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* National Reports are annexed to this report

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SUMMARY

1 INTRODUCTION

Introduction

The coastal zone of the Red Sea and Gulf of Aden (RSGA) has witnessed a rapid economic and tourism growth in the past three decades, which led to changes in the structure and dynamics of the communities live or tend to frequenting these areas, which in turn led to many environmental effects of human activities, increasing threat posed by pollutants resulting from these activities since the sea is the final destination for these pollutants.

Several coastal investment projects in the countries of the region are planned, especially in the petroleum and petrochemical industries. This rapid industrial development, accompanied by an increase in the use of raw materials and chemicals besides energy consumption, will create high pollution rate hotspots, not to mention the increased risk caused by the spread and accumulation of pollutants in the marine environment.

Four PERSGA countries (Egypt, Jordan, Sudan and Yemen) have ratified Stockholm Convention and concluded in the NIP development process that the reduction or elimination of POPs is a respective national priority and that they are committed to take appropriate actions towards the reduction of the releases of unintentionally produced persistent organic pollutants (UP-POPs). Due to the trans-boundary movement of POPs and the special nature of the coastal zone of the Red Sea and Gulf of Aden, it is of importance to take preventive measures to reduce the negative impact of industrial activities and human settlements on the environment of the coastal zone. These preventive measures can be more effective if they are undertaken in a coordinated manner at the regional level. It can be further improved if the regular collection and interpretation of environment related scientific data are also undertaken at the regional level, together with the development of harmonized legislations and interventions. The participating countries have therefore decided to integrate their collective efforts under the regional umbrella of PERSGA and take united actions in reducing UP-POPs releases from selected industrial sources.

The four participating countries have agreed that close cooperation is needed to collectively implement the SC's measures concerning introduction of best available techniques (BAT) and best environmental practices (BEP) for the coastal zone industries. The countries have further agreed that it could be possible that a larger impact on the environment and the coastal zone economy be attained if the cooperation is made at regional level rather than each country intervenes alone at the industries of its own coastal zone.

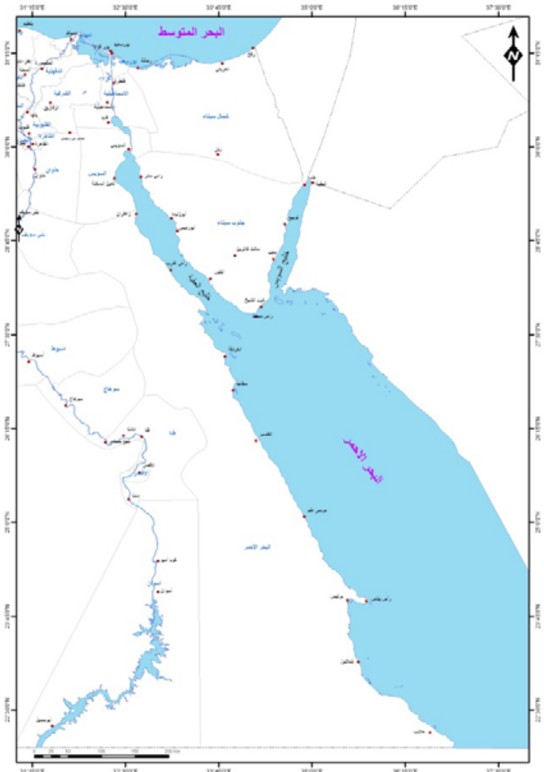
Red Sea Basin Profile

The Red Sea Basin is blessed with a variety of regional merits such as climate, coastal beaches that are famous for water and marine treasures, including coral reef and different kinds of fish and snails, as well as marine islands … etc. Such merits directed developmental activities towards the touristic sector as a pioneer project of integrated development that could be invested in the marine environment that in turn could be a base for touristic attraction in the Red Sea Region. Ever since the old ages, the Red Sea region has been blessed with a unique environmental system all along the coast of the Red Sea that extends to reach about 2000 km.

Country and Coastline Profile of Egypt:

Egypt is one of the largest countries in Africa. It enjoys a unique geographical location, being situated on the northeastern corner of the African continent. The population increased from 60 million in 1996, to 76,699,427 million (inside and outside Egypt) in 2006 according to census final results of CAPMAS.

While the total area is more than one million km^2, only 7.83% of the total area is inhabited and most of it lies along both sides of Nile River.



Red sea, Suez and South Sinai Governorates.

The Red Sea coast of Egypt, including the Gulfs of Suez and ‘Aqaba and the intervening Sinai Peninsula, is about 1,500 km in length. It is divided into three governorates:

1- **South Sinai Governorate**

South Sinai covering an area of 28,438 km2 is located in the peninsula of land between the Gulf of Suez on the west and the Gulf of Aqaba on the east.

The area is characterized by its:

- Natural and reasonably pristine environment with five protected areas, covering 40% of the land area of South Sinai, having been declared since 1983;
- Tourism potential with over 1.7 million international tourists visiting the area in 2003;
- Petroleum resources along the Gulf of Suez which account for much of the oil production in Egypt;
- Mineral resources, being a significant producer of non-metallic and ornamental stone.

The land area can be divided into four broad geographical regions:

- Gulf of Suez with little tourism, four significant towns, most of South Sinai mineral and petroleum production industry,
- Gulf of Aqaba which is the prime tourism local, and practically no agriculture;
- The central mountains which are very dry and have no towns except St Katherine, the population is almost exclusively Bedouin and there is a small amount of agriculture at Wadi Feiran, there are few tourism activities, the exceptions being the cultural attractions of St Katherine and desert camping and safaris;
- And the northern desert which has almost no settlements, agriculture, tourism or other attractions, and is entirely flat desert unrelieved by prominent features.

The 610 kilometers of coastline contain some of the most significant tourist destinations of the country, whilst inland there are also attractions. The area is defined by the demands of tourists, Bedouin, national protectorates and the desire of central Government to increase the population of the area by migration from other areas of Egypt.

2- Suez Governorate:

- Suez governorate is one of the Canal and Sinai governorates. It is situated east of Delta, north of Suez Gulf, linked with other Egyptian governorates by main roads railroads, and ring road.
- The governorate is famous for its technical training centers, the petroleum-engineering expertise and petrol refineries.
- There are five important ports in Suez governorate: (El-Sokhna port, Tewfiq port, Adabeya port, petrol basin port, and El-Atka fishing port). There are three sorting area, serving export and import commodities, in addition to a specialized area / container for oil tanks and petroleum refinery.
- The governorate is famous for its natural resources such as (limestone, clay, coal, petroleum, marble, line and stone quarries)
- Suez governorate has many famous tourist attractions such as (El-Ein El-Sokhna area, an important recreational and medical center) in addition to a variety of historic sites like Moses' springs, Muhammad Aly Palace, Roman Catholic Church and Judaic Hill at El- Khoor).
- Suez Gulf is the most important source of petroleum production in Egypt.
- The governorate is one of the important sites for the large cement companies in Egypt.
- There is an industrial city at Ataka, and the industrial development organization (IDA) made an expansion for its area to become 1168 feddan.
- Suez public free zone was established in 1975 on two locations:-
  - Port Tewfik location (an area of 75660 m2), adjacent to Suez port's fence
  - Adabeya location (an area of 247208 m2) overlooking Suez bay coast at 5km distance from Adabeya Port.
- Suez city is a strategically located. Its maritime and commercial port enjoys additional advantages e. g. :(roads & communication networks, five ports, faculties and institutes and labor force).
- It is equipped with utilities and basic infrastructure (roads, water, sewage system, electricity, telecommunications network, a customs integrated unit, a maritime unit and a security unit).

3- Red Sea Governorate:

Red sea Governorate is one of the largest governorates in Egypt with a total area of 120000 km² and history extends back to the pharaohs, the Romans the Christians era and the Islamic era, its unique & amazing beaches and coral reefs made it one of the favorite tourist destination attracting lots of tourists, diving and snorkeling fans from all over the world. It is located between the Nile and the Red Sea in the southeast of the country and its southern border forms part of Egypt's border with Sudan.

The Governorate consists of six cities as follows Ras Gharib, Hurghada, Safaga, Quseir, Marsa Alam and Shalateen.

The length of the Red Sea coast reaches to about 1080 km, starting from El-Zafarana in the north until the Egyptian-Sudanese boarders deep in the south, and this area represents about 1/3 of the total coastal areas in Egypt.

It extends from Southern of Cairo – Suez desert road till the boundaries of Egypt with Sudan. This is a sterile area characterized by a range of mountains 2000-meters high that stretch along the coast of the Red Sea. It is rich with minerals and quarries. Kusair, Ghurgada, Ras Gharb, Safaga, Halayeb and Shalatene are small Red Sea harbours.

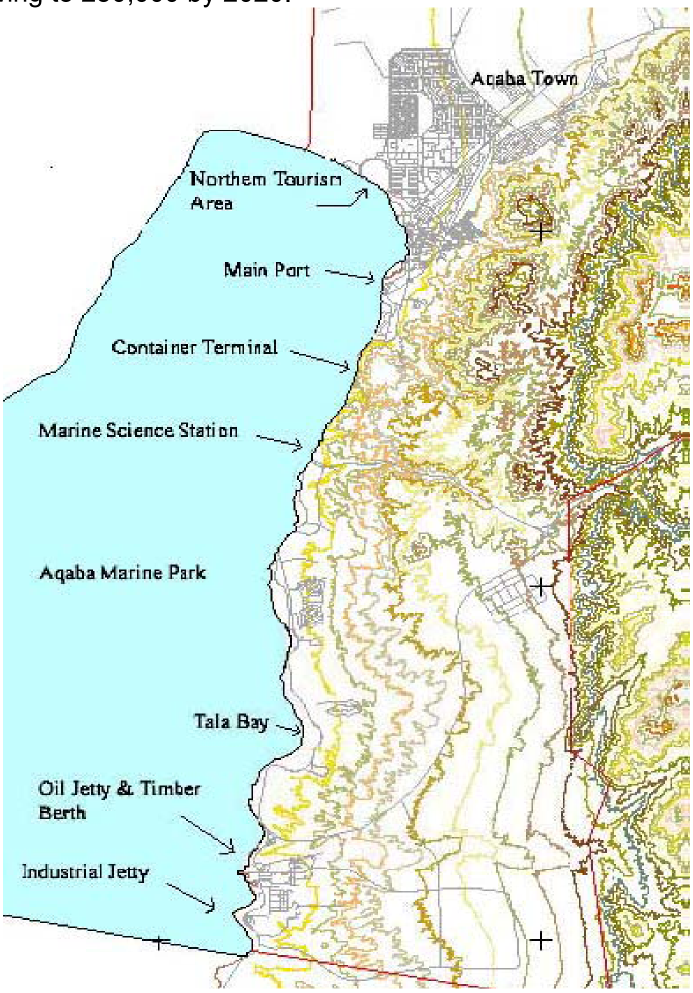
Country and Coastline Profile of Jordan:

The Hashemite Kingdom of Jordan lies in the Middle East and the Arab world, extending between the latitudes of 29°11` N and 33°22` N, and the longitudes of 34°59` E and 39°12` E. The area of the country is 92,000 km^2, of which more than three-quarters is desert. Jordan has a population of about 6 million, with a growth rate of 2.3%.

Jordan's marine coastline is only 27 km long. It forms the north eastern corner of the Gulf of Aqaba stretching from the head of the Gulf to the border with Saudi Arabia. This coastline contains a number of strategic assets essential to the economic development of the country. Within this small stretch lie the nation's sea ports, an industrial zone geared largely to the export of fertilizers and related industries, and a growing tourist industry which is centered around the attractive environment of the area - an environment which includes a delicate marine eco-system. The town of Aqaba, with a population of around 100,000, lies at the north eastern tip of the Gulf. The key coastline features are illustrated in Figure 1.1.

Jordan's entire coastline lies within one national and municipal jurisdiction - that of the Aqaba Special

Economic Zone (ASEZ). The ASEZ was established in 2001 to attract and facilitate investment in Aqaba in the areas of tourism, industry, port development, infrastructure, utilities and commercial services. The ASEZ is governed by the Aqaba Special Economic Zone Authority (ASEZA), which acts both as a municipal government regulator, as well as a regional development agency, investment promoter and facilitator. A Master Plan for the Zone was published in 2001 to guide the development of the Zone, which foresees the population of Aqaba growing to 250,000 by 2020.



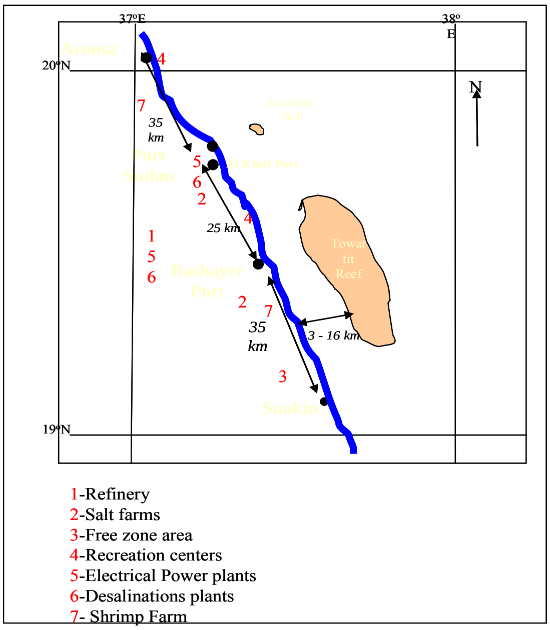
The key coastline features (Aqaba)

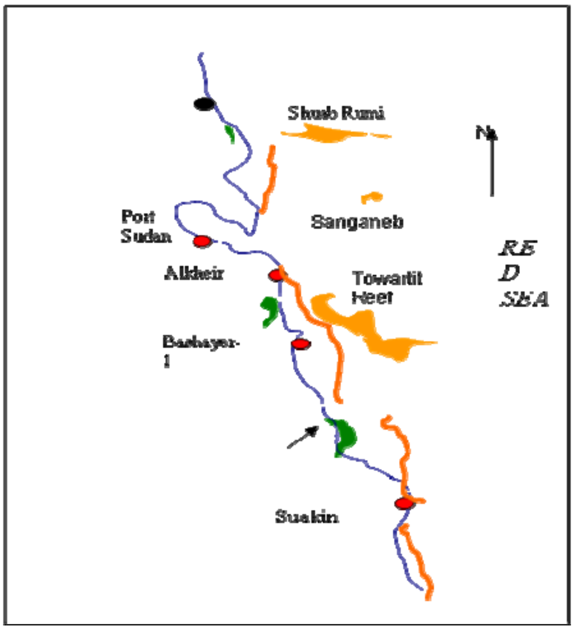
Country and Coastline Profile of Sudan:
Sudan is the biggest country in Africa and Middle East, with a plain land of 250.4 million hectares. It sharing the border with nine African countries: Eritrea and Ethiopia to the east, Kenya, Uganda and republic of Congo to the south the Central African Republic and Chad to the west, and Libya and Egypt to the north. Geographically Sudan lies to the eastern segment of the Africa within the tropical zone between longitude 22° to 38° east.

Sudanese Red Sea coastline is some 750 Km long, not including all embayment and inlets. Numerous islands are scattered along the coast, the majority of which have no water or vegetation. The dominant coastal forms are silty beaches, rocky headlands and salt marches, commonly boarded with mangroves. The principal environmental issues are

- Coastal habitat destruction by development
- Pollution from land-base sources (e.g. waste open burning)
- Passing ships pollution

The main city at the coastline is Port Sudan with a population around 500,000. All activities are concentrated between Arous village in the North and Sawakin port in the South in distance of 100Km approximately.





The major industrial activities are three power stations, three desalination plants and harbor dockyard. Tire and oil seeds factories which are used to be part of the main industrial activities are now closed out.

Country and Coastline Profile of Yemen
The Republic of Yemen lies in the southwestern part of Asia and in the south of Arabian Peninsula. It is bounded on the north by Saudi Arabia and south by the Arab sea and Aden Gulf, to the east lays Oman and to the west is the Red Sea.
Yemen has many islands along its coasts on the Red Sea and the Arab Sea. The largest island is Soctora, which is on the Arab Sea. The new administrative division of Yemen consists of (20) governorates in addition to the capital secretariat.

Coastline of Yemen
The main coastal cities are Aden (northwestern side of the Gulf of Aden) Hodeideah (southeastern side of the Red Sea) and Mukalla (northeastern side of the Gulf o of Aden) (See the map of Yemen)
The Red Sea and Gulf of Aden region of Yemen represent a complex and unique tropical marine ecosystem with extraordinary biological diversity and a remarkably high degree of endemism.
It is also an important shipping lane linking the world's major oceans. Western Gulf of Aden and Arabian Sea region is a highly productive fishery region due to the Upwelling phenomenon, supporting a feed web that ultimately sustains the fish community.
The coastline is also an important shipping lane linking the world's major oceans. About 100 million tonnes of oil transits the Red Sea annually.
Both the Red Sea and the Gulf of Aden are designated "special areas" under the international MARPOL Convention.
There are nine governorates located along the Yemeni coastline, Haja, Al-Hudaydah, Taiz (Red Sea), Lahj, Aden, Abyan, Shabowa, Hadramout and Al-Mahra (Gulf of Aden and Arabian regions).

2 METHODOLOGY

2.1 General information

The methodology; the “Standardized Toolkit for Identification of Dioxin and Furan Releases” was developed by UNEP Chemicals in 2005 (further referred to as Toolkit [1]). The Stockholm Convention, on its second meeting in Geneva 1-5 May 2006, recommended this methodology for the development of PCDDs and PCDFs release inventories (UNEP/POPS/COP.2/CRP/15)[i] under the Stockholm Convention. The most recent version of 2.1 was adopted for the preparation of the coastal zone inventories of the participating countries of the Project; Egypt, Jordan, Sudan and Yemen.

After extensive discussions and peer review of the national coastal zone inventories, the regional preliminary inventory for the Red Sea and Golf of Aden was compiled on the basis of the national reports.

The inventories at the national level have been conducted according to steps of the Toolkit. The Toolkit is designed as a simple and standardized methodology and accompanying database to enable assembly of consistent national and regional PCDD/PCDFs inventories.

The Toolkit has been developed for use by countries that do not have their own measured PCDD/PCDFs data from their sources. These countries utilize the default emission factors provided in this Toolkit. By this approach, the Toolkit is a method for the cost effective and rapid collection of the necessary information to develop a robust PCDD/PCDF inventory.

The Toolkit gives a five-step approach, to develop inventories. This approach was extended with another step, which was the compilation of the national reports to a regional report. The six steps of the regional inventory development are as follows:

1. Applying Screening Matrix of the Standardized Toolkit to identify Main Source Categories;
2. Identifying existing activities in each Main Source Categories and classifying them into Sub-Categories;
3. Gathering detailed information on the processes through applying the Toolkit's Questionnaires and classifying the technologies into similar groups having similar PCDD/Fs release pattern;
4. Quantifying the identified sources with default and/or measured emission factors;
5. Developing the national inventories and writing the national PCDD/Fs reports for the coastal zones;
6. Compilation of the national inventories to a regional PCDD/Fs report.

2.2 Organization of the inventory development

The National Implementation Plan development has created the initial capacity and expertise in all participating countries for the development of the PCDD/Fs inventories. The preliminary NIP PCDD/Fs inventories were used as an important source documents for the development of the coastal zone inventories. The project aimed at engaging this expertise therefore the national counterpart institutions were requested to nominate National Experts for the inventory development.

PERSGA has signed Terms of References with the National Experts. The counterpart organizations provided access to information for the National Experts. Depending the area to be cover by the inventories in some cases PCDD/F task teams were formed. All members of the teams received training on PCDD/Fs inventory development.

1 UNEP Chemicals: Standardized Toolkit for Identification of Dioxin and Furan Releases, Edition 2.1, Geneva, December 2005

The information collection and inventory development lasted from September 2009 to January 2010. PERSGA received the draft inventories in February and March 2010. The final national coastal zone inventories were approved by June 2010. The POPs Unit of PERSGA developed the regional inventory in July 2010.

2.3 Detailed methodology for PCDD/Fs inventory development

2.3.1 Step 1: Screening Matrix: Main Source Categories

In the first step ten main source categories are identified for each release vectors as shown in Table 1.

No.	Main Source Categories	Air	Water	Land	Product	Residues
1	Waste Incineration	X				X
2	Ferrous and Non-Ferrous Metal Production	X				X
3	Heating and Power Generation	X		X		X
4	Production of Mineral Products	X				X
5	Transport	X				
6	Open Burning	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
10	Identification of Potential Hot-Spots	Probably registration only to be followed by site specific evaluation				

Table 1: Main source categories of the Toolkit

2.3.2 Step 2: Subcategories Identification

In the second step, subcategories within each Main Source Category were identified. For comparability, each of the ten Main Source Categories has been divided into a series of subcategories. The list of subcategories is detailed in the following table (Table 2) .

For each subcategory listed, an investigation had established the presence or absence of the activity in the coastal zone of each country.

Waste Incineration	Transport
Municipal solid waste incineration	4-Stroke engines
Hazardous waste incineration	2-Stroke engines
Medical waste incineration	Diesel engines
Light-fraction shredder waste incineration	Heavy oil fired engines
Sewage sludge incineration	**Open burning Processes**
Waste wood and waste biomass incineration	Biomass burning
Destruction of animal carcasses	Waste burning and accidental fires
Ferrous and Non-Ferrous Metal Production	**Production and Use of Chemicals and Consumer Goods**
Iron ore sintering	Pulp and paper production
Coke production	Chemical industry
Iron and Steel production and foundries	Petroleum industry
Copper production	Textile production
Aluminum production	Leather refining
Lead production	**Miscellaneous**
Zinc production	Drying of biomass
Brass and bronze production	Crematoria
Magnesium production	Smoke houses
Other non-ferrous metal production	Dry cleaning
Shredders	Tobacco smoking
Thermal wire reclamation	**Disposal/Landfills**
Heat and Power Generation	Landfills and waste dumps
Fossil fuel power plants	Sewage and sewage treatment
Biomass power plants	Composting
Landfill, biogas combustion	Open water dumping
I-household heating and cooking (biomass)	Waste oil disposal (non-thermal)
Domestic heating (fossil fuels)	**Hot Spots**
Production of Mineral Products	Production sites of chlorinated organics
Cement production	Production sites of chlorine
Lime production	Formulation of chlorinated phenols/pesticides
Brick production	Application sites of dioxin-contaminated pesticides
Glass production	Timber manufacture
Ceramics production	PCB containing equipment
Asphalt mixing	Dumps of waste/residues from categories 1-9
	Sites of relevant accidents
	Dredging of sediments

Table 2: Subcategories of the Toolkit

2.3.3 *Step3: Information Gathering*

In the third step detailed information about the size and scale (e.g., tons of waste burned, tons of copper produced) of each process were gathered.

Information sources:

- Ministry of Industry, Industrial Statistic Department
- Ministry of Environment
- Central Statistic Bureau
- Civil Defence Department
- Ministry of Finance
- Ministry of Health
- Sea Ports Corporation
- Earlier PCDD/Fs inventories, etc.

Information needed to classify process and subcategories were obtained by questionnaires of the Toolkit designed for each source category. Detailed databases were developed for each individual location through direct visits and contact of responsible authorities.

2.3.4 Step 4: Process Classification and Source Quantification

The Toolkit further classifies each subcategory into several groups of technologies and processes that have the same pattern for PCDD/Fs releases. For each of these similar technologies default emission factors are provided. In step four based on the questionnaires and the Toolkit each identified source is classified into one of the group of technologies of the Toolkit.

Emission factor is the amount of PCDD/Fs (in µg I-TEQ) that is released to any of the five vectors (air, water, land, product and residue) per unit feed material or product produced. The annual releases for a particular source can be calculated by multiplying the emission factor provided for that particular technology with the activity data of the facility.

Source strength (Dioxin emission per year) = Emission Factor X Activity Rate

Currently there is a lack of locally measured PCDD/Fs emission factors to increase the quality and accuracy of the inventory. In the absence of such laboratory backed-up information the default emission factors of the Toolkit were applied for quantification. To assess the total releases theoretically five calculations have to be made, i.e. to all vectors, namely air, water, land, product, residue from each source. Of course defending on the technology some of the vectors are not applicable.

The calculation of the annual releases (or Source Strength) of each source is as follows:

Source Strength (PCDD/PCDF released per year) = ∑ Emission Factor Air X Activity Rate
+ ∑ Emission Factor Water X Activity Rate
+ ∑ Emission Factor Land X Activity Rate
+ ∑ Emission Factor Product X Activity Rate
+ ∑ Emission Factor Residue X Activity Rate

Activity Rate is the amount of feed material processed or product produced in tons or litres per year. The output of step 4 is source strength in form of an annual PCDD/PCDF release for each subcategory.

2.3.5 Step 5: Compilation of national inventories

Annual releases from all identified subcategories are added up to calculate the annual release estimate for each main source categories in each country. Finally the reports are written according the a standardized format.

To ease the calculation of the annual release estimates an electronic calculation aid is provided. This is an excel worksheet, which contains all emission factors for all kinds of group of technologies. The annal releases are automatically calculated based on the activity data. These inventory databases are also part of the inventory report and have been submitted to PERSGA.

2.3.6 Step 6: Development of the regional PCDD/Fs inventory

Based on the national coastal zone PCDD/Fs inventories the POPs Unit of PERSGA has developed the preliminary regional PCDD/Fs report. This activity included two main steps; the compilation of the regional release estimates and the development of the regional PCDD/Fs inventory report. The compilation of the national release estimates were undertaken by developing a regional inventory database, which is linked to the national inventory databases. In this way the changes in the national reports trigger an automatic updating mechanism in the regional PCDD/Fs release estimate.

The releases are summarized for each sector and for each country, then an average release estimate is calculated for each one thousand kilometre coastline.

Based on the national inventory reports and the regional PCDD/Fs release estimate the regional PCDD/Fs release inventory report has been developed. It was decided that the national reports would be part of the regional inventory report, but for practical reasons they would not be printed in the hard copies of the regional report. The national coastal zone PCDD/Fs reports are available on the internet on the web page of PERSGA (www.persga.org).

