement Production

There are two cement clinker plants in Sri Lanka. The Kankasanthurai cement clinker producing plant has not operated for some years due to the civil war in the North- East area. The other cement clinker producing plant at Puttlam is operated by Holcim Lanka (pvt) Ltd. Miocene limestone and clay are the principal raw materials utilized by the cement factory. The plant is of the dry type and is fired with coal and also with used tyres. It can also be fired by fuel oil when energy prices make this advantageous. Production capacity of the plant is 500,000 t per annum. An electrostatic precipitator (ESP) is used for air pollution control. A temperature of 200-300 ^{0}C is maintained in the ESP.

Holcim is actively developing the use of alternative fuels to reduce the consumption of coal in the production of cement. To date whole tyres have been successfully fed to the back end of the kiln. Rice husks are also used along with sawdust through the multifuel burner. About 600t of paddy husk from Anuradhapura and 400 t from the Kandy area were collected for this purpose. Plans are being developed to use other waste materials after testing and approval.

The plant operators report that they are required by the Holcim management to operate a recognised environmental management system if they are to burn alternative fuels. In addition continuous monitoring has been installed at the plant for emissions of particulate, acid gases and volatile organic compounds. In January 2004 stack tests for PCDD/F were carried out. The results are given below.

Table 2.4.1: Results of Cement Kiln Stack Test –January 2004

Compound Name	Quantity (ng)	TEF	Value (ngTEQ/Nm^3)	Standard * (ngTEQ/Nm^3)
2,3,7,8 – TCDF	0.3	0.1	0.0075	-
2,3,7,8 – TCDD	0.0068	1	0.0017	-
1,2,3,7,8 – PeCDF	0.11	0.05	0.0014	-
2,3,4,7,8 – PeCDF	0.12	0.5	0.0151	-
1,2,3,7,8 – PeCDD	0	0.5	0	-
1,2,3,4,7,8 – HxCDF	0.062	0.1	0.0016	-
1,2,3,6,7,8 – HxCDF	0.038	0.1	0.001	-
2,3,4,6,7,8 – HxCDF	0.02	0.1	0.0005	-
1,2,3,7,8,9 – HxCDF	0	0.1	0	-
1,2,3,4,7,8 – HxCDD	0	0.1	0	-
1,2,3,6,7,8 – HxCDD	0.0069	0.1	0.0002	-
1,2,3,7,8,9 – HxCDD	0	0.1	0	-
1,2,3,4,6,7,8 – HpCDF	0.03	0.01	0.0001	-
1,2,3,4,7,8,9 – HpCDF	0	0.01	0	-
1,2,3,4,6,7,8 – HpCDD	0.026	0.01	0.0001	-
OCDF	0	0	0	-
OCDD	0	0	0	-
Dioxins and Furans-TEQ	**0.72**	-	**0.0292**	-

- **Remarks :**

- The concentration of air emission is based on the reference condition at temperature of 25^{0}C, pressure of 760 mm.Hg and excess oxygen content of 10%

- TEF : Toxicity Equivalence Factors according to US. EPA. Standard

- TEQ : The value have calculated using the toxicity equivalence factors (TEF)
- WHO maximum exposure limit for long term safety of individuals is 10 ng/Nm3 TEQ

Lime Production

Lime is produced in Sri Lanka by traditional methods. Corals, sea shells and dolomite are the main raw materials. Biomasses such as forest wood and coconut logs are commonly used for burning of raw materials in cylindrical kilns. The biomass is arranged alternatively in between the raw material in the kiln. The maximum temperature within the kiln is around 700-850 ^{0}C. No pollution control systems are used and the heavy smoke is directly released into the environment.

Deposits of coral occur inland along the coastal plain as patches and lenses. The best known coral deposits are found in the Akurala – Hikkaduwa area, where they occur as much as six metres below an overburden layer with heavy blocks of massive coral. The mining of coral is banned within a distance of 300 metres inland from the high water mark of the coast and within a distance of 2 km offshore. Corals are mainly used for lime production.

Annual production of construction lime is given in the Table 2.5.

Table 2.5: Production of lime in Sri Lanka

Type of Lime	Year				
	1988	1999	2000	2001	2002
Coral (tons)	35,403	42,621	752,72	94,160	64,584
Dolomite (tons)	4,973	20,024	30,806	37,433	14,400
Total (t)					78,984

Source: Sri Lanka Mineral Year Book 2003, Geological Survey & Mines Bureau, Sri Lanka

A Study conducted by the Technical Service Division of the Industrial Development Board has reported that there are 12 large scale (3.5 – 4 t), 10 medium scale (2 t) and 21 small scale (<1 t) dolomite lime kilns in the Matale district. Further it also reported that 39 dolomite lime kilns are located in the Kandy district particularly in the Digana area.

Information collected from the Technical Service Division of the Industrial Development Board indicates that 1.8 tons of fire wood is needed to produce one ton of dolomite lime and 0.5 tons of fire wood is needed to produce one ton of coral lime.

Emissions are estimated by using the higher emission factor from the Toolkit but it is recognised that emissions may be higher due to the lack of controls on this process.

2.4.2 Brick production

Manufacture of bricks is a well established traditional industry in Sri Lanka. It is estimated that there are about 10,000 brick manufacturers in the country. Most of the brick manufacturers operate at a small scale with kiln capacities ranging from 24000 to 15000 bricks per kiln, per firing. About 60% of the brick kilns are concentrated in three districts i.e. Gampha (30%), Kurunagala 17% and Puttalam 12% where required raw materials (clay) is in abundance.

In the brick manufacturing process, fine clay is treated manually by men or using buffaloes. Wet bricks are moulded in wooden mould by hand. Green bricks with moisture content of about 20 – 30% are stacked to make a temporary kiln. Two to five tunnels depending on the size of the kiln are kept at the bottom for feeding of fuel wood. Flue gases pass through the gaps of the stacked bricks and escape into the atmosphere with no flue gas treatment.

Major types of biomass fuel used in the brick industry are forest wood (60%,) coconut trunk (24%), coconut husk (11%)and wood off-cuts (5%). A total of 31,739.58 t of biomass is reported to be used (476 TJ). Total brick production was not available and therefore estimates are made based on the fuel used using factors from the power//heat sector.

Large scale brick production is carried out in one facility with an annual production of 1200 t. For this plant releases are estimated on the basis of production using the emission factor applicable to plants with no gas cleaning.

2.4.3 Glass Production

Glass is produced in Sri Lanka using silica sand and using used glass (recycling). There are three licensed glass manufacturing industries in Sri Lanka. Hari Glassware Products (Pvt) Ltd started in 1992 and produces glassware like lamps chimneys, lamp bottoms, jars, and table ware; production capacity is about 2.5 tonnes per day. The glassware are manufactured by melting (recycled) broken glasses, sand and other raw materials in a furnace oil fired melting furnace at 1400 ^{0}C temp. The molten mixture is mouth – blown into glassware or with the help of a manually operated machine converted into glassware. No pollution controls are fitted.

Lanka Glass Manufacturing co. Ltd. Manufactures glass tumblers, tableware and glass blocks and items with a capacity of 60 tonnes per day. The furnaces are fired with kerosene (1050 kg/day), furnace oil (10440 kg/day) and LPG (3500 kg/day). No pollution controls are fitted.

Total annual production is estimated at 44062.5 t. The emission factor applied is for plants with no gas cleaning.

2.4.4 Ceramics Production

Ceramics are produced in Sri Lanka with a variety of technologies. These range from very basic traditional technology using temporary kilns fired with wood to state-of-the-art facilities making products mainly for export.

For example, the ceramic production facility at Horana uses fully automated process technology (Italian) to produce about 100,000 m^2 of tiles per month (2000 t/month). Raw materials are blended and then taken through two driers – the first a spray drier, the second for the formed tiles, a direct fired (kerosene) drier. Firing is done in a kerosene-fired kiln which operates at a peak temperature of approximately 1200 °C. Other state of the art facilities use LPG or electricity for firing.

In the traditional tile production it is estimated that there are up to 452 tile factories in the country. Out of 452 factories, 357 (79%) are located in the North Western Province.

The technology used in the tile industry was imported from South India about 100 years ago. Fine clay, sand and grit mixed in the right proportion in a pug mill and green tiles are moulded in a hydraulic or a hand press. Then the wet tiles are stacked in open racks for drying by natural ventilation. The green tiles are fired in two stages. In the first stage, the raw tiles are subjected to a low temperature for a period of two to four days. In the second stage, the tiles are subjected to a high ftemperature for a period of one to two days. Heating is stopped when the bottom layer is red hot. Then the tiles are subject to slow cooling. The tiles are then removed from the kiln, sorted and stored.

The specific consumption of fuel wood in the manufacturing was found 0.76 t of fuel wood per 1000 tiles and it is estimated that about 37,200 t (520.8 TJ) of fuel wood is consumed per annum for manufacture of tiles.

To estimate releases we consider the large-scale production on the basis of output and apply the lower emission factor since the kilns are largely state-of-the-art. For the traditional kilns fired by wood we

estimate releases based on the amount of wood burned and using factors for biomass combustion from the power and heat generation section.

2.4.5 Asphalt Mixing

Asphalt mixing is a significant industrial activity in Sri Lanka. Asphalt is mainly used for carpeting the roads. The Road Development Authority (RDA) is mainly responsible for the maintenance of National Highways, consisting of 11,650 km of A and B grade roads. According to the information collected from the RDA about 4.8 km bond facing and 6.839 km asphalt surfacing was done in 2002. The quantities of asphalt used for the bond facing and the asphalt surfacing are 31,718 tonnes and 23,155 tonnes respectively. These data relate only to a part of the road network. Data from the CEA on production capacity for asphalt indicates an annual output of 565,000 t and this figure is used for the inventory. There are fixed plants and many temporary plants also for which we have no information.

