United Nations
Environment Programme

Asia Toolkit Project
on Inventories of Dioxin and Furan Releases
National PCDD/PCDF Inventories

Prepared by
UNEP Chemicals, Geneva

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This publication is produced within the framework of the Inter-Organization Programme for the Sound Management of Chemicals (IOMC).

The **Inter-Organization Programme for the Sound Management of Chemicals (IOMC)** was established in 1995 by UNEP, ILO, FAO, WHO, UNIDO and OECD (Participating Organizations), following recommendations made by the 1992 UN Conference on Environment and Development to strengthen cooperation and increase coordination in the field of chemical safety. In January 1998, UNITAR formally joined the IOMC as a Participating Organization. The purpose of the IOMC is to promote coordination of the policies and activities pursued by the Participating Organizations, jointly or separately, to achieve the sound management of chemicals in relation to human health and the environment.

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Preface

The "Asia Toolkit Project on Inventories of Dioxin and Furan Releases" was implemented by UNEP Chemicals with the financial support of the US Government and supported five countries in Asia to develop their first inventories of releases of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans and to test the Dioxin/Furan Toolkit. The Toolkit had been developed by UNEP Chemicals to assist countries in undertaking inventories of dioxin and furan releases, and to do so in a harmonized and rigorous manner.

The project started in October 2001 with a kick-off workshop in Hanoi, where country experts were trained on the Toolkit. The five countries then developed their inventories using the Toolkit. The country experts came together again at a second workshop in Bandar Seri Begawan; Brunei Darussalam, 17-19 December 2002, to discuss their preliminary inventories. The experience gained and the conclusions from the workshop are contained in "Report - Inventory Evaluation Workshop for the Asia Toolkit Project on Inventories of Dioxin and Furan Releases, Bandar Seri Begawan, Brunei Darussalam, 17-19 December 2002" that is available at www.chem.unep.ch/pops. This report compiles the five final inventories.

UNEP Chemicals thanks the five participating countries - Brunei Darussalam, Jordan, Lebanon, Philippines, and Vietnam – for their willingness to be part of this exercise, and appreciates the countries' continued interest and dedication to this project. The experiences gained and the constructive comments provided by the countries have contributed to the improved Toolkit, published in May 2003.

This report is also available through the Internet at http://www.chem.unep.ch/pops.

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DIOXIN AND FURAN INVENTORY

FOR

BRUNEI DARUSSALAM

Bandar Seri Begawan, 2003

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Abbreviation and Acronyms

a	year (annum), 365 days
ADt	Air Dried tons
BLNG	Brunei liquefied natural gas
BSB	Bandar Seri Begawan
BTU	British Thermal Unit
d.m.	dry matter
HFO	heavy fuel oil
HW	hazardous waste
I-TEQ	International Toxic Equivalent
K	(Degree) Kelvin
L	liter
MBTU	10^3 BTU
MMBTU	10^6 BTU
MSW	Municipal solid waste
NA	Not applicable (not a relevant vector)
ND	Not determined/no data (in other words: so far, no measurement available)
PCB	Polychlorinated biphenyl
PCDD	Polychlorinated dibenzo-*para*-dioxins
PCDF	Polychlorinated dibenzofurans
PCP	Pentachlorophenol
POPs	persistent organic pollutants
RON	octane number
TEQ	Toxic Equivalent
yr	year

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A Consultative Committee helped to shape the contents of this report and the time and interest of this Committee is gratefully acknowledged. Members of the Committee were representatives from Ministry of Health, Department of Forestry, Department of Environmental, Parks and Recreation, Department of Electrical Services, Petroleum Unit, Land Transport Department, Marine Department, Economic and Planning Development Department, Municipal Board, Drainage and Sewerage Department, Brunei Shell Petroleum Co., Ltd. and Brunei Liquefied Natural Gas.

Many others contributed their time, advice, comments and written materials in the making of this report. The following people have in many ways, contributed to the production of this report: Dr. Haji Ibrahim Haji Abdul Rahman, Dr. Lim Lee Hoon, Martinah Haji Tamit, Pg. Shamhary Pg. Dato Mustapha, Haji Sofi Hasni Haji Sharbini, Norharniah Haji Jumat, Haji Md. Noor Haji Salleh, Hjh Saunah Haji Mohammad, Zailani Yuin, Julaihi Haji Jali and Hjh Mardiana Haji Mohammad.

Finally, very special thanks go to Dr. Heidelore Fiedler, Scientific Affairs Officer, UNEP Chemicals, for her invaluable professional expertise, advice, guidance and inspiring support to the project.

The Brunei Darussalam Inventory of Dioxin and Furan Releases

1 INTRODUCTION

Dioxins (polychlorinated dibenzo-*p*-dioxins, PCDD) and furans (polychlorinated dibenzofurans, PCDF) are two of the twelve Persistent Organic Pollutants (POPs) being addressed in a global treaty known as the "Stockholm Convention on Persistent Organic Pollutants". The Convention deals with POPs, a class of toxic chemical substances that can harm human health and the environment.

POPs are produced and released into the environment by human activity (anthropogenic). Some of these substances are pesticides (aldrin, chlordane, dieldrin, endrin, heptachlor, DDT, mirex and toxaphene) while others are industrial chemicals (hexachlorobenzene and polychlorinated biphenyls) and unwanted by-products of industrial processes or combustion (dioxins and furans).

1.1 The Inventory

This section describes the wide varieties of industries, processes and activities that were identified as the main sources of PCDD/PCDF. In some categories where emission factors are available in the toolkit, average annual releases of PCDD/PCDF to the environment of Brunei were estimated. The sources of PCDD/PCDF in all the main categories listed in the toolkit were discussed. Tables 2-11 (Appendix A), which were generated by the EXCEL programs, show input and out put data for releases to air, water, land, in products and residues. Where there is no activity involved in a particular category, a zero load was indicated in the table.

The screening and gathering of information were carried out all over Brunei Darussalam which included a workshop attended by various government departments on the 22-24 January 2002. The inventory was then written based on the data collected from the various governments and private agencies to which questionnaires were sent. Where necessary, visits and interviews were carried out to get more information regarding the activities involved. Altogether there are 46 participants taking part in this project. The Toolkit provided was then used to calculate and estimate the PCDD/PCDF releases from all of the listed ten main source categories including subcategories therein that are relevant to Brunei Darussalam. This inventory was prepared using the data compiled for the year 2001.

1.2 Country Background

Brunei Darussalam, on the northwest coast of Borneo Island, lies 442 kilometers north of the equator. The total land area of Brunei Darussalam is 5,765 square kilometers, with a coastline of about 100 miles. The total population in 2002 was estimated to be 340,800. About 85 % of the population lives in the coastal area where almost all social, cultural and economic activities are concentrated.

Brunei Darussalam has four administrative districts: Brunei Muara District, Tutong District, Belait District and Temburong District. The Capital and main center of population, Bandar Seri Begawan, is situated 15 kilometers from the mouth of the Brunei River in the Brunei Muara District. The main center of activity of the oil and gas sector is in the Belait District. There are four main rivers in Brunei Darussalam namely the Brunei River, Tutong River, Belait River and Temburong River. The drainage basins of these rivers cover a catchment's area of 4,260 square kilometers approximately 75% of the country's land area.

The country's economy has been largely dependent on petroleum hydrocarbons since the late 1920's. For the past two decades roughly over 95% of exports and 58-88% of GDP were accounted for by the oil and gas sector. Aware of the uncertainties associated with a heavy reliance on a single, non-renewable commodity the government of Brunei Darussalam has embarked on broad-based strategies to diversify its economy by shifting to non-oil resources based industries.

Environmental protection and conservation are an integral part of Brunei Darussalam's development process to ensure sustainable development in line with the long-term objectives of maintaining a clean and healthy environment. The long-term policies and actions needed to protect and conserve the environment from pollution and excessive exploitation of natural resources and the administrative mechanisms are laid down in the National Development Plans (NDPs).

Concerning chemical management, currently the only Brunei Darussalam law applicable to toxic chemicals is the Poisons Act, which primarily regulates pharmaceuticals and pesticides through a regulatory system. Realising the limitation of existing poison act, effort has been made to draft a new law to further control and regulate industrial chemicals especially toxic chemicals to minimize the risk to both human health and the environment.

2 PROCESS CLASSIFICATION AND SOURCE QUANTIFICATION

2.1 Waste Incineration

The incineration of waste is categorized according to the types of wastes burned as listed in 1.1-1.7. In this context, incineration means destruction in a technological furnace of some sort. In many instances waste may be burned in the open i.e. with no technological incinerator at all, such cases are addressed in Section 6.0. Also, the burning of fuel such as wood or other clean biomass for the generation of energy is addressed in Section 3.

2.1.1 Municipal solid waste (MSW) incineration

There is no MSW incinerator in Brunei Darussalam. MSW is disposed off by landfill at various locations in each of the four districts of Brunei Darussalam. There is a proposal to establish an MSW incinerator in Brunei but it has not been approved.

2.1.2 Hazardous waste (HW) incineration

There is no incinerator for hazardous waste in Brunei Darussalam.

2.1.3 Medical waste (MW) incineration

There are three MW incinerators available in Brunei Darussalam. They are located one in each of the main hospital at Raja Isteri Pengiran Anak Selaha hospital (Pictures 1 & 2), Bandar Seri Begawan, at Suri Seri Begawan hospital, Kuala Belait and at Penaga hospital, Seria.

Picture 1: The Medical Waste Incinerator at RIPAS hospital

All the incinerators consist of a primary chamber operating at temperature range of 816 °C–927 °C and an after burner or a secondary chamber that operates at 982 °C – 1,090 °C. The operating temperatures of both chambers are maintained at those temperatures using pollution control microchip to ensure complete combustion of wastes. Most of the PCDD/PCDF formed would have essentially been destroyed under the operating condition set in these chambers.

The wastes are introduced into the sample chamber, which is attached to first chamber manually. They are then fed into the first chamber of the furnace automatically. When all the wastes are burned for a particular day, the incinerator will be turned off and residues (Picture 3) are kept inside the bottom part of the lower chamber until they are cooled down. The residues are then removed from the lower chamber the following morning and are disposed off at landfill sites before subsequence operation.

Picture 2. The chimneys of MWI at RIPAS hospital

The rates of medical waste burned at Raja Isteri Pengiran Anak Saleha hospital was 140 kg/h for 500 hours, at Suri Seri Begawan hospital was 80 kg/h for 1,248 hours and at Penaga hospital was 50 kg/h for 504 hours. All types of incinerators are classified under class 2, which is controlled, batch type combustion, with minimal air pollution control system. Emission factors used under this category are 3,000 and 20 µg TEQ/t of waste for air and residues releases respectively. In 2001, the three incinerators produced a total of 195.0 tons of medical wastes. Using the emission factors above, a total of 585.0 mg TEQ of PCDD/PCDF was emitted to the air while 3.9 mg TEQ released as residues.

Picture 3: The bottom ash of MWI at RIPAS ready for disposal

2.1.4 Light-fraction shredder waste incineration

This fraction is disposed off at landfill.

2.1.5 Sewage sludge incineration

Sewage sludge is disposed off at landfill.

2.1.6 Waste wood and waste biomass incineration

Waste wood and waste biomass is disposed off at landfill.

2.1.7 Combustion of animal carcasses

No information is available.

2.2 Ferrous and Non-Ferrous Metal Production

The iron and steel industry as well as the non-ferrous metal industry are highly material and energy intensive industries, which are not available in Brunei. Only one of the following listed industries is related to Brunei i.e. the production of coke.

2.2.1 Iron ore sintering

No iron is produced in Brunei Darussalam.

2.2.2 Coke production

There is no coke production in Brunei Darussalam. However, a similar product, i.e. charcoal, is produced in Brunei Darussalam. There is only one charcoal industry in Brunei Darussalam and it is situated in Pulau Baru Baru. It produces about 30 tons of charcoal annually. Charcoals are produced by burning mangrove woods at a specially designed chamber (Pictures 4 & 5). The wall of chamber is constructed as a cylindrical shape with several openings at the lower part of the wall. Above the cylindrical wall, a cone shape roof is built with an opening at the top end, which is used as an outlet for the smoke. The smoke produced is also vented through openings at the base of the cylindrical wall to allow heat to be distributed evenly to all woods placed in the chamber. Each batch of woods is burned continuously for about 20 days.

Picture 4: The picture shows charcoal factory

Picture 5: The charcoal factory with charcoal packed in bags ready for distribution

This method of charcoal production is classified under class 1, i.e. no gas cleaning with emission factors of 3 and 0.006 µg TEQ/ton of wood used for air and water releases, respectively. With about 30 tons of charcoal produced annually, this yielded an estimated 90 and 1.8 µg TEQ of PCDD/PCDF to the air and water respectively.

2.2.3 Iron and steel production and foundries

No iron and steel are produced in Brunei Darussalam.

2.2.4 Copper production

No copper is produced in Brunei Darussalam.

2.2.5 Aluminum production

No aluminum is produced in Brunei Darussalam.

2.2.6 Lead production

No lead is produced in Brunei Darussalam.

2.2.7 Zinc production

No zinc is produced in Brunei Darussalam.

2.2.8 Brass production

No brass is produced in Brunei Darussalam.

2.2.9 Magnesium production

No magnesium in produced in Brunei Darussalam.

2.2.10 Other non-ferrous metal production

None of these is produced in Brunei Darussalam.

2.2.11 Shredders

No shredders are available in Brunei Darussalam.

2.2.12 Thermal wire reclamation

There is no reclamation of wire by thermal process in Brunei Darussalam.

2.3 Power Generation and Heating

This category includes power stations, industrial firing places (furnaces) and installation for providing space heating, which are fired with fossil fuels, biogas including landfill gas, and biomass only. It is divided into five sub-categories as listed in Sections 3.1–3.5. The main release vectors are air and residue. Land is considered a release vector only in the case of domestic heating and cooking either using biomass (mostly wood) or fossil fuel. Releases to land can occur if residues are dumped on the ground.

The formation of PCDD/PCDF is low in large, well-controlled fossil fuel power plants because the combustion efficiency is usually fairly high and the fuel used is homogeneous. However, where smaller plants or biomass are used, the fuel may be less homogeneous and burned at lower temperature. These conditions can result in increased formation of PCDD/PCDF.

2.3.1 Fossil fuel and power plants

In Brunei Darussalam, natural gas and diesel fuel are used as fuel to generate electric power in most part of the country. Temburong is the only district that uses diesel fuel for power generation due to its location, which is isolated from the rest of the districts in the country.

Since the power is generated by clean natural gas, it is expected to produce negligible quantity of PCDD/PCDF to the air. The natural gas is produced locally from Brunei Shell Petroleum Company Sdn Bhd (BSP) fields and Block B Joint Venture (BBJV) operated by Total Fina Elf.

Release of PCDD/PCDF is mainly to the air. In 2001, an estimated 37,318,108 MMBTU of natural gas was consumed. Given that 1 BTU (British Thermal Unit) produces an equivalence of 1.054×10^3 J of energy, a total of 3.9333×10^{16} J (39,333 TJ) of energy was produced. Emission factor for natural gas and diesel fuel based on power generation is 0.5 µg TEQ/TJ. Therefore, an estimated 19,666 µg TEQ/yr (19.67 mg TEQ/yr) was emitted from power stations generated from natural gas.

For the Temburong district, the amount of diesel fuel consumed for the generation of power in 2001 was 7,302,084 liters, which is equivalent to 6,206,771 kg of fuel (density of diesel fuel = 0.85 kg/L). Average heating value for diesel fuel is 44.5 MJ/kg of fuel and therefore a total of 276.2 TJ of energy was produced. Using the emission factor of 0.5 µg TEQ/TJ, this generated 138.1 µg TEQ/yr (0.138 mg TEQ/yr) of PCDD/PCDF. Therefore an estimated total of 19.8 mg TEQ/yr (19.67 + 0.138 mg TEQ/yr) of PCDD/PCDF was generated by power stations in 2001.

2.3.2 Biomass power plants

Biomass is not used for power plant in Brunei Darussalam.

2.3.3 Landfill, biogas combustion

There is no sufficient gas produced by landfill or biogas for power generation in Brunei Darussalam.

2.3.4 Household heating and cooking (biomass)

Biomass might be used for household cooking in some rural areas in Brunei Darussalam but its contribution to PCDD/PCDF release is not significant.

2.3.5 Domestic heating (fossil fuels)

Domestic heating is not applicable to Brunei Darussalam as it has an equatorial climate, which does not require heating system at home. However, natural gas is used extensively for cooking throughout the country. Cylinders that contain 14 kg of liquefied petroleum gas (LPG), a mixture of butane and propane gases, are mostly used at home mainly for cooking. Only houses in the area of Seria and Kuala Belait get their gas supplies from BSP through pipelines connecting each house to the main pipe supply of gas.

There is no emission factor for LPG. Therefore the closest one, i.e. the emission factor for natural gas of 1.5 μg TEQ/TJ for air release is used. Heating value of LPG is 46 MJ/kg. In 2001, the supply of LPG to houses in Brunei Darussalam was 23,659.32 m^3, which is equivalent to 12,776,032.8 kg of fuel (1 $m^3 \approx$ 540 kg). This amount of fuel would generate 588 TJ of energy and therefore the emission of PCDD/PCDF to air through domestic use of natural gas was 0.882 mg TEQ/yr.

The supply of natural gas using pipeline consumed about 36,010,580 m^3 of fuel in 2001. This is equivalent to 1,451,226 MMBTU (1000 $m^3 \approx$ 40.3 MMBTU), which generates 1,530 TJ of energy (1 BTU $\approx$1.054 x 10^3 J of energy, refer Section 3.1). Using an emission factor of 1.5 μg TEQ/TJ for natural gas, this produces 2.295 mg TEQ/yr of PCDD/PCDF. In total, 3.177 mg TEQ/yr (0.882 + 2.295 mg TEQ/yr) of PCDD/PCDF was released to air from domestic cooking in 2001.

2.4 Production of Minerals

This category involved high-temperature processes for melting (glass, asphalt), baking (brick, ceramics), or thermally induced chemical transformation (lime, cement). In these processes, fuel combustion generates PCDD/PCDF as unwanted byproducts. Additionally, formation of PCDD/PCDF may be linked to the process raw materials used.

2.4.1 Cement production

There is one only cement industry in Brunei Darussalam. The cement is produced in this industry by grinding clinkers with gypsum. Emission of PCDD/PCDF has been associated with the production of clinkers at high temperature. Since both the clinkers and the gypsums are imported from other countries and the production of cement does not employ high temperature, contribution of this industry to PCDD/PCDF release is expected to be negligible. In addition to this, bag filter is used as an air pollution control in this industry.

2.4.2 Lime production

No lime is produced in Brunei Darussalam.

2.4.3 Brick production

Clay is used to produce bricks. Other materials are added to the clay to achieve desired porosity and other good qualities. There are six brick production industries in Brunei Darussalam. Typically, bricks are produced by using tunnel type kilns with firing temperature of about 1,000 °C. Kerosene, charcoal, waste timber or woods are used as fuels for such systems. None of these industries use any pollution control to clean the gas that is released into the atmosphere. These industries are classified under class 1 which is a system without a dust control. Emission factor for air under this category is 0.2 µg TEQ/t of brick produced. In 2001, a total of 69,754 tons of brick were produced and this contributed to an emission of 13.95 mg TEQ/yr of PCDD/PCDF to air.

2.4.4 Glass production

No glass is produced in Brunei Darussalam.

2.4.5 Ceramics production

No ceramics are produced in Brunei Darussalam.

2.4.6 Asphalt mixing

There are four asphalt-mixing industries in Brunei Darussalam. Asphalt is used for high quality road surface throughout the country. These industries use bitumen together with rock chips, sand and fillers to produce asphalt. Heating is used to dry the rock chip, sand and fillers. The hot mixtures are mixed with hot bitumen to generate asphalt.

Typically asphalt-mixing industries are equipped with gas cleaning systems that consist of bag house filter, cyclone and wet scrubber at about 100 °C. Under these conditions the asphalt-mixing industries are classified under category 2 with emission factor of 0.007 µg TEQ/t of asphalt produced. In 2001, a total of 713,280 tons of asphalt was produced giving rise to 4.99 mg TEQ/yr of PCDD/PCDF release to air.

2.5 Transportation

The release of PCDD/PCDF from transportation depends on the types of engines as well as the types of fuel used. The major fuels used in transportation are gasoline, diesel and LPG. Engine type can be classified under (i) 4-stroke engines which are used in cars, light trucks, motorcycles and other vehicles (ii) 2-stroke engines which includes most small gasoline powered internal combustion engines used today in boats, jet-skis, mopeds, small motorcycles, tut-tuks, lawnmowers, chain-saws and other vehicles (iii) diesel powered engines which are used in heavy trucks, light trucks, passenger cars, heavy construction equipment, boats, diesel generator, pumps and farm equipment including tractors and other large equipment (iv) heavy oil fired engines which are used for ships, tanks, stationary power generators and other very large quasi stationary motors. Different emissions occur during different phases such as start-up and engine warming for all types of engines. Here the emission factors quoted are based a steady state condition.

2.5.1 Four-Stroke engines

Since 1995 all cars imported into Brunei Darussalam are required to have catalytic converters fixed to their exhaust pipe. The cars fitted with catalytic converter must use unleaded petrol. Unleaded fuel was first introduced in Brunei in 1995 and totally phased out in March 2001. Altogether 257,778.17 m^3 of unleaded petrol was consumed in 2001. However, Emission factor for passenger cars using unleaded petrol is zero. Therefore, a negligible amount of PCDD/PCDF is released to the environment.

2.5.2 Two-Stroke engines

The type of two-stroke engines mostly available in Brunei Darussalam is passenger boats using unleaded fuel (regular RON 85). It is estimated that, in 2001, these boats ran 500,000 km. Fuel consumption is 9 L/km and density of this fuel is 0.74 kg/L. The two-stroke engine in Brunei Darussalam would therefore consume a total of 3,330 tons of fuel. The emission factor for this type of transport using unleaded fuel is 3.5 µg TEQ/t to air. The estimated value for the emission of PCDD/PCDF is 8.33 mg TEQ/yr to air.

2.5.3 Diesel powered engines

Transportation that uses diesel engines are heavy and light trucks, some passenger cars, heavy construction equipments, tanks, diesel generators, pumps, and farm equipment such as tractors and other large equipments. The method used for the calculation of PCDD/PCDF release to air is based on the information obtained on the amount of diesel that was supplied to all forms of transportation that consumed diesel as their fuel.

In 2001, the amount of diesel fuel used in transportation, industry (e.g. operation of generators) and others (agriculture, residential and commercial) was 134820.98 m^3 which is equivalent to 117,294 tons (density 1 $m^3 \approx 0.87$ ton). Using the emission factor for diesel engines of 0.5 µg TEQ/t, the amount of PCDD/PCDF release to air was 58.65 mg TEQ/yr.

2.5.4 Heavy oil fired engines

In other countries, heavy fuel oil (HFO) fired engine are used in ship, tanks and other very large stationary motors. However, in Brunei Darussalam the ships and tanks use diesel fuel. There are 177 ships registered in Brunei Darussalam from 1984 to Jan – March 2002. Since these ships use diesel fuel and there is only one emission factor for all type of diesel engines, calculation for emission of PCDD/PCDF to air is included in Section 5.3 above.

2.6 Uncontrolled Combustion Processes

Uncontrolled combustion processes are typically poor combustion processes and may be significant sources of PCDD/PCDF. This category can be divided into two sub-categories as listed below (Sections 6.1 – 6.2). The burning of biomass covers those burnings that occur in the open; this will include forest fires (deliberate and accidental), burning of grassland, and destruction by fire of agricultural residues in the field. However, controlled combustion in appliances such as stoves, furnaces and boiler plants are excluded from this category. Whereas the waste burning and accidental fires sub-category, a broad and poorly quantified sector, includes the deliberate combustion of waste materials for disposal where no furnace or similar is used – for example the burning of domestic and other waste in piles in the open, the burning of waste in landfills – both deliberate and accidental, fires in buildings, cars and similar vehicles.

Brunei Darussalam has laws to protect the public from the consequences of open burning that are likely to endanger human life, to cause the destruction of or damage to any property, or to cause any injury, annoyance or obstruction or to vitiate the atmosphere so as to make it noxious to the health of the public or any section of the public or any persons who may have access to use any public right. Under Section 6 of the Brunei Minor Offence Act (Chapter 30), burning or setting fire to any material to the annoyance, inconveniences or danger to the public is an offence with a fine of B$250.00. In addition, under Section 83(3) of the Constitution of Brunei Darussalam, open burning during a prescribed period is an offence and shall be liable on conviction to a fine not exceeding B$100,000.

2.6.1 Biomass Burning

This can be classified into (a) forest fires, (b) grassland, (c) bush fires and (d) agricultural residue burning. However, due to the difficulty in estimating the amount of material burned, estimations quoted by New Zealand are used in the calculations where for forest fire 10 tons of materials were burned per hectare of land, 20 tons/ha in bush fire and 2.5 tons/ha for grass fire and agricultural residues.

In 2001, an estimated 549 hectares of forest trees were burned which amounted to 5,490 tons of material burned. Using the emission factors for forest fire which are 5 µg TEQ/t and 4 µg TEQ/t of material burned to air and land releases, respectively, these correspond to 27.45 mg TEQ/yr of PCDD/PCDF release to air and 21.96 mg TEQ/yr release to land.

For the same year, an estimated 411 hectares of grassland was burned which correspond to 1,028 tons of material burned. Using the emission factors for grassland fire of 5 μg /t and 4 μg TEQ/t of material burned to air and land releases respectively, these correspond to 5.14 mg TEQ/yr of PCDD/PCDF release to air and 4.11 mg TEQ/yr release to land.

An estimated 130 hectares of agricultural residues were burned in 2001, which amounted to 325 tons of materials burned. Using the emission factors of 30 μg TEQ/t and 10 μg TEQ/t of material burned to air and land releases respectively, these correspond to 9.75 mg TEQ/yr of PCDD/PCDF release to air and 3.250 mg TEQ/yr release to land.

Bush fires accounted for 20 hectares of the land areas, which correspond to 400 tons of material burned. Using the emission factors for bush fire of 5 μg TEQ/t and 4 μg TEQ/t of material burned to air and land releases respectively, these amounted to 2.00 mg TEQ/yr of PCDD/PCDF release to air and 1.60 mg TEQ/yr release to land.

2.6.2 Waste Burning and Accidental Fires

This can be classified into (a) Landfill fires, (b) Accidental fires in houses, factories, (c) Uncontrolled domestic waste burning, (d) Accidental fires in vehicles, and (e) Open burning of wood (construction/demolition). There is occasional uncontrolled domestic waste burning as well as open burning of wood arises from construction and demolition but no estimation of the amount of material burned has been carried out. There are occasional landfill fires but there is also no information regarding the amount and types of materials burned. Therefore, estimations of PCDD/PCDF release from the above sources are not possible. In 2001, 44 cases of accidental fires in vehicles have been reported. Using the emission factors of 94 and 18 μg TEQ/event of vehicle fire, this accounted for 4.14 mg TEQ/yr release to the air and 0.79 mg TEQ/yr release as residue. A total of 105 events of accidental houses and factories fires occurred in 2001. However, due to the vast variation of house content, estimation of the amount of material burned is not feasible.

2.7 Production and Use of chemical and Consumer goods

The releases of dioxin and furan from production of chemicals and consumer goods may be due to PCD/PCDF input with the raw materials themselves or formation in the production process. This category describes the potency of the chemicals and consumer goods production sector to generate dioxins and furans and gives findings from measured data and information on characteristics to estimate/quantify release of PCDD/PCDF from the various activities in this sector. Altogether there are 5 subcategories as listed in Sections 7.1-7.5. The releases of PCDD/PCDF may occur via various pathways resulting in contamination of air, water, and soil or in the product. In addition, the residues may contain dioxin and furan contamination as well. For all the activities listed in this sector, the major emissions are not into the atmosphere but into other compartments.

2.7.1 Pulp and paper mills

There is no pulp and paper mill in Brunei Darussalam.

2.7.2 Chemical industries

There is no chemical industry in Brunei Darussalam.

2.7.3 Petroleum industry (refinery)

The only potential source for PCDD/PCDF within the petroleum refining industry is the re-generation of the catalyst used during catalytic cracking of the larger hydrocarbons molecules into smaller, lighter molecules. Emissions of PCDD/PCDF to water may occur upon discharge of the wastewater. In 2001, an estimated 370804 m^3 of wastewater has been discharged. Since there is no emission factor for all the media, estimation of the emission of PCDD/PCDF is not possible.

2.7.4 Textile plants

The sources of PCDD/PCDF from the textile industry originate from the various stages of textile preparations. These include such treatments of raw material as dyeing, printing, scouring, bleaching, singeing, mercerizing and water-intensive wet-processing stages. There is no pre-treatment of raw materials in Brunei because the entire textile related products, which include fiber, yarn and fabric, are imported into Brunei for further processing into finished goods. There are six clothes factories in Brunei Darussalam, which do not contribute to the emission of PCDD/PCDF.

2.7.5 Leather plants

There is no leather plant in Brunei Darussalam.

2.8 Miscellaneous

This category comprises 5 sub-categories that could not be classified in the other Main Source Categories. They are listed in Sections 8.1- 8.5. Drying processes involved hot gas brought into direct contact with the material to be dried. Formation of PCDD/PCDF occurs mostly due to reaction of the hot gases with stray organics. Whereas for crematories, the sources of PCDD/PCDF may be is due to the inefficient combustion process and the inhomogeneity of the input material which includes coffins, embalming fluids and decoration materials that may contain chlorinated chemicals and plastics, metal-based colours and non-combustible materials. Residues from dry cleaning are another source of PCDD/PCDF where dioxin-containing chemicals (mainly PCP and dyestuffs) have been concentrated after dry cleaning process.

2.8.1 Drying of biomass

There is no drying of biomass, such as wood chips or green fodder, in Brunei Darussalam.

2.8.2 Crematoria

Being a Muslim country, cremating is not a common practice even among the Chinese community, which accounted for about 15% of the population. There is only one crematorium in Brunei and in 2001; six cremations had been carried out. The furnace is fired using natural gas without any flue gas cleaning system. Assuming an emission factor of 90 µg /cremation to air release under a condition without control, this amounted to 0.540 mg TEQ/yr of PCDD/PCDF release to the air.

2.8.3 Smoke houses

There is no smoke house in Brunei Darussalam.

2.8.4 Dry cleaning residues

There are quite a number of dry cleaning launderettes in Brunei Darussalam but some of the smaller ones only serve as transit for sending and collection points and do not actually involve in the dry cleaning process. Therefore, estimation is based only on the big companies, which would be the major contributors to the release of PCDD/PCDF. PCDD/PCDF have been detected in the distillate residues from dry cleaning, which therefore contributed to the release as residues. An estimated 77,205 kg (about 77 tons) of textiles have been dry-cleaned in 2001. Based on the amount of distillation residue generated per kg of textiles cleaned, an estimated 3 g of distillation residues were generated per kg of textiles. Therefore a total of 231,615 g (equivalent to about 0.232 tons) of distillation residues was produced. Heavy textiles such as carpets are cleaned using aqueous based detergent and not dry clean. Therefore it can be assumed that all the textiles are normal textiles without PCP-treated which has an emission factor of 50 µg TEQ/t of the distillation residue. This corresponds to 0.0116 mg TEQ/yr of PCDD/PCDF release as residue.

2.8.5 Tobacco smoking

An estimated 20,000 cigars and 62 million cigarettes were imported in 2001. Only releases to air are significant in this case. With emission factors of 0.3 pg I-TEQ per cigar and 0.1 pg I-TEQ per cigarette of PCDD/PCDF release to air, these activities correspond to 0.006 mg TEQ/yr and 6.2 mg TEQ/yr from cigar and cigarette respectively.

2.9 Disposal/Landfill

This category addresses some disposal options other than incineration or thermal recycling. The cause for the presence of PCDD/PCDF is that dioxins and furans have been formed in the other processes but the contamination will be concentrated or dispersed by the management options as listed below (Sections 9.1-9.5). Examples of products contaminated with PCDD/PCDF have been addressed in the earlier sections especially in section 7, the production and use of chemical and consumer goods. The presence of dioxins and furans in the general human environment as consumer goods and in residues, including house dust, results in the fact that "normal" household waste contains PCDD/PCDF

2.9.1 Landfills and waste dumps

Waste dumps in the landfills are mainly domestic wastes and therefore it is classified under the non-hazardous waste category. This has an emission factor of 30 pg TEQ/L of leachate released. Altogether there are 4 landfills in Brunei Darussalam, which produce in total an estimated 300,000 tons of waste in 2001. However, estimation of the leachate from these landfills is not possible and therefore the amount of PCDD/PCDF release in water cannot be estimated.

2.9.2 Sewage and sewage treatments

The amount of PCDD/PCDF entering a sewage system or treatment works depends on the sources of wastewater. Wastewater includes human wastes (sewage), water from washing of people and clothes, in some cases storm water run-off and industrial effluents released to sewer. In Brunei Darussalam, it is estimated that on average, 365 liters of water is used per person per day. Using an estimated population of 344,500 in 2001, the amount of wastewater produced was 45,896 million liters. The sewage treatment plants in Brunei Darussalam are classified under the urban environment category with the removal of sludge. Under this classification, emission factor of PCDD/PCDF release to water is 0.5 pg I-TEQ/L and 100 µg TEQ/t dry matter of residue. This corresponds to 22.95 mg I-TEQ/yr release to water.

In Brunei Darussalam, sewage water effluent consists of 0.4 % of raw sludge, which contains 3% dry matters. Therefore the total amount of raw sludge produced 5508 tons of dry matter, which correspond to 550.80 mg TEQ/yr of PCDD/PCDF release as residues.

2.9.3 Composting

There is only one company that is dealing with a large scale-composting business. The garden wastes, which are collected from the company's own nursery, are ground and mixed with bacteria in a container. This mixture is left for 3-4 weeks at 55-70 °C. Since the materials involved are all garden wastes, the emission factor is classified under the green materials that do not impact environment and has a value of 5 µg TEQ per ton of dry matter contributing to residue release. In 2001, an estimated 10 tons of compost are produced which amounted to 0.05 mg TEQ/yr of PCDD/PCDF release as residues.

2.9.4 Open water dumping

Refer to section 9.5 below

2.9.5 Non-combustion waste oil disposal

There is no regulation as yet in Brunei to control the release of waste through open water dumping and waste oil disposal to the aqueous system. As a result, estimation of the amount of waste releases has not been carried out. Oils from cars, other motors etc can be recycled in Brunei but a minimal charge will be incurred for the transportation of used oil to the recycling site. This minimal charge has made the recycling program not very popular.

2.10 Hot Spots

This category exists as the direct result of disposal practices as described in Section 9 or of inadequate disposal of contaminated materials. It gives an indicative list of activities that might have resulted in the contamination of soils or sediments with PCDD/PCDF. If one of the activities listed below has been performed or is being practiced, there is a high probability to detect PCDD/PCDF contamination. Quantitative numbers cannot be given but in many cases concentrations will be several orders of magnitude higher than background concentrations. Each of such potential hot-spots needs a site-specific evaluation starting with a historic evaluation if the suspected activities have been taken place or are presently performed. Therefore, it is important to obtain an estimate of the magnitude of e.g. chemicals produced or used, time-scale of the activities (month, years, decades).

2.10.1 Production sites of chlorinated organics

There is no production of chlorinated organics in Brunei Darussalam.

2.10.2 Production sites of chlorine

There is no production of chlorine in Brunei Darussalam.

2.10.3 Formulation sites of chlorinated phenols

There is no formulation of chlorinated phenols in Brunei Darussalam.

2.10.4 Application sites of chlorinated phenols

There is no application site of chlorinated phenols in Brunei Darussalam.

2.10.5 Timber manufacture and treatment sites

There are four timber factories in Brunei and a total of 8152 m^3 of timber were treated with a Copper-Chrome-Arsenic (CCA) formulation in 2001. Since no pentachloropheno preservatives are used in any of the factory, the release of PCDD/PCDF is considered to be none or not significant.

2.10.6 PCB-filled transformers and capacitors

PCB-containing transformer or capacitor is a source of PCDF in the environment. The concentration of PCDF increases with increasing age and time of operation of the PCB-containing transformer. A dumping site for transformers, which stores 210 transformers manufactured from 1955 to 1985, was inspected. There was no indication that PCB fluid was used for any the stored transformer. Instead, Diala B Shell, a highly refined base oils, was used for all the stored transformers. Therefore the release of PCDF from these transformers is expected to be none or very low. However, judging from the age of the transformers, the presence of PCB-fluid may be possible. It would be helpful if information such as the make, producer and date of manufacture of the PCB-based transformers are made available so that comparison can be made with those available in Brunei.

2.10.7 Dumps of water/residues from categories 1-9

Residues from the clinical waste incinerators, accidental fires in houses, factories, uncontrolled domestic burning, accidental fires in vehicles, open burning of wood from construction/demolition sites, crematoria, dry-cleaning and wastewater treatment may pose as hot spot under this subcategory. However, nearly all the residues created in the above activities are dumped in the landfills which therefore pose as an important hot-spot for the release of PCDD/PCDF into the environment

2.10.8 Sites of relevant accidents

Sites of relevant accidents such as fires can produce soot and residues with various concentrations of PCDD/PCDF depending on the types of materials burned. Similar to the above case (Section 10.7), most of the residues resulting from fires are transported and dumped in the landfills. Some of the soot or residues may be washed away by rain.

2.10.9 Dredging of sediments

Dredging of sediments from harbours is often necessary to maintain the depth of the harbours for ship. However, these sediments may be contaminated with PCDD/PCDF. Normally, the sediments are being dredged and placed on land, which result in transferring the PCDD/PCDF contamination from its original location to another. In Brunei Darussalam, a slightly different approach is carried out. Dredging is done four times a week and the sediments are thrown three kilometers away from the port into the ocean. Therefore insignificant amount has gone to the land.

2.10.10 Kaolinitic or ball clay sites

There is no mining of kaolinitic or ball clay in Brunei Darussalam.

3 SUMMARY

The quantities of dioxin and furan releases from all categories are summarized in Table 1. An estimated 1,401 mg TEQ of PCDD/PCDF was released into the environments of Brunei Darussalam in 2001. For comparison, an estimated 2,100 g TEQ was released from known sources by the USA (Travis and Nixon, 1996), which is about 1,500-times higher than that release in Brunei Darussalam. Table 1 shows that waste incineration (42.0%) and disposal/landfill (41.0%) are the major contributors to known environmental sources of PCDD/PCDF. Next are uncontrolled burning (5.7%), transport (4.8%) and production of mineral products (4.4%). The other categories each contributed to less than 2% of the total emission. The results in Table 1 are also plotted as bar chart and are shown in Figure 1, which compares the PCDD/PCDF releases for categories 1-9. Figure 2 compares the PCDD/PCDF released from all the media. It shows that release to air is the predominant medium contributing to 52.9% of the total, followed by residue (39.3%), product (3.0%), land (2.2%) and water (1.6%). This order of arrangement is probably due to the fact that the emission factors for air release are the most complete as compare to the other media.

It should be noted that for a few of the subcategories, where estimations of the amount of materials used were not feasible, emissions due to these subcategories were not calculated and therefore the quantities of PCDD/PCDF are not included in the estimation summarized in Table 1. This may results in the underestimation of the PCDD/PCDF releases in those categories. For example, estimation of the amount of materials burned under subcategories of uncontrolled burning which include landfill fires, uncontrolled domestic waste burning, accidental fires in houses and factories, were not feasible. Therefore emissions due to these subcategories could not be carried out (refer 6.2 (a), (b), (c), and (e)). Therefore the "actual" estimated amount of the PCDD/PCDF releases from this category should be higher than the 80.19 mg TEQ/a as stated in Table 1.

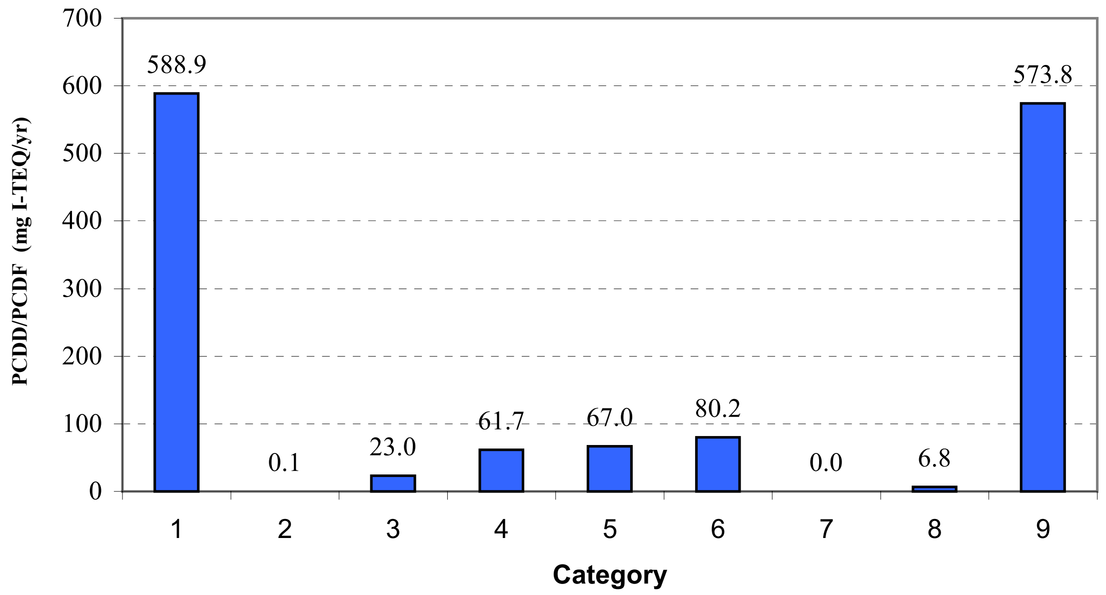
Similarly, due to the difficulty in the estimation of leachate from the landfills, *etc.* (refer sections 9.1, 9.4 and 9.5), the "actual" emission releases from the disposal/landfill category is expected to be higher than the stated amount of 573.8 mg TEQ/yr in Table 1. The amount of PCDD/PCDF released by the waste incineration and disposal/landfill are comparable, i.e. 588.9 mg TEQ/yr and 573.8 mg TEQ/yr respectively. Should measurement or estimation is made possible for the leachate; the disposal/landfill category may have a higher contribution to the release of PCDD/PCDF than the waste incineration. This is supported by the fact that the landfills are also an important and major hot spot in Brunei Darussalam (refer 10.7 and 10.8).

Table 1: An overview of the national releases of PCDD/PCDF in Brunei Darussalam (2001)

Category	Source Categories	Annual Release (mg TEQ/yr)					Total*
		Air	Water	Land	Product	Residue	All media
1	Waste Incineration	585.0	-	-	-	3.900	588.9
2	Ferrous and non-ferrous metal production	0.090	0.0018	0	0	0	0.0918
3	Power generation and heating	22.98	-	-	-	-	22.98
4	Production of mineral products	18.94	-	-	42.80	-	61.74
5	Transport	66.97	-	-	-	-	66.97
6	Uncontrolled combustion processes	48.48	-	30.92	-	0.792	80.19
7	Production of chemicals, consumer goods	0	0	0	0	0	0
8	Miscellaneous	6.746	-	-	-	0.012	6.758
9	Disposal/Landfill	-	22.95	-	0.050	550.8	573.8
10	Identification of Hot Spots						
1- 9	Total	749.2	22.95	30.92	42.85	555.0	1,401

**Total of all media of each category*
- represents either NA or ND or NA/ND

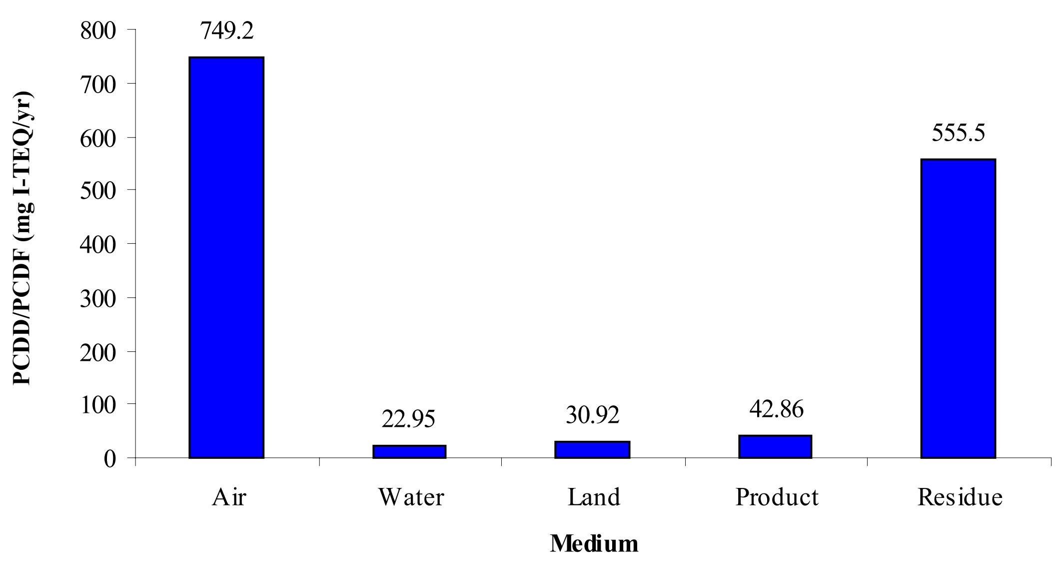
Figure 1: Comparison of PCDD/PCDF releases for categories 1-9



Keys:

1 = Waste incineration
2 = Ferrous and non-ferrous metal production
3 = Power generation and heating
4 = Production of mineral products
5 = Transport
6 = Uncontrolled combustion processes
7 = Production of chemicals, consumer goods
8 = Miscellaneous
9 = Disposal/landfill

Figure 2: Comparison of PCDD/PCDF releases from all media (categories 1-9)



4 CONCLUSION

The Toolkit is very useful for the estimation release of PCDD/PCDF into the environment. In Brunei Darussalam the major sources of PCDD/PCDF releases are from medical waste incinerators and residues of sewage treatment plant. The residues are dumped into landfill and this had caused the PCDD/PCDF in the residues to be transferred to the land. Both sources have contributed to 82% of total release into environment.