3 RELEASE ESTIMATES INTO THE MAIN SOURCE CATEGORIES

3.1 MAIN CATEGORY NO 1 - WASTE INCINERATION

Waste incinerators are listed in sub-paragraph (a) in Part

II of Annex C and therefore have to be addressed with priority in implementing BAT and BEP. The regional inventory exercise concluded that some of the subcategories of waste incineration are not undertaken in the RSGA region.

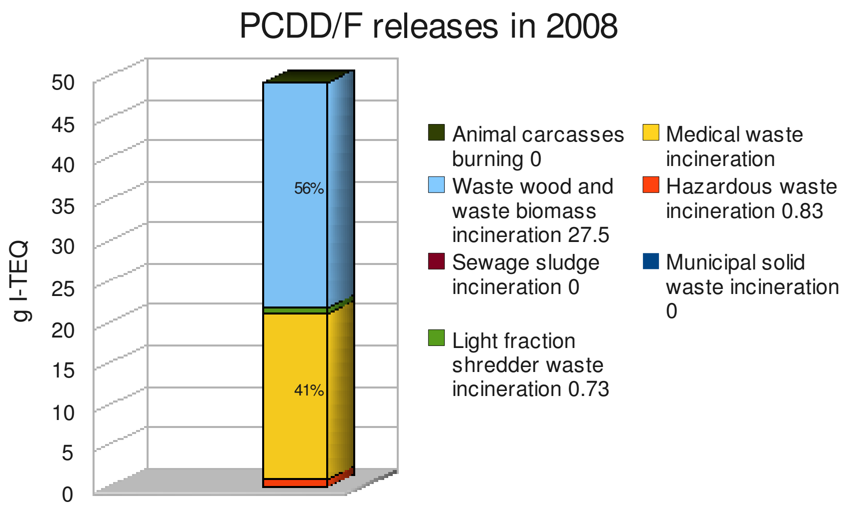


Illustration 1: Waste incineration, PCDD/F releases per sub-sector

Facilities for municipal solid waste incineration and sewage sludge incineration were not found. The total releases of PCDD/F were 49.38 g I-TEQ in 2008. The major source of the releases is waste wood and waste biomass incineration with 27.5 g I-TEQ, which is undertaken only in Yemen (Illustration 1).

The second highest source of the releases is medical waste incineration. It contributed 20.32 g I-TEQ PCDD/F releases to the total releases from the waste incineration.

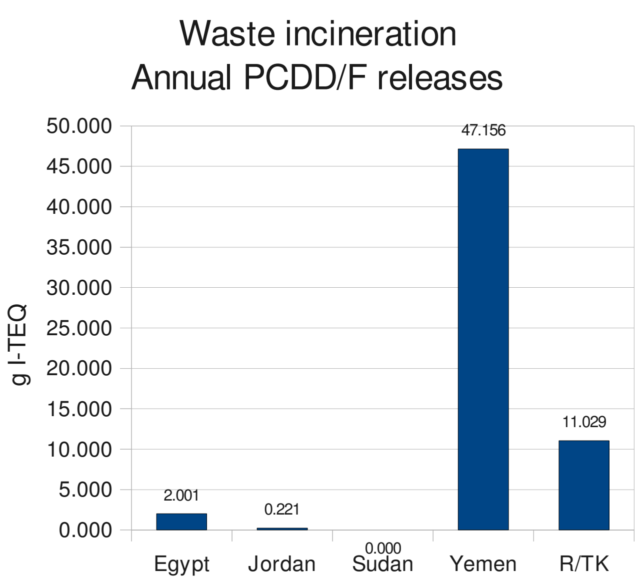


Illustration 2: Waste incineration, country-wise distribution of the PCDD/F releases

The highest PCDD/F releases were observed in Yemen (Illustration 2). The reason for that is the long coastal zone and a heavy concentration of human settlements and industrial activities in the coastal zone. Incineration is almost non existent in Sudan. This does not mean that waste related releases are not present. On the contrary due mixing all types of wastes together and burning them open air the releases appear in another sector open burning processes, which is discussed later in the inventory.

3.1.1 Municipal solid waste incineration

3.1.1.1 General Information

Municipal solid waste includes any type of solid waste generated by households, residential activities, and/or waste material to be disposed of by people during their normal course of living activities. It also includes domestic-like wastes produced in industrial, commercial or agricultural activities. Although the composition of municipal solid waste varies considerably from country to country, it is considered non-hazardous and common constituents are paper and cardboard, plastics, food and kitchen residues, cloth and leather, wood, glass, and metals as well as dirt and rocks and other inert materials. Small quantities of hazardous materials often cannot be eliminated such as batteries, paints, drugs, and some household chemicals.

Municipal solid waste (MSW) may be burned in a wide array of devices ranging from small, batch-type muffle furnaces to large, highly sophisticated mass burn systems with grates, heat recovery boilers for steam generation and air pollution control (APC) plants at the back end.

Municipal solid waste incineration has not been observed in the coastal zone of the RSGA.

3.1.2 Hazardous waste incineration

3.1.2.1 General Information

Hazardous waste (HW) refers to residues and wastes, which contain hazardous materials in significant quantities. Generally spoken, all materials including consumer goods, which require special precautions and restrictions during handling and use, belong to this group. Any consumer goods, which are labeled as such and have entered the waste stream, must be considered hazardous waste. These include solvents and other volatile hydrocarbons, paints and dyes, chemicals including pesticides, herbicides, and other halogenated chemicals, pharmaceutical products, batteries, fuels, oils and other lubricants, as well as goods containing heavy metals. Also, all materials contaminated with these materials such as soaked rags or paper, treated wood, production residues, etc., must be considered hazardous waste. The term “hazardous waste” as used in the Toolkit does not include medical waste since the location from where these wastes originate and the technology for hazardous waste and medical waste treatment are different. Typically hazardous waste is burned either in special technology incinerators or in rotary kiln type furnaces. Special technology incinerators include very low technology drum type, grate type, or muffle type furnaces.

The inventory has identified one cement company in Egypt which co-incinerates hazardous wastes in cement kilns, with annual PCDD/F releases of 0.0202 g TEQ/a to air and 0.809 g TEQ/a to residue.

3.1.2.2 Emission factors

For the quantification of the PCDD/F releases the emission factors of the Toolkit were used (Table 3).

Classification	Emission Factors - µg TEQ/t HW Burned	
	Air	Residue (Fly Ash Only)
1. Low technology combustion, no APCS	35,000	9,000
2. Controlled combustion, minimal APCS	350	900
3. Controlled combustion, good APCS	10	450
4. High technology combustion, sophisticated APCS	0.75	30

Table 3: Emission factors for hazardous waste incineration.

3.1.2.3 Results

Hazardous waste incineration was only observed in Egypt, where hazardous waste is co-incinerated in a cement factory. Total annual waste that is disposed of in this way was estimated to be 26 970 tons (Table 4). The PCDD/F releases from this sector was 0.829 g I-TEQ in the reference year (Illustration 3). This means 0.185 g I-TEQ releases per each thousand kilometre coastline.

Country	Estimated annual source strength (tons)
Egypt	26,970
Jordan	0
Sudan	0
Yemen	0
Total:	**26,970**

Table 4: Hazardous waste incineration, annual source strength

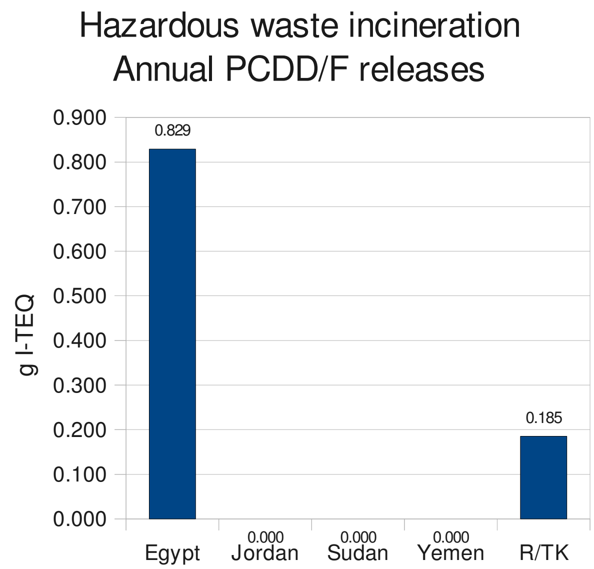


Illustration 3: Hazardous waste incineration, PCDD/F releases

3.1.3 Medical Waste Incineration

3.1.3.1 General Information

Medical waste is considered to be every waste generated from medical activities regardless if these activities take place in a hospital or are performed by a medical doctor, dentist or any other physician. The waste generated during these activities contains in many cases infectious materials, secretes, blood, pharmaceuticals and packaging materials and/or tools used during or for the medical treatment of people or animals. To reliably destroy viruses, bacteria, and pathogens this waste is often thermally treated (by incineration or pyrolysis). Further, due to its origin and its composition, medical waste can contain toxic chemicals, e.g., heavy metals or precursors, which may form dioxins and furans. In many countries, medical waste is a waste that requires special surveillance.

In the coastal zones of the Red Sea and Golf of Aden medical waste is treated differently. In Jordan due to the fast growing of the population and economy of the Aqaba Free Economic Zone (ASEZ) the demand for improved health care is growing. Two of the Zone's three hospitals announcing or have begun the construction of new facilities. Commensurate with growth in medical care is expected to be a parallel growth in generated medical or clinical waste needing treatment prior to disposal.

In Aqaba, there is only one medical waste incinerator at the Islamic Hospital, which no longer meets recommended practice and international standards. It is situated too close to human residential areas. The rest of the Zone's clinical waste, despite sorting efforts, is indifferently disposed of in the Aqaba City Landfill, without any treatment. ASEZ plans to stop the medical incinerator and to dispose of the all the medical waste outside the Zones' territory.

In Yemen most of the hospitals at the coastal zone directorates (Taiz, Abyan, Hajja and Lahj). have absolutely no control over the combustions process and they lack any air pollution control (APC). There was only one hospital, the Ibn Khaldoon Hospital in Lahj, where the combustion was controlled and facility was equiped with APC.

The problem of medical waste is also well known and of high concern to the local authorities in Sudan. In Port Sudan there are two main hospitals with capacity of 754 beds and six private hospitals with capacity of 371 beds. All wastes of these hospitals are disposed off together with domestic wastes. There are no incinerators of any kind exist in these hospitals for medical waste treatment. The Ministry of Health contracted a company to collect medical waste from hospitals and private clinics but finally it is mixed with municipal solid waste for disposal.

At the Egyptian coast 13 medical waste incinerators (two of them are not working) were identified, Suez Governorate has 3 incinerators, Red Sea Governorate has 3 incinerators and South Sinai Governorate has 7 incinerators.

3.1.3.2 Emission factors

The Toolkit recommends the use of the following emission factors (Table 5).

Classification	Emission Factors - µg TEQ/t Medical Waste Burned	
	Air	Residue
1. Uncontrolled batch type combustion, no APCS	40,000	200 *
2. Controlled, batch type combustion, no or minimal APCS	3,000	20 *
3. Controlled, batch type combustion, good APCS	525	920 **
4. High technology, continuous, controlled combustion, sophisticated APCS	1	150 **

* refers only to bottom ash left in the combustion chamber
** refers to the combined bottom and fly ashes

Table 5: Emission factors for medical waste incineration

3.1.3.3 Results

Medical waste incineration is a common sector for almost all countries that participated in the inventory development. The largest amount of medical waste is being incinerated in Yemen (Table 6), while in Sudan despite of all efforts for segregation, separation and collection medical waste ends up in open dump sites posing significant health risks for the citizens. The total PCDD/F releases from this sector is 20.32 g I-TEQ. The highest releases were observed in Yemen (18.92 g I-TEQ). The average PCDD/F releases per each thousand kilometre of coastline is 4.53 g TEQ (Illustration 4).

Country	Estimated annual source strength (tons)
Egypt	525
Jordan	6
Sudan	0
Yemen	5,850
Total:	**6,381**

Table 6: Medical waste incineration, annual source strength

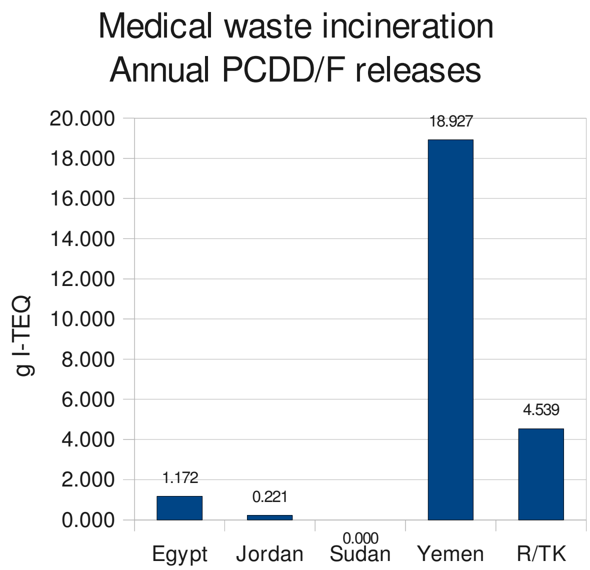


Illustration 4: Medical waste incineration, PCDD/F releases

3.1.3.4 Incomplete information

In Yemen the inventory used a 2.43 kg medical waste generation per bed per day to calculate the annual activity data for those hospitals for which information on the weight of the generated medical waste could not be collected.

3.1.4 Light fraction shredder waste incineration

3.1.4.1 General Information

Light-fraction shredder waste (LFSW) in the inventory describes the light fraction derived from shredder. In many countries, large items such as old vehicles, white goods, bulky containers, etc., are shredded in order to reduce the volume as well as enable the separation of recoverable materials such as metals from plastics and composites. Typical separation mechanisms include screening, sifting, and fractionation processes, which utilize the weight differences between the materials or the magnetic properties of ferrous metals in order to fractionate the shredder aggregate into ferrous metals, non-ferrous metals, glass, other heavy inerts, and light-weight aggregate fractions. In some cases the light fraction has little use and may be combusted for disposal.

Five light–fraction shredder waste incinerators were identified in Yemen. Two of them operate according to low environmental standards due to applying old technologies. The other three have appropriate combustion temperatures in the main chamber and are equipped with sophisticated air pollution control devices. The older ones have approximately half the capacity of the new ones.

3.1.4.2 Emission factors

For the quantification of the PCDD/F releases the emission factors of the Toolkit were used (Table 7)

Classification	Emission Factors - µg TEQ/t LFSW Burned	
	Air	Residue
1. Uncontrolled batch type combustion, no APCS	1,000	ND
2. Controlled, batch type combustion, no or minimal APCS	50	ND
3. High technology, continuous, controlled combustion, sophisticated APCS	1	150

Table 7: Emission factors for light fraction shredder waste incineration.

3.1.4.3 Results

Light fraction shredder waste incineration was observed in Yemen during the inventory preparation. This source is rather insignificant compared to other sources of the main source category No 1: waste incineration. By burning 2 432 tons from the light fraction from a shredding 0.73 g I-TEQ PCDD/F was released in the reference year (Table 8, Illustration 5).

Country	Estimated annual source strength (tons)
Egypt	0
Jordan	0
Sudan	0
Yemen	2,432
Total:	**2,432**

Table 8: Light fraction shredder waste incineration, annual source strength

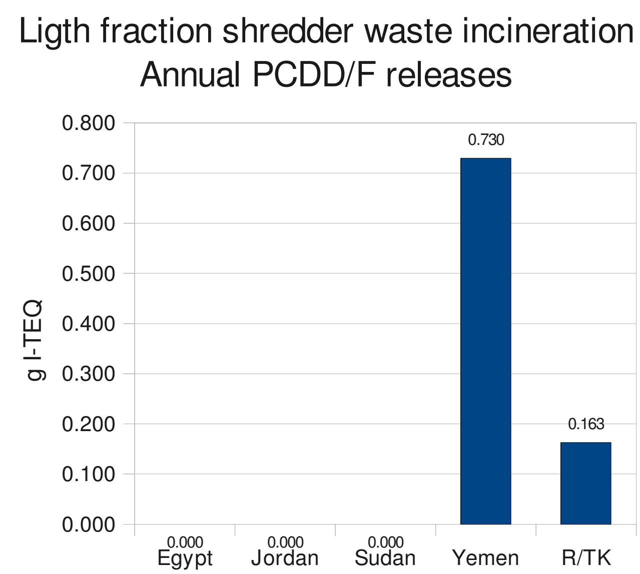


Illustration 5: Light fraction shredder waste incineration, PCDD/F releases

3.1.5 Sewage sludge incineration

3.1.5.1 General Information

Sewage sludge is the product of any wastewater treatment processes regardless of its origin (e.g., wastewater from municipal, agricultural or industrial activities). Wastewater always contains solids, which are normally removed during the treatment process. Since PCDD/PCDF are virtually insoluble in water, the bulk of the PCDD/PCDD adsorbs to the solids present in the wastewater. This sludge can be either incinerated, otherwise treated (co-combustion in power plants or cement kilns, undergo wet oxidation, pyrolysis, gasification, etc.) or landfilled. Incineration of sewage sludge is not common in the RSGA region. The inventory exercise could not locate any sewage sludge incinerators.

3.1.6 Waste wood and waste biomass incineration

3.1.6.1 General Information

This subcategory addresses the combustion of waste wood and waste biomass in furnaces under controlled conditions. It deals with the incineration of wood and biomass, which may have been treated or become mixed with treated wood or contaminated biomass. This waste biomass is incinerated in furnaces under conditions ranging from no control to highly control.

This practice has been undertaken in Yemen. Old furnaces with intermittent system were observed. There was no or very little use of air pollution control equipment.

3.1.6.2 Emission factors

Classification	Emission Factors - μg TEQ/t Biomass Burned	
	Air	Residue (Fly Ash Only)
1. Older furnaces, batch type operation, no APCS	100	1,000
2. Updated, continuously operated and controlled facilities, some APCS	10	10
3. Modern state-of-the-art facilities, continuous controlled operation, full APCS	1	0.2

Table 9: Emission factors for waste wood and biomass incineration.

During the inventory the following emission factors were applied for calculating the annual PCDD/F releases (Table 9).

3.1.6.3 Results

Waste wood and biomass incineration was only observed in Yemen. The annual production capacity of the plant was 25 000 tons in 2008 (Table 10). This contributed to 27.5 g I-TEQ PCDD/F releases to the environment. Waste wood and biomass incineration was the second largest PCDD/F release source in the waste incineration source category(Illustration 6).

Country	Estimated annual source strength (tons)
Egypt	0
Jordan	0
Sudan	0
Yemen	25,000
Total:	**25,000**

Table 10: Waste wood and biomass incineration, annual source strength

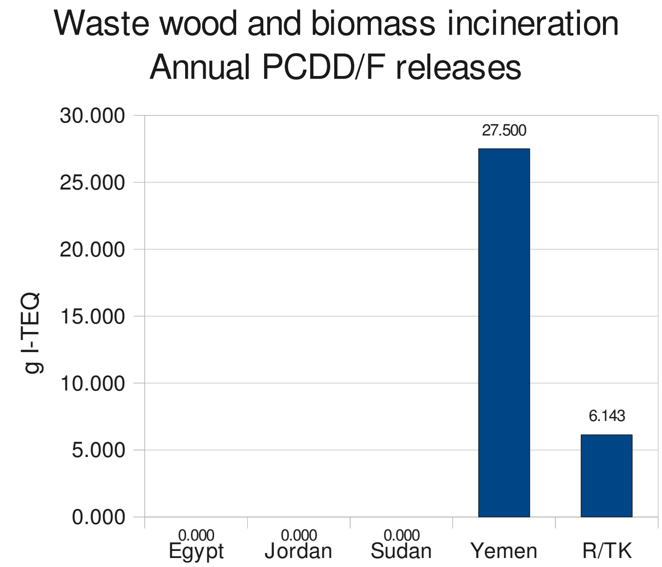


Illustration 6: Waste wood and biomass incineration, PCDD/F releases

3.1.7 Animal carcasses burning

3.1.7.1 General Information

The thermal destruction of animal carcasses can be applied to avoid public health risks resulting from natural decay of carcasses. The combustion process itself is often poorly controlled and incomplete combustion is the norm rather than the exception, since the main purpose is disinfection and complete eradication of all biological activity rather than complete combustion or even energy conversion.

3.1.7.2 Emission factors

To assess the PCDD/F releases from this source category the standard emission factors of the Toolkit were used (Table 11).

Classification	Emission Factors - µg TEQ/t Animal Carcasses Burned	
	Air	Residue
1. Older furnaces, batch type operation, no APCS	500	ND
2. Updated, continuously operated and controlled facilities, some APCS	50	ND
3. Modern state-of-the-art facilities, continuous controlled operation, full APCS	5	ND

Table 11: Emission factors for incineration of animal carcasses.

3.1.7.3 Results

Incineration of animal carcasses was observed only in Jordan. The slaughter house in Aqaba had recently installed a small, but state-of-the-art incinerator. The total annual weight of the carcasses that were incinerated in 2008 was 200 kg (Table 12). This resulted in releases below the calculation limit of the Toolkit, therefore no graph is presented.

Country	Estimated annual source strength (tons)
Egypt	0
Jordan	0.2
Sudan	0
Yemen	0
Total:	**0.2**

Table 12: Animal carcass burning, annual source strength

3.2 Main category no 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. Considerable amounts of the mass input become outputs in the form of off-gases and residues. The most relevant emissions are those to air.

In the Toolkit, primary metallurgical processes are understood to be those aimed at obtaining metals such as iron, copper, aluminum, lead, zinc, etc., from their original ores, whether sulfidized or oxidized, through such processes as concentration, smelting, reduction, refining, etc. Secondary metallurgical processes utilize scrap metals, often coated with plastics, paints, used batteries (for lead productions), oils, etc., or slags and fly ashes from metallurgical or other processes as raw materials into their processes. In this chapter, the term “primary” metal production should only be applied when no used or waste material enters into the process as the metal source.

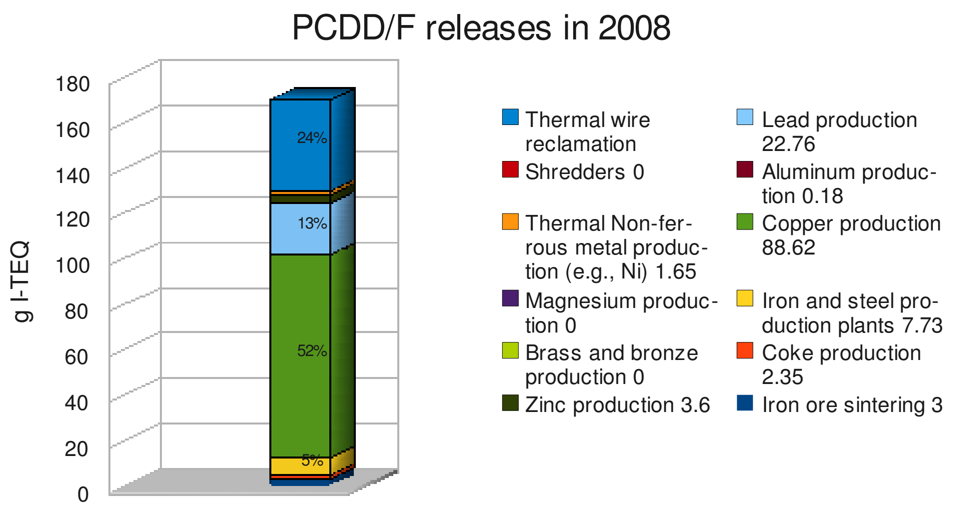


Illustration 7: Ferrous and non-ferrous metal production, PCDD/F releases per sub-sector

Production of metals, particularly if the production is from secondary raw materials has been recognized as a source of dioxins and furans. In addition, processes that need chlorination such as the electrolytic production of magnesium from seawater and dolomite may generate PCDD/PCDF. Dioxins and furans or their precursors may be present in some raw materials and thus enter the process or they are newly formed from short-chain hydrocarbons via de novo synthesis in furnaces or abatement systems. PCDD/PCDF are easily adsorbed onto solid matter and r
scrubber solids, and fly ash filter dust.

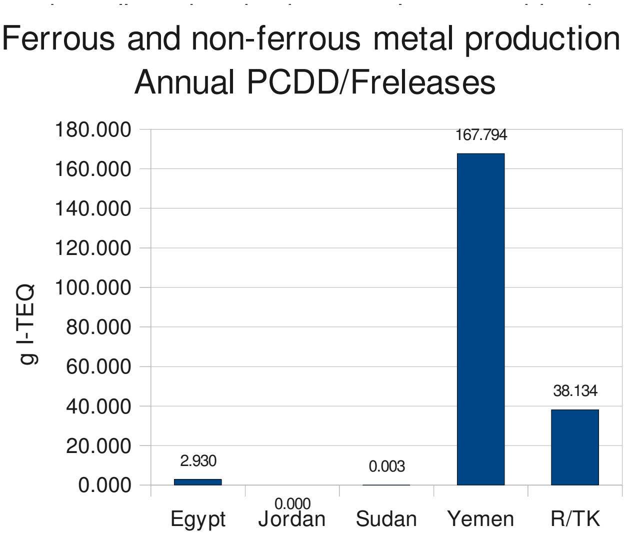


Illustration 8: Ferrous non-ferrous metal production, country-wise distribution of the PCDD/F releases

Since formation of PCDD/PCDF (and other unintentionally formed POPs) are thought to originate through high temperature thermal metallurgical processes, hydrometallurgical processes are not considered a PCDD/PCDF source in this inventory and thus, their releases have not been estimated.

Due to the cheap energy resources around the Read Sea and Gulf of Aden these heavy industries tend to move into this region, particularly to Yemen and Egypt. It was also observed that small-sized industries utilize outdated technologies, particularly in the case of Yemen which results in high dioxin and furan releases.

The total releases from this main source category was 170 g I-TEQ in 2008. Copper production is the leading sub-sector which accounts for 52% of the releases in this source category (Illustration 7). The second most significant source is thermal wire reclamation with 24% share. The most significant sources were found in Yemen, where this sector alone released 167 g I-TEQ dioxins and furans; 98% of the total releases of this main source category (Illustration 8).