2.4.6 Estimated Releases – Category 4, Production of mineral products

Table 2.6: Estimated emissions from production of mineral products

		Activity statistic	Emission factor				Estimated annual release, g I-TEQ			
			Air	Land	Product	Residue	Air	Land	Product	Residue
Cement production		500000 t	**0.05** µg I-TEQ/t	**NA**	**ND**	**0.003**	**0.025**	**NA**	**ND**	**0.0015**
Lime Production		79000 t	10 µg I-TEQ/t	ND	ND	ND	0.790	ND	ND	ND
Brick Production	**Small-scale***	476 TJ (wood fuel consumed)	500 µg I-TEQ/TJ	NA	ND	ND	0.238	NA	ND	ND
	Large-scale	1200 t	0.2 µg I-TEQ/t	NA	ND	ND	0.0002	NA	ND	ND
Glass production		44100 t	0.2 µg I-TEQ/t	ND	ND	ND	0.009	ND	ND	ND
Ceramics production **	**Large scale**	86000 t	0.02 µg I-TEQ/t	NA	ND	ND	0.002	NA	ND	ND
	Traditional	521 TJ	500 µg I-TEQ/TJ	NA	ND	ND	0.261	NA	ND	ND
Asphalt mixing		565,000 t	0.07 µg I-TEQ/t	ND	ND	ND	0.040	ND	ND	ND
Total							1.37			0.002

Notes: the fuels used may mean that higher emissions would be found.

* Total brick production was not available and therefore estimates are made based on the fuel used using factors from the power/heat sector.

** To estimate releases large-scale production was considered on the basis of output and the lower emission factor was applied since the kilns are largely state-of-the-art. For the traditional kilns fired by wood we estimated releases based on the amount of wood burned and using factors for biomass combustion from the power and heat generation section.

2.5 Transportation

Sri Lanka banned the import and use of leaded gasoline in 2002.

Table 2.7 : Annual sales of petroleum products, (t)

Year	Jet/kerosene	Gasoline	Diesel	HFO
1998	235,909	204,351	1,225,608	575,966
1999	243,365	213,070	1,412,839	578,486
2000	229,101	224,379	1,730435	736,707
2001	227,804	249,510	1,674,847	810,550
2002	228,419	286,805	1,799,102	779,763

Source: Annual Report 2002, Central Bank of Sri Lanka

This section considers releases of PCDD/F from transport.

At present transport fuel consumption is rising rapidly and the sector is dominated by the use of diesel.

There are a significant number of motorcycles (576,000) and tricycles (120,000) of a total of 1.165 million vehicles used for local transport within the Sri Lanka vehicle fleet (Min of Environment 2004).

Observation indicates that maintenance may be limited and emissions of particulate from some diesel fuelled vehicles are high. Leaded gasoline was banned from June 1st 2002.There are no requirements for catalytic converters although some imported vehicles may have catalysts fitted.

Gasoline

Total consumption of petrol (gasoline) for transport was 249.5 kt in 2001 ((source Sri Lanka Energy Balance 2001, Energy Conservation Fund, Colombo, Table 2.21).

Prior to the banning of leaded gasoline in June 2002 the penetration of unleaded fuel in the vehicle fleet is not known but data for 2000 indicate that only 3.9 kt of a total 228 kt of gasoline was unleaded (source Motor Fuel Quality Improvements in Sri Lanka, Urban Air Quality Management Project, Ministry of Environment Sri Lanka, May 2003). For the purposes of making an initial estimate of emissions we assume that until June 1st 2002 all gasoline used was leaded and after that all was unleaded and proportion consumption based on five months before the ban and seven months after and.the steady consumption through the year was assumed.

Again to make an initial estimate it is assumed that the vehicle fleet does not have catalyst equipped vehicles and although there may be some with catalytic converters there is no requirement in place for this technology.

Leaded fuel consumed (assuming 2002 similar to 2001) is 104kt

Unleaded fuel consumed is 145.5kt

The number of motorcycles and three wheelers is large (c 700,000 compared to 160,000 other gasoline vehicles) and about 30% of the gasoline is estimated to be consumed in these vehicles (which are mainly 2 stroke) (industry source).

Diesel

Total consumption of diesel for Sri Lanka for use in road, rail and inland and coastal waterways was 1536.7 kt in 2001 (source Sri Lanka Energy Balance 2001, Energy Conservation Fund, Colombo, Table 2.21). The poorer performance with regard to particulate emissions compared to European and US engines that have provided the emission factors suggests that releases may be higher than those estimated.

Future trends

Consumption is increasing, in particular for diesel but no data are yet available for 2002.

Measures are under consideration to reduce emissions from the increasing vehicle fleet which may improve emissions of PCDD/F although we have no information on the changes proposed. Regulations were gazetted for controlling Carbon Monoxide and Hydrocarbon emissions in the year 2003. Adoption of these regulations will automatically reduce PCDD/F as well. From 2003 on there is no use of leaded fuel so that emissions from this sub-sector will not continue.

2.5.1 Estimated Releases – Category 5, Transportation

Table 2.8: Estimated emissions from Transportation

Subcategories	Classification	Activity statistic	Emission factor		Estimated annual release, g I-TEQ	
			Air	Residue	Air	Residue
4 stroke engines	Leaded gasoline	72.8 kt	2.2 µg I-TEQ/t	NA	0.16	-
	Unleaded gasoline	101.8 kt	0.1 µg I-TEQ/t	NA	0.01	-
2 stroke engines	Leaded fuel	31.3 kt	3.5 µg I-TEQ/t	NA	0.11	-
	Unleaded fuel	43.6 kt	2.5 µg I-TEQ/t	NA	0.11	-
Diesel engines		1536.7 kt	0.1 µg I-TEQ/t	ND	0.15	ND
Total					0.54	ND

.Notes: no estimate for aircraft or shipping using heavy oil (mainly consumed off-shore)

2.6 Uncontrolled Burning

2.6.1 Biomass burning

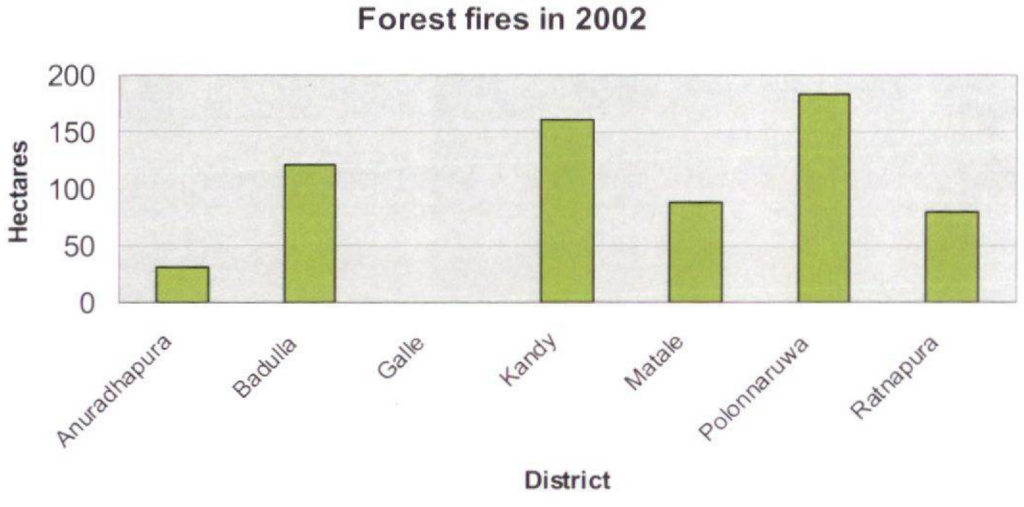
2.6.1.1 Forest fires/scrub fires

Forest fires in Sri Lanka are generally induced by man either due to negligence, deliberate action or vandalism. In 2002 about 641.65 hectares of forest plantations were destroyed (Forest Department). Forests were also destroyed for chena cultivation, preparing for grazing for domestic cattle, for

collecting of bee honey and for hunting of animals but these practices have largely been stopped (ME&NR -1).

The mass of vegetation exposed to burning was considered as 2.5 t/ha. These forest fires occurred in the forest plantations where the density was very low and only grasses can be seen on the ground. The figure shows magnitude of the areas exposed to forest fires on a district basis.

Figure 2.2: Forest Fires in 2002 in Sri Lanka



Source: Forest Department

There were also 50 hectares of natural forest and 950 ha of grassland burned in 2002 (Wildlife Department). Estimated masses of material burned in each were taken as 20 t/ha (forest) and 2.5 t/ha (grassland).

2.6.1.2 Chena Cultivation

Chena or shifting cultivation established itself easily in the Dry Zone where conditions favoured it and in many ways was a sensible system.

Widespread deforestation has reduced the extent of forest lands to a level where shifting cultivation can no longer be practiced. The peasant farmers are now forced to keep on cultivating the same plot of land. Soil erosion and impoverishment have reduced such cultivation to the state of the subsistence agriculture. The term chena cultivation is still applied to this system of rain fed farming though shifting cultivation is only rarely practiced now. (NCS). Consequently no estimate for releases from this practice is made.

Land is routinely cleared in the tea industry after a period to regenerate it. An estimated 1415 ha were reported cleared each year (The Sri Lanka Tea Industry, Agricultural Profile of the corporate sector, October 2002). For the purposes of making an estimate we assumed that the mass of materials burned is 2.5 t/ha giving a mass of 3537 t of material.

Other land may be cleared in the agricultural industry and material burned, but no information was available to make any estimates. The Agriculture Department does not encourage the burning of residues.

2.6.1.3 Agricultural residue burning

Rice husk and bagasse are the main agricultural residues that are thought to be burned. Substantial amounts of rice husk are used for par boiling of rice (see Section 2.3.2). The majority of the remaining rice husk is believed to be burned as a waste (371,989 t).

Paddy husk is major by-products of the paddy milling process, and at present 540,000 t of husk is produced annually (IPHTRDC). The usage and quantity of paddy husk is available. About 23,000 t of paddy husk is used for the tobacco curing activities (see Section 2.8.1) and 210,136 t of paddy husk has been used for the paddy par- boiling activities (Section 2.3.2). Remaining material is believed to be used in various industrial purposes and in poultry farm activities with the remainder being burned. To make an initial estimate we assume that 300,000 t would end up being burned in the open (observation of practices suggests that the usual practice is to dump and burn the residues, but action is illegal and there is little data).

Bagasse from sugar cane production carried out on a small scale may be burned as a waste. No data were available to estimate the amount that would be burned in this way and no estimate of emissions can be made.