The main release routes of PCDD/PCDF are the air and the landfill. The other main categories contribute to the release of PCDD/PCDF in quantities that are not very significant. They are made up of about 20% of the total amount of PCDD/PCDF released into the environment.

5 RECOMMENDATION

Every country should implement laws that would regulate release of PCDD/PCDF into the environment and the government should initiate activities such as recycling of materials that are not commercially viable.

6 COMMENTS ON THE STANDARDIZED TOOLKIT

Most of the comments are related to the limitations as stated on page 6 of the Toolkit, i.e. little is known about process and emission factors for processes and technologies used in less developed countries and region-specific feedstock or input materials. Therefore it will be helpful if the following information

(1) Estimation of the material burned in biomass burning are based on the New Zealand data which can be quite different from those found in Brunei, i.e. the amount of material found in the New Zealand forest/grassland might be very different from those in Brunei. Therefore emission factors for the tropical type forest, if make available, should provide a better estimation for Brunei emission.

(2) More information and data is needed for the estimation of house fire emission.

(3) Describe ways of how leachate or seepage from landfill and dumps can be estimated since many types of residues are dumped on the landfill, which as a result has become one of the important hot spot. In addition, due to the different mixtures of wastes dumped on landfill perhaps it is necessary that samples from the leachate are collected and sent for analysis.

(4) Emissions from accidental house fire cannot be estimated because of the vast variations of house material, which is difficult to estimate.

(5) Site of PCB-filled transformers and capacitors as a hot spot – it would be helpful if information such as the make, producer and date of manufacture of the PCB-based transformers are made available so that comparison can be made with those available in Brunei.

Appendix A: Release Listing per Category and Subcategory

Table 2: Waste incineration

Source categories	Potential Release Route (µg TEQ/t)				Residues		Production t/a	Annual release (mg TEQ/a)				
Category 1. Waste Incineration	Air	Water	Land	Products	Fly Ash	Bottom Ash		Air	Water	Land	Fly Ash	Bottom Ash
(a) Municipal solid waste incineration												
1. Low Technol. Combustion, no APC system	3,500		NA	NA	0	75	0	0				0
2. Controlled comb. Minimal APC	350		NA	NA	500	15	0	0				0
3. Controlled comb., good APC	30		NA	NA	200	7	0	0				0
4. High tech. Comb. Sophisticated APCS	0.5		NA	NA	15	1.5	0	0				0
(b) Hazardous waste incineration												
1. Low Technol. Combustion, no APC system	35,000		NA	NA	9,000		0	0				0
2. Controlled comb., minimal APC	350		NA	NA	900		0	0				0
3. Controlled comb., good APC	10		NA	NA	450		0	0				0
4. High tech. Comb., sophisticated APCS	0.75		NA	NA	30		0	0				0
(c) Medical/hospital waste incineration												0
1. Uncontrolled batch combustion, no APCS	40,000		NA	NA		200	0	0				0
2. Controlled comb. minimal APC	3,000		NA	NA		20	195	585.0				3.900
3. Controlled comb., good APC	525		NA	NA	920		0	0				0
4. High tech. Comb. Sophisticated APCS	1		NA	NA	150		0	0				0
(d) Light fraction shredder waste incineration												
1. Uncontrolled batch combustion, no APCS	1,000		NA	NA			0	0				0
2. Controlled, batch, no or minimal APC	50		NA	NA			0	0				0
3. High tech. Comb. Sophisticated APCS	1		NA	NA	150		0	0				0
(e) Sewage sludge incineration												
1. Old furnaces, batch, no/little APCS	50		NA	NA	23		0	0				0
2. Updated, continuously, some APCS	4		NA	NA	0.5		0	0				0
3. State-of-the -art, full APCS	0.4		NA	NA	0.5		0	0				0

Table 2: Waste incineration (cont´d.)

Source categories	Potential Release Route (µg TEQ/t)				Residues		Production t/a	Annual release (mg TEQ/a)				
Category 1. Waste Incineration	Air	Water	Land	Products	Fly	Bottom		Air	Water	Land	Fly Ash	Bottom
(f) Waste wood and waste biomass incineration												0
1. Old furnaces, batch, no/little APCS	100		NA	NA	1,000		0	0				0
2. Updated, continuously, some APCS	10		NA	NA	10		0	0				0
3. State-of-the -art, full APCS	1		NA	NA	0.2		0	0				0
(g) Animal carcasses burning												
1. Old furnaces, batch, no/little APCS	500		NA	NA			0	0				0
2. Updated, continuously, some APCS	50		NA	NA			0	0				0
3. State-of-the -art, full APCS	5		NA	NA			0	0				0
Waste Incineration								**585.0**				**3.900**

Table 3: Ferrous and non-ferrous metal production

Source categories	Potential Release Route (µg TEQ/t)					Production t/a	Annual release (mg TEQ/a)				
Category 2. Ferrous and Non-ferrous metal production	Air	Water	Land	Products	Residues		Air	Water	Land	Products	Residues
(a) Iron ore sintering											
1. High waste recycling, incl. (Oil contaminant. Materials)	20	ND	ND	ND		0					
2. Low waste use, well controlled plant	4	ND	ND	ND		0					
3. High technology, emission reduction	0.3	ND	ND	ND		0					
(b) Coke production											
1. No gas cleaning	3	ND	0.06	ND		30	0.009	0.0018			
2. Afterburner/dust removal	0.3	ND	0.06	ND		0					
(c) Iron and steel production plants and foundries											
Iron and steel plants											
1. Dirty scrap, scrap preheating, limited controls	10	ND	ND	NA		0					
2. Clean scrap/virgin iron, afterburner, fabric filter	3	ND	ND	NA		0					
3. Clean scrap/virgin ions, BOS furnaces	0.1	ND	ND	NA		0					
4. Blast furnaces with APC	0.01	ND	ND	NA		0					
Foundries											
1. Cold air cupola or rotary drum, no APCS	10	ND	ND	ND		0					
2. Rotary drum - fabric filter	4.3	ND	ND	ND		0					
3. Cold air cupola, fabric filter	1	ND	ND	ND		0					
4. Blast cupola or induction furnace, fabric filter	0.03	ND	ND	ND		0					
(d) Copper production											
1. Sec. Cu - Basic technology	800	ND	ND	ND		0					
2. Sec. Cu - well controlled	50	ND	ND	ND		0					
3. Sec. Cu - optimized for PCDD/PCDF control	5	ND	ND	ND		0					
4. Smelting and casting of Cu/Cu alloys	0.03	ND	NA	NA		0					
5. Prim. Cu – all type.	0.01	ND	ND	ND		0					

Table 3: Ferrous and non-ferrous metal production (cont´d.

Source categories	Potential Release Route (µg TEQ/t)					Production t/a	Annual release (mg TEQ/a)				
Category 2. Ferrous and Non-ferrous metal production	Air	Water	Land	Products	Residues		Air	Water	Land	Products	Residues
(e) Aluminium production (all sec.) Processing scrap Al, minimal treatment of inputs											
1. Simple dust removal	150	ND	ND	ND		0					
2. Scrap treatment, well controlled, good APCS	35	ND	ND	ND		0					
3. Shaving/turning drying	10	ND	ND	ND		0					
4. Optimized process, optimized APCS	1	ND	ND	ND		0					
(f) Lead production											
1. Scrap containing PVC battery separator	80	ND	NA	NA		0					
2. PVC free scrap in blast furnaces with FF	8	ND	NA	NA		0					
3. PVC/Cl_2 free scrap in furnaces other than blast or blast furnace with scrubber	0.5	ND	NA	NA		0					

Table 3: Ferrous and non-ferrous metal production (cont´d.)

Source categories	Potential Release Route (µg TEQ/t)					Production t/a	Annual release (mg TEQ/a)				
Category 2. Ferrous and Non-ferrous metal production	Air	Water	Land	Products	Residues		Air	Water	Land	Products	Residues
(g) Zinc production											
1. Kiln with no dust control	1,000	ND	ND	ND		0					
2. Hot briquetting/rotary furnaces, basic control	100	ND	ND	ND		0					
3. Comprehensive control	5	ND	ND	ND		0					
4. Melting (only)	0.3	ND	ND	ND		0					
(h) Brass production											
1. Simple melting furnaces	1	ND	ND	ND		0					
2. Sophisticated equipment, e.g. induction ovens with APCS	0.1	ND	ND	ND		0					
(i) Magnesium production											
1. Using MgO/C thermal treatment in C12, no effluent	250	9,000	NA	ND		0					
treatment, poor APCS											
2. Using MgO/C thermal treatment in C12,	50	24	NA	ND		0					
comprehensive pollution control											
(j) Thermal non-ferrous metal production (e.g. Ni)											
1. Contaminated scrap, simple or no dust control	100	ND	ND	ND		0					
2. Clean scrap, good APCS	2	ND	ND	ND		0					
(k) Shredders											
1. Metal shredding plants	0.2	NA	NA	ND		0					
(l) Thermal wire reclamation											
1. Open burning of cable	5,000	ND	ND	ND		0					
2. Basic furnace with after burner, wet scrubber	40	ND	NA	ND		0					
3. Burning electric motors, brake shoes, etc., afterburner	3.3	ND	NA	ND		0					
Ferrous and non-ferrous metal production							**0.009**	**0.0018**			

Table 4: Power generation and heating

Source categories	Potential Release Route (µg TEQ/TJ)					Production TJ/a	Annual release (mg TEQ/a)				
Category 3. Power generation and heating	Air	Water	Land	Products	Residues		Air	Water	Land	Products	Residues
(a) Fossil fuel power plants											
1. Fossil fuel/waste co-fired power boilers	35	NA	NA	NA		0	0				
2. Coal fired power boilers	10	NA	NA	NA		0	0				
3. Heavy fuel fired boilers	2.5	NA	NA	NA		0	0				
4. Light fuel/oil/natural gas fired power boilers	0.5	NA	NA	NA		39,609	19.805				
(b) Biomass power plants							0				
1. Other biomass fired power boilers	500	NA	NA	NA		0	0				
2. Wood fired power boilers	50	NA	NA	NA		0	0				
(c) Landfill and biogas combustion							0				
1. Biogas-fired boilers, motors/turbines and flaring	8	NA	NA	NA		0	0				
(d) Household heating and cooking - Biomass							0				
1. Contaminated wood/biomass fired stoves	1,500	NA	NA	NA		0	0				
2. Virgin wood/biomass fired stoves	100	NA	NA	NA		0	0				
(e) Domestic heating - fossil fuels							0				
1. Coal fired stoves	70	NA	NA	NA		0	0				
2. Oil fired stoves	10	NA	NA	NA		0	0				
3. Natural gas fired stoves	1.5	NA	NA	NA		2,118	3.177				
Power generation and heating							**22.982**				

Table 5: Production of mineral products

Source categories	Potential Release Route (µg TEQ/t)					Production t/a	Annual release (mg TEQ/a)				
Category 4. Production of mineral products	Air	Water	Land	Products	Residues		Air	Water	Land	Products	Residues
(a) Cement kilns											
1. Wet kilns, ESP temperature > 300 °C	5	NA	ND	ND		0	0				
2. Wet kilns, ESP/FF temperature 200 to 300 °C	0.6	NA	ND	ND		0	0				
3. Wet kilns, ESP/FF temperature < 200 °C and all types	0.15	NA	ND	ND		0	0				
(b) Lime							0				
1. Cyclone/no dust control	10	ND	ND	ND		0	0				
2. Good dust abatement	0.07	ND	ND	ND		0	0				
(c) Brick											
1. Cyclone/no dust control	0.2	ND	ND	ND		69,754	13.95				
2. Good dust abatement	0.02	ND	ND	ND		0	0				
(d) Glass											
1. Cyclone/no dust control	0.2	ND	ND	ND		0	0				
2. Good dust abatement	0.015	ND	ND	ND		0	0				
(e) Ceramics											
1. Cyclone/no dust control	0.2	ND	ND	ND		0	0				
2. Good dust abatement	0.02	ND	ND	ND		0	0				
(f) Asphalt mixing											
1. Mixing plant with no gas cleaning	0.07	ND	ND	ND		0	0				
2. Mixing plant with fabric filter, wet scrubber	0.007	ND	ND	ND		713,280	4.99			42.80	
Production of mineral products							**18.94**			**42.80**	**0**

Table 6: Transport

Source categories	Potential Release Route (µg TEQ/t)					Production t/a	Annual release (mg TEQ/a)				
Category 5. Transport	Air	Water	Land	Products	Residues		Air	Water	Land	Products	Residues
(a) 4-stroke engines											
1. Leaded fuel	2.2	NA	NA	NA		0	0				
2. Unleaded fuel without catalyst	0.1	NA	NA	NA		0	0				
3. Unleaded fuel with catalyst	0	NA	NA	NA		0	0				
(b) 2-stroke engines											
1. Leaded fuel	3.5	NA	NA	NA		0	0				
2. Unleaded fuel without catalyst	2.5	NA	NA	NA		3,330	8.325				
(c) Diesel engines											
1. Diesel engines	0.5	NA	NA	NA		117,294	58.647				
(d) Heavy oil fired engines											
1. All types	4	NA	NA	NA		0	0				
Transport							**66.97**				

Table 7: Uncontrolled combustion processes

Source categories	Potential Release Route (µg TEQ/t)					Production t/a	Annual release (mg TEQ/a)				
Category 6. Uncontrolled combustion processes	Air	Water	Land	Products	Residues		Air	Water	Land	Products	Residues
(a) Fires/burning - biomass											
1. Forest fires	5	ND	4	NA		5,490	27.45		21.96		
2. Grassland and moor fires	5	ND	4	NA		1,028	5.14		4.11		
3. Agricultural residue burning (in field)	30	ND	10	NA		325	9.75		3.25		
4. Bush fires	5	ND	4	NA		400	2.00		1.60		
(b) Fires, waste burning, landfill fires, industrial fires,											
accidental fires											
1. Landfill fires	1,000	ND	NA	NA		ND					
2. Accidental fires in houses, factories	400	ND	see	NA		ND					
3. Uncontrolled domestic waste burning	300	ND	resi-	NA		ND					
4. Accidental fires in vehicles (per event)	94	ND	due	NA		44	4.14				0.792
5. Open burning of wood (construction/demolition)	60	ND	ND	NA		ND					
Uncontrolled combustion processes							**48.48**		**30.92**		**0.792**

Table 8: Production of chemicals and consumer goods

Source categories Category 7. Production of chemical, consumer goods	Potential Release Route (µg TEQ/t) Air	Water	Land	Products	Residues	Production t/a	Annual release (mg TEQ/a) Air	Water	Land	Products	Residues
(a) Pulp and paper mills											
Boilers (per ton of pulp)						0					
1. Black liquor boilers, burning of sludges, wood	0.07					0					
2. Bark boilers only	0.4					0					
Sludges	µg TEQ/ ADt	µg TEQ/L	µg TEQ/ ADt	µg TEQ/t sludge		0					
1. Kraft process, old technology (Cl2)	4.5	70	4.5	1000		0					
2. Kraft process, modern technology (C1O2)	0.06	2	0.2	10		0					
3. TMP pulp											
4. Recycling pulp											
Pulp and paper											
1. Kraft pulps/papers from primary fibers, Cl2				8		0					
2. Sulfite papers, old technology (Cl2)				1		0					
3. Kraft papers, new technology (ClO2, TCF), unbleached papers				0.5		0					
4. Sulphite papers, new technology (ClO2, TCF)				0.1		0					
5. Recycling paper				10		0					

Table 8: Production of chemicals and consumer goods (cont´d.)

Source categories Category 7. Production of chemical, consumer goods	Potential Release Route (µg TEQ/t) Air	Water	Land	Products	Residues	Production t/a	Annual release (mg TEQ/a) Air	Water	Land	Products	Residues
(b) Chemical industry											
PCP											
1. European, American production (chlorination of phenol with Cl2)				2,000,000		0					
2. Chinese production (thermolysis of HCH)				800,000		0					
3. PCP-Na				500		0					
PCB											
1. Low chlorinated, e.g. Clophen A30, Aroclor 1242				15,000		0					
2. Medium chlorinate e.g. Clophen A40, Aroclor 1248				70,000		0					
3. Medium chlorinate e.g. Clophen A50, Aroclor 1254				300,000		0					
4. High chlorinated e.g., Clophen A60, Aroclor 1260				1,500,000		0					
Chlorinated pesticides											
1. Pure 2,4,5-Trichlorophenoxy acetic acid (2,3,5-T)				7,000		0					
2. 2,4,5-Trichlorophenol (2,4,6-PCPh)				700		0					
3. Dichlorprop				1,000		0					
4. 2,4-Dichlorophenoxy acetic acid (2,4-D)				700		0					
5. 2,4,6-Trichlorophenyl-4'-nitrophenyl ether (CNP)											
Old technology				300,000		0					
New technology				400		0					

Table 8: Production of chemicals and consumer goods (cont´d.)

Source categories	Potential Release Route (µg TEQ/t)					Production t/a	Annual release (mg TEQ/a)				
Category 7. Production of chemical, consumer goods	Air	Water	Land	Products	Residues		Air	Water	Land	Products	Residues
6. Chlorobenzenes				ND		0					
7. Chlorine production with graphite anodes				NA		0					
Chloranil											
1. P-chloranil via chlorination of phenol				400,000		0					
2. P-chlorinil via hydrochinone				100		0					
3. Dyestuffs on chloranil basis (old, Class 1)				1,200		0					
4. O-chlorinil via chlorinationof phenol				60,000		0					
ECD/VCM/PVC											
1. Old technology, EDC/VCM, PVC		1				0					
2. Modern plants											
EDC/VCM and/or EDC/VCM/PVC	0.95	0.015		0.03		0					
PVC only	0.0003	0.03		0.1		0					
(c) Petroleum refineries											
1. All types	ND	NA	NA	NA		0					
(d) Textiles plants											
1. Upper limit	NA	ND	NA	100		0					
2. Lower limit	NA	ND	NA	0.1		0					
(e) Leather plants											
1. Upper limit	NA	ND	NA	1,000		0					
2. Lower limit	NA	ND	NA	10		0					
Production of chemicals, consumer goods											

Table 9: Miscellaneous

Source categories	Potential Release Route (µg TEQ/t)					Production t/a	Annual release (mg TEQ/a)				
Category 8. Miscellaneous	Air	Water	Land	Products	Residues		Air	Water	Land	Product	Residue
(a) Drying of biomass											
1. Clean wood	0.007	NA	ND	0.1		0	0				
2. Green fodder	0.1	NA	ND	0.1		0	0				
3. PCP-or otherwise treated biomass	10	NA	ND	0.5		0	0				
(b) Crematories							0				
1. No control	90	NA	ND	ND		6	0.54				
2. Medium control	10	NA	ND	ND		0	0				
3. Optimal control	0.4	NA	ND	ND		0	0				
(c) Smoke houses							0				
1. Treated wood, waste fuels used as fuel	50	NA	ND	ND		NS	0				
2. Clean fuel, no afterburner	6	NA	ND	ND		NS	0				
3. Clean fuel, afterburner	0.6	NA	ND	ND		NS	0				
(d) Dry cleaning residues							0				
1. Heavy textiles, PCP-treated, etc.	NA	NA	NA	NA		NS	0				
2. Normal textiles	NA	NA	NA	NA		0	0				0.0116
(e) Tobacco smoking											
1. Cigar (per item)	0.0003	NA	NA	NA		20,000	0.006				
2. Cigarette (per item)	0.0001	NA	NA	NA		62,000,000	6.2				
Miscellaneous							6.746	0	0	0	0.0116

Table 10: Disposal/Landfill

Source categories	Potential Release Route (µg TEQ/t)					Production L/a or t/a	Annual release (mg TEQ/a)				
Category 9. Disposal/Landfill	Air	Water	Land	Products	Residues		Air	Water	Land	Product	Residues
(a) Landfill leachate											
1. Hazardous waste	NA	200	NA	NA		NP					
2. Non-hazardous waste	NA	30	NA	NA		NP					
(b) Sewage/sewage treatment											
1. Industrial, mixed domestic with chlorine relevance											
No sludge removal		5	NA	NA		0					
With sludge removal		0.5	NA	NA		0					
2. Urban environment											
No sludge removal		2	NA	NA		0					
With sludge removal		0.5 pg-TQ/L	NA	NA		45,896,000,000 L/a		22.95			
						5,508 t/a					550.8
3. Remote and residential or modern treatment plant		0.5	NA	NA		0					
(c) Open water dumping											
1. Contaminated waste waters	NA	50	NA	NA		ND					
2. Uncontaminated wastewaters	NA	5	NA	NA		ND					
(d) Composting											
1. All organic fraction	NA	ND	NA	100		0					
2. Garden, kitchen wastes	NA	ND	NA	15		0					
3. Green materials, not impacted environments	NA	ND	NA	5		10				0.050	
(e) Waste oil disposal											
1. All fractions	4	ND	ND	ND		ND					
Disposal/Landfill								**22.95**		**0.050**	**550.8**

Table 11: Identification of Hot spots

Source categories	Potential Release Route (µg TEQ/t)					Production t/a	Annual release (mg TEQ/a)				
Category 10. Identification of Hot Spots	Air	Water	Land	Products	Residues		Air	Water	Land	Product	Residues
	x indicates need for site-specific evaluation										
(a) Production sites of chlorinated organics											
1. Chlorophenol and derivatives or PCB											
2. Other chlorinated organics											
(b) Production sites of chlorine											
1. With graphite electrodes											
2. Without graphite electrodes											
(c) Formulation of chlorinated phenols/pesticides											
(d) Application sites of dioxin-contaminated pesticides											
(e) Timber manufacture											
1. Using pentachlorophenol, other dioxin-contaminating preservatives											
2. No use of PCP, not open to the environment											
(f) PCB containing equipment											
1. Leaching											
2. Not leaching											
(g) Dumps of waste/residues from categories 1-9		x	x								
(h) Sites of relevant accidents		x	x								
(i) Dredging of sediments		x	x								
(j) Kaolinitic or ball clay sites											
Identification of Hot Spots											

Identification and Quantification of Dioxin and Furan Releases in Jordan

Final Report

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Jordan

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UNEP Chemicals

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Executive Summary

This report presents the findings of the project on the identification and estimation of dioxin/furan releases in Jordan. The investigated source categories include: waste incineration; ferrous and non-ferrous metal production; power generation; production of mineral products; transport; uncontrolled combustion process; production and use of chemicals and consumer goods; dry cleaning and tobacco smoking; disposal; and hot spots. The implementation of the project has begun since February 2002 and was finalized by the end of April 2003. The study has been conducted by using the “Toolkit for Identification of Dioxin and Furan Releases” developed by UNEP Chemicals in 2001. The key goal of the Toolkit is to assist countries in identifying sources and estimating releases of dioxins and furans. It covers all known sources of environmental releases, and attempts to do so in a way that provides a basis for comparability.

The procedures adopted by the project team are as follows: first, the sources relevant to the reported categories and subcategories are identified. Second, the needed information on the processes has been collected by applying the standard questionnaire. The design of the later has been based on the background information on the dioxin formation. Once the questionnaires are filled, quantifying the emissions from the identified sources has been estimated. This has been achieved by using the default/measured emission factors as provided by the Toolkit. Then the results are reported.

The estimated emissions and concentrations, which have been determined are presented for each category and subcategory. The findings of the study suggest that the largest contribution of the Dioxin and Furan releases comes from the following subcategories: uncontrolled burning of solid waste disposal and waste water disposal. It is expected that such results shall have an impact on the environmental policy in general and of those subcategories in particular. Furthermore, it is believed that the need to introduce a monitoring program has become very essential in order to verify the results and monitor the trends. Identified hot spots and suggestions for future plan are also presented. Finally, the report is structured into four sections. Section one gives an over view about Jordan. Section two introduces the method and procedures adopted by the project team. Section three contains estimates for the releases of dioxin and furan from the investigated sources. Section four concludes the study and suggests direction for further work.

1 INTRODUCTION

This report presents the findings of the project on the identification and estimation of dioxin/furan releases in Jordan. The implementation of the project has begun since February 2002 and it is still going on. Jordan has recently, signed and ratified the Global Convention on Persistent Organic Pollutants (POPs). The Convention calls upon Parties to reduce the total releases of by-products such as polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans ((PCDF) with the goal of continuing minimizations and where feasible, ultimate elimination.

The case that POPs is toxic and persistent chemicals that bioaccumulate in the environment and transfer across borders presents a global concern. It can be said that implementing the study indicates a positive response to the global concern. In other words, Jordan recognizes the problem and commits itself to meet its obligation as a party to the POPs Convention.

1.1 Country Profile

Jordan is a country with a total land area of 89,340 sq km and a population of about 5.2 million. The population is concentrated in three regions. The middle region covers a small area of 15,395 sq km with population density per sq km of about 211.7 while the northern region area is 28,870 sq km which is larger. However, the population density is 49.6. The third is the southern region which comprises the largest area in the country (45,080 sq km) but with the smallest population density of 10.9 inhabitants per sp. km. Thus the middle region contains the major activities such as transport activities, industrial, business, etc. This is evident from the large population density. Further, Jordan is dominated by an arid climate and fragile ecological systems. The total cultivated area according to 1999 statistics is 3,054 thousand donum (donum =1000 sq. meter). And the majority of this land is located in the middle and northern regions.

The country has suffered several times from sudden increase in population as a result of political instability in the region. Jordan has also witnessed rapid industrial development since 1950, the population was 600,000 in 1950 and according to 1994 statistics figures is 4,095,579. Number of hospitals was 14 in 1950 and has increased to 93 in 2002, with a total number of 9,000 beds. In order to promote development of the industrial sector, the government of Jordan has established a number of zones to house small and medium size industries. The government has taken serious actions for implementing programs for environmental protection. The New "Jordanian Environmental Law" was passed in October 1995 with main objectives emphasizing on the need for sustainable development and environmental protection.

In 1980, the Organization for Industrial Zones was declared. Accordingly, several industrial zones were established in a number of cities in the kingdom. A total of 350 industries and manufacturing companies have been established in Amman Industrial City, with a total investment of one billion USD according to 1997 statistics.

2 METHODOLOGY

The study has been performed by the "Toolkit for Identification of Dioxin and Furan Releases" developed by UNEP Chemicals in 2001. The key goal of the Toolkit is to assist countries in identifying sources and estimating releases of dioxins and furans.

It covers all known sources of environmental releases, and attempts to do so in a way that provides a basis for comparability.

Table 2-1: Screening Matrix

Main Source Categories	Air	Water	Land	Product	Residue
1-Waste Incineration	X				X
2-Ferrous and Non-Ferrous Metal Production	X		X		X
3-Power Generation	X		X		X
4-Production of Mineral Products	X				
5-Transport	X				
6-Uncontrolled Combustion Process	X	X	X		X
7-Production and Use of Chemicals and Consumer Goods	X	X		X	X
8-Miscellaneous	X	X	X	X	X
9-Disposal	X	X	X	X	X
10-Identification of Hot Spots	Registration to be followed by site-specific evaluation.				

To quantify the dioxin and furan releases from the various categories the team has developed questionnaires based on the background information on the dioxin formation. Once the questionnaires are filled, the releases are estimated. This is achieved by using the emission factors as provided by the Toolkit.

2.1 Study Background

The basic aim of this project is to identify sources of PCDD/PCDF emission and release routes relevant to all sectors .The recommended five step approach for establishing national dioxins release inventory was adopted in this study as illustrated in which involve the following guidelines and main activities:

- Identifying sources relevant to the reported categories
- Identifying activities and sources relevant to subcategories
- Collecting needed information on the processes by applying the standard questionnaire.
- Quantifying emissions from identified sources with default/measured emission factors.
- Reporting results using the standard format.

2.2 Project Team

A national team was formed in February 2002 and comprises a group of environmental engineers, a local expert and a project coordinator. Periodical meetings were planned and each member of the team was assigned a task for each given category so as to collect needed information or data from activities, which have a potential release of PCDD/PCDF into one or more of the five compartments in Jordan.

3 ESTIMATING AVERAGE ANNUAL RELEASES FROM THE MAIN CATEGORIES AND SUBCATEGORIES

Average annual releases to each vector (air, water, land, products and residues) for each process been identified have also been calculated using the equation been provided (Page 15 of the Standardized Toolkit 2001) and presented in grams of toxic equivalents (TEQ) per year and all the date collected and related calculations in this project where for the year 2000.

The recommended calculations for annual source strength indicated in the Toolkit have also been considered and results obtained have been tabulated in the standardized format provided in the Toolkit.

The main source categories of Table 1 are broken down into subcategories as suggested in the Toolkit. They are included in the study. The following illustrates the activities and relevant information which have been obtained.

3.1 Category of Waste Incineration

The following subcategories of the inventory matrix-sector 1 have been identified and considered important to the situation in Jordan.

3.1.1 Municipal Solid Waste Incineration

At present time municipal solid waste incineration is not practiced in Jordan and there are no incinerators available in the country. Land filling is the main widely used and adopted practice by the Greater Amman Municipality and other municipalities. One of the major and main land filling sites is located in an area between Amman and Zarka which is the second largest city in the country. This landfill receives solid waste from greater Amman area and from Zarka Governorate. The daily waste land filled amounts to 2,200 ton. The second largest landfill site is close to the Syrian border. It serves Irbid Governorate, receiving a daily waste of approximately 350 t.

Small scale solid waste dumping sites are available in almost all other towns and villages.

3.1.2 Hazardous Waste Incineration.

Hazardous waste incinerators do not exist in the country. Ministry of Environment is currently in the process of establishing a comprehensive plan for managing hazardous waste in the country.

3.1.3 Medical Waste Incineration

Medical waste is known to the concerned authorities locally as the waste generated in hospitals. Large or major hospitals such as King Hussein Medical City has acquired an incinerator for medical waste. It is worth mentioning that most of the incinerators are under the class of low-tech combustion with no or minimal APC system. Uncontrolled batch combustion accounts for the major release routes with small part can be classified under controlled batch with APC. The major routes for emissions are to air and fly and bottom ash. Waste generated in clinics, laboratories, pharmaceutical industries and others have not been accounted for. This is because the waste from such sources ends up in landfills. The estimation of dioxins release from Medical Wastes Incineration is shown below. The hospital waste incineration were classified into the classes 2 and 3

Total number of hospitals was 91 in 2001
Total number of beds was 8,977 in 2001

In July, 2002 :
Total number of hospitals is 93
Total number of beds is 9,197
Total number of hospitals that have incinerators is 33
Total number of beds served by incinerators is 5,478
Total number of beds not served by incinerators is 3,719

Assumptions:

- The increase in bed number within 7 months = 9,197- 8,977 = 220 beds
- The increase in bed number within 1 year = 12/7 * 220 = 377 beds/a
- Assume that the annual increment in bed number is constant , the total number of beds in the base year 2000 is: 8,977-377 = 8,600 beds
- Medical wastes generated from each bed is 0.5 kg
- Occupancy rate is 90 %

Quantities of Medical Wastes :

8,600*0.5 * 0.001 *365 *0.90 = 1,412.55 t/a

- The hospitals that have no incinerators use the incinerators of other hospitals
- 80 % of the incinerators have no APC systems (class 2)
- 20 % of the incinerators have a sort of APC systems (class 3)

Calculations

1. **Release to air :**

80% *1,412.55 = 1,130.04 t/a E.F (3,000) µg TEQ/t
20% *1,412.55 = 282.51 t/a E.F (525) µg TEQ/t

*1,130.04 * 3,000 = 3,390,120 µg TEQ/a*

*282.51 * 525 = 148,317 µg TEQ/a*

2. **Residues :**

1,130.04* 20 = 22,600.8 µg TEQ/a
282.51 * 920 = 259,909.2 µg TEQ/a

***Total PCDD/PCDF releases to air:**
3,390,120 + 148,317.75 = 3,538,437.75 µg TEQ/a
= **3.54 g TEQ/a**

***Total PCDD/PCDF releases as residues :**
22,600.8 + 259,909.2 = 282,510 µg TEQ/a
= 0. 28 g TEQ/a

**** Grand Total of PCDD/PCDF Releases From Medical Waste Incineration**

3.54 (air) + 0. 28 (residue) = 3.82 g TEQ/a

3.1.4 Light –Fraction Shredder Waste Incineration

Waste shredding does not exist in Jordan.

3.1.5 Sewage Sludge Incineration

Sludge is not incinerated in Jordan and it is either recycled or simply dumped. Very limited quantities have been incinerated in an old type furnace with little APC. Potential routes are to air and fly ash, which cannot be quantified presently.

3.1.6 Waste Wood and Waste Biomass Incineration

Limited quantities of biomass and waste wood are generated annually in Jordan. This is due the fact that forestry and agricultural land is also limited in the country. Most of agricultural activities are based on growing a number of crops and fruit bearing trees. The generated waste is dumped rather than burned. This means that waste incineration of this type of waste does not constitute a major source for PCDD/PCDF releases.

3.1.7 Animal Carcass Burning

Animal carcass burning is practiced at a small scale with no APC. Only, few facilities are equipped with APC systems. The major release routes are mainly to air . The estimation of PCDD/PCDF releases from animal carcasses burning are as follows:

a. Poultry Farms:
Natural death cases: 20 per 40,000 animals/day
Total number of chickens in farms having incinerators = 5,000,000
Average weight of a chicken is 1 kg
Daily death cases : 20/40 ,000 * 5,000,000 = 2 ,500 chicken
= 2 .5 t
Yearly incinerated quantities = 2.5 * 365 = 912.5 t

b. Goat Farms:
It has been estimated that the daily weight of incinerated goats is 0.25 t
Yearly incinerated quantities is 0.25 * 365 = 91.25 t

Total quantities of Animal Carcass Burning is 912.5 + 91.25 = 1,003.75 t/a
With little APC system E.F. to air is 500 µg TEQ/t (class 1)

Total PCDD/PCDF releases to Air from Animal Carcass Burning is

1,003.75 * 500 = 501,875 µg TEQ/a = 0.50 g TEQ/a

3.2 Category of Ferrous and non-Ferrous Metal Production.

Heavy metal industries such as iron ore sintering, coke production and other metal production such as copper, aluminum, lead, zinc, brass do not exist in Jordan. The only subcategories of this industries relevant in this category are iron and steel production and foundries, magnesium production and thermal wire reclamation. The following subcategories of Ferrous and non-Ferrous metal production have been reviewed, data concerning each sector has been collected and compiled in utilizing the relevant questionnaire.

3.2.1 Iron and Steel Production and Foundries:

Iron is mainly produced in Jordan for building construction and the major products are manufactured by reforming imported iron pellets. A total of eleven manufacturing and reforming industries are located in two governorates, Amman and Zarka. This type of activity is not relevant under the Toolkit. Only two out of the eleven factories produce iron from metal scrap recycling. Quantities produced by the two factories have been accounted for in calculating PCDD/PCDF emissions since scrap metallic parts do contain paints, polymeric materials, plastics, lubricants and other organic compounds.

Table 3-1: PCDD/PCDF Releases from Iron and Steel Production.

Iron & Steel Plants	Production t/a	E.F. to Air µg TEQ/t	Releases to Air (µg TEQ/a)	E.F. to Residues µg TEQ/t	Releases to Residues (µg TEQ/a)
Plant 1	40,000	10	400,000	15	600,000
Plant 2	15,000	10	150,000	15	225,000
Total	**55,000**		**550,000**		**825,000**
Grand Total	**1. 375 g TEQ/a**				

Foundries:

Recycling metallic materials is common and it is becoming a growing business in Jordan. There are six major foundries in Jordan engaged in aluminum, brass, lead, copper smelting. They are mainly based on relevant industrial waste collected by individuals seeking their living. All these foundries are located in greater Amman area. There are about 100 small foundries scattered in the whole country. The total capacity of the foundries has been estimated from data collected directly and through the management of each of the foundries. Annual releases of PCDD/PCDF from such sources are mainly to air. All of these foundries are using either cold air cupola or rotary drum furnaces without using APCS. The PCDD/PCDF releases have been estimated as in Table (3.2.3.1)

Table 3-2: PCDD/PCDF Releases from the Foundries

Foundries (Plants)	Production t/a	Emission Factor to Air µg TEQ/t	Releases to Air (µg TEQ/a)
Plant 1	1,440	10	14,400
Plant 2	900	10	9,000
Plant 3	480	10	4,800
Plant 4	240	10	2,400
Plant 5	144	10	1,440
Plant 6.	240	10	2,400
Sum of other 100 small foundries	500	10	5,000
Total	**3, 944**		**39,440**
0. 04 g TEQ/a			

3.2.2 Aluminum production

Aluminum is mainly produced in Jordan by reforming imported aluminum pellets. A total of four manufacturing and reforming industries are located in Amman. Only two out of the four factories produce aluminum profiles from scrap recycling. Quantities produced by the two factories have been accounted for in calculating PCDD/PCDF emissions. This is because scrap parts do contain paints, polymeric materials, plastics, lubricants and other organic compounds.

Table 3-3: PCDD/PCDF Releases from Aluminum Production

Aluminum Plants	Production t/a	E.F. to Air µg TEQ/t	Release to Air (µg TEQ/a)	E.F. to Residue µg TEQ/t	Release to Residue (µg TEQ/a)
Plant 1	600	35	21,000	400	240,000
Plant 2	2,000	35	70,000	400	800,000
Total	**2,600**		**91,000**		**1,040,000**
Grand Total	**1.131 g TEQ/a**				

3.2.3 Thermal Wire Reclamation

The major reclamation of metallic wires is for copper. Such practices are common among individuals seeking copper for scrap recycling. Data for estimated quantities and annual emissions are calculated below:

Regarding the Northern Region Solid Waste Management Study conducted in 1998, the total quantity of both red and yellow copper collected by the local contractor was 4.8 t/a from Akeder landfill which receives 127,750 t/a.

Applying this ratio to the total solid waste (1,423,500 t/a) received by all sites in the country, the total quantity of copper wire is 53.485 t/a.

It is assumed that same quantity is collected before reaching the landfills, hence the overall quantity is 53.5 * 2 = 107 t/a.

From the information gathered at some wire and cable plants, the percentage of coating material (PVC) is about 20%. Hence the burned material is calculated as :

107 * 0.2 = 21.4 t/a

By applying the emission factor of class 1 to the air (5,000 µg TEQ/t)

The Total releases to Air = 21.4 * 5,000 = 0.107 g TEQ/a.

3.3 Category of Power Generation and Heating

Power generation and heating are limited to processes that involve combustion of fuel for generating necessary heat and energy. Fossil fuels are the main sources for power generation and heating in Jordan. Biomass power plants, landfill biogas and biomass use for heating and cooking are not significant sources for energy in Jordan.

Jordan relies on the import of petroleum oil mainly from Iraq and additional quantities of fuel oil are also imported to provide additional needed quantities of fuel oil for large industries and for the needs of power plants. Table 3.3.1.1 contains a list of the various types of fuels that were consumed in Jordan in the year 2000. The following subcategories have been recognized to be significant for this study.

3.3.1 Fossil Fuel Power Plants

Fuel oil ASTM-D4 constitutes the major type of fuel used for power generation. There are two major power plants operating on fuel oil in Zarka and in Aqaba. Moreover, Jordan is utilizing natural gas reserves, only for generating electricity. The Electricity Authority and some of the industries in Jordan have a number of generators. The generators use heavy fuel oil and diesel fuel type D2. The annual emissions of PCDD/PCDF have been calculated as shown in Table 3.3.1.1

Table 3-4: Power Generation and Heating

Station	Type of Fuel	Consumption t/a	Total Capacity GW/a	E.F. µg TEQ/TJ	Releases to Air g TEQ/a
Power Station No 1	HFO	863,735	3,477.0	2.5	0.087
Power Station No 2	HFO	1,360,866	5,694.0	2.5	0.136
Power Station No 3	HFO	67,452	192.72	2.5	0.007
Power Station No 4 (Gas Turbines)	HFO	183,960	525.60	2.5	0.018
Power Station No 5 (Gas Turbines	Diesel	183,960	525.60	0.5	0.004
Power Station No 6	Diesel	68,985	197.10	0.5	0.002
Power Station No 7	Diesel	306,600	876.00	0.5	0.007
Power Station No 8	N. Gas	229,846		0.5	0.006
Private Power Stations	Diesel	61,320	175.20	0.5	0.001
Total					**0. 27**

The estimated releases of PCDD/PCDF from Power Generation and Heating sector are shown below:

Power Station No 1

Heavy Fuel Oil (HFO) consumption per year to produce 3477GW/a is 863,735 t

863,735*40,000 = 34,549,400,000 MJ/a

= 34,549.4 TJ/a

Potential release to air = 34,549.4*2.5 = 86,373.5 µg TEQ/a

= 0.0863 g TEQ/a

Power Station No 2

Heavy Fuel Oil (HFO) consumption per year to produce 5,694 GW/a is 1,360,866 t

1,360,866*40,000 = 54,434,640,000 MJ/a

= 54,434.64 TJ/a

Potential release to air = 54,434.64 *2.5 = 136,086.6 µg TEQ/a

= 0.1361 g TEQ/a

Power Station No 3

Quantity of fuel = 0.35*192,720 MW/a *1000

= 67,452,000 kg/1000 = 67,452 t/a

Heavy Fuel Oil (HFO) consumption per year to produce 19,272 GW/a is 67,452 t

67,452*40,000 = 2,698,080,000 MJ/a

= 2,698 TJ/a

Potential release to air = 2,698 * 2.5 = 6,745.2 µg TEQ/a

= 0.0067 g TEQ/a

Power Station No 4 (Gas Turbines) :

Quantity of fuel = 0.35*525,600 MW/a*1000

= 183,960 t/a

Heavy Fuel Oil (HFO) consumption per year to produce 525.600 GW/a is 183,960 t

183,960 *40,000 = 7,358,400,000 MJ/a

= 7,358.4 TJ/a

Potential release to air = 7,358.4 * 2.5 = 18,396 µg TEQ/a

= 0.0183 g TEQ/a

Power Station No 5 (Gas Turbines) :

Quantity of diesel = 0.35*525,600 MW/a*1000

= 183,960 t/a

Diesel consumption per year to produce 525.6 GW/a is 183,960 t

183,960*45,000 = 8,278,200,000 MJ/a

= 8,278.2 TJ/a

Potential release to air = 8,278.2 * 0.5 = 4,139.1 µg TEQ/a

= 0.0041 g TEQ/a

Power Station No 6

Diesel consumption per year to produce 197.1 GW/a is 68,985 t

68,985 *45,000 = 3,104,325,000 MJ/a

= 3,104.3 TJ/a

Potential release to air = 3,104.* 0.5 =1,552 µg TEQ/a

= 0.0016 g TEQ/a

Power Station No 7

Diesel consumption per year to produce 876 GW/a is 306,600 t

306,600 * 45,000 = 13,797,000,000 MJ/a

= 13,797 TJ/a

Potential release to air = 13,797 * 0.5 = 6,898.5 µg TEQ/a

= 0.0069 g TEQ/a

Power Station No 8

Quantity of natural gas per year is 287,307,800 CM

For natural gas 1 cubic meter weighs 0.0008 t.

Natural gas consumption is 287,307,800 * 0.0008 = 229,846.24 t/a

229,846.24 * 48,000 = 11,032,619,520 MJ/a

= 11,032.6 TJ/a

11,032.6 * 0.5 = 5,516.3 µg TEQ/a

= 0.0055 g TEQ/a

Power Station No 9

Diesel consumption per year to produce 175.2 GW/a is 61,320 t

61,320 * 45,000 = 2,759,400,000 MJ/a

= 2,759.4 TJ/a

Potential release to air = 2,759.4 * 0.5 = 1,3797 µg TEQ/a

= 0.0014 g TEQ/a

3.3.2 3.3.2 Landfill, Biogas Combustion

Landfill gas and biogas utilization has recently been utilized on a very limited scale only in one Amman landfill site within a pilot plant to produce electricity. An amount of 1,480,617 CM of landfill gas and 125,199 CM of biogas was produced in the year 2000. The total consumption of the gas to produce 2,506 MW/a is 1,525 t.

Using the heating value of 20 MJ/kg, the releases to the air is calculated as follows:

20*1000 MJ/t

20,000*1,525 = 30,500,000 MJ/a

= 30.5 TJ/a

Potential release to air = 30.5 * 8 = 244 µg TEQ/a = 0.0002 g TEQ/a

3.3.3 Domestic Heating and Cooking (Fossil fuel).

Central heating in indoor is common in certain parts of the capital Amman, the major part of the society still relies on LPG , Kerosene, and Diesel fuel (oil fired stoves) .The annual dioxin releases from domestic heating and cooking is calculated below:

Quantity of oil is 422,031.9 t/a

Heating value = 46,000 MJ/t

Total heating value = 422,031.9*46,000 = 19,413,467,400 MJ/a

= 19,413.5 TJ/a

Potential release to air = 19,413.5 * 10 = 194,135 µg TEQ/a

= 0.1941 g TEQ/a

3.4 Category of Production of Mineral Products

3.4.1 Cement Production

There are three factories in the country for cement manufacturing. Two of those factories are concerned with Portland cement production. The first is situated in Fuheis city, which is about 15 km from Amman. The second factory was established 15 years ago in the southern part of the country. The total production capacity of the two factories is 4 million t/a. The third factory is only manufacturing white cement with a total capacity of 135,000 t/a. Heavy fuel oil is the main fuel being used in the three factories. It is classified as dry kilns with APCS and the ESP/FF temperature < 200 ºC. They all use dry process and therefore present class plants. Calculations of

PCDD/PCDF emissions are given as follows: -

Table 3-5: PCDD/PCDF and Furan Releases from the Cement Production

Cement Factories	Production t/a	E.F. to Air µg TEQ/t	Releases to Air (µg TEQ/a)	E.F. to Residues µg TEQ/t	Releases to Residues (µg TEQ/a)
Factory 1	2,000,000	0.15	300,000	0.003	6,000
Factory 2	2,000,000	0.15	300,000	0.003	6,000
Factory 3	135,000	0.15	20,250	0.003	405
Total	**4,135,000**		**620,250**		**12,405**
Grand Total	**0. 63 g TEQ/a**				

3.4.2 Lime Production

Lime is produced in Jordan by only one factory located in the suburb of Amman. Annual production for lime during the year 2000 was reported to be 6,000 t. Calculations for PCDD/PCDF emissions are given as follows:

Table 3-6: PCDD/PCDF Releases from Lime Production.