3.2.1 Iron ore sintering

3.2.1.1 General Information

Sinter plants are associated with iron manufacture, often in integrated iron and steel works. The sintering process is a pre-treatment step in the production of iron where fine particles of metal ores are agglomerated by combustion. Agglomeration is necessary to increase the passage for the gases during the blast furnace operation. Typically, sintering plants are large (up to several hundred square meters) grate systems used to prepare iron ore (sometimes in powder form) for use in a blast furnace. In addition to iron ore, there is usually a carbon source (often coke) and other additions such as limestone. In some cases wastes from various parts of the steel making process are present. In the sintering process, burners above the grate belt heat the material to the required temperature (1,100-1,200 °C), which causes the fuel in the mixture to ignite. The flame front passes through the sintering bed as it advances along the grate causing agglomeration. Air is sucked through the bed. The process is finished once the flame front has passed through the entire mixed layer and all fuel has been burned. Cooled sinter is transferred to screens that separate the pieces to be used in the blast furnace (4-10 mm and 20-50 mm) from the pieces to be returned to the sinter process (0-5 mm as "return fines", 10-20 mm as "hearth layer").

3.2.1.2 Emission factors

To assess the PCDD/F releases from this source category the standard emission factors of the Toolkit were used (Table 13).

Classification	Emission Factors – µg TEQ/t of Sinter Produced				
	Air	Water	Land	Product	Residue
1. High waste recycling including oil contaminated materials	20	ND	ND	NA	0.003
2. Low waste use, well controlled plant	5	ND	ND	NA	0.003
3. High technology emission reduction	0.3	ND	ND	NA	0.003

Table 13: Emission factors for iron ore sintering.

3.2.1.3 Results

Iron ore sintering was only observed in Yemen. A new plant has been producing iron in Aden through mainly recycling scrap iron. The amount of recycled iron is 120,000 tons/year. Several other plants have been identified in Hodaida and Taiz. These facilities use scrap metals as well, with high waste recycling, including oil-contaminated materials. The total activity rate of this sector was 150 225 tons in 2008 (Table 14). The annual releases were 3 g I-TEQ (Illustration 9).

Country	Estimated annual source strength (tons)
Egypt	0
Jordan	0
Sudan	0
Yemen	150,225
Total:	**150,225**

Table 14: Iron ore sintering

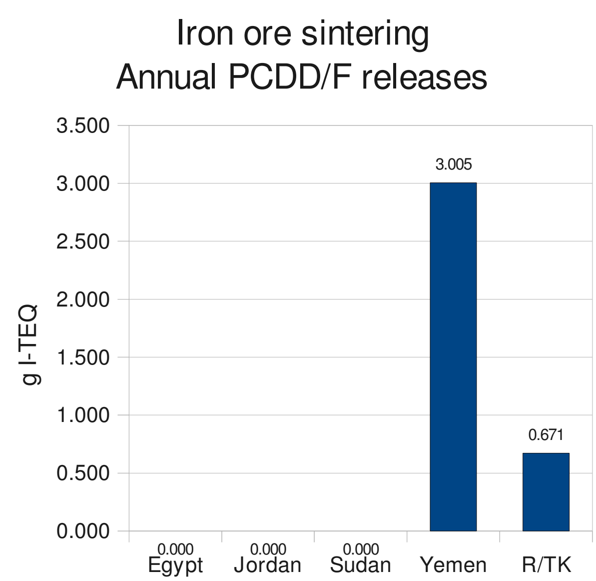


Illustration 9: Iron ore sintering, PCDD/F releases

3.2.2 Coke production

3.2.2.1 General Information

Coke is produced from hard coal or from brown coal by carbonization (heating under vacuum). In “coke ovens”, coal is charged into large vessels, which are subjected to external heating to approximately 1,000 °C in the absence of air. Coke is removed and quenched with water. The major use of coke – at least in industrialized countries - is in the iron and steel industry .

3.2.2.2 Emission factors

To assess the PCDD/F releases from this source category the standard emission factors of the Toolkit were used (Table 15).

Classification	Emission factors – µg TEQ/t of Coke Produced				
	Air	Water	Land	Product	Residue
1. No gas cleaning	3	0.06[1]	NA	ND	ND
2. APC with afterburner/dust removal	0.3	0.06[1]	NA	ND	ND

[1] Use factor of 0.006 µg TEQ/t where water treatment is applied

Table 15: Emission factors for coke production.

3.2.2.3 Results

Charcoal is one of goods used in large quantities in Yemen. Several factories have been identified in the coastal zone. Charcoal is used in many ways, ranging from using it for water pipe, cooking especially roasting meat, fish, chicken, etc. Table 16 summarizes the total activity data for charcoal production. The total annual releases were found to be 2.35 g I-TEQ in Yemen, while this activity has net been observed in any other participating countries (Illustration 10).

Country	Estimated annual source strength (tons)
Egypt	0
Jordan	0
Sudan	0
Yemen	784,829
Total:	**784,829**

Table 16: Coke production, annual source strength

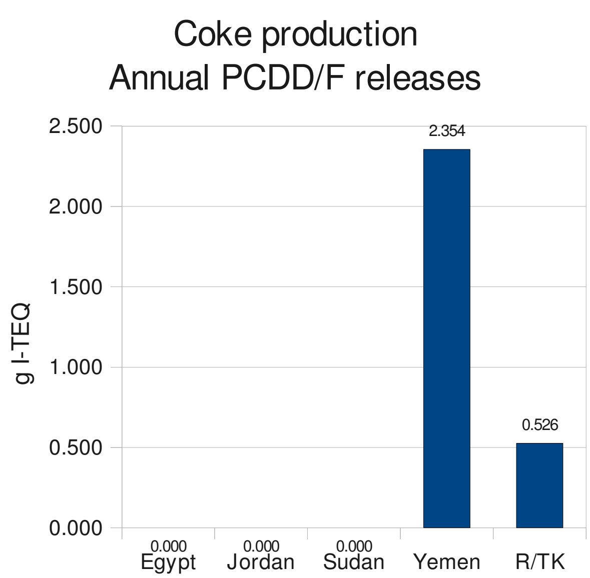


Illustration 10: Coke production, PCDD/F releases

3.2.2.4 Incomplete information

The Toolkit does not have a dedicated emission factor for the production of charcoal from wood. This process can be carried out in many small units, which taken together may represent a considerable production. In this inventory for initial estimates of dioxins and furan releases the emission factors given in this section for simple plants were applied (class 1). The amount of charcoal production indicated in the inventory does not represent the total amount, since the production is undertaken in small scale by the informal sector where documentation is almost completely missing.

3.2.3 Iron and steel production plants and foundries

3.2.3.1 General Information

The iron and steel industry is a highly material intensive industry with raw materials such as ores, pellets, scrap, coal, lime, limestone (in some cases also heavy oil and plastics) and additives and auxiliaries. It also consumes much energy. More than half of the mass input becomes outputs in the form of off-gases and solid wastes or by-products. The most relevant emissions are those to air with the emissions from sinter plants to dominate the overall emissions for most of the pollutants.

In this section all processes used in the manufacture of iron and steel should be covered. Four routes are currently used for the production of steel: the classic blast furnace/basic oxygen furnace route, direct melting of scrap (electric arc furnace), smelting reduction and direct reduction. For the purpose of the Toolkit, a categorization can be done by the type of the input material: in this way, blast furnaces (BF) are used only for the production of pig iron and are fed with iron ores from either sintering plants or pelletizing plants. Blast furnaces do not utilize scrap. Scrap is being used in electric arc furnaces (EAF), Basic Oxygen Furnaces (BOF) as well as in foundries where cupola furnaces (CF) and induction furnaces (IF) are found.

3.2.3.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 17).

Classification	Emission Factors – µg TEQ/t of LS				
	Air	Water	Land	Product	Residue
Iron and Steel Making					
1. Dirty scrap (cutting oils, general contamination), scrap preheating, limited controls	10	ND	NA	NA	15
2. Clean scrap/virgin iron, afterburner and fabric filter	3	ND	NA	NA	15
3. Clean scrap/virgin iron, EAF designed for low PCDD/PCDF emission, BOF furnaces	0.1	ND	NA	NA	1.5
4. Blast furnaces with APCS	0.01	ND	ND	ND	ND

Table 17: Emission factors for Iron and steel making.

3.2.3.3 Results

Iron and steel making is undertaken in Egypt and in Yemen. The inventory in Egypt included two iron and steel companies in Suez governorate with annual release of 0.08g I-TEQ to air and 1.20g I-TEQ to residue. Both plants use the BOF process. Their annual production rate is 800 000 tons (Table 18). In Yemen three facilities were found in Aden, two in Hodaida and one in Abyan. Dirty scrap are used in the process with limited controls. The annual production rate is 258 000 tons which correspond to 6.45 g I-TEQ releases (Illustration 11). It is interesting to conclude that in Yemen the releases are more than five times higher than in Egypt although in Egypt three time more amount of iron is produced. The reason is the use of non-clean scrap metals in Yemen, while in Egypt the plants use clean raw materials.

Country	Estimated annual source strength (tons)
Egypt	800,000
Jordan	0
Sudan	0
Yemen	258,000
Total:	**1,058,000**

Table 18: Iron and steel industries, annual source strength

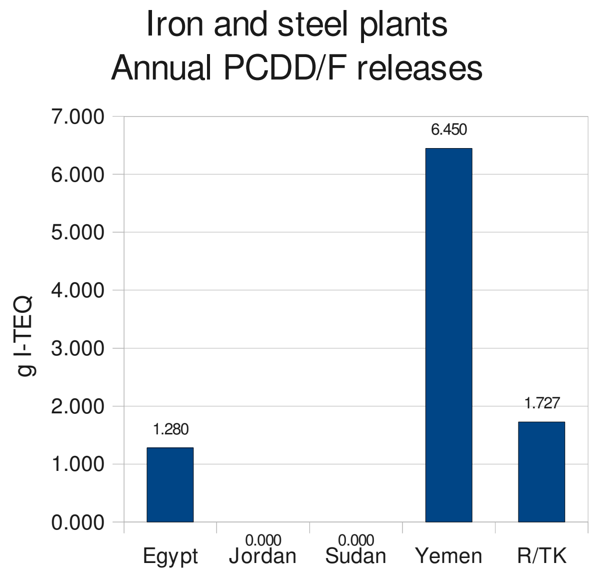


Illustration 11: Iron and steel plants, PCDD/F releases

3.2.4 Copper production

3.2.4.1 General Information

Thermal copper generation and releases of PCDD/PCDF are of special interest as copper (Cu) is the most efficient metal to catalyse the formation of PCDD/PCDF. When analysing the copper production sector for PCDD/PCDF releases, it is important to differentiate between primary and secondary production. Primary copper production was not located in the inventory.

Secondary copper is produced by pyro-metallurgical processes and is obtained from scrap or other copper-bearing residues such as slags and ashes. Since used copper can be recycled without loss of quality, secondary copper production is an important sector. Since secondary feed material can contain organic materials, de-oiling and de-coating methods are applied, also to minimize the formation of PCDD/PCDF in the subsequent stages of the copper production. The stages used for secondary copper production are generally similar to those for primary production but the raw materials are usually oxidic or metallic and therefore, the smelting of secondary raw materials uses reducing conditions.

3.2.4.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 19).

Classification	Emission Factors – µg TEQ/t of Copper				
	Air	Water	Land	Product	Residue
1. Sec. Cu - Basic technology	800	ND	NA	NA	630
2. Sec. Cu - Well controlled	50	ND	NA	NA	630
3. Sec. Cu - Optimized for PCDD/PCDF control	5	ND	NA	NA	300
4. Smelting and casting of Cu/Cu alloys	0.03	ND	NA	NA	ND
5. Prim. Cu, well-controlled, with some secondary feed materials	0.01	ND	NA	NA	ND
6. Pure primary Cu smelter with no secondary feed materials	ND	ND	NA	NA	NA

Table 19: Emission factors for copper production.

3.2.4.3 Results

Only secondary copper production facilities were located in Sudan and in Yemen. All of them apply basic technologies, without any air pollution control measures. In Yement a factory producing electrical cables was observed in Abyan governorate which is located on the Gulf of Aden and another one in the governorate of Taiz. Their total annual production was 61 970 tons (Table 20). In Sudan only one small-scale facility was located in copper smelting from scrap materials. The foundry use cold air cupola furnace without any air pollution control system. It is located at the Sea Ports Corporation. Picture xxx shows the melting process.

Illustration 12: Secondary copper melting in Sudan

The total release for this sub-sector is 88.6 g I-TEQ, which is the highest in the ferrous and non-ferrous metallurgical processing source category (Illustration 13).

Country	Estimated annual source strength (tons)
Egypt	0
Jordan	0
Sudan	1
Yemen	61,970
Total:	**61,971**

Table 20: Copper production, annual source strength

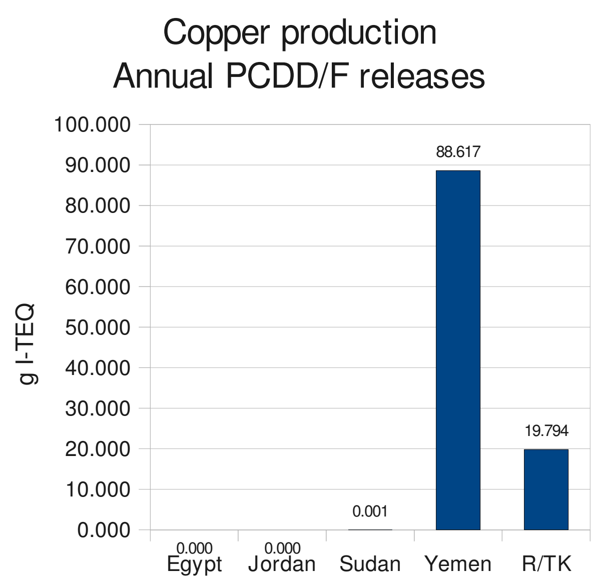


Illustration 13: Copper production, PCDD/F releases

3.2.5 Aluminium production

3.2.5.1 General Information

Aluminium can be produced from aluminium ore, most commonly bauxite, or from scrap. The first method is commonly referred to as primary production whereas the second is commonly referred to as secondary production.

Basically all used aluminium can be recycled into aluminium, which has the same quality as primary aluminium. Secondary aluminium is obtained by remelting Al scrap, shavings, and other materials containing aluminium. Secondary aluminium production can be performed in a variety of furnaces, where rotary drum furnaces are used when salt, e.g., cryolite (sodium aluminium fluoride), is added whereas in a variety of furnaces, e.g., rotary drum, hearth furnaces or induction furnaces normally do not require salt. Induction furnaces are predominantly used in foundries when oxide-free scrap is fed. The aluminium smelted in the furnaces is run off for refining, alloying, or keeping warm in converters. Scrap material may be contaminated with oils, plastics, paints and other contaminants. Releases of PCDD/PCDF may occur from scrap melting where organic contaminants and chlorine are present and also from refining (where hexachloroethane or chlorine may be used) and pretreatment such as thermal cleaning of scrap.

3.2.5.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 21).

Classification	Emission Factors – µg TEQ/t of Aluminum				
	Air	Water	Land	Product	Residue
1. Thermal processing of scrap Al, minimal treatment of inputs and simple dust removal	100	ND	NA	NA	200
2. Thermal Al processing, scrap pre-treatment, good controls, filters with lime injection	35	ND	NA	NA	400
3. Thermal Al processing, scrap pre-treatment, well-controlled, fabric filters with lime injection	3.5	ND	NA	NA	100
4. Optimized for PCDD/PCDF control – afterburners, lime injection, fabric filters and active carbon	0.5	ND	NA	NA	100
5. Shavings/turning drying (simple plants)	5	NA	NA	NA	NA
6. Thermal de-oiling of turnings, rotary furnaces, afterburners, and fabric filters	0.3	NA	NA	NA	NA
7. Pure primary Al production	ND	NA	NA	NA	ND

Table 21: Emission factors for aluminium production.

3.2.5.3 Results

In Sudan two small local foundries re-melt approximately five tons of aluminium scraps (Table 22). The product is reformed and shaped for different purposes. This thermal process is performed without dust removal or any pollution control system. Therefore this thermal process classified as (class 1) with 100 and 200 µg TEQ/a emission factor for PCDD/PCDF released to air and residue respectively (Illustration 14).

In Yemen more than ten factories were found to be engaged in the production and formation of ready aluminium metal. These plants collect and reproduce aluminium scrap locally. Technologies use scrap aluminium without any pre--treatment and very minimal dust removal is applied during the production processes.

Country	Estimated annual source strength (tons)
Egypt	0
Jordan	0
Sudan	5
Yemen	500
Total:	**505**

Table 22: Aluminium production, annual source strength

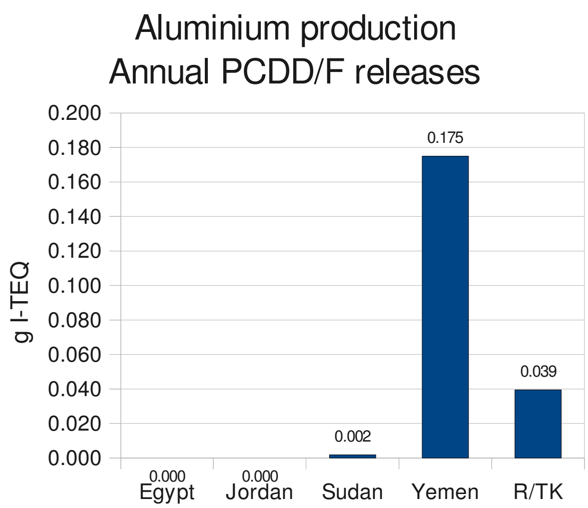


Illustration 14: Aluminium production, PCDD/F releases

3.2.6 Lead production

3.2.6.1 General Information

Two main routes for primary lead production from sulfide ores are available – sintering/smelting and direct smelting. Emissions from direct smelting are low and not considered in the Toolkit. No data are available on releases from sintering/smelting for primary lead production.

Considerable quantities of lead are recovered from scrap materials, in particular vehicle batteries. A variety of furnace designs are used including rotary furnaces, reverberant, crucible, shaft, blast and electric furnaces. Continuous direct smelting processes may be used.

PCDD/PCDF emissions may be linked to high organic matter on scrap materials and the presence of chlorine in particular a link between the use of PVC separators in vehicle batteries and PCDD/PCDF emissions has been made.

3.2.6.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 23).

Classification	Emission Factors – µg TEQ/t of Lead				
	Air	Water	Land	Product	Residue
1. Lead production from scrap containing PVC	80	ND	NA	NA	ND
2. Lead production from PVC/Cl_2 free scrap, some APCS	8	ND	NA	NA	50
3. Lead production from PVC/Cl_2 free scrap in highly efficient furnaces, with APC including scrubbers	0.5	ND	NA	NA	ND
4. Pure primary lead production	ND	NA	NA	NA	ND

Table 23: Emission factors for lead production.

3.2.6.3 Results

There are two factories outside Hodaida in the direction of Hodaida-Taiz road in Yemen which are engaged in lead production. They are extracting lead from scrap car batteries containing (PVC). Table 24 summarizes the production of secondary lead scrap containing PVC in Yemen, which was 284 473 tons in 2008. The corresponding releases were 22.7 g I-TEQ (Illustration 15). This sector is the third largest contributor to PCDD/F releases in the ferrous and non ferrous metallurgical processing sector.

Country	Estimated annual source strength (tons)
Egypt	0
Jordan	0
Sudan	0
Yemen	284,473
Total:	**284,473**

Table 24: Lead production

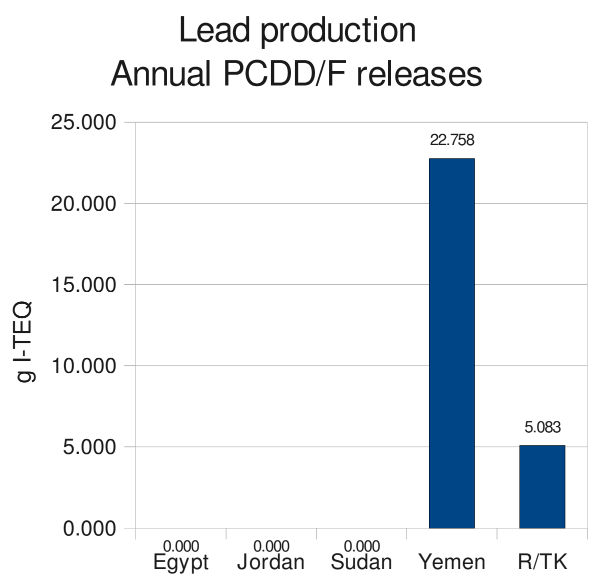


Illustration 15: Lead production, PCDD/F releases

3.2.7 Zinc production

3.2.7.1 General Information

Zinc may be recovered from ores by a variety of processes. The occurrence of lead and zinc ores in combination means that there may be considerable overlap between these sectors. Crude zinc may be produced in combination with a lead ore blast furnace or be recovered from the slag from such processes in rotary kilns. A variety of scrap materials may be used for zinc recovery as well as secondary raw materials such as dusts from copper alloy production, electric arc steel-making (e.g., filter dusts and sludge), residues from steel scrap shredding, scrap from galvanizing processes. The zinc generating process from secondary raw materials can be done in a zinc recovery rotary kiln (Waelz kiln), which is up to 95 meter long with internal diameters of around 4.5 meter; they are lined with refractory material. The granulated blast-furnace slag is mixed with other zinc intermediates, e.g. steel dusts, it travels down the kiln and is heated to reaction temperature by combustion of gases from a burner at the discharge end. In the slag-fuming process, a mixture of coal dust and air is injected into a liquid blast furnace slag at 1,150-1,250 °C in a water-jacketed furnace. The slag is directly delivered to the blast furnace. The processing of impure scrap such as the non-metallic fraction from shredders is likely to involve production of pollutants including PCDD/PCDF. Relatively low temperatures are used to recover lead and zinc (340 and 440 °C). Melting of zinc may occur with the addition of fluxes including zinc and magnesium chlorides.

3.2.7.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 25).

Classification	Emission Factors – µg TEQ/t of Zinc				
	Air	Water	Land	Product	Residue
1. Kiln with no APCS	1,000	ND	NA	NA	ND
2. Hot briquetting/rotary furnaces, basic dust control; *e.g.*, fabric filters/ESP	100	ND	NA	NA	ND
3. Comprehensive pollution controls, e.g., fabric filters with active carbon/DeDiox technology	5	ND	NA	NA	ND
4. Zinc melting	0.3	ND	NA	NA	NA
5. Primary zinc production	ND	ND	NA	NA	ND

Table 25: Emission factors for zinc production.

3.2.7.3 Results

One Zinc production facility was found in Yemen. It is located in Hodaida and does not apply any dust control. Annual production activity is 3 600 tons (Table 26) which corresponds to 3.5 g I-TEQ annual releases (Illustration 16).

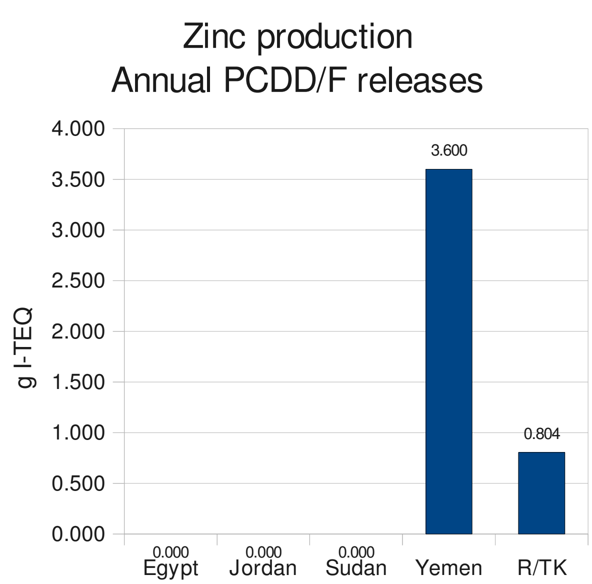


Illustration 16: Zinc production, PCDD/F releases

Country	Estimated annual source strength (tons)
Egypt	0
Jordan	0
Sudan	0
Yemen	3,600
Total:	**3,600**

Table 26: Zinc production, annual source strength

3.2.8 Brass and bronze production

3.2.8.1 General Information

Brass is a hard yellow shiny metal that is an alloy of copper (55 %-90 %) and zinc (10 %-45 %). The properties of brass vary with the proportion of copper and zinc and with the addition of small amounts of other elements, such as aluminium, lead, tin, or nickel. In general, brass can be forged or hammered into various shapes, rolled, etc. Brass can be produced by either re-melting the brass scrap or melting stoichiometric amounts of copper and zinc together.

In principle, either one or both can be primary or secondary metal. Bronze is a hard yellowish-brown alloy of copper and tin, phosphorus, and sometimes small amounts of other elements. Bronzes are harder than copper and brasses. Bronze is often cast to make statues. Most bronze is produced by melting the copper and adding the desired amounts of tin, zinc, and other substances. The properties of the alloy depend on the proportions of its components. Brass and bronze can be produced in simple, relatively small melting pots or in more sophisticated equipment such as induction furnaces equipped with APC systems.

Brass or bronze production was not observed in the participating countries.

3.2.9 Magnesium production

3.2.9.1 General Information

The production of magnesium from ores is largely based on either the electrolysis of MgCl2 or the chemical reduction of oxidized magnesium compounds. The raw materials used are dolomite, magnesite, carnallite, brines or seawater depending on the process. Magnesium can also be recovered and produced from a variety of magnesium-containing secondary raw materials .

The electrolysis process is more widely used. This process seems to be of most interest from the point of view of PCDD/PCDF formation and release. Secondary magnesium production is not addressed in the Toolkit.

In the thermal reduction process calcined dolomite is reacted with ferro-silicon sometimes together with aluminium in a furnace or retort vessel. The calcination process takes place by decarbonization and dehydration of dolomite limestone. For the calcination process for dolomite, often a rotate or vertical furnace is used.

Magnesium production was not observed in the participating countries.

3.2.10 Thermal Non-ferrous metal production (e.g., Ni)

3.2.10.1 General Information

A variety of processes are undertaken to produce and refine non-ferrous metals. The exact processes used and the propensity to form PCDD/PCDF are complex and exact emission factors are not available. Thermal metal processes can release PCDD/PCDF and emissions will be influenced by the degree of contamination on the scrap materials and the capture and treatment of the flue gases. Lowest emissions can be expected where the raw materials are clean and gas treatment comprehensive – including dust control by fabric filters, lime injection and possibly activated carbon addition and in some cases an afterburner.