2.6.2 Estimated Releases – Category 6, Uncontrolled combustion – biomass burning

Table 2.9: Estimated emissions from biomass burning

Subcategory	Classification	Activity statistic	Emission factor			Estimated annual release, g I-TEQ		
			Air	Water	Land	Air	Water	Land
Biomass burning	**Forest fires (natural)**	1000 t	5 µg I-TEQ/t	ND	4 µg I-TEQ/t	0.005	ND	0.004
	Plantation fires	1600 t	5 µg I-TEQ/t	ND	4 µg I-TEQ/t	0.008	ND	0.006
	Grassland fires	2380 t	5 µg I-TEQ/t	ND	4 µg I-TEQ/t	0.012	ND	0.010
	Land clearing (tea industry)	3540 t	5 µg I-TEQ/t	ND	4 µg I-TEQ/t	0.018	ND	0.014
	Burning agricultural residues (rice husk only)	300,000 t	30 µg I-TEQ/t	ND	10 µg I-TEQ/t	9.0	ND	3.0
Total						9.04	ND	3.03

Notes: value for agricultural residues rice husks set to the higher emission factor since tests on rice husks referenced in the Toolkit gave higher results.

2.6.2.1 Landfill fires

The collection of solid waste is the responsibility of the relevant Local Authority. In the principal urban areas a waste collection system is operated to collect general waste from households and businesses.

Waste collection is typically by tractor and trailers and in Colombo by waste trucks.

Presently, there are efforts to segregate recyclables from the waste and some composting schemes are also in operation or being developed.

Most collected waste is taken into designated dump sites which are often low-lying or wetland areas closer to the town/city. Generally the dumps are left open and not covered. In a few cases, covering with soil on a daily or on a periodic basis is carried out to reduce complaints from neighbours. Frequently, accidental fires occur in the dump sites due to methane accumulation from waste breakdown.

The total waste collected by municipal councils is 1567 t per day (see Section 2.9.1), Total waste collection (whole country) is 2838 t per day (Database of Municipal Solid Waste In Sri Lanka, Ministry of Environment and Natural Resources, 2005).

Colombo Municipal Council (CMC), the largest Local Authority in Sri Lanka, accounts for 680 t/d. CMC collects waste from households on a regular basis to be dumped at the disposal yard located at Madampitya near the Kelani river. Disposal at this dump site was started about 10 years back. Accidental fires occur frequently and last for considerable periods (weeks).

The estimated quantity of solid wastes dumped from 1994 is 1,752,000 t at an average of 700 t/d with the annual rate of increases of 2%. No information is available on the amount of material that burns. Since fires are frequent we made an initial estimate by assuming that 10% of the input waste would end up being burned (25,000 t). At this site composting has been developed and the amount of waste being added to the dump has decreased (since 2003).

For the remainder of the country dumpsites are generally poorly controlled and fires may also start accidentally or may be deliberately set to reduce waste volume and nuisance. There are believed to be differences in the prevalence of waste burning depending on whether the area of the country is dry or wet. To estimate releases we assume, that at least 10% is burned at the dump site, giving a total of 73,500 of waste that is burned in dumps.

Further study is required to fully characterize these practices.

2.6.2.2 Accidental fires in buildings

No data was available on the amount of material that was consumed in accidental fires and no estimate can be made at this time.

2.6.2.3 Uncontrolled domestic waste burning

Although there is a waste collection service (described above) in the main urban areas, there appears to be a significant fraction of waste that ends up being burnt by the side of the road or in other collection points. Sweepings from parks, streets and gardens are frequently burned. Approximate average data from the database on municipal waste suggests about third of all waste (arising outside CMC) is not collected (Database of Municipal Solid Waste In Sri Lanka, Ministry of Environment and Natural Resources, 2005). Of the estimated 1000 t per day not collected a fraction is burned. To make an initial estimate we assume 12% is burned (based on the easily combustible fraction) giving 120 t per day (44,000 t per year).

In rural areas waste burning may well be more prevalent.

2.6.2.4 Accidental fires in vehicles

No information was available to estimate releases from accidental fires in vehicles.

2.6.2.5 Open burning of wood wastes

No data was available on burning of waste wood to make an estimate of releases.

Saw dust arising in saw mills is often burned. Some saw dust is used in the cement kiln. In one district (Moratuwa) an estimated 11,086 t per year is burned in the open.

2.6.3 Estimated Releases – Category 6, Uncontrolled combustion - waste burning

Table 2.10: Estimated releases from uncontrolled waste burning and accidents

Classification	Activity statistic	Emission factor				Estimated annual release, g I-TEQ			
		Air	Water	Land	Residues	Air	Water	Land	Residue
Landfill fires	25,000 t CMC 73,500 t (rest of country)	*1000 µg I-TEQ/t	ND	NA	ND	98.5	ND	ND	ND
Accidental fires in buildings	No data	400 µg I-TEQ/t	ND	See residues	400 µg I-TEQ/t	ND	ND	See residues	ND
Uncontrolled burning of domestic and other wastes	44,000 t	**300 µg I-TEQ/t	ND	See residues	600 µg I-TEQ/t	13.2	ND	See residues	26.4
Accidental fires in vehicles	No data	94 µg I-TEQ per event	ND	ND	18 µg I-TEQ per event	ND	ND	ND	ND
Open burning of waste wood	No data					ND	ND	ND	ND
Total						**112**			**26.4**

Note:

* High levels of PCDD/PCDF have been associated with poor combustion conditions and mixed wastes such as hazardous wastes, hospital wastes industrial wastes etc.,.

** Low levels of emission factor have been considered in the toolkit as the domestic wastes are less contaminated with PCDD/PCDF releasing substances.

2.7 Production and Use of Chemicals

2.7.1 Pulp and Paper Production

There are two pulp and paper industries in Sri Lanka.

The Emplipitiya pulp and paper factory was started in 1974. The Government decided to set up this Industrial Project at Empbilipitiya with a view to locating industries in the rural areas using the abundant raw materials, mainly rice straw, for processing into value added paper products. 1056 t of writing & Printing Paper was produced in 2002. The details of raw materials and chemicals used in year 2002 are given in the table.

Historically, bleaching involved the use of chlorine but over recent years hydrogen peroxide has been used.

Table 2.11: Details of raw materials and chemicals used by Embilipitiya paper factory in year 2002

Type of Raw Material used	Quantity Used (t)	Type of Chemical Used	Quantity used (t)
Pulp Wood	303	Caustic	76.2
Waste Paper	760	Chlorine	-
Imported Pulp	310	Alum	82.1
		Resin	9.5
		China Clay	13.4
		Starch	20

The total quantity of wastewater discharged from the industry was about 12,000 m^3 /day. This wastewater is discharged to the nearby river after passing through two settling tanks and the aeration lagoon. Fifty tons of sludge collected in the settling tanks is dumped within the premises each year.

Walachchanai Paper Mills by the name of National Paper Co. Ltd was started in 1956. The manufacturing capacity of the plant is paper – 30 t/day and paper boards – 40 t/day. Solid waste generated from industrial activities is around 4600 kg/day which is land filled. Two furnaces burn three thousand gallons of furnace oil daily. Sludges are not burned. Emissions from the fossil fuelled boilers are addressed in Section 2.3.1. Hydrogen peroxide is believed to be used for bleaching.

Table 2.12: Details of raw materials and chemicals used in Walaichchanai paper factory in year 2002

Type of Raw Material used	Quantity Used (t)	Type of Chemical Used	Quantity used (t)
Waste Paper	4450	Alum	278.4
Imported Pulp	220	Resin	64.1
		China Clay	3.6
		Starch	1.4

The total quantity of wastewater discharged from the factory was 11,000 m^3/day and 750 t of sludge was produced in year 2002.

Both mills use chlorine free bleaching and are believed to import only non-chlorine bleached pulp. They both process a significant amount of recycled paper.

No data is available on releases of PCDD/F from such processes to water or in residues and therefore no estimate is made. The Toolkit gives a concentration of 10 µg I-TEQ/t in the product (recycled paper). This may well not reflect modern waste papers but is used for making an initial estimate.

In the past, when chlorine was used, the sludge generated and the effluents would have contained PCDD/F and dumps of sludge may have led to contamination of the area where they were dumped and it seems also likely that ponds containing black liquor were allowed to leaked to the sea.

2.7.2 Chemical production and use

There is no significant chemical production in Sri Lanka.

There are chemical formulation facilities which prepare pesticide formulations for agricultural use.

A wide variety of chemical products are imported. There are regulations that govern the import of pesticides but not for other industrial chemicals.

The use of pentachlorophenol (PCP) and related salts, 2,4,5T and 2,4D is prohibited. No information was found relating to the use of chlorophenols or other potentially contaminated compounds identified in the Toolkit.

PCDF releases will occur from the PCB transformers that are known to be present in Sri Lanka. A comprehensive inventory of PCB equipment is currently being compiled

Releases from the leakage of PCB equipment will contribute PCDF to the environment and are likely to be a major source of PCB in the environment.

There is one petroleum refinery in Sri Lanka. Releases have been associated with the regeneration of catalysts in refinery operations. There is insufficient information to make any estimate of releases.

2.7.3 Textile processing

The garment manufacturing industry is a major employer and a foreign currency earner in Sri Lanka. The manufacture of garments is not considered as a source of PCDD/F. However, the management of solid wastes from this sector can potentially lead to some releases in instances where the wastes are burnt either in purpose-built incinerators or at conditions closer to open burning (see Section 2.1).

Textile dyeing and finishing is also carried out in Sri Lanka.

Pollution control for textile processing is managed by the CEA, the BOI or the North Western Provincial Environmental Authority. Approximately 20 plants are controlled by the CEA and 40 by BOI. The same environmental standards are basically applied to all plants. All modern plants would have waste water treatment systems and be subject to release limits. A few older plants would still be operating with no treatment plants. However, over the coming years common treatment plants are due to be completed for these.

The water treatment would typically consist of coagulation and flocculation with biological treatment if necessary. In Colombo the effluent would discharge to the sewer systems and in other areas the effluent would be released to water courses. In the BOI zones the plants have a pre-treatment only and the effluent is released to a central biological treatment plant.

Sludge from the treatment systems is dewatered and land filled or spread on waste land (not agricultural).

Pentachlorophenol and related products are not used for textile treatment in Sri Lanka but there is a possibility that imported cloth may have been treated prior to import. In addition there is the possibility that some dyes may contribute PCDD/F to the textiles. There are no test data that relate to current Sri Lankan production and there is no basis on which to make estimates of releases to the environment.

Dyes are imported from several countries and it was not possible to identify dyes that might be contaminated with PCDD/F.