Plants	Production t/a	E.F. to the Air (µg TEQ/t)	Releases to Air (µg TEQ/a)
Total Capacity of Lime Production	6,000	10	60,000
Total	6,000		**0.06 g TEQ/a**

3.4.3 Brick Production

There are two heat-treated brick production plants in Jordan; the calculated emissions from these two plants are shown below:

Table 3-7: PCDD/PCDF Releases from the Bricks Production.

Bricks Plants	Production t/a	E.F. to the Air (µg TEQ/t)	Releases to the Air (µg TEQ/a)
Plant 1	1,200	0.2	240
Plant 2	750	0.2	150
Total	**1, 950**		**0.0004 g TEQ/a**

3.4.4 3.4.4 Glass Production

Only recycling glass is practiced in Jordan. Large glass manufacturing industries do not exist in the country. A total of six small glass recycling workshops are located in a number of cities in Jordan. Mainly, handcrafts and souvenirs are produced from such recycled glass.

3.4.5 3.4.5 Ceramics Production

Ceramics production has been developed and widely spread in Jordan since the year 1970. A total of five major ceramic factories are producing ceramic tiles, and sanitary related products and other products for local and export markets. The annual production of ceramics for the year 2000 as recorded by the manufacturing industries was 55,625 t. Estimated PCDD/PCDF emissions from this sector are shown as follows:

Table 3-8: PCDD/PCDF Releases from the Ceramics Production.

Plants	Production t/a	E.F. to Air µg TEQ/t	Releases to Air (µg TEQ/a)
Plant 1	13,600	0.2	2,720
Plant 2	500	0.2	100
Plant 3	7,000	0.2	1,400
Plant 4	525	0.2	105
Plant 5	34,000	0.2	6,800
Total	**0. 011 g TEQ/a**		

3.4.6 Asphalt Mixing

There are three major asphalt mixing companies located in midland and in the north of the country. They provide the needs of this sector in Jordan. The annual production of ready and mixed asphalt for the year 2000 for the existing twenty asphalt mixing plants has been reported to be 1,581,000 tons. Asphalt mixers are classified into two classes; class 1 includes 8 mixers that have no gas cleaning systems, the other 12 mixers have either fabric filters or wet scrubbers and they are classified in class 2. Formation of PCDD/PCDF resulting from mixing of hot minerals (rock chips, sand, fillers) with hot bitumen to obtain asphalt. The estimated PCDD/PCDF emissions from this source are given in the table below:

Table 3-9: PCDD/PCDF Releases from Asphalt Mixing

Asphalt Mixers	Production t/a	E.F. to Air µg TEQ/t	Releases to Air (µg TEQ/a)	E.F. to Residues µg TEQ/t	Releases to Residues (µg TEQ/a)
Class 1	601,000	0.07	42,070	ND	-
Class 2	980,000	0.007	6,860	0.06	58,800
Total	**1,581,000**		**48,930**		**58,800**
Total	**0.108 g TEQ/a**				

3.5 Category of Transportation

The transport sector in Jordan has witnessed a rapid development since the early 1970s. The registered vehicles for the year 2000 based upon type of engine classifications are illustrated below. The country transportation relies mainly on the combustion of gasoline (mostly leaded and to a lesser extent unleaded) to run the large fleet of cars both private and rental cars. There is very few diesel fuel ASTM –D2 in Jordan. They are used to run diesel engines mainly for lorries, buses, and heavy transporting trucks. Heavy oil engines such as private and industrial power generation, ships and tanks transporting goods are operating from the port of Aqaba. The calculation of the annual release of PCDD/PCDF from transportation sector is given below:

3.5.1 4- Stroke Engines:

Leaded fuel (gasoline)

Number of vehicles 250,550
Average distance traveled 16,000 km/a
Fuel consumption per vehicle 0.11 l/km
Annual fuel consumption per vehicle = 16,000*0.11*0.00074 = 1.3024 t/a
Total fuel consumption = 250,550*1.3024 = 326,316 t/a
PCDD/PCDF releases to air (E.F. 2.2 µg TEQ/t) = 326,316 *2.2 = 717,895.9 µg TEQ/a
= 0.72 g TEQ/a

2) Unleaded fuel (gasoline) without catalyst

Number of vehicles 3,200
Average distance traveled 16,000 km/a
Fuel consumption per vehicle 0.11 l/km
Annual fuel consumption per vehicle = 16,000*0.11*0.00074 = 1.3024 t/a
Total fuel consumption = 3,200*1.3024 = 4,167.68 t/a
PCDD/PCDF releases to air (E.F. 0.1 µg TEQ/t) = 4,167.68 *0.1 = 416.786 µg TEQ/a
= 0.0004 g TEQ/a

3.5.2 2- Stroke Engines:

1) Leaded fuel (gasoline)

Number of vehicles 5,000
Average distance traveled 16,000 km/a
Fuel consumption per vehicle 0.081 l/km
Annual fuel consumption per vehicle = 16,000*0.081*0.00074 = 0.95904 t/a
Total fuel consumption = 5,000*0.95904 = 4,795.2 t/a
PCDD/PCDF to air (E.F 3.5 µg TEQ/t) = 4,795.2 *3.5 = 16,783.2 µg TEQ/a
= 0.0168 g TEQ/a

3.5.3 Diesel Engines:

Number of vehicles 165,011
Average distance traveled 18,000 km/a
Fuel consumption per vehicle 0.13 l/km
Annual fuel consumption per vehicle = 18,000*0.131*0.00085 = 2.0043 t/a
Total fuel consumption = 165,011*2.0043 = 330,731.54 t/a
PCDD/PCDF releases to air (E.F 0.5 µg TEQ/t) = 330,731.54 *0.5 = 165,365 µg TEQ/a
= 0.1654 g TEQ/a

Table 3-10: The Annual Emissions of PCDD/PCDF from the Transportation Category.

Classification	**Fuel Consumption t/a**	**E.F. to Air µg TEQ/t**	**Releases to Air g TEQ/a**
1- 4 Stroke Leaded Fuel Engine (gasoline)	326,316	2.2	0.7179
2- Unleaded Fuel without catalyst (gasoline)	4,167.68	0.1	0.0004
3- 2 -Stroke Leaded Fuel Engine (gasoline)	4,795.2	3.5	0.0168
4- Diesel Engine	330,731	0.5	0.1654
Total			**0. 9005**

3.6 Category of Uncontrolled Combustion Process

3.6.1 Biomass Burning

Fires/burning – biomass

Jordan is classified as an arid country. Less than 1% of the area is covered by forests. Due to limited precipitation rate and lack of water resources, the grassland area is small and mainly used as grazing lands or landscapes. Agricultural residues burning are getting less. Such residues are mainly consumed in animal feeding. Jordan is not a wood producing country. Wood is a valuable material imported from different countries. The later explains reason behind having limited amounts of wood burning.

Uncontrolled domestic waste burning can be occasionally noticed in very few small areas. Civil Defense Directorate/Fire Fighting Department (FFD) is responsible for fighting and reporting on large and medium size fire in houses, factories and vehicles. The small size fires are rarely recorded. Following is the estimated amounts of PCDD/PCDF releases from this category:

3.6.1.1 Forest Fires:

Estimated PCDD/PCDF Releases From Forest Fires

Total number of trees burnt in the year 2000 was 20, 215 trees
Total burnt area was 79.2 hectares
The weight of 1 hectare equals 23 t
The total weight trees burnt was 79.2 * 23 = 1,821.6 t/a

***Total PCDD/PCDF releases to Air :**

1,821.6 * 5 = 9,108 µg TEQ/a E.F. (5 µg TEQ/t)
= 0.0091 g TEQ/a

***Total PCDD/PCDF releases to land :**

1,821.6 * 4 = 7,286.4 µg TEQ/a E.F. (4 µg TEQ/t)
= 0 .0073 g TEQ/a

Total PCDD/PCDF Releases From Forest Fires = 0.0091 (air) + 0 .0073(land) = 0.016 g TEQ/a

3.6.1.2 Grassland and Moor Fires

Estimation of PCDD/PCDF Releases From Grassland and Moor Fires

- Total area burnt 215 hectares

- *1 hectare of grass weighs 8 t.*
- weight of grass burnt = 215 * 8 = 1720 t/a

***Total PCDD/PCDF releases to Air :**

1720 * 5 = 8600 µg TEQ/a E.F. (5 µg TEQ/t)
= 0.0086 g TEQ/a

***Total PCDD/PCDF releases to land :**

1720 * 4 = 6880 µg TEQ/a E.F. (4 µg TEQ/t)
= 0.0069 g TEQ/a

Total PCDD/PCDF Releases From Grassland and Moor Fires = 0.0086 (air) + 0 .0069 (land) = 0.016 g TEQ/a

3.6.1.3 Agricultural Residue Burning

Estimation of PCDD/PCDF Releases From Agricultural Residue Burning

- Total area burnt 417 hectares

- *1 hectare of residue weighs 10 t.*
- *weight of residue burnt = 417* 10 = 4170 t/a*

***Total PCDD/PCDF releases to Air :**

4170*30 = 125,100 µg TEQ/a E.F. (30 µg TEQ/t)
= 0.1251 g TEQ/a

***Total PCDD/PCDF releases to land :**

4170*10 = 41,700 µg TEQ/a E.F (10 µg TEQ/t)
= 0.0417 g TEQ/a

Total PCDD/PCDF Releases From Agricultural Residue Burning **0.1251 (air) + 0.0417 (land) = 0. 167 g TEQ/a**

3.6.2 Waste burning and accidental fires

3.6.2.1 Landfill fires

By law, it is prohibited to burn waste at landfills. However, most landfill sites are under control. Some fire occurrences could be noticed as a result of scavengers' activities nearby limited number of sites. Table 3.6.b.1 summarizes municipal solid waste dumping sites and the estimated PCDD/PCDF releases from them.

Table 3-11: Municipal solid waste dumping sites & estimated PCDD/PCDF releases.
*Emission Factor 1,000 µg TEQ/t

Region	No.	Site	Waste quantities t/day	% incineration	Incinerated Quantities t/day	Incinerated Quantities t/a	PCDD/PCDF releases µg TEQ/a*
North	1-	Akeder	350	1	3.5	1,277.50	1,277,500
	2-	Mafraq	100	-	-	-	-
	3-	Kufranja	90	2	1.8	657	657,000
	4-	N.Shuna	100	-	-	-	-
	5-	Tayba	30	-	-	-	-
	6-	Sarrow	80	-	-	-	-
	7-	U.quttein	30	80	24	8,760	8,760,000
Total			**780**		**29.3**	**10,694.50**	**10,694,500**
Middle	1-	A.G.M	2,200	1	22	8,030	8,030,000
	2-	Madaba	150	-	-	-	-
	3-	Humra	140	-	-	-	-
	4-	Dlail	70	5	3.5	1,277.50	1,277,500
	5-	Deban	20	-	-	-	-
	6-	D.Alla	30	30	9	3,285	3,285,000
	7-	Azraq	10	40	4	1,460	1,460,000
Total			**2,620**		**38.5**	**14,052.50**	**14,052,500**
South	1-	Aqaba	80	1	0.8	292	292,000
	2-	Maan	50	-	-	-	-
	3-	Karak	85	15	12.75	4,653.70	4,653,750
	4-	Tafila	50	-	-	-	-
	5-	Shoubak	20	90	18	6,570	6,570,000
	6-	Ayl	20	20	4	1,460	1,460,000
	7-	Quaira	20	20	4	1,460	1,460,000
	8-	Husainia	15	15	2.25	821.25	821,250
	9-	S.Shouna	40	15	6	2,190	2,190,000
	10-	G.Safi	20	30	6	2,190	2,190,000
Total			**400**		**53.8**	**19,636.95**	**19,636,950**
Grand Total			**3,800**		**121.6**	**44,383.95**	**44,383,950**

Total release of PCDD/PCDF from landfill fires to air: 44.384 g TEQ/a

3.6.2.2 Accidental Fires in Houses and Factories

- Total number of house fires in the year 2000 was 1,300 events
- Total number of factory fires in the year 2000 was 1,856 events

The overall events = 1,300 + 1,856 = 3,156 events

Total PCDD/PCDF release to air;
3,156*400 = 1,262,400 µg TEQ/a E.F. to air (400 µg TEQ/event)
= 1. 262 g TEQ/a

Total PCDD/PCDF release as residues:
3,156*400 = 1,262,400 µg TEQ/a E.F. to residue (400 µg TEQ/event)
= 1. 262 g TEQ/a

Hence, Total PCDD/PCDF release from Accidental Fires in Houses and Factories is 1.262 + 1.262 = 2.525 g TEQ/a

3.6.2.3 Uncontrolled Domestic Waste Burning:

Estimation of PCDD/PCDF Releases From Uncontrolled Domestic Waste Burning
Yearly estimated quantities of waste burning = 3,000 t.

***Total PCDD/PCDF to air :**
3,000*300 = 900,000 µg TEQ/a E.F. (300 µg TEQ/t)
= 0 .9 g TEQ/a

***Total PCDD/PCDF releases as residues :**
3,000 *600 = 1,800,000 µg TEQ/a E.F. (600 µg TEQ/t)
= **1.8 g TEQ/a**

Total PCDD/PCDF Releases From Uncontrolled Domestic Waste Burning
0.9 (air) + 1.8 (residue) = 2.7 g TEQ/a

3.6.2.4 Accidental Fires in Vehicles

Estimation of PCDD/PCDF Releases From Accidental Fires in Vehicles
- Total number of vehicle fires in 2000 was 561 events

***Total PCDD/PCDF releases to air :**
561* 94 = 52,734 µg TEQ/a E.F. (94 µg TEQ/event)
= 0 .05273 g TEQ/a

***Total PCDD/PCDF releases as residues:**
561* 18 = 10,098 µg TEQ/a E.F. (18 µg TEQ/event)
= 0.0101 g TEQ/a

Total PCDD/PCDF Releases From Accidental Fires in Vehicles
= 0 .053 (air) + 0.01 (residue)
= 0.063 g TEQ/a

3.6.2.5 Open Burning of Wood

Estimation of PCDD/PCDF Releases From Open Burning of Wood

- Yearly estimated quantities of wood burning = 500 tons

***Total PCDD/PCDF releases to Air:**
500* 60 = 30,000 µg TEQ/a E.F. (60 µg TEQ/t)
= 0.03 g TEQ/a

***Total PCDD/PCDF releases as residues :**
500 *10 = 5,000 µg TEQ/a E.F. (10 µg TEQ/t)
= 0.005 g TEQ/a

Total PCDD/PCDF Releases From Open Burning of Wood

0.03 (air) + 0.005 (residue) = 0.035 g TEQ/a

3.7 Category of Production and Use of Chemicals and Consumer Goods.

3.7.1 Pulp and Paper Mill Industry

Estimations of PCDD/PCDF releases from pulp and paper production are not applicable to Jordan. The needs of the country are imported. The only significant activity in use concerning recycled paper for producing card board and carton is practiced by one factory. The capacity of the factory and the estimated releases of dioxin are shown below.

Table 3-12Table 3.7.1 PCDD/PCDF Releases from the Recycling Paper.

Paper Plants	Production ton/a	E.F. to the Product (µg TEQ/t)	Releases to the Product (µg TEQ/a)
Plant 1	8,400	10	84,000
Plant 2	12,700	10	127,000
Plant 3	10,800	10	108,000
Total	**31,900**		**0.319 g TEQ/a**

3.7.2 Chemical Industry

PCP, EDC, PCB are not applicable to Jordan. PVC is not manufactured in Jordan. Processing PVC is associated with shaping and reforming in order to produce various products. The releases of PCDD/PCDF associated with processing PVC is shown below:

Table 3-13Table 3.7.2.1: The Releases of PCDD/PCDF Associated with Processing PVC.

PVC Plants	Production t/a	E.F. to the Product µg TEQ/t	Releases to Product (µg TEQ/a)
Plant 1	2,000	0.1	0.0002
Plant 2	1,000	0.1	0.0001
Plant 3	1,600	0.1	0.00016
Plant 4	600	0.1	0.00006
Plant 5	900	0.1	0.00009
Plant 6	3,000	0.1	0.0003
Plant 7	300	0.1	0.00003
Plant 8	3,500	0.1	0.00035
Plant 9	3,000	0.1	0.0003
Plant 10	1,000	0.1	0.0001
Total	**16,900**		**0.002 g TEQ/a**

3.7.3 Petroleum Refinery

According to the information given by Jordan Petroleum Refinery, the capacity of catalytic reforming unit is 1,400 t/d. In this process no industrial wastewater is produced. During the regeneration process caustic soda and water are added. The catalyst amount remains constant and it is changed and returned back to the country of origin at the end of the assumed age (15-20 years).

The catalytic cracking unit capacity is 640 t/d. The catalyst consumption in this process is 90 kg/d. The water discharge is estimated to be 72 CM/d.

3.7.4 Textile Plants

Textile production in Jordan is usually based on using imported cotton, wool and polyester threads. Dyestuff used to color the textile is based on chloranil. Bleaching and finishing processes utilize chlorinated chemicals. Calculation of estimated PCDD/PCDF emissions from this source is based on the lower limit emission factor since no production of textile raw material is produced in the country. The calculated PCDD/PCDF emissions are given in the table below:

Table 3-14: PCDD/PCDF Releases from Textile Plants

Textile Plants	Production t/a	E.F. to Product µg TEQ/t	Releases to Product (µg TEQ/a)
Plant 1	1,050	0.1	105
Plant 2	450	0.1	45
Plant 3	150	0.1	15
Plant 4	90	0.1	9
Plant 5	75	0.1	7.5
Total	**1, 815**		**181. 5 µg TEQ/a**

3.7.5 3.7.5 Leather Plants

Leather is produced in Jordan by only one factory located in Zarka, the second largest city in the country. The annual production of leather for the year 2000 was reported to be 1,300 tons. Calculations for PCDD/PCDF emissions are given as follows: -

Table 3-15: PCDD/PCDF Releases from Leather Plants

Leather Plants	Production t/a	E.F. to Product (µg TEQ/t)	Releases to Product (µg TEQ/a)
Total Tanning Capacity	1,300	10	13,000
Total			**0.013 g TEQ/a**

3.8 Category of Miscellaneous

Drying of Biomass, Crematoria, and Smoke Houses are not practiced or existing in Jordan. The applicable sub- categories to be worked on are Dry Cleaning and Tobacco Smoking.

3.8.1 Dry Cleaning:

Dry cleaning services in Jordan are located in main cities. The total quantity of perchloroethylene consumed by the main dry cleaning services has been reported to be 110 ton. About 10% of this quantity is estimated as a loss. Types of textile subjected to cleaning with this material have been found to be in the ratio of 3:1(Heavy : Light). The over all residues of PCDD/PCDF in various types of textile products have been calculated using emission factors given for each product and for 11 ton of the solvent been distilled off. The following illustrates calculation for PCDD/PCDF emissions from this source.

110* 10 % = 11 tons is lost during dry cleaning process and as residues in textiles.

It is estimated that only 1% of the lost quantity remains as residues in textiles.
So, 0.01*11= 0.11 t.
Quantity of residues remain in heavy textiles = 0.11*0.75 = 0.0825 t.
Quantity of residues remain in light textiles = 0.11*0.25 = 0.0275 t.

Table 3-16: PCDD/PCDF Releases from Dry Cleaning

Classification	**Weight t/a**	**E.F. to Residues µg TEQ/t**	**Releases to Residues (µg TEQ/a)**
1. Heavy Textiles	0.0825	3,000	247.5
2. Light Textiles	0.0275	50	1.375
Total			**0.0003**

3.8.2 Tobacco Smoking:

It has been reported that the number of cigarettes consumed in Jordan during 1999 was 4 billion. Although the per capita consumption of cigarettes has been decreased during the period (1993 – 1999) by 16%, it makes sense to use the same figure when making the calculation for the year 2000.

Cigar smoking is not common in the country. Statistics reported a quantity of 6,500 kg was imported in 2000 and the average weight of a cigar was taken as 10 grams for calculation purpose.

Statistics show also that 104,750 kg of tanbac has been imported for hubbly bubbly and tobacco pipe smoking. For the seek of calculation, this quantity is converted to cigars of 10 grams for each. Then the calculation is made accordingly as follows:

Number of cigars : (6,500 *1000/10) + (104,750*1000/10) = 11,125,000

Number of cigarettes is 4,000,000,000

Table 3-17: PCDD/PCDF Releases from Tobacco Smoking

Classification	Number of items	E.F. to Air pg TEQ/item	Releases to Air (µg TEQ/a)
1. Cigars	11,125,000	0.3	3.3375
2. Cigarettes	4,000,000,000	0.1	400
Total			0.0004

3.9 Category of Disposal/Landfill

3.9.1 Landfills and Waste Dumps

Leachate of Disposal sites. It is expected that the amount of leachate generated from the disposal sites in the country is very limited. This is because most of the land filled waste is disposed in an area that receives very limited amount of rainfall. However, there is a need to investigate the disposal sites in other areas which receive relatively high amount of precipitation.

3.9.2 Sewage and Sewage Treatment.

A questionnaire was developed in a away which accounts for the fact that the amount of releases is affected the type of waste water received and the degree of the treatment (See the questionnaire in Annex 2

3.9.2.1 Information on PCDD/PCDF formation and sewage:

Sludge is the solid residues resulting from the treatment of wastewater. The pollutants present in the wastewater are concentrated in the sludge and therefore the later is regarded as a sink for PCDD/PCDF formed and emitted previously in other process and products. The content of PCDD/PCDF in sludge has been reviewed (UNEP, 2001). For example, countries like Germany and Austria have introduced legislation to analyze domestic sludge for PCDD/PCDF.

This study focuses on estimating the content of PCDD/PCDF in domestic sludge. It is worth mentioning that the quantity of dioxins and furans entering the waste water system and treatment plant depends on the sources of wastewater. It is known that waste water system which does not receive industrial pollutants generates low concentrations of dioxins and furans. This suggests that the generation of dioxins and furans from areas that have no industries and are underdeveloped is expected to be low. On the other hand, higher levels of dioxins and furans are expected from urban areas with mixed industry and use of PCDD/PCDF containing consumer goods. Industries discharging their waste water without any treatment to public sewers contribute highly to the levels of PCDD/PCDF in sewage sludge. Total Releases of PCDD/PCDF from Investigated Waste Water Treatments in Jordan is 11.62 grams.

3.9.2.2 Domestic Waste Water Management in Jordan

So far, The study covers the waste water treatment plants operated by the Water Authority (WAJ). It is worth mentioning that only 70% of the population is served by public sewers. The rest is either collected in septic tanks or in cesspits. The mode of treatment which is in operation is Biological (Secondary Treatment). For example, the Activated sludge, Tricking Filters and Stabilization Ponds are the types of adopted treatment systems.

In the context of the study, one has to mention that there are provisions for treating certain industrial wastewater within the domestic wastewater treatment plants operated by WAJ. This practice leads to the increase of PCDD/PCDF releases. Further, sludge application to land could be a concern due to the high emission factor of PCDD/PCDF releases. The emission factors of PCDD/PCDF releases to water and residue are shown in Table 3.9.2.2.1

Table 3-18: PCDD/PCDF Emission Factors for Wastewater

Classification	Water: pg I-TEQ/L	Product: µg TEQ/t d.m.*
1-Mixed domestic and industrial input (with chlorine relevance)	5 ; no sludge removal	1,000
1-Mixed domestic and industrial input (with chlorine relevance)	0.5; with sludge removal	1,000
2-Urban environments	2; no sludge removal	100
2-Urban environments	0.5; with sludge removal	100
3-Remote environments or input control	0.5	10

* d.m.: dry matter

Calculation of PCDD/PCDF Releases from Waste Water Treatment Plants:

Class 1-a includes:
As Samra, Aqaba, Mafraq, Ramtha, Madaba, Baqaa and Fuhais Treatment Plants.

Total yearly water discharge: 73,150,380 CM (73,150,380,000 L/a)

PCDD/PCDF Releases to water : (E.F. to water 5 pg TEQ/L)

73,150,380,000 * 5 = 365,75,900,000 pg TEQ/a = **0.366 g TEQ/a**

Yearly generation of sludge as dry matter (based on the figure given by Metcalf and Eddy (1980) which is 150 kg of generated sludge per 1,000 CM of wastewater

73,150,380 * 0.15/1000 =10,972 t

PCDD/PCDF Releases through sludge (residue): (E.F. residue 1,000 µg TEQ/t)

10, 972*1,000 = 10,972,000 µg TEQ/a = **10.972 g TEQ/a**

Hence total release from Class 1-a = 0.366 + 10.972= 11.338 g TEQ/a.

PCDD/PCDF Releases from class (1-b) Waste Water Treatment Plants

Class 1-b includes:
PCDD/PCDF Releases to water : (E.F. to water 0.5 pg TEQ/L)

Southern Area and Slaughter Houses Wastewater Treatment Plants

Total yearly water discharge: 1,056,375 CM = 1,056,375,000 L/a

1,056,375,000 * 0.5 = 528,187,500 pg TEQ/a **= 0.0005 g TEQ/a**

Yearly generation of sludge as dry matter

1,056,375 *0.15/1000 = 158.46 t.

PCDD/PCDF Releases through sludge(residue) (E.F. to residue1000 µg TEQ/t)

158.46*1,000 = 158,460 µg TEQ/a = **0. 1585 g TEQ/a**

Hence total release from Class 1-b : 0.0005 + 0. 1585 = 0.159 g TEQ/a.

PCDD/PCDF Releases from Class (2-a) Wastewater Treatment Plants

Class 2-a includes:
Salt, Jarash, Karak, Abu Nusair, Tafeeleh, Kufrenjeh and Wadi Arab Treatment Plants

Total yearly discharge: 6,169,960 CM (6,169,960,000 L/a)

PCDD/PCDF Releases to water**:** (E.F. to water is 2 pg-L-TEQ)

6,169,960,000*2 = 12,339,920,000 pg TEQ/a **= 0.0123 g TEQ/a**

Yearly generation of sludge as dry matter

6,169,960 *0.15/1,000 = 925.5 t.

PCDD/PCDF Releases through sludge (residue): (E.F.to residue 100 µg TEQ/t)

925.5* 100 = 92,550 µg TEQ/a = **0.093 g TEQ/a**

Hence total release from Class 2-a : 0.0123 + 0.093 = 0.1053 g TEQ/a.

PCDD/PCDF Releases from Class 2-b Wastewater Treatment Plants

Class 2-b includes:
Maan and Wadi Essir Wastewater Treatment Plants

Total yearly discharge: 1,096,825 CM (1,096,825,000 L/a)

PCDD/PCDF Releases to water: (E.F. to water is 0.5 pg TEQ/L)

1,096,825,000*0.5 = 548,412,500 pg TEQ/a = **0.0006 g TEQ/a**

Yearly generation of sludge as dry matter

1,096,825*0.15/1,000 = 164.5 t.

PCDD/PCDF Releases through sludge(residue): (E.F. to residue100 µg TEQ/t)

164.5*100 = 16,450 µg TEQ/a **= 0.0165 g TEQ/a**

Hence total release from Class 2-b : **0.0006 + 0.0165 = 0.0171 g TEQ/a**.

Total PCDD/PCDF Releases from Wastewater Treatment Plants

1. **To water: 0. 379 g TEQ/a**
2. **To residue: 11. 241 g TEQ/a**

3.9.3 Open Water Dumping

As mentioned earlier**,** some areas are still not served by public sewerage system. Those areas are residential, commercial or even industrial. The generated wastewater is usually collected in septic tanks or cesspools. Then they are transported to wastewater treatment plants. Due to some restriction, wastewater treatment plants can not receive additional quantities of sewage.

A total of 11 authorized dumping sites are distributed through out the country, most of them are located within the vicinity of solid waste landfill sites. According to statistics conducted in 2000, the total quantities of wastewater dumped in such way are estimated to be 14,200 CM/d.

It is assumed that the water is classified as contaminated wastewater with emission factor of 50 pg TEQ/L (to water).

Calculation of PCDD/PCDF Releases to water due to Open Water Dumping

14,200 *1000 = 14,200,000 L/d.

14,200,000 * 365 = 5,183,000,000 L/a

The total PCDD/PCDF Releases to water due to Open Water Dumping
5,183,000,000 *50 = 259,150,000,000 pg TEQ /a = 0.259 g TEQ/a

3.9.4 Waste Oil Disposal

Jordan consumption of mineral oil is about 30,000 t/a. 69% of this amount is locally produced. 33% of the total used oil amount is returned back to Jordan Petroleum Refinery. The non-thermal disposal of the waste oil takes place in different forms, sprayed on the unpaved roads, mixed with wastewater, and other uses. It has been estimated that the amount disposed through non-thermal ways is 3,500 t/a

Applying the emission factor to air (4 µg TEQ/t)

Total PCDD/PCDF releases to air from waste oil disposal = 3,500 * 4 = 14,000 µg TEQ/a
= 0.014 g TEQ/a

3.10 Category of Hot Spots

3.10.1 Dumps of Waste/Residues.

*** Ruseifa Landfill Site:**

The landfill site at Ruseifa is situated to the east of Amman at a distance of about 10 km. from the city center. The site comprises two locations for dumping municipal solid waste at a distance of about 1km. from each other. The old site location was closed in 1980, and since 1922 solid waste and even different types of waste materials including toxics were dumped for over 60 years at the location. Burning of waste was often noticed, in spite of the fact that the site is no more been used. Negative impacts on ground water due to leachate migration in addition to emission of gases effect people living and has received much concern from local authorities for improving surrounding environment at that location. Even though the old site is still poses a great risk for health of people living in nearby areas.

In the old site it is still been noticed occasional eruption of fires and dispersion of smoke and bad odor. Landfill gas leakage has been traced in a number of houses in nearby areas. This site has been recognized to be a source of toxic emissions and a number of studies have been conducted to determine the level and the types of emissions.

Proper land filling procedures are practiced in the new landfill site, and a pilot plant for biogas utilization has been constructed. The percentage of plastics in the municipal waste was found to be about 14% as indicated in one study.

***The Wadi Al Qatar Area.**

It was an industrial dump site that got used to receive industrial wastewater during the period 1986-1995. The site was an abandoned phosphate quarry located 10 km from Amman city center.

*** Kufr Awan Dumping Site:**

This waste dumping site started to receive municipal waste in late eighties. For its impact noticed on water resource in the area it was closed in 1998. The area of the site is about

25, 000 square meter and the daily waste quantity was estimated to be 30 t.

*** Sludge from Al Samra Waste water.**

The removed sludge from the stabilization ponds of As Samra wastewater treatment plant is disposed of within the boundaries of the plant.

3.10.2 Site of Relevant Accidents

A chemical industry with a chloralkali process was using mercury. The industry has now been closed after a severe mercury contamination. It is estimated that a 6000 CM of contaminated sand with mercury from a catastrophic release in November 1988. The polluted site is near Zarka area which 15 km away from Amman city.

4 CONCLUSION

Based upon data collected and estimates calculated for PCDD/PCDF emission from different sources in Jordan, it can be concluded that the main sources identified are those relevant to the uncontrolled combustion processes with a total annual releases (49.9 g TEQ/a), this accounts for more than 70 % of the overall emissions of the different source categories considered in this study. However, this source emission will be further investigated in the national project on POPs, which has been implemented since the beginning of the year 2003. Moreover, emissions from sewage treatment plants accounts for 16.7 % of the total PCDD/PCDF emissions. The estimated total amount of PCDD/PCDF releases calculated for the first 9 categories is (71.144) gram for the year 2000, as illustrated in Table 4.1.

Table 4-1: Summary of PCDD/PCDF Releases

Cat	Source Categories	Annual Releases (g TEQ/a)						
		Air	Water	Land	Products	Residue	Total	%
1	Waste Incineration	4.040	0.000	0.000	0.000	0.3	4.323	6.076
2	Ferrous and Non-Ferrous Metal Production	0.787	0.000	0.000	0.000	1.9	2.652	3.728
3	Power Generation and Heating	0.461	0.000	0.000	0.000	0.0	0.461	0.649
4	Production of Mineral Products	0.741	0.000	0.000	0.000	0.1	0.812	1.141
5	Transportation	0.768	0.000	0.000	0.000	0.0	0.768	1.08
6	Uncontrolled Combustion Processes	46.780	0.000	0.056	0.000	3.1	49.899	70.14
7	Production of Chemicals and Consumer Goods	0.000	0.000	0.000	0.336	0.0	0.336	0.472
8	Miscellaneous	0.001	0.000	0.000	0.000	0.0	0.001	0.001
9	Disposal/Land filling	0.014	0.638	0.000	0.000	11.2	11.892	16.72
10	Identification of Potential Hot-Spots							
1-9	**Total**	**53.6**	**0.6**	**0.1**	**0.3**	**16.5**	**71.144**	**100.0**

5 ANNEX 1 - REFERENCES AND SOURCES:

5.1 Site visits & Interviews

- Hospitals
- Cement Plants
- Steel Plants
- Aluminum Plants
- Lime Plants
- Brick Plants
- Ceramics Plants
- Asphalt Mixing Plants
- Pulp and Paper Mills
- Chemical Industries
- Petroleum Refinery
- Power Generation Plants
- Textile Plants
- Leather Plants
- Dry Cleaning Services
- Landfills and Waste Dumps
- Sewage Treatment Plants
- Open Water Dumping Sites

5.2 Contacts:

- Ministry of Health
- Ministry of Agriculture
- Ministry of Energy & Mineral Resources
- Ministry of Trade & Industry
- Ministry of Water & Irrigation
- Customs Department
- Directorate of Civil Defense
- Department of General Statistics
- Greater Amman Municipality
- Royal Scientific Society
- Traffic Department
- Amman Chamber of Industry
- Port Corporation
- Jordan Petroleum Refinery

5.3 References:

COWIconsult, RSS. “ Industrial Pollution Control in Jordan”, Amman, 1994

Metcalf & Eddy “ Wastewater Engineering, Treatment, Disposal & Ruse”, 1980

JICA “ Basic Design Study Report on the Project of Solid Waste Management in Major Local Areas in Jordan, Amman, 1996

IGIP, Loock, JCE, CES “ Northern Region Solid Waste Management Project” Amman, 1999

Department of Statistics “ External Trade Statistics , part 3” Amman, 2000

6 ANNEX 2: LIST OF ABBREVIATIONS AND UNITS

a	Year (annum)
APC(S)	Air pollution control (system)
CM	Cubic meter
d	Day
d.m.	Dry matter
donum	1,000 square meter
EDC	1,2 –Dichloroethane
E.F.	Emission factor
ESP	Electrostatic precipitator
g	Gram
GCEP	General Corporation for Environment Protection (in Jordan)
GW	Gigawatt
h	Hours
kg	Kilogram
km	Kilometer
L , l	Liter
MJ	Megajoule
MOEnv	Ministry of Environment (Jordan)
MW	Megawatt
NA	Not applicable
NaOH	Sodium hydroxide
ND	Not determined (no data)
PCB	Polychlorinated biphenyls
PCDD	Polychlorinated dibenzo–para–dioxins
PCDF	Polychlorinated dibenzofurans
PCP	Pentachlorophenol
POPs	Persistent organic pollutants
PVC	Polyvinylchloride
RSS	Royal Scientific Society (Jordan)
t	Ton
TEQ	Toxic Equivalent
TJ	Zerajoule
UNEP	United Nations Environment Programme

7 ANNEX 3: SAMPLES OF SOME SELECTED QUESTIONNAIRES

1- Waste Incineration

☐ Hazardous Waste ☐ Medical/Hospital Waste ☐ Animal Carcass

Location: ___________________________________
Number of Furnaces: _____________________

1- Operation Condition:

☐ Batch Type ☐ Discontinuous ☐ Continuous

Unit Capacity: ___________________________ (tons of waste/hour)

Operation Hours: _____________________

Furnace Type:

☐ Mass-Burn/Water wall (Grate) ☐ Fluidized-bed

☐ Stoker ☐ Rotary Kiln

☐ Other (specify) _________________________________

Furnace Temperature: ____________________________ ºC

2- Air Pollution Control System Type:

☐ Electrostatic Precipitator ☐ Cyclone
☐ Bag house Filter ☐ Wet Scrubber
☐ Dry Scrubber ☐ Lime Injection
☐ Noah Injection ☐ Active Carbon/Coke Injection
☐ Carbon Filter ☐ Catalytic Converter/SCR System
☐ Induced or Forced Draft Fan ☐ none

A- Inlet Temperature:______ ºC
B- Outlet Temperature:_____ ºC
C- Flue Gas Flow Rate:_________((Nm³/hour)
D- Heat Recovery System: ☐ Yes ☐ No

3- Furnace Type:____
a- Air Pollution Control ☐Yes ☐ No
b- Number of Lines: _________________________________

c- Operation Condition: ☐ Batch Type ☐ Discontinuous ☐ Continuous
d- Degree of Certainty:_____________
e- Bottom Ash Disposal:____________(tons/hour)
f- Fly Ash Disposal:_______________ (tons/hour)
g- Water Discharge:_______________ (tons/hour)
h- Water Filtration: ☐ Yes ☐ No
i- Sludge Discharge:_______________(tons/hour)
j- Waste Capacity:________________ (tons/hour)
k- Final Source Classification:_________________

Ferrous & Non-ferrous Metal Industry

☐ ***Iron & Steel*** ☐ ***Aluminum*** ☐ ***Copper*** ☐ ____________

Location: ____

Type: ☐ foundry ☐ re-melting ☐

other (specify)

Number of Furnaces/Lines:

Furnace Type/Manufacturer: ____

Total Capacity:

Input material	(unit)	Final Product	(unit)
Pig iron	____________	__________________	__________
Iron & steel scrap	____________	__________________	__________
Foundry returns	____________	__________________	__________
Metal turnings	____________	__________________	__________
Ore (specify)	____________	__________________	__________

Operational hours: ________________________________

Furnace Type:

☐ Blast fur.(cupola) ☐ Electric induction fur. ☐ Electric arc
☐ Cowper ☐ Rotary kilns ☐ Other___________

Furnace temperature ____________ ºC

Abatement Pollution Control System:

☐ Electrostatic Precipitator ☐ Cyclone
☐ Bag house Filter ☐ Wet Scrubber
☐ Dry Scrubber ☐ Lime Injection
☐ NaOH Injection ☐ Active Carbon/Coke Injection
☐ Carbon Filter ☐ Catalytic Converter/SCR System
☐ Induced or Forced Draft Fan ☐ None
☐ Other (specify) ________________

Presence of after burner: ☐ Yes ☐ No

If yes, temperature: _________ ºC

Scrubbing system used:

☐ Lime ☐ Active carbon ☐ Other _______________

3- Power Generation

Energy Production – Power Plants

Location:____________________________________

Number of Furnaces:____

Type: ☐ Batch Type ☐ Discontinuous ☐ Continuous

Furnace Type/Manufacturer: ____

Fuel used:____________________________ amount __________________________

Capacity:

	Raw material	(unit)	Final Product	(unit)
1-				
2-				
3-				
4-				
5-				
6-				
7-				

Operational hours: ________________________________

	Furnace Type	Furnace temperature ºC
a)		
b)		
c)		
d)		
e)		
f)		

Abatement Pollution Control System:

- ☐ Electrostatic Precipitator
- ☐ Cyclone
- ☐ Bag house Filter
- ☐ Wet Scrubber
- ☐ Dry Scrubber
- ☐ Lime Injection
- ☐ NaOH Injection
- ☐ Active Carbon/Coke Injection
- ☐ Carbon Filter
- ☐ Catalytic Converter/SCR System
- ☐ Induced or Forced Draft Fan
- ☐ None
- ☐ Other (specify) ________________

Abatement Pollution Control System Temperature:____________________ ºC

4 - Mineral Products Production – Cement Production

Location:____________________________________
Number of Furnaces:____
Type: ☐ Batch Type ☐ Discontinuous ☐ Continuous

Manufacturer: ____
Fuel used:__________________________________ amount: ____________________

Capacity:

	Raw material	(unit)	Final Product	(unit)
1-				
2-				
3-				
4-				
5-				
6-				
7-				

Operational hours: ___________________________________

	Furnace Type	Furnace temperature ºC
a)		
b)		
c)		
d)		
e)		
f)		

Abatement Pollution Control System:

☐ Electrostatic Precipitator
☐ Bag house Filter
☐ Dry Scrubber
☐ NaOH Injection
☐ Carbon Filter
☐ Induced or Forced Draft Fan
☐ Other (specify) _________________
☐ Cyclone
☐ Wet Scrubber
☐ Lime Injection
☐ Active Carbon/Coke Injection
☐ Catalytic Converter/SCR System
☐ None

Abatement Pollution Control System Temperature:______________________ ºC

Input Material	Description	Amounts
Fuel:		
Raw material & wastes		

5 - Transportation

Total Number of Vehicles:____________________________

Passenger Cars

	Leaded Gasoline	Unleaded Gasoline	Diesel
# Vehicles	______________	________________	________
Total km p.a.	______________	________________	________
Fuel consumption (l/km, l/a)	______________	________________	________
APCS*: (Yes/No)	______________	________________	________
APCS Temperature ºC	______________	________________	________

Remarks:____

____

Busses

	Leaded Gasoline	Unleaded Gasoline	Diesel
# Busses	______________	________________	________
Total km p.a.	______________	________________	________
Fuel consumption (l/km, l/a)	______________	________________	________
APCS*: (Yes/No)	______________	________________	________
APCS Temperature ºC	______________	________________	________

Remarks:____ ______

Trucks

Trucks:_________________ Total km p.a. :________________

Diesel consumption (l/km, l/a):__________________ APCS*: (Yes/No): __________

APCS Temperature _________________ºC

Remarks:____ ______

Ships

Ships:_________________ Total km p.a. :________________

Diesel consumption (l/km, l/a):__________________ APCS*: (Yes/No): __________

APCS Temperature _________________ºC

Remarks:____ ______

Trains

Trains:_________________ Total km p.a. :________________

Diesel consumption (l/km, l/a):__________________ APCS*: (Yes/No): __________

APCS Temperature _________________ºC

Remarks:____ ______

*APCS: here means Catalyst ,Particulate removal (for Diesel)

6- Uncontrolled Burning
(Open Burning)

Forest/Bush Fires

Events p.a.:________________ Material Burnt:____________________________ (t)

Areas of country: ☐ Coastal ☐ Inland
Types of vegetation in fire: * ______________________ *____________________
* ______________________ * ____________________
* ______________________ * ____________________

Remarks*: (method used to estimate amount of material)*

____

____

____

____

Grassland Fires

Events p.a.:________________ Material Burnt:____________________________ (t)

Areas of country: ☐ Coastal ☐ Inland
Types of vegetation in fire: * ______________________ *____________________
* ______________________ * ____________________
* ______________________ * ____________________

Agricultural Field Burning (Harvest Residues)

Events p.a.:________________ Material Burnt:____________________________ (t)

Areas of country: ☐ Coastal ☐ Inland

Remarks*: (Main types of material involved, main crops, any related information composition)*

____

____

____

Uncontrolled Domestic Waste Burning

Events p.a.:________________ Material Burnt:____________________________ (t)

Areas of country: ☐ Coastal ☐ Inland
Remarks: (*Estimation of frequency and quantity, typical conditions, any information on composition of waste or nature of fire)*

____

____

____

Landfill Fires

Events p.a.:________________ Material Burnt:___________________________ (t)

Areas of country: ☐ Coastal ☐ Inland
Types of material in fire: * ______________________ * ____________________
* ______________________ * ____________________
* ______________________ * ____________________

Remarks: (*Details of how estimates are arrived at)*

____
____
____

Accidental Fires in Buildings and Factories

Events p.a.:________________ Material Burnt:___________________________ (t)

Areas of country: ☐ Coastal ☐ Inland
Types of material in fire: * ______________________ * ____________________
* ______________________ * ____________________
* ______________________ * ____________________

Accidental Fires Vehicles

Events p.a.:________________ Material Burnt:___________________________ (t)

Areas of country: ☐ Coastal ☐ Inland
Types of material in fire: * ______________________ * ____________________
* ______________________ * ____________________
* ______________________ * ____________________

Open Burning of Wood, e.g. Construction/demolition wastes

Events p.a.:________________ Material Burnt:___________________________ (t)

Areas of country: ☐ Coastal ☐ Inland
Types of material in fire: * ______________________ * ____________________
* ______________________ * ____________________

7- Chemical Industry

3- Pulp and Paper Industry
(Information with relevance to water/effluent generation and inputs into wastewater)

Location:____

Number of Plants:____

Capacity (t/a):____

CI-B :____

Water Discharge:__________________ L/h _______________________m^3/a

Water Treatment:
* Settling Pond_______________________________
* Aerated Lagoon _____________________________
* Secondary Treatment ________________________
* Tertiary Treatment______________________
* Others (specify) ____________________________

Sludge Generate (t/a) ____

Sludge Disposal:
* Land Fill ____________________________
* Land farming ____________________________
* On-Site ____________________________
* Combustion (energy recovery)_________
* Others (specify) ____________________________

8- Questionnaire For Waste Water Treatment Plants

Name & of Company: ____

No. of Plants : ____

Hydraulic Load_________________________________ CM/a

Waste Water Treatment Type:

Stabilization Pond
Aerated Lagoon
Secondary Treatment

(Activated Treatment)

Tertiary Treatment
Others (please specify)
Sludge Generation: __________________________t/a
Sludge Disposal:

Landfill

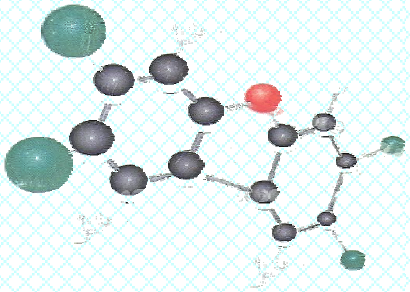
Land farming
On-Site
Combustion (energy recovery)

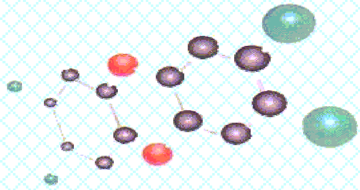
Others (please specify)

Flow:	CM/d
TSS: (in):	mg/L
TSS (out):	mg/L
COD (in):	mg/L
COD (out):	mg/L
BOD (in):	mg/L
BOD (out):	mg/L

National Inventory on Dioxins and Furans Releases in Lebanon – 1999

Ministry of Environment





- 2003-

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Abbreviations and Acronyms

2,4,5-T	2,4,5,-trichlorophenoxyacetic acid
°C	Degrees Celsius
a	Year, annum (365 days)
APC (S)	Air pollution control (System)
BAT	Best available techniques/technologies
b.w	body weight
CNP	2,4,6-trichlorophenyl-4’-nitrophenyl ether
d.m.	Dry matter
EDC	1,2-Dichlorine
EPA	Environmental Protection Agency
ESP	Electrostatic precipitator
GEF	Global Environment Facility
GoL	Lebanese Government
h	Hours
HW	Hazardous waste
I-TEF	International Toxicity Equivalency Factor
I-TEQ	International Toxic Equivalent
L	Liter
MSW	Municipal solid waste
NA	Not applicable (not a relevant release route)
ND	Not determined/ no data
PCB	Polychlorinated biphenyls
PCDD	Polychlorinated dibenzo-*para*-dioxins
PCDF	Polychlorinated dibenzofurans
PCP	Pentachlorophenol
POPs	Persistent organic pollutants
PVC	Polyvinylchloride
t	Ton
TEF	Toxicity Equivalency Factor
TEQ	Toxic Equivalent
UV	Ultra-violet
UNEP	United Nations Environment Programme
VCM	Vinyl chloride monomer

WHO	World Health Organization
CSHPF:	Conseil Superieur d'hygiéne Publique en France
GEF	Global Environment Facility
GDP	Growth
MoA:	Ministry of Agriculture
MoE	Ministry of Environment
pg:	Picogram

Executive Summary

The present document summarizes the results of the first National Inventory for identification and quantification of dioxins and furans releases in Lebanon. The purpose of this study is to evaluate the Lebanese situation concerning the presence of two persistent organic pollutants - dioxins and furans- and to estimate the effect of these releases on the environment and the human health. The realization of this work is a very important step for Lebanon to confirm its compliance to Stockholm Convention, signed in May 2001 and ratified by the law numbered 432 issued on the 8th of August 2003.