3.2.10.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 27).

Classification	Emission Factors – µg TEQ/t of Product				
	Air	Water	Land	Product	Residue
1. Thermal non-ferrous metal processes – contaminated scrap, simple or no APCS	100	ND	NA	NA	ND
2. Thermal non-ferrous metal processes – clean scrap, fabric filters/lime injection/afterburners	2	ND	NA	NA	ND

Table 27: Emission factors for thermal non-ferrous metal reclamation.

3.2.10.3 Results

The inventory includes one company in Egypt that produces ferro manganese with annual capacity of 16 500 tons (Table 28). The calculated releases are 1.65 g I-TEQ to air (Illustration 17).

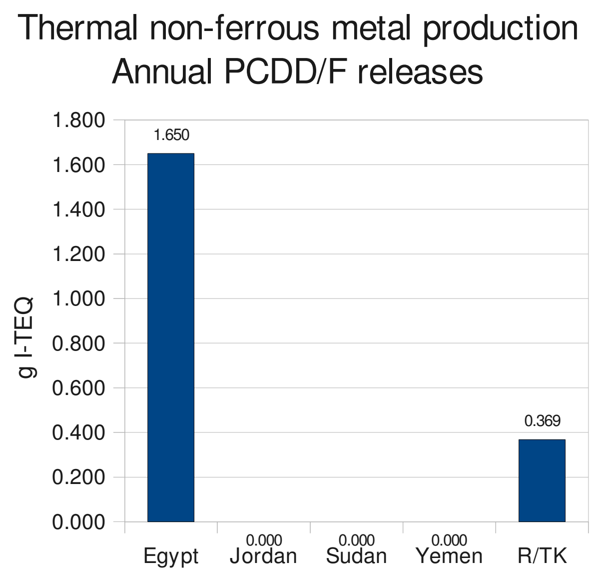


Illustration 17: Thermal non-ferrous metal production, PCDD/F releases

Country	Estimated annual source strength (tons)
Egypt	16,500
Jordan	0
Sudan	0
Yemen	0
Total:	**16,500**

Table 28: Thermal non-ferrous metal production, annual source strength

3.2.11 Shredders

3.2.11.1 General Information

Generally shredders are used to reduce the size of the input materials into smaller particles. Most often they are used to shred auto mobiles. Given that these machines are able to swallow complete auto mobiles in one go and chop them into small, fist size chunks of metal, they also accept other feedstock. In practice, much light scrap such as bicycles, office furniture, vending machines and so-called “white” goods, e.g., refrigerators, stoves, washing machines, etc., and “brown” goods, e.g., television sets, radios, etc., are fed into shredders. Shredders are large-scale machines, which are equipped inside with one or more anvil(s) or breaker bar(s) and lined with alloy steel wear plates. An electric motor drives the rotor with the free-swinging alloy steel hammers. Beneath the shredder is a vibratory pan, which receives the shredded material discharged through the grates. Typically a ferrous metal stream is produced, which is relatively clean and consists of small (50 mm) pieces of steel and a “fluff” stream, which contains the fragments of non-ferrous metals and other materials that entered the shredder (also known as fragmentizer). For potential emissions from the thermal treatment.

This practice was not observed during the inventory taking.

3.2.12 Thermal wire reclamation

3.2.12.1 General Information

Burning of cable is the process in which copper and lead are recovered from wire by burning the insulating material. In its most basic form, this process takes place in the open and consists of scrap wire, which is burned to remove wire coverings. In many countries this would be considered to be an illegal operation. More sophisticated operations would use a furnace with gas clean-up consisting of afterburners and scrubbers. In this process, all ingredients to form PCDD/PCDF are present: carbon (sheath), chlorine (PVC or mould- resistant agents) and a catalyst (copper).

3.2.12.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 29).

Classification	Emission Factors – µg TEQ/t of Material				
	Air	Water	Land	Product	Residue
1. Open burning of cable	5,000	ND	ND	ND	ND
2. Basic furnace with afterburner and wet scrubber	40	ND	NA	ND	ND
3. Burning electric motors and brake shoes, *etc.* – afterburner fitted	3.3	ND	NA	ND	ND

Table 29: Emission factors for thermal wire reclamation.

3.2.12.3 Results

Thermal wire reclamation was observed in Yemen. Nine sites were investigated in the coastal areas, in the Governorates of Taiz, Hodaida, Hadhramout coast (Mukalla), Shabwa, Lahj, Al-Mahra, Hajja and Abyan. The largest one produces 3 600 tons of cables, while the smallest one 187 tons annually. The total activity rate is 8 167 tons (Table 30). This sector is the second highest contributor to the dioxin and furan releases in the ferrous and non ferrous metallurgical processing sector with 40.8 g I-TEQ/a (Illustration 18). The releases are very high due to the lack of any air pollution control systems and due to the presence of copper, which is excellent catalyst for dioxin and furan releases.

Country	Estimated annual source strength (tons)
Egypt	0
Jordan	0
Sudan	0
Yemen	8,167
Total:	**8,167**

Table 30: Thermal wire reclamation, annual source strength

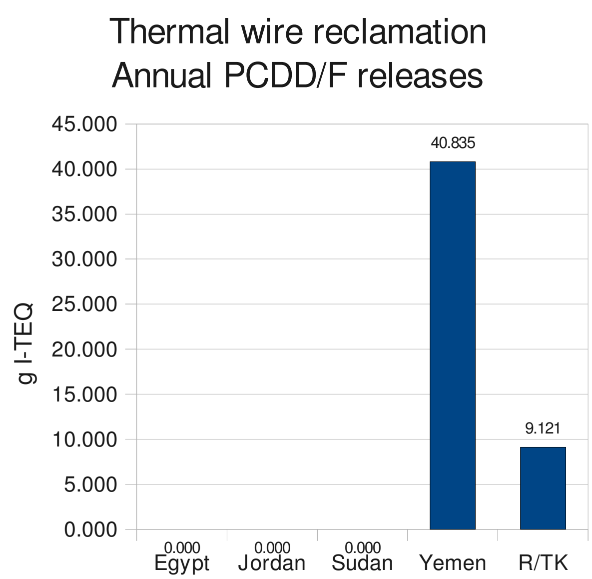


Illustration 18: Thermal wire reclamation, PCDD/F releases

3.2.12.4 Incomplete information

There was no organized thermal wire reclamation to recover copper or aluminium identified during the inventory process in other countries, though we believe that this activity is practised.

3.3 Main category no 3 - Heat and power generation

The category of power generation and heating includes power stations, industrial firing places (furnaces) and installations for providing space heating, which are fired with fossil fuels (including the co-combustion of up to 1/3 of waste), biogas including landfill gas, and biomass. The main release vectors are air and residue. Land is considered a release vector only in case of domestic heating and cooking either using biomass (mostly wood) or fossil fuels. Releases to land can occur if residues are dumped on the ground.

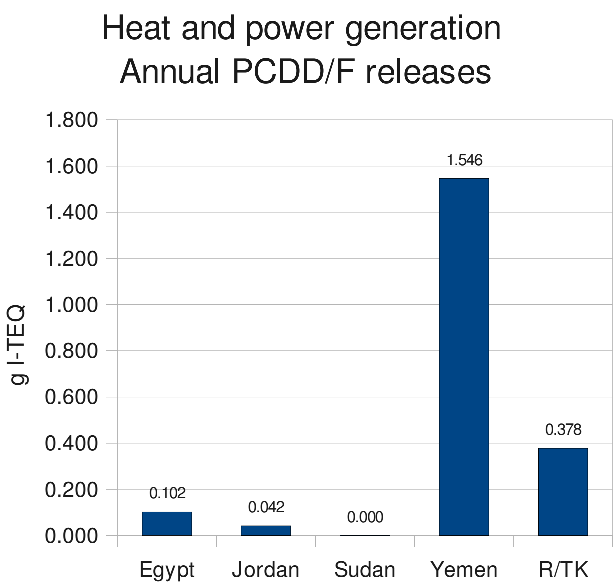


Illustration 19: Heat and power generation, country-wise distribution of the PCDD/F releases

As generation of heat or power is the aim of these plants, in the case of the combustion of biomass or fossil fuels, the amount of PCDD/PCDF cannot easily be equated to the weight (tons) of fuel burnt. The preferred basis to report emissions of PCDD/PCDF is the heating value of the fuel. As the heat or power output is the "product" of the processes this Main Source Category relates the default emission factors derived from the available data to the heating value of the fuel. The default emission factors are given in µg I-TEQ/TJ of heat input. The reason is the extremely wide variety of fuels used for power generation. The range of heating values of various fuels are also provided in the Toolkit.

The total releases of the heat and power generation sector were 1.7 g I-TEQ in 2008 (Illustration 20). This amount is rather insignificant compared to the uncontrolled combustion sector, where the total releases were above 500 g I-TEQ. The reason is that heating and energy generating facilities optimize the burning process and thus increase their profits. Another reason is the cleanliness of the fuel, by means of heaving low chlorine content. The highest contributor in this sector is the domestic heating and cooking, where the combustion process can not be controlled, there aren't any air pollution control systems. This sector accounts for 61% of the total releases in the power generation and heating source category.

Majority of the releases occur in Yemen; approximately 1.5 g I-TEQ dioxins and furans are released into the environment (Illustration 19). Due to the population density and the length of the coast 88% of the releases in this sector is from Yemen. The average releases per each kilometre coastline is 0.3 g I-TEQ.

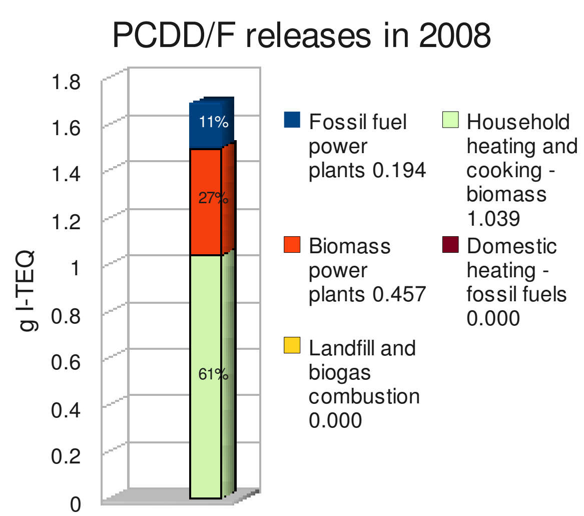


Illustration 20: Heat and power generation, PCDD/F releases per sub-sector

3.3.1 Fossil fuel power plants

3.3.1.1 General Information

Fossil fuel fired power plants generate the majority of the electricity consumed in today's world. In most Western countries, fossil fuel based power generation accounts for 50–70 % of the overall power production. In many developing nations as well as countries with economies in transition, fossil fuel based generation accounts for over 90 % of the overall power production in the public and industrial sectors.

Four categories are defined within this subcategory according to the types of fuels used, namely coal, heavy fuel oil, light fuel oil and natural gas, as well as any type of fossil fuel in a combination with the co-combustion of any kind of waste or sludge. For all four categories, it is assumed that reasonably well-operated and maintained power steam generators are employed in order to maximize power output. In all cases, air and residue are the only two release vectors under consideration.

Fossil fuel is burned in a wide array of devices for power generation ranging from small stoker fired furnaces to large elaborate highly sophisticated boiler/burner systems with extensive air pollution control (APC) plants at the back end.

Heavy fuel oil is also combusted for power generation purposes. It is usually burned in specially designed burners incorporated in the boiler walls. The formation of PCDD/PCDF is favoured during co-combustion of liquid or sludge wastes such as waste oil and/or used solvents.

Light fuel oil and natural gas are always fired in specially designed burners and are not likely to generate large amounts of PCDD/PCDF since both are very high calorific, clean burning fuels with little to no ash. Only if liquid or sludge waste is co-fired higher concentrations of PCDD/PCDF may be formed.

3.3.1.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 31).

Classification	Emission Factors - µg TEQ/TJ of Fossil Fuel Burned		
	Air	Water	Residue
1. Fossil fuel/waste co-fired power boilers	35	ND	ND
2. Coal fired power boilers	10	ND	14
3. Heavy fuel fired power boilers	2.5	ND	ND
4. Shale oil fired power plants	1.5	ND	*
5. Light fuel oil/natural gas fired power boilers	0.5	ND	ND

Table 31: Emission factors for fossil fuel power plants.

3.3.1.3 Results

The inventory of the Egyptian Red Sea coastal zone included nineteen fossil fuel power plants for generating electricity with annual 49 427 TJ capacity (Table 32). The calculated releases are 0.1 g I-TEQ to air (Illustration 21).

In Jordan this subcategory covers fossil fuel electricity generation for distribution through the national grid and also fuel use in boilers for industrial heating and processing. Activity data relating quantity of fuel used in boilers of hotels, industries, asphalt mixer…etc. was sourced from the different sectors through field visits. Twentyone locations have been identified including hotels, industrial boilers, etc.

Suez Governorate has the largest emission of dioxins and furans to air compared to other Governorates.

Light fuel oil and Diesel are used as fuel to produce electric power in three power stations at Port Sudan city.

In Yemen two facilities were located in Mukalla and in Hidaida. They burn waste oil to produce energy. Several other power plants and industrial boilers were located. The annual capacity in this sector is 35 776 tons.

Due to the very thorough inventory data collection in Jordan more sources were identified than in the other countries, thus the releases of PCDD/F are comparatively higher than in the case of other countries. The highest releases were observed in Egypt (0.10 g I-TEQ) followed by Yemen with 0.05 g I-TEQ.

Country	Estimated annual source strength (TJ)
Egypt	49,427
Jordan	46,961
Sudan	245
Yemen	35,776
Total:	**132,409**

Table 32: Fossil fuel power plants, annual source strength

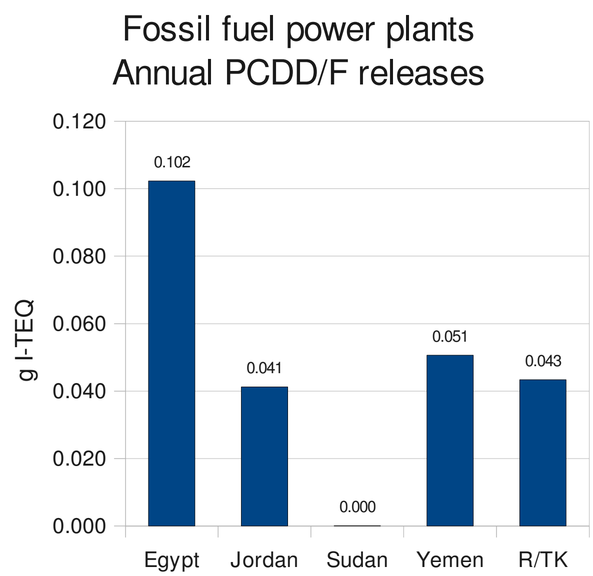


Illustration 21: Fossil fuel power plants, PCDD/F releases

3.3.1.4 Incomplete information

The inventory data collection could not cover all the sources in Egypt and in Yemen. The next inventory taking will investigate this sector in more detail.

3.3.2 Biomass power plants

3.3.2.1 General Information

Many countries and regions rely heavily on the combustion of biomass for power and heat production. Whether it is wood including twigs, bark, saw dust, wood shavings, etc., peat, and/or agricultural residue (e.g., straw, citrus pellets, coconut shells, poultry litter, camel excretes, etc.). In most cases, biomass is burned directly and without any addition of fossil fuels in small, continuously operated steam boilers. For the Toolkit, two categories are defined within this subcategory according to the types of biomass fuel used, namely wood fired boilers, and all other types of biomass fired boilers. For both categories, it is assumed that reasonably well-operated and maintained power steam generators are employed in order to maximize power output. In all cases, air and residue are the only two release vectors under consideration. This category does not address firing of contaminated wood, which is covered in open burning main source category.

3.3.2.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 33).

Classification	Emission Factors - µg TEQ/TJ of Biomass Burned		
	Air	Water	Residue
1. Mixed biomass fired power boilers	500	ND	ND
2. Clean wood fired power boilers	50	ND	15

Table 33: Emission factors for biomass power plants.

3.3.2.3 Results

Two biomass installations were observed in the inventory process. One in Jordan using clean wood as fuel to generate steam and electricity. In Yemen clean wood is used for generating heat for lime production. The amount of fuel wood is considered here, which is 7 036 tons (Table 34). The total annual releases of this sector is 0.45 g I-TEQ (Illustration 22).

Country	Estimated annual source strength (TJ)
Egypt	0
Jordan	4
Sudan	0
Yemen	7,032
Total:	**7,036**

Table 34: Biomass power plants, annual source strength

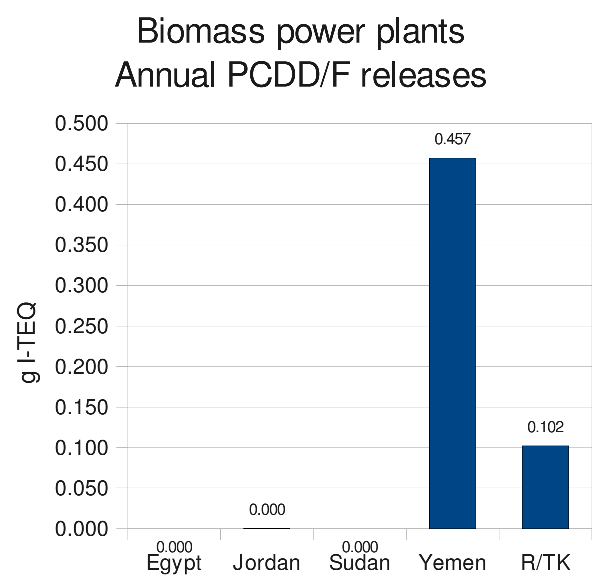


Illustration 22: Biomass power plants, PCDD/F releases

3.3.3 Landfill and biogas combustion

3.3.3.1 General Information

Landfill gas and biogas are both generated from anaerobic digestion of organic matter. The resulting gas is a mixture of carbon monoxide (CO), carbon dioxide (CO2), methane (CH4), and ammonia (NH3), and smaller fractions of combustible gases as well as a large fraction of water (H2O). The combustible portion of the gas is usually around 50 % and the heating value is 15–25 MJ/kg depending on the origin of the gas. The combustion of landfill and biogas either occurs in a flare, in gas motors or turbines and or other power generating devices.

The combustion of these gases for power generation takes place predominantly in either gasfired boilers or gas motors/turbines. Both systems closely resemble their templates firing natural gas. The combustion process is virtually residue free.

Biogas collection and combustion was not observed during the inventory process.

3.3.4 Household heating and cooking – Biomass

3.3.4.1 General Information

Heating and cooking in residential households with biomass is common practice in many countries. In most cases the fuel of preference is wood, however, other biomass fuels may be used such as straw, peat, etc.. The Toolkit lists two individual categories within this subcategory and the main difference between these two categories is the purity of the fuel. Such differentiation was not done in the public and industrial sectors for power and heat generation where the use of contaminated biomass, e.g. wood, is considered waste wood disposal. Thus, the differentiation is between virgin biomass and contaminated biomass such as treated and/or painted wood, straw heavily impacted by chlorinated pesticides. Air, residue, and in some cases land are the release vectors under consideration.

Biomass for residential heating and cooking is burned in a wide array of devices ranging from small, open pit stoves and fireplaces to large elaborate highly sophisticated wood burning stoves and ovens. The combustion of biomass for household heating and cooking takes place predominantly in devices of increasing combustion efficiency as the gross national product and the state of development of individual countries increase.

3.3.4.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 35).

Classification	Emission Factors - µg TEQ/TJ of Biomass Burned		Concentration µg TEQ/t ash Residue
	Air	Land	
1. Contaminated biomass fired stoves	1,500	ND	1,000
2. Virgin biomass fired stoves	100	ND	10

Table 35: Emission factors for household heating and cooking.

3.3.4.3 Results

Household heating and cooking was only calculated in Yemen, where significant amount (10 387 tons) of biomass is used for cooking. This correlates to 1 g I-TEQ dioxins and furans releases. (Table 36, Illustration 23).

Country	Estimated annual source strength (TJ)
Egypt	0
Jordan	0
Sudan	0
Yemen	10,387
Total:	**10,387**

Table 36: Household heating and cooking, annual source strength

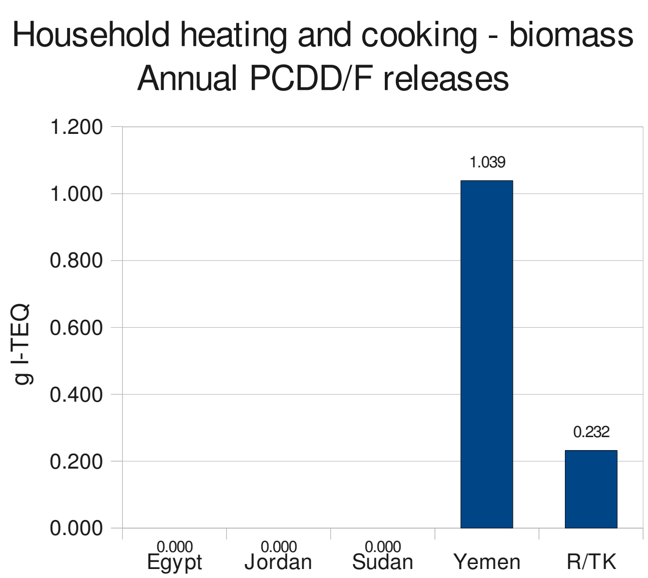


Illustration 23: Household heating and cooking - biomass, PCDD/F releases

3.3.4.4 Incomplete information

The inventory data collection could not cover all the sources, especially in Egypt and in Sudan. The next inventory taking will investigate this sector in more detail.

3.3.5 Domestic heating - Fossil fuels

3.3.5.1 General Information

Fossil fuel is used extensively for domestic heating, especially in developed countries and in countries with economies in transition. Coal, (light fuel) oil and (natural) gas are the main sources of fossil fuel used for domestic heating, which will constitute the three categories within this subcategory. For all three categories, it is assumed that reasonably well-operated and maintained heating ovens are employed in order to maximize heat output. In all cases air is the release vector under consideration. In case of coal combustion, residue must also be considered as a potential release vector. Fossil fuel is burned in devices from small stoker fired furnaces to large elaborate highly sophisticated boiler/burner systems for central heat generation in large multi unit residential buildings.

3.3.5.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 37).

Classification	Emission Factors - µg TEQ/TJ of Fossil Fuel Burned Air	Concentrations – ng TEQ/kg Ash Residue
1. High chlorine coal-fired stoves	15,000	30,000
2. Coal fired stoves	100	5,000
3. Oil fired stoves	10	NA
4. Natural gas fired stoves	1.5	NA

Table 37: Emission factors for domestic heating.

3.3.5.3 Results

This sector is rather insignificant due to the warm climate of the countries. Household cooking with natural gas fired stoves are present, though. The inventory concluded 192 TJ power in this sector (Table 38). The releases of PCDD/Fs are negligible, therefore no graph is presented.

Country	Estimated annual source strength (TJ)
Egypt	0
Jordan	177
Sudan	15
Yemen	0
Total:	**192**

Table 38: Domestic heating - fossil fuel, annual source strength

3.3.5.4 Incomplete information

The inventory data collection could not cover all the sources, especially in Egypt and in Yemen. The next inventory taking will investigate this sector in more detail.

3.4 Main category no 4 - Production of mineral products

This section summarizes high-temperature processes in the mineral industry. Raw materials or fuels that contain chlorides may potentially cause the formation of PCDD/PCDF at various steps of the processes, e.g., during the cooling phase of the gases or in the heat zone. Due to the long residence time in kilns and the high temperatures needed to fabricate the product, emissions of PCDD/PCDF are generally low in these processes.

The total releases in this main sector was 15.7 g I-TEQ in 2008 (Illustration 25). The major contributor is brick production accounting for 49% of the total releases. The second highest source is lime production with 31%, while the third most significant source of the releases is due to cement production (14%). In the case of brick and lime production the reason for the high releases is the way of production. In both cases the informal sector is involved in the production with small scale hand made kilns. Many time they burn wastes as well, since it is a relative cheap source of energy.

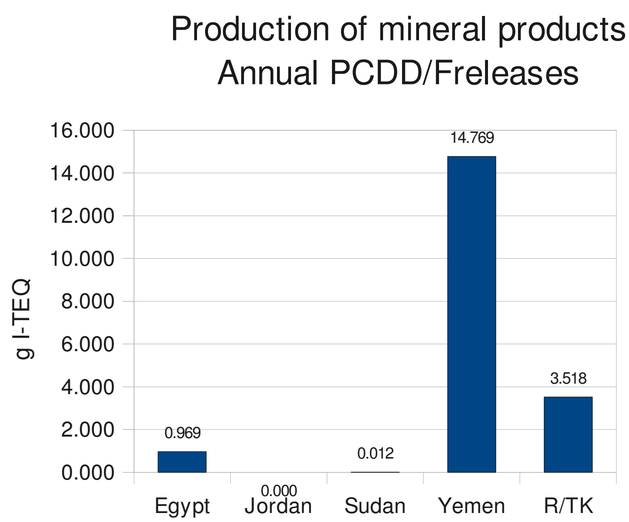


Illustration 24: Production of mineral products, country-wise distribution of the PCDD/F releases

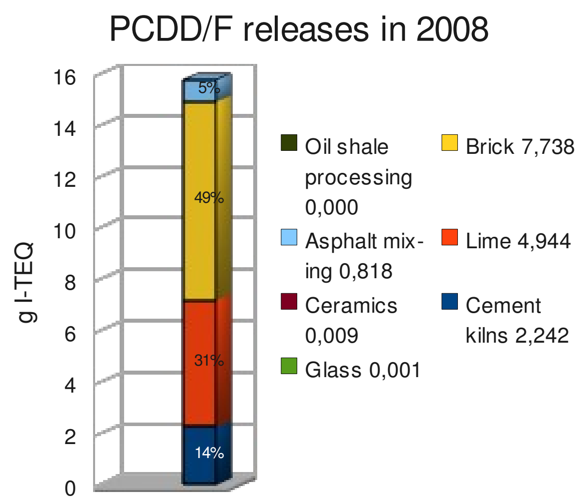


Illustration 25: Production of mineral products, PCDD/F releases per sub-sector

Among the four participating countries the most significant source of releases is Yemen (Illustration 24). The reason is the population density and the fact that here people produce clay bricks and lime themselves. The average releases per kilometre is 3.5 g I-TEQ. This source category is completely missing in Jordan.