The absence of PCP suggests that levels of PCDD/F will be low but at present there is insufficient information on this sector to be sure that no PCDD/F is introduced into the process or formed during operations. Therefore further study is required.

The total production of textiles within the processing industry was 13523.9 t in 2002 (CEA database). Textiles are also produced in BOI approved industries, out of which most of the production is exported. A significant quantity of textile is imported, processed and re-exported. Ready made cloth is also imported to Sri Lanka for local uses. It is possible that the imported material might contain chemicals such as PCP, but at present we have no information.

2.7.4 Leather processing

The processing of leather is an important industry in Sri Lanka. Ten licensed tanneries are located in the Colombo and Gampaha Districts. The production capacity of these tanneries varies between 300 to 2000 tons of raw hides per year. (CEA-3). Both chromium and vegetable tanning processes are used in Sri Lankan tanneries. It is estimated that more than 80% of the leather produced, is manufactured by chromium tanning process. The total output of the was 17,863.8 t in 2002.

A typical tannery obtains salted hides and convert these into leather by the following steps; Soaking in water, adding lime, fleshing, trimming, splitting, deliming, bating, pickling, chromium tanning, sammying/ cutting/ sorting, shaving, neutralizing, retanning, dyeing, fat liquoring, drying, trimming, staking, buffing, impregnation, hot plating, rebuffing and undusting, colouring, drying, hot plating and measuring and grading. In the tanning process, several steps involve chemical processes and some involve physical processes. The chemical used in the industry are internationally accepted chemicals such as lime, ammonia, Wattle Bark (Acacia), chrome (BASF), sodium flakes (BASF/DIAR) and sulphuric acid (BASF/DIAR). There is no evidence on the usage of PCP in the tanning processes in Sri Lanka. The hides are dried using natural processes. Pentachlorophenol is not used.

The adverse environmental impacts related to the tanneries in Sri Lanka are; river water pollution, improper disposal of solid wastes and emissions with unpleasant odours (during hides storage and production activities).

Considering the above environmental issues the Government of Sri Lanka has decided to relocate all the tanneries at Batta Atta industrial estate in Hambanthota district located in the southern part of Sri Lanka. This industrial estate provides a modern waste water treatment system with a chromium recovery plant.

Since no PCP is used it seems that any PCDD/F present in effluents, wastes and products would arise from dyes or other sources of contamination or in finished processes. There is no obvious reason to expect high levels of contamination but additional review and study may be required.

2.7.5 Estimated Releases – Category 7, Production and Use of Chemicals

Table 2.13: Estimated releases from chemical production and use

Category	Activity statistic	Emission factor					Estimated annual release, g I-TEQ				
		Air	Water	Land	Product	Residues	Air	Water	Land	Product	Residue
Pulp and paper production	26,600 t	NA	ND	NA	10 µg I-TEQ/t	ND	NA	ND	ND	0.266	ND
Petroleum refineries	No data	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Textile processing	13524 t	NA	ND	NA	0.1 µg I-TEQ/t	ND	NA	ND	NA	0.001	ND
Leather processing	17,864 t	NA	ND	NA	10 µg I-TEQ/t	ND	NA	ND	NA	0.179	ND
Total										**0.446**	

Note: Textiles processing figures are from CEA registered plants only.

2.8 Miscellaneous Sources

2.8.1 Thermal drying of biomass

Most of the biomass which is dried uses solar heat only. There are drying processes in the tea processing industry as well as the tobacco industry.

2.8.1.1 Tea Industry

Tea processing is the main consumer of fuel wood in the industrial sector. It is estimated that about 326,000 t (4564 TJ) of fuel wood (dry basis) is consumed annually in this sector. Biomass is used to generate hot air for drying tea. The design of the present dryers is about a century old and is a British design. All dryers are coupled to tubular heat exchangers or single finned tube heat exchangers. The most commonly used heat exchanger is the multi - tubular tube heater.

The Tubular Air Heater is a steel construction with a cast iron combustion chamber and cast iron tubes consisting of oval and circular sections. The hot combustion gases pass through the oval and circular tubes and then escape to the atmosphere. The combustion chamber is fitted with fire bares and provisions are made to allow ash to fall and accumulate below the fire bed.

To make an estimate of releases the data given for biomass firing are used combined with the mass of fuel used (expressed as TJ using an average calorific value of 14 MJ/kg). The emission factor used is that for mixed biomass and close to that given in the text for clean wood (although the tables show a different figure).

2.8.1.2 Tobacco Industry

Tobacco growing and curing is one of the well established industries in Sri Lanka. Ceylon Tobacco Company controls this industry to meet its requirements of tobacco. There are 1946 tobacco curing barns in the country consuming about 23,000t of Paddy husk per annum.

The curing of tobacco is carried out in three stages as follows:

(i) Yellowing Stage:

The tobacco leaves are heated from ambient temperature to about 30 – 42 ^{0}C in 24- 36 hours to remove about 20 – 30 % water and to initiate certain biological processes.

(ii) Colour Setting and Leaf Drying Stage:

Temperature is maintained at about 40 to 50^{0}C to stop the biological and enzymic activities. About 50% of moisture is removed at this stage and subsequently the temperature is increased to about 50 to 60^{0}c for drying of lamina.

(iii) Steam Drying:

At this stage moisture in the leaf and in the stem will be completely removed.

From 1997, all barns in the country were converted to use paddy husk instead of wood as fuel due to the scarcity and the escalating cost of the latter.

In the paddy husk furnace, husk is burned in an inclined grate type burner and the resulting flue gases pass through a flu pipe system and finally into the chimney under the action of natural draft. Heating is regulated by controlling the amount of paddy husk that is fed into the furnace,

To make an estimate of releases the amount of fuel burned (23,000 t) expressed on a energy basis (322 TJ) is combined with the emission factors for mixed biomass firing for category 3.

2.8.2 Crematoria

In Sri Lanka cremation of the deceased is practiced in some instances .

Cremation is carried out both in technological crematoria in urban areas and also in pyres constructed out of wood particularly by some Hindu and Buddhist devotees. Information on crematoria was collected through the Commissioners of the Local Governments by a prepared questionnaire on the basic information such as Province, District, Local Authority, number of cremations in 2002 and whether any pollution control systems are incorporated in the crematoria. According to the information collected from the above survey, all crematoria in Sri Lanka are of single chamber system with no afterburning systems incorporated. These crematoria have stacks of adequate heights to disperse emissions.

Most of the Crematoria are located in the coastal areas and in the Colombo District. The total number of cremations in 2002 is given in ·

Table2.14: Details of Crematoria in Sri Lanka

Province	District	No of Crematoria	No of Cremations in 2002
North Central	Anuradhapura	2	147
North Western	Kurunegala	2	437
Uva	Badulla	1	166
Western	Colombo	14	3454
Western	Gampha	11	1218
Western	Kalutara	4	473
Southern	Galle	11	2267
Southern	Hambantota	3	308
Southern	Matara	6	1226
Sabaragamuwa	Ratnapura	1	150
Central	Matale	1	205
Central	Kandy	7	564
Central	Nuwara-Eliya	2	100

Since there are no controls the higher emission factor is applied.

No information was available from which to estimate releases from pyres used as the traditional means to cremate bodies in some cases.

2.8.3 Smoke houses

Smoking is not a widely used method for food preservation in Sri Lanka. There are smoke houses to smoke tobacco and rubber during processing.

The smoking is fuelled by wood and the amount of wood burnt is accounted under Section 2.3.2.

2.8.4 Dry Cleaning

Dry cleaning is carried out typically using perchlorethylene. Total imported perchlorethylene was reported to be 58,972 kg (Customs data). Sample data from dry cleaning opreators suggests that residues may be produced at the rate of up to 30% of the input of perchloroethylene. This would suggest total residue production of up to approximately 18 t for the whole industry.

To estimate releases we apply the emission factors relevant to normal textiles. The fate of the residues is not known but it may end up either in the general waste stream or be released into the sewers.

2.8.5 Tobacco smoking

Cigarettes, cigars and "beedi" are manufactured using tobacco. The beedi are a small brown miniature cigar which are smaller than cigarettes (estimated mass ¼ of a cigarette). Manufacture and imports of cigarettes are controlled by the Ceylon Tobacco Co. Ltd., (CTC). Information collected from the CTC revealed that 5014.7 million cigarettes were manufactured in 2002. Cigar and beedi are manufactured by small scale industries as well. The quantities of these two items can be calculated by using the information per capita consumption estimated by the Census Department.

It is estimated that the cigar and beedi consumption per month per person are 0.47and 4.15 respectively. Considering the above consumption rate it is calculated that 107.199 million cigars and 946.54 million beedi are consumed per year.

The emission factor used for beedi was taken as ¼ of that for a cigarette (0.025 pg I-TEQ/unit) based on the relative mass.

2.8.6 Estimated Releases – Category 8, miscellaneous sources

Table 2.15: Estimated releases from miscellaneous sources

Category	Classification	Activity statistic	Emission factor		Estimated annual release, g I-TEQ	
			Air	Residues	Air	Residue
Drying of biomass	**Tea industry**	4560 TJ	500 µg I-TEQ/TJ	15 µg I-TEQ/TJ	2.28	0.068
	Tobacco industry	322 TJ	500 µg I-TEQ/TJ	15 µg I-TEQ/TJ	0.161	0.005
Cremation	**Technological**	11307	90 µg I-TEQ/ per cremation	ND	1.01	ND
	Pyres	No data	ND	ND	ND	ND
Smoke houses	See biomass power generation/heating					
Dry cleaning	Normal textiles	18 t	NA	50 µg I-TEQ/t	-	0.0009
Tobacco smoking	Cigarettes	5014.7 million	0.1 pg I-TEQ/unit	NA	0.0005	-
	Cigars	107.199 million	0.3 pg I-TEQ/unit	NA	0.00003	-
	Beedi	946.54 million	0.025 pg I-TEQ/unit	NA	0.00002	-
Total					**3.46**	**0.074**