The methodology followed to achieve the inventory was prepared by UNEP-chemicals and published in the " standardized toolkit for identification and Quantification of dioxin and furan releases." The used protocol organize the potential sources in 10 main categories, each category is subdivided into subcategories of different classes depending on the magnitude of the emissions. The toolkit provides, for each class or process, an estimated emission factor to be used in order to calculate the total emissions of PCDD/PCDF that might be released in the country.

Dioxins and furans are unintended by-products of combustion and many industrial processes, detectable in traces amount in the atmosphere, water, land and residues and virtually in the global ecosystem. Once emitted, they can travel for long distances and last for a long time. In the process they accumulate in fatty tissues and increase in concentration as they move higher in the food chain.

Establishing the inventory, required several steps:

- First, identifying the main source categories existing in the country,
- Then, identifying the subcategories existing in the country,
- Afterward, gathering detailed information on the processes and classifying processes into similar groups and,
- Finally, quantifying the identified sources with default emission factors.

1 GENERAL INFORMATION ON LEBANON

The Republic of Lebanon is a small country in the Middle East region between Palestine and Syria. It is located on the east shore of the Mediterranean with two long mountainous chains beginning in the north side of the country and ending in the south, dividing the country into two parts: the west coastal zone that has a maximum width of 4 to 5 kilometers, then when we move east we will encounter the first chain of mountains called west chain of Lebanon after which comes the Bekaa Valley that is comprised between the two chains the east and the west ones.

⇨ ***Area:***

- Land area 10,542 m^2
- Land boundaries total 454 km,
- Palestine 79 km, Syria 375 km
- Coast line 225 km
- Territorial sea 12 nm

Figure 1: Lebanon's map

⇨ ***Climate***: Mediterranean; mild to cool, wet winters with hot dry summers

⇨ ***Natural resources***: Limestone, iron ore, salt and water

⇨ ***Land use:*** *- Arable land 6%*
- Forest and woodland 13 %
- Other irrigated land 61 %

⇨ ***Population: 4.350 million (1999)***

⇨ ***Administrative divisions***: 6 governorates -muhafazat-: Al-Bekaa, Al-Janub (South), Nabatiyyeh, Ash-Shamal (North), Beirut, Jabal Lubnan (Mount Lebanon).

Economy: The Lebanese economy is mostly based on trade and tourism with a relatively low load on agriculture and even lower load on industry. The Lebanese industrial sector does not comprise large number of heavy industrial activities, most of which are transforming activities. The main factories in the country are agro industrial ones.

⇨ ***National Product:***

- Nominal GDP: $16,462 million (2000 est.)
- National product real growth rate: 0% (2000 est.)
- Balance of payment: $-289 million (2000

⇨ ***Budget:***

- Revenues: LBP 4,552 billion (2000)
- Expenditures: LBP 10,424 billion (2000)

⇨ ***Industries:***

- Lebanon's industrial sector counts 22,025 establishments. This total excludes water, power, and construction activities. The Lebanese industrial sector is not very diversified. Indeed, the bulk (i.e. 88.6%) the industrial establishments belong to 8 major industrial branches: food and beverages, textiles, clothing and fur, leather and tanning, wood products (excluding furniture), non-metallic products, metal products, furniture and assimilated products.

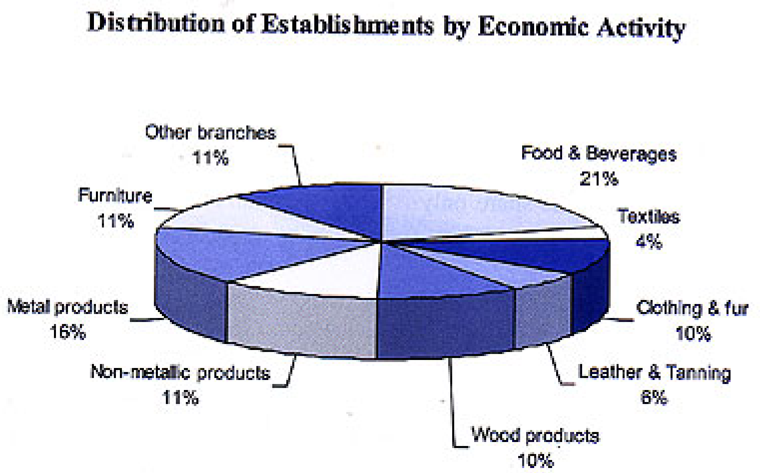


Figure 2: Distribution of Establishments by Economic Activity

⇨ ***Agriculture :*** Accounts for about one-third of GDP, principal products: potatoes, grapes, citrus fruits, apples, tomatoes, wheat, tobacco, sugar beet.

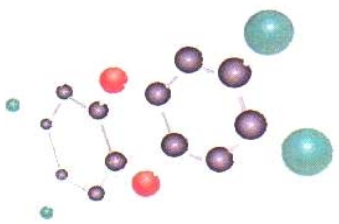
⇨ ***Mining:*** Lebanon has a few natural resources. There are minor deposits of high-grade iron ore, asphalt, coal, lignite, phosphates and salt, all of which are exploited for internal consumption. There are also quarries for building-stone, sand and lime suitable for use in construction.

⇨ ***Inland transportation:***

- Roads: length of roads is 7.100 km
- Railways: there are 378 km in total. The system is being modernized.
- Air: the international airport is Beirut, airport code: BEY
- Shipping: the largest and busiest ports are Beirut, Tripoli, Jounieh, Sidon and Tyre.

2 General information on PCDD/PCDF

"Dioxin" is the general term for the polychlorodibenzo-para-dioxins and polychlorodibenzofurans. They are two persistent organic pollutants classified as halogenated aromatic hydrocarbons.



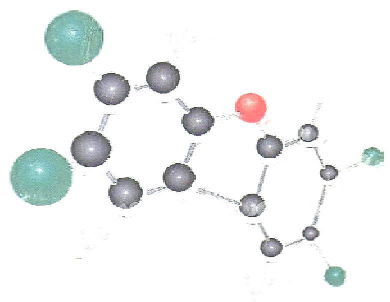


Figure 3 and Figure 4: Structure of the polychlorodibenzo-para-dioxin molecule (left) and structure of the polychlorodibenzofuran molecule (right)

Neither dioxins nor furans are produced commercially, and they have no known use. They are by-products resulting from the production of other chemicals. Dioxins may be released into the environment through the production of pesticides and other chlorinated substances. Furans are a major contaminant of PCBs. Both dioxins and furans are related to a variety of incineration reactions, and the synthesis and use of a variety of chemical products.

Dioxins and furans have been detected in emissions from the incineration of hospital waste, municipal waste, hazardous waste, car emissions, and the incineration of coal, peat and wood.

2.1 Dioxin Properties:

Polychlorinated dibenzo-para-dioxins and polychlorinated dibenzofurans are two groups of planar tricyclic compounds that have very similar chemical structures and properties. They may contain between 1 and 8 chlorine atoms; dioxins have 75 possible positional isomers and furans have 135 positional isomers. The chemical properties of each of the isomers have not been elucidated; these properties vary with the number of chlorine atoms present.

The tables below summarize some of these properties:

Table 1: Dioxins and furans properties

Dioxins				
Homologue Group	**Molecular weight (g/mole)**	**Vapor pressure (Pa x 10^{-3})**	**Water Solubility (mg/m^3)**	**Log K_{OW}**
M_1CDD	218,5	73-75	295-417	4,75-5,00
D_2CDD	253,0	2,47-9,24	3,75-16,7	5,60-5,75
T_3CDD	287,5	1,07	8,41	6,35
T_4CDD	322,0	0,00284-0,275	0,0193-0,55	6,60-7,10
P_5CDD	356,4	0,00423	0,118	7,40
H_6CDD	391,0	0,00145	0,00442	7,80
H_7CDD	425,2	0,000177	0,0024	8,00
O_8CDD	460,0	0,000953	0,000074	8,20
Furans				
Homologue Group	**Molecular weight (g/mole)**	**Vapor pressure (Pa x 10^{-3})**	**Water Solubility (mg/m^3)**	**Log K_{OW}**
D_2CDF	237,1	14,6	14,5	5,44
T_3CDF	306,0	0,199	0,419	6,1
P_5CDF	340,42	0,0172	0,236	6,5
H_6CDF	374,87	0,0031-0,0036	0,0177-0,0083	7,0
H_7CDF	409,31	0,00054-0,00057	0,00135	7,4
O_8CDF	443,8	0,000101	0,00116	8,0

As other POPs, dioxins and furans have the following properties:

1. ***Persistence in the environment***: Dioxins and furans are considered to be very stable and persistent, as illustrated by the half-life of TCDD in soil of 10-12 years.

2. ***Lipophilic:*** These molecules are soluble in lipids; hence their penetration through the cells membranes is very common.

3. ***Bioaccumulation and biomagnitude***: The persistence, combined with high partition coefficients (up to 8.20 for OCDD) provides the necessary conditions for these compounds to bioconcentrate in organisms. A bioconcentration factor of 26,707 has been reported in rainbow trout (Salmo gairdneri) exposed to 2,3,7,8-TCDD.

4. ***Semi volatility***: they tend to enter the air, travel long distances on air currents, and then return to earth. . They may repeat this process many times as the "jump" north. The colder the climate, however, the less they tend to evaporate, resulting in their accumulation in the polar regions, thousands of kilometers away from their original sources. This means that any release to the environment represents a potential global threat.

Dioxins emitted from combustion and industrial sources, or re-entrained from environmental reservoirs, are transported to distant locations through atmospheric or aquatic pathways. The dioxins are deposited on agricultural crops, taken up in the food supply, and then bioaccumulated and biomagnified through the food chain.

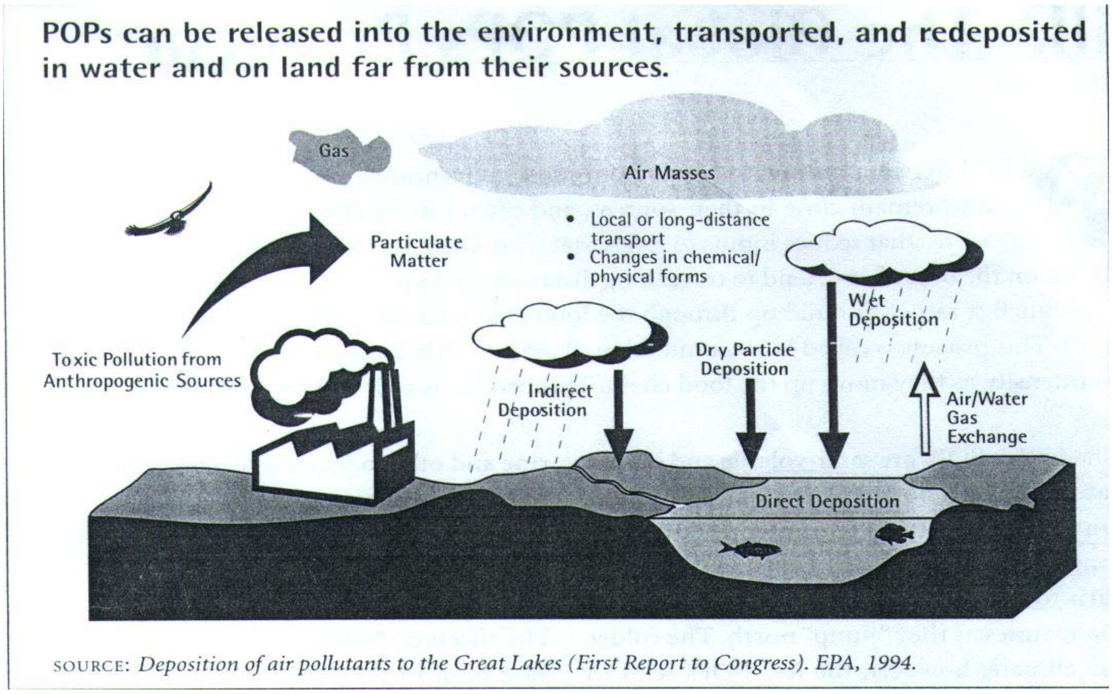


Figure 5: Transport of POP molecules in the different media of the environment

2.2 Toxic Equivalent:

Of the 210 dioxins and furans, 17 contribute most significantly to the toxicity of complex of mixtures. These congeners have a common, receptor-mediated mechanism of action but don't have the same toxic effects.

Since dioxins are always present as mixtures of different molecules and in order to facilitate a comparison mixtures. Each congener is given a toxicity equivalence factor (TEF) based on its specific ability to elicit dioxin-like effects. The congener 2,3,7,8-tetrachlorodibenzo-p-dioxin is the most toxic congener and is given a TEF of one. Other congeners are given TEFs that are fractions of one.

TEFs are regarded as risk management tools and they do not necessarily represent actual toxicity with respect to all endpoints. Rather, they tend to overestimate the toxicity of mixtures. These factors are given in the figure below:

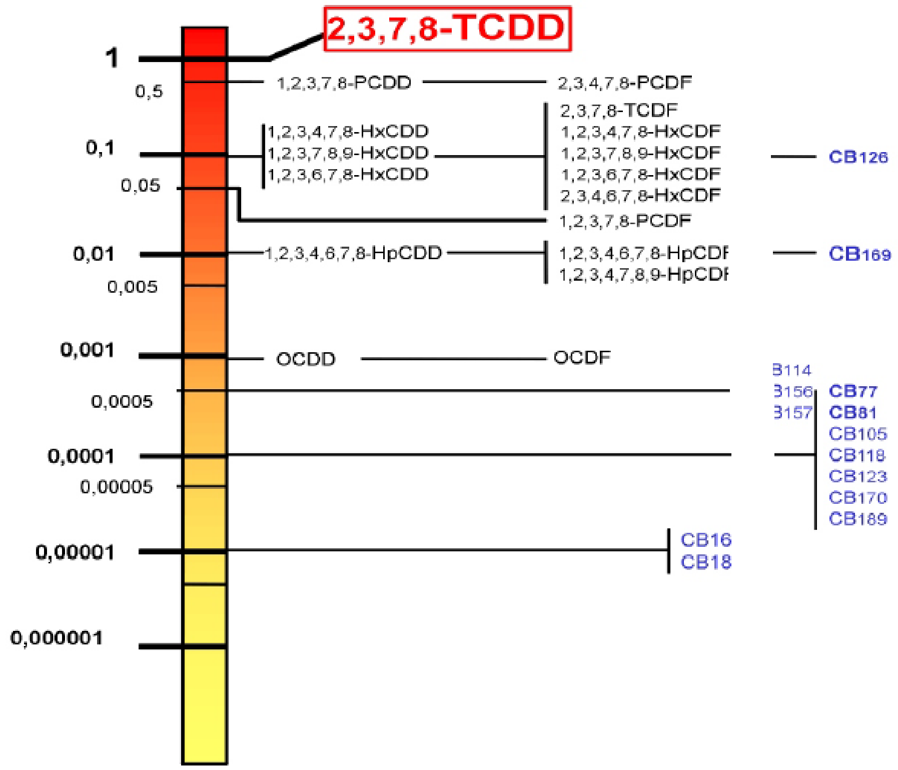


Figure 6: TEF of different dioxin congeners

The sum of the measured concentration of each congener multiplied by its TEF gives the total toxic equivalent (TEQ)

$$TEQ = \Sigma(congener_n * TEF_n)$$

2.3 Human Exposure:

Human exposure to background contamination with PCDD/PCDF is possible via several routes:

- Inhalation of air and intake of particles from air
- Ingestion of contaminated soil
- Dermal absorption
- Food consumption

In 1990, a WHO working group concluded that 90 % of the daily intake (from background contamination) results from ingestion. Especially, foodstuffs of animal origin are responsible for the daily intake of approximately 2 pg TEQ/kg bw/ day. All other foodstuffs, especially, the non-fatty ones, are of minor importance in terms of PCDD/PCDF intake. The average of daily intake proposed by WHO is 1- 4 pg TEQ /kg/day

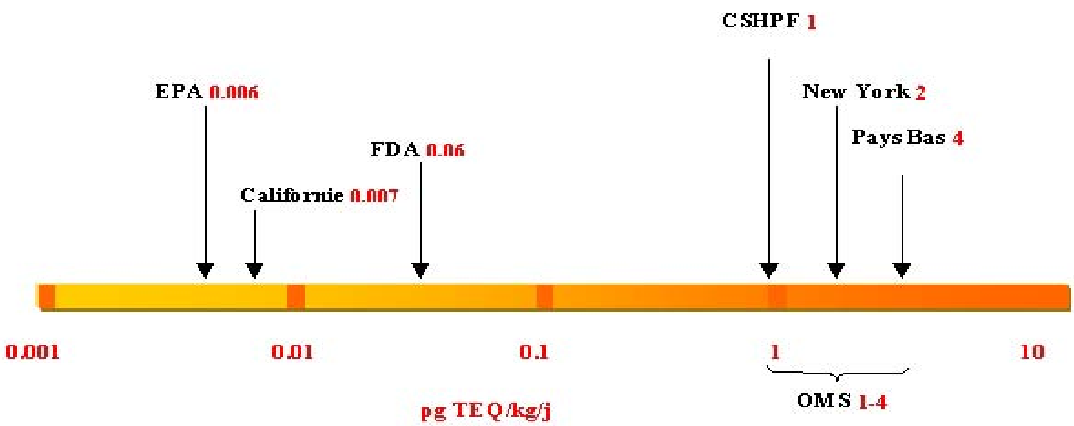


Figure 7: Average of dioxin daily intake proposed by different countries and organizations

2.4 Formation of dioxins:

Dioxins are formed as unintentional by-products in a wide range of processes. Especially in the presence of some chlorinated compounds called dioxin precursors. In addition researchers have found that PCDD/F will be generated during all combustion processes including incineration of waste, the combustion of solid and liquid fuels and the thermal processing of metals.

Dioxins sources are subdivided into two groups:

- Primary sources including Industrial-chemical processes and thermal processes
- Secondary sources or Reservoirs

A- Industrial-chemical processes:

During the production of some chlorinated aromatic molecules, called precursors, or during their combustion dioxins and furans will be formed. In fact, under temperatures between 200°C and 500°C, and in oxidant conditions, the precursors undergo some molecular rearrangements inducing the production of dioxins and furans. In wet-chemical processes the propensity to generate PCDD/PCDF during the synthesis of chemical compounds decreases in the following order:

Chlorophenols > Chlorobenzene > Aliphatic chlorinated compounds > inorganic chemical compounds

Here are some examples of dioxin precursors compounds

PCB	**Chlorophenols**	**Chlorobenzenes**
(x<5 et y<5)	(x<5)	(x<6)

Figure 8: Structure of different dioxin precursors

The favorable factors for the formation of PCDD/PCDF are:

- High temperature
- Alkaline media
- Presence of UV light
- Presence of radicals in the reaction mixture.

A very good example of this is what happened in Sevesso -Italy in 1976, during the synthesis of a defoliant 2,4,5-Trichlorophenoxyacetic acid. The optimal temperature for the reaction is 125 °C, if it exceeds this limit, a very exothermic reaction will occur leading to the formation of tetrachlorodibenzodioxin knowing to be very toxic. The exothermicity of the reaction had induced the explosion of the reactor and the spreading of the dioxin.

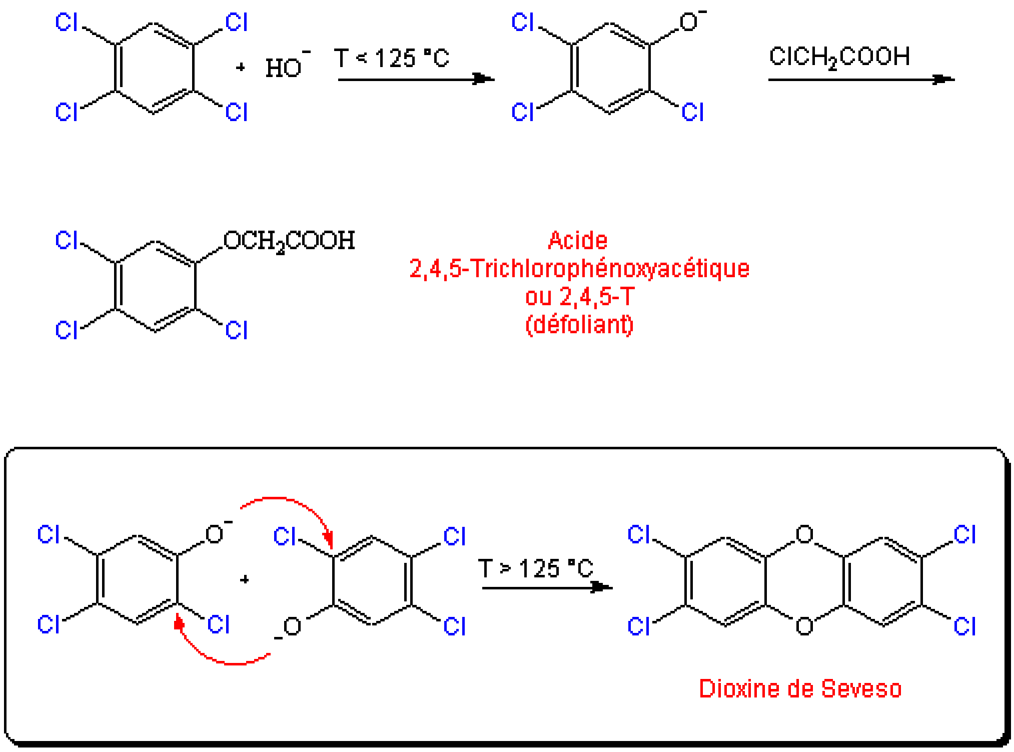


Figure 9: Mechanism of formation of dioxin during 2,4,5-T production

B. Thermal processes:

Thermal processes constitute the main source of dioxin emissions these days.

Therefore Waste incineration is a very important emission source, depending on the process used the concentration of PCDD/PCDF in the flue gases can vary.

Knowing that dioxins and furans are present in very small quantities in the wastes and since the energy produced during the combustion is capable of broking the chemical bonds and destroying the original molecules and produce carbonic gas, water vapor, hydrochloric acid….etc , the formation process of PCDD/PCDF during the incinerations are not very well understood.

In fact, during the incineration the combustion is not totally complete and the material is not totally transformed into CO_2 and H_2O, *etc.* Therefore the chemical composition of the gases of the flame is very complex. It contains molecules, atoms , radicals, *etc.*

No doubt, dioxins can be reformed in the media of the reaction form different elements such carbon, oxygen, hydrogen and Chlorine present as atoms or radicals. The destruction and reformation of dioxins are illustrated in the following chemical equilibrium:

$$12\,C + (10\text{-}n)\,H + 2\,O + n\,Cl \rightleftharpoons C_{12}H_{(10\text{-}n)}O_2Cl_n \quad (1)$$

When the incineration gases leave the combustion zone, they pass through heat exchangers for cooling and arrive to the electro filters, in order to retain the dust.

Dioxins are adsorbed on the particles surface. However it was observed that the concentration of dioxins in the gases is more important at the way out of the electro filters than at the entrance.

Two theories tend to explain it:

- Some authors think that a reformation of dioxins had occurred in the electro filters so called **synthesis " novo"**. It's a synthesis in a solid phase where dioxins are formed on the particles surface during complex reactions..
- Another theory proposes the ***desorption*** of dioxins in the electro filters. Dioxins will pass through the filters and arrive to the gas treatment system.

PCDD/PCDF are formed in every process where substances containing chlorine are burned with carbon and in presence of Oxygen and of a convenient catalyst such as copper at high temperatures exceeding 300°C.

Preferably the formation of PCDD/PCDF take place in the zone where the combustion gases are cooled from 450°C to 250°C (novo Synthesis) and not in the combustion chamber.

C. Secondary Sources of PCDD/PCDF = reservoirs

Dioxin reservoirs are those matrices where PCDD/PCDF are already present, either in the environment or as products. The PCDD/PCDF found in these reservoirs are not newly generated but concentrated from other sources. A characteristic of the reservoir sources is that they have the potential to allow re-entrainment of PCDD/PCDF into the environment.

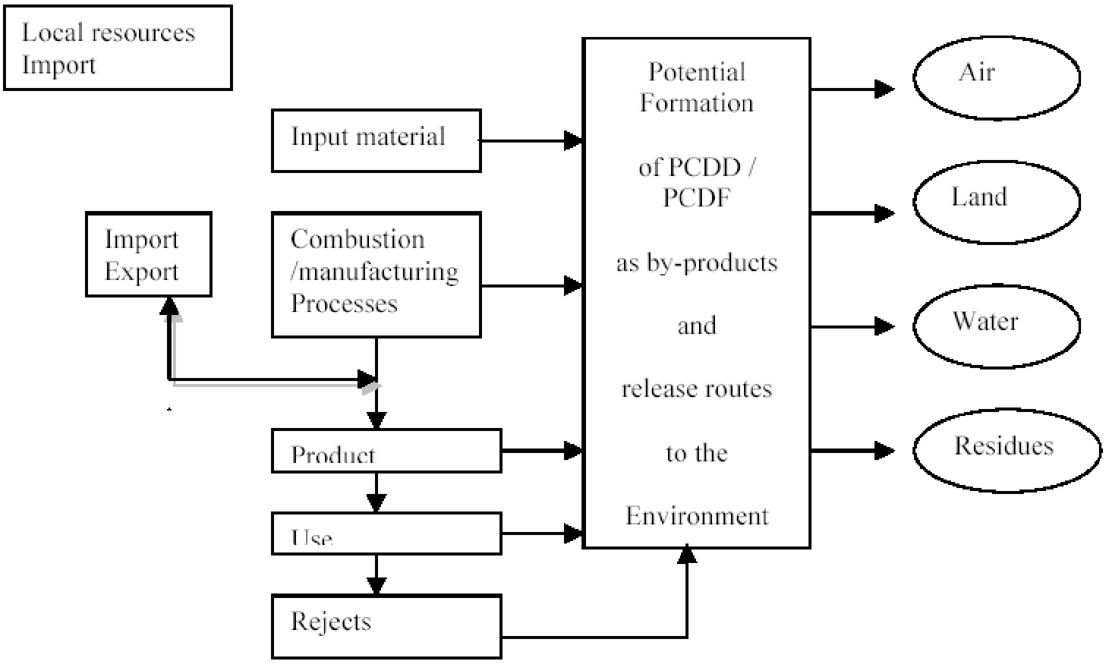


Figure 10: Potential release routes of PCDD/PCDF as a by-product into the three environmental media air, water and Land and /or to product and waste.

2.5 Release of PCDD/F:

2.5.1 Releases to Air:

Releases of PCDD/PCDF into the atmosphere occur either from stationary sources, which are mostly associated with industrial activities such as production and manufacturing or from diffuse or dispersed sources, which are mostly related to the use and application of PCDD/PCDF containing products. PCDD/PCDF emitted either of these two source categories can undergo long-range transport and thus, PCDD/PCDF can be detected in air at locations far from the origin of its release.

Examples of processes releasing PCDD/PCDF into air include off-gases from:

- Combustion processes
- Metal processing operations, e.g. sintering, metal smelters, etc..
- Drying and baking operations, smoke houses, *etc.*
- Other thermal processes e.g. pyrolysis, ash recycling, cracking, *etc.*

Four conditions, present either individually or in combination, potentially cause the generation of PCDD/PCDF releases to the air:

- High temperatures (above 200°C) processes and/or incomplete combustion
- Organic carbon
- Elemental chlorine
- PCDD/PCDF containing products.

Actual dioxin formation potential and actual release will depend on process conditions and air pollution controls applied, Technologies have been developed to reduce formation of PCDD/PCDF and to control emissions to very low levels for many processes.

2.5.2 Release to Water:

PCDD/PCDF releases to water can occur with the discharge of wastewater, run-off from contaminated sites or application of dioxin contaminated chemicals /products, e.g. direct application of pesticides, dumping of wastes, etc. PCDD/PCDF may be present in a discharge if the PCDD/PCDF formed in the industrial production process, entered the industrial process with the feed material, or leached form a repository. Consequently, the criteria used to identify potential releases of PCDD/PDCF to water include:

- Wastewater discharge from processes involving chlorine and/or PCDD/PDCF contaminated products or combustion, incineration and other thermal processes where wet scrubbers are used to clean flue gases.
- Use of PCDD/PDCF contaminated pesticides (especially PCP and 2,4,5-T) and other chemicals (especially PCB);
- Leachate from storage and/or disposal sites of PCDD/PDCF contaminated materials.

2.5.3 Release to Land:

Sources releasing PCDD/PDCF to land can be divided into two classes: PCDD/PDCF contaminated product “applied” to land directly or PCDD/PDCF deposited onto land via environmental processes. In all cases, land serves as a sink for the PCDD/PDCF from which they can be released into the food chain through uptake by plants and/or animals.

2.5.4 Release in products:

Major sources of environmental contamination with PCDD/PDCF in the past were due to production and use of chlorinated organic chemicals and the use of elemental chlorine in the pulp and paper industry. In these processes, there are four factors, which favor the formation of PCDD/PDCF:

- Elevated temperatures
- Alkaline media
- Presence of UV-light
- Presence of radicals in the reaction mixture/chemical process.

The highest concentrations of PCDD/PDCF have been found in chlorinated phenols and their derivates. Wastes and residues from production are also contaminated with PCDD/PDCF.

PCDD/PDCF reduction comes from modification of the problematic step of the production process. Reduction of releases can also be accomplished by restrictions on the uses of a chemical, by substitution or bans in some cases. This type of source control of the PCDD/PDCF at all points in the products life cycle, including consumer waste. Effective control of the PCDD/PDCF source to the product leads to benefits in several other environmental compartments and media at the same time.

2.5.5 Release in Residues:

An almost infinite number of processes can transfer PCDD/PDCF to wastes or residues. However, the most likely types of wastes can be classified according to their origin, since PCDD/PDCF are always a by-product.

Because PCDD/PDCF are persistent and widely dispersed in the environment low concentrations of PCDD/PDCF are contained in normal municipal solid waste as well as industrial, hospital and other solid waste streams collected during normal every day activities. These include consumer products such as plastics, paper, cloth, household chemicals and food and especially products used in industry such as solvents, oils, paints.

PCDD/PDCF concentrate in solid waste streams from combustion and thermal industrial processes such as fly ash, bottom ash, and other dust. Particulate matter from combustion and thermal industrial processes contains unburned carbon where PCDD/PDCF adsorbs. Fine fly ashes and dusts collected form thermal processes contain by-product PCDD/PDCF in a concentrated form.

In general, low combustion process control and high particle removal efficiency of the air pollution control (APC) system mean higher concentrations of PCDD/PDCF in the solid residue. Moreover chemical production involving elemental chlorine leads to wastes containing PCDD/PDCF. Obviously, effluents form the pulp and paper making as well as municipal sewage waters are PCDD/PDCF contaminated waste streams.

The potential for residues to cause environmental contamination or exposure to PCDD/PDCF depends greatly on how the residue is treated and disposed of.

3 PROTOCOL FOR THE PREPARATION OF THE INVENTORY:

3.1 Procedure:

The estimate of average annual release to each vector (air, water, and land, in products and residues) for each process identified, is calculated by this basic equation:

Source strength (dioxin emissions per year) = Emission factor x "Activity rate" (1)

The PCDD/PCDF emission per year will be calculated and presented in grams of Toxic equivalents (TEQ) per year. The annual Source Strength is calculated by multiplying the release of PCDD/PCDF per unit of feed material processed or product produced – referred to as the emission factor – with the amount of feed material processed or product produced (tons or liters per year) – referred to as the Activity rate.

The protocol used in order to establish the inventory is indicated in the Toolkit. The main sources are divided to ten categories and each category is subdivided into several subcategories regrouping all the activities suspected to be a potential source of PCDD/PCDF releases.

Five steps are necessary to accomplish the inventory and therefore to evaluate the situation in the country:

1. ***Identify the Main Source Categories***
2. ***Check Subcategories to identify existing activities and sources in the country***
3. ***Gather detailed information on the processes and classify processes into similar groups***
4. ***Quantify identified sources***
5. ***Establish a full inventory.***

3.2 Categories

The main PCDD/PCDF Source Categories listed in table 3.1 are broad to capture the wide variety of industries, processes and/or activities known to potentially cause releases of PCDD/PCDF. The ten Categories are designed to have common characteristics.

The large X indicates the release routes expected to be predominant, and the small x shows additional release routes to be considered.

The tables 2 to 11 illustrate the different subcategories and their corresponding release routes.

Table 2: Main Source Categories

No	Main Categories and Subcategories	Potential Release Route				
		Air	Water	Land	Product	Residue
1	Waste incineration	X				X
2	Ferrous and non ferrous production	X				X
3	Power Generation and Heating	X		X		X
4	Production de mineral Products	X				X
5	Transport	X				
6	Uncontrolled Combustion Processes	X	X	X		X
7	Production and Use of Chemical products and consumer goods	X	X		X	X
8	Miscellaneous	X	X	X	X	X
9	Disposal	X	X	X		X
10	Identification of Potential « Hot spots »	Registration only to be followed by site-specific evaluation				

Table 3: Category 1- Waste incineration

N°		Main Categories and Subcategories	Potential Release Route				
			Air	**Water**	**Land**	**Product**	**Residues**
1		**Waste Incineration**	**X**				**X**
	a	**Municipal solid waste Incineration**	X	(x)			X
	b	Hazardous waste Incineration	X	(x)			X
	c	Medical waste Incineration	X	(x)			X
	d	Light fraction shredder waste Incineration	X				X
	e	Sewage Sludge Incineration	X	(x)			X
	f	Waste wood and waste biomass Incineration	X				X
	g	Combustion of animal carcasses	X				X

A waste incineration is categorized according to types of waste burned.

Incineration in this context means destruction in a technological furnace of some sort; open burning and domestic burning in barrels and boxes does not belong to these subcategories.

Wastes differ in combustion characteristics and combustion equipment also typically differs for each of the waste incineration subcategories.

Table 4: Category 2- Ferrous and non-ferrous metal production

			Potential Release Route				
N°.		**Main Categories and Subcategories**	**Air**	**Water**	**Land**	**Product**	**Residue**
2		**Ferrous and non ferrous Production**	**X**				**X**
	a	Iron ore Sintering	X				X
	b	Coke Production	X	X	X	X	X
	c	Iron and steel Production and foundries	X				X
	d	Cupper Production	X				X
	e	Aluminum Production	X				X
	f	Lead Production	X				X
	g	Zinc Production	X				X
	h	Brass Production					
	i	Magnesium Production		X			X
	j	Other non-ferrous metal Production	X	X			X
	l	Shredders	X				X
	m	Thermal wire reclamation	X	(x)	X		X

Production of ferrous and non-ferrous metals is now the largest source of PCDD/PCDF in many European countries. The important metal production processes are mainly thermal and major releases are to air via flue gas and to residue via flue-gas-cleaning wastes.

Table 5: Category 3- Power generation and Heating

			Potential Release Route				
N°		**Main Categories and Subcategories**	**Air**	**Water**	**Land**	**Product**	**Residue**
3		**Power Generation and Heating**	**X**				**X**
	a	Fossil fuel power plants	X				X
	b	Biomass power plants	X				X
	c	Landfill, biogas combustion	X				X
	d	Household heating and cooking (biomass)	X				X
	e	Domestic Heating (fossil fuel)	X				X

In large, well-controlled fossil fuel power plants, the formation of PCDD/PCDF is low since the combustion efficiency is usually fairly high and the fuels used are homogeneous. However, significant mass emissions are still possible as large volumes of flue gases are emitted with small concentrations of PCDD/PCDF

Table 6: Category 4- production of Mineral products

			Potential Release Route				
N°		**Main Categories and Subcategories**	**Air**	**Water**	**Land**	**Product**	**Residue**
4		**Production of Mineral Products**	**X**				**X**
	a	Cement production	X				X
	b	Lime Production	X	X	X	X	X
	c	Brick Production	X				X
	d	Glass Production	X				X
	e	Ceramics Production	X				X
	f	Asphalt mixing	X				X

These are high-temperature processes for melting (glass, asphalt), baking (brick, ceramics), or thermally induced chemical transformation (lime, cement).

In them, fuel combustion generates PCDD/PCDF as unwanted by-products.

Table 7: Category 5- Transport

			Potential Release Route				
N°.		**Main Categories and Subcategories**	**Air**	**Water**	**Land**	**Product**	**Residue**
5		Transport	**X**				
	a	4- Stroke engines	X				
	b	2- Stroke engines	X				
	c	Diesel engines	X				(x)
	d	Heavy oil fired engines	X				(x)

Transportation relies heavily on the combustion of gasoline (leaded and unleaded), Kerosene, diesel fuel and heavy fuel. Poor maintenance, low fuel quality, and poor combustion efficiency are likely to result in increased PCDD/PCDF releases

Table 8: Category 6- Uncontrolled Combustion Processes

			Potential Release Route				
N°		**Main Categories and Subcategories**	**Air**	**Water**	**Land**	**Product**	**Residue**
6		**Uncontrolled Combustion Processes**	**X**				**X**
	a	(Clean) Biomass burning	X	(x)	(x)		X
	b	Waste burning and accidental fires de déchets	X	(x)	(x)		X

Uncontrolled combustion processes are typically poor combustion processes, and may be significant sources of PCDD/PCDF.

Table 9: Category 7 - Production and Use of Chemicals and Consumer Goods

			Potential Release Route				
N°.		**Main Categories and Subcategories**	**Air**	**Water**	**Land**	**Product**	**Residue**
7		**Production and use of Chemicals and Consumer Goods consommation**	**X**	**X**		**X**	**X**
	a	Pulp and Paper mills	X	X		X	X
	b	Chemical industry	X	X	(x)	X	X
	c	Petroleum industry	X				X
	d	Textile plants		X		X	
	e	Leather plants		X		X	

Dioxin and furan releases from production of chemicals and consumer goods may be due to PCDD/PCDF input with the raw materials themselves or formation in the production process. Indicators of high probability to form PCDD/PCDF in chemical manufacturing processes are:

- High temperature
- Alkaline media
- Presence of UV-light as an energy source
- Presence of radicals in the reaction mixture/chemical process

Table 10: Category 8- Miscellaneous

			Potential Release Route				
N°		**Main Categories and Subcategories**	**Air**	**Water**	**Land**	**Product**	**Residue**
8		**Miscellaneous**	**X**	**X**	**X**	**X**	**X**
	a	Drying of biomass	X				
	b	Crematories	X				X
	c	Smoke houses	X			X	X
	d	Dry cleaning		X	X	X	
	e	Tobacco smoking	X				

Crematories may be a source of PCDD/PCDF releases since the combustion process is usually inefficient and the input materials are inhomogeneous. Coffins, embalming fluids, and decoration materials may contain chlorinated chemicals and plastics, metal-based colors and non-combustible materials.

Residues from dry cleaning are another miscellaneous source of PCDD/PCDF, where dioxin-containing chemicals have been concentrated after the dry cleaning process

Table 11: Category 9- Disposal

N°		Main Categories and Subcategories	Potential Release Route: Air	Water	Land	Product	Residue
9		**Disposal**		**X**	**X**		
	a	Landfills and waste dumps		X	X		
	b	Sewage and sewage treatment	(x)	X	X		(x)
	c	Open water dumping		X			
	d	Waste oil disposal (non thermal)		X	X		

Table 11 lists the significant non-thermal /non combustion waste disposal practices, which can lead to PCDD/PCDF releases predominantly to water and land. These practices include land filling of any kind of waste including sewage sludge, waste oil dumping and open water dumping of wastes and sludge.

In order to determine the release route rate of PCDD/PCDF the amount of waste disposed of and the concentration of available PCDD/PCDF must be determined. Especially the co-disposal of mixed wastes can be a major source of PCDD/PCDF releases.

Table 12: Category 10- Identification of Potential "Hot Spots"

N°.		Main Categories and Subcategories	Potential Release Route: Air	Water	Land	Product	Residue
10		**Identification of "Hot Spots"**	Registration only to be followed by site-specific evaluation				
	a	Production sites of chlorinated organics			X		
	b	Production sites of chlorine			X		
	c	Formulation sites of chlorinated phenols			X		
	d	Application sites of chlorinated phenols	X	X	X	X	
	e	Timber manufacture and treatment sites		X	X	X	X
	f	PCB-filled transformers and capacitors				X	X
	g	Dumps of wastes/residues	X	X	X		X
	h	Sites of relevant accidents		X	X		X
	i	Dredging of sediments					X
	j	Kaolinitc or ball clay sites			X		

Site-specific evaluation of each hot spot should determine its current status: immediate threat or potential for releases in the future.

3.3 Information gathering

Gathering detailed information on the dioxin emissions for all the categories and subcategories required visits to some of the sites, contacts with industrialists association and industrial syndicates, research work, review of the national industrial statistics and the regional economic activity records, consulting specialized references, *etc.*

3.4 Classification of the processes

Emissions from processes listed as "subcategories" can vary by orders of magnitude depending on the process technology or operation. The toolkit contains a complete listing of the different subcategories and processes within each subcategory and indicates how to classify processes and choose appropriate emission factors.

To ensure that all activities are accounted for, the sum of the activity rates for the individual classifications should equal the total amount of material processed within the subcategory.

3.5 Compilation of the inventory

To compile the inventory, an estimate for every subcategory has to be completed. Therefore the detailed inventory is build up from each estimated release for all subcategories.

Next, the annual emissions of all individual subcategories are added to give the emissions across all five potential vectors for the Ten Main Source Categories.

Finally, the emissions of all ten Main Source Categories are added up and the national inventory can be calculated, which represents the total estimated release from all identified and quantified sources in the country.

4 ANALYSIS PER CATEGORY:

4.1 Category 1: Waste incineration

a. Municipal solid waste incineration:

No solid waste was incinerated in Lebanon

b. Hazardous waste incineration:

No hazardous waste was incinerated in Lebanon

c. Medical waste incineration:

Among the Lebanese hospitals, only two were and still incinerating their medical waste. In 99, one of the incinerators had a double chamber and the second had only one chamber but none of these incinerators was equipped with any air pollution control system.

Table 13: PCDD/F Emissions for the Medical waste incinerators subcategory

Class of the incinerator	Production of waste T / a	Emission factor (µg TEQ/ TJ)		Emission (g TEQ / a)	
		Air	Residues	Air	Residues
Single chamber incinerator with no APCS	281.25	40,000	200	11.24	0.056
Double chamber incinerator with no APCS	109.5	3,000	20	0.329	0.002
Total	**390.75**	_	_	**11.579**	**0.058**

d. Light fraction shredder waste incinerator:

No light fraction shredder waste was incinerated

e. Sewage sludge incinerator:

No sewage sludge was incinerated

f. Waste wood incinerator:

No waste wood was incinerated

g. Animal carcasses burning

No Animal carcasses were burnt.

4.2 Category 2: Ferrous and non-ferrous production

a. Iron ore sintering

This activity was not realized in the country

b. Coke production:

No coke was produced in Lebanon

c. Steel Foundries:

The only available data concerning the steel foundries emissions consists on the production, in 99, of approximately 75000 tons by one plant that is not currently running. The type of the furnace and the filters are unknown, thus, an assumption was made considering the emission factors related to rotary drum and fabric filters.

Table 14: PCDD/F Emissions for the steel foundries subcategory

Classification	Production T/a	Emission factor (µg TEQ/ t)		Emission (g TEQ / a)	
		Air	Residues	Air	Residues
Rotary drum – Fabric Filters	75,000	4.3	0.2	0.323	0.015

d. Copper production:

No copper was produced in Lebanon

e. Aluminum production:

In 1999, the production of secondary Aluminum had reached 10000 t by two facilities working in the same technology and same conditions .The temperature of the furnaces varies between 700°C and 850°C. These facilities are classified as class 1 for thermal processing of aluminum with minimal treatment of inputs.