3.4.1 Cement kilns

3.4.1.1 General Information

Principal raw materials are clay and limestone. Cement manufacture begins with calcination, which is the decomposition of calcium carbonate (CaCO3) at about 900 °C to leave calcium oxide (CaO, lime) and carbon dioxide (CO2). Afterwards, lime reacts at temperatures typically around 1,400-1,500 °C with silica, alumina, and ferrous oxide to form silicates, aluminates, and ferrites of calcium (= clinker). The clinker is then ground or milled together with gypsum (CaSO4) and other additives to produce cement.

There are four main process routes for the manufacture of cement: the dry, semi-dry, semi- wet and wet processes. In the dry process, the raw materials are ground and dried to raw meal, which is fed to the pre-heater or pre-calciner kiln (or more rarely into a long dry kiln). The dry process requires less energy than the wet process. Today, the majority of the clinker kilns use the dry process (WBCSD 2004). The older technology is the wet process where raw materials (very often with high moisture content) are ground in water to form a pumpable slurry, which is fed directly into the kiln or first into a slurry dryer. A greater amount of heat per ton of clinker produced is needed for the wet process to evaporate the additional water than in other processes.

Typical fuels used are coal, oil, gas or petroleum coke. In many cases a variety of alternative fuels derived from wastes are also used to supplement the fossil fuel. The wastes used may include: waste oils, solvents, animal meals, certain industrial wastes, and in some cases hazardous wastes. Most of these will be fired at the burner (hot) end of the kiln. Tires are often used and may be added to the kiln some distance from the hot end as whole tires or chipped.

3.4.1.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 39).

Classification	Emission Factors – µg TEQ/t of Cement				
	Air	Water	Land	Product	Residue
1. Shaft kilns	5.0	ND	ND	ND	ND
2. Old wet kilns, ESP temperature >300 °C	5.0	ND	ND	ND	NA
3. Rotary kilns, ESP/FF temperature 200-300 °C	0.6	ND	NA	ND	NA
4. Wet kilns, ESP/FF temperature <200 °C Dry kilns preheater/precalciner, T<200 °C	0.05	ND	NA	ND	NA

Table 39: Emission factors for cement production.

3.4.1.3 Results

The inventory of Egypt includes four companies for cement production in the Suez Governorate with annual expected releases of 0.7 g TEQ to air (Illustration 26). The highest emission was observed from the Egyptian Cement Company (0.5 g TEQ/a to air) and is due to the large amount of cement produced per year (10,000,000 ton/a) which represents about 63.5% of the total annual production in Suez Governorate (15 755 046 tons) . The plants apply wet kilns with sophisticated APC.

There are four cement factories in Yemen. Three are located in the coastal zone, one in Taiz applying the dry process, one in Lahj and one in Hodaida governorates using the wet process. The total annual capacity is 2 357 125 tons (Table 40), which is less than in Egypt and still the releases are two times higher. This strongly reflects the potential release reductions which could be saved by applying BAT/BEP.

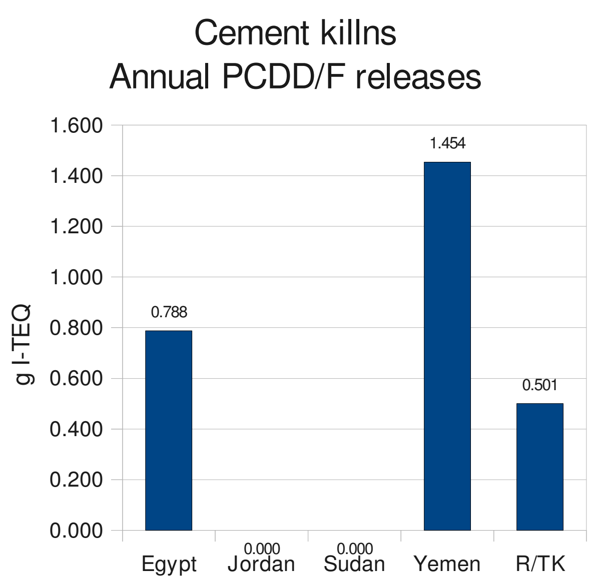


Illustration 26: Cement kilns, PCDD/F releases

Country	Estimated annual source strength (tons)
Egypt	15,755,046
Jordan	0
Sudan	0
Yemen	2,357,125
Total:	**18,112,171**

Table 40: Cement killns, annual source strength

3.4.2 Lime

3.4.2.1 General Information

Lime is used in a wide range of products. Quicklime (or burnt lime) is calcium oxide (CaO) produced by decarbonization of limestone (CaCO3). Slaked lime is quicklime with water content and consists mainly of calcium hydroxide (Ca(OH)2). Major users of lime are the steel industry, construction, pulp and sugar industries.

The lime making consists of the burning of calcium and/or magnesium carbonate at a temperature between 900 and 1,500 °C. For some processes, much higher temperatures are needed. The calcium oxide product (CaO) from the kiln is generally crushed, milled, and/or screened before being conveyed into a silo. The burned lime is either delivered to the end user for in the form of quicklime or reacted with water in a hydrating plant to produce hydrated lime or slaked lime.

Different fuels - solid, liquid, or gaseous - are used in lime burning. The fuels provide the energy to calcine the lime but also interact with the process. Most kilns can operate on more than one fuel. The lime burning process involves two phases:

1. Providing sufficient heat at above 800 °C to heat the limestone and cause decarbonization, and

2. Holding the quicklime at sufficiently high temperatures (around 1,200-1,300 °C) to adjust reactivity.

Most of the kilns are either shaft or rotary design. Most kilns are characterized by the counter-current flow of solids and gases. Fluidized bed kilns and rotary hearths may also be found.

3.4.2.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 41).

Classification	Emission Factors – µg TEQ/t of Lime Produced				
	Air	Water	Land	Product	Residue
1. No dust control or contaminated, poor fuels	10	NA	ND	ND	ND
2. Lime production using dust abatement	0.07	NA	ND	ND	ND

Table 41: Emission factors for quicklime production.

3.4.2.3 Results

The inventory in Yement located thirty-six incinerators (Keer) for production of lime in Hadramawt coast. Seventeen of them are operating in Shamosha, and seven in Boish. The rest of incinerators are temporarily not functioning e.g.: six incinerators in Boish and six in Sheher. The main fuel is timber, tires, waste lube oils, and sometimes using animal dung and saw dust. The fuel used in Shamosa is timber, while in Boish waste lube oil is used as well. Burning dry fuel varies according to lime (Alnorah) required. The quality is relative to the use of wood: if dry, the quality is excellent. In the event of the use of waste lube oils the quality is poor. The annual production capacity is 49 4190 tons in Yemen (Table 42). The annual release from this sector in Yemen is 4.9 g TEQ/a (Illustration 27).

In Egypt one company was located in the Suez Governorate. The annual 24 000 tons, which is half the amount they produce in Yemen. At the same time the releases are more than 99% less due to appropriate technologies.

This sector releases the second highest amount of dioxins and furans into the environment.

Country	Estimated annual source strength (tons)
Egypt	24,000
Jordan	0
Sudan	0
Yemen	494,190
Total:	**518,190**

Table 42: Lime production, annual source strength

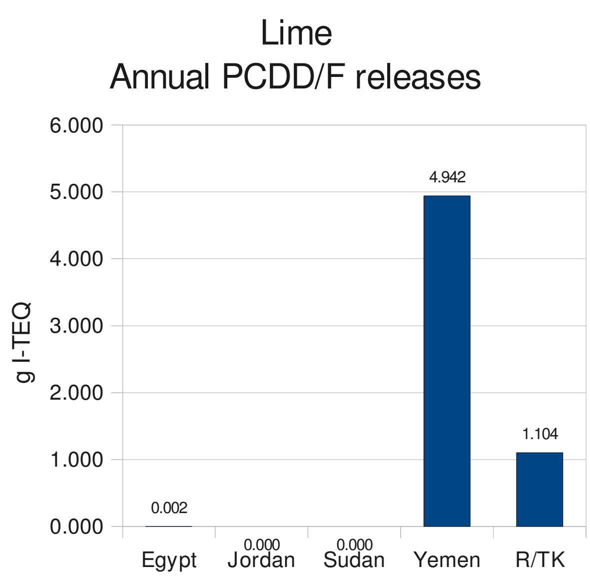


Illustration 27: Lime production, PCDD/F releases

3.4.3 Brick

3.4.3.1 General Information

Bricks are predominantly made from clay with some additional materials added to achieve desired porosity and other characteristics. Industrial production typically uses tunnel type kilns with firing temperatures of around 1,000 °C. Fuels for such systems would be oil or gas and attention is paid to gas cleaning with fluoride removal in some cases. More basic brick firing may be carried out with a variety of kiln types and different fuels. In some cases there will be little in the way of gas cleaning technology.

3.4.3.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 43).

Classification	Emission Factors – µg TEQ/t of Brick Produced				
	Air	Water	Land	Product	Residue
1. No dust control or contaminated, poor fuels	0.2	NA	NA	ND	ND
2. Brick production using dust abatement	0.02	NA	NA	ND	ND

Table 43: Emission factors for brick production.

3.4.3.3 Results

Red bricks from clay are only produced in Yemen. The steps of small scale production are 1.) the mud is mixed with animal dung then divided into cubes, 2.) the cubes are left to dry in the sun for one to two days, 3.) the dry mud is introduced to an incineration furnace which is built of bricks in the form of pillars, 4.) there is a pit filled with wood and diesel is poured on wood for flaring, 5.) after completion of burning of firewood, the animal dung component of the brick is burnt. Bricks are left inside the furnace for a period of seven to ten days. Finally, the bricks are removed from the furnace. The quantity of production varies. The inventory located four incinerators that produced weekly and another one which produced biweekly. There were other four incinerators that produced every ten days. Only one incinerator is noticed in Hadramaut coast (Mukalla). The total amount of bricks produced in a year is 38 687 569 tons (Table 44). Annual releases are 7.7 g I-TEQ (Illustration 28), which are the highest for the production of mineral goods main source category.

Country	Estimated annual source strength (tons)
Egypt	0
Jordan	0
Sudan	0
Yemen	38,687,569
Total:	**38,687,569**

Table 44: Brick production, annual source strength

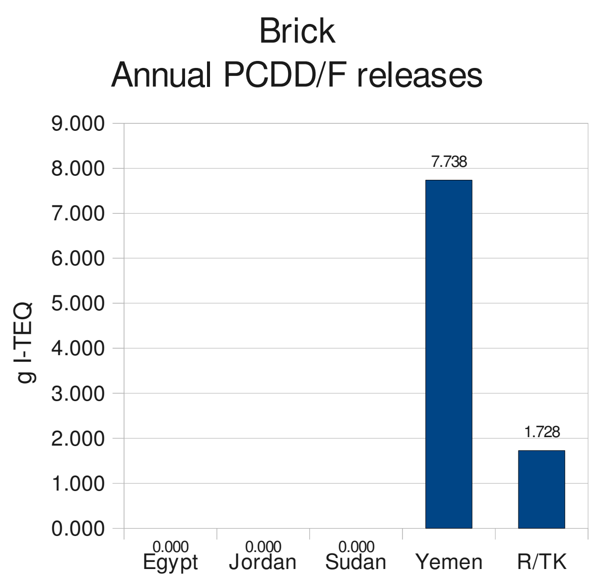


Illustration 28: Brick production, PCDD/F releases

3.4.4 Glass

3.4.4.1 General Information

Furnaces used for glass manufacture may be continuously or intermittently operated. Typical fuels are oil and gas. The raw materials are principally sand, limestone, dolomite and soda. In addition a wide range of other materials may be used to achieve desired properties such as color, clarity, and for purification. Chlorinated and fluorinated compounds may be added . In some modern glass furnaces gases are cleaned with sorbents and electrostatic precipitators or fabric filters .

3.4.4.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 45).

Classification	Emission Factors – µg TEQ/t of Product				
	Air	Water	Land	Product	Residue
1. No dust control or contaminated, poor fuels	0.2	NA	ND	ND	ND
2. Glass production using dust abatement	0.015	NA	ND	ND	ND

Table 45: Emission factors for glass production.

3.4.4.3 Results

The inventory process identified one company for glass production in the Suez Governorate in Egypt. Annual production is 36 000 tons of glass (Table 46). The company applies good abatement system, therefore the releases are almost negligible (0.001 g I-TEQ) Illustration 29.

Country	Estimated annual source strength (tons)
Egypt	36,000
Jordan	0
Sudan	0
Yemen	0
Total:	**36,000**

Table 46: Glass production, annual source strength

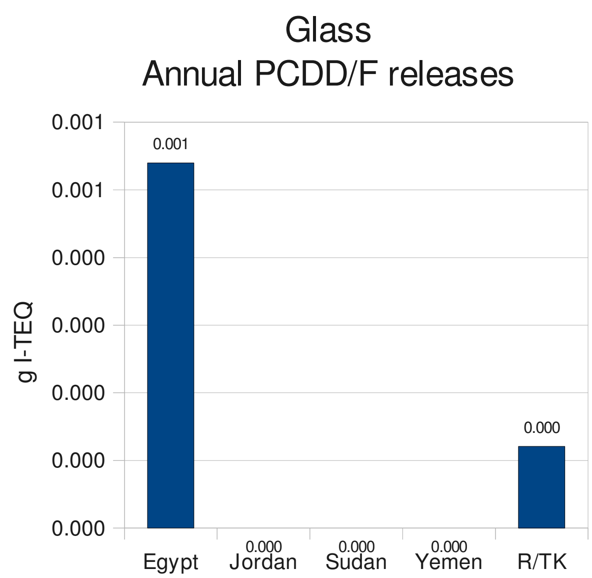


Illustration 29: Glass production, PCDD/F releases

3.4.5 Ceramics

3.4.5.1 General Information

The Toolkit could not collect enough information to consider the production of ceramics as a source of PCDD/PCDF. It is likely that because it is a thermal process PCDD/PCDF will be released to air. It is proposed that an estimate be made by the application of the emission factors developed for brick making above.

3.4.5.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 47).

Classification	Emission Factors – µg TEQ/t of Brick Produced				
	Air	Water	Land	Product	Residue
1. No dust control or contaminated, poor fuels	0.2	NA	NA	ND	ND
2. Brick production using dust abatement	0.02	NA	NA	ND	ND

Table 47: Emission factors for ceramics production.

3.4.5.3 Results

The inventory exercise identified one company producing ceramics in the Suez Governorate in Egypt. The annual capacity of the facility is 433 750 tons of ceramics (Table 48), which corresponds to 0.009 g I-TEQ dioxin and furan releases, due to good dust abatement techniques (Illustration 30).

Country	Estimated annual source strength (tons)
Egypt	433,750
Jordan	0
Sudan	0
Yemen	0
Total:	**433,750**

Table 48: Ceramics, annual source strength

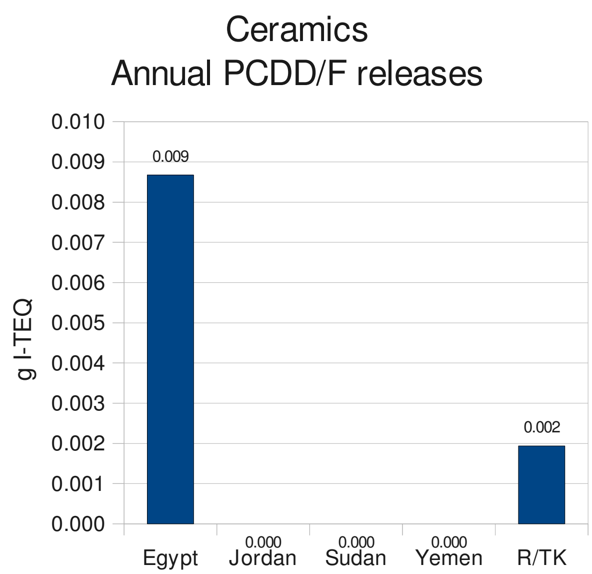


Illustration 30: Ceramics production, PCDD/F releases

3.4.6 Asphalt mixing

3.4.6.1 General Information

Asphalt is used for road construction and generally would consist of rock chips, sand, fillers bound together in bitumen. Fillers can include fly ash from incineration or power plants. The first stage of the process is generally an air-drying unit for the minerals. The hot minerals are then mixed with hot bitumen to obtain asphalt.

Asphalt mixing plants in industrialized countries may typically have gas cleaning consisting of fabric filters or wet dust control devices.

3.4.6.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 49).

Classification	Emission Factors – µg TEQ/t of Asphalt				
	Air	Water	Land	Product	Residue
1. Mixing plant with no gas cleaning, poor fuels	0.07	NA	ND	ND	ND
2. Mixing plant with fabric filter or wet scrubber	0.007	NA	ND	ND	0.06

Table 49: Emission factors for asphalt mixing.

3.4.6.3 Results

Asphalt mixing is present everywhere in the coastal zone as it develops very fast. In the case of Jordan asphalt is produced outside ASEZA (the Free Economy Zone) and is imported, therefore it is not indicated in the report. There are four asphalt mixing facilities in Port Sudan city. All of them are stationary and do not have gas cleaning filter or wet dust control devices. The total annual capacity of three of them is 175 000 tons (Table 50). No information could be collected about the the fourth company which works only upon request.

In Egypt the total releases were 0.17 g I-TEQ in 2008 (Illustration 31). In Yemen asphalt mixing plants in all of the eight provinces can be found. The total activity rate is 9 074 400 tons with 0.63 g I-TEQ dioxin and furan releases.

Country	Estimated annual source strength (tons)
Egypt	2,440,000
Jordan	0
Sudan	175,000
Yemen	9,074,400
Total:	**11,689,400**

Table 50: Asphalt mixing, annual source strength

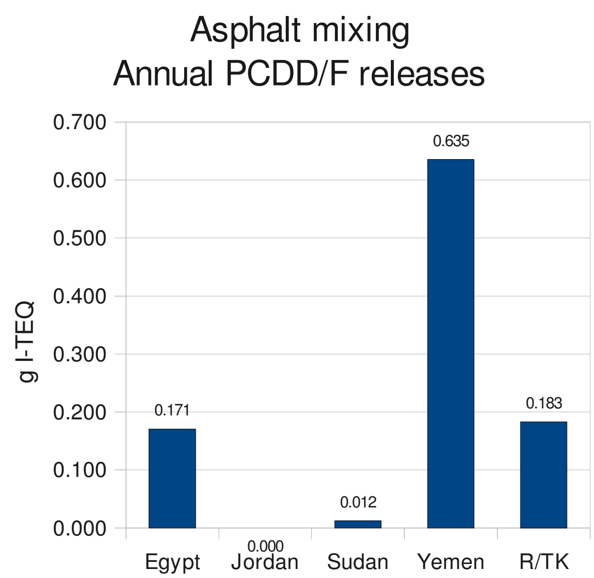


Illustration 31: Asphalt mixing, PCDD/F releases

3.4.6.4 Incomplete information

The inventory data collection could not cover all the sources, especially in Sudan for one company. The next inventory taking will investigate this sector in more detail.

3.4.7 Oil shale processing

3.4.7.1 General Information

Shale is a fine-grained sedimentary rock whose original constituents are clays or muds. Oil shale is a general term applied to a group of fine black to dark brown shales rich enough in bituminous material (called kerogen) to yield petroleum upon distillation. The kerogen in oil shale can be converted to oil through pyrolysis. During pyrolysis the oil shale is heated to 500 °C in the absence of air and the kerogen is converted to oil and separated out, a process called "retorting".

Oil shale processing is non-existing in the countries covered by the inventory exercise.

3.5 Main category no 5 - Transportation

The major fuels used in transportation are gasoline, diesel, and liquefied petroleum gas (LPG). In the Toolkit, emission factors are given for the type of fuel and the type of combustion engine.

There is a growing market for other fuels for which, so far, there are no dioxin measurements available. In order to accommodate releases from these fuels, the following assignments are included:

- For LPG-fuelled cars: take emission factor for 4-stroke engines with catalyst (category 5a3);
- For oil/gas or oil/gasoline mixtures: the emission factor for Diesel should be applied (category 5c).

So far, the occurrence of PCDD/PCDF has not been reported from aircrafts.

Transport sector is present in all of the participating countries. The highest releases (6.7 g I-TEQ) were observed in Egypt (Illustration 32). This mainly due to the strong shipping industry which uses heavy oil fuel which is not as clean as gasoline or diesel. The total releases from this sector is 11 g I- TEQ. Predominant releases are due to the heavy oil fired engines which represents 64 % of the total releases (Illustration 33). The second larges source is four-stroke engines due to their large numbers. The third place is occupied by two-stroke engines mainly because of the incomplete combustion and the co-incineration of motor oils in the engines.

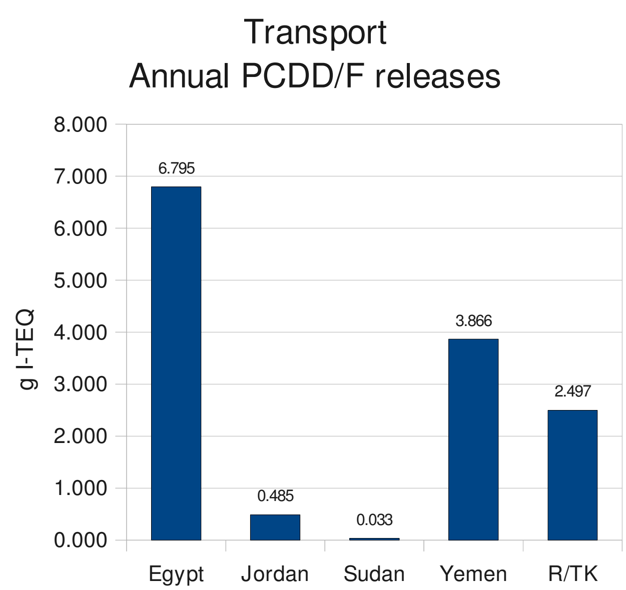


Illustration 32: Transport, country-wise distribution of the PCDD/F releases

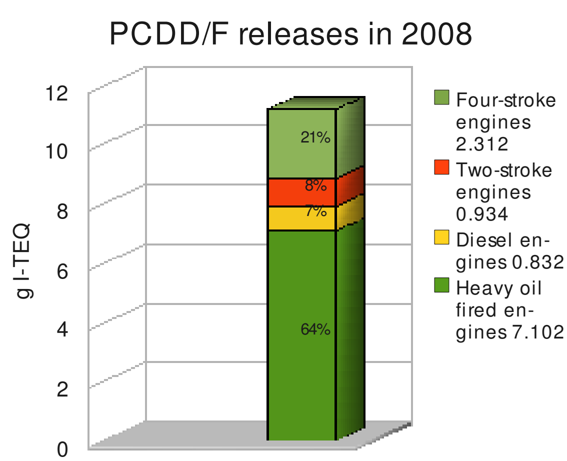


Illustration 33: Transport, PCDD/F releases per sub-sector

3.5.1 Four-Stroke engines

3.5.1.1 General Information

Most gasoline powered internal combustion engines used today in cars, light trucks, motorcycles and other vehicles are 4-stroke engines. These engines follow the thermodynamic combustion cycle invented by Nicolaus Otto, which consists of 4 strokes, namely the intake stroke, the compression stroke, the ignition and combustion stroke, and the exhaust stroke. These four strokes are completed during two full revolutions of the crankshaft. Like all combustion processes, internal combustion engines produce PCDD/PCDF as an unwanted byproduct. Higher emissions have been associated with the use of chlorinated scavengers used in leaded gasoline.

However, when unleaded gasoline is used and a catalytic converter is installed for the removal of NOx as well as unburned hydrocarbons, the emissions of PCDD/PCDF are negligible. The only release vector is into the air.

3.5.1.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 51).

Classification	Emission Factors – µg TEQ/t of Fuel Burned				
	Air	Water	Land	Product	Residue
1. Leaded fuel *	2.2	NA	NA	NA	NA
2. Unleaded fuel without catalyst *	0.1	NA	NA	NA	NA
3. Unleaded fuel with catalyst *	0	NA	NA	NA	NA

* if consumption data are given in liters (L), note that 1 L of gasoline has a mass of 0.74 kg; thus, a conversion factor of 0.00074 must be used to convert liters into tons

Table 51: Emission factors for four-stroke engines.

3.5.1.3 Results

In Egypt 21 9647 tons of fuel was used at the coastal zone in 2008 (Table 52). The highest emission was from Suez Governorate (0.00832gTEQ/a) followed by Red Sea Governorate (0.00476gTEQ/a) and then South Sinai Governorate (0.00338gTEQ/a, with annual expected releases from Red Sea Coast Governorates of 0.01647g TEQ/a to air[2].

Some of the cars in Aqaba are modern and fitted with catalytic converter but most are without catalytic converter. Activity data for the amount of petrol fuel consumed in 4-stroke internal combustion engines were sourced from the Aqaba Traffic Division. in Jordan since 2007 all types of gasoline fuel are unleaded. The total fuel consumed was 24 309 tons .

Due to the relative low population figure of Port Sudan the releases from this sector are insignificant.

In Yemen the total fuel consumption was 10 409 530 tons, representing 2.29 g I-TEQ dioxin and furan releases into the environment, which is the highest among the four countries (Illustration 34).

Country	Estimated annual source strength (tons)
Egypt	219,647
Jordan	24,309
Sudan	30,075
Yemen	10,409,530
Total:	**10,683,561**

Table 52: Four-stroke engines, annual source strength

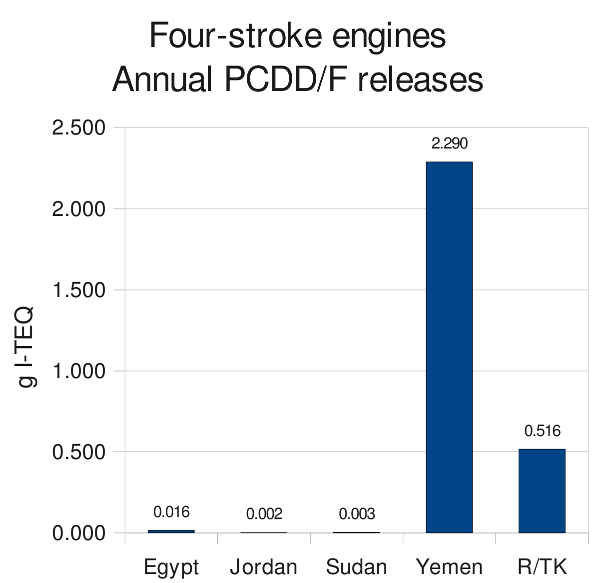


Illustration 34: Four-stroke engines, PCDD/F releases

2 From the Egyptian PCDD/F inventory, please see electrical annexes.

3.5.1.4 Incomplete information

In Egypt the inventory assumed that 25% of the total fuel consumption was unleaded fuel with catalyst. In Yemen there are two types of fuel, one with 1 % sulfur and one lower grade with 3 % sulfur. This could not be taken into consideration in the inventory process. In Jordan and Sudan the emission factor for unleaded fuel without catalyst was applied.