Notes: emission factors for mixed biomass used from category 3

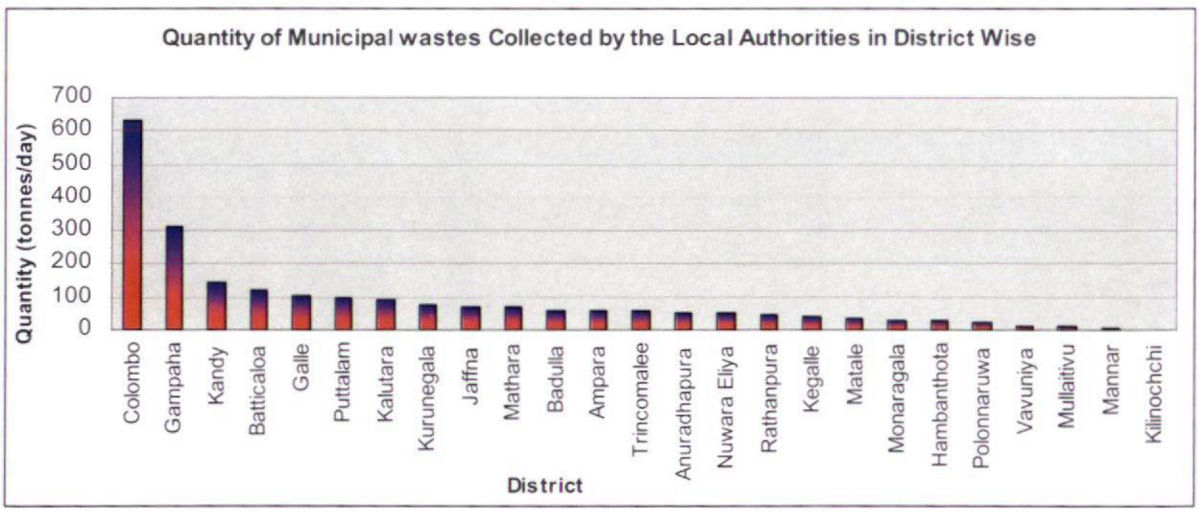
2.9 Disposal and Landfill

2.9.1 Landfills and waste dumps

Solid waste comprises non-liquid waste material from domestic, institutional, market, medical, commercial and industrial sources, and street and garden sweepings. The various components constitute discarded organic waste, packages in the form of metals, plastics or glass, cut pieces from garment factories etc. Over 80% of domestic and commercial waste is organic and biodegradable

Domestic and similar wastes collected are typically dumped in dump sites. These dump sites do not have liners and therefore no leachate controls. No measures are taken to minimise generation or release of leachates. Almost, all the waste generated in the domestic sector is collected by the relevant local Authorities in urban, suburban and in small towns other than in the small villages. In some instances, wastes form industrial operations, hospitals and other types of hazardous wastes are also collected and dumped at the same dumps.

Figure 3.3: Quantity of Municipal Wastes Collected by the Local Authorities in Sri Lanka



Source: Database of Municipal Solid Waste in Sri Lanka - 2005. Ministry of Environment and Natural Resources

Across all the local Authorities in Sri Lanka a total of 2838 tons of solid wastes per day are collected (ME&NR -2005]. A small, but increasing, fraction of this waste has been used for composting by some local Authorities.

As described in Section 2.6.2.1, there are frequent fires at dump sites which are often attributed to the spontaneous combustion of methane generated as a breakdown product of the waste.

There is insufficient information available at this time to make an estimate of releases that may result from the land filling/dumping of wastes other than by accidental fires (see Section 2.6.2.1). In addition to a lack of data on the flow of any leachate there is no information available on the likely levels of PCDD/F in the wastes. The fact that wastes are dumped into largely uncontrolled sites with few controls on the wastes taken and no leachate control indicates that the landfills/dumps are likely to contribute to environmental pollution. Further assessment would be required to assess releases of PCDD/F.

2.9.2 Sewage and sewage treatment

The management of sewage and wastewaters varies across Sri Lanka.

In Colombo there is a sewer network system which collects domestic, commercial and industrial wastewater discharges. The collected wastewaters are discharged into the sea without any treatment. The only large conventional sewerage system in the Colombo area has 254 km of gravity severs and 13 pumping stations in CMC area, three in Kolonnawa Urban Council area and two in the Dehiwela/ Mt. Lavinia Municipal Council Area. Wastewater is discharged without any treatment to the open ocean at two locations in Wellawatte and Modara (NSF-2000). It is estimated that about 45,000 m^3 (Colombo Environmental Improvement Project, EIA report, est 1998) and 67,500 to 90,000 m^3 (State of the Environment in Sri Lanka, Ministry of the Environment and Natural Resources, 2002) of sewerage and other wastewater is being discharging daily from Modara and Wellawatta pumping stations respectively.

Apart from CMC, in other urban areas, the sewage is discharged into the water bodies which located near such areas. There are no records on the quantity discharged. Therefore, the estimation of release of PCDD/PCDF is not possible.

There are a few sewage treatment plants in housing schemes operated by the NWS&DB as well as major hotel schemes. These plants are located at Mattegoda housing scheme - Kottawa, Raddolugama housing scheme Ja-Ela , Soysapura housing scheme-Ratmalana, Hantana housing scheme Kandy and at Kataragama town. These plants are mainly extended aeration type and the generation of sludge is small. The sludge generated from these treatment plants are just dumped near the treatment plant or used for agriculture. The quantification of generation of sludge is very difficult as there are no records on such waste. For the purposes of making an initial estimate of releases we summed effluent volumes and sludge production from the five housing schemes for which data were available. This gave a total effluent of 2.97 million m^3 per day and 208 t of sludge per year.

Some industrial facilities have their own treatment plants. For example a two stage plant (aeration and settlement) treating primarily domestic waste water from the large workforce (5000 at one site) prior to discharge into surface waters. These are considered under the relevant industry sections.

2.9.3 Open water dumping

Most large scale industries have water treatment systems as noted previously. The outfall from the sewer network in Colombo is addressed in Section 2.9.2. Other informal waste dumpings into water courses cannot be quantified.

2.9.4 Composting

Commercial composting is done in some places in Sri Lanka. The largest plant is located at Bleomendhal dump site. This dump site is used for the dumping of Municipal solid wastes collected in the Colombo Municipal Council area since 1994. The estimated quantity of solid wastes dumped from 1994 is 1,752,000 t at an average of 600 t/day.

Burns Environmental and Technologies (Pvt) Ltd established in Sept. 2002 is involved in the manufacture of compost fertilizers by using the municipal solid wastes collected in the CMC area. In 2002 only a small amount was produced. Current production is believed to be in the range 30,000-60,000 t per year.

The solid waste brought to the site is sorted out for bio degradable materials. The sorted wastes are levelled and treated with slurry substrate for de-fouling and accelerated bio- conversion. Afterwards treated waste is stacked in long windrows of 3 to 5 m height. The temperature of the heap reaches 70-80 °C which kills pathogens and ensures proper fermentation. The decomposed biomass is processed through separating, grading and sieving machines. The fully matured and stabilised organic manure is recovered and packed for marketing.

There are also smaller scale compost production sites around the country.

For the purposes of making an initial estimate of potential releases in compost we take the production figure of 60,000 t and apply the emission factor given in the Toolkit for compost made using the complete organic fraction (ie unsorted wastes) of 100 µg I-TEQ/t. There is no data available from Sri

Lanka to indicate whether this value is appropriate for the types of wastes and environmental conditions that are found. The data used to generate the emission factor may be heavily influenced by the presence of certain waste fractions and chemicals that are less likely to be found in Sri Lanka.

2.9.5 Waste oil disposal

Details on the generation of waste oil/used oil in the canteens, restaurants and businesses are not available. But a significant amount of waste oil has been collected from the oil filters in tourist hotels and disposed either along with the municipal solid waste or just dumped within the premises.

According to the Assessment of the Current Status of Hazardous Waste Generation, Treatment and Disposal in Sri Lanka prepared by the ERM Consultants revealed that 22540 t of waste oils are generated per year. The details of waste generators and the quantities generated are given in Table 2.16

Table 2.16: Quantity of Waste oil Generated in Sri Lanka in 2002

	Name of Waste oil generator	Quantity t/year
1.	Ships	
	a. SLPA	3,000
	b. Colombo Dockyard Ltd	207
2.	CGR	558
3.	Service Stations/ Vehicle Uses	14525
4.	Thermal Power generators	
	a. Private Power Plants	2161
	b. CEB	1953
5.	Industrial Utilities	136
Total		**22540**

Source: Assessment of the Current Status of Hazardous Waste Generation, Treatment and Disposal in Sri Lanka – ERM Consultants.

There is no proper disposal method of waste oil. Almost all the waste oils are re used for various industrial purposes, particularly in the small scale metal melting industries where these oils are used as alternative fuels for the furnaces. No records are available on the usage of the oils in any industrial sectors. There are no emission factors given in the toolkit for the waste oil treatment. However, in most cases these oils are used as alternative fuel for the categories in the other sectors and the estimation of PCDD/PCDF in the respective sectors may also include the burning of waste oil.

At present there is no information available on the composition of the waste oils and in particular whether they may contain PCB.

Given the significant amounts of waste oil it will be important to consider potential releases from this source.

2.9.6 Estimated Releases – Category 9, Disposal, Landfill

Table2.17: Estimated releases from Disposal and Landfill

Subcategory	Classification	Activity statistic	Emission factor			Estimated annual release, g I-TEQ		
			Water	Product	Residues	Water	Product	Residue
Sewage and sewage treatment	Housing schemes with treatment	2,970,000 m^3 (effluent) 208 t (sludge)	0.5 pg I-TEQ/l	NA	100 µg I-TEQ/	0.001 g I-TEQ	NA	0.022
	Untreated outfall to sea (Colombo only)	45,200,000 m^3	0.5 pg I-TEQ/l	NA	NA	0.023	NA	NA
Open water dumping		No data						
Composting		60 000 t	NA	100 µg I-TEQ/t	NA	NA	6.0	NA
Waste oil		25400 t	ND	ND	ND	ND	ND	ND
Total						**0.024**	**6.0**	**0.022**

2.10 Hot Spots/Contaminated Sites

There is no routine assessment of contaminated sites at present in Sri Lanka and no analytical data or facilities available to assess possible contamination.

2.10.1 Production sites of chlorinated organics

There has been no production of chlorinated organic chemicals in Sri Lanka.

2.10.2 Production sites for chlorine

Chlorine was previously produced at one site in Sri Lanka. The Paranthan Chemicals Corporation manufactured chlorine and related products based on the electroysis of brine using cells fitted with carbon electrodes. No information was available on the amount of residual material or the means of disposal.