Table 15: PCDD/F Emissions for the Aluminum production subcategory

4.2.1 Classification	Production T/a	Emission factor (µg TEQ/ t)		Emission (g TEQ / a)	
		Air	Residues	Air	Residues
Thermal processing of aluminum with minimal treatment of inputs.	10,000	150	400	1.5	4

f. Lead production:

Lebanon generates and recycles approximately 7,000 tons of lead-acid batteries from cars and uninterrupted power supply systems. Two plants with adequate environmental provisions and such as rotary drums and fabric filters recycle more than 90 percent of this quantity. These two facilities extract the lead from the batteries at a temperature of 150- 600°C and smelt it into lead ores and also manufacture various finished products including new car batteries, pellets (packed into the cartridge of shotguns) and shields (used in hospitals against radiation). The hard plastic casing (usually polypropylene) is also recovered and shredded to produce pots. The remaining 10 percent of lead-acid batteries are processed in a limited number of very small operations without proper environmental control (e.g., lead dust releases) or administrative permits.

Table 16: PCDD/F Emissions for the lead production subcategory

Classification	Production T/a	Emission factor (µg TEQ/ t)		Emission (g TEQ / a)	
		Air	Residues	Air	Residues
Sec. Lead PVC/Cl_2 free scrap, blast furnaces with FF	3780	8	_	0.034	_
Sec. Lead from scrap, PVC battery separators	420	80	_	0.03	_
Total	**4200**	**_**	**_**	**0.064**	**_**

g. Zinc production:

No Zinc was produced in Lebanon

h. Brass production:

No brass was produced

i. Magnesium production

No Magnesium was produced in Lebanon

j. Thermal non –ferrous production:

No production in the country

k. Shredders:

No data is available

l. Thermal wire reclamation:

The used cables are treated to separate the plastic from the metal; the plastic is recycled out site and the copper is sent abroad for recycling.

4.3 Category 3: Power generation and heating

a. Fossil fuel power plants:

In this point we consider the consumption of combustibles intended to the generation of electricity to EDL and to the private sector. The types of fuel used for the power generation are gas/diesel oil, heavy fuel oil.

The table below shows the consumption of the combustibles used for this purpose, the emissions factors and the total emissions of PCDD/ PCDF.

Table 17: PCDD/F Emissions for the Fossil fuel power plants subcategory

Combustible	Energetic equivalent TJ	Emission factor (µg TEQ/ TJ)		Emission (g TEQ / a)	
		Air	Residues	Air	Residues
Fuel Oil	54,297[a]	2.5	_	0.136	_
Light oil/ natural gas	48,675[b]	0.5	_	0.024	_
Total	**102,972**	_	_	**0.160**	_

a-the heating value of the fossil oil is considered = 41.5 MJ/Kg

b- the heating value of the light oil/ natural gas is considered = 44.5 MJ/Kg

b. Biomass power plants:

No power is generated using biomass

c. Landfill and biogas combustion:

No power is generated from this subcategory: The total gas released from landfills is estimated to 540,000 m^3 / year. Knowing that the gas composition is 88 % of CO_2, 6 % of CH_4 and 6 % of N_2, so the mass of the gas was found equal to 658 tons and the emissions of PCDD/PCDF to the atmosphere are estimated to **0.005 g TEQ / a**

d. Household heating and cooking biomass:

According to FAO resources there's approximately 200,000 tons of biomass (not contaminated) burnt per annum, 120,000 tons is used for heating and 80,000 tons are being open burnt. This quantity will be considered in category 6- uncontrolled combustion processes – subcategory Open burning.

The table below shows the consumed wood, the emission factors and the total emissions of PCDD/ PCDF

Table 18: PCDD/F Emissions for the household heating and cooking biomass subcategory

Combustible	Energetic equivalent TJ	Emission factor (µg TEQ/ TJ)		Emission (g TEQ / a)	
		Air	Residues	Air	Residues
Wood	1,800[a]	100	20	0.18	0.03

a- The heating value of the wood used is considered =15MJ/Kg

e. Domestic heating – fossil fuels:

The fossil fuels used for heating (institutional and residential) are light oil/diesel and natural gas.

Table 19: PCDD/F Emissions for the Domestic heating-fossil fuels subcategory

Combustible	Energetic equivalent TJ	Emission factor (µg TEQ/ TJ)		Emission (g TEQ / a)	
		Air	Residues	Air	Residues
Light oil/ diesel	5,479 [a]	10	_	0.055	_
Natural Gas	6,189 [b]	1.5	_	0.009	_
Total	**11,668**	**_**	**_**	**0.064**	**_**

a-the heating value of the diesel is considered = 44.5 MJ/Kg

b- the heating value of the natural gas is considered = 48 MJ/Kg

4.4 Category 4: Mineral production

a. Cement production:

All Lebanese cement plants use the dry process and had produced in 99 about 2,970,504 tons at a temperature about 1400°C

Table 20: PCDD/F Emissions for the cement production subcategory

Type of process	Production T/a	Emission factor (µg TEQ/ T)		Emission (g TEQ / a)	
		Air	Residues	Air	Residues
Dry process	2,970,504	0.15	0.003	0.446	0.009

b. Lime production:

Only one facility produced about 4000 tons per year, the temperature of the rotary kiln is around 1000°C with no APC system.

Table 21: PCDD/F Emissions for the lime production subcategory

Dust abatement system	Production T/a	Emission factor (µg TEQ/ t)		Emission (g TEQ / a)	
		Air	Residues	Air	Residues
None	4,000	10	_	0.04	_

c. Brick production:

Only one facility produced about 750 tons in an Intermittent Shuttle Kiln / Fornoceramica , Portugal at 970°C

Table 22: PCDD/F Emissions for the brick production subcategory

Dust abatement system	Production T/a	Emission factor (µg TEQ/ T)		Emission (g TEQ / a)	
		Air	Residues	Air	Residues
None	750	0.2	_	0.019	_

d. Glass production:

Two main facilities, working under the same conditions, produce about 96,250 tons at an average temperature of 1200°C

Table 23: PCDD/F Emissions for the glass production subcategory

Gas treatment	Production T/a	Emission factor (µg TEQ/ TJ)		Emission (g TEQ / a)	
		Air	Residues	Air	Residues
None	96,250	0.2	_	0.013	_

e. Ceramic production:

Two facilities are operating in Lebanon, for tiles and sanitary ware. The total production is approximately 62,000tons. The furnace types are Tunnel Kiln, Shuttle kiln and Carfer Roller kiln at temperature varying between 1140-1180°C for tiles and 1220 °C for Sanitary ware.

Table 24: PCDD/F Emissions for the ceramic production subcategory

Dust abatement system	Production T/a	Emission factor (µg TEQ/ TJ)		Emission (g TEQ / a)	
		Air	Residues	Air	Residues
None	62,000	0.2	_		

f. Asphalt mixing:

In 99, the amount of asphalt mixed had reached around 357,000 tons. At that time, all asphalt-mixing plants were equipped with filters.

Table 25: PCDD/F Emissions for the asphalt mixing subcategory

Gas treatment	Production T/a	Emission factor (µg TEQ/ TJ)		Emission (g TEQ / a)	
		Air	Residues	Air	Residues
Fabric filters	357,000	0.007	0.06	0.002	0.021

4.5 Category 5: Transport

The transport sector in Lebanon is the predominant sector in terms of energy consumption. This sector constitutes a fleet of around 1.3 million registered vehicles, characterized as being relatively old and poorly maintained. It is estimated that over 70 % of the vehicles are more than 15 years old. Lebanon has a car owner rate of around 3 persons / vehicle, close to that of developed countries.

The total import and consumption of petroleum products in Lebanon in 1999 has reached around 4,961,965 Tons. The Lebanese government has reclaimed the exclusive right to import fuel oil in 1996 and diesel import in 1997, as for the gasoline; it's still imported by the private sector.

Passenger cars constitute up to 75 % if the total number of registered vehicles whereas mainly small trucks, minivans and buses constitute the rest.

Leaded gasoline fuel has been the main fuel used for land transport. Pursuant to Law 341/2001 on reducing air pollution from the transport sector,

The GoL has put in place price incentives for the use of unleaded gasoline.

Unleaded gasoline was first introduced in Lebanon in small amounts in 1993 to meet demand of new car models equipped with catalytic converters (Hashisho and El-Fadel, 2001). Since then, unleaded gasoline has assumed an ever more important share of total gasoline consumption, from less than five percent in 1995 to almost 20 percent in 1999, and presumably more since.

The maximum lead content in unleaded gasoline, as specified by the Ministry of Energy and Water, is 0.008 ml/l, compared to 0.15 ml/l for super grade gasoline (98 Octane) and 0.4 ml/l for regular grade (92 Octane). Therefore, as unleaded gasoline becomes more widely used, lead emissions will decrease proportionally.

It's very important to mention that the maintenance of catalytic converters is very poor and therefore their efficiency decreases with time.

The coming table describes the estimated distribution of different types of Gasoline.

Table 26: Amounts of imported gasoline

<table>
<tr><td rowspan="4">Imported gasoline</td><td rowspan="2">Leaded gasoline</td><td>4-stroke engines</td><td>1,030,626 tons</td><td colspan="2">95 % of total gasoline</td><td rowspan="2">1,084,870 tons</td><td rowspan="4">T o</td></tr>
<tr><td>2-stroke engines</td><td>54,243 tons</td><td colspan="2">5% of total gasoline</td></tr>
<tr><td rowspan="2">Unleaded gasoline</td><td rowspan="2">4-stroke engines</td><td>Without catalyst</td><td>172,856 tons</td><td>66.66 % of unleaded gasoline</td><td rowspan="2">259,226 Tons</td></tr>
<tr><td>With catalyst</td><td>86,408 tons</td><td>33.33% of unleaded gasoline</td></tr>
</table>

a. 4- stroke engines:

The table below shows the consumption of gasoline, the emissions factors to the air and the total emissions of PCDD/ PCDF.

Table 27 PCDD/F Emissions for the 4-stroke engines subcategory

Classification	Consumption (t)	Emission Factor (µg TEQ/ t)	Emission (g TEQ/a)
Leaded Gasoline	1,030,626	2.2	2.267
Unleaded Gasoline without catalyst	172,856	0.1	0.017
Unleaded Gasoline with catalyst	86,408	0	0.000

b. 2-stroke engines:

As mentioned above the consumption of leaded gasoline for 2-stroke engines is estimated to be 54,243 tons. Considering the emission factor of 3.5 **µg TEQ/ T,** the emission of PCDD/PCDD will be estimated to **0.19 g TEQ / a.**

c. Diesel engines:

The quantity of Diesel used for this sector is estimated to 140,895 tons, the corresponding emission factor is **0.1 µg TEQ/ T,** therefore the emission of Dioxin and furan **is 0.007 g TEQ / a.**

d. Heavy oil fired engines :

None of the transport means used in Lebanon is running on heavy oil (no trains nor big tankers to be considered)

4.6 Category 6: uncontrolled combustion processes

a. Fires / burning biomass:

⇒ ***Forest and grassland fires:***

According to data from the ministry of Agriculture, the estimated surface of burnt land is 1521 hectare subdivided to 75% of grassland and 25% of forest fires. Assuming that the fire consumes 6 and 18 tons per hectare for grassland and forests respectively, the amount of biomass consumed in fires is 13689 tons.

Table 28: PCDD/F Emissions for the forest and grassland fires subcategory

	Area (ha)	Biomass burnt Tons /	Biomass burnt in Tons	Emission factor (µg TEQ/ t)		Emission (g TEQ / a)	
				Air	Land	Air	Land
Grassland fires	1140.75	6	6844.5	5	4	0.034	0.027
Forest fires	380.25	18	6844.5	5	4	0.034	0.027

⇒ ***Agricultural residue burning:***

This Agricultural activity is of minor importance since field burning of crop residues is not a common practice in Lebanon. It is estimated that 1 % of the crop residues, specifically wheat, barley and oats, are burned.

Crop biomass = crop production * 2 = crop production + crop residues.

So, the total crop residues = total crop production = 72.5 tons in 1999 of wheat, barley and oats.

Therefore, the estimated quantity of residues burned = 1% of the total crop residues = 0.725 tons. This is a very small quantity that doesn't affect the total dioxin and furan releases.

b. Fires, waste burning, Landfill fires

⇒ ***Landfill fires***

The combustion of the biogas in landfills is a controlled process, thus it is considered in the power generation category- subcategory - landfill and biogas combustion.

⇒ ***Accidental fires in houses, factories….. (event)***

According to data from the Lebanese Civil Defense, 643 fires were reported in 1999. The magnitude of the damage, caused by these fires, vary tremendously and there's no information on the quantities of the burned material.

Using the emission factors of the toolkit, the total emission of PCDD/PCDF will be **0.257 g TEQ / a** for both air and residues.

⇒ ***Uncontrolled domestic waste burning***

The solid waste generation is estimated to be 285 Kg/ Person/ year .In 1999 the population was 4,350,000. Hence, the total solid waste generated is equal to 1,239,750 tons: 741,100 tons are collected by SUKOMI – a waste management plant – and 10 % of the rest is open burned resulting in emitting **16.156 g TEQ / a** to the air and **32.134 g TEQ / a** to residues**.**

⇒ ***Accidental fires in vehicles (event)***

According to the Civil Defense resources, 425 vehicles fires were reported in 1999. These fires have released **0.04 g TEQ of PCDD/PCDF** into the air and **0.008 g TEQ** into residues.

⇒ ***Open burning of wood***

As mentioned in the third category – power generation sector, subcategory household heating and cooking biomass – there are 80,000 tons of wood burned in the open, resulting in emitting **4.800 g TEQ of PCDD/PCDF** in the air and **0.8 g TEQ** in the residues.

4.7 Category 7: Production of chemicals, consumer goods:

a. Pulp and paper mills:

Paper industry is one of the major industries in Lebanon. It does not involve dried pulp. Dried chlorine free pulp is imported from other countries.

About 70,000 tons of paper are recycled in Lebanon every year. These papers may be contaminated with PCDD/PCDF, the emission factor to be considered is 10 µg TEQ/ t, and the corresponding total emissions are **0.7 g TEQ/ a**

b. Chemical industry:

The production of chemicals such as pentachlorophenol (PCP) polychlorinated biphenyls (PCB); 2,4,5-trichlorophenoxyacetic acid; chloranil; 2,4,6-trichlorophenyl-4'-nitrophenyl ether (CNP); chlorobenzenes; chlorine production; ethylene dichloride or 1,2 dichloroethane (EDC); chlorinated aliphatic compounds (perchloroethylene production) is not realized in the country.

c. Petroleum industry:

There are two non-functioning petroleum refineries in Lebanon; all the petroleum needed is imported.

d. Textiles Plants:

The clothing and textiles industries seem to be the most affected by the economic slowdown. The clothing sector lost 25% of its establishments and 40% of its workers between 1994 and

1998. Output in this sector fell by 33%, whereas an average 11.5% increase was observed in the industrial sector.

The estimated production of textiles is 450 tons per year.

The quantity of textiles consumed in the country in 99 is calculated by this formula = Production + import – Export = 450 + 6,169 - 4,391 = 2,228 tons

Using the emission factor of 0.1 µg TEQ / ton, the total emission would be = 0.000228 g TEQ per year

e. Leather Plants

The leather production in Lebanon is not very strong. The estimated production in 1999 is 83 tons. The quantity of leather consumed in 1999 in Lebanon is calculated by this formula = Production + import – Export = 83 + 2,675 – 343= 2,415 tons

Using the lower limit of emission factor, the estimated dioxin releases in the product would be =0.02415 g TEQ/ year.

4.8 Category 8: Miscellaneous

a. Drying of Biomass:

This activity is not practiced in the country

b. Crematoria:

Only one hospital burns an average of 2.860 tons of human organs and bodies in a double chamber incinerator. Using the following emission factors **10 µg TEQ/ t** to the air and **2.5 µg TEQ/ t** to the residues, the total emission of dioxin and furan will be negligible.

c. Smoke houses:

This activity is not practiced in the country

d. Dry cleaning residues:

According to the number of registered dry cleaning plants and to the estimated quantity of perchloroethylene used- approximately 54 tons- and assuming that the generation ratio of residues is 0.01Tons of residues / ton of solvent, the estimated quantity of residues (not contaminated) would be 0.54 tons contaminated with less than 0.05 mg TEQ – a negligible amount.

e. Tobacco smoking:

Tobacco smoking caused a release of **0.0009 g TEQ / a** to the air which is less than **1 mg TEQ** The data needed for this part was given by the “ Règie Libanaise des tabacs et tombacs ” it is rearranged in the following table:

Table 29: Emissions of PCDD/F from tobacco smoking subcategory

	Number of items	Emission factor to the air (pg TEQ/ item)	Emission (g TEQ/ a)
Cigars	1,000,000	0.3	0.000
Cigarettes	8,000,000,000	0.1	0.0008
Tombac*	1,020,000,000	0.1	0.0001

* The tombac sold in 99 was 1,020 tons = 1,020,000,000 g / year, and assuming that the mass of one cigarette is 1 g, we can estimate that the amount of tombac is equivalent to 1,020,000,000 cigarettes

4.9 Category 9: Disposal

a. Landfill leachates:

The total solid waste generation in Lebanon is estimated to 1.239.850 tons per year, 741,100 tons are collected and 10 % of the remained quantity is open burnt which results in a dumping of 448,875 tons of solid waste. Assuming that leachate produced is approximately 10 % of the mass of solid waste, which is equal to approximately 45 tons. Considering that the density of leachate is the same as water = 1 g/cm^{3}, the estimated liters of leachate produced per year would be 45 Kiloliters. Using the emission factor of 30 pg TEQ/L, the total release of PCDD/PCDF into water would be negligible.

b. Sewage treatment:

This activity is not practiced in the country

c. Open water dumping:

The wastewater generation is estimated to be 120 L /capita/ day. Hence there is 180,894,000 Liters of wastewater released to the environment with no treatment. We assume that all this water is not contaminated.

The emission factor used for release into water is **5 pg TEQ / Liter,** and the emission of PCDD/PCDF will be **0.904 g TEQ/a**

d. Composting:

7,814.10 tons of compost was produced in 1999 using organic fraction.

This compost is contaminated with **0.78 g TEQ of PCDD/PCDF** according to the emission factor mentioned in the toolkit (100 µg TEQ / t)

e. Waste oil disposal:

According to Lebanon State of the Environment Report Ministry of Environment/LEDO, the vehicle fleet consumes about 28,000 tons of imported motor lubricating oils and generates about 21,000 tons of used oil per year (MoE/ETEC, 1998) -The remainder (approximately 25 percent) is consumed by engines.

A significant proportion of vehicle owners (especially trucks and buses) change their engine oil themselves. Oil change by Do-it-Yourselfers accounts for 6,400 tons of lubricating oil consumed annually (or 22.3 percent of the total consumption) and corresponding waste oil is presumably discharged directly into the environment (soil and water). Of the remaining consumption (21,600 tons), 79 percent (17,000 tons) were surveyed (MoE/ETEC, 1998). This quantity of engine oil generates 12,500 tons of used oils.

Nationwide nearly 58 percent of waste oils are collected and reused, primarily as energy supplements (MoE/ETEC, 1998). Thirteen percent are disposed in water bodies, either directly (streams, rivers) or indirectly (sewers), and the remaining 29.4 percent are disposed on land. Waste collection/reuse reaches 90 percent of waste oils generated in the Bekaa and is as low as 34 percent and 48 percent, respectively, in the South and Mount Lebanon.

Therefore, the quantity of waste oil disposed is approximately 42 % of the total 21,000 tons, which is equal to 8820 tons per year.

Using the emission factor for release in the air – **4 µg TEQ/t** – all emission will be assessed to **0.035 g TEQ**

4.10 Category 10: Identification of Hot Spots

a. Production sites of chlorinated organics

Such activities doesn't exist in the country

b. Production sites of chlorine

No chlorine production in the country

c. Formulation of chlorinated phenols/ pesticides

No production of chlorinated phenols and pesticides in Lebanon

d. Application sites of dioxin-contaminated pesticides

In 1998, the MoA banned 110 pesticides (Decision 94/1, dated 20/5/98), including aldrin, dieldrin, endrin and DDT, all of which are known to be very potent and persistent in the environment.

In 1999, Lebanon imported 1,530 tons of pesticides, and almost 32,000 tons of fertilizers. Fungicides and insecticides represent the largest share of imported pesticides, followed by herbicides, acaricides, and nematicides.

24.390 tons of 2,4-Dichlorophenoxyacetic acid used as herbicides were imported from different countries like Germany, Jordan, china, Hungary, Taiwan and France. Although Lebanon no longer imports a whole range of persistent pesticides, Lebanese soils are potentially contaminated from persistent chemicals and residues, the result of many years of unrestricted application of dangerous pesticides. Many pesticides that were commonly used in Lebanon contain compounds that persist in the environment for more than 20 years. While current pesticides do not contain such chemicals, they may however react in the soil to produce new persistent compounds that potentially pollute the soil and groundwater.

Pesticide application is a hazardous activity. Inadequate and/or excessive application has been observed and frequently reported. Although the MoA and several NGOs are focusing more efforts to training farmers on handling and use of pesticides, a high rate of illiteracy among farmers remains an obstacle to effective communication and training. For example, illiterate farmers often use excessive application rates because they cannot read the instructions on the labels. Furthermore, many small scale vendors and retailers dilute the pesticide to achieve higher revenues.

Accordingly, farmers may observe reduced efficiencies and resort to increasing application rates based on personal judgment. This unfortunate practice also leads to excessive rates of application. It has also been reported that farmers do not respect minimum withdrawal periods (i.e., crops are sprayed a few days before harvesting).

Clearly, the health impacts of such practices are alarming and should not be under- estimated.

e. Timber manufacture and Treatment Sites

No available data concerning the use of PCP in the timber manufacture or any other practices.

f. PCB containing equipment

A study made by COGIC consultants crew in 1995 mentioned the presence of 15,000 transformers in Lebanon and approximately 20 % are contaminated with PCB. But the power of the transformers and the quantity of the oil used is unknown. A inspection for PCB was made on 50 samples taken from 4 different sites: Jieh, Zouk, Baouchrieh and Hraichy. Among the 50 samples, nine were found contaminated (20 % of all the samples).

Other references, with more details on these sites, have mentioned that the amount of Pyralène used in Jieh was 31.275 tons, in Zouk, the quantity of Askarel reported was 6 tons.

The samples taken from Hraichy were not contaminated and there was no clear information on the quantity of contaminated used oils in Baouchrieh.

The last site contains 650 transformers, 34 of them were examined and eight were found contaminated (approximately 23 % of the site’s equipment were contaminated). Ignoring the power of the transformers and the quantities of the oil, making any assumptions would be too faulty.

So, the only data available concerning the quantity of contaminated oils is **36.275 tons of Pyralène and Askarel.** The chlorinate content in these oils is unknown too.

g. Dumps of waste/residues from categories 1-9

There are six large-scale seafront dumps (e.g., Normandy, Borj Hammoud, Tripoli, Sour and Saida) that further exacerbates coastal ecosystems and cause significant pollution of marine waters. Four of them are still operational; as well as other inland dumps (i.e., Baalbeck and Zahle).

These dumps are certainly contaminated with PCDD/PCDF because there's no segregation of the waste at any stage and absence of any waste management till now.

h. Sites of relevant accidents

In 1999 a Power station was the target of an Israelian bombardment and certainly all the equipment had exploded and especially the transformer and capacitors with PCB of the site. Which make the site a very potential reservoir of PCDF and maybe PCDD.

i. Dredging of sediments

No practicing of such activities.

5 CONCLUSION

5.1 - Total Emissions of Dioxins in Lebanon :

77.5 g TEQ of PCDD/PCDF are emitted in Lebanon, by different sources. The Appendix “Main Categories” shows the results of the releases in the different media of the environment.

The main emissions are caused by the uncontrolled combustion processes sector (70 %) followed by the waste incineration sector (15 %)

The production of PCDD/PCDF in Lebanon is 7.4 ***mg/ km*** ^{2} ***/ annum*** and ***0.017 mg/ capita/ annum.***

5.1.1 Emissions in the air

About 38.5 g TEQ of PCDD/F are released in Lebanon, the major part is due to uncontrolled combustion processes (70%), followed by the waste incineration sector (15 %) et the rest is emitted by other sources.

5.1.2 Emissions in the water

1.0 g TEQ/a released in the water to the disposal / Landfill sector

5.1.3 Emissions in the land

The uncontrolled combustion processes contribute in emitting a very small amount of PCDD/F in the Land

5.1.4 Emissions in the product

0.8 g TEQ/a is liberated in the products deriving equally from the production of consumer goods sector and the disposal sector.

5.1.5 Emissions in the residues

The residues coming from the uncontrolled combustion processes and from the ferrous and non-ferrous production sector are responsible for emitting 37g of TEQ / annum.

5.2 Uncertainties

The results of the inventory are considered as a primary data containing a certain degree of uncertainties. These uncertainties results from:

- The fact that the calculation is based on some standardised emission factors, non-specific to the country. Knowing that the PCDD/PCDF analysis are very high and if we have to add the costs for taking the samples, which may be several thousand dollar in case of stack samples), the adoption of this protocol seems the only reasonable and affordable way to get some basic information on the situation of the country concerning these pollutants.
- The fact that some values are based on some under or over estimation of the emissions due to a lack of data.
- The absence, in certain cases, of appropriate emission factors.

6 APPENDIX: SUMMARY OF RESULTS

Cat.	Source Categories	Annual Releases (g TEQ/a)					
		Air	Water	Land	Products	Residue	**Total**
1	Waste Incineration	11.579	0.000	0.000	0.000	0.1	11.637
2	Ferrous and Non-Ferrous Metal Production	1.887	0.000	0.000	0.000	4.0	5.902
3	Power Generation and Heating	0.349	0.000	0.000	0.000	0.0	0.349
4	Production of Mineral Products	0.520	0.000	0.000	0.000	0.0	0.550
5	Transportation	2.464	0.000	0.000	0.000	0.0	2.464
6	Uncontrolled Combustion Processes	21.010	0.000	0.055	0.000	33.0	54.035
7	Production of Chemicals and Consumer Goods	0.700	0.000	0.000	0.024	0.0	0.748
8	Miscellaneous	0.000	0.000	0.000	0.000	0.0	0.000
9	Disposal/Landfilling	0.035	0.964	0.000	0.781	0.0	1.781
10	Identification of Potential Hot-Spots						0.000
1-9	**Total**	**38.5**	**1.0**	**0.1**	**0.8**	**37.1**	**77.465**

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INVENTORY OF DIOXINS AND FURANS IN THE PHILIPPINES

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Executive Summary

The Philippines belong to Southeast Asia, an archipelago between the Philippine Sea and the South China Sea, east of Vietnam with geographical coordinates of 13 00 N and 122 00 E. Total area is at 300,000 km^2 with 1,830 km^2 and 298,170 km^2 for water and land, respectively. The terrain is mostly mountains with narrow to extensive coastal lowlands and has tropical marine climate of northeast monsoon during November to April and southwest monsoon during the months of May to October. As of July 2002, the population was 84.5 million with 1.99% growth rate. The country is faced with environmental issues such as uncontrolled deforestation in watershed areas; soil erosion; air and water pollution in Manila; increasing pollution of coastal mangrove swamps which were important fish breeding grounds. It is party to several environmental international agreements like Biodiversity, Climate Change, Desertification, Endangered Species, Hazardous Wastes, Law of the Sea, Marine Dumping, Nuclear Test Ban, Ozone Layer Protection, Ship Pollution, Tropical Timber 83, Tropical Timber 94, Wetlands. It also signed, but had not ratified yet the following: Climate Change-Kyoto Protocol, Stockholm Convention on Persistent Organic Pollutants POPs and the Rotterdam Convention on Prior Informed Consent (PIC).

The Asia Pacific Regional Dioxin Pilot Project supports the Stockholm Convention on Persistent Organic Pollutants (POPs) as member economies in favor were requested to identify and quantify dioxin and furan (PCDD/PCDF) sources and releases. Funded by the US government, this project piloted the *Standardized Toolkit for Identification and Quantification of Dioxin and Furan (PCDD/PCDF) Releases* (UNEP, 2001) in five countries that include the Philippines. The Toolkit was developed by the United Nations Environment Programme (UNEP) – Chemicals to provide technical expertise to developing countries that had no previous national PCDD/PCDF inventory studies. The present knowledge about sources of PCDD/PCDF was based on experiences from industrialized countries and this study would be able to provide an initial step towards filling the gap of PCDD/PCDF inventories on the global scale.

The Industrial Technology Development Institute of the Department of Science and Technology (ITDI-DOST) as member of the National Inter-agency Committee on POPs actively participated in the Inter-governmental Negotiating Committee (INC) on POPs and was chosen by UNEP-Chemicals to implement the said pilot project. This was the first Philippine national PCDD/PCDF inventory undertaking.

Results of the full country inventory estimate for PCDD/PCDF was limited to the information obtained through the data trail process adopted for this study. It did not include actual sampling and analysis of emissions from industries identified as potential sources. Note that retrieval rate of reformatted UNEP questionnaires were low influencing the certainty of emission factor selection. This was remedied through continuous consultation with experts from UNEP-Chemicals, industry trade associations and government regulatory agencies.

Consolidated PCDD/PCDF inventory conducted for each main source category and sub-category yielded 534.06 g TEQ/a as total annual released to all environmental compartment. Uncontrolled combustion processes ranked 1st with 187.05 g TEQ/a followed by power generation and cooking at 157.23 g TEQ/a and at 3rd place was production of chemicals and consumer goods valued at 91.56 g TEQ/a. Air had the highest PCDD/PCDF contamination that totaled 327.67 g TEQ/a with 35% attributed to uncontrolled combustion of agricultural residues, 30% from firewood cooking and 18% from biomass fired boilers sub-categories. Product and land had similar PCDD/PCDF contamination level at 77.64 and 46.86 g TEQ/a, respectively. Lastly, water and residues had contamination degree at 43.80 and 40.49 g TEQ/a, respectively.

A significant finding was that the major source of PCDD/PCDF contamination for air and land was uncontrolled combustion of agricultural residues. This was in congruence to the preliminary investigation conducted by US-EPA on open burning that PCDD/PCDF released from such activity was higher compared to municipal solid waste incinerators operating in the US. Note that Philippine waste incineration activity contributed only 7.1% of the total PCDD/PCDF released to the environment. Other major sources of PCDD/PCDF released to products, water and residues were leather plants, open water dumping and household biomass cooking stoves, respectively.

Generally, the Toolkit was handy for initial country-based identification of PCDD/PCDF major sources of releases. It showed interesting results that in the ordinary would be overlooked. It also served as an excellent guiding instrument especially in the formulation of policies and management strategies such as National Implementation Plan (NIP) for PCDD/PCDF. Taxing part of the estimation work was the reconciling of Toolkit's data requirement and actual available data reported in the country. Selection of appropriate conversion factors for the reconciliation exercise was very challenging as well as activity assumption methods applied to achieve results with acceptable confidence level.

Technology-based solution even low-end type was found to significantly address environmental issues like PCDD/PCDF releases. Other measures that may be adopted were observance of product responsibility and life cycle considerations for export commodity implications. Suppliers of raw materials must be responsible in the quality and integrity of the goods they market. Finished products bearing contamination due to raw materials must be minimized if not eliminated from the commodity life cycle. The international community would be the driving force that facilitates the establishment of a healthy global infrastructure for this norm to thrived and be strengthened. Ecological risk assessment tools may be utilized as safety nets for trading new materials/goods and products in the global market. The international community also encouraged the implementation of proven best available technologies (BAT) and best environmental practices (BEP) such as catalytic fabric filter for PCDD/PCDF decomposition.

Finally, validation of results from this PCDD/PCDF inventory study must be undertaken to verify the accuracy of the Toolkit in terms of identifying major sources in the country. This required actual measurement of PCDD/PCDF to all environmental compartments of major sources identified in the study as well as activity gaps discovered while using the Toolkit. Priority economic activities for immediate investigation were also identified. Moreover, a scientific approach to establish confidence level for emission factor application must be developed for inclusion in this Toolkit. At present, preliminary results of this inventory survey were used as basis for the determination of PCDD/PCDF level in Filipino breast-feeding mothers.

1 INTRODUCTION

The Asia Pacific Regional Dioxin Pilot Project supports the Stockholm Convention on Persistent Organic Pollutants (POPs) as parties in favor were requested to identify and quantify dioxin and furan (PCDD/PCDF) sources and releases. Funded by US government, this project piloted the *Standardized Toolkit for Identification and Quantification of Dioxin and Furan (PCDD/PCDF) Releases* (UNEP, 2001) in five (5) countries that include the Philippines. The Toolkit was developed by the United Nations Environment Programme (UNEP) – Chemicals to provide technical expertise to developing countries that had no previous national PCDD/PCDF inventory studies. The present knowledge about sources of PCDD/PCDF was based on experiences from industrialized countries and this study would be able to provide an initial step towards filling the gap of PCDD/PCDF inventories on the global scale.

PCDD/PCDF were known environmental contaminants formed unintentionally in many industrial and combustion processes. These were detected in all environmental compartments due to chemical, physical, biological stability, long-range transport, lipophilicity and persistence of the 2,3,7,8 substituted congeners. These congeners were considered the most toxic and proven as human carcinogen. Exposure to PCDD/PCDF were associated with risk of severe skin lesions, depressed immune system, nervous system abnormalities, altered liver function and lipid metabolism.

To reduce emission to the environment and minimize human exposure, sources must be identified and quantified. The UNEP-Chemicals developed a simple and standardized Toolkit specifically for this purpose. This Toolkit also compiled databases of emission factors for PCDD/PCDF that were initially adopted by participating countries to arrive at a consistent national and regional inventory.

The Industrial Technology Development Institute of the Department of Science and Technology (ITDI-DOST) as member of the National Inter-agency Committee on POPs actively participated in the Inter-governmental Negotiating Committee (INC) on POPs and was chosen by UNEP-Chemicals to implement the said pilot project. This was the first Philippine national PCDD/PCDF inventory undertaking. It was facilitated through series of awareness raising activities and multi-sectoral consultations with stakeholders such as government agencies, non-government organization, trade associations, industries, academe, research institutions and other people's organizations. Economic national accounts were affirmed at the conference as an indispensable source of data that were easily accessible for the inventory. However, bulk of the work was experienced by ITDI on the processing and refinement of these national local data to fit the UNEP Toolkit requirement. These were some of the gaps that were identified that must be addressed to further make the Toolkit user-friendly.

The Philippines belong to the region of Southeast Asia, an archipelago between the Philippine Sea and the South China Sea, east of Vietnam with geographical coordinates of 13 00 N and 122 00 E. Total area is at 300,000 km^2 with 1,830 km^2 and 298,170 km^2 for water and land, respectively. The terrain is mostly mountains with narrow to extensive coastal lowlands and has tropical marine climate of northeast monsoon during November to April and southwest monsoon during the months of May to October. As of July 2002, the population was 84.5 million with 1.99% growth rate. The country is faced with environmental issues such as uncontrolled deforestation in watershed areas; soil erosion; air and water pollution in Manila; increasing pollution of coastal mangrove swamps which were important fish breeding grounds. It is party to several environmental international agreements like Biodiversity, Climate Change, Desertification, Endangered Species, Hazardous Wastes, Law of the Sea, Marine Dumping, Nuclear Test Ban, Ozone Layer Protection, Ship Pollution, Tropical Timber 83, Tropical Timber 94, Wetlands. It also signed, but had not ratified yet the following: Climate Change-Kyoto Protocol, Stockholm Convention on Persistent Organic Pollutants (POPs) and Rotterdam Convention on Prior Informed Consent (PIC).

The economy depended primarily on agriculture which supports major local and export industries such as food, beverage, frozen seafood as well as ceramics, leather and textile goods. To reconcile the economic activity of the country with the UNEP identified potential sources of PCDD/PCDF, the inventory study focused on five major economic sectors namely: Forestry, Mining, Manufacturing, Power Generation and Transport Services. It also evaluated waste disposal practices and records of fire damages as these were included in UNEP Toolkit as potential sources of PCDD/PCDF. Appendix A summarized these identified source categories, available data and their sources.

2 NATIONAL INVENTORY SCOPE

This inventory study was from 1999 base year production data. Whenever available, activity rate of each industry category were initially lifted from industry profiles, annual reports and other data acquired from national economic records, industry association and historical industry production data. Individual company data surveyed by the project team (Appendix B) were done to validate initial information gathered and served as basis for assignment of appropriate emission factor from the UNEP Toolkit. The results of the inventory estimates were based on the survey questionnaires retrieved and advice from national trade associations concern.

Figure 1 described the data trail undertaken by the project team to attain full country inventory estimates for PCDD/PCDF. Philippine Standard for Industry Classification (PSIC) was the key element for screening local industries on PCDD/PCDF main source and sub-category matrix. From this stage, the team gathered central data for industry production and activity rate from the National Statistics Coordination Board (NSCB) and concerned industry trade associations. These central data were further verified by coordinating with data source providers of NSCB and the associations. Table 2-1 summarized macro data gathered for the inventory. A total of 7,300 industries were screened for potential sources of PCDD/PCDF and 706 were selected.

UNEP survey questionnaires were given to these pre-screened industries as part of the verification process. Ten regions were assessed with 32 sites visited (Figure 2). Field data information such as detailed process design, production input/output, as well as pollution control and management technologies installed were determined. Upon verification, extrapolation estimates for activity rate values as advised by NSCB and industry experts were done for data to be compatible with UNEP Toolkit requirement. The extrapolated activity rate was used to calculate PCDD/PCDF average annual releases for each industry category by substituting the derived values on the UNEP recommended formula shown below:

Source Strength = Emission Factor X “Activity Rate”

Where:	Source Strength = Dioxin emission per year
	Emission Factor = release of PCDD/PCDF per unit of feed material processed or product produced (ug I-TEQ)
Activity Rate.	= amount of feed material processed or product produced (tons or liters per year)

Results of the full country inventory estimate for PCDD/PCDF was limited to the information obtained through the data trail process adopted for this study. It did not include actual sampling and analysis of emissions from industries identified as potential sources. Note that retrieval rate of reformatted UNEP questionnaires were low influencing the certainty of emission factor selection. This was remedied through continuous consultation with experts from UNEP-Chemicals, industry trade associations and government regulatory agencies.

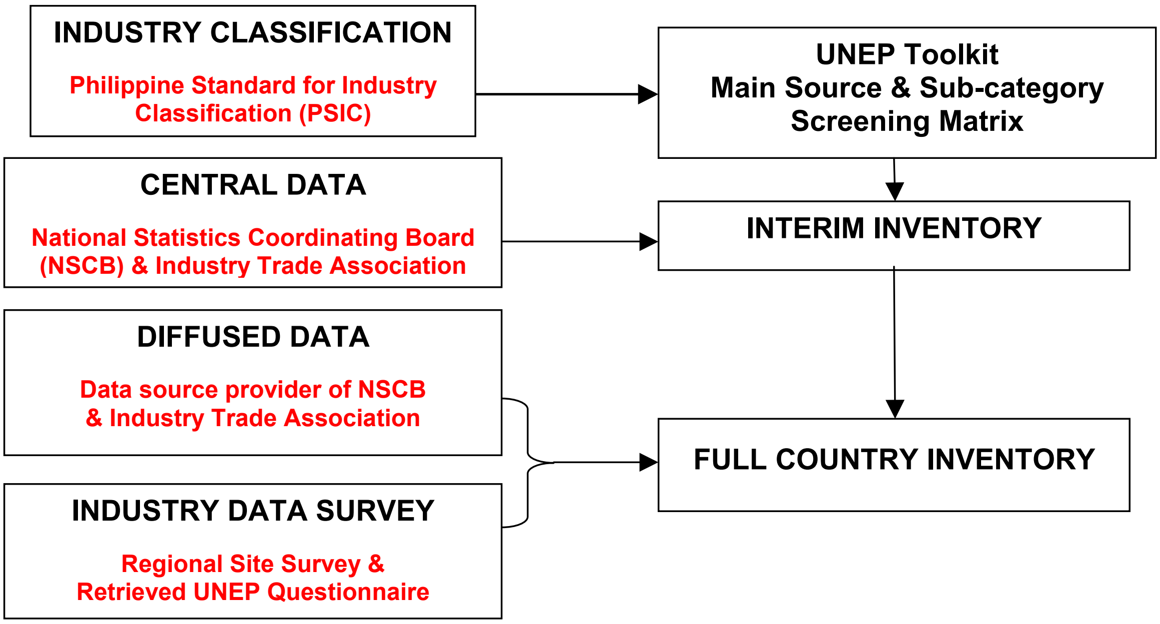

Figure 1. Philippine PCDD/PCDF Inventory Data Trail

Table 2-1: Macro Data Matrix for the PCDD/PCDF Inventory

Source	**Type**	**Data Treatment**
Philippine Chamber of Commerce	List of Member Companies, contact address and product / category	Out of 1,100 industries, 200 were pre-selected and given UNEP questionnaire.
Environmental Unit of Board of Investment – DTI	List of Companies that are potential sources of dioxin and industry profiles	Served as basis for validation and site visits. Profiles were used for extrapolation estimates.
Standards and Testing Division – ITDI	List of industry clients	Out of 6,200 client industries, 506 were pre-selected and were given UNEP questionnaire
Environmental Health Services of DOH	List of Gov't retained and private hospitals with incinerator	Data were validated and used in Toolkit Excel spreadsheet
Fertilizer and Pesticide Authority	Summary of Pesticide Importation CY 2000	No import records for specific pesticides like PCP, PCP-Na, CNP, 245-T, chloranil, etc were found
Mines and Geosciences Bureau	Mining Profile and Production for year 2000	Extraction and processing were validated for application to Toolkit Excel spreadsheet
National Statistical Coordination Board	Statistical data for year 1999 Domestic	Data were validated, extrapolated as advised by experts from NSCB and trade association. Derived data were then used in Toolkit Excel spreadsheet
Maritime Industry Authority (MARINA)	Inventory of Sea Vessels for 1999	There were 27,871 Registered Sea Vessels. Fuel consumption was reconciled with NSCB report.

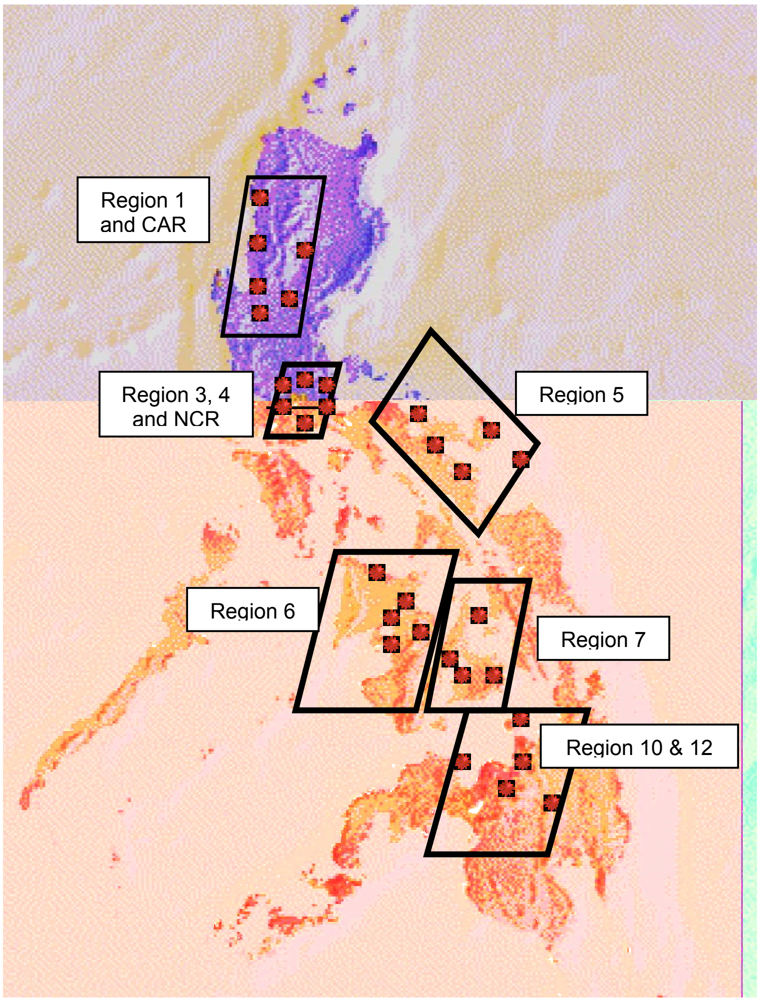

Figure 2. Coverage of PCDD/PCDF Site Survey

3 RESULTS OF THE NATIONAL PCDD/PCDF INVENTORY

Major industry activities were screened for classification in the UNEP Toolkit's identified potential sources of PCDD/PCDF. Table 3-1 shows the Philippines industry classification to UNEP screening matrix for main source categories and sub-categories as well as environmental compartment where PCDD/PCDF would likely be released. It was observed from this table that classification/coding system adopted by UNEP Toolkit and Philippine industries/economic indicators (PSIC) were very different. To institutionalize in the Philippines the UNEP standardized Toolkit for PCDD/PCDF national inventory, these classification systems must be reviewed and harmonized.

The succeeding sections discussed the inventory results by main source category and its sub-category. These included data source and validation, technology description and flow process in relation to existing economic sectors profile, extrapolation methods used for estimation of PCDD/PCDF releases and rationale for emission factor selection.