3.5.2 Two-Stroke engines

3.5.2.1 General Information

Most small gasoline powered internal combustion engines used today in boats, jet-skis, mopeds, small motorcycles, tuk-tuks, lawnmowers, chain saws, and other vehicles are 2- stroke engines. These engines follow the same thermodynamic combustion cycle as the 4- stroke engines; however, it consists of only 2 strokes, namely the combined exhaust and intake stroke, and the compression, ignition and combustion stroke. The most striking difference to the 4-stroke engine is the fact that all strokes occur during only 1 full revolution of the crank shaft. Lubrication is usually by oil added with the fuel. Therefore, higher amounts of pollutants may be released and efficiency may be lower compared to 4-stroke engines.

However, the simplicity and low production cost of 2-stroke engines make it an ideal motor especially for small engines. Like all combustion processes, 2-stroke engines also produce PCDD/PCDF as an unwanted byproduct. The only release vector is into the air. All other release vectors are not present.

3.5.2.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 53).

Classification	Emission Factors – µg TEQ/t of Fuel Burned				
	Air	Water	Land	Product	Residue
1. Leaded fuel *	3.5	NA	NA	NA	NA
2. Unleaded fuel without catalyst *	2.5	NA	NA	NA	NA

* if consumption data are given in liters (L), note that 1 L of gasoline has a mass of 0.74 kg; thus, a conversion factor of 0.00074 must be used to convert liters into tons

Table 53: Emission factors for two-stroke engines.

3.5.2.3 Results

In Egypt the total (unleaded) fuel consumption of the two-stroke engines was estimated to be 9 598 tons (Table 54). In Jordan it was 324 tons, while in Yemen 259 686 tons of fuel was used by this sector. The reason for this is the high population figure at the coast in Yemen and that people use motorbikes more often than in other countries of the region. The highest releases are form Yemen with 0.9 g I-TEQ (Illustration 35).

Country	Estimated annual source strength (tons)
Egypt	9,598
Jordan	324
Sudan	0
Yemen	259,686
Total:	**269,608**

Table 54: Two-stroke engines, annual source strength

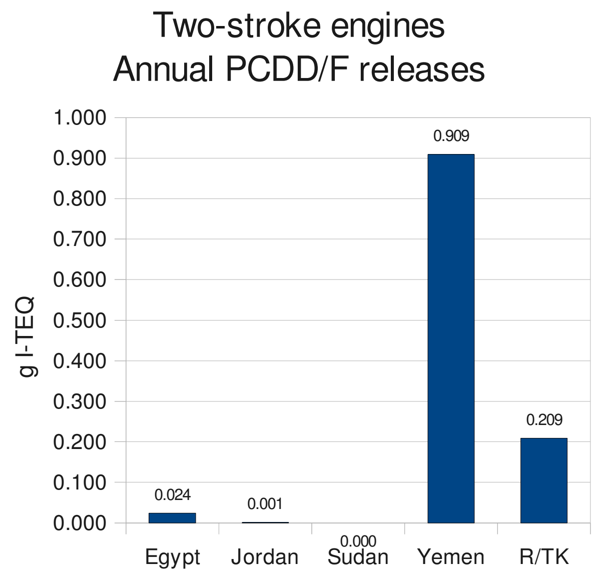


Illustration 35: Two-stroke engines, PCDD/F releases

3.5.2.4 Incomplete information

In Sudan the inventory team could not estimate this sector. During the next inventory development, this sector will also be elaborated. In the case of Jordan emission factors for leaded fuel was used in the calculation.

3.5.3 Diesel engines

3.5.3.1 General Information

Diesel engines are used in heavy trucks, light trucks, passenger cars, heavy construction equipment, boats, Diesel generators, pumps, and farm equipment including tractors and other large equipment. They usually use Diesel (light oil) and a 4-stroke cycle. Compression is used for ignition rather than a spark. Air is taken into the cylinder and compressed. Diesel fuel is added at high pressure and burned. This results also in a more efficient use of fuel and lower specific emissions. Unfortunately, particle emissions in form of soot are also associated with the operation of Diesel engines due to incomplete combustion especially during start-up, warming and load changes. Deposition of this soot can lead to releases via residues. Particulate emissions from Diesel engines are well known to contain high concentrations of polycyclic aromatic hydrocarbons (PAH). However, no PCDD/PCDF concentrations in Diesel soot are available. There is only one class of emission factor for Diesel engines.

3.5.3.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 55).

Classification	Emission Factors – µg TEQ/t of Diesel				
	Air	Water	Land	Product	Residue
Diesel engines *	0.1	NA	NA	NA	ND

* if consumption data are given in liters (L), note that 1 L of Diesel has a mass of 0.85 kg; thus, a conversion factor of 0.00085 must be used to convert liters into tons

Table 55: Emission factors for diesel engines.

3.5.3.3 Results

Diesel fuel consumption in Jordan is mostly related to sea vessels as they are required to use diesel when sailing on national waters. The engine of the Jerash (Oil Tanker), which is anchored in Aqaba as a storage tank, is running continuously. The total annual diesel fuel consumption is detailed in Table 56.

In Egypt the largest emission to air was observed from Suez Governorate and is due to the large number of transportation means.

The highest release 0.48 g I-TEQ in this source sector is form Jordan due to large consumption of diesel fuel (Illustration 36).

Country	Estimated annual source strength (tons)
Egypt	357,761
Jordan	4,822,335
Sudan	15,392
Yemen	3,125,108
Total:	**8,320,596**

Table 56: Diesel engines, annual source strength

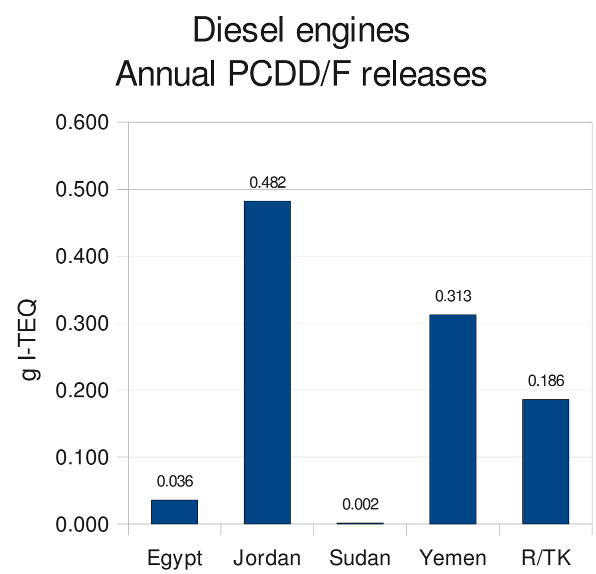


Illustration 36: Diesel engines, PCDD/F releases

3.5.3.4 Incomplete information

During the next inventory development, this sector will be investigated thoroughly since it is questionable that Jordan has the highest consumption of diesel fuel among the participating countries.

3.5.4 Heavy oil fired engines

3.5.4.1 General Information

Heavy fuel oil (HFO) fired engines are used for ships, tanks, stationary power generators, and other very large quasi-stationary motors. The availability of emission factors is very limited and according to the Toolkit no distinction can be made with respect to composition of the fuels with respect to e.g., chlorine content, type of catalytic metals present, etc. Based on very limited data, only one default emission factor to air was determined.

Waste oils are often burned in motors (stationary or in ships); they are also included in this subcategory.

3.5.4.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 57).

Classification	Emission Factors – µg TEQ/t of Fuel Burned				
	Air	Water	Land	Product	Residue
All types	4	NA	NA	NA	ND

Table 57: Emission factors for heavy fuel fired engines.

3.5.4.3 Results

The highest heavy fuel oil consumption and PCDD/F releases were observed in Egypt due to the heavy shipping industry. The total amount of heavy fuel oil used in shipping was 1 679 748 tons which represents 6.719 g I-TEQ dioxin and furan releases (Table 58, Illustration 37).

Country	Estimated annual source strength (tons)
Egypt	1,679,748
Jordan	0
Sudan	7,200
Yemen	88,631
Total:	**1,775,579**

Table 58: Heavy oil fired engines, annual source strength

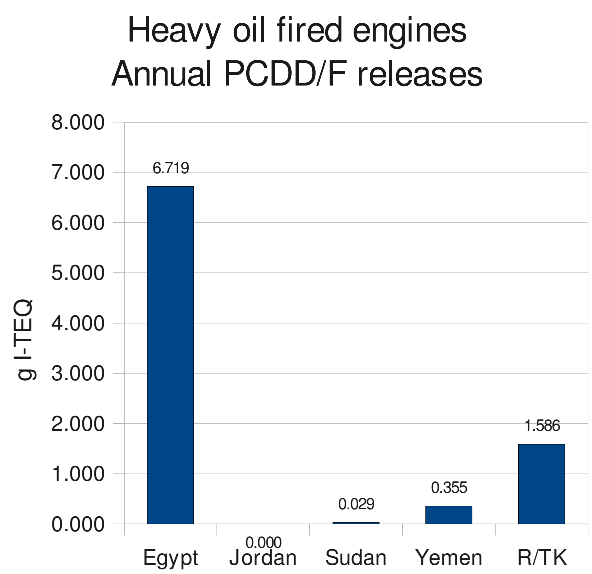


Illustration 37: Heavy oil fired engines, PCDD/F releases

3.6 Main category no 6 - Open burning processes

Open burning processes considered in this section are the combustion of harvest residues, trees or bushes in the open air where no incinerator, stove or boiler is used. This category also includes the informal "disposal" of waste in barrels or in the open air as well as landfill fires, or accidental fires in buildings, vehicles, etc. In general, none of these combustion processes and fires is controlled, thus they result in poor combustion conditions due to inhomogeneous and poorly mixed fuel materials, chlorinated precursors, humidity, or catalytically active metals present in the waste.

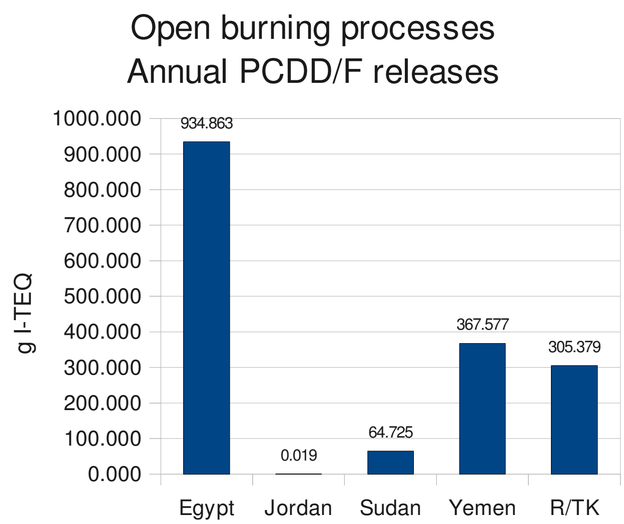


Illustration 38: Open burning processes, country-wise distribution of the PCDD/F releases

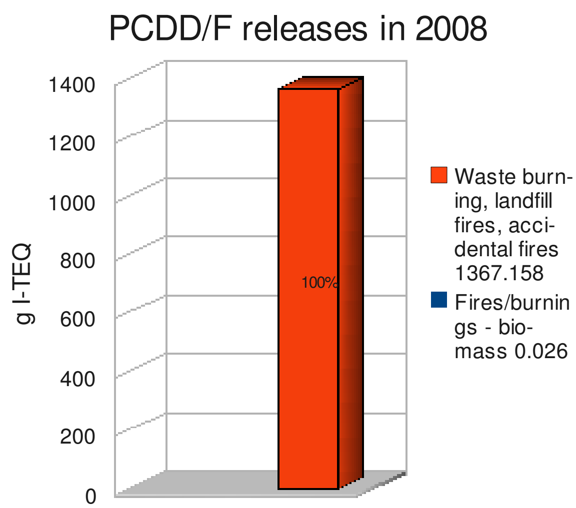


Illustration 39: Open burning processes, PCDD/F releases per sub-sector

Open burning processes, especially landfill and dumpsite fires are the most significant source of dioxins and furans releases. The total PCDD/F release from this sector is 1367.1 g I-TEQ (Illustration 39). Within this main source category nearly 100% of the releases is due to dumpsite and landfill fires. In Egypt due to the extensive population pressure and heavy tourism activities the releases are 934.8 g I-TEQ (Illustration 38). The second highest releases were observed in Yemen with 357.5 g I-TEQ.

Generally the problem is that the waste is mixed when it reaches the landfill or dumpsite. It contains organic kitchen wastes, plastics, metals, wood, paper and electronic materials. Some of them especially PVCs contain high amount of chlorines. At the same time the burning process is uncontrolled, the temperature is not high enough to destroy PCDD/Fs. On the contrary these burning processes and conditions (metal catalyst, high chlorine content) favour the formation of unintentionally produced POPs. This sector should receive the highest attention, since major release reductions could be achieved with proper waste, specifically municipal waste management.

3.6.1 Fires/burnings – biomass

3.6.1.1 General Information

This category covers the burning of biomass where it occurs in the open environmentn (i.e. excluding controlled combustion in appliances such as stoves, furnaces and boiler plants). This sub- category includes forest fires as well as burning of grassland or harvest residues such as straw, in the field. Pre-harvest burning is a common practice in some crops, such as sugar cane, to facilitate harvest. Post-harvest field burning, stubble and ditches, is a common practice to remove residues, control weeds, and release nutrients for the next crop cycle. It is a quick and labour saving tool in crop residue disposal as in rice and sugar cane production.

3.6.1.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 59).

Classification	Emission Factors – µg TEQ/t of Material Burned				
	Air	Water	Land	Product	Residue
1. Forest fires	5	ND	4	NA	NA
2. Grassland and moor fires	5	ND	4	NA	NA
3. Agricultural residue burning (in the field), impacted, poor conditions	30	ND	10	NA	NA
4. Agricultural residue burning (in the field), not impacted	0.5	ND	10	NA	NA

Table 59: Emission factors for biomass burning.

3.6.1.3 Results

Average precipitation in the coastal area is extremely low, except for a few locations such as the Tokar delta in Sudan which receives substantial runoff seasonal streams originating in Ethiopian and Eritrean highland. Subsequently agricultural activities around the Red Sea is very low. Mostly agricultural residues are not burned but are used for animal care and construction of indigenous buildings.

In Yemen agricultural activities are mostly dominant in the mountains, where herbal and grass plants are burned annually, especially in winter. The total amount of agricultural waste which is burned in a year is 917 tons, which correspond to 0.02 g I-TEQ PCDD/F releases (Table 60, Illustration 40). In other participating countries this activity was not observed.

Country	Estimated annual source strength (tons)
Egypt	0
Jordan	0
Sudan	0
Yemen	917
Total:	**917**

Table 60: Fires/burning - biomass, annual source strength

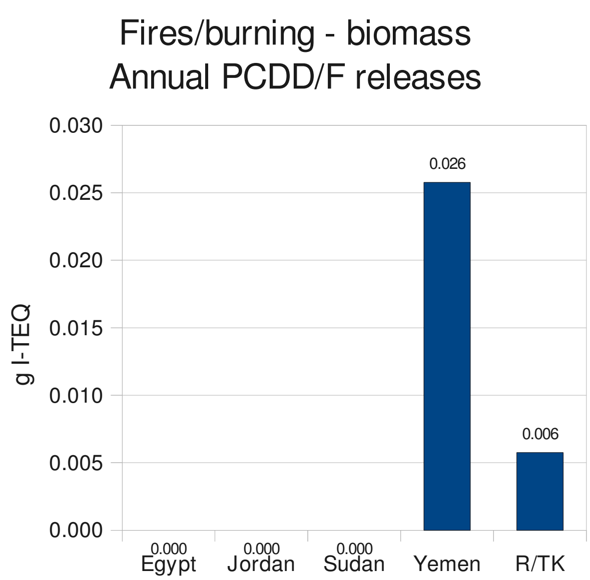


Illustration 40: Fires/burning - biomass, PCDD/F releases

3.6.1.4 Incomplete information

In Yemen the burning of agricultural waste was estimated at a rate of 5 hectares in each governorate and 4 tons of waste biomass are burned per hectare. Sick and infected branches are burnt at a rate of 0.5 kg /year/tree.

3.6.2 Fires, waste burning, landfill fires, industrial fires, accidental fires

3.6.2.1 General Information

The Toolkit 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 or accidental - fires in buildings, cars and similar vehicles. The following categories as shown in Table 54 were selected for consideration.

Uncontrolled domestic waste burning should include all instances where waste is burned with no pollution controls and therefore includes burning in the open in piles, in barrels or in home fires. The burning of waste in landfills is considered as a separate category. An estimate of the amount of PCDD/PCDF remaining in solid residues can be derived for this practice and is expressed in terms of PCDD/PCDF per unit of waste burned.

Accidental fires are very variable and the emissions will depend strongly on the materials burned and on the nature of the fire. There is limited information on emissions from these fires and a single indicative figure is given to cover all accidental fires excluding fires in vehicles. PCDD/PCDF will be present in residues that may be disposed of or left on the ground.

3.6.2.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 61).

Classification	Emission Factors – µg TEQ/t of Material Burned				
	Air	Water	Land	Product	Residue
1. Landfill fires	1,000	ND	600	NA	[600]
2. Accidental fires in houses, factories	400	ND	400	NA	[400]
3. Uncontrolled domestic waste burning	300	ND	600	NA	[600]
4. Accidental fires in vehicles	94 (per vehicle)	ND	18 (per vehicle)	NA	[18 (per vehicle)]
5. Open burning of wood (construction/demolition)	60	ND	10	NA	[10]

Table 61: Emission factors for waste burning and accidental fires.

3.6.2.3 Results

This sector is the leading source for PCDD/Fs releases. Total releases were 1367.1 g I-TEQ in 2008. In Egypt municipal solid waste is collected and dumped where self ignition and combustion takes place releasing dioxins and furans. The expected levels of dioxin and furan emissions from these dump sites were estimated to be 584g I-TEQ to air and 350.4 g I-TEQ to land[3]. The total releases reach 934 g I-TEQ (Illustration 41).

3 Please consult the Egyptian PCDD/Fs inventory for further details.

In Jordan ASEZA Banned domestic waste burning, thus uncontrolled domestic waste burning has not been undertaken. Accidental fires occur and is presented in Table 62.

In Sudan the waste collected from Port Sudan city is openly burned in certain location around the city. Medical waste is collected separately but finally it is dumped at the same place where other municipal waste is taken. Depending the direction of the wind sometimes the smouldering smog covers the city.

In Yemen the municipal waste is collected and dumped outside the cities. The national inventory indicates the amount of waste which is burned in each governorate. Municipal governments have started many projects on municipal waste management, but none of them seemed to be sustainable. The Government has allocated and environment fund, which covers the cost of waste collection, but not enough for proper management of the waste. The total amount of waste that was estimated to be burned in 2008 was 1 010 922 tons. The average releases per each thousand kilometre of coastline is 305.3 g I-TEQ.

Country	Estimated annual source strength (tons)
Egypt	584,591
Jordan	67
Sudan	40,552
Yemen	385,712
Total:	**1,010,922**

Table 62: Waste burning, landfill fires, annual source strength

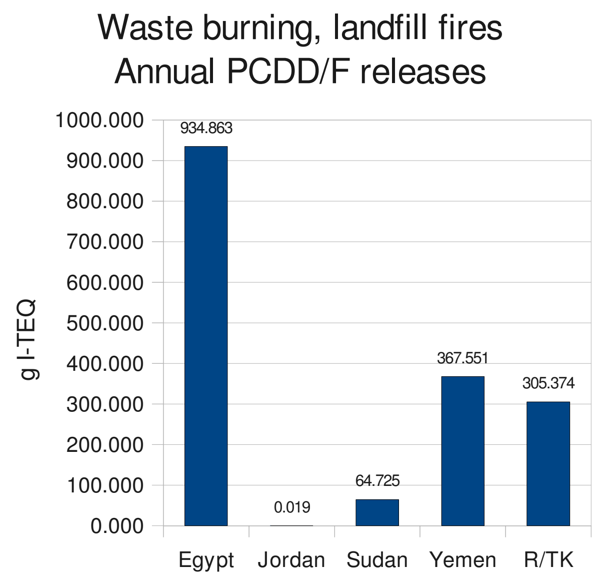


Illustration 41: Waste burning, landfill fires, PCDD/F releases

3.6.2.4 Incomplete information

The Egyptian team supposed that 50% of the total amount of landfill wastes was burnt.

3.7 Main category no 7 - Production of chemicals and consumer goods

This section describes the potency of the chemicals and consumer goods production sector to generate PCDD/PCDF and gives findings from measured data and information on characteristics to estimate/quantify release of PCDD/PCDF from the various activities in this sector. 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 air but into other compartments.

Within this main source category only two activities have been quantified. In other words, production of organic chlorine containing chemicals, such as pesticides, PVCs is virtually non existing. Textile production has not been observed in the coastal zone and pulp and paper industries have not been located either.

There are several oil fields around the Red Sea coast, thus oil refineries are present. Majority of the dioxin and furan releases are due to flaring (0.6 g I-TEQ). The largest source is Egypt in this regards releasing approximately 0.6 g I-TEQ in this main source category (Illustration 42). This represents 95% of the total release from this main source category. The other 5 % is due to leather plants (Illustration 43).

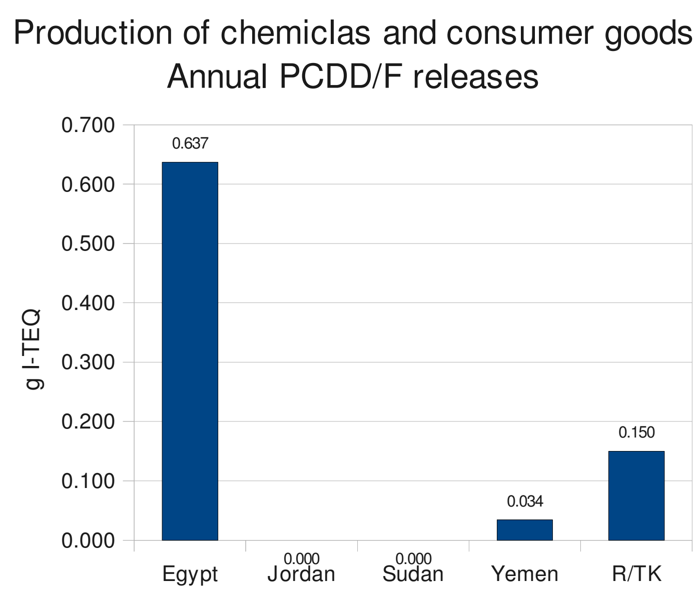


Illustration 42: Production of chemicals and consumer goods, country-wise distribution of the PCDD/F releases

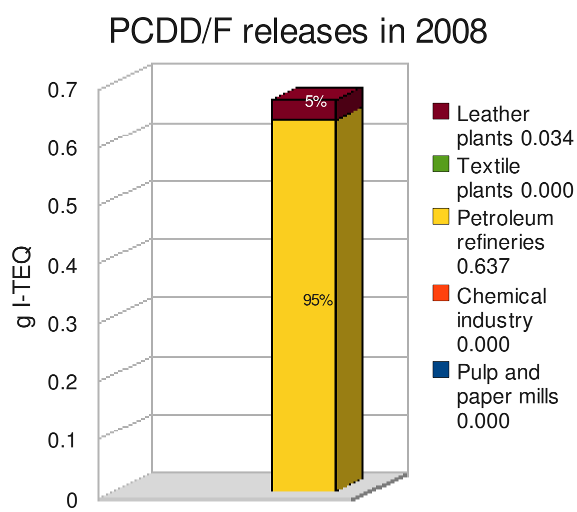


Illustration 43: Production of chemicals and consumer goods, PCDD/F releases per sub-sector

3.7.1 Pulp and paper mills

3.7.1.1 General Information

In general terms, paper is a sheet of fibers with a number of added chemicals that affect the properties and quality of the sheet. Besides fibers and chemicals, manufacturing of pulp and paper requires large amounts of process water and energy (as steam and electricity). Pulp for papermaking may be produced from virgin fiber by chemical or mechanical means or may be produced by re-pulping of recovered paper. A paper mill may utilize pulp made elsewhere (= non-integrated pulp mills) or may be integrated with the pulping operations at the same site (= integrated pulp mills). Kraft pulp mills can be both non-integrated and integrated operations whereas sulfite pulp mills are normally integrated with paper production. Mechanical pulping and recycled fiber processing is usually an integrated part of the papermaking but has become a stand-alone activity in a few cases.

Papermaking industries have not been observed during the inventory process.

3.7.2 Chemical industry

3.7.2.1 General Information

PCDD and PCDF can be formed in chemical processes where chlorine is involved. The following processes have been identified as sources of PCDD and PCDF with a decreasing probability of generating PCDD/PCDF from top to bottom:

- Manufacture of chlorinated phenols and their derivatives,
- Manufacture of chlorinated aromatics and their derivatives,
- Manufacture of chlorinated aliphatic chemicals,
- Manufacture of chlorinated catalysts and inorganic chemicals.

For some of the processes the formation of PCDD and PCDF is implicit from the manufacturing process, e.g., through direct chlorination of phenols when purified by distillation or through chlorophenate condensation.

None of the above mentioned processes have been observed during the inventory exercise.