The production of chlorine using carbon electrodes has been shown to result in high levels of PCDD/F, particularly in the sludge and wastes from the process. There may be significant contamination associated with this practice although the relatively small scale of the unit will limit the scale of the problem.

2.10.3 Formulation sites for chlorinated phenols

There is no formulation of the higher chlorinated phenols in Sri Lanka and no information on any such activity in the recent past.

2.10.4 Application sites for chlorinated phenols

There is no information to indicate that higher chlorinated phenols have been used in the recent past in Sri Lanka.

2.10.5 Timber manufacture and treatment sites

There is one major timber treatment site in Sri Lanka which has used creosote and CCA (copper, chrome, arsenic) up to at least 1990. Furnace oil is now used instead of CCA. There may have been some use of pentachlorophenol before this but there is no record available.

2.10.6 PCB filled transformers and capacitors

A comprehensive inventory of PCB equipment in Sri Lanka is currently underway. The inventory should provide data on the presence of PCBs in electrical equipment that is both in use and being stored for disposal. Leakage of PCB from these items of equipment, stored fluids and contaminated soils would all lead to a release of PCDF which are present in the fluids. During the years of unrest in Sri Lanka many transformers have apparently been blown up, and this may have led to a contamination of the environment with both PCB and PCDD/F both from any PCB fluid contained in the transformer as well from formation if the fluid is burned.

The inventory of PCB equipment being conducted as part of the NIP will contain details that are relevant here.

2.10.7 Dumps or wastes/residues from categories 1-9

No information was available to identify particular dump sites of potentially contaminated materials.

2.10.8 Sites of relevant accidents

See Section 2.10.6 relating to destruction of transformers. Other sites of accidents were not identified in this phase of the work.

2.10.9 Dredging of sediments

PCB have been detected in the sediments from Colombo harbour and dredging of such sediments would result in a transfer of accumulated pollutants (which may include PCDD/F). No information was available to identify potentially contaminated sites at this time.

2.10.10 Kaolinitic or Ball Clay sites

Ball clay has been identified as a raw material in some ceramic processes. There is no information available to decide whether this material is similar to those clays identified overseas with high levels of PCDD/F.

Chapter
3

3. Country Inventory

The inventory of releases for the year 2002 is summarised in Table 3.1

It was possible to make estimates of releases for all the main categories and to identify two types of potential "hot spot". Uncertainties and gaps are discussed in Section 3.1 and the inventory can be improved and strengthened as additional information relating to activities, process classification and better emission factors become available.

The best data were available on air emissions and the inventory of releases to air is more complete than for releases to water, land, products or residues. There is almost no information on releases to water, in products or to land. Limited information is available on releases to residues.

The largest calculated releases are to air (171 g I-TEQ per year) and in residues (79.5 g I-TEQ per year). Based on limited data, releases to water were estimated at 0.079 g I-TEQ per year and in products at 6.27 g I-TEQ per year.

The largest estimated air emissions are from category 6, uncontrolled burning processes (waste and biomass), category 1, waste incineration, category 3, the generation of heat and power, category 2, metal production and processing and category 8, miscellaneous. These account for over 99% of the total estimated emissions to air.

The main source categories contributing to estimated releases in residues were category 2, metal processing and category 6, uncontrolled combustion, when together account for over 99% of estimated releases.

Table 3.1: Summary Inventory of Releases for Sri Lanka, 2002

	Category	Releases, g I-TEQ per year				
		Air	Water	Land	Products	Residues
1	Waste Incineration	20.3	0.055	NA	NA	0.133
2	Ferrous and non-ferrous metal production and processing	5.52	ND	NA	NA	49.8
3	Power generation, heat and cooking	19.3	ND	ND	NA	0.096
4	Mineral products	1.37	NA	ND	ND	0.002
5	Transport	0.54	NA	NA	NA	ND
6	Uncontrolled combustion	121	ND	ND	NA	29.4
7	Chemical and consumer products production and use	ND	ND	ND	0.446	ND
8	Miscellaneous	3.46	ND	ND	ND	0.074
9	Disposal/landfill	ND	0.024	ND	6.00	0.022
10	"Hot spots"	Site of chlorine				

	Category	Releases, g I-TEQ per year				
		Air	Water	Land	Products	Residues
		production. Residues from chlorine bleaching of pulp				
	Total	171	0.079	ND	6.45	79.5

The releases estimated for category 6, the uncontrolled burning of biomass and wastes, are dominated by releases to air from combustion of wastes in landfills and dumps and combustion of domestic and similar waste that is never collected. It is inherently difficult to estimate the amounts of waste that are burned in the frequent landfill fires which are believed to result primarily from spontaneous ignition of accumulated methane gases. The best possible estimate was used to develop the initial release calculation. Future actions to improve the management of wastes and in particular plans to increase the amount of waste being composted should contribute to reduced releases in future.

A significant fraction of waste is not collected by the authorities and a fraction of this is known to be burned for disposal. Again there is no accurate data on the mass of this material and therefore rough estimates had to be made. Further data in this area will allow release estimates to be improved.

Within this category the other potentially significant source is the burning of agricultural residues. It was possible to estimate releases from the burning of rice husk which were approximately 9 g I-TEQ per year. The burning of rice husk as a waste product is widely practiced and beneficial uses should be sought (note that recently trials have been carried out to burn rice husk as an alternative fuel in the cement kiln). It was not possible to estimate releases from other residues that may be burned in the open. Higher emissions factors have been reported in the literature for releases from rice husk and further data is required to improve the estimates.

For all the open burning categories it was felt that emissions factors that were based on local conditions and local wastes and biomass would help greatly to improve estimates of releases.

Category 2, the production and processing of metals is estimated to contribute significantly to overall releases of PCDD/F in Sri Lanka. In particular this applies to the processing of non-ferrous metals. The processing of scrap copper which originates in the Middle East is a major industry. The processing plants are fitted with basic wet scrubbers to reduce releases of pollutants to air and the feed materials have to meet the requirements of the Basel Convention (95% metal). Emissions to air and residues have been calculated. The calculated release associated with the flue gas treatment residues is the largest estimated residue release. These residues are meant to be re-exported to the country from where the scrap originates so that with proper management there should not be a significant release to the environment in Sri Lanka. Further information is required to fully characterise this potentially significant source of releases of PCDD/F to air and residues and attention should be paid to potential releases to water arising from the use of wet scrubbers.

The processing of scrap aluminium is also becoming a significant activity. The industrial facilities benefit from scrap sorting and wet flue gas scrubbing which will reduce releases compared to the worst cases. In addition to the industrial-scale processing there is also a

widespread, cottage-scale industry melting aluminium (as well as brass) for local products. There is little data that allows us to estimate the magnitude of releases from this sector but it is clear that occupational exposures to pollutants are high.

Releases estimated for category 3, the use of fossil fuels and biomass for heat, power and cooking, are dominated by high estimates of air emissions from the widespread use of wood as fuel for cooking. Sri

Lanka is highly dependent on biomass fuels for primary energy for cooking and in various sectors of industry. The higher emission factors that have been associated with the use of biomass and the large amounts used lead to the relatively significant estimates of releases. In the fossil fuel categories the largest estimate of air releases relates to the use of heavy oil for power generation. Few data are available to estimate these releases so the estimates may be improved in future with local or international test data.

Category 1, waste incineration, is estimated to contribute approximately 12% of estimated air releases. However, this is confined to medical waste incineration only. There is incomplete information on the management of medical wastes but in the main they are believed to be burned in very basic incinerators or in the open, some enters the general municipal waste stream. Improvements to the management of medical waste are being studied. One modern hospital has a two chamber purpose designed incinerator which is fitted with a wet scrubbing system to control air pollution. Although the overall, estimated, releases from this plant are relatively low (in terms of the inventory) the operational practice of discharging all effluent from the scrubber (solid residues included) to sewer will result in a release of PCDD/F to water and does not represent good practice.

Incomplete information was available on category 7 but the initial indications are that although the textile and leather industries are relatively large in Sri Lanka, the absence of pentachlorophenol, at least in domestic use, gives some assurance that this is not a major source. No data were available to evaluate releases to water in this sector.

The Stockholm Convention lists sources of particular concern with regard to releases of PCDD/F. Of those sources noted as having highest potential for releases we have been able to estimate releases for:

waste incinerators which are not widely used at present;

cement kilns - not currently burning hazardous wastes and with low measured emissions in normal operation;

pulp and paper production – no current use of chlorine for bleaching (but some historic use);

processing of copper scrap (potentially significant as noted), secondary production of aluminium and zinc (releases estimated, aluminium becoming a more significant industry and with a widespread cottage scale processing).

The Convention also lists several other processes that should be considered as potentially significant sources. Of these we have been able to estimate releases for those believed to be present in Sri Lanka.

3.1 Main gaps and uncertainties

The process of developing the inventory was based on both field research (site visits, interview, and personal contacts) and statistical information and the use of the Toolkit to provide default emission factors. In the absence of comprehensive measured data there will always be uncertainty associated with the estimates made.

Gaps identified include:

A lack of information to enable an estimate of releases associated with industries (textiles primarily) burning wastes, in particular textile off cuts and other waste.

A lack of data on several categories of accidental fires.

Appropriate emission factors for sectors (identified as ND, no data available within the Toolkit and inventory). Of particular significance would be the lack of data on releases to water, for example associated with the textile and leather industries.

The lack of emission factors that relate to the burning of wastes (typical of those found in Sri Lanka) and biomass (again characteristic of Sri Lanka) is noted and further testing will greatly increase confidence in the estimated emissions.

There were significant uncertainties associated with some of the estimates, which relate both to the availability and accuracy of data on activities and the emission factors that were applied in some cases.

Significant uncertainty is noted in relation to the amounts of waste that are ultimately burned in dumps and landfills, the fate of medical wastes and the quantities of biomass that are used in the country.

There is uncertainty also over the appropriate emissions factors for the metal processes, biomass combustion and related to textile and leather processing in addition to the burning of wastes in dumps and in the open.

Chapter
4

4. FUTURE REVISIONS OF THE INVENTORY

The inventory is designed to be updated regularly to reflect changes in activity levels, improved emission factors and any changes that would affect releases.

Trends that can be identified at present include:

Category 1 – Waste incineration

An estimate of releases associated with incineration of textile off-cuts would increase estimated releases.

Category 2 – Metals processing

Production of aluminium has increased (2002 was the year of commissioning for the industrial facility) contributing to increasing releases.