Table 3-1: Philippines PCDD/PCDF Main Source Category and Sub-Category

PSIC CODE	UNEP Code	Category/Sub-Category	Air	Water	Land	Product	Residue
92	1	Waste Incineration	X				X
351,352,356	b	Hazardous Waste Incineration					
94	c	Medical/Hospital Waste Incineration					
12	g	Animal Carcasses Burning					
21, 22	2	Ferrous and Non-Ferrous Metal Production	X				X
371	a	Iron Ore Sintering					
221/354	b	Coke Production (Production of Coal and Charcoal)					
371, 381	c	Iron and Steel Production Plants and Foundries					
213/372	d	Copper Production					
219	e	Aluminum Production					
219	f	Lead Production					
214	j	Thermal Non-ferrous Metal (Nickel)					
371,372,381	m	Wire Reclamation by Combustion (copper wire recycling)					
42	3	Power Generation and Cooking	X		X		X
422	a	Fossil Fuel Power Plant					
11	b	Biomass Power Plant					
HH,159,111,116	d	Household Cooking – Biomass (using wood, rice hull, bagasse)					
159,HH	e	Domestic Cooking					
22	4	Production of Mineral Products	X				X
363	a	Cement					
229	b	Lime					
50	c	Brick					
362	d	Glass					
361	e	Ceramics					
354	f	Asphalt Mixing					
71	5	Transport	X				
711, 712 & 713	a	4-stroke Engines					
711., 712& 713	b	2-stroke Engines					
353, 354	c	Diesel Engines					
353, 354	d	Heavy Oil Fired Engines					
11, 15	6	Uncontrolled Combustion Processes	X	X	X		X
11, 15	a	Fires/Burning-biomass					
842, HH	b	Fires, waste burning, landfill fires, industrial fires, accidental fires					
35,31,32,34	7	Production of Chemicals and Consumer Goods	X	X		X	X
341	a	Pulp and Paper Mills					
351,352,356	b	Chemical Industry					
353	c	Petroleum Industry					
321	d	Textile Plants					
323, 324	e	Leather Plants					
None	8	Miscellaneous	X	X	X	X	X
973	a	Drying of Biomass					
92	b	Crematories					
311, 312	c	Smoke Houses					
11,15,HH	d	Dry Cleaning Residues					
92	9	Disposal / Landfill	X	X	X		X
92	a	Landfill and Waste Dumps					
43	b	Sewage/Sewage Treatment					
14	c	Open Water Dumping					
HH	d	Composting					
92	e	Waste Oil Disposal					
	10	ID of Potential Hot-Spots					
351,352,356	a	Production Sites of Chlorinated Organics					
351,352,356	b	Production Sites of Chlorine					
151, 331	e	Timber Manufacturing and Treatment Sites					
411,412	f	PCB Filled Transformer					
92	g	Dredging of Sediments					
91	h	Sites of relevant accidents					

3.1 Main Category 1 – Waste Incineration

The incineration of waste is strongly associated with PCDD/PCDF emissions. In fact, this lead lawmakers in the Philippines to ban the use of incineration under Republic Act 8749 also known as the Philippine Clean Air Act of 1999. The extent of the ban however is still under debate as Supreme Court decision upheld the ban as not absolute. Presently, waste incineration application is mainly on medical/hospital wastes. Hazardous waste and animal carcasses are considered as marginal users of the technology. The former is also used as co-fired fuel by cement, mining, power plants and paper industries.

Table 2-1 shows the inventory of medical, animal carcasses and industrial waste incinerators acquired from the Environmental Health Services of the Department of Health (EHS-DOH). Status of the operation of industrial waste was gathered from the Environmental Management Bureau of Department of Environment and Natural Resources (EMB-DENR). Information on the animal carcasses waste incinerators was from the Bureau of Animal Industry of Department of Agriculture (BAI-DA).

Table 3-2: Inventory List of Incinerators by Regions

Region	**Hospital Waste Treatment Facility**		**Animal Carcasses Incinerator**		**Industrial Waste Processing**	**Pharmaceutical Laboratories with Possible Incinerator**
	Number of Facilities	Capacity, kg/day	Number of Facilities	Status/ Capacity, kg/day	Number of Facilities	Number of Facilities
1	**3**	300	**1**	Not operational		
2	**2**	300	**1**	Not operational		
3	**2**	300	**1**	Not operational		**1**
4	**2**	300	**1**	9 kg/wk	**7**	**3**
5	**2**	300	**1**	9 kg/wk		
6	**2**	300	**1**	7 kg/wk		
7	**3**	300			**1**	
8	**1**	300				
9	**1**	300				
10	**1**	300	**1**	8 kg/wk		
11	**2**	300				
12	**1**	300				
CARAGA			**1**	Not yet operational		
CAR	**1**	300	**1**	70 kg/wk	**1**	
ARMM			**1**	9 kg/wk		
NCR	**19**	15 unitsx x 300 4 units X 500	**1**	70 kg/wk	**4**	**2**

3.1.1 Hazardous Waste Incineration

This type of incinerator is used for destruction of industrial waste some of which were classified as hazardous waste. At the time of the inventory activity only one industrial incinerator was permitted to operate up to the year 2000 and was owned by the largest crop protection company in the Philippines. Its line of business was formulation and packing of high quality crop protection products, consumer care household insecticides and animal hygiene products. Most of the other industries send their waste to this facility for treatment of their waste after their permit to operate incinerator was expired. Chemical wastes were collected via dust filters and were thermally treated at 800 to 1,200°C. Contaminated materials and containers were also co-incinerated with the chemical waste. It had cyclone dust collector that precipitates dust particles from emissions. This incinerator was categorized as quite good and efficient based on ocular inspection conducted by the project team with UNEP experts. This was class 3 (1B3) in the Toolkit bearing 10 and 450 μg TEQ/t emission factor for air and residue (fly ash), respectively (UNEP, 2001). This company reported that it had treated 7,813 and 7,703 tons of formulated chemical wastes for 1999 and 2000, respectively. In this case, no extrapolation were applied as data were directly encoded on the Excel sheet for calculation of PCDD/PCDF releases to environmental media identified.

PCDD/PCDF annually released to air and fly ash were estimated at 0.078 and 3.52 g TEQ/a, respectively for the year 1999. These accounted for 0.02% to air and 100% to fly ash on waste incineration total releases. Validation study through actual sampling and analysis of residues should be encouraged since results indicated half came from this activity as fly ash. It would also be advisable to trace final disposal practices of fly ash that the industry had adopted should there be significant PCDD/PCDF content. In relation to the overall impact of these emissions to the environment, the hazardous waste incinerator contributed 0.021 % to air and 9.24 % to residues.

3.1.2 Medical / Hospital Waste Incinerator

There was a moratorium issued for the ban on medical waste incinerator until year 2003. From 1999 to present, government retained hospitals were permitted to operate 30 units with 300 kg/day at 26 units and 500 kg/day capacity at 4 units. All of the facilities were of the batch type and either controlled or uncontrolled type of incinerator with no or minimal air pollution control system (APCS). Data gathered for total volume of waste treated were based on 83–100% installed capacity utilization, conservative assumption that all these units operate on full capacity was preferred. Estimation of PCDD/PCDF releases for medical waste incinerator considered the following:

1. Default emission factor (UNEP, 2001) selected

   a. For **300 kg** capacity incinerator with controlled combustion, operated in batch type mode, without or minimal APCS, Class 2 default emission factor (IC2) was applied to which the potential release route in μg TEQ/t for Air = 3,000; Residues / Bottom Ash = 20;

   b. For **500 kg** capacity incinerator with uncontrolled batch combustion and no APCS, Class 1 default emission factor (1C1) was applied. which had potential release route in μg TEQ/t for Air = 40,000; Residues / Bottom Ash = 200

2. Operation activity = daily at maximum capacity of 300 or 500 kg;

3. Activity rate was calculated as

$$\mathbf{1C1} = (\text{No. of incinerator})(\text{capacity}) \times \frac{1t}{1{,}000\ kg} \times \frac{365\ day}{a}$$

$$= (4)(\mathbf{500\ kg}) \times \frac{1\ t}{1{,}000\ kg} \times \frac{365\ day}{a}$$

$$= 2{,}000\ kg \times \frac{1\ t}{1{,}000\ kg} \times \frac{365\ day}{a}$$

$$= \frac{730{,}000}{1{,}000}$$

Thus: **1C1 = 730 t/a**

$$\mathbf{1C2} = (\text{No. of incinerator})(\text{capacity}) \times \frac{1t}{1000\ kg} \times \frac{365\ day}{a}$$

$$= (26)(\mathbf{300\ kg}) \times \frac{1\ t}{1000\ kg} \times \frac{365\ day}{a}$$

$$= 7800\ kg \times \frac{1\ t}{1000\ kg} \times \frac{365\ day}{a}$$

$$= \frac{2847000}{1000}$$

Thus: **1C2 = 2847 t/a**

Substituting the 1C1 and 1C2 values to the Excel sheet gave 29.2 and 8.5 g TEQ/a, respectively released to air while 0.146 and 0.057 g TEQ/a, respectively released to bottom ash. The medical waste incinerator contributed 99.95 % and 46.42 %, respectively to air and residues as bottom ash releases for waste incineration category. 77.3 % and 72 % of which came from the 500kg/day model that was an old technology. The overall impact of medical waste incinerator to the 1999 PCDD/PCDF annual releases was 11.52 % to air and 0.58 % to residues as bottom ash. The same validation study as with hazardous waste incinerator could be adopted as well as the ultimate fate of bottom ash must be investigated.

3.1.3 Animal Carcasses Incinerator

These incinerators were operated by the Regional Animal Disease Diagnostic Lab (RADDL) of BAI for the treatment of rabies infected dog heads from the necropsy examination. The incinerators were of the simple box-type oven kiln usually made of cement with brick lining and some of which had chimney as air vent while others had none. Operational hours ranged from 3 hrs to a whole day per batch that were conducted on a weekly or twice a month basis. Fuel used were predominantly firewood, coconut husk and twigs. Ashes were used as fertilizers or disposed to landfill.

Table 3-2 values showed that a total of 26 tons were regularly incinerated annually. Using this data, estimated PCDD/PCDF releases to air were at 0.013 g TEQ/a wherein emission factor applied was 500 µg TEQ/t as incinerator type were of the older furnaces, batch type operation and no APC (UNEP, 2001). This comprised nominal amount compared to the other types of incinerator. Ashes were safe as fillers for fertilizer since there were no PCDD/PCDF released to residues unlike hazardous and medical waste incinerators.

3.2 Main Category 2 – Ferrous and Non-Ferrous Metal Production

The Mines and Geo-science Bureau (MGB) of the DENR regulated most of the industry activities that fall under this category. This included mining operations for base metals were copper (Cu), lead (Pb), zinc (Zn) and aluminum (Al) as well as iron and ferro-alloy metals particularly iron (Fe) and nickel (Ni). Non-metallic minerals such as limestone mining was also included in the inventory study but was discussed in the mineral production category to follow UNEP Toolkit category format.

Iron ore sintering, iron and steel production plants and foundries as well as wire reclamation combustion were classified by the PSIC as manufacturing industries and data on these activities were gathered from ITDI inventory survey questionnaire, metal casting (foundry) industry survey study conducted by Metals Industry Research and Development Center of the Department of Science and Technology (MIRDC-DOST) in consultation with industry trade associations such as Philippine Steel-makers Association and Philippine Steel Rolling Mills Association (PSRMA).

3.2.1 Iron Ore Sintering

ITDI site survey in one sintering plant was the basis for this sub-category. The plant was a pioneer enterprise with sinter machine rated capacity of 5,000,000 t/a. It also operated limestone and dolomite mining activity to ensure steady supply of flux for the sintering process. Sintering involved burning mixing fine iron ore with solid fuel (coke breeze and anthracite) and flux in blast furnace at 1,400 °C. Combustion unit used were vertical rotary kiln and ignition furnace. The system employed APC such as electrostatic precipitator (ESP), cyclone and bag filter (BF). The company reported 4,206,996 tons production for 1999.

This sub-category applied emission factor for air and residues at 0.3 and 0.003 µg TEQ/t of sinter produced. It belonged to class 3 that had high technology emission reduction as observed from the APCS employed by the company. (UNEP, 2001) PCDD/PCDF released to air and residues were calculated at 1.262 and 0.013 g TEQ/a for 1999. This was almost negligible impact to the overall effect on PCDD/PCDF annual releases both in the ferrous and non-ferrous category and the full inventory estimate. This company also operated one of the biggest limestone mining and production to ensure steady supply this as raw material for iron sintering. Detailed discussion on this was presented in Section 3.4.2

3.2.2 Coke Production as Charcoal

Coal proven reserves were estimated at 369 million MT with 89% (296 million) as minable by open pit. The bulk of Philippine coal was sub-bituminous in rank that had 0.3 – 5 % sulfur (S) content. Local coal production was sold mainly to coal-fired cement and power plants while the remaining were sold to coconut oil mill, fertilizer plant and nickel ore dryer. (BED, 1985) These mined coals were not further processed into coke and was directly utilized by the said industries. Thus, estimation of PCDD/PCDF released to the environment was only considered in energy production fuelled by coal to avoid double counting of this type of activity rate.

ITDI survey team visited a typical charcoal production plant and ocular inspection showed that no gas cleaning device were installed. Raw materials used were usually wood and coconut husk. Charcoal products from wood for 1999 were at 81,000 m^3 (NSCB, 2000). These were the marketed type used mainly for cooking. This value was converted to tons using the factor 0.18 t/m^3 (Openshaw, 1983). The calculated value for marketed charcoal production was 14,580 t/a. This was substituted from the Excel spreadsheet under class 1 -

no gas cleaning with emission factor for air and water at 3 and 0.006 ug TEQ/t (UNEP, 2001). This yielded PCDD/PCDF released at 0.044 and 2.62 X 10^{-9} g TEQ/a, respectively. It was observed that the production of charcoal had no significant effect on PCDD/PCDF released.

3.2.3 Iron and Steel Production Plants / Foundries

MIRDC-DOST surveyed 178 foundry shops and attained 59% (105) respondent. Table 3-3 presented listing of combustion units used for their process. No APCS were installed in any of the responding foundries. Most of the foundries used scrap metals such as cast iron, mild steel, stainless steel, aluminum and aluminum composition ingots, bronze and brass for their process. Predominantly, cast iron and aluminum scrap were used. Production capacity was at 539,986 t/a for 51 participating shops. Iron foundries with no gas cleaning were assigned emission factor 10 ug TEQ/t for air releases (UNEP, 2001). These were values encoded at Excel spreadsheet that gave 5.4 g TEQ/a PCDD/PCDF released to air. This again was negligible impact compared to the other sources.

Table 3-3: Combustion Units used by Responding Foundries

Type of Combustion Unit	Number of Units
Crucible Furnace	76
Induction Furnace	57
Reverbatory Furnace	14
Arc Furnace	3

The regional inventory survey conducted by ITDI encountered deviation from the conventional usage of furnaces enumerated above. Locally fabricated drum-type furnaces (Figure 3) were used as pre-processing of scrap metals by some foundries. A particular foundry shop visited had integrated permanent mold making for metal cast agricultural plow. Individual firing of metals casts were done in the finishing process. Such locally produced furnaces should be evaluated further to better classify these installations according to the emission factors provide in the Toolkit.

Figure 3:
Locally Fabricated Drum-type Furnace

3.2.4 Copper Production

The production of copper during the past ten years had consistently dropped to 61% in volume due mainly to a host of technical, economic and environmental factors that befell the industry. Out of the 6 copper mining players only 3 were on operation for the year 1999 with copper concentrate produced at 151,220 t/a (MGB, 2000). Copper mining was categorized as primary production bearing emission factor for air release at 0.01 ug TEQ/t of copper produced (UNEP, 2001). PCDD/PCDF released to air was estimated at 0.002 g TEQ/a for 1999. This also was negligible effect compared to the other sources.

3.2.5 Aluminum Production

Before, aluminum was one of the base metals mined in the country but was not sustained especially with the introduction of the recycling processes. The inventory study team was able to acquire the Philippine Recyclers Movement's listings on existing recyclers. This was the basis of the data source for aluminum recycling survey. There were about 8 establishments engaged in this line of business including two of the biggest packaging companies that used 4,689.43 t/a of scrap aluminum. Virgin and scrap aluminum were processed by remelt furnace to cleanse and extract target alloy before casted into rolling ingots, milled and extruded to form aluminum billets or cans. Aluminum recycling was classified as thermal processing of scrap with minimal treatment of inputs and simple dust removal (class 1) with 150 and 400 ug TEQ/t emission factor for PCDD/PCDF released to air and residue, respectively (UNEP, 2001). Releases were estimated at 0.703 and 1.876 g TEQ/a, respectively. Note that recycling process in smaller amount had greater emission releases compared to primary production of base metals like Cu even if this was an effective catalyst for PCDD/PCDF formation.

3.2.6 Lead Production

Battery recycling was the main source for this category. This was composed of battery reconditioners, cottage melters, smaller battery recyclers and secondary lead smelters. Recycled products were mostly sold to Philippine Recyclers Inc. (PRI) while other players were wheel weights, lead solder or fishing sinkers. Scrap smelting process and furnaces were mostly reverberatory and only one rotary that process total annual tonnage of recycled material at 5,600 t/a. (Wilson, 1999)

The battery recycling was assigned 0.5 ug TEQ/t of lead as it fell under class 3 – Sec. Lead, PVC/Cl2 free scrap in furnaces other than blast or blast furnace with scrubber (UNEP, 2001). PCDD/PCDF released to air were estimated at 0.003 g TEQ/a. Results had similar impact for copper production.

3.2.7 Thermal Non-ferrous Metal Production as Nickel

Nickel (Ni) production in the country experience unprecedented increase in production in 2000 with doubled figure in six years time. For 1999, production was pegged at 625,276 DMT beneficial ore (MGB, 2000). PCDD/PCDF released to air was estimated at 1.251 g TEQ/a. Upon advised by UNEP-Chemical expert, the process for Ni adopted the class 2 wherein conditions was equivalent to primary production in mining activity (UNEP, 2001).

3.3 Main Category 3 – Power Generation and Cooking

Department of Energy (DOE) regulated all power related activities in the country. The passage of the omnibus power bill had leveled the playing fields for private entities to participate in the power generation businesses. The National Power Corporation (NPC) once the sole source of electricity power in the country was the subject of privatization for this newly passed bill. Independent Power Producers (IPP) had at least 35 – 40 % market shares for the past 5 years and on the rising trend as full implementation of the said bill was attained. Primary energy consumption reports of DOE were the basis for the PCDD/PCDF inventory for this category. Energy mix was composed of oil, coal hydro, geothermal, natural gas and biomass.

Household/domestic cooking had variety of energy source ranging from the liquid petroleum gas (LPG) to biomass like wood, rice hull, bagasse, charcoal, kerosene and biogas. Data source utilized for this sub-category were NSCB petroleum and forestry production reports, Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD) of the DOST publication (ISBN 971-20-0414-7, 1996) as well as database of operational small biogas systems (Maramba, 1996). Values derived for this sub-category were extrapolated using conversion factors recommended at the data sources papers. Environmental Natural Resources Accounting Project (ENRAP) valuation estimates whenever appropriate was also applied.

3.3.1 Fossil Fuel Power Plants

NSCB 1999 report on primary energy consumption by source type was verified at DOE annual report. DOE conversion factors were used to derive TJ values from MBFOE data routinely reported by the said department (Appendix D). There were 3 types of fuel used for power generation and they were coal, bunker "C" fuel and diesel. Extrapolated values of energy production were 106,293.58; 88,557.22 and 14,789.28 TJ/a, respectively. PCDD/PCDF estimated release to air for these sources were found to be 1.0629; 0.2214 and 0.0074 g TEQ/a, respectively. Coal-fired power plants released 1.488 g TEQ/a to residues. The total released to air and residues for this sub-category was 1.29 and 1.488 g TEQ/a. These had minimal impact on the overall PCDD/PCDF releases to the environment as compared to non-ferrous production category.

3.3.2 Biomass Power Plants

This type of power generation was classified as new and renewable source of energy utilized by commercial and industrial sectors (DOE, 1995 and 2001). Steam and power generation were the major uses of biomass in the industrial sector. They mainly comprised industries producing biomass wastes that can be used as fuel such as sugar processing, logging/wood products and paper processing. Fuel source were varied ranging from agricultural wastes such as bagasse, coconut husk/shell, rice hull, wood/wood waste, charcoal and others. This biomass not only fueled boilers for generation of electricity but also driers, furnaces/kilns, gasifiers and other technology for heating. Heating values for enumerated fuel sources (Appendix E) were lifted from Philippine Energy Plan (DOE, 1996) and Statistics Division of the Department of Economics and Social Affairs (UN, 2002). Extrapolated values (Appendix D) for bagasse, coconut husk/shell, rice husk, wood / wood waste and charcoal were 64,007.41; 58,825.28; 39,216.85; 241,874.17 and 27,510.88 TJ/a, respectively these gave total energy production of 431,434.60 TJ/a. Emission factor used was 500 ug TEQ/TJ biomass burned as these were mixed materials (UNEP, 2001). PCDD/PCDF estimated release to air and residue were at 106.87 and 0.363 g TEQ/a, respectively. Impact of biomass power plant was significant contributing to 98.6 % for this main source category. The overall impact to total PCDD/PCDF releases was 15.31 %. Biomass power plant was found to be substandard considering the energy production and PCDD/PCDF release ratio when compared to fossil fuel power plants' performance.

3.3.3 Household Cooking

This sub-category was quite difficult to survey due to the diffused data source. For these sector marketed and non-marketed fuelwood were used as basis for the estimation of PCDD/PCDF releases. Nearly 70% of the total biomass consumption comes from the residential sector with cook stoves as the major end user. Fuelwood and agricultural residues used for household energy amounted to 87 % and 12 % of total residential consumption, respectively. Animal manure still had a meager share as compared to other biomass resources used in the residential sector. Marketed fuelwood produced for 1999 was 49,000 m^3 (NSCB, 2000) and was estimated to produce 1, 155 TJ/a using conversion factors of 1.4 m^3/t and 33 MJ/kg (Openshaw, 1983) with 100 ug TEQ/TJ emission factor (UNEP, 2001) applied. PCDD/PCDF estimated release to air and residues were 0.1155 and 0.0231 g TEQ/a, respectively.

There was extrapolation adopted for non-marketed fuel wood devised by ENRAP (Appendix D). Estimated non-marketed fuelwood consumption for 1999 was 1.87×10^{10}kg/a with energy equivalent to 342, 210 TJ/a. Classification used was the same as marketed fuelwood resulting in PCDD/PCDF estimated releases to air and residues at 34.2210 and 6.8442 g TEQ/a, respectively. These releases were relatively high especially for residues.

3.3.4 Domestic Heating for Cooking

Aside from biomass cook stoves, the residential sector living in the urban and sub-urban areas used other fuel for cooking. These cooking fuels were liquid petroleum gas (LPG), kerosene, charcoal and biogas. The 1999 consumption rate for these fuels were 11,904,000 barrel; 5,178,000 barrel; 81,000 m^3 (NSCB, 2000) and 376 m^3 (Maramba, 1998), respectively. These values were extrapolated to energy produced from burning these fuel using appropriate conversion factors for average weight and heating value (Perry, 1984 and UNEP, 2001). Energy consumed was calculated (Appendix D) at 174.12; 30,469.7; 481.14; 9.024 TJ/a, respectively. Emission factors applied were based on the fuel type wherein class 1 – coal; class 2 – oil and class 3 – natural gas at 70, 10 and 1.5 ug TEQ/TJ, respectively for released to air while for class 1 - 5,000 ng TEQ/kg residues as ash (UNEP, 2001). Natural gas classification combined LPG and biogas as they had same heating value and effect. Total PCDD/PCDF estimated released to air and residues were 0.338 and 2.41 g TEQ/a.

3.4 Main Category 4 – Production of Mineral Products

Mineral resources deposits such as coal, fertilizer, salt, sand and gravel, marble, clay, limestone, feldspar, dolomite, magnesite, phosphate rock, guano, sulfur, industrial gemstone and decorative minerals abound in the country as major and important source of raw material for construction, agriculture and power generation. The major mineral commodities were sand, gravel, coal and cement. Coal was already discussed in Section 3.2.2. Thus, this section dealt with other mineral products associated with PCDD/PCDF generation like cement and limestone. Brick, glass, ceramics and asphalt mixing were also included though they belong to manufacturing, allied petroleum products and construction group according to PSIC.

3.4.1 Cement Production

The cement sector covers the manufacture of clinker, portland cement, pozzolan cement and other types of cement. There were 21 cement plants all over the country, 13 of which were located in Luzon, 3 in Visayas and 5 in Mindanao. Philippine Cement Manufacturers Corporation (PHILCEMCOR) represented cement producers. Historical demand-supply situation showed that an average of 5.9% decreased in production was realized for the last 4 years. The existing capacities of the 21 cement plants were 22.24 million MT as of the end of 2000. (DTI, 2001)

ITDI conducted regional survey for cement plants and all used the dry process due to less energy consumption per ton of clinker produced. Note that waste to energy scheme was becoming popular to the industry and some co-fired waste with fossil fuel using worn-out tires, waste oil and solvents. The last 2 were enlisted as hazardous under Republic Act (RA) 6969 also known as the Toxic Substances and Hazardous and Nuclear Wastes Control Act of 1992. The cement industry was assigned as class 3 – dry kilns with all types of APC bearing emission factors of 0.15 and 0.003 μg TEQ/t of cement produced (UNEP, 2001).

Annual production of cement for 1999 was 313,938.10 bags (NSCB, 2000) or 12,557,524 t/a. Estimated PCDD/PCDF released to air and residue were found to be 1.884 and 0.038 g TEQ/a, respectively. The results were very minimal and had no significant effect to the total PCDD/PCDF released for the year 1999.

3.4.2 Lime Production

The Philippines has an abundant supply of cement raw materials such as limestone, shale/sandstone, siliceous sand, lime, diorite, calcite and gypsum. MGB records showed that limestone reserves were 4 billion MT (Table 3-4) with expected life of 260 years.

Table 3-4: Limestone Deposits in the Philippines

Region	Estimated Deposit (Million MT)	Region	Estimated Deposit (Million MT)
I	1,082	VI	80
II	21	VII	529
III	333	X	81
IV	499	XI	56
V	688	XII	507
TOTAL	3,876		

The cement industry had consumed 12,590,800 t/a for the year 1999 (NSCB, 2000). The processing of limestone as raw material for cement was not classified under the Toolkit as they were directly fed into the cement kiln from the quarry after de-sizing through a series of crushing and sieving method.

ITDI regional survey was also conducted to one limestone mining and processing plant as well as small-scale lime producers. One of the biggest limestone mining operation and processing plant in the country belongs to an iron sintering company as mentioned in Section 3.2.1. Average annual production capacity for limestone was 4,800 t/day. This was sent to the sinter lime plant for further processing for utilization in iron ore sintering. For 1999, a total of 1,752,000 t/a high grade lime was produced. The sinter lime plant on the other hand was assigned class 2 that had high-energy efficient kilns and fitted with fabric filter gas cleaner bearing emission factor for air at 0.07 ug TEQ/t lime produced (UNEP, 2001). PCDD/PCDF estimated release to air was 0.123 g TEQ/a.

Other lime production plants visited by ITDI were composed of quicklime and hydrated lime producers. Products of the latter were also known as industrial and agricultural lime. The industrial lime was mainly for production of muscovado and refined sugar while agricultural lime was for soil conditioner, disinfectants and growth promoter of basic food for cultured fishes. Quicklime was consumed in large quantities by metallurgical industry in the treatment of copper, gold and silver ores, in manufacture of steel, smelting and refining of copper and other base metals while other chemical applications were in petroleum refining, insecticides, bleaching powder in tanner and paint ingredient. Table 3-5 summarized 1999 lime consumed by industry. Sugar centrals and refineries top the list followed by mining and last was aquaculture.

Table 3-5: List of Lime Consumer by Industry

Industry	Consumption, MT
Sugar Central / Refineries	19,454.06
Mining Companies	12,659.00
Aquaculture	3,115
Grand Total	35,228.06

The manufacture of lime was found to be of the crude type. One cooperative with 12 t/day capacity used this small-scale method where individual limers produced quicklime from small dug-out holes called "beehive kilns" and used firewood as fuel for calcination process. The quicklime was bought by the cooperative and processed them into hydrated lime through manual hydration and screening of dust particulates using improvised sprinklers and screens. During hydration (Figure 4) quicklime slowly crumbles and powderized as extreme heat evolved. The uncooked portion termed as "balag-ang" was sorted with a wooden stick. Lime powder was then screened either manually or using mechanized blower. Lime collected was then bagged and packed at 40 kg.

Figure 4: Cooking of Quicklime During Hydration Process

This crude type method of producing quicklime and hydrated lime also fell under class 1 as it had poorer combustion and no gas cleaning systems employed. The sum of quicklime and hydrated lime production was 35,228.06 t/a (Table 3-4). Estimated PCDD/PCDF released to air was 0.352 g TEQ/a.

Considering the above sources, total lime production was calculated at 1,787,228 t/a. Estimated PCDD/PCDF released to air was 0.475 g TEQ/a. This accounted to 18.7% of this main source category and 0.14 % of total PCDD/PCDF released for 1999. Limestone used as raw material for cement production was the main contributing factor for high PCDD/PCDF released to air.

3.4.3 Brick Production

Bricks were the oldest type of building materials usually used as facades of buildings or structures. There were special types of bricks like refractories used for lining of furnaces. These types of brick plants were visited in different regions of the country. Basic process involved clay molded into uniform blocks and baked in high temperature kiln. Most of these plants used rotary and tunnel kiln type with firing temperature ranging from 1000 – 1740 ^{0}C. Fuels for firing were heavy fuel and biomass (rice husk/hull). The surveyed brick plants were categorized as class 1 - smaller less well-controlled kilns, with no gas cleaning technology installed and class 2 - modern facilities with high standard of combustion control and energy efficient. Total annual production was estimated at 33,678 t/a with PCDD/PCDF released to air at 0.003 g TEQ/a. This is negligible compared to other sub-category releases.

3.4.4 Glass Production

Industry activities associated for this sub-category were the manufacture of float glass and packaging for beverages. A number of these companies practiced reuse and recycling in their process. Informal sectors that engaged in glass blowing for production of decorative items were also observed. ITDI survey revealed that a total of 646,154 t/a was estimated for 1999. PCDD/PCDF released to air was 0.129 g TEQ/a, which was quite high compared to similar processes like bricks and ceramics releases.

3.4.5 Ceramics Production

The local ceramic industry manufactured articles for household, industrial and other construction-related items. These included earthenware, porcelain or stoneware as well as tiles and bathroom accessories. Household ceramic industries participated in the ITDI regional survey. A total of 38 industries for 1999 produced 115 million pieces/a of decorative and functional ceramics or equivalent to roughly 167,985.74 t/a. Production process involved smaller less well-controlled kilns with cyclone or no gas cleaning technology installed. PCDD/PCDF released to air was 0.034 and like bricks production, this had negligible impact to the overall releases.

ITDI survey team also investigated backyard type of ceramics making. Another data gap identified that needs refining by UNEP experts since the technology applied in the Philippines is less sophisticated than the processes described in the Toolkit. This cottage industry was a family owned business that produced 12,000–24,000 pieces/a of ceramic jars or maximum equivalent to 240 t/a. The oven kiln was a dug-up pit with dimensions, 20 X 2 X 3 m. Chute feeds for loading firewood was provided for the combustion chamber. The firewood was stored in a makeshift shed.

3.4.6 Asphalt Mixing

Potholes in major roads and highways were repaired using asphalt. These were usually produced as allied products of the petroleum refining companies. It was reported that for 1999, a total of 907,000 barrels/a (NSCB, 2000) or equivalent to 148, 527.25 t/a (Appendix D) asphalt was produced using conversion factors 1,030 g/L (WHO, 1993) and 0.16 m3/barrel (Perry, 1984). Mixing process was assigned class 1 – mixing plant with no gas cleaning. Estimated PCDD/PCDF released to air was 0.01040 g TEQ/a and had no significant bearing on the overall releases.

3.5 Main Category 5 – Transport

Generally, this main source category dealt with fuel consumption per transportation mode. This included land transport (cars, jeepneys, all utility vehicles [AUV], buses, trucks and tricycles) and sea vessels (ships, tankers, barges, fishing vessels, ferry boats and motor boats). There were distinct fuels used for each type of transportation. Fortunately, data available (DOE, 2001 and NSCB, 2000) catered to this requirement resulting in minor estimation and conversion methods (Appendix D). Note that reference base year 1999 was a leaded gasoline period. Unleaded gasoline was imposed at 2000 following total phase-out of leaded gasoline of the same year.

3.5.1 4-Stroke Engine

Light vehicles like privately owned cars, AUVs and taxi cabs were the popular 4-stroke engines that ply the thoroughfares of the country. These were the major users of leaded (premium gasoline) and unleaded gasoline. For 1999, there were a total of 2,448,250 gasoline-fueled vehicles (NSCB, 2000). Out of this, 52.85% were light vehicles and 0.4 % was trucks and buses. For 4-stroke engine sea vessels, premium gasoline was also used in motor pump boats as passenger transport or fishing. It was reported that sales of premium gasoline and premium unleaded were 13,070,000 and 4,843,000 barrels/a, respectively (NSCB, 2000). These were equivalent to 9,671.80 and 3,583.82 t/a using the conversion factor of 0.74 kg/L (UNEP, 2001). Total PCDD/PCDF estimated releases to air was 0.022 g TEQ/a for 4-stroke engine. Note that classification used for unleaded was without catalytic converters as observed in the inventory. This had no significant impact on the overall PCDD/PCDF releases.

3.5.2 2-Stroke Engine

Motorcycles were the most common 2-stroke engines used in the country. There were about 1,144,666 motorcycles and tricycles that comprised 46.75% of all gasoline-fueled vehicle for 1999 (NSCB, 2000). Tricycles were public utility vehicles that transport people and goods from remote areas to the main road or highway. Regular gasoline was solely used by this transport sector with 1999 sales of 5,420,000 barrels/a (NSCB, 2000) or 4,010.80 t/a. The latter was converted using the same factor as 4-stroke engine. Total PCDD/PCDF estimated releases to air was 0.014 g TEQ/a for 2-stroke engine. This had basically the same impact as 4-stroke engine though it was 47% less in number.

3.5.3 Diesel Engines

There were about 1,057,751 diesel-fueled vehicles with 72% passenger jeepneys for 1999 (NSCB, 2000). These were unique colorful public utility vehicles only made in the Philippines. It had reconditioned diesel engine that were imported as surplus from developed countries like Japan while the body was locally fabricated. Likewise, diesel-fueled sea crafts such as large fishing vessels and passenger ferryboats were also surveyed. Diesel fuel was extensively used by two sectors namely the transport and power. Reported diesel fuel sales for 1999 were 42,109,000 barrels/a (NSCB, 2000), 92.97% or 33, 278.47 t/a (Appendix D) used by the transport sector. PCDD/PCDF estimated release to air was 0.002 g TEQ/a. The low result showed that diesel-fueled vehicles had insignificant impact to the total PCDD/PCDF released to air.

3.5.4 Heavy Oil Fired Engines

Inventory for this sub-category included shipping vessels, tanks and barges. Similar to diesel fuel, heavy oil was extensively used by the power and transport (sea vessels) sector. There were 27,871 registered sea vessels in 1999 (MARINA, 2000). Heavy oil consumption for 1999 was 41,222,000 barrels/a (NSCB, 2000) with 57% or 22,805.24 t/a (Appendix D) used by the transport sector. PCDD/PCDF estimated release to air was 0.091 g TEQ/a. Though it registered low in overall PCDD/PCDF released to air, it had the highest release for transport main source category accounting to 79 % of total releases.

3.6 Main Category 6 – Uncontrolled Combustion Processes

Accidental fires in forest, residential and industrial often occurred in the country especially during the summer months of March to May. Deliberate burning activities such as kaingin system (slash and burn farming) existed in the rural areas as well as indiscriminate burning of waste from household and agricultural crops. The former was recently prohibited by Republic Act (RA) 9003 – *"Ecological Solid Waste Management Act"* of 2000. Spontaneous combustion incidents in landfills and open dumpsite were also common. These were all included in this category except for burning of household waste and spontaneous combustion. The latter was not enough to be considered as a full-blown landfill/open dumpsite fires that necessitate firefighters intervention. These incidents were low level or slow fires (smoldered-type fires) that were left alone to burn and naturally dissipate. Preliminary studies on open burning of wastes showed that PCDD/PCDF emissions were at its highest during the smoldering phase (US-EPA, 1997). This fitted the description of spontaneous combustion incidents in the country and was identified as another data gap of the Toolkit for future consideration by UNEP experts as the activity fell between Category 6-B-1 and 3 landfill fires and uncontrolled domestic waste burning. PCDD/PCDF estimation for this category was found to be very challenging especially in the selection of appropriate conversion factor – amount of material expected to be involved in fire, based on the land area. Thus, assumptions were adopted to achieve acceptable results.

3.6.1 Biomass Burning

Forest fires and "kaingin" or the slash and burn practice to shift cultivation damaged 18,313 and 14,430 hectares in land area, respectively for 1998 (NSCB, 2000). It was estimated that materials burned were 787,459 and 620,490 t/a using the conversion factor of 43 t/ha (DENR, 1997). For convenience, kaingin activity was classified grassland and moor fires (UNEP, 2001) as they exhibited similar foliage structure. PCDD/PCDF estimated release to air were 3.9 and 3.1 g TEQ/a, respectively while for land were 3.1 and 2.5 g TEQ/a respectively.

For agricultural residue burning, this had been a common practice every harvest period. Rice straw and hull were burned (Figure 5) and plowed into the rice fields as a form of fertilizer for the next planting season. For 1999, a total of 4,122,600 t/a (Appendix D) of rice husk/hull (Shell, 2002) and straw was estimated using ratio and assumptions as advised by experts from Philippine Rice Research Institute. PCDD/PCDF estimated releases to air and land resulted to 123.36 and 47.12 g TEQ/a, respectively.

Figure 5: Rice hull burning after harvest

3.6.2 Accidental Fires

Fire Safety and Enforcement Division of Bureau of Fire Protection (FSED-BFP) had furnished the project team with information on nationwide fire incidence. A total of 6,357 fire incidences amounting to PhP3.99 B in property damages were reported for 1999 (BFP, 2000). About 51% or 3,247 cases were structural in nature while 6% or 397 involved vehicular/ship vessels. Total amount of materials burnt per area were extrapolated using the California Air Resources Board Model developed for Structural and Automobile Fires (CARB, 1994) modified to suit local conditions such as infrastructure profile, real estate and vehicle valuation (Appendix D). For structural fires at the National Capital Region (NCR), a total of 863 incidences were reported with 612 cases or 71% related to residential fires while 251 or 29% were industrial fires. Assuming that average value of residence was PhP 4,595.10/m^2 (NSCB, 2000), extrapolated amount of total combustible materials burnt (CARB, 1994) gave 1,836 tons/a (Appendix D). Likewise, average value of industrial facility was PhP 6,970.20/m2 (NSCB, 2000), amount of total combustible materials burnt (CARB, 1994) for industrial fires were 9,989.80 tons/a (Appendix D). PCDD/PCDF estimated release to air and residue due to structural fires were 4.73 for both.

For vehicular fires, 3.1% or 72 cases were reported at NCR for 1999. Assuming that average value of land transport (car, jeepneys, bus and trucks) was PhP500,000/unit, extrapolated value for combustible materials (CARB, 1994) yielded a total of 101.76 tons/a (Appendix D). PCDD/PCDF estimated releases to air and residue were 0.0096 and 0.0018 g TEQ/a.

Accidental fires as a whole had very minimal impact to the overall average annual PCDD/PCDF released to air and residue.

3.7 Main Category 7 – Production and Use of Chemicals and Consumer Goods

The activities related to this category were mostly the manufacturing sector. Products such as paper, inorganic chlorine, petroleum, textile and leather were included in the inventory survey. Whenever appropriate, extrapolation method (NSO, 2002) were adopted in the estimation of activity rate for each sub-category.

3.7.1 Pulp and Paper Mills

The pulp and paper industry had grown rapidly in terms of capacity and production. Presently, 42 operating mills with total capacity at 1,100,000 MT per year and 80% capacity utilization. Table 3.5 listed the breakdown of this industry and their actual production for 2001 (PULPAPEL, 2002). The dominance of recycling mills utilized the locally collected wastepaper as their raw material. De-inking technology was adopted for this process. The pulping method employed by Philippine mills was the Kraft process with elemental chlorine bleaching and recovery of energy from the digestion liquor. On the average, paper mills spend PhP 2,000 /MT of finished product on power and fuel. Large-scale firms usually owned 30MW bunker "C" fired diesel-generating plant to supply its energy requirement with power consumption at 700-985 kWh/MT and fuel used between 200-230 L/MT. Water requirement was 15-30 m^3/MT sourced from deep well pumps. (DTI, 1999)

Table 3-6: Number of Pulp / Paper Mills, Machines and Actual Production

Industry Type	Number of Establishments	Number of Machines	2001 Production, MT
Integrated Pulp and Paper Mill	1	3	127,750
Pulp Mills	4	4	5,475
Recycling Mills	37	69	1,129,310
Total	42	76	1,262,535

PCDD/PCDF emissions to products and sludges were categorized into 2 main process namely, class 1- Kraft pulps/papers with chlorine bleaching and class 5 / 4 – Recycling paper for pulp/paper, respectively. Thus, 2001 total PCDD/PCDF estimated releases to water, product and residues were 0.60, 12.36 and 12.32 g TEQ/a, respectively. For 1999, back-track extrapolation used volume of production ratio that resulted to lower values by 30 - 40% (NSO, 2002).

3.7.2 Chemical Industry

Regional inventory survey was conducted for this sub-category that consisted of only one chemical industry producing inorganic chlorine as caustic soda, hydrochloric acid and liquid chlorine. The process was through electrolytic production of sodium chloride salt in diaphragm cells. The capacity of the plant was 18,000 t/a. The company had absorption of waste chlorine in milk lime and subsequent settling and neutralization of resulting hypochlorite with urea for their pollution control system. Estimation of PCDD/PCDF releases was not estimated since production of inorganic chlorine is not relevant and not quantified.

Importation records (NSO, 1998 and BIS-DTI, 2000) were also investigated to verify production rate and historical trend pattern on POPs related chemical usage. Since 1995 to 1999, the Philippines had imported million tons of chemicals from countries such as Hongkong, Malaysia, Korea, Taiwan, Italy, Germany, Netherlands, France, Belgium, Britain, Spain, Israel, China, Portugal, Denmark, Sweden, Switzerland, Australia, Finland, Chile, Romania, Norway, New Zealand, United States, Japan, Singapore, Indonesia, Bahrain, Russia, Canada and Thailand. Appendix F compilation of chemicals imported during this period. Chlorinated chemicals such as VCM had a total importation of 25,852.62 t, tricholoroethylene (TCE) at 5,925.82 t and compounds containing un-fused furan ring at 5 kg for the last 5 years. Fortunately, no records showed any importation of pentachlorophenol (PCP) that was associated with wood preservation, textile and leather manufacturing. The Fertilizer and Pesticide Authority (FPA) banned this chemical more than 20 years ago.

3.7.3 Petroleum Industry

There were three large players in the Philippine petroleum industry. Though for the past 5 years, deregulation of oil prices encouraged new players/investors to participate in this once monopolized playing field of oil refinery. Total petroleum product sales for 1999 were 136,742 thousand barrels/a (NSCB, 2000) or equivalent to 18,811,350.49 t/a (DOE, 2001). These values were encoded in the Excel spreadsheet of UNEP Toolkit for future reference as no emission factors were assigned at this time for this type of industry activity.

3.7.4 Textile Plants

The Philippine textile industry experienced a decreasing trend in production for the past 3 years as 17 out of the 49 companies ceased operation. In the absence of accurate statistics, performance of textile industry was gauged from amount of staple fiber supply. These fibers consisted of cotton, polyester, rayon and acrylic. Cotton, rayon and acrylic were mainly imported while polyester used to be produced locally until 1996. For 1999, a total of 116,169 MT/staple fibers were supplied to the textile industries for processing. Imported staple fibers were 99% and 29% of this came from US cotton. (PTRI-DOST, 2001)

Textile processes were spinning, weaving, knitting, dyeing, printing, finishing and non-woven fabrics. Table 3-7showed the current structure of the textile industry per activity (BOI, 1999). Majority of the industries were engaged in knitting yet spinning had the highest registered capacity or volume of production. The activity rate for this sub-sector was derived from extrapolated 1988 to 1999 volume of textile production (Table 3-8) using growth rate of the gross value added (GVA) in textile industry at constant 1985 prices (NSCB/UNDP, 2000). Note that available data gathered was from volume of cotton textile production, 46-53% of total staple fiber supply used by the said industry. Emission factors for upper bound limit were adopted for the PCDD/PCDF estimated releases to products that resulted to 9.97 g TEQ/a accounting for 18% of overall releases to products. Conservative assumption was chosen due to high percentage of raw material imported and large volumes of effluent water generated by this industry.

Table 3-7: Current Status of Philippine Textile Industry, 1998

Activity	Number Firms	1998 Registered Capacity, MT	Percent Contribution
Spinning	85	209,471	31
Filament Yarn Polyester – 1 company Nylon – 1 company	2	 12,600 8,640	 1.9 1.3
Weaving	58	133,961	20
Knitting	119	176,397	26
Finishing	35	133,168	20
Total	299	674,237	100

Table 3-8: Volume of Production in Cotton Textile Industry (MT) and Gross Value Added (GVA) Growth Rate (%) at Constant Prices, 1988–1999.

Year	Volume of Production, MT	GVA Growth Rate, %2/	% Contribution Based on Staple Fiber Supply
1988	146,3001/		51
1989	161,530	10.41	51
1990	143,729	-11.02	52
1991	139,532	-2.92	53
1992	122,760	-12.02	48
1993	121,864	-0.73	50
1994	112,858	-7.39	53
1995	120,002	6.33	51
1996	117,590	-2.01	52
1997	113,780	-3.24	53
1998	108,751	-4.42	41
1999	99,659	-8.36	47

1/ ENRAP Phase III 2/ National Accounts, NSCB NSCB & UNDP, 2000

3.7.5 Leather Plants

Profile of Philippine leather and leathergoods industry had 3 main groups namely tanning, footwear and goods. Each of these industries was discussed separately to account fully the coverage of this widely diverse industry.