3.7.3 Petroleum refineries

3.7.3.1 General Information

Within the petroleum refining industry, only one potential source for PCDD/PCDF has been reported, which is the re-generation of the catalyst used during catalytic cracking of the larger hydrocarbon molecules into smaller, lighter molecules. Emission factors for this process have not yet been developed. The Toolkit identified flaring which generates PCDD/PCDF. This practice could be quantified. The same emission factor as listed for Landfill/Biogas Combustion was used. The emission factor in this case should be calculated based on the heating value of the gas burnt and is given per TJ.

3.7.3.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 63).

Classification	Emission Factor - µg TEQ/TJ of Gas Burned Air	Emission Factor - µg TEQ/m^3 of Gas Burned Air
Flares	8	0.0003

Table 63: Emission factors for flaring.

3.7.3.3 Results

The inventory in Egypt concluded that the petroleum industries release 21 23 317 301 TJ energy into the environment with flaring (Table 64). This also corresponds to an annual dioxin and furan releases of 0.6 g I-TEQ (Illustration 44). The highest emission was observed in South Sinai Governorate (0.3394gTEQ/a) followed by the Red Sea Governorate (0.2343gTEQ/a) and then Suez Governorate (0.0632gTEQ/a).

Country	Estimated annual source strength (TJ)
Egypt	2,123,317,301
Jordan	0
Sudan	0
Yemen	0
Total:	**2,123,317,301**

Table 64: Petroleum refineries, annual source strength

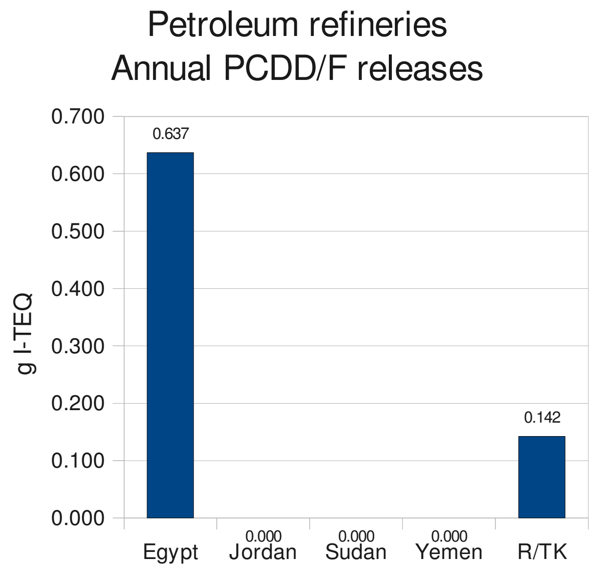


Illustration 44: Petroleum refineries, PCDD/F releases

3.7.4 Textile plants

3.7.4.1 General Information

The textile industry is comprised of a diverse, fragmented group of establishments that produce and/or process textile-related products, which include fiber, yarn, fabric for further processing into finished goods. These may range from small “back street” operations with few controls to large-scale highly sophisticated industrial operations with comprehensive pollution controls. The process of converting raw fibers into finished textile products is complex; thus, most textile mills specialize. The textile industry is being targeted as a potential source of PCDD/PCDF as:

- Pesticides such as pentachlorophenol, known to be contaminated with PCDD/PCDF, can enter the plant via raw materials, e.g., cotton, being treated with PCP;
- Dyestuffs on the basis of chloranil can be used to colour the textiles;
- Finishing processes may utilize chlorinated chemicals contaminated with PCDD/PCDF and washing processes at alkaline media are part of the textile finishing processes; and
- Large volumes of effluent water are released into the environment.

Woven and knit fabrics cannot be processed into finished goods until the fabrics have passed through several water-intensive wet-processing stages (also known as finishing) such as fabric preparation, dyeing, printing, and finishing. Natural fibers typically require more processing steps than artificial fibers. Relatively large volumes of wastewater are generated, containing a wide range of contaminants that must be treated prior to disposal. Significant quantities of energy are used for heating and cooling chemical baths and drying fabrics and yarns.

3.7.4.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 65).

Classification	Emission Factors – µg TEQ/t of Textile				
	Air	Water	Land	Product	Residue
1. Upper limit	NA	ND	NA	100	ND
2. Lower limit	NA	ND	NA	0.1	ND

Table 65: Emission factors for textile production.

3.7.4.3 Results

Three factories are engaged textile production. One of them is publicly owned, while the other two are owned by the private sector. Total production was 3037000 meter in 2008, which equals to 2 277 tons (Table 66). Total releases are 0.0002 g TEQ/a, which is insignificant and therefore no graph was prepared.

Country	Estimated annual source strength (tons)
Egypt	0
Jordan	0
Sudan	0
Yemen	2,277
Total:	**2,277**

Table 66: Textile plants, annual source strength

3.7.5 Leather plants

3.7.5.1 General Information

Contamination of commercial leather products with dioxins and furans has been reported and based on the PCDD/PCDF pattern, it can be assumed that PCP is the source for the contamination. This assumption is underlined by the fact that since the ban of PCP in Germany in the year 1989, which sets a maximum concentration of 5 mg PCP/kg in the final product, the PCDD/PCDF concentrations in leather goods decline.

In contrast to textiles, PCP once applied on leather is not so easily removed by washing processes. In leather "breast-wallets" concentrations of PCDD/PCDF up to 430 ng I-TEQ/kg, in leather shoes up to 6,400 ng I-TEQ/kg were found. Although in many countries, the use of PCP has decreased, at least in shoes, the PCDD/PCDF concentrations did not decrease and in Germany, peak concentrations of 2,100 and 3,000 ng I-TEQ/kg were detected in leather shoes bought in 1991. In the year 1996, highly elevated concentrations continued to exist

3.7.5.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 67).

Classification	Emission Factors – µg TEQ/t				
	Air	Water	Land	Product	Residue
1. Upper limit	NA	ND	NA	1,000	ND
2. Lower limit	NA	ND	NA	10	ND

Table 67: Emission factors for leather refining.

3.7.5.3 Results

In Yemen three tanneries were located in Hodaida. They are all owned by the private sector. Leather production in 2008 was 3 400 tons, representing 0,03 g I-TEQ dioxin and furan releases (Table 68, Illustration 45).

Country	Estimated annual source strength (tons)
Egypt	0
Jordan	0
Sudan	0
Yemen	3,400
Total:	**3,400**

Table 68: Leather plants, annual source strength

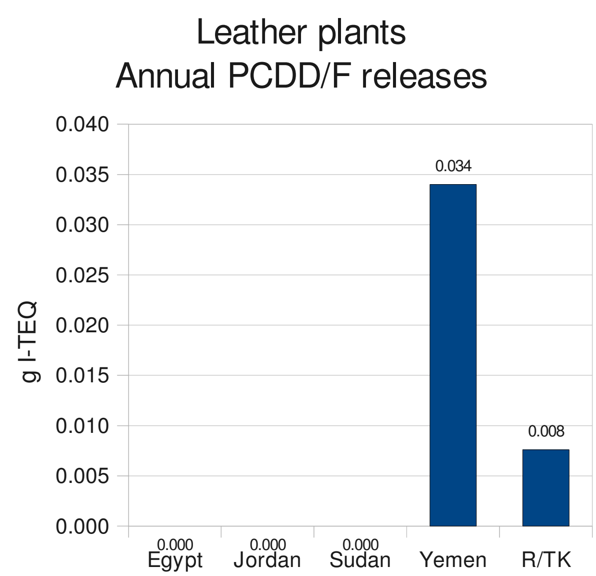


Illustration 45: Leather plants, PCDD/F releases

3.8 Main category no 8 - Miscellaneous

This category of the Toolkit comprises eight processes that could not be classified in the other Main Source Categories. This Section also includes two processes (drying of green fodder, smoke houses), which may be considered to be combustion processes, e.g., waste wood combustion. They are dealt with here because green fodder drying can have a severe impact on PCDD/PCDF concentrations in feedstuffs and foods and therefore for human exposure as was shown recently in Germany. Also, although not well investigated, smoking of meat and fish can result in higher concentrations of PCDD/PCDF in the foodstuffs and consequently directly impact human body levels.

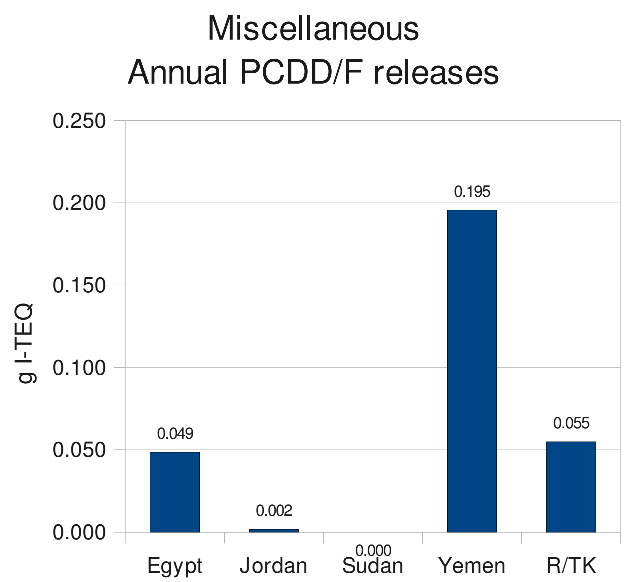


Illustration 46: Miscellaneous,, country-wise distribution of the PCDD/F releases

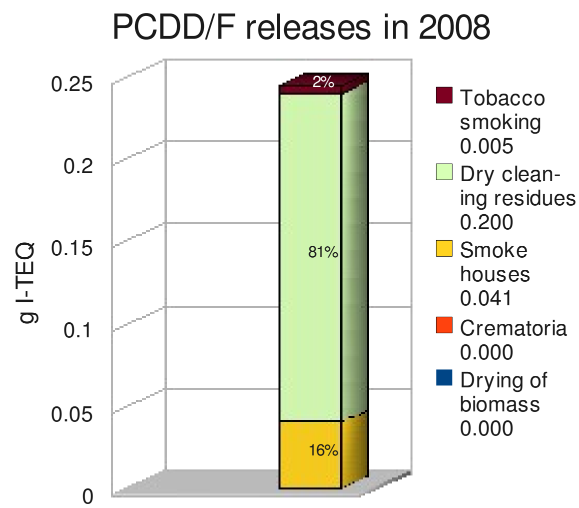


Illustration 47: Miscellaneous, PCDD/F releases per sub-sector

The major releases from the miscellaneous main source category are from dry cleaning 0.2 g I-TEQ and form smoke houses 0.04 g I-TEQ which represent 81% and 16% of the total releases respectively (Illustration 47). This sector, with its 0.23 g I-TEQ dioxin and furan release, is not an important source among the nine categories of the Toolkit. The highest releases within this sector was observed in Yemen with 0.19 g I-TEQ followed by Egypt with 0.04 g I-TEQ (Illustration 46).

3.8.1 Drying of biomass

3.8.1.1 General Information

Drying of biomass, e.g., wood chips or green fodder, occurs either in drums or in the open without containment. In the absence of measured data, copra and other local biomass (very often for export)are included under this category. Under controlled conditions, clean fuels such as wood are used. In a recent accident in Germany, it has been shown that contaminated wood has been used as the fuel resulting in very high concentrations of PCDD/PCDF in the green meal.

Biomass drying has not been observed during the inventory undertaking.

3.8.2 Crematoria

3.8.2.1 General Information

Cremation is a common practice in many societies to destroy human bodies by burning. The essential components for cremation are the charging of the coffin (and the corpse), the main combustion chamber, and where applicable the afterburning chamber. In some cases, a dust separator or more sophisticated gas treatment are present. Finally, gases leave through the stack. Most furnaces are fired using natural oil or natural gas; some run on electricity. Crematoria are usually located within cities and close to residential areas and normally, stacks are relatively low. Both facts result in relatively immediate impacts on the environment and humans.

Due to religious concerns in Arabic countries this practice is virtually non existent.

3.8.3 Smoke houses

3.8.3.1 General Information

Smoking food for preservation of meat and fish is common practice in many countries. As smoke houses are normally relatively small installations, combustion conditions may not be optimal and from the fuel – wood in most cases – there is a dioxin formation potential. PCDD/F releases are related to the cleanliness of the fuel and the combustion process.

3.8.3.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table Table 69).

Classification	Emission Factors				
	Air µg TEQ/t	Water	Land	Product µg TEQ/t	Residue µg TEQ/t Residue
1. Treated wood used as fuel	50	NA	NA	ND	2,000
2. Clean fuel, no afterburner	6	NA	NA	ND	20
3. Clean fuel, afterburner	0.6	NA	NA	ND	20

Table 69: Emission factors for smoke houses.

3.8.3.3 Results

Along the coast of the Red Sea and Golf of Aden smoking of fish is not popular to preserve fish. The preferred conservation method is salting, therefore except for Egypt, this activity was not observed during the inventory process.

In Egypt 5 318 tons of fish is conserved by smoking annually, which releases 0.04 g I-TEQ dioxins and furans into the environment (Table 70, Illustration 48).

Country	Estimated annual source strength (tons)
Egypt	5,318
Jordan	0
Sudan	0
Yemen	0
Total:	**5,318**

Table 70: Smoke houses, annual source strength

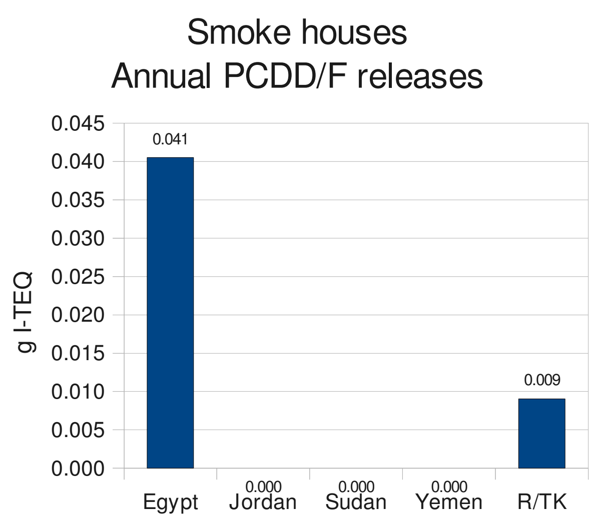


Illustration 48: Smoke houses, PCDD/F releases

3.8.3.4 Incomplete information

The following assumptions were used in Egypt:

Each smoke house installation produces an average of 50 kg smoking food / day, each smoke house installation in any hotel produces an average of 100 kg smoking food / week. The residue represents 6 – 10 % with average about 8 % of the total production (by weight).

3.8.4 Dry cleaning residues

3.8.4.1 General Information

PCDD/PCDF have been detected in the distillation residues from dry cleaning (cleaning of textiles with solvents – not washing with water). The contamination of the textiles with PCDD/PCDF, i.e. from use of PCP as a biocide to protect the textile or the raw material – wool, cotton, etc. – or from dyestuffs, was identified as the source of the contamination. The dry cleaning process itself does not generate any PCDD/PCDF. During the dry cleaning process, the PCDD/PCDF contamination is extracted from the textiles and transferred into the solvent. The solvent is distilled for recovery and reuse and consequently, the PCDD/PCDF are concentrated in the distillation residues, which normally are disposed of. Detailed research has shown that the PCDD/PCDF concentrations in the distillation residues do not depend on the solvent present in the dry cleaning process. Therefore, the influence of the solvent used is negligible; typical solvents are perchloroethylene, petrol, or fluorocarbons.

3.8.4.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 71).

Classification	Emission Factors – µg TEQ/t of Distillation Residue				
	Air	Water	Land	Product	Residue
1. Heavy textiles, PCP-treated, *etc.*	NA	NA	ND	ND	3,000
2. Normal textiles	NA	NA	ND	ND	50

Table 71: Emission factors for dry cleaning residues.

3.8.4.3 Results

Dry cleaning is a common way of cleaning cloths. Many small scale shops were located along the coast of the Red Sea and Golf of Aden. Generally these small shops ship the cloths to larger facilities, where the cleaning actually takes place. In Egypt, according to the national inventory, majority of the cloths are taken out of the coastal zone for cleaning. This is the reason why, despite of the heavy tourism activities and high population figures, the Egyptian activity data is only two times more than what was observed for this activity in Jordan (Table 72). The highest releases are from Yemen, where the population figure is high and dry cleaning activities are undertaken at the coastal zone (Illustration 49).

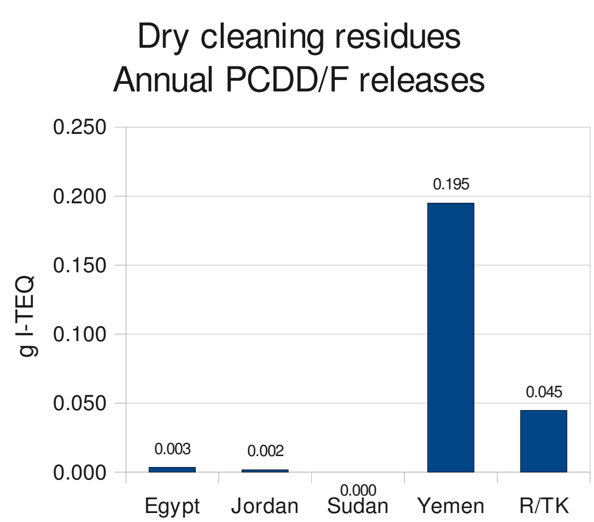


Illustration 49: Dry cleaning residues, PCDD/F releases

Country	Estimated annual source strength (tons)
Egypt	67
Jordan	34
Sudan	0
Yemen	131
Total:	**232**

Table 72: Dry cleaning, annual source strength

3.8.4.4 Incomplete information

Dry cleaning is practised in almost every larger cities. In Egypt, in many cases the cloths are taken out of the coastal zone for cleaning, in other words the facilities are outside the scope of the inventory. The rest is calculated on the following assumption: that the amount of distillation residue = 5 – 15 kg / month with average of 10 kg / month which equal to 0.120 t / year for each dry cleaning laundry. This sector will however need to be better mapped during the next inventory exercise.

3.8.5 Tobacco smoking

3.8.5.1 General Information

As any other thermal process, “combustion” of cigarettes and cigars produces PCDD/PCDF. Investigations of the ten most popular brands smoked in Germany gave “emissions” of 0.1 pg I-TEQ/cigarette. There are no results from cigars. Only releases to air are addressed; any other releases are insignificant.

3.8.5.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 73).

Classification	Emission Factors – pg I-TEQ/Cigar or Cigarette				
	Air	Water	Land	Product	Residue
1. Cigar	0.3	NA	NA	NA	NA
2. Cigarette	0.1	NA	NA	NA	NA

Table 73: Emission factors for tobacco smoking

3.8.5.3 Results

The largest amount of cigars and cigarettes are smoked in Egypt, thus the releases are the highest (Table 74, Illustration 50). The Toolkit does not provide emission factor for smoking water pipe, thus this information is missing form the

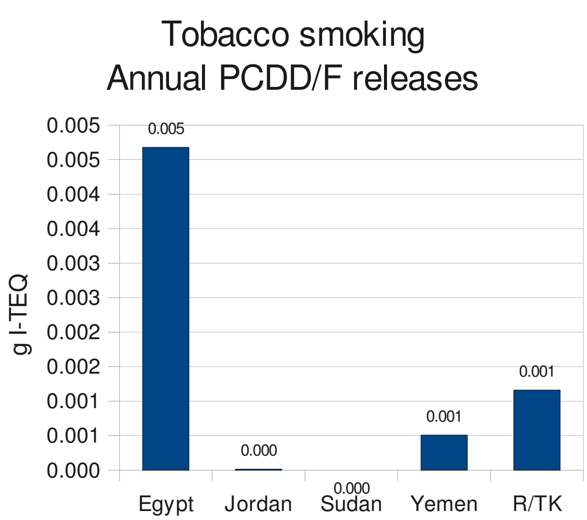


Illustration 50: Tobacco smoking, PCDD/F releases

inventory.

Country	Estimated annual source strength (item)
Egypt	46,823,346,100
Jordan	146,000,000
Sudan	0
Yemen	5,100,000,000
Total:	**52,069,346,100**

Table 74: Tobacco smoking, annual source strength

3.8.5.4 Incomplete information

The Egyptian inventory calculated the amount of cigarettes on the basis of the average number of smokers per total No. of population and tourists in the three governorates. In other cases like in Jordan, the customs data was used, since tobacco products are always extra taxed. This assumption techniques still need to be harmonized between the countries.

In Sudan the following assumption was used:

Number of population in the coastal zone is 1,300,000. 10% of the population smokes 5 cigarette per individual/ day. According to information from Custom Department (Illegal Trade Section) the amount of water pipe tobacco in the year is about 25 Kg. Assuming that this amount represent only 0.1% of the real amount entering Port Sudan, then the total amount would be 25 ton. This should be divided by the average weight of one dose which is used in the water pipe, which in the case of Yemen, was estimated to be 50 g.

In Egypt the assumption was that 1.) the number of smokers represents about 20% of the total population (for each Governorate), 2.) that the number of smokers represents about 10% of the total No. of tourists (for each Governorate), 3.) that every person smoke 20 cigarette /day x 365 day / year =7300 cigarette / year.

3.9 Main category no 9 – Disposal

The way in which waste is handled and disposed of can have severe effects on the formation and release of PCDD/PCDF. This Section addresses some disposal options other than incineration or thermal recycling.

The presence of PCDD/PCDF 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. There are a few data available on PCDD/PCDF concentration in municipal solid waste: the numbers range from relatively low concentrations around a few ng I-TEQ/kg to concentrations above 100 ng I-TEQ/kg with peak concentrations orders of magnitude higher (especially when dust fractions are present).

It includes the releases of PCDD/PCDF from landfills, from sewage from composting operations, as well as disposal operations addressing waste oils, other than burning.

The total releases of dioxins and furnas from this sector were 13.1 g I-TEQ (Illustration 52). The leading source of releases is landfill leachate accounting for 52% of the total releases from this main source category.

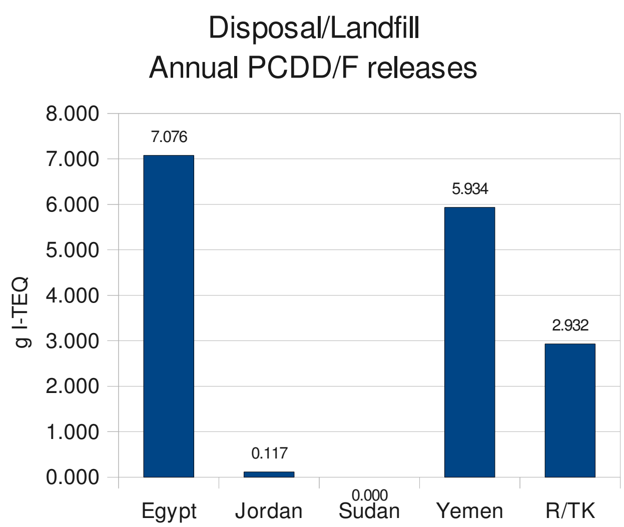


Illustration 51: Disposal, country-wise distribution of the PCDD/F releases

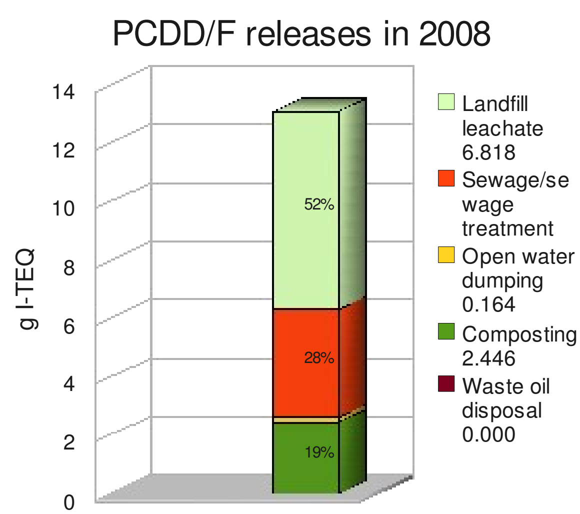


Illustration 52: Disposal, PCDD/F releases per sub-sector

It is followed by sewage treatment activities with 28% of the releases, while the third major route is composting (19%). Egypt and Yemen are the major sources of the releases with 7,0 and 5.9 g I-TEQ per annum (Illustration 51). The average releases per thousand kilometre are 2.9 g I-TEQ, which is comparable with the releases from the transport sector.

3.9.1 Landfill leachate

3.9.1.1 General Information

For the purposes of the Toolkit landfills and waste dumps are places where waste is disposed of by burying in the ground or piling on the surface. Accordingly, a landfill is a controlled engineered waste storage site with respect to inputs/types of wastes, location of different types of waste and management (gas and water collection, etc.), whereas a dump is largely unregulated and typically contains mixed waste that was disposed of without any pollution prevention devices.

Degradation of organic materials takes place in a landfill and in a dump, which results in the formation of gases (with methane as a major constituent). The passage of water through the waste results in a leachate. When no collection systems are installed, landfill gases and leachate escape from the landfill in an uncontrolled manner. So far, in the landfill gases, no PCDD/PCDF could be quantified; thus the emission factor to air is not applicable in this section.

3.9.1.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 75).

Classification	Emission Factors – pg TEQ/L in Water and µg TEQ/t in Residues Disposed of				
	Air	Water	Land	Product	Residue
1. Hazardous wastes	NA	200	NA	NA	50
2. Non-hazardous wastes	NA	30	NA	NA	6

Table 75: Emission factors for landfill leachate.

3.9.1.3 Results

In the case of landfill leachate the releases should be calculated on the basis if the leachate. In many countries, however, due to the lack of engineered landfills, where leachate is collected, the leachate sweeps into the soil. Due to the dry climate of the region, the amount of the leachate would not be high. In Egypt the inventory team estimated the amount of the leachate as 584 000 tons (Table 76). In Yemen the team assessed this sector as 308 021 tons. In Sudan and Jordan this sector was not estimated. The total annual releases from this sector is 6.8 g I-TEQ, the majority of the releases is from Egypt and Yemen (Illustration 53). In Jordan ASEZA estimates that the zone produces some 100 tones per day of solid waste, up from 65 tones per day in 1999. Recently, waste tonnage has said to temporarily stabilize. The Port of Aqaba collects some 3 tons of garbage each day, as compared to 100 tons/day collected from Aqaba homes and businesses.