Category 3 – power and energy production

Increased demand for power is likely to increase emissions.

Category 4 – mineral products

The cement kiln is taking steps to use alternative fuels. Emissions data should be available to indicate any impact on releases.

Category 5 – transport

The use of transport fuels is increasing rapidly which will tend to increase releases. However, the banning of leaded gasoline during 2002 will lead to reduced emissions compared to the current inventory.

Category 6 – uncontrolled combustion

Increases in the amount of waste composted should lead to reductions in the amount of waste that burns – but it is not possible to estimate the impact as yet.

Some agricultural residue and sawdust is now being used as fuel for the cement kiln which would reduce the estimated releases.

Category 7 – chemical production and use

No impacts are apparent.

Category 8 – miscellaneous

No impacts are apparent.

Category 9 – disposal

Increases in composting would lead to greater estimated releases in compost production but the current estimate is very uncertain.

Chapter
5

5. CONCLUSIONS AND RECOMMENDATIONS

The process of developing an inventory has been successful and it was possible to make estimates for all main source categories which are suitable to identify the major sources of releases of PCDD/F in Sri Lanka.

The Toolkit provided a valuable guide to facilitate the development of the inventory. Local emissions data was almost entirely absent and generating more appropriate emissions factors based on local conditions, processes and materials would significantly strengthen elements of the inventory.

In general good statistical information is available on those industries that are regulated by the Central Environment Authority and operated under the Board of Investment systems. Information on other processes was harder to gather in some cases.

The main sources of releases of PCDD/F in Sri Lanka were identified as:

The uncontrolled combustion of wastes, primarily in dumps and in the open;

The processing of metals, in particular scrap copper where a significant amount of PCDD/F is likely to be associated with the residues from gas cleaning systems;

The incineration of medical wastes which is largely carried out under very poorly controlled conditions;

Burning of biomass in homes for cooking, industry and for disposal of agricultural residues.

Estimates of releases to air and residues were far greater than for releases to water, land or in products. This reflects both the nature of the main sources (thermal processes giving air emissions and residues from gas cleaning and combustion) and a lack of data to estimate releases to other media.

The process of assembling the inventory has allowed a valuable and extensive database of knowledge on a wide range of processes and activities to be assembled. This knowledge should be reviewed, stored and used as a basis for updating the inventory with any necessary additions, changes and corrections. It will also be of considerable use in assessing other pollutant sources to the environment in Sri Lanka.

The inventory and supporting information forms a sound basis to be used to develop country priorities (related to the inventory), suitable action plans and options to meet the obligations of the Stockholm Convention.

Actions related to the inventory of sources are likely to include:

Work to improve release estimates – for example to refine estimates of releases from uncontrolled combustion of wastes;

Work to fill identified gaps – for example releases from the incineration of textile wastes;

Longer term projects to improve estimates based on new and improved data - for example to generate appropriate emissions factors for key processes in Sri Lanka, such as emissions from local waste and biomass under conditions found here;

The development and assessment of a series of options to reduce and control releases and to reduce the likelihood of human exposure to releases (for example by ensuring proper management of residue streams).

In addition inventories of other unintentionally produced POPs will be developed and strengthened. At this stage only initial and partial estimates have been made for releases of HCB and PCB as detailed below. Clearly these partial inventories are for initial orientation only.

5.1 Preliminary identification of possible measures

This section outlines some initial ideas on measures that might be taken. These are offered as an input to the next stage of the NIP development project when country priorities will be set and appropriate action plans developed along with detailed assessment of available options and the implications of those options.

By this survey estimates on PCDD/F were made using the TEQ levels given in the "Toolkit". In the Toolkit ten major categories have been identified as major PCDD/F generating sources and these sources are sub-categorised and further subdivided into classes according to the mode of processing. Hence, in the tool kit approximately 175 types of activities have been identified as POP generating sources with TEQ values specified for each class. In almost all instances TEQ values are expressed in terms of µg/tonne (except for in very few instances it is expressed in terms of pg/ng instead of µg units). A very wide variation in these TEQ values are noted ranging from 0.007µg/t (under class 2 of asphalt mixing) to 1,500,000 µg/t (under PCB filled transformers and capacitors categorised under hot spots) levels. Therefore, for purpose of convenience, all activities identified in the tool kit were divided into five basic ranges depending on the magnitude of TEQ levels assigned.

Range 1 : Those activities with TEQ levels higher than 10,000 g/t.
Range 2 : Those activities with TEQ levels ranging between 1,000 to 10,000 g/t..
Range 3 : Those activities with TEQ levels ranging between 100 to 1000 g/t.
Range 4 : Those activities with TEQ levels ranging between 10 to 100 g/t.
Range 5 : Those activities with TEQ levels less than 10 g/t.

Activities involved in the manufacture of organochlorine compounds, uncontrolled incineration of hazardous wastes and management of PCB containing equipment are included in the above mentioned highest range. With regard to Sri Lanka situation in relation to the said activities, the country is neither engaged in manufacture of organochlorines nor incineration of hazardous waste. However, Sri Lanka has PCB containing equipment and as per the toolkit improper management of such equipment can lead to the emission of dioxins/furans at very high levels. Presently, a separate task team is engaged in preparing an inventory of PCB equipment in Sri Lanka. The outcome of this survey can be utilised in preparing the plan required for management of PCB equipment (handling/disposal). During preparation of this management plan, serious attention is required methodologies not only to prevent leakage of PCBs but also to prevent transformation of PCBs into furans.

With regard to range 2, there are no industrial activities in Sri Lanka included under this range. However, hospital waste incineration falls under this range. In Sri Lanka, only a very few hospital waste incinerators are in place. Technical operations of these incinerators need to be studied in detail in order to identify measures required to prevent dioxins/furans emissions.

In Sri Lanka there are several activities falling under range 3 (those activities ranging between 100 to 1000 µg/t). These are as follows:

* Land fill fires (1000)
* Accidental fires in houses, factories
* Uncontrolled domestic waste burning
* Secondary scrap metal smelting activities using waste oil and those operating without air pollution control measures.

Land fill fires are noted in considerable amounts in Sri Lanka mainly in the Colombo city. In Colombo a land fill site is in operation and it is exposed to frequent fires. Such fires are mainly due to unplanned

solid waste management practices adopted. Accumulation of highly biodegradable waste material at landfill sites lead to the generation of methane gases resulting frequent fires. Hence, adequate separation of the bi-degradables from non-degradables is required prior to disposal at land fill sites. The separated bio-degradables can be processed for composting as practised at present. Further, the existing landfill sites should be transformed into well engineered waste disposal sites where provisions will be made for extraction and reuse of methane gases. These provisions will avoid occurrence of accidental fires.

In addition to preparation of well engineered landfill sites action also should be taken for the preparation of a proper hazardous disposal facility in Sri Lanka as handling/disposal of POPs containing wastes (such as PVC containing material, PCB equipment) require specific treatment and disposal techniques.

With regard to uncontrolled open burning, all citizens of the country should be educated on adverse impacts due to such burning. Laws also need to be formed to ban uncontrolled open air burning.

Certain industries are compelled to carry out open air burning on a large scale as these industries are in need of completely destroying their rejected products with of view of preventing infiltration of such products into the market. The burning nature of such products reveals that such burned material contains a very high calorific value. Therefore, due to such burning not only dioxins/furans emissions take place but a considerable amount of harnessable energy is also wasted. Hence, such industries need to be provided with technology capable of destroying their rejected products in a manner that the energy generated due to burning can be harnessed and dioxins/furans prevented.

With regard to secondary scrap smelting, in Sri Lanka all cottage industries engaged in the said activity carry out smelting operations using waste oil and without air pollution control measures. As per the tool kit, such smelting activities especially those engaged in secondary aluminium processing contribute considerable levels of dioxins/furans emissions. These smelting activities are helpful in proper management of scrap accumulating in Sri Lanka. Hence, the Government should provide subsidies to these cottage scale smelters in installing the necessary pollution control devices. They also should be requested to completely stop use of waste oil and the Government should financially help them in obtaining diesel for their smelting activities. These pollution control techniques are presently in use by the BOI approved smelting activities at HEPZ and MEPZ.

The management of waste oil generated in Sri Lanka can be carried out by re-using of such oils by industries equipped with necessary pollution control devices.

A national level programme needs to be initiated in the country with regard to importation of all chemicals into the country. Laws need to be made in the country that all chemical imports need to be accompanied with the CSDS indicating the types/functional groups containing therein. This will enable to keep a record on types of chemicals coming into the country. Importation of any PCP/HCB or any dioxins/furans or any POPs likely compounds should be banned.

Chapter
6

6. OBSERVATIONS ON THE USE OF THE TOOLKIT

In general the Toolkit provided a valuable guide for the assembling of the inventory of releases of PCDD/F within Sri Lanka.

The team had some problems in classifying some processes and selecting the appropriate emission factors in some cases. In part this relates to the fact that most emissions data is generated in a few developed countries and processes do not always compare easily with those identified in Sri Lanka.

There was concern over the absence of emission factors that reflected potential releases from biomass use (in industry and for cooking) and burning for disposal and waste burning. The team felt that the types of biomass and wastes found in Sri Lanka and the conditions and processes involved may differ very greatly from those in other countries and these sources are very important in Sri Lanka.

In other processes such as the small-scale melting of metals using open crucible furnaces fired with waste oils, the traditional methods of making bricks and ceramics and the making of charcoal from coconut shells it was difficult to make adequate estimates.

Some errors and inconsistencies were found in the Toolkit; for example a figure for emissions from biomass use Table 38 did not agree with the text (the seven fold difference would make a significant change to calculated emissions in some cases). The electronic spreadsheet simplifies data calculations but can easily lead to problems where units of emissions factors do not match the activity statistics in some cases. Great care is needed to eliminate such potential errors.

In future greater clarity in some process descriptions and the factors that help to distinguish between classes would be helpful; for example in terms of types and performance of air pollution controls, "contaminated or mixed biomass".

Chapter
7

7. Inventory of unintentional HCB releases

Hexachlorobenzene (HCB) is listed as a POP for control under the Stockholm Convention. HCB has been produced for use as a pesticide, and it has also been used as an intermediate in chemical production. It may also be found as a by-product in manufacture of other chemicals and can be produced by combustion processes. In principle HCB is likely to be formed and released by processes that produce PCDD/PCDF and therefore all sources of PCDD/PCDF are potential sources of HCB.