3.7.5.1 Leather Tanneries

Leather tanning was done either at the cottage industry level that produces small output or at an industrialized scale capable of processing large volume of hides. There were close to 100 firms in the leather tanning industry, most of which were backyard undertakings dispersed in Bulacan, Cavite and Marikina. These had an aggregate annual rated capacity of 46.5 million square feet of finished leather or approximately 10,156 t/a using mean conversion factor 4578.5 ft^2/t. This supplies 90% of total leather requirement for the domestic market in the footwear and leather goods industry. Raw and finished leather export totaled 20.114 t earning US$ 39,637 in 1995. Some large-scale tanneries and most of the reptile skin tanneries export commodities mostly from calf, bovine, chrome blue wet hides, reptile and aquatic. Tannin process involved chromium sulfate that imparts blue green color to the leather. The vegetable tanning, leached liquors from barks, leaves, fruits and roots were used as tanning agents. About US$ 2.76 M (PhP 75 M) was spent for chemicals, vegetable tanning extracts and dyes used to process hides and skins into commercial leather products. Local tanners had been using imported extracts (mimosa, quebracho, chestnut) from Brazil and other South American countries. (BOI, 1996)

The 1999 volume of production output was extrapolated using similar method from textile cotton production (NSCB/UNDP, 2000). Table 3-9 presented 1994 to 1999 volume of production in leather industry. Conservative assumption was adopted for similar reasons as the textile industry. PCDD/PCDF estimated releases to product at 55.32 g TEQ/a. The overall impact to product was 71.25% making leather tanning as the major source of PCDD/PCDF from products.

Table 3-9: Volume of Production in Leather Tanneries (MT) and Gross Value Added (GVA) Growth Rate (%) at Constant Prices, 1994 – 1999.

Year	Volume of Production, MT	GVA Growth Rate, %2/
1994	36,6221/	1.38
1995	42,104	14.97
1996	47,586	13.02
1997	53,568	12.57
1998	55,812	4.19
1999	55,315	-0.89

1/ Sum of Production Output by Beamhouse and Tanyard
2/ National Accounts, NSCB

3.7.5.2 Leather Footwear

The number of firms engaged in manufacture of leather footwear was 1,059 and clustered in Marikina, the shoe center of the country. Major raw materials needed for footwear were leather uppers and linings, soles/insoles and accessories. Around 80% of these materials were imported due to the absence or poor quality of locally produced counterparts. Raw hides and skins were imported from USA, Taiwan, Denmark, Germany and Hongkong. Estimated minimum capacity of 11.52 M pairs/a on an industry-wide basis. Of the total production capacity, 60-70% was directed to foreign markets mostly USA, Japan, Australia, Canada and other European countries. (BOI, 1996)

3.7.5.3 Leathergoods

Leather goods industry was widely scattered in Bulacan, Metro Manila, Laguna, Quezon, Bicol and Cebu. There were 6,000 manufacturers mostly cottage to small and medium enterprises (SMEs). Big manufacturers with foreign investments were usually based in Philippine Economic Zone Authority (PEZA) with major foreign investors from Japan, Germany, Korea and China. These were valued at PhP882M from about 24 firms/PEZA. Total capacity of this sector was difficult to estimate yet it was confirmed that the industry only utilized 40-60% of their installed capacity. Total production from 1986 to 1995 was estimated at 121,470,348 units with travel goods comprising the largest bulk. From 1997 to 2001 an average export growth rate of 1.09% was attained. The product coverage for this industry were handbags and belts, travel goods and gloves. Generally, these products had functional or utilitarian uses. About 80% of the sector's raw material requirement was imported. Among these were finished leather, linings, adhesives, fasteners and metal accessories (BOI, 1996).

The last 2 leather manufacturers discussed above were not included in the PCDD/PCDF estimation due to difficulty in acquiring accurate volume of production data as well as tracing their ultimate fate/final destination (market locally or exported). Thus, for this sub-category only tannery was considered.

3.8 Main Category 8 – Miscellaneous

This category considers activity rates related to crematoria, smoke houses and tobacco smoking. Dry cleaning had very small operations and was omitted from the survey. Most of the data gathered for this category were from national accounts and their data provider.

3.8.1 Crematoria

Local Chinese communities practiced cremation of their dead in the country. There were about 3 big funeral companies that provide this kind of service. Small funeral parlors usually referred their costumers these companies as well. The crematoria operate at a temperature of 400–1,000 ^{0}C fuelled with LPG (2) or electricity (1). Sum of bodies cremated per day were approximately 13 or equivalent to 284.7 t/a. PCDD/PCDF estimated released to air and residue was 0.026 and 0.001 g TEQ/a, respectively. Again this had the similar effect as drying of biomass though the volume was not as comparable.

3.8.2 Smoke Houses

This activity was clustered in the Southern Tagalog region of the country and was applied to fish products only. For this sub-category, fish production for 1999 was 2,822,100 t/a (NSCB, 2000). Out of this volume about 33,048 MT were processed to smoke fish (FAO, 2000) that was approximately 1.2%. Substituting this value at the Excel spreadsheet of UNEP Toolkit yielded 0.198 g TEQ/a. This had higher emission released to air compared to crematoria.

3.8.3 Tobacco Smoking

Tobacco annual production for 1999 was reported at 51,700 t/a (NSCB, 2000). Mostly cigarette were the final product of tobacco accounting for roughly 90% or 46,530 t/a. Thus, cigars were about 10% or 5,170 t/a. PCDD/PCDF estimated release to air was 0.002 and 0.005 g TEQ/a.

3.9 Main Category 9 – Disposal / Landfill

Proper management and disposal options of municipal solid wastes (MSW) were extensively discussed in the Ecological Solid Waste Management Act of 2000 also known as Republic Act (RA) 9003. Data acquired for this category were taken from various studies conducted by different government and non-government institutions, international cooperation agencies and private technology providers in support for the formulation of the said RA. Landfill, waste dumps and open water dumping were the only activities observed for this category.

3.9.1 Landfill and Waste Dumps

Metro Manila MSW were serviced by 3 final disposal facilities namely open dumpsites (Catmon, Malabon and Payatas, Quezon City), controlled dumpsite (Lingonan, Valenzuela) and sanitary landfills (San Mateo, Rizal and Carmona, Cavite). The landfills were 73 and 65 hectares in land area, respectively. Hazardous wastes were found to be disposed in controlled landfill and were estimated to be 1,460 t/a for 1999. Similarly, non-hazardous wastes from Metro Manila and some regions of the country were estimated to be at 1,503,922 t/a (MMDA, 2001 and ITDI survey). From this volume of MSW, methane gas was estimated at 304,544.205 t/a (ASEAN, 1981) while leachate was 539,720.01 t/a from 45% moisture content (Perry, 1984 and MMDA, 2001). Total PCDD/PCDF estimated release to water as leachate was 0.30 g TEQ/a for hazardous waste and 16.19 g TEQ/a for non-hazardous waste. The latter was quite high accounting for more than 1/3 (37%) of the overall released to water by this main source category.

3.9.2 Open Water Dumping

This activity was considered illegal dumping of wastes that eventually find their way into the metropolis water systems. Yearly this unlawful practice had cost undue flooding in the cities. It was estimated that 25% or 534,360 t/a of total MSW generated were illegally dumped (MMDA, 2001). PCDD/PCDF released into water was calculated at 26.72 g TEQ/a and was about 37% of the total impact by this category.

3.10 Main Category 10 – Hot Spots

Production and application of chemicals such as chlorinated organics and phenols were not duly recorded in any of the concerned agencies that regulate them. Thus, this category dealt with PCB-filled transformers and capacitors used by the power generating plants. Reports from one of the government-owned power generating corporation showed that a total of 26,160 L of PCB containing transformer oils were commissioned from 1965 – 1979. Some of these were retro-filled with non-PCB type transformer oils last 1992 while others were either still in use or stored safely at their facilities. There were also other possibilities that electric cooperatives not serviced by this particular corporation used PCB-containing transformer oil in widespread proportions as the geographical structure dictated (7,100 islands). These were not surveyed and would be a good follow-up study in the future.

4 PHILIPPINE NATIONAL PCDD/PCDF INVENTORY

Consolidated PCDD/PCDF inventory conducted for each main source category and sub-category yielded **534.06** g TEQ/a as total annual released to all environmental compartment. Uncontrolled combustion processes ranked 1st with 187.05 g TEQ/a followed by power generation and cooking at 157.23 g TEQ/a and at 3rd place was production of chemicals and consumer goods valued at 91.56 g TEQ/a. Air had the highest PCDD/PCDF contamination that totaled 327.67 g TEQ/a with 35% attributed to uncontrolled combustion of agricultural residues, 30% from firewood cooking and 18% from biomass fired boilers sub-categories. Product and land had similar PCDD/PCDF contamination level at 77.64 and 46.86 g TEQ/a, respectively. Sources for contamination were from leather plants at 55.32 g TEQ/a and uncontrolled combustion of agricultural residues at 41.23 g TEQ/a, respectively. Lastly, water and residues had contamination degree at 43.80 and 38.09 g TEQ/a, respectively. Major source was from open water dumping at 26.72 g TEQ/a or equal to 62% total PCDD/PCDF released to water. Likewise, sludge from paper industries and household biomass fired cooking stoves were the primary sources for PCDD/PCDF released to residues at 13.32 and 12.55 g TEQ/a or a total of 32% and 31% contribution, respectively. Table 4-1 summarized PCDD/PCDF contamination by source and environmental compartments while Appendix G compiled PCDD/PCDF estimated releases per main category and sub-category.

Table 4-1: Philippines National PCDD/PCDF Inventory, 1999

Cat	Source Category	Annual Releases (g TEQ/a)					Total/ Sector
		Air	Water	Land	Product	Residue	
1	Waste Incineration	37.83	0.00	0.00	0.00	3.72	41.55
2	Ferrous and Non-ferrous Metal Production	8.66	0.00	0.00	0.00	1.89	10.55
3	Power Generating and Cooking	142.84	0.00	0.00	0.00	14.39	157.23
4	Production of Mineral Products	2.53	0.00	0.00	0.00	0.038	2.57
5	Transportation	0.12	0.00	0.00	0.00	0.00	0.12
6	Uncontrolled Combustion Processes	135.46	0.00	46.86	0.00	4.7304	187.05
7	Production of Chemicals and Consumer Goods	0.00	0.60	0.00	77.64	13.32	91.56
8	Miscellaneous	0.23	0.00	0.00	0.00	0.001	0.23
9	Disposal/Landfilling	0.00	43.20	0.00	0.00	0.00	43.20
10	Identification of Potential Hot-Spots						
1-9	Total	327.67	43.80	46.86	77.64	38.09	534.06

This PCDD/PCDF inventory study identified uncontrolled combustion of agricultural residues as the major source for air and land contamination. This was in congruence to the preliminary investigation conducted by US-EPA on open burning. PCDD/PCDF released from such activity was higher compared to municipal solid waste incinerators operating in the US (USEPA, 1997). Note that Philippine waste incineration activity contributed only 7.08 % of the total PCDD/PCDF released to the environment. Other major sources of PCDD/PCDF released to products, water and residues were leather plants, open water dumping and household biomass cooking stoves, respectively.

Reduction of PCDD/PCDF releases from open burning of agricultural wastes (rice straw and husk/hull) could easily be attained through effective utilization of these wastes into the following:

- Fuel in direct combustion for improved rice hull cooking stoves (Sukic, 2002) and gasification (ITDI, 1998);

- Mulching and soil amendment materials for organic farming (Aldas, 2000) as well as processing into charcoal vinegar as natural pesticide (Nishiki, 2002);

- Paper making (IRRI, 2000); and

- Feeds for agricultural livestock

This substantiate that technology-based solution even low-end type significantly addressed environmental issues like PCDD/PCDF releases. As cited, improved rice-hull cooking stoves minimized consumption of firewood for household biomass cooking stoves through substitute fuel waste utilization. Thus, PCDD/PCDF releases from firewood cooking stoves correspondingly decreased by implementing such waste substitution program. Resource recovery from processing wastes for high valued products also facilitate reduction and effective management of PCDD/PCDF releases. Moreover, use of natural pesticides through charcoal vinegar process may eliminate dependence on chemical based-pesticides.

Additional measures that may be adopted to address concerns on leather products and other similar commodities were observance of product responsibility and life cycle considerations (Hosseinpour, 2001). Suppliers of raw materials must be responsible in the quality and integrity of the goods they market. Finished products bearing contamination due to raw materials must be minimized if not eliminated from the commodity life cycle. The international community would be the driving force that facilitates the establishment of a healthy global infrastructure for this norm to thrived and be strengthened. Ecological risk assessment tools may be utilized as safety nets for trading new materials/goods and products in the global market.

The international community also encouraged the implementation of proven best available technologies (BAT) and best environmental practices (BEP). Environmentally conscious multi-national companies had voluntarily retrofitted some of these BAT/BEP in their chlorine industry (Mischer, 2002), waste incineration (Francois, 2002), metal producing facilities (Weiss, 2002) and crematoria (Schetter, 2002). The latter interestingly used fabric filters with decomposing catalyst for PCDD/PCDF achieving very low PCDD/PCDF standard (0.1 ng TEQ/m^3) normally imposed in European countries. In fact, some of their technology providers were US-based companies that had developed high-efficient treatment technologies yet low-capital retrofitting expenses (Gore, 2002).

5 TOOLKIT DATA GAPS

It was proposed that copra production also be considered amongst the activities described in the Toolkit. The Philippines was the world's biggest supplier of coconut oil from copra meal. From 1992 to 1996, world production of coconut averaged 9.65 million MT or in copra terms were equivalent to about 51.07 billion nuts. Of this total, close to 70% was supplied by Indonesia, India and the Philippines. Around 80% of the countries' coconut production was processed into coconut oil for export. For 1999, coconut production was 12,504,000 MT/a and about 10,003,200 MT or 51.94 billion nuts (as copra) was processed into coconut oil.

Copra or dried coconut meat (kernel) was the most widely traded commodity. This was used as feedstock for coconut oil extraction by the conventional mechanical extraction method. Various copra drying methods were employed using natural sunlight, direct fire, and hot-air, the last 2 methods used coconut shell as fuel. Drying reduced moisture content of the kernel from approximately 50 down to 6-8%. Trading of copra goes through a series of intermediate buyers. Small volumes processed by individual farmers or cooperatives were sold either to barrio (village) or town traders who, in turn, sold accumulated truck loads of copra to oil millers. (UCAP, 2001) Trading set-up was found to be similar to that of crude-type production of quicklime (Section 3.4.2). Though the copra drying process closely resembled category 8-A-1 Drying of biomass using clean wood (coconut shell), further validation study on appropriate emission factors especially PCDD/PCDF released to products must be conducted.

Generally, the Toolkit was handy for initial country-based identification of PCDD/PCDF major sources of releases. It showed interesting results that in the ordinary would be overlooked. It also served as an excellent guiding instrument especially in the formulation of policies and management strategies such as National Implementation Plan (NIP) for PCDD/PCDF. Taxing part of the estimation work was the reconciling of Toolkit's data requirement and actual available data reported in the country. Selection of appropriate conversion factors for the reconciliation exercise was very challenging as well as activity assumption methods applied to achieve results with acceptable confidence level.

6 RECOMMENDATION

Validation of results from this PCDD/PCDF inventory study must be undertaken to verify the accuracy of the Toolkit in terms of identifying major sources in the country. This required actual measurement of PCDD/PCDF to all environmental compartments of major sources identified in the study as well as activity gaps discovered while using the Toolkit. Priority economic activities for immediate investigation were agricultural waste residue burning, biomass fired-boilers and firewood cooking for **air emission**; agricultural residue burning, forest fires and kaingin to include their crop produce for **releases to land**; leather, paper, textile/garments/apparel for **releases to products**; open water dumping and landfill leachates for **water effluent**; household biomass cooking, pulp & paper sludge and wood fired-boilers for **releases to residues**; and copra, foundries, domestic cooking, crude method of quicklime production, cottage ceramics industry, spontaneous combustion at landfills/open dumpsites for **identified activity gaps**. Moreover, a scientific approach to establish confidence level for emission factor application must be developed for inclusion in this Toolkit. At present, preliminary results of this inventory survey were used as basis for the determination of PCDD/PCDF level in Filipino breast-feeding mothers.

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APPENDIX A

Sources of Information on Industrial Processes and Activity Statistics for PCDD/PCDF Source Inventory

SOURCES OF INFORMATION ON INDUSTRIAL PROCESSES AND ACTIVITY STATISTICS FOR PCDD/PCDF SOURCE INVENTORY
(Reference Year = 1999)

SECTOR	SUB CAT.	SOURCE CATEGORIES	CLASS	AVAILABLE DATA	DATA SOURCE
1		***Waste Incineration***			
	a	Hazardous Waste Incineration	4	7813 t/a	• Industry participant verified by DENR
	b	Medical/Hospital Waste	2	2847 t/a	• DOH data calculated based on total capacity
			1	730 t/a	• DOH data calculated based on total capacity
	c	Animal Carcasses Burning	1	25.5 t/a	• Phil. Animal Health Center, & Regional Animal Disease Diagnostic Lab., BAI-DA
2		***Ferrous and Non-Ferrous Metal Production***			
	a	Iron Ore Sintering	3	4,206,996 t/a	• NSCB • ITDI Survey
	b	Coke Production (coal and charcoal)	1	14,580 t/a as Charcoal	• NSCB • Calculated value based on DOE conversion factor
	c	Iron and Steel production plants and foundries Iron and Steel Plants/Foundries Foundries	1	539,986 t/a (51 firms responded; 178 surveyed)	• MIRDC Survey

SECTOR	SUB CAT.	SOURCE CATEGORIES	CLASS	AVAILABLE DATA	DATA SOURCE
	d	Copper Production	5	151,220 t/a	• NSCB • Verified by MGB-DENR
	e	Aluminum Production (all Sec.)	1	4689.43 t/a	• ITDI Regional Survey & Phone Survey • Recyclers Movement of the Philippines
	f	Lead Production	3	5,600 t/a	• ITDI Regional Survey • Field Study Report on Lead Batteries (paper sent by UNEP Expert)
	j	Thermal Non-ferrous metal Prod. as Ni	2	625,276 t/a	• NSCB • Verified by MGB-DENR
3		***Power Generation and Heating***			
	a	Fossil Fuel Power Plants	2	106, 293.58 TJ/a	• NSCB • DOE Derived Values
			3	88, 557.22TJ/a	• NSCB • DOE Derived Values
			4	14, 789.28 TJ/a	• NSCB • DOE Derived Values
	b	Biomass Power Plants	1	189,560.42 TJ/a (biomass fired) 241,874.17 TJ/a (wood fired)	• NSCB & NPC • DOE Derived Values
	d	Household Cooking – Biomass (using wood, ipa, bagasse)	2	343,365 TJ/a	• NSCB • ENRAP Calculation

SECTOR	SUB CAT.	SOURCE CATEGORIES	CLASS	AVAILABLE DATA	DATA SOURCE
	e	Domestic Cooking	1	481.14 TJ/a (Charcoal)	• NSCB • DOE Conversion Derived Value
			2	30,469.70 TJ/a (Kerosene)	• NSCB • DOE Conversion Derived Value
			3	174.12 TJ/a (LPG) & 9.024 TJ (at 376 cum. Biogas systems)	• NSCB • DOE Conversion Derived Value
4		***Production of Mineral Products***			
	a	Cement Kiln	3	12,557,524 t/a	• NSCB • Verified by MGB-DENR and BOI-DTI
	b	Lime	1	35,228.06 t/a	• NSCB • Verified by MGB-DENR and BOI-DTI
			2	1, 752, 000 t /a	• NSCB • Verified by MGB-DENR and BOI-DTI
	c	Brick	1	13,824 t/a	• ITDI RegionalSurvey
			2	19,854 t/a	• ITDI Regional Survey
	d	Glass	1	646,154 t/a	• ITDI Regional Survey
	e	Ceramics	1	167,986 t/a	• ITDI Regional Survey • Verified by BOI-DTI
	f	Asphalt Mixing	1	148, 527.25 t/a	• DOE Report • NSCB

SECTOR	SUB CAT.	SOURCE CATEGORIES	CLASS	AVAILABLE DATA	DATA SOURCE
5		***Transport***			
	a	4-stroke Engines	1	3, 584 t/a	• NSCB • Toolkit Conversion
			2	9, 672 t/a	• NSCB • Toolkit Conversion
	b	2-Stroke Engines	1	4.010.8 t/a	• NSCB
	c	Diesel Engines	1	33, 278 t/a	• NSCB less NPC Consumption
	d	Heavy Oil Fired Engines	1	22, 805 t/a	• NSCB less NPC Consumption
6		***Uncontrolled Combustion Processes***			
	a	Fires/Burning-Biomass	1	787,459 t/a	• NSCB • ENRAP factor for Kaingin ave. fuel loading @ 43 t/ha
			2	620,490 t/a	• NSCB • ENRAP factor for Kaingin ave. fuel loading @ 43 t/ha
			3	4, 122, 600 t/a	• NSCB • ENRAP factor for Kaingin ave. fuel loading @ 43 t/ha
	b	Fires, waste burning, landfill fires, industrial fires, accidental fires	2	11, 826 t/a	• FSED-BFP • NSCB
			4	101. 76 t/ a	• FSED-BFP • NSCB

SECTOR	SUB CAT.	SOURCE CATEGORIES	CLASS	AVAILABLE DATA	DATA SOURCE
7		***Production of Chemicals and Consumer Goods***			
	a	Pulp Paper Mills (Sludge)	1 4	133,225 t/a 1,129,310 t/a	• ITDI Regional Survey • BOI-DTI Industry Profile
		(Pulp and Paper)	1 5	133,225 t/a 1,129,310 t/a	• ITDI Regional Survey • BOI-DTI Industry Profile
	c	Petroleum Industry	1	18, 811, 350.49 t/a	• ITDI Regional Survey
	d	Textile Plants	1	99, 659 t/a	• DTI Profile import fiber included
	e	Leather Plants	1	55, 315 t/a	• DTI Profile 800mt capacity with 30% utilization=240mt
8		***Miscellaneous***			
	b	Crematories	1	285 t/a	• ITDI Survey
	c	Smoke Houses	2	33,048 t/a	• ITDI Survey
	e	Tobacco Smoking	1	5,170 t/a	• NSCB
			2	46, 350 t/a	• NSCB • ITDI Survey
9		***Disposal/Landfill***			
	a	Landfill and Waste Dumps	1	1,460 t/a	• ITDI Survey • MMDA

SECTOR	SUB CAT.	SOURCE CATEGORIES	CLASS	AVAILABLE DATA	DATA SOURCE
			2	539,720 t/a	• ITDI • MMDA
	c	Open Water Dumping		534,360 t/a	• MMDA

Legend:

BAI-DA	Bureau of Animal Industry, Department of Agriculture
MGB-DENR	Mines and Geosciences Bureau, Department of Environment and Natural Resources
BOI-DTI	Board of Investment, Department of Trade and Industry
DENR	Department of Environment and Natural Resources
DOE	Department of Energy
DOH	Department of Health
ENRAP	Environment and Natural Resources Accounting Project
FSED-BFP	Fire Safety and Enforcement Division, Bureau of Fire Protection
MIRDC	Metals Industry Research and Development Center
MMDA	Metro Manila Development Authority
NPC	National Power Corporation
NSCB	National Statistical Coordination Board

APPENDIX B
Project Team Composition

August 13, 2001

ITDI Special Order No. 302
Series of 2001

Subject **Designation of Personnel under the Project entitled "National Inventory of Dioxin and Furan Releases"**

In connection with the implementation of the above-mentioned project, the following personnel are designated to perform the functions and at the monthly rates specified:

NAME	DESIGNATION
Dr. Christopher M. Silverio	Program Leader
Alexandra F. Pablo	Project Leader
Ma. Victoria M. Pasagui	Project Staff Level III
Lucila S. Salinas	Project Staff Level III
Carmel C. Gacho	Project Staff Level II
David L. Herrera	(Alternate)
Mario Josefino V. Capule	Project Staff Level II
Emelda A. Ongo	Project Staff Level II
Adonis T. Marquez	Project Staff Level I
Reymundo K. Adan	(Alternate)
Henry C. Brillante	Project Staff Level I
Rizalito E. Catha	(Alternate)
Efren G. Najera	Project Staff Level I
Violeta F. Mabuti	(Alternate)
For DOST-RO staff	Project Staff Level (24)

DR. ERNESTO P. LOZADA
Director

APPENDIX C

Philippine Standard for Industry Classification

APPENDIX D

Detailed Computation of Activity Rate for Estimation of PCDD/PCDF Releases

APPENDIX E

Heating Value of Different Fuel Sources

PRODUCT SPECIFIC GRAVITY RANGES

	Specific Gravity	Barrels Per Tonne
Crude Oil	0.80-0.97	8.0-6.6
Aviation gasoline	0.70-0.78	9.1-8..2
Motor Gasoline	0.71-0.79	9.0-8.1
Kerosen	0.78-0.84	8.2-7.1
Gas Oil	0.82-0.92	7.8-6.9
Diesel Oil	0.82-0.92	7.8-6.9
Lubricating Oil	0.85-0.95	7.5-6.7
Fuel Oil	0.92-0.99	6.9-6.5
Asphalthic Bitumen	1.00-1.10	6.4-5.8

CONVERTING INTO BARRELS-OF-FUEL-OIL-EQUIVALENT (BFOE)

Energy Forms are converted into a common unit, BFOE, based on fuel oil equivalents at 18,600 Btu/lb as follows:

Electricity	600 kwh	1.0000
Regular Gasoline	1bbl	0.8470
Premium	1bbl	0.8624
Kerosene	1bbl	0.8798
Diesel Oil	1bbl	0.9328
LPG	1bbl	0.6384
Aviation Gas	1bbl	0.8475
Fuel Oil		
Pitch	1bbl	1.0058
PPC	1bbl	1.0197
Coal (10,000 BTU/lb	1MT	3.5300
Alcohol	1bbl	0.5561
Bagasse	1MT	1.4400
Coconut Oil	1bbl	1.0000

APPROXIMATE HEAT ENERGY CONTENTS OF FUEL

	BTU/lb	MJ/kg
Crude Oil	18,000-19,500	42.45
Gasoline	20,500	47.70
Kerosene	19,800	46.10
Benzole	18,100	42.10
Ethanole	11,600	27.00
Gas oil	19,200	44.70
Fuel Oil (bunker)	18,300	42.60
Coal (bituminous)	10,200-14,600	23.73
LNG (natural gas)	22,300	51.90

Crude Oil	=0.1344 TOE/Bbl
Barrel of Fuel Oil Equivalent	=0.1444 TOE/MT
Coal	=0.488 TOE/MT
Electricity	=0.086 TOE /MWH

Source: Department Of Energy

APPENDIX F

Compilation of Chemicals Imported from 1995-1999

APPENDIX G

Compiled PCDD/PCDF Releases by Main Categories and Sub-Categories

Sector	Source Categories	Annual Releases (g TEQ/a)					Total / Sector
		Air	Water	Land	Product	Residue	
1	Waste Incineration	37.8320	0.0000	0.0000	0.0000	3.7188	41.5508
2	Ferrous and Non-Ferrous Metal Production	8.6640	0.0000	0.0000	0.0000	1.8884	10.5524
3	Power Generation and Cooking	142.8408	0.0000	0.0000	0.0000	14.3892	157.2300
4	Production of Mineral Products	2.5345	0.0000	0.0000	0.0000	0.0377	2.5722
5	Transportation	0.1158	0.0000	0.0000	0.0000	0.0000	0.1158
6	Uncontrolled Combustion Processes	135.4576	0.0000	46.8578	0.0000	4.7303	187.0457
7	Production of Chemicals and Consumer Goods	0.0000	0.5995	0.0000	77.6398	13.3225	91.5618
8	Miscellaneous	0.2301	0.0000	0.0000	0.0000	0.0007	0.2308
9	Disposal/Landfilling	0.0000	43.2016	0.0000	0.0000	0.0000	43.2016
10	Identification of Potential Hot-Spots						
1-9	**Total**	**327.6748**	**43.8011**	**46.8578**	**77.6398**	**38.0876**	**534.0611**

Sector	Subcat.	Class	Source Categories	Potential Release Route (µg TEQ/t) Air	Water	Land	Products	Residues Fly Ash	Residues Bottom Ash	Production t/a	Annual release g TEQ/a Air	Annual release g TEQ/a Water	Annual release g TEQ/a Land	Annual release g TEQ/a Products	Annual release g TEQ/a Fly ash	Annual release g TEQ/a Bottom Ash
1			**Waste incineration**													
	a		**Municipal solid waste incineration**							0	0.000	0	0	0	0.000	0.000
		1	Low technol. combustion, no APC system	3,500		NA	NA	0	75		0.000				0.000	0.000
		2	Controlled comb., minimal APC	350		NA	NA	500	15		0.000				0.000	0.000
		3	Controlled comb., good APC	30		NA	NA	200	7		0.000				0.000	0.000
		4	High tech. combustion, sophisticated APCS	0.5		NA	NA	15	1.5		0.000				0.000	0.000
	b		**Hazardous waste incineration**							7,813	0.078	0	0	0	3.516	0.000
		1	Low technol. combustion, no APC system	35,000		NA	NA	9,000			0.000				0.000	0.000
		2	Controlled comb., minimal APC	350		NA	NA	900			0.000				0.000	0.000
		3	Controlled comb., good APC	10		NA	NA	450		7,813	0.078				3.516	0.000
		4	High tech. combustion, sophisticated APCS	0.75		NA	NA	30			0.000				0.000	0.000
	c		**Medical/hospital waste incineration**							3,577	37.741	0	0	0	0.000	0.203
		1	Uncontrolled batch combustion, no APCS	40,000		NA	NA		200	730	29.200				0.000	0.146
		2	Controlled, batch, no or minimal APCS	3,000		NA	NA		20	2,847	8.541				0.000	0.057
		3	Controlled, batch comb., good APC	525		NA	NA	920			0.000				0.000	0.000
		4	High tech, continuous, sophisticated APCS	1		NA	NA	150			0.000				0.000	0.000
	d		**Light fraction shredder waste incineration**							0	0.000	0	0	0	0.000	0.000
		1	Uncontrolled batch comb., no APCS	1,000		NA	NA				0.000				0.000	0.000

Sector	Subcat.	Class	Source Categories	Potential Release Route (µg TEQ/t)						Production	Annual release	Annual release	Annual release	Annual release	Annual release	Annual release
								Residues		t/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
				Air	Water	Land	Products	Fly Ash	Bottom Ash		Air	Water	Land	Products	Fly ash	Bottom Ash
		2	Controlled, batch, no or minimal APC	50		NA	NA				0.000				0.000	0.000
		3	High tech, continuous, sophisticated APCS	1		NA	NA	150			0.000				0.000	0.000
	e		**Sewage sludge incineration**							0	0.000	0	0	0	0.000	0.000
		1	Old furnaces, batch, no/little APCS	50		NA	NA	23			0.000				0.000	0.000
		2	Updated, continuously, some APCS	4		NA	NA	0.5			0.000				0.000	0.000
		3	State-of-the-art, full APCS	0.4		NA	NA	0.5			0.000				0.000	0.000
	f		**Waste wood and waste biomass incineration**							0	0.000	0	0	0	0.000	0.000
		1	Old furnaces, batch, no/little APCS	100		NA	NA	1,000			0.000				0.000	0.000
		2	Updated, continuously, some APCS	10		NA	NA	10			0.000				0.000	0.000
		3	State-of-the-art, full APCS	1		NA	NA	0.2			0.000				0.000	0.000
	g		**Animal carcasses burning**							26	0.013	0	0	0	0.000	0.000
		1	Old furnaces, batch, no/little APCS	500		NA	NA			26	0.013				0.000	0.000
		2	Updated, continuously, some APCS	50		NA	NA				0.000				0.000	0.000
		3	State-of-the-art, full APCS	5		NA	NA				0.000				0.000	0.000
1			**Waste Incineration**							**11,416**	**37.832**	**0**	**0**	**0**	**3.516**	**0.203**

Sector	Subcat.	Class	Source Categories	Potential Release Route (µg TEQ/t)					Production	Annual release				
				Air	Water	Land	Products	Residues	t/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
2			**Ferrous and Non-Ferrous Metal Production**							**Air**	**Water**	**Land**	**Product**	**Residues**
	a		**Iron ore sintering**						**4,206,996**	**1.262**	**0**	**0**	**0**	**0.013**
		1	High waste recycling, incl. oil contamin. materials	20	ND	ND	ND	0.003		**0.000**				**0.000**
		2	Low waste use, well controlled plant	4	ND	ND	ND	0.003		**0.000**				**0.000**
		3	High technology, emission reduction	0.3	ND	ND	ND	0.003	4,206,996	**1.262**				**0.013**
	b		**Coke production**						**14,580**	**0.044**	**2.6244E-09**	**0**	**0**	**0**
		1	No gas cleaning	3	0.06	ND	ND	ND	14,580	**0.044**	**2.6244E-09**			
		2	Afterburner/ dust removal	0.3	0.06	ND	ND	ND		**0.000**	**0**			
	c		**Iron and steel production plants and foundries**						**0**	**0.000**	**0.0**	**0.0**	**0.0**	**0.000**
			Iron and steel plants											
		1	Dirty scrap, scrap preheating, limited controls	10	ND	ND	NA	15		**0.000**				**0.000**
		2	Clean scrap/virgin iron, afterburner, fabric filter	3	ND	ND	NA	15		**0.000**				**0.000**
		3	Clean scrap/virgin iron, BOS furnaces	0.1	ND	ND	NA	1.5		**0.000**				**0.000**
		4	Blast furnaces with APC	0.01	ND	ND	NA	ND		**0.000**				
			Foundries						**539,986**	**5.400**	**0**	**0**	**0**	**0.000**
		1	Cold air cupola or rotary drum, no APCS	10	ND	ND	ND	ND	539,986	**5.400**				
		2	Rotary Drum - fabric filter	4.3	ND	ND	ND	0.2		**0.000**				**0.000**
		3	Cold air cupola, fabric filter	1	ND	ND	ND	8		**0.000**				**0.000**
		4	Hot air cupola or induction furnace, fabric filter	0.03	ND	ND	ND	0.5		**0.000**				**0.000**
	d		**Copper production**						**151,220**	**0.002**	**0.0**	**0.0**	**0.0**	**0.0**
		1	Sec. Cu - Basic technology	800	ND	ND	ND	630		**0.000**				**0.000**
		2	Sec. Cu - Well controlled	50	ND	ND	ND	630		**0.000**				**0.000**
		3	Sec. Cu - Optimized for PCDD/PCDF control	5	ND	ND	ND	300		**0.000**				**0.000**
		4	Smelting and casting of Cu/Cu alloys	0.03	ND	NA	NA	ND		**0.000**				
		5	Prim. Cu – all types	0.01	ND	ND	ND	ND	151,220	**0.002**				
	e		**Aluminum production (all sec.)**						**4,689**	**0.703**	**0**	**0**	**0**	**1.876**
		1	Processing scrap Al, minimal treatment of inputs, simple dust removal	150	ND	ND	ND	400	4,689	**0.703**				**1.876**
		2	Scrap treatment, well controlled, good APCS	35	ND	ND	ND	400		**0.000**				**0.000**

			Source Categories	Potential Release Route (µg TEQ/t)					Production	Annual release				
Sector	Subcat.	Class		Air	Water	Land	Products	Residues	t/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
		3	Shavings/turning drying	10	ND	ND	ND	NA		0.000				
		4	Optimized process, optimized APCS	1	ND	ND	ND	400		0.000				0.000
	f		**Lead production**						**5,600**	0.003	0	0	0	0
		1	Sec. lead from scrap, PVC battery separators	80	ND	ND	ND	ND	0	0.000				
		2	Sec. from PVC/Cl2 free scrap, blast furnaces with FF	8	ND	ND	ND	ND		0.000				
		3	Sec. Lead, PVC/Cl2 free scrap in furnaces other than blast or blast furnace with scrubber	0.5	ND	ND	ND	ND	5,600	0.003				
	g		**Zinc production**						**0**	0.000	0	0	0	0
		1	Kiln with no dust control	1,000	ND	ND	ND	ND		0.000				
		2	Hot briquetting/rotarry furnaces, basic control	100	ND	ND	ND	ND		0.000				
		3	Comprehensive control	5	ND	ND	ND	ND		0.000				
		4	Melting (only)	0.3	ND	ND	ND	ND		0.000				
	h		**Brass production**						**0**	0.000	0	0	0	0
		1	Simple melting furnaces	1	ND	ND	ND	ND		0.000				
		2	Sophisticated equipment, e.g. induction ovens with APCS	0.1	ND	ND	ND	ND		0.000				
	I		**Magnesium production**						**0**	0.000	0.000	0	0	0.000
		1	Using MgO/C thermal treatment in Cl2, no effluent treatment, poor APCS	250	9,000	NA	ND	0		0.000	0.000			
		2	Using MgO/C thermal treatment in Cl2, comprehensive pollution control	50	24	NA	ND	9,000		0.000	0.000			0.000
	j		**Thermal Non-ferrous metal production (e.g., Ni)**						**625,276**	1.251	0	0	0	0
		1	Contaminated scrap, simple or no dust control	100	ND	ND	ND	ND		0.000				
		2	Clean scrap, good APCS	2	ND	ND	ND	ND	625,276	1.251				
	l		**Shredders**						**0**	0.000	0	0	0	0
		1	Metal shredding plants	0.2	NA	NA	ND	ND		0.000				
	m		**Thermal wire reclamation**						**0**	0.000	0	0	0	0
		1	Open burning of cable	5,000	ND	ND	ND	ND		0.000				
		2	Basic furnace with after burner, wet scrubber	40	ND	NA	ND	ND		0.000				
		3	Burning electric motors, brake shoes, etc., afterburner	3.3	ND	NA	ND	ND		0.000				
2			**Ferrous and Non-Ferrous Metal Production**						**5,548,347**	**8.664**	**0.000**	**0.000**	**0.000**	**1.888**

			Source Categories	Potential Release Route (µg TEQ/TJ)					Production	Annual release	Annual release	Annual release	Annual release	Annual release
Sector	Subcat.	Class		Air	Water	Land	Products	Residues	TJ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
3			**Power Generation and Heating**							**Air**	**Water**	**Land**	**Products**	**Residues**
	a		**Fossil fuel power plants**						**209,640.08**	**1.2917**	**0.0000**	**0.0000**	**0.0000**	**1.4881**
		1	Fossil fuel/waste co-fired power boilers	35	NA	NA	NA	ND		**0.0000**				
		2	Coal fired power boilers	10	NA	NA	NA	14	106,293.58	**1.0629**				**1.4881**
		3	Heavy fuel fired power boilers	2.5	NA	NA	NA	ND	88,557.22	**0.2214**				
		4	Light fuel oil/natural gas fired power boilers	0.5	NA	NA	NA	ND	14,789.28	**0.0074**				
	b		**Biomass Power Plants**						**431,434.59**	**106.8739**	**0.0000**	**0.0000**	**0.0000**	**3.6281**
		1	1. Other biomass fired power boilers	500	NA	NA	NA	ND	189,560.42	**94.7802**				
		2	2. Wood fired power boilers	50	NA	NA	NA	15	241,874.17	**12.0937**				**3.6281**
	c		**Landfill and biogas combustion**						**0.00**	**0.0000**	**0.0000**	**0.0000**	**0.0000**	**0.0000**
		1	Biogas-fired boilers, motors/turbines and flaring	8	NA	NA	NA	NA		**0.0000**				
	d		**Household heating and cooking - Biomass**						**343,365.00**	**34.3365**	**0.0000**	**0.0000**	**0.0000**	**6.8673**
		1	Contaminated wood/biomass fired stoves	1,500	NA	NA	NA	2,000		**0.0000**				**0.0000**
		2	Virgin wood/biomass fired stoves	100	NA	NA	NA	20	343,365.00	**34.3365**				**6.8673**
	e		**Domesting cooking - Fossil fuels**					ng TEQ/kg Ash	**31,133.98**	**0.3387**	**0.0000**	**0.0000**	**0.0000**	**2.4057**
		1	Coal fired stoves (charcoal)	70	NA	NA	NA	5,000	481.14	**0.0337**				**2.4057**
		2	Oil fired stoves (kerosene)	10	NA	NA	NA	ND	30,469.70	**0.3047**				
		3	Natural gas fired stoves (LPG)	1.5	NA	NA	NA	ND	183.14	**0.0003**				
3			**Power Generation and Heating**						**1,015,574**	**142.8408**	**0.0000**	**0.0000**	**0.0000**	**14.3892**

			Source Categories	Potential Release Route (µg TEQ/t)					Production	Annual release	Annual release	Annual release	Annual release	Annual release
Sector	Subcat.	Class		Air	Water	Land	Products	Residues	t/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
4			**Production of Mineral Products**							**Air**	**Water**	**Land**	**Products**	**Residues**
	a		**Cement kilns**						**12,557,524**	**1.884**	**0**	**0**	**0**	**0.038**
		1	Wet kilns, ESP temperature >300 °C	5	NA	ND	ND	1		**0.000**				**0.000**
		2	Wetkilns, ESP/FF temperature 200 to 300 °C	0.6	NA	ND	ND	0.1		**0.000**				**0.000**
		3	Wet kilns, ESP/FF temperature <200 °C and all types of dry kilns	0.15	NA	ND	ND	0.003	12,557,524.00	**1.884**				**0.038**
	b		**Lime**						**1,787,228**	**0.475**	**0**	**0**	**0**	**0**
		1	Cyclone/no dust control	10	ND	ND	ND	ND	35,228.06	**0.352**				
		2	Good dust abatement	0.07	ND	ND	ND	ND	1,752,000	**0.123**				
	c		**Brick**						**33,678**	**0.003**	**0**	**0**	**0**	**0**
		1	Cyclone/no dust control	0.2	NA	ND	ND	ND	13,824	**0.003**				
		2	Good dust abatement	0.02	NA	ND	ND	ND	19,854	**0.000**				
	d		**Glass**						**646,154**	**0.129**	**0**	**0**	**0**	**0**
		1	Cyclone/no dust control	0.2	NA	ND	ND	ND	646,154	**0.129**				
		2	Good dust abatement	0.015	NA	ND	ND	ND		**0.000**				
	e		**Ceramics**						**167,986**	**0.034**	**0**	**0**	**0**	**0**
		1	Cyclone/no dust control	0.2	NA	ND	ND	ND	167,986	**0.034**				
		2	Good dust abatement	0.02	NA	ND	ND	ND		**0.000**				
	f		**Asphalt mixing**						**148,527**	**0.01040**	**0**	**0**	**0**	**0.000**
		1	Mixing plant with no gas cleaning	0.07	NA	ND	ND	ND	148,527.25	**0.01040**				
		2	Mixing plant with fabric filter, wet scrubber	0.007	NA	ND	ND	0.06		**0.000**				**0.000**
4			**Production of Mineral Products**						**15,341,098**	**2.535**	**0**	**0**	**0**	**0.038**

			Source Categories	Potential Release Route (µg TEQ/t)					**Consumption ***	**Annual release**	**Annual release**	**Annual release**	**Annual release**	**Annual release**
Sector	Subcat.	Class		Air	Water	Land	Products	Residues	**t/a**	**g TEQ/a**	**g TEQ/a**	**g TEQ/a**	**g TEQ/a**	**g TEQ/a**
5			**Transport**							**Air**	**Water**	**Land**	**Products**	**Residues**
	a		**4-Stroke engines**						**13,256**	**0.009**	**0**	**0**	**0**	**0**
		1	Leaded fuel	2.2	NA	NA	NA	ND	3,584	**0.008**				
		2	Unleaded fuel without catalyst	0.1	NA	NA	NA	ND	9,672	**0.0010**				
		3	Unleaded fuel with catalyst	0.00	NA	NA	NA	NA		**0.000**				
	b		**2-Stroke engines**						**4,011**	**0.014**		**0**	**0**	**0**
		1	Leaded fuel	3.5	NA	NA	NA	ND	4,011	**0.014**				
		2	Unleaded fuel without catalyst	2.5	NA	NA	NA	ND		**0.000**				
	c		**Diesel engines**						**33,278**	**0.002**	**0**	**0**	**0**	**0**
		1	Diesel engines	0.1	NA	NA	NA	ND	33,278	**0.002**				
	d		**Heavy oil fired engines**						**22,805**	**0.091**	**0**	**0**	**0**	**0**
		1	All types	4	NA	NA	NA	ND	22,805	**0.091**				
5			**Transport**						**73,350**	**0.116**	**0**	**0**	**0**	**0**

* Assuming that consumption equals sales

Conversion factors:volume -> mass	L	kg
Gasoline	1	0.74
Diesel	1	0.85
Heavy Fuel Oil	1	0.97

			Source Categories	Potential Release Route (µg TEQ/t)					Production	Annual release				
Cat	Subcat.	Class		Air	Water	Land	Products	Residues	t/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
6	6		**Uncontrolled Combustion Processes**							**Air**	**Water**	**Land**	**Products**	**Residues**
	a		**Fires/burnings - biomass**						**5,530,549**	**130.718**	**0**	**46.858**	**0**	**0**
		1	1. Forest fires	5	ND	4	NA	ND	787,459	**3.937**		**3.150**		
		2	2. Grassland and moor fires (kaingin)	5	ND	4	NA	ND	620,490	**3.102**		**2.482**		
		3	3. Agricultural residue burning (in field)	30	ND	10	NA	ND	4,122,600	**123.678**		**41.226**		
	b		**Fires, waste burning, landfill fires, industrial fires, accidental fires**						**11,928**	**4.740**	**0**	**0.000**	**0**	**4.730**
		1	Landfill fires	1,000	ND	NA	NA	ND		**0.000**				
		2	Accidental fires in houses, factories (per event)	400	ND	See residues	NA	400	11,826	**4.730**				**4.730**
		3	Uncontrolled domestic waste burning	300	ND	See residues	NA	600		**0.000**				**0.000**
		4	Accidental fires in vehicles (per event)	94	ND	See residues	NA	18	101.76	**0.0096**				**0.0018**
		5	Open burning of wood (construction/demolition)	60	ND	ND	NA	10		**0.000**				**0.000**
6	**6**		**Uncontrolled Combustion Processes**						**5,542,477**	**135.458**	**0**	**46.858**	**0**	**4.730**