Country	Estimated annual source strength (tons)
Egypt	584,000
Jordan	0
Sudan	0
Yemen	308,021
Total:	**892,021**

Table 76: Landfill leachate, annual source strength

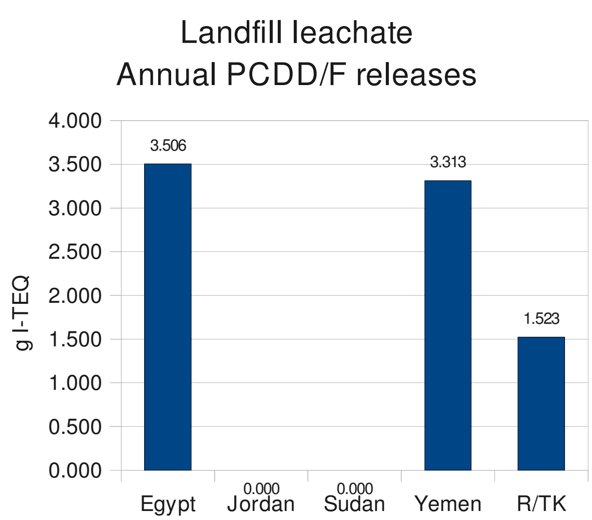


Illustration 53: Landfill leachate, PCDD/F releases

3.9.1.4 Incomplete information

Egypt assumed that 50% of the total amount of landfill wastes were disposed of and that the leachate represents about 10% of the amount disposed. The data collected in this sector needs further clarification and re-assessment. The next inventory will investigate this sector under scrutiny.

3.9.2 Sewage/sewage treatment

3.9.2.1 General Information

This section includes aqueous releases that are collected in a central system. The final discharge may be with or without treatment of these effluents, with or without generation of sludge. The direct discharge into the environment is addressed in open water dumping, the next section.

Sewage sludge considered here is the solid residue from treatment of wastewater – in particular wastewater arising from human sanitation and households. Wastewater can include human wastes (sewage), water from washing of people and clothes, in some cases storm water run-off, and industrial effluents released to sewer. Since most of the contamination present in the sludge has its origin in other processes or products, sewage sludge may be considered to be a sink for PCDD/PCDF formed and emitted previously by other sources.

However, the handling of the sludge can cause releases of PCDD/PCDF. Concentrations of sewage sludge have been studied in several countries. Further, countries such as Germany and Austria, with legislation in place, routinely analyze sewage sludge for PCDD/PCDF. In this Section, domestic sewage sludge is considered only.

The amount of PCDD/PCDF entering a sewage system or treatment works will depend on the sources of the wastewater. Inputs to wastewater may be highly variable and thus, estimates are difficult to make. The lowest concentrations are expected in areas with no industry and in remote or undeveloped environments. In such cases concentrations of PCDD/PCDF in runoff are low (with no atmospheric deposition). Low concentrations may be expected also in countries with stringent controls on discharge of industrial effluents to sewer and effective controls on PCP, etc. on textiles and no use of chlorine-bleached toilet paper. Higher levels can be expected in urban areas with mixed industry and use of dioxin-containing consumer goods.

Occasionally, direct discharges of industrial effluents without any treatment can cause very high levels of PCDD/PCDF in sewage sludge.

3.9.2.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 77).

Classification	Emission Factors			
	Air	Water pg I-TEQ/L	Land	Product = Residue µg TEQ/t d.m.
1. Mixed domestic and industrial inputs (with chlorine relevance)	NA NA	5 [a] 0.5 [b]	NA NA	1,000 1,000
2. Urban environments	NA NA	2 [a] 0.5 [b]	NA NA	100 100
3. Remote environments or input control (and here treatment systems in place)	NA	0.1	NA	10

a = no sludge removal, b = with sludge removal

Table 77: Emission factors for sewage treatment.

3.9.2.3 Results

The amount of sewage is directly linked to the population figure and level of water network. In that case of Egypt, where household water network and sewage collection are developed high amount of sewage is collected (Table 78). The Aqaba water Company estimates that for the year 2008, a 5475000 m3 waste water was received in the Aqaba waste water treatment plant. The total quantity of sludge was 1095 ton. All the sludge is stored in the drying bonds. The highest releases are from Egypt reaching 3.5 g I-TEQ/a (Illustration 54). The average releases for each thousand kilometre are 0.8 g I-TEQ.

Country	Estimated annual source strength (tons)
Egypt	225,000,000
Jordan	5,475,000
Sudan	0
Yemen	32,028,009
Total:	**262,503,009**

Table 78: Sewage/sewage treatment, annual source strength

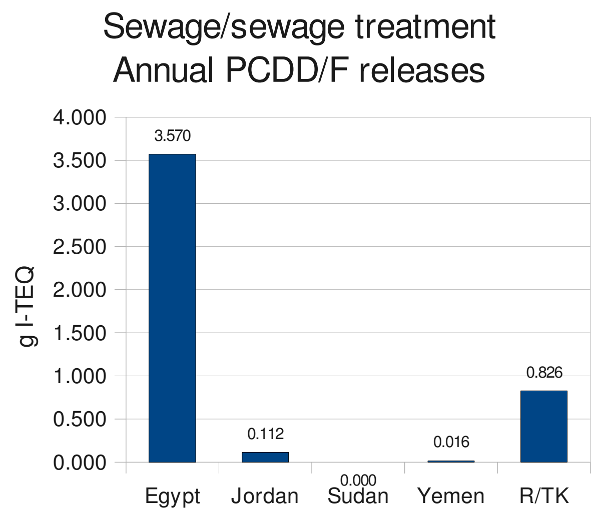


Illustration 54: Sewage/sewage treatment, PCDD/F releases

3.9.2.4 Incomplete information

In Egypt the following estimations were applied. The sludge generation at waste water treatment plants was considered to be 0.4 % of raw sludge in effluent water and the effluent contains 3 % of dry matter.

Sewage system, with proper sanitation network in Sudan, exists only in Khartoum and meets the demands of about 0.5% of the population and small parts of industrial area.

3.9.3 Open water dumping

3.9.3.1 General Information

Open water dumping is a waste or wastewater management practice and the tail-end of other industrial or domestic activities. In this section, only effluents or other wastes directly discharged into the environment are considered. In most cases, discharges occur into receiving waters, i.e. rivers, lakes or oceans.

As in the previous section, this section does not address industrial effluents, which are covered under the respective industries.

3.9.3.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 79).

Classification	Emission Factors – µg TEQ/m³				
	Air	Water	Land	Product	Residue
1. Mixed domestic and industrial inputs	NA	0.005	NA	NA	NA
2. Urban environments	NA	0.0002	NA	NA	NA
3. Remote environments or input control	NA	0.0001	NA	NA	NA

Table 79: Emission factors for open water dumping.

3.9.3.3 Results

Open water dumping does not exist in Egypt due to proper sewage collection network. In Sudan this sector could not be estimated (Table 80). The annual releases from this sector are 0.16 g I-TEQ. The majority of the releases are generated in Yemen (Illustration 55).

Country	Estimated annual source strength (tons)
Egypt	0
Jordan	876,000
Sudan	0
Yemen	31,970,195
Total:	**32,846,195**

Table 80: Open water dumping, annual source strength

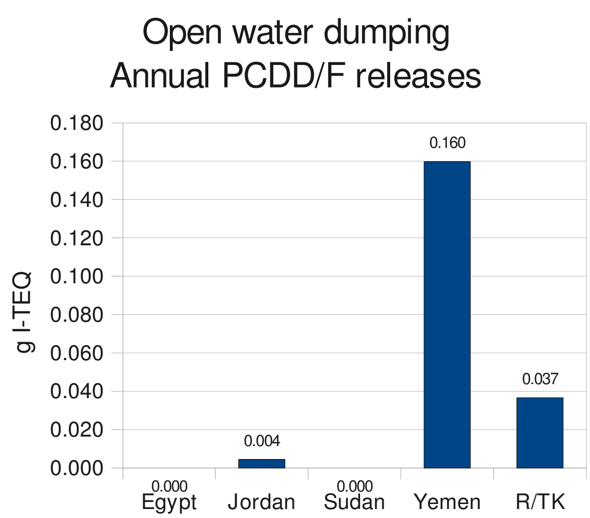


Illustration 55: Open water dumping, PCDD/F releases

3.9.3.4 Incomplete information

In Sudan limited industries discharge their wastewater on land or open dumping. No compiled data exist for such discharge. Household wastewater is disposed of in open pit latrines and in septic tanks. This practice is only found in urban areas. Also no figures were available for the percentage of domestic wastewater or sludge treated by different systems (septic tanks, pit latrines etc.). According to the study conducted in Khartoum State, the wastewater generated per capita is 80 litres per day. In Port Sudan there is scarcity in water, therefore we assume the wastewater generated is about 60 litres per capita per day. The population of Port Sudan is about 500,000.

3.9.4 Composting

3.9.4.1 General Information

Composting is a popular method of disposal for wastes originating from kitchen activities, gardening, park and other public/private area maintenance, agriculture, and forestry. Basically, any organic material can be composted and this disposal process generally has a high degree of acceptance in the public. The composting process results in a loss of about 50 % on a weight basis of the input material. The average water content of compost is 30 %. Data from Europe have shown that contamination with PCDD/PCDF in compost can be high if the total organic fraction is being composted. Fractions, which may enter the composting process and which may have high concentrations of PCDD/PCDF. Such materials are e.g., the content of vacuum cleaners or any fine particles such as house dust, soil from contaminated land entering with vegetable and other plant's leftovers, leaves from alleys impacted by traffic using leaded gasoline, greens from cemeteries or other pesticide treated organic wastes. This practice will result in an unacceptable contamination of the final product not suitable for use in horticulture.

3.9.4.2 Emission factors

PCDD/F releases from this source category were assessed by using the standard emission factors of the Toolkit (Table 81).

Classification	Emission Factors - µg TEQ/t d.m			
	Air	Water	Land	Product = Residue
1. All organic fraction	NA	NA	NA	100
2. Garden, kitchen wastes	NA	NA	NA	15
3. Green materials from not impacted environments	NA	NA	NA	5

Table 81: Emission factors for composting

3.9.4.3 Results

There was only one composting plant in Red Sea Governorate with capacity of 160 t / day, but accidentally it was burnt, and does not operate. There is another plant under construction in South Sinai Governorate with capacity of 240 t / day, and it is expected to start int 2011.

In Yemen all organic materials are composted to fertilizers in Hadramawt coast towns: Sheher and Ghail Bawazier. The composted materials include fish, organic kitchen wastes, garden wastes, farm wastes. Total quantity resulting from the process of conversion to fertilizer in Hadramawt coast (Sheher and Ghail Bawazier) is 24 455 tons (Table 82).

Total annual releases of dioxins and furans to products resulting from the process of conversion to fertilizer in Yemen is 2.4 g TEQ (Illustration 56).

Country	Estimated annual source strength (tons)
Egypt	0
Jordan	0
Sudan	0
Yemen	24,455
Total:	**24,455**

Table 82: Composting, annual source strength

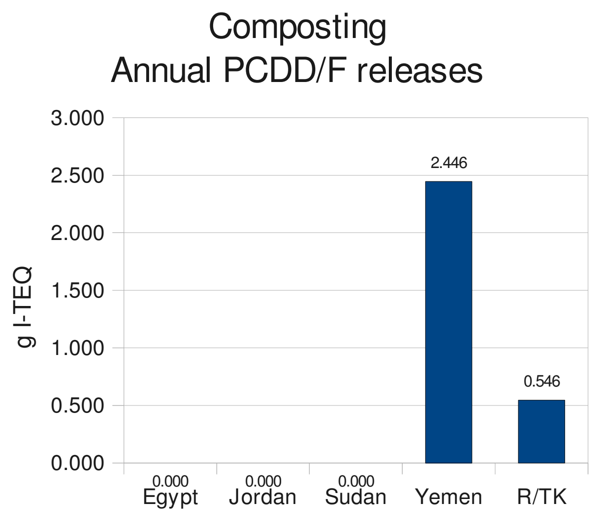


Illustration 56: Composting, annual PCDD/F releases

3.9.5 Waste oil disposal

3.9.5.1 General Information

For the purpose of the Toolkit, waste oils (or used oils) are defined as any petroleum-based, synthetic, or plant- or animal-based oil that has been used. Waste oils may originate from two large sources: used industrial oils, and vegetable or animal waste oils. Among the industrial waste oils, three main oil streams can be identified: industrial oil (for example, hydraulic oil, engine lubricant, cutting oil); garage or workshop oil; and transformer oil.

Waste oils have been found to be contaminated with polychlorinated dibenzo-p-dioxins

(PCDD), polychlorinated dibenzofurans (PCDF) and polychlorinated biphenyls (PCB). PCB- containing oils from transformers are addressed in Main Category 10.

At present there is no available evidence that PCDD/PCDF or PCB are newly formed in waste oil refineries. The data available indicate that the PCDD/PCDF and PCB released from waste oil refineries or waste oil handling and management plants are from industrial, intentional production of PCB or chlorobenzenes that are present in the waste oils either by contamination in the synthesis process (of these chemicals) or have become contaminated during the use phase or earlier recycling processes.

Non-thermal waste oil disposal has not been assessed in the inventory of the participating countries.

For waste oil treatment, according to the data obtained from the Ministry of Petroleum / Egyptian General Petroleum Corporation only one company in Egypt located in Alexandria Governorate is responsible for this issue and there was no waste oil treatment in Red Sea Coast.

3.10 Main category no 10 - Identification of potential hots spots

This Section is provided to give an indicative list of activities that might have resulted in the contamination of soils or sediments with PCDD/PCDF. Quantitative emission factors are not provided. This sector include locations where there is a likely hood dioxin and furan releases. They are called as potential hot-spots. Each of the locations needs a site-specific evaluation starting with a historic evaluation.

Current inventory activities have not collected information in this regard. PERSGA is committed to identify these locations, if any, and therefore have initiated a monitoring programme to this end. Soil, sediment and biological samples will be taken and analysed in each participating countries. These monitoring locations will be regularly re-assessed to establish time-trend of the PCDD/F concentration levels.

4 ASSESSMENT OF THE INVENTORY RESULTS

The inventory exercise was undertaken initially in four countries, Egypt, Jordan, Sudan and Yemen. The PCDD/F inventory collected information on industrial point sources and on diffuse sources such as open burning processes or cigarette smoking.

The total PCDD/F releases in the participating countries was **1629.95 g I-TEQ** (Table 83). In the following chapters its distribution is discussed based on the main source categories, release routes such as air, land, water, etc., and based on the countries of the releases.

4.1 RELEASES INTO MAIN SOURCE CATEGORIES

The total PCDD/F releases in the coastal zone of the participating RSGA countries were 1 629.95 g I-TEQ. The highest releases were observed in the open burning main source category, where the releases reached 1 367.18 g I-TEQ, which is 84% of the total PCDD/F releases (Illustration 57). Within this main source category, as it was indicated above, open burning of waste is the most significant source. Due to the high population density around the coast, and due to the improper and unsound municipal waste management practices, large amount of municipal waste is burned at the landfills or dumpsites. These burning processes are uncontrolled and far away from complete combustion. This result in very high releases of Annex C POPs and other pollutants.

The second highest source of the dioxins and furan releases is ferrous and non-ferrous metal production. The releases from this main source category was 170.72 g I-TEQ, which is a bit more than one tenth of the releases form open burning processes. As heavy industries are moving into this region the releases from this source category will increase in the future. To outweigh this trend and achieve continuous release reduction, as is required by the Article 5 of the Stockholm Convention, release reductions in some other sectors should be achieved. In this regard significant potential lies in discouraging open burning processes; implementing sound municipal waste management practices.

The third highest releases was observed in waste incineration main source category with 49.37 g I-TEQ, followed by the production of mineral products, which released 15.75 g I-TEQ PCDD/Fs. These three sectors, including ferrous and non-ferrous metal production, are particularly important for the introduction of BAT and BEP, which could increase the competitiveness of these industries and reduce the UP-POPs and other pollutant releases.

The releases from these sectors (except for open burning) are demonstrated in Illustration 58.

	Egypt	Jordan	Sudan	Yemen	*R/TK*	**Total**
Waste incineration	2.001	0.221	0.000	47.156	*11.029*	**49.379**
Ferrous and Non-Ferrous Metal Production	2.930	0.000	0.003	167.794	*38.134*	**170.728**
Heat and Power Generation	0.102	0.042	0.000	1.546	*0.378*	**1.691**
Production of Mineral Products	0.969	0.000	0.012	14.769	*3.518*	**15.751**
Transportation	6.795	0.485	0.033	3.866	*2.497*	**11.180**
Open Burning Processes	934.863	0.019	64.725	367.577	*305.379*	**1367.183**
Production and Use of Chemicals and Consumer Goods	0.637	0.000	0.000	0.034	*0.150*	**0.671**
Miscellaneous	0.049	0.002	0.000	0.195	*0.055*	**0.246**
Disposal/Landfill	7.076	0.117	0.000	5.934	*2.932*	**13.127**
Total	**955.423**	**0.886**	**64.774**	**608.873**	***364.073***	**1629.955**

Table 83: PCDD/F releases from different source categories at the coastal zone of the RSGA (g I-TEQ)

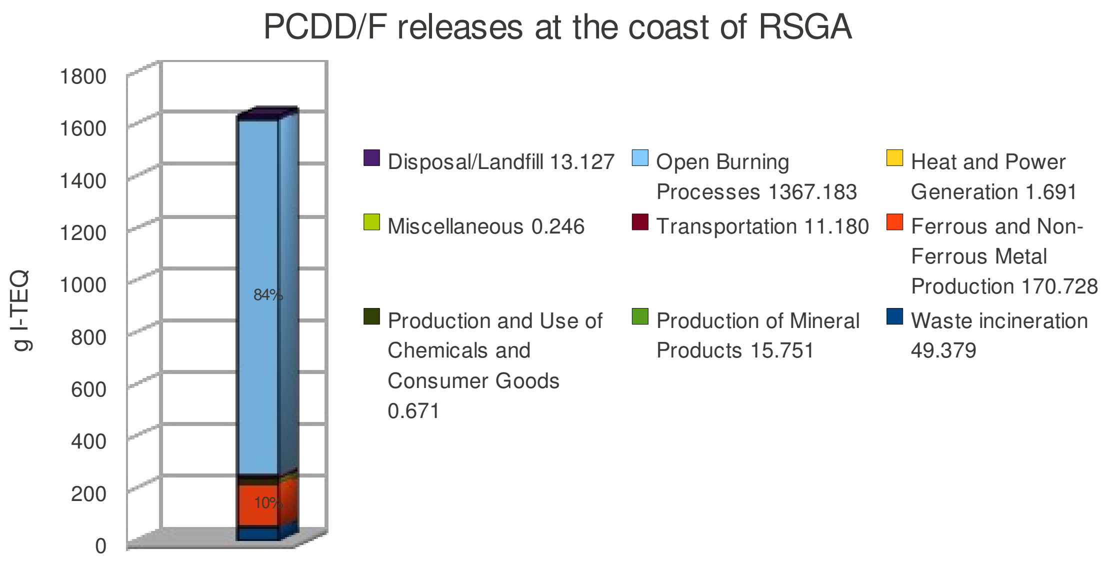


Illustration 57: PCDD/F releases from different source categories at the coastal zone of the RSGA

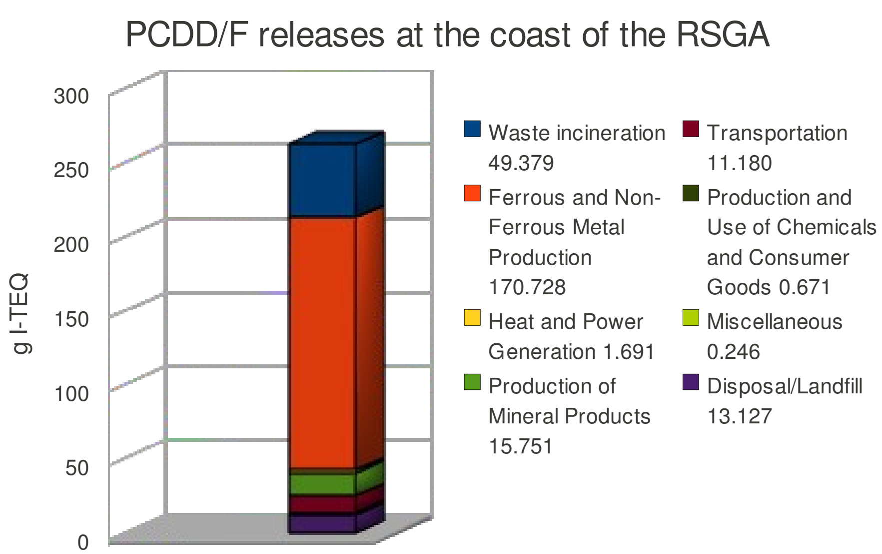


Illustration 58: PCDD/F releases from main source categories (except for open burning processes) at the coastal zone of the RSGA

4.2 PCDD/F RELEASES INTO DIFFERENT MEDIA

The inventory concluded that the highest release of dioxins and furans is to air. The emission data of the partcipating countries added up to 920.17 g I-TEQ PCDD/F releases into the air, which is 57% of the total releases (Table 84, Illustration 59). Air emission was followed by releases to land or soil. In this case 581.79 g I-TEQ was calculated which is 36% of the total releases. The third place is taken by releases into residues, which accounts for 7%.

These figures clearly show that majority of the releases are due to combustion processes, where pollutants are mostly released to air, fly or bottom ash (residue) and land, particularly if the burning takes place on land, or the residues, containing the pollutants, are landfilled.

Releases to products and water are insignificant, partly because these pollutants are not water-soluble; they rather adsorb on solid particles such as sediments, and because in these countries are generally lacking chemical industries which produce organo-chlorine chemicals where elemental chlorine is involved in the process in alkaline environment.

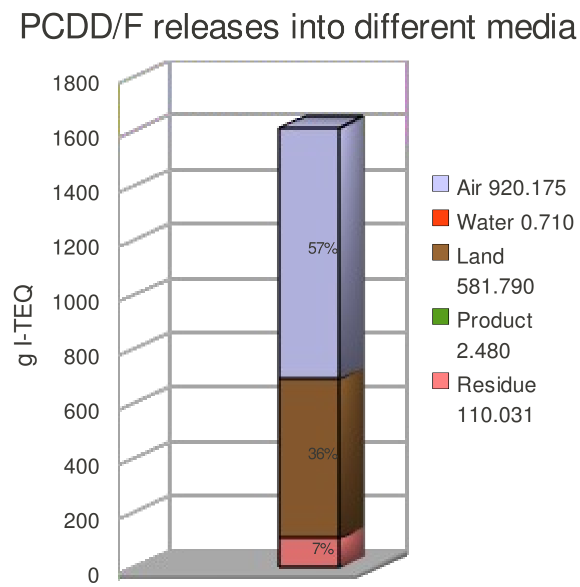


Illustration 59: PCDD/F releases into different media

	Air	Water	Land	Product	Residue
Egypt	595.448	0.512	350.631	0.000	8.832
Jordan	0.759	0.007	0.008	0.000	0.112
Sudan	40.484	0.000	0.000	0.000	24.290
Yemen	283.484	0.191	231.151	2.480	76.798
Total	**920.175**	**0.710**	**581.790**	**2.480**	**110.031**

Table 84: PCDD/F releases into different media (g I-TEQ)

4.3 COUNTRY RELEASES

Since the inventories were compiled at the national level it was decided that the shares of each participating country from the releases would also be presented. There are several reasons for either high or low releases, such as population density, industrial activities, energy resources, level of development, or length of the coastline, etc. Therefore countries could not be judged based on these figures, however this information can be important for future planning and to draw time-trend conclusions, once the inventory development will be undertaken on a regular bases.

The inventories are also important to develop action plans tin order to protect the unique quality of the environment of the Red Sea and Gulf of Aden.

The highest releases of PCDD/Fs was calculated in Egypt with 955.42 g I-TEQ (Illustration 60). The most important reason for it is the long and heavily populated cast-line, with its waste problem, and energy and transportation needs. Less important, but still significant is the presence of heavy industries. There are many efforts for solving these difficulties, especially because Egypt is utilizing the vast tourism potential of the Red Sea.

The second most significant source of dioxin and furan releases is Yemen with 608.87 g I-TEQ. Here again population pressure, municipal waste management difficulties, energy demand, heavy transportation needs are the key factors. Industries are also significant sources of the releases especially because there are many small- and medium-scale facilities, which use were outdated technologies in many cases without any means of air pollution control.

The third place is taken by Sudan. It has a long coastline, with one major city Port Sudan, where population pressure is not very high and industries are virtually non-existing. The major obstacle here is the management of the medical and municipal waste.

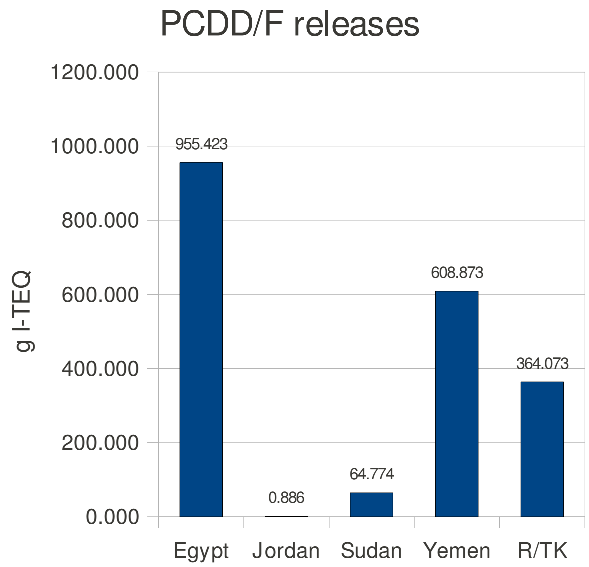


Illustration 60: Total PCDD/F releases per country

Jordan has the lowest releases among the four countries, There are several reasons for it. First, the coastline is very short, only 36km. The concentration of industries and population is high and drastically increasing. Due to the limited length of the coast, its value is very high and careful planning has led to symbiosis between industrial activities, improved living standards of the population and boosting tourism. Especially the tourism is sensitive for the environment, thus it is considered with priority. Still there is a window for improving, especially in the power generation sector.

5 PRIORITY SECTORS AND LOCATIONS FOR BAT/BEP INTRODUCTION

ANNEXES

BIBLIOGRAPHY

i UNEP Chemicals: Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases , Geneva, Switzerland, Edition 2.1, December 2005