When compared to PCDD/F there is very little data available on the sources of HCB as a by-product and any attempt to assemble an inventory is limited by this lack of data. In some cases the limited data that is available would not have been generated by modern methods or may not relate to processes that are currently used adding further uncertainty.

7.1 Chemical production and use

There is no significant production of chemicals in Sri Lanka and therefore no releases of HCB are expected from this source.

No data was available to enable any estimate of potential presence of HCB as a contaminant in chemicals imported to Sri Lanka.

Information on chemicals that may be contaminated with HCB which is unintentionally formed is available from the Binational Toxics Strategy for the Great Lakes (http://www.epa.gov/bns/baphcb/stephcb.html) and the following are identified – chlorothalonil, dimehtyl tetrachloro-terephthalate, pentachloronitro-benzene and picloram. Other potential sources include the manufacture of chlorinated solvents such as carbon tetrachloride, perchlorethylene, ethylene dichloride and 1,1,1 trichlorethane.

7.2 Combustion and thermal sources

HCB can be formed in a variety of combustion and thermal processes. Experimental systems have demonstrated such formation.

There is a real lack of data available to estimate potential emissions from the various categories of thermal process such as combustion for power and heat (all types), burning of wastes and metal processing.

The main source related to combustion in Sri Lanka is likely to be the open or poorly controlled burning of wastes and other materials. The inventory for dioxins and furans has shown that poorly controlled or uncontrolled combustion is a major activity and major source of PCDD/F.

Preliminary estimates of possible releases of hexachlorobenzene from open waste burning can be made by combining the estimated mass of waste (domestic/industrial/commercial) burned in landfill fires and in the open with initial estimates for emission factors derived from testing in the US.

A series of tests on simulated domestic waste burned in barrels in the US produced four data points with an average of 0.0353 mg/kg HCB produced per kg of waste burned (Evaluation of emissions from the open burning of household waste, US EPA, EPA-600/R-97-134a, November 1997).

Table 7.1 : Estimated air releases of HCB from open burning

		Activity statistic	Emission factor	Estimated annual release,
			Air	Air
Open burning of wastes	Landfill fires and open burning	142,500 t	0.035 mg/kg	4990 g

Other releases would be expected from the other principal sources of PCDD/F identified in Sri Lanka, and in particular other uncontrolled combustion processes, incineration and processing of metals.

Chapter
8

8. INVENTORY OF PCB RELEASES

Polychlorinated biphenyls are well known as *intentionally* produced POPs and were widely used in electrical equipment as well as in a variety of other "closed" and "open" uses (a separate inventory of electrical equipment that is contaminated with PCB is underway in Sri Lanka and will be reported under the NIP project). PCB can also be formed as unintentional POPs. They may be released by a variety of processes, both where they are formed and then released as well as by the processing of materials which are contaminated with PCB from various sources (such as leaking equipment, scrap metal, waste oils). As with HCB all sources of PCDD/F are likely to also be sources of PCB.

There is very few data available to quantify releases of PCB as unintentionally produced POPs. Inventories of PCB releases usually identify leaks from electrical equipment as a main source of PCB release to the environment. It should be noted that the Stockholm Convention requires inventories of PCB which are unintentionally produced, but those leaking from electrical equipment were intentionally produced but would *enter the environment* unintentionally.

PCB may be formed in some chemical production processes and some thermal processes in a manner similar to the formation of dioxins and furans. PCB may also be present in materials, wastes and releases to air and water as a result of contamination of input/feed materials with PCB.

In Sri Lanka an initial review of the findings of the inventory of PCDD/F sources suggests that the principal sources of PCB as an unintentionally produced POP are likely to be:

Waste combustion – in the open and in dumps; and

Wood/biomass combustion;

Waste incineration;

Metal processing.

Other sources will include:

Oil combustion.

Releases associated with the widespread use of waste oils (for example for small-scale metal melting) may be significant.

Emission factors for releases of PCB expressed as "dioxin-like" PCB or as total PCB are lacking for most sectors and sources and in particular for processes that would be representative of those carried out in Sri Lanka.

Studies for the UK Government[2] reviewed available data on emission factors for combustion processes (and summarised inventories that had been completed at the time of writing). Emissions of PCB, expressed using the WHO toxic equivalency factors (a weighting system similar to that used for dioxins and furans to simplify the handling of complex mixtures of the chemicals) were generally between about 5 and 10 % of the emissions of dioxins and furans (expressed as toxic equivalent). In their studies on barrel burns (burning mixed domestic waste under poorly controlled conditions) Lemieux[3] and

colleagues have measured PCB releases and note that the TEQ due to PCB tracked the TEQ due to PCDD/PCDF and the values were approximately 5% of the TEQ from PCDD/PCDF.

For the purposes of developing an initial estimate we can use the value of 10 % as a likely, but realistic upper bound and consider the principal sources of PCDD/F and estimate releases to air from incineration, power generation and uncontrolled combustion processes.

To make an initial estimate of release of total PCB we used the average emission factor calculated from the data of Lemieux *et al* for the baseline runs burning mixed waste in barrels. Clearly these estimates are approximate and provide initial indications only.

Table 8.1: Estimated releases of dioxin-like PCB (TEQ) for principal combustion sources

		Activity statistic	**Emission factor, TEQ**	**Estimated annual release, g TEQ**	**Emission factor (total)**	**Estimated annual release – g total**
			Air	**Air**	**Air**	**Air**
Waste incineration	Medical waste (poor)	6600 t	300 µg TEQ/t	2.0	ND	ND
Biomass burning	Agricultural residue combustion	300,000 t	3 µg TEQ/t	0.9	ND	ND
Open burning of wastes	dump fires	98,500 t	100 µg TEQ/t	9.85	126,000 µg/t	12,400 g
	Uncontrolled burning of domestic	44,000 t	30 µg TEQ/t	1.32	126,000 µg /t	5500 g
Total				14 g TEQ		18,000 g

Note emission factor for PCB as TEQ is based on 10% of emission factor for PCDD/F.

The work on PCB and HCB is clearly very limited and only initial estimates can be made at this time. Further work can be expected as more emission factors become available.

Chapter
9

9. MAIN SOURCES AND PRIORITIES

Largest identified sources

Main sources of PCDD/F release identified in Sri Lanka are as follows,
Incineration of medical waste
Copper production
Heavy oil fired engines
Use of biomass fuels – in industry and household cooking
Burning agricultural residues (rice husk)
Landfill fires and uncontrolled burning of wastes
Biomass drying

Incineration of medical wastes
The majority of medical waste is burned either in primitive incinerators or in pits
There is one well controlled incinerator

Emissions from uncontrolled burning are high – mainly to air but residues also will be contaminated (not just PCDD/F)
Modern incinerator discharges effluent untreated to sewer

Priorities related to medical waste
Better data on the source and fate of the wastes (including waste that enters the municipal waste stream)
Link to work on methods of safe disposal (e.g. autoclaving)
Health, safety as well as bio safety considerations

Metal processing
The processing of potentially contaminated scrap metals can cause high releases
Small-scale processing can give rise to high local releases and worker exposure
The presence of controls on scrap input and the gas cleaning required on BOI projects will reduce releases
Considerable PCDD/F may be present in residues
Liquid discharges may be occurring from systems with wet scrubbers

Priorities for metals sector
Review estimates in the light of improved information on specific processes (for example clarification of processes used in steel sector)
Identify chemicals used for purification (Al)
Update estimated releases if additional emission factors become available (eg for small-scale processes or for copper processing using similar technology)
Consider tests – eg of residues and/or emissions

Power generation using heavy oil
Emissions calculated to be relatively high
Very limited emissions data
Possible contamination of fuels with recycled oils
Priorities for oil firing
Improved estimates based on further testing
Consider testing used oil for PCB in case there is any contamination being recycled (relevant to processes using waste oil)

Use of biomass fuels
Biomass is widely used in Sri Lanka
Higher emissions have been linked to biomass than to fossil fuels
Many uses
Drying of tobacco
Paddy-par-boiling
Cooking
Limited data on emission factors available

Priorities for biomass
To improve information on activities (amounts and characteristic processes)
To identify any significant use of contaminated (or potentially contaminated) biomass
Review estimates in the light of any additional data that becomes available eg from testing in Sri Lanka or elsewhere

Burning of agricultural residues
Large amounts of paddy husk assumed to be burned in the open
Emissions tests are limited
Japanese tests on rice husk showed high emissions

Priorities for agricultural residue burning
Further study on the source and fate of rice husk and other agricultural residues
Review and update estimates in the light of any new data from Sri Lanka or elsewhere
Consider alternative ways to manage rice husk wastes (and others)

Landfill fires and uncontrolled waste burning
Potentially a very polluting practice
Dump sites and open burning
Information available suggests frequent fires started at landfills/dumps by methane accumulation
Data incomplete
Few emissions factors are available

Priorities for waste burning
Improve information on amounts of waste being burned at dumps and without being collected
Consider involvement in international work on emissions related to open waste burning
Update estimates in the light of improved data on quantities and emission factors

Actions to "fill gaps"
In carrying out the review and development of the action plan develop plans and proposals to fill gaps and improve understanding:
Projects to gather more data for source estimation (with no need for measurement)
Projects to carry out measurements
Measurements of environmental burdens/exposure
Use of overseas case studies and data

Options development and assessment
Develop a series of options for controls or other measures
Consider the costs and impacts (positive and negative)
Address both source magnitude and potential for exposure

Exposure assessments could be simple qualitative or based on more complex risk assessments (proposals for these?)

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VISITS AND INTERVIEWS

Following site visits were made by the Task team along with the international consultant.

1. Nawinna Waste dump site
2. Maharagama Cancer Hospital incinerator
3. Narahenpita Apollo Hospital incinerator
4. Horana Aramangolla Industrial Estate – Foundry
5. Horana Export Processing Zone – Aluminium melting industry
6. Horana Export Processing Zone – Copper melting industry
7. Malabe Kaduwella – cottage – scale metal processing industries
8. TheShakthi Tea Factory Horana – Bio mass Combustion
9. Body Line Garment, Horana- Sewage treatment plant and waste incinerator
10. Royal Porcelains Pvt Ltd, Horana
11. Kaduwela – Cottage – scale lime kilns
12. Palliyapitiya, Dhunagaha – Divulapitiya -Coconut charcoal production

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