			Source Categories	Potential Release Route (µg TEQ/t)					Production	Annual release				
Cat.	Subcat.	Class		Air	Water	Land	Products	Residue	t/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
7			**Production of Chemicals, Consumer Goods**							Air	Water	Land	Product	Residues
	a		**Pulp and paper mills**											
			Boilers (per ton of pulp)						0	0.000	0	0	0	0.000
		1	Black liquor boilers, burning of sludges, wood	0.07				1000		0.000				0.000
		2	2. Bark boilers only	0.4				1000		0.000				0.000
			Sludges	Water		Residue			1,262,535		0.600	1,262,535		0.600
				µg TEQ/ADt	pg TEQ/L	µg TEQ/ADt		µg TEQ/t sludge						
		1	Kraft process, old technology (Cl2)	4.5	70	4.5		100	133,225	133,225		0.600		
		2	Kraft process, modern technology (ClO2)	0.06	2	0.2		10				0.000		
		3	TMP pulp									0.000		
		4	Recycling pulp						1,129,310	1,129,310		0.000		
			Pulp and paper	Air	Water	Land	Product	Residue	1,262,535	0	0	0	12.359	0
		1	Kraft pulps/papers from primary fibers, Cl2				8		133,225				1.066	
		2	Sulfite papers, old technology (Cl2)				1						0.000	
		3	Kraft papers, new technology (ClO2, TCF), unbleached papers				0.5						0.000	
		4	Sulfite papers, new technology (ClO2, TCF)				0.1						0.000	
		5	Recycling paper				10		1,129,310				11.293	
	b		**Chemical industry**	Air	Water	Land	Product	Residue						
			PCP						*0*	*0*	*0*	*0*	*0.000*	*0*
		1	European, American production (chlorination of phenol with Cl2)				2,000,000						0.000	
		2	Chinese production (thermolysis of HCH)				800,000						0.000	
		3	PCP-Na				500						0.000	

			Source Categories	Potential Release Route (µg TEQ/t)					Production	Annual release				
Cat	Subcat.	Class		Air	Water	Land	Products	Residue	tion	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
			PCB	Air	Water	Land	Products	Residue	t/a	0	0	0	0.000	0
		1	Low chlorinated, e.g., Clophen A30, Aroclor 1242				15,000							
		2	Medium chlorinated, e.g., Clophen A40, Aroclor 1248				70,000						0.000	
		3	Medium chlorinated, e.g., Clophen A50, Aroclor 1254				300,000						0.000	
		4	High chlorinated, e.g., Clophen A60, Aroclor 1260				1,500,000						0.000	
			Chlorinated Pesticides	Air	Water	Land	Products	Residue	0	0	0	0	0.000	0
		1	2,4,5-Trichlorophenoxy acetic acid				7,000						0.000	
		2	2,4,6-Trichlorophenol				700						0.000	
		3	Dichlorprop				1,000						0.000	
		4	2,4-Dichlorophenoxy acetic acid				700						0.000	
		5	2,4,6-CNP (chloronitrophen)						*0*	*0*	*0*	*0*	*0.000*	*0*
			Old technology				300,000						0.000	
			New technology				400						0.000	
		6	Chlorobenzens				ND	ND						
		7	Chlorine production with graphite anodes				NA	ND						
			Chloranil	Air	Water	Land	Products	Residue	0	0	0	0	0.000	0
		1	*p*-chloranil *via* chlorination of phenol				400,000						0.000	
		2	*p*-chloranil *via* hydrochinone				100						0.000	
		3	Dyestuffs on chloranil basis				1,200						0.000	
		4	*o*-chloranil *via* chlorination of phenol				60,000						0.000	
			ECD/VCM/PVC	Air	Water	Land	Products	Residue	0	0	0	0	0.000	0.000
		1	Old technology, EDC/VCM, PVC		1						0			
		2	Modern plants						*0*	*0*	*0*		*0.000*	*0.000*
			EDC/VCM and/or EDC/VCM/PVC	0.95	0.015		0.03	2		0	0		0	0.000
			PVC only	0.0003	0.03		0.1	0.2		0	0		0.000	0.000

			Source Categories	Potential Release Route (µg TEQ/t)					Production	Annual release				
Sector	Subcat.	Class		Air	Water	Land	Products	Residue	t/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
	c		**Petroleum refineries**	Air	Water	Land	Products	Residue	**18,811,350**	0	0	0	0	0
		1	All types	ND	NA	NA	NA	ND	18,811,350					
	d		**Textile plants**	Air	Water	Land	Products	Residue	**99,659**	0	0	0	**9.9659**	0
		1	Upper limit	NA	ND	NA	100	ND	99,659				**9.9659**	
		2	Lower limit	NA	ND	NA	0.1	ND					**0**	
	e		**Leather plants**	Air	Water	Land	Products	Residue	**55,315**	0	0	0	**55.315**	0
		1	Upper limit	NA	ND	NA	1,000	ND	55,315				**55.315**	
		2	Lower limit	NA	ND	NA	10	ND					**0**	
7			**All Main Sectors**							**0.000**	**0.600**	**0**	**77.640**	**13.323**

			Source Categories	Potential Release Route (µg TEQ/t)					Production	Annual release	Annual release	Annual release	Annual release	Annual release
Sector	Subcat.	Class		Air	Water	Land	Products	Residues	t/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
8			**Miscellaneous**							Air	Water	Land	Products	Residues
	a		**Drying of biomass**						0	0.000	0	0	0.000	0
		1	Clean wood	0.007	NA	ND	0.1	ND		0.000			0.000	
		2	Green fodder	0.1	NA	ND	0.1	ND		0.000			0.000	
		3	PCP- or otherwise treated biomass	10	NA	ND	0.5	ND		0.000			0.000	
	b		**Crematoria**						285	0.026	0.000	0		0.001
		1	No control	90	NA	ND	NA	2.5	285	0.026				0.001
		2	Medium control	10	NA	ND	NA	2.5		0.000				0.000
		3	Optimal control	0.4	NA	ND	NA	2.5		0.000				0.000
	c		**Smoke houses**						33,048	0.198	0	0	0	0
		1	Treated wood, waste fuels used as fuel	50	NA	ND	ND	see wood		0.000				
		2	Clean fuel, no afterburner	6	NA	ND	ND	com-	33,048	0.198				
		3	Clean fuel, afterburner	0.6	NA	ND	ND	bustion		0.000				
	d		**Dry cleaning residues**						0	0	0	0	0	0.000
		1	Heavy textiles, PCP-treated, etc.	NA	NA	NA	NA	3,000						0.000
		2	Normal textiles	NA	NA	NA	NA	50						0.000
	e		**Tobacco smoking**						51,700	0.006	0	0	0	0
		1	Cigar (per item)	0.3	NA	NA	NA	NA	5,170	0.002				
		2	Cigarette (per item)	0.1	Na	NA	NA	NA	46,530	0.005				
8			**Miscellaneous**						85,033	0.230	0	0	0.000	0.001

			Source Categories	Potential Release Route (µg TEQ/t)					Production	Annual release				
Sector	Subcat.	Class		Air	Water	Land	Products	Residues	t/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
9			**Disposal/Landfill**							**Air**	**Water**	**Land**	**Products**	**Residues**
	a		**Landfill leachate**						**541,180**	**0**	**16.484**	**0**	**0**	**0**
		1	Hazardous waste	NA	200	NA	NA		1,460		**0.292**			**0**
		2	Non-hazardous waste	NA	30	NA	NA		539,720		**16.192**		**0**	**0**
	b		**Sewage/sewage treatment**						**0**	**0**	**0.000**	**0**	**0**	**0.000**
		1	Industrial, mixed domestic with chlorine relevance						*0*	*0*	*0.000*	*0*	*0*	*0.000*
			No sludge removal		5	NA	NA	1,000		**0**	**0.000**			**0.000**
			With sludge removal		0.5	NA	NA	1,000		**0**	**0.000**			**0.000**
		2	Urban environments						*0*	*0*	*0.000*	*0*	*0*	*0.000*
			No sludge removal		2	NA	NA	100		**0**	**0.000**			**0.000**
			With sludge removal		0.5	NA	NA	100		**0**	**0.000**			**0.000**
		3	Remote and residential or modern treatment plant		0.5	NA	NA	10		***0***	***0.000***			***0.000***
	c		**Open water dumping**						**534,360**	**0**	**26.718**	**0**	**0**	**0**
			Contaminated waste waters	NA	50	NA	NA	NA	534,360		**26.718**			
			Uncontaminated wastewaters	NA	5	NA	NA	NA			**0.000**			
	d		**Composting**						**0**	**0**	**0**	**0**	**0.000**	**0**
		1	All organic fraction	NA	ND	NA	100	NA					**0.000**	
		2	Garden, kitchen wastes	NA	ND	NA	15	NA					**0.000**	
		3	Green materials,not impacted environments	NA	ND	NA	5	NA					**0.000**	
	e		**Waste oil disposal**						**0**	**0.000**	**0**	**0**	**0**	**0**
		1	All fractions	4	ND	ND	ND	ND		**0.000**				
9			**Disposal/Landfill**						**1,075,540**	**0.000**	**43.202**	**0**	**0.000**	**0**

			Source Categories	Potential Release Route (µg TEQ/t)				
Sector	Subcat.	Class		Air	Water	Land	Products	Residues
10			**Identification of Hot Spots**	x indicates need for site-specific evaluation				
	a		**Production sites of chlorinated organics**					
		1	Chlorophenols and derivatives or PCB		x	x		
		2	Other chlorinated organics			x		
	b		**Production sites of chlorine**					
		1	with graphite electrodes		x	x		
		2	without graphite electrodes		x	x		
	c		**Formulation of chlorinated phenols/pesticides**		x	x		
	d		**Application sites of dioxin-contaminated pesticides**			x		
	e		**Timber manufacture**					
		1	Using pentachlorophenol, other dioxin-containing preservatives		x	x		
		2	No use of PCP, not open to the environment		x	x		
	f		**PCB containing equipment**					
		1	Leaching		x	x		
		2	Not leaching		x	x		
	g		**Dumps of waste/residues from categories 1-9**		x	x		
	h		**Sites of relevant accidents**		x	x		
	g		**Dredging of sediments**		x	x		

MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT
VIET NAM ENVIRONMENTAL PROTECTION AGENCY

FINAL REPORT INVENTORY ON DIOXIN AND FURAN RELEASES IN VIET NAM

Hanoi, 2003

Vietnam 2002
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I BACKGROUND

Vietnam is a coastal nation in the South East Asian region. It has an area of around 331,000 km^2 where is home to 78.4 million inhabitants. The country lies within a hot and humid tropical climate zone and as a result, the weather pattern varies from province to others across the country. In summer, the average temperature is above 25°C, while it falls down to 15°C in winter.

Since the introduction of its economic renovation (*Doi Moi*) by the Government of Vietnam during the 1980s of the last century, many significant achievements have been made in the growth of the national economy. GDP has doubled during the last ten years, and to which a share of agriculture has dropped from 38.7% to 24.3%; while the industry has increased to 36.6% from 22.7%; and the service has increased to 39.1% from 38.6%.

Along with economic development, environmental pollution issues have tended to be increased. These include agricultural pollution caused by residues of chemical pesticides and fertilizers; pollution due to wastes discharged from industrial production activities, especially hazardous wastes generated from chemical, electronic, oil and gas industries that are being strongly developed in Vietnam.

In the last years, the Government of Vietnam has issued a large number of new policies to ensure environmental protection and sustainable development. Vietnam has acceded to many international environmental treaties in tandem with its economic integration, and committed its international obligations to preserve the Earth - a common home to the humanity.

On 23 May 2001, Vietnam together with other nations and international organizations signed the Convention on Persistent Organic Pollutants (POP or Stockholm Convention). Then, Vietnam officially ratified the Convention on 22 July 2002 and became the 13th State Party among 30 nations who have ratified the Convention, and committed to limit and phase out the production and use of POPs that cause potential damages to environmental and human health.

To support Vietnam's environmental protection by developing relevant measures to effectively manage dioxin and furan by-products (that are subject to the Convention) released from production processes, and to help Vietnam enable to prepare its necessary conditions on the other hand, to participate in the Stockholm Convention when it becomes effect, UNEP Chemicals has provided Vietnam with relevant methods to establish national dioxin and furan release inventories since 2002.

Having carried out the inventories under the guidance of UNEP Chemicals, Viet Nam Environmental Protection Agency (VEPA) has received initial inventory results submitted by provinces and cities. Synchronously, VEPA has launched several field surveys in various to update collected information and data, and then synthesized and prepared a national initial report on dioxin and furan release inventories in Vietnam. This report aims to:

- Synthesize and assess the existing dioxin and furan release sources in the country;
- Initially identify quantities of dioxin and furan released from different sources according to the Guidance of UNEP Chemicals; and

- Support Vietnamese policy-makers in the development of relevant national plans to respond to POPs with the goal of complying with the Party's obligations to the Stockholm Convention.

II METHODS AND STEPS TO CARRY OUT DIOXIN AND FURAN INVENTORIES IN VIETNAM

To facilitate the establishment of dioxin and furan release inventories nationwide; UNEP Chemicals' technical publication " Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases" was translated into Vietnamese. A national workshop on the introduction of methods to establish the inventories was organized for local managers from 61 provinces/cities. Dr. Heidelore Fiedler, a scientific affairs officer of UNEP Chemicals participated and introduced necessary steps to establish dioxin and furan release inventories at the workshop.

Participants to the workshop include representatives from departments of Science, Technology & Environment, Industry, and Health from 61 provinces and cities across the country. The workshop was organized in two days in Hanoi from 11-12 December 2001. The participants received hard copies and soft disks of relevant tables for the inventories in both Vietnamese and English versions.

Following the workshop, the former Ministry of Science, Technology and the Environment (MoSTE) issued and circulated its official letter 199/BKHCNMTg dated 23 January 2002 among line ministries and provincial/city People's Committees throughout the country, requesting their budget allocations (VND 100 million each in average) for establishing dioxin and furan release source inventories in respective provincial territories and reporting under the report format of UNEP Chemicals to MoSTE. To facilitate the provincial level dioxin and furan release source inventories, MoSTE also provided relevant consultations and responses to inquiries raised by them.

Therefore, the provincial-level dioxin and furan release source inventories were carried out from February to December 2002, and the inventory reports were submitted to the former National Environment Agency (NEA) for synthesis. The initial results gained from provincial/city dioxin and furan release source inventories were synthesized by NEA in compliance with the format of report provided from UNEP Chemicals' publication " Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases" in 2002. In this report, those release source categories which are not available in Vietnam are excluded.

III SUMMARIES OF DIOXIN AND FURAN RELEASE INVENTORIES

III.1 Waste Incineration

According to " Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases", waste incineration should be divided into sub-categories by different types of wastes. It is noticed that there are few incinerators being under operation in Vietnam. At present, there are two incinerators with a moderate capacity just installed in Hanoi and Ho-Chi-Minh City to provide the treatment of municipal solid wastes and part of medical wastes. Most of domestic solid wastes are sent to landfills for disposal, leading to over-load landfills facing many provinces. Vietnam has embarked upon the planning and construction of sanitary landfills for solid waste disposal in provinces. A small part of these solid wastes has been openly burned at sources without any devices/burners.

III.1.1 Incineration of Domestic Solid Wastes

Domestic solid wastes are primarily disposed at landfills. The very small amount is currently incinerated mainly in Hanoi and Ho-Chi-Minh City. Thus, this sub-category releases not any significant amount of dioxin and furan into the environment.

III.1.2 Incineration of Hazardous Wastes

Estimates by the Asian Development Bank predict that Vietnam's hazardous waste generation accounted for around 547,000 tonnes in 2000 and this figure would increase to 813,000 tonnes by 2005. It is thus anticipated that amount of hazardous wastes generated in Vietnam tends to be increasingly growing. Most of hazardous wastes generated from industrial production are primarily disposed at landfills. Because, there is no waste separation at sources, most of hazardous wastes generated from domestic activities are treated together with other general domestic waste streams at open dumps. Currently, Vietnam is planned to treat some sorts of hazardous wastes by using cement kilns. These hazardous wastes are being stored pending for treatment. Because of that there is no source of dioxin and furan releases from this sub-category.

III.1.3 Incineration of Medical Hazardous Wastes

Previously, medical wastes were collected and pre-treated through sterilization before being disposed at landfills. Currently, 25 small and medium capacity Belgium incinerators are being constructed at 25 provincial hospitals in Vietnam within the framework of the Austrian ODA funded project. Medical wastes are destroyed locally at hospitals by the existing incinerators, which are the type with two combustion chambers and a simple air control, and treatment system that can maintain a temperature above 1.000^{o}C. However, because of small amounts of medical waste, they are operated discontinuously and primarily by batch.

Results of the inventories indicate that an annual dioxin and furan release to air accounts for approximately 2,602 kg TEQ/year. And the annual residues in fly ash and bottom ash are as low as 0.146 g TEQ and 0.017 g TEQ, respectively.

III.1.4 Incineration of Light-Fraction Shredder Wastes

This light-fraction shredder waste is very small in terms of volume generated in Vietnam. The primary waste is scrap cotton that is usually burned in open places in rural areas. The total dioxin and furan release to air accounts for around 0.001 g TEQ.

III.1.5 Incineration of Sewage Sludge

Sludge collected from wastewater treatment plants is primarily disposed of at landfills. As a result, there is a very small amount of sludge incinerated, which includes sludge generated from oil and gas production and exploitation activities. There are no dioxin and furan releases to air from this sub-category.

III.1.6 Incineration of Waste Wood and Waste Biomass

Wastes under this sub-category are primarily generated from wood and wood processing industries. These are usually burned in open places. Dioxin and furan releases to air and in residues in fly ash annually account for 0.162 g TEQ and 0.162 g TEQ respectively.

III.1.7 Incineration of Animal Carcasses

The incineration of animal carcasses is rarely applied, and thus the amount of animal carcasses burnt is very low in Vietnam. As the result, dioxin and furan release under this sub-category is as low as around 0.158 g TEQ per year.

In summary, the total dioxin and furan releases to air and in residues by the incineration and/or combustion of all the sub-categories are 3.36 g TEQ and 0.82 g TEQ per year respectively.

III.2 Ferrous and Non-ferrous Metal Production

In Vietnam, major metal production sectors are iron and steel industries primarily. However, due to lack of investments these industries are less developed, and still operate old and obsolete production technologies. Thus dioxin and furan releases in this category are very low. The total releases to air and in residues annually account for 1.10 g TEQ and 2.64 g TEQ respectively. The detailed releases by specific sub-categories are presented below:

III.2.1 Iron Ore Sintering

Most of iron ore sintering plants are located in Thai Nguyen province, and their annual production is not large. As a result, their dioxin and furan releases to air are as low as around 0.050 g TEQ.

III.2.2 Coke Production

Vietnam's coke production annually accounts for approximately 7000 tonnes. While its dioxin and furan releases to air are 0.021 g TEQ yearly, the release to water is not significantly found.

III.2.3 Steel Production Plants and Steel Furnaces

The steel production sub-category is a major contributor to dioxin and furan releases. The total amount of dioxin and furan releases to air from this sub-category is 0.241 g TEQ annually while the total amount releases from foundries only accounts for 0.3 g TEQ.

III.2.4 Copper Production

In this sub-category, dioxin and furan releases are primarily produced from secondary copper production lines. The total annual amounts of dioxin and furan releases to air and in residues from the secondary copper production are 0.360 g TEQ, and 0.3 g TEQ respectively.

III.2.5 Aluminium Production

In the aluminium production industry, dioxin and furan releases to air are mainly from the thermal processing of scrap aluminium that treats and removes contaminated oil and simple dust from the scrap materials. Its emission factor accounts for 0.189 g TEQ. But much more releases of dioxin and furan in residues occur in the thermal processing of aluminium, well-controlled treatment of scrap aluminium, and purification with limestone spraying. The annual release in residues accounts for 1.89 g TEQ.

III.2.6 Lead Production

Dioxin and furan releases from the lead production primarily come from the recovery of scrap materials from PVC separators in vehicle batteries. In this sub-category, the quantity of dioxin and furan releases to air is 0.032 g TEQ/year.

III.2.7 Zinc Production

A very low quantity of dioxin releases is found, and mainly comes from furnaces without dust control. Its quantity of the releases to air is 0.107 g TEQ/year.

III.2.8 Other Metal Production

The quantity of dioxin and furan emissions is very low and even not identified.

III.2.9 Metal Shredding

The metal shredding annually may produce dioxin and furan releases, but with a small quantity of 0.008 g TEQ.

III.2.10 Thermal Wire Reclamation

Burning of cable in open places becomes a potential source of dioxin and furan emissions. Available statistics indicate that the quantity of dioxin and furan releases to air is about 0.054 g TEQ.

III.3 Power Generation and Heating

III.3.1 Fossil Fuel Burned Power Plants

Vietnam's power consumption heavily relies on hydropower electric generation sources, and as a result, its fossil fuel burned power generation plants are fewer. The quantities of dioxin and furan releases to air and in residues from this sub-category annually account for 0.812 g TEQ and 0.1 g TEQ respectively.

III.3.2 Biomass Burned Power Plants

The quantity of dioxin and furan emissions to air is 0.121 g TEQ/year.

III.3.3 Landfill and Biogas Combustion

Gases generated from landfills and digesters are usually recovered to produce energy. The quantity of dioxin and furan releases to air accounts for 0.054 g TEQ/year.

III.3.4 (Biomass Combustion) for Household Heating and Cooking

In Vietnam, biomass includes scrap wood; straws and other biomass materials are commonly used as fuels for cooking. Available statistics show that the quantities of dioxin and furan releases to air and in residues account for 3.548 g TEQ/year and 0.7 g TEQ/year respectively.

III.3.5 Fossil Fuel Based Domestic Heating

While in Southern Vietnam it is warm all the year round, it is cold in Northern provinces, especially mountainous areas where mixed coal and mud burned stoves are dominantly used for both cooking and heating. As a result, the quantities of dioxin and furan releases in residues and to air are as relatively high as 41.6 g TEQ/year and 0.589 g TEQ/year respectively.

In summary, the total quantity of dioxin and furan releases under this category 3 accounts for 5.12 g TEQ/year to air, and 42.51 g TEQ/year in residues.

III.4 Mineral Production

III.4.1 Cement Kilns

Cement production is a relatively well developed industry in Vietnam, and this industry currently operates different types of cement kilns. In accordance with provincial reports on the inventories, total quantities of dioxin and furan releases to air and in residues are 0.635 g TEQ/year and 0.043 g TEQ/year respectively.

III.4.2 Lime Production

Lime is a product produced in a large amount in Vietnam. Lime is mainly made by using manual kilns without dust and gas control. The total quantity of dioxin and furan emissions to air is 0.596 g TEQ/year.

III.4.3 Brick Production

In Vietnam, bricks are mainly produced by a large number of manual and small sized brick kilns. This is the manual production sub-category that potentially pollutes the environment with its emissions from the burning process. The total quantity of dioxin and furan emissions to air accounts for 0.722 g TEQ/year.

III.4.4 Glass Production

The glass production in Vietnam mostly operates small sized and manual furnaces without dust and emission control. As a result, the total quantity of dioxin and furan emissions to air is 0.02 g TEQ/year.

III.4.5 Ceramics Production

Ceramic articles are one of Vietnamese handicraft products well known and preferred by many foreign markets in the world. However, this manually manufacturing sector seriously pollutes the air environment and this has been attributed to rudimentary kilns currently being operational. The total quantity of dioxin and furan emissions to air accounts for 0.113 g TEQ/year.

III.4.6 Asphalt Mixing

The quantity of dioxin and furan releases from the asphalt mixing is 0.094 g TEQ/year, and this is resulted from the operation of mixing equipment without gas purifiers (0.081 g TEQ/year). The dioxin and furan releases in residues are 0.113 g TEQ/year.

In summary, the total quantity of dioxin and furan emissions from the category 4 is 2.18 g TEQ/year to air and 0.16 g TEQ/year in residues.

III.5 Transport

Vietnam has banned the import of leaded gasoline and phased out its use since the first of July 2001. This means that there remains a limited volume of leaded gasoline imported previously. Our estimates of total dioxin and furan releases in this category below have been made on the basis of unleaded gasoline without catalyst. The total quantity of dioxin and furan emissions to air is 0.98 g TEQ/year for this category.

III.5.1 Four Stroke Engines

Motorcycles are dominantly a means of transport in Vietnam. In response to increase in the fleet of motorcycles, the Government of Vietnam has embarked upon the development of relevant policies to limit such an accelerated growth of the fleet. The quantity of dioxin and furan emissions to air from this type of engines is 0.094 g TEQ/year.

III.5.2 Two Stroke Engines

The quantity of dioxin and furan emissions to air from this type of engines is 0.294 g TEQ/year.

III.5.3 Diesel Engines

A fleet of diesel powered vehicles including around ten million is currently running in Vietnam, and the total quantity of dioxin and furan emissions to air from this type of engines is 0.539 g TEQ/year.

III.5.4 Heavy Oil Fired Engines

This type of engines is rarely found in Vietnam, and as a result, the total quantity of dioxin and furan emissions to air is as the lowest as 0.053 g TEQ/year.

III.6 Uncontrolled Combustion Processes

III.6.1 Biomass Burning

This category of biomass burning is primarily due to forest fires in Vietnam. Risk of forest fires has tended to be increased in dry season, particularly in southern provinces. The frequency of forest fire occurrence also increases year by year in the country. In addition, because of farming practices traditionally applied by mountainous people, a large amount of vegetation in farming fields is also burned. As a result, the factor of dioxin and furan emissions to air caused by burning of straws and forest fires is 2.691 g TEQ/year. And the quantity of dioxin and furan releases in residues caused by the burning is 1.053 g TEQ/year.

III.6.2 Waste Burning and Accidental Fires

This category is not easy to establish inventories as such the burning and fires occur quickly and in small scales. Provincial estimates synthesized indicate that dioxin and furan releases to air and in residues are 0.272 g TEQ/year and 0.516 g TEQ/year respectively.

In summary, total dioxin and furan emissions are 2.963 g TEQ/year to air, 1.053 g TEQ/year to land, and 0.516 g TEQ/year in residues in this category 6.

III.7 Production and Use of Chemicals and Consumer Goods

III.7.1 Pulp and Paper Mills

As Vietnam paper industry mainly relies on pulp imported for its paper production and therefore, very less pulping is taken place in the country. Following are results obtained from inventories of the releases according to the sub-categories of UNEP Chemicals.

a. From boilers: mainly from burning of black liquor, sludge and wood, and the total quantity of dioxin and furan releases in residue accounts for 0.830 g TEQ/year.

b. Wastes, pulp and paper sludge: total quantities of dioxin and furan releases to water and in residues account for 0.002 g TEQ/year and 0.082 g TEQ/year respectively.

c. Pulp and paper products: mainly concentrate in the products, and the total quantity of dioxin and furan releases in product accounts for 0.420 g TEQ/year.

III.7.2 Chemical Industry

PCB containing oils/greases are not produced in Vietnam and there are no chemical industries that produce PCP and PCB.

Chlorinated pesticides are of a release in products is 0.198 g TEQ/year.

EDC/VMC/PVC: PVC is not produced in Vietnam, and as a result finished PVC is primarily imported as raw materials to its production. Because of that, there is no dioxin and furan release at all.

III.7.3 Textile and Garment Plants

Textile and garment industry is well developed in Vietnam. The quantity of dioxin and furan releases in products accounts for 0.018 g TEQ/year.

III.7.4 Leather Plants

Leather production industry is not well developed in Vietnam and as a result, the quantity of dioxin and furan releases in products accounts for 0.320 g TEQ/year.

In summary, in this category, the emissions of dioxin and furan to air are not significant while the release to water is 0.002 g TEQ/year. A small concentration of dioxin and furan is also found in products (1.957 g TEQ/year) and a release of dioxin and furan in residue accounts for 0.912 g TEQ/year.

III.8 Other Processes

III.8.1 Drying of Biomass

The total dioxin and furan releases to air and in products account for 0.099 g TEQ/year and 0.066 g TEQ/year respectively in this sub-category.

III.8.2 Crematoria

The total dioxin and furan releases to air and in residues account for 0.005 g TEQ/year and 0.001 g TEQ/year respectively.

III.8.3 Smoke Houses (for Preserving Foods)

The total dioxin and furan releases to air account for 0.152 g TEQ/year.

In this category 8, the total dioxin and furan releases to air, and in products and residues account for 0.257 g TEQ/year, 0.066 g TEQ/year and 0.001 g TEQ/year respectively.

III.9 Disposal/Landfill

III.9.1 Leachate at landfills

The total dioxin and furan releases to water is 0.676 g TEQ/year

III.9.2 Sewage/ Sewage Treatment

The total dioxin and furan releases to water and in residues account for 0.002 g TEQ/year and 0.606 g TEQ/year respectively.

III.9.3 Untreated Wastewater Discharges

The total dioxin and furan releases to water is 0.775 g TEQ/year

III.9.4 Composting

The total dioxin and furan releases in products account for 0.162 g TEQ/year.

III.9.5 Waste Oil Disposal (Non-Thermal)

The total dioxin and furan releases to air are 0.001 g TEQ/year.

In summary, in this category the total dioxin and furan releases to air and water and in products and residues are 0.001 g TEQ/year, 1.453 g TEQ/year, 0.162 g TEQ/year, and 0.606 g TEQ/year respectively.

III.10 Identified Hot Spots

III.10.1 Chlorinated Organic Production Sites

No products of chlorinated organics are produced in Vietnam

III.10.2 Chlorine Production Sites

No products of chlorine are produced in Vietnam

III.10.3 Chlorinated Phenol Formulation Sites

Chlorinated phenols are mainly formulated into pesticides through the bottling and packaging processes. These bottling and packaging activities are usually taken place in pesticides production plants. However, inventories have just been launched over 26 obsolete pesticides storehouses that require urgent treatments due to their serious contamination. Other pesticides production sites and storage where inventories have not yet been taken, and as a result no data are available for these hot spots relating to dioxin contamination.

III.10.4 Chlorinated Phenol Application Sites

Chlorinated phenols are used under the form of formulated compounds mainly as insecticides, herbicides (2,4-D) for agricultural application. We have been unable to identify where pesticides have been over-applied and/or risks of pesticides contamination have been imposed on land. This can be attributable to financial constraints. In the future, it is expected that Vietnam in cooperation with international organizations and experts, would enable to identify and zone hot spots where are contaminated with pesticides applied for agriculture, as well as predict potential pollution, and develop and adopt relevant national policies and plans for pollution mitigation and treatment and food safety.

III.10.5 Timber Manufacture and Treatment Sites

In Vietnam there are a number of craft villages where wooden handicrafts are produced. Environmental pollution caused by timber pre-processing processes has become an urgent concern in the country. However, there has not been any specific research or assessment of possible dioxin and furan emissions carried out so far in these craft villages.

III.10.6 PCB- Transformers and Capacitors

Vietnam has used multiple transformers and capacitors made in the former Soviet Union, and as the result, the volume of PCB containing oils in this category is large. A separate report on PCB containing oils will be produced, as the inventories are being on-going nationwide. While the number of PCB related hot spots has not yet been identified in the country but due attention has been paid to hot spots, namely power plants and transformer stations where leakage of PCB containing oils are likely to occur in production, transport and storage activities.

III.10.7 Dumps of Wastes/Residues from Categories 1-9

In Vietnam, dumps of wastes are sites where mixed wastes are disposed of and because of that it is very difficult to identify where PCDD/PCDF containing wastes or products have been disposed of. However, it is determined that potential risks of environmental pollution imposed by these wastes or products exist and need to be identified.

III.10.8 Sites of Relevant Accidents

Few large fires have been occurred in Vietnam. In 2002, there was the largest fire occurred in a six-story trade building in Ho-Chi-Minh City. However, because of various constraints we were unable to identify dioxin and furan emissions from the accident.

III.10.9 Dredging of Sediments and Sludge

Dredging of sediments is frequently taken place in canals, rivers and harbours in the country. There is not any analysis launched to quantify concentrations of PCDD/PCDF contained in sediments dredged from these streams in Vietnam, and therefore there is no data available and warning of environmental pollution caused by potential PCDD/PCDF containing sediments.

III.10.10 Kaolinitic or Ball Clay Sites

Due to limited knowledge and financial capacities, analysis of PCDD/PCDF concentrations in kaolinitic and/or ball clays in Vietnam.

III.10.11 Typical PCDD/PCDF Hot Spots

Unlike other countries in South East Asia and in the world, Vietnam has suffered a chemical welfare launched by the USA from 1961 to 1972. A total amount of herbicides sprayed over southern Vietnam during this period was from 72 million liters (Westing) to 100 million liters (Stellman), corresponding to between 170kg of dioxins (as estimated by American scientists, Westing) and around 540kg of dioxins (as estimated by Russian scientists, Phokin). Given a half-life of dioxins that takes ten years, there was an amount of 23 kg of dioxins remained in southern Vietnam in 2002. Analysis of dioxin residues in both the environment and human bodies indicate high levels in southern Vietnam, and even higher than those in such industrially developed countries as USA, Canada and Australia (A. Schecter et al.). We have initially identified heavily PCDD/PCDF contaminated sites with dioxin concentrations raised up millions ppt, in most of closed American military airports, namely Bien Hoa, Da Nang and Phu Cat that need to be cleaned up. In addition, dioxin concentrations at 48 sites where toxic chemicals were released from the crashed aircraft during their spraying operations have not been identified.

IV COMMENTS ON INVENTORY RESULTS

In summary, the total quantities of dioxin and furan releases of the nine categories are 15.97 g TEQ/year to air, 1.46 g TEQ/year to water, 1.05 g TEQ/year to land, 2.19 g TEQ/year in products, and 48.16 g TEQ/year in residues.

However, these results need to have further reviews and discussions about the emission factors of some categories. It seems that the emission factors are appropriate to industrially developed countries but are very high for developing countries. For example, the emission factors of the category 1 – *Incineration of Wastes* - (3,500 µg TEQ/t for domestic waste, 35,000µg TEQ/t for hazardous waste and 40,000 µg TEQ/t for medical waste) are very high for developing countries where these types of wastes are predominantly destroyed by applying low technology incinerators with simple air control system.

Moreover, because the economy of developing countries primarily depends on agriculture but not industry that is commonly less developed, waste compositions may vary from one country to another. Since most of wastes are disposed of at unsanitary landfills, and burned in open places or with low technology, we are afraid that the factors proposed by UNEP Chemicals are irrational. In reality, many analytical evidence are documented to demonstrate that dioxin concentrations in human body samples in developing countries are very low and many time lower than those in developed countries. In some cases, the concentrations are even not identified.

With these justifications, it is afraid that the results of dioxin and furan release inventories in developing countries may be higher than the actual levels.

V CONCLUSIONS AND RECOMMENDATIONS

The Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases published by UNEP Chemicals proves very useful and helps us enable to understand and identify potential sources of dioxin and furan releases within the economic development setting. In addition, the Toolkit also helps us draw up a full picture of potential pollution and risks that dioxin and furan by-products may cause to, and impose on, local human communities during the country's economic development process.

The national workshop with inputs contributed by UNEP Chemicals consultants has been viewed as a scientifically significant event. From this, local managers at all levels have benefited relevant and basic knowledge in dioxin and furan, and especially skills in the identification of potential sources of dioxin and furan releases in economic development activities, and the prediction of threats to environmental pollution and community health imposed by these by-products.

Major sources of dioxin and furan releases presented in this report are to air and in residues. For other sources, the total dioxin and furan releases are insignificant. All the results obtained may serve as a tool to help the Government of Vietnam, particularly Vietnamese policy-makers enable to develop and implement relevant policies, plans, and resolutions to effectively manage and control dioxins and furans in particular, and POPs in general.

We highly appreciate a close coordination and technical assistance timely provided by UNEP Chemicals for their exchange of relevant information, clear and specific introduction of relevant knowledge and experiences in dioxin and furan release inventories and quantification in other countries. It is our hope that further assistance will be provided by UNEP Chemicals for Vietnam to help it enable to develop a national action plan of POPs, to build national capacities to effectively manage and control dioxin and furan release sources, as well as to identify, analyze and assess the hot spots, and predict potential risks of environmental pollution imposed by these pollutants. UNEP Chemicals also needs to provide developing countries with more technical and financial assistance to remediate and /or clean up these hot spots and help them enable to implement their international obligations to the Convention on POPs.

VI ANNEXES

VI.1 Tables

Table 1: Summary of national releases of dioxins and furans

	Source Categories	Annual Releases (g TEQ/a)					
Cat.		Air	Water	Land	Product	Residue	**All media**
1	Waste Incineration	3.36	0.00	0.00	0.00	0.82	**4.18**
2	Ferrous and Non-Ferrous Metal Production	1.10	0.00	0.00	0.00	2.64	**3.73**
3	Power Generation and Heating	5.12	0.00	0.00	0.00	42.51	**47.64**
4	Production of Mineral Products	2.18	0.00	0.00	0.00	0.16	**2.34**
5	Transportation	0.98	0.00	0.00	0.00	0.00	**0.98**
6	Uncontrolled Combustion Processes	2.96	0.00	1.05	0.00	0.52	**4.53**
7	Production of Chemicals and Consumer Goods	0.00	0.00	0.00	1.96	0.91	**2.87**
8	Miscellaneous	0.26	0.00	0.00	0.07	0.00	**0.32**
9	Disposal/Landfilling	0.00	1.45	0.00	0.16	0.61	**2.22**
10	Identification of Potential Hot-Spots						
1-9	Total	**15.97**	**1.46**	**1.05**	**2.19**	**48.16**	**68.82**

Table 2: Dioxin and furan releases of Waste Incineration

Subcat.	**Source categories**	**Production t/a**	**Annual release (g TEQ/a)**					
	Waste Incineration		Air	Water	Land	Product	Fly ash	Bottom ash
a	Municipal solid waste incineration	1.124	0.170	0	0	0	0.350	0.011
b	Hazardous waste incineration	84	0.272	0	0	0	0.132	0.0
c	Medical/hospital waste incineration	1.234	2.602	0	0	0	0.146	0.017
d	Light fraction shredder waste incineration	13	0.001	0	0	0	0.0	0.0
e	Sewage sludge incineration	0	0.0	0	0	0	0.0	0.0
f	Waste wood and waste biomass incineration	16,235	0.162	0	0	0	0.162	0.0
g	Animal carcasses burning	315	0.158	0	0	0	0.0	0.0
	Waste Incineration	**19.004**	**3.364**	**0**	**0**	**0**	**0.790**	**0.028**

Table 3: Dioxin and furan releases of Ferrous and Non-Ferrous Metal Production

Subcat	**Source categories**	**Product-ion t/a**	**Annual release (g TEQ/a)**				
	Ferrous and Non-Ferrous Metal Production		**Air**	**Water**	**Land**	**Product**	**Residue**
a	Iron ore sintering	4,390	0.050	0	0	0	0.0
b	Coke production	7,002	0.021	0.0	0	0	0
c	Iron and steel production plants and foundries	89,090	0.247	0.0	0.0	0.0	0.459
	Iron and steel plants						
	Foundries	1,960	0.020	0	0	0	0.0
d	Copper production	981	0.360	0.0	0.0	0.0	0.3
e	Aluminium production (all sec.)	4,725	0.189	0	0	0	1.890
f	Lead production	6,865	0.032	0	0	0	0
g	Zinc production	467	0.107	0	0	0	0
h	Brass production	100	0.0	0	0	0	0
I	Magnesium production	0	0.0	0.0	0	0	0.0
j	Thermal Non-ferrous metal production (e.g., Ni)	561	0.008	0	0	0	0
l	Shredders	38,838	0.008	0	0	0	0
m	Thermal wire reclamation	4,111	0.054	0	0	0	0
	Ferrous and Non-Ferrous Metal Production	**159,090**	**1.095**	**0.0**	**0.0**	**0.0**	**2.635**

Table 4: Dioxin and furan releases of Power Generation and Heating

Sub cat.	Source categories	Production TJ/a	Annual release (g TEQ/a)				
	Power Generation and Heating		Air	Water	Land	Product	Residue
A	Fossil fuel power plants	416,318	0.812	0	0	0	0.1
B	Biomass Power Plants	1,751	0.121	0	0	0	0.0
C	Landfill and biogas combustion	6,780	0.054	0	0	0	0.0
D	Household heating and cooking - Biomass	35,337	3.548	0	0	0	0.7
E	Domestic heating - Fossil fuels	9,619	0.589	0	0	0	41.6
	Power Generation and Heating	**469,805**	**5.124**	**0**	**0**	**0**	**42.5**

Table 5: Dioxin and furan releases of Production of Mineral Products

Subcat.	Source categories	Production t/a	Annual release (g TEQ/a)				
	Production of Mineral Products		**Air**	**Water**	**Land**	**Product**	**Residue**
a	Cement kilns	3,166,106	0.635	0	0	0	0.043
b	Lime	214,447	0.596	0	0	0	0
c	Brick	5,768,388	0.722	0	0	0	0
d	Glass	136,701	0.020	0	0	0	0
e	Ceramics	682,598	0.113	0	0	0	0
f	Asphalt mixing	3,043,580	0.094	0	0	0	0.113
	Production of Mineral Products	**13,011,819**	**2,181**	**0**	**0**	**0**	**0.156**

Table 6: Dioxin and furan releases of Transport

Subcat.	Source categories	Consumption t/a	Annual release (g TEQ/a)				
	Transport		**Air**	**Water**	**Land**	**Product**	**Residue**
a	**4-Stroke engines**	682,573	0.094	0	0	0	0
b	**2-Stroke engines**	116,931	0.294		0	0	0
c	**Diesel engines**	10.775,192	0.539	0	0	0	0
d	**Heavy oil fired engines**	13,290	0.053	0	0	0	0
	Transport	**11,587,986**	**0.979**	**0**	**0**	**0**	**0**

Table 7: Dioxin and furan releases of Uncontrolled Combustion Processes

Subcat.	Source categories	Production t/a	Annual release (g TEQ/a)				
	Uncontrolled Combustion Processes		**Air**	**Water**	**Land**	**Product**	**Residue**
a	Fires/burnings - biomass	145,526	2.691	0	1.053	0	0
b	Fires, waste burning, landfill fires, industrial fires, accidental fires	84,922	0.272	0	0.0	0	0.516
6	**Uncontrolled Combustion Processes**	**230.448**	**2.963**	**0**	**1.053**	**0**	**0.516**

Table 8: Dioxin and furan releases of Production of Chemicals, Consumer Goods

Subcat.	Source categories	Product-ion t/a	Annual release (g TEQ/a)				
	Production of Chemicals, Consumer Goods		**Air**	**Water**	**Land**	**Product**	**Residue**
a	Pulp and paper mills						
	Boilers (per ton of pulp)	830	0.0	0	0	0	0.830
	Sludges	5,480		0.002			0.082
	Pulp and paper	139,913	0	0	0	0.420	0
b	Chemical industry						
	PCP	0	*0*	*0*	*0*	*0.0*	*0*
	PCB	0	0	0	0	0.0	0
	Chlorinated Pesticides	496	0	0	0	0.198	0
	Chloranil	0	0	0	0	0.0	0
	ECD/VCM/PVC	0	0	0	0	0.0	0.0
c	Petroleum refineries	0	0	0	0	0	0
d	Textile plants	115,177	0	0	0	1.018	0
e	Leather plants	320	0	0	0	0.320	0
	Production of Chemicals, Consumer Goods	262,215.6	**0.0**	**0.002**	**0.0**	**1.957**	**0.912**

Table 9: Dioxin and furan releases of Miscellaneous

Subcat.	Source categories	Production t/a	Annual release (g TEQ/a)				
	Miscellaneous		**Air**	**Water**	**Land**	**Product**	**Residue**
a	Drying of biomass	638,475	0.099	0	0	0.066	0
b	Crematoria	243	0.005	0.0	0		0.001
c	Smoke houses	22,840	0.152	0	0	0	0
d	Dry cleaning residues	0	0	0	0	0	0.0
e	Tobacco smoking	1,918	0.0	0	0	0	0
	Miscellaneous	**663,476**	**0.257**	**0**	**0**	**0.066**	**0.001**

Table 10: Dioxin and furan releases of Disposal/Landfill

Subcat.	Source categories	Product-ion t/a	Annual release (g TEQ/a)				
	Disposal/Landfill		**Air**	**Water**	**Land**	**Product**	**Residue**
A	Landfill leachate	22,529	0	0.676	0	0	0
B	Sewage/sewage treatment	4,530	0	0.002	0	0	0.606
C	Open water dumping	141,551	0	0.775	0	0	0
D	Composting	18,082	0	0	0	0.162	0
e	Waste oil disposal	336	0.001	0	0	0	0
	Disposal/Landfill	**187,029**	**0.001**	**1.453**	**0**	**0.162**	**0.606**

Table 11: Identification of Hot Spots

Subcat.	Source categories	Potential Release Route (µg TEQ/t)				
		Air	**Water**	**Land**	**Product**	**Residue**
	Identification of Hot Spots					
a	Production sites of chlorinated organics					
b	Production sites of chlorine					
c	Formulation of chlorinated phenols/pesticides					
d	Application sites of dioxin-contaminated pesticides		X	X		
e	Timber manufacture					
f	PCB containing equipment					
g	Dumps of waste/residues from categories 1-9					
h	Sites of relevant accidents					
g	Dredging of sediments					

VI.2 EXEL files

	Source Categories	Annual Releases (g TEQ/a)				
Cat.		Air	Water	Land	Product	Residue
1	Waste Incineration	3.364	0.0	0.0	0.0	0.8
2	Ferrous and Non-Ferrous Metal Production	1.095	0.0	0.0	0.0	2.6
3	Power Generation and Heating	5.124	0.0	0.0	0.0	42.5
4	Production of Mineral Products	2.181	0.0	0.0	0.0	0.2
5	Transportation	0.979	0.0	0.0	0.0	0.0
6	Uncontrolled Combustion Processes	2.963	0.0	1.053	0.0	0.5
7	Production of Chemicals and Consumer Goods	0.0	0.002	0.0	1.957	0.9
8	Miscellaneous	0.257	0.0	0.0	0.066	0.0
9	Disposal/Landfilling	0.001	1.453	0.0	0.162	0.6
10	Identification of Potential Hot-Spots					
1-9	**Total**	**15.97**	**1.46**	**1.05**	**2.19**	**48.16**