REPUBLIC OF SUDAN

HIGHER COUNCIL FOR ENVIRONMENT AND NATURAL RESOURCE

RED SEA STATE MINISTRY OF ENVIRONMENT

Study Report

Prepared for the project:

Promotion of Strategies to Reduce Unintentional Production of Pops in the Red Sea and Gulf of Aden (PERSGA) Coastal Zone

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Regional Organization for the Conservation of Environment of the Red Sea and Gulf of Aden (PERSGA)

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Project Team

In connection with implementation of Dioxin and Furan Inventory the following personnel are designated as Project Team

Disclaimer of Liability: With respect to the material included in this document, legal liability and responsibility for the accuracy, completeness and sources of data and information are completely held by the consultant.

Mr. Adam Ali Mohamed

Mr. Ali Mohamed Ali

Miss. Sittnour Hassan Mohamed

Mr. Muhmood Ali Al Basheir

CONTENT

SUMMRY

The present document summarizes the results of the inventory for identification and quantification of dioxins and furans releases in Sudanese Red Sea Coast. The purpose of this study is to evaluate the Sudanese situation in coastline concerning the presence of the two persistent organic pollutant classes - dioxins and furans. The realization of this work is a key step for Sudan to confirm its compliance to Stockholm Convention, signed in May 2001. Furthermore the dioxin and furan inventory is one base for the development of an action plan for reduction or elimination of their releases.

The study has been conducted by the task team using the "Toolkit for Identification of Dioxin and Furan Releases" developed by UNEP Chemicals in 2005.

The Toolkit assists countries in identifying sources and estimating releases of dioxins and furans. It attempts to cover all known sources of environmental releases and is the best approach to produce comparable inventories.

The procedures proposed by the toolkit and used by the project team is the five steps approach:

1. Apply Screening Matrix to identify Main Source Categories

2. Check subcategories to identify existing activities and sources in the country

3. Gather detailed information on the processes and classify processes into similar groups by applying the Standard Questionnaire

4. Quantify identified sources with default/measured emission factors

5. Apply nation-wide to establish full inventory and report results using guidance given in the standard format

The results were finally compiled in this inventory report.

The estimated emissions and concentrations, which have been determined, are presented for each category and subcategory. The investigated source categories include: waste incineration; ferrous and non-ferrous metal production; power generation; production of mineral products; the transport sector; open burning processes; production and use of chemicals and consumer goods; miscellaneous, disposal; and hot spots..

The PCDD/PCDF inventory conducted for these main source categories and the respective subcategories yielded a total annual released to all environmental compartments of 65.64 g TEQ/a.

Uncontrolled combustion processes ranked 1st with an emission of 64.58 TEQ/a (98.4% of total emission). This main contribution came from uncontrolled waste burning at open sites.

Other sources contributing to the total emission in the percent range were from category Disposal/landfills 1.67% , category5, transport (0.05%); category 4, production of mineral (0.02%).

The releases to the five compartments/media – air, water, land, residues and products – were assessed. According to the toolkit approach, the main emission vectors were to air (40.4165 g; 62.53% of total releases) and residues (24.2216 g; 36.90% of total releases) with no releases to residue and water 1.1g; 1.67%. However since PCDD/PCDF are semi-volatile compounds and can transgress from one media to another, the emission vectors only give an idea of the direct releases from the sources and not of the final contamination. For example the main emission source of the coastline in uncontrolled waste burning with a direct release of 24.22g to residues. However, this can also be viewed as a direct contamination of land since the residues of uncontrolled waste combustion are just scattered all over the land and mixed with soil and additionally distributed by the wind. Furthermore this widely distributed contaminated residues/soil/land has the potential to directly contaminate water by wash out via rain.

The report is structured into six sections. Section one gives an introduction to the inventory and an overview about Sudanese Red Sea Coast. Section two introduces the methodology and procedures used for the establishment of the inventory. Section three contains estimates for the releases of dioxin and furan from the investigated sources. Section four concludes the study summery. Section five gives Criteria for selecting the priority locations and Priority locations for BAT/DEP implementation. Finally section six is annexes.

1INTRODUCTION

1.1 General information for Dioxins

Polychlorodibenzo-para-dioxins (PCDD) and Polychlorodibenzo-furans (PCDF) and for ease reference, are sometimes collectively referred to in this report as "Dioxins" are 2 of the 12 UNEP chemicals internationally recognized as persistent organic pollutants (POPs). Figures below show structure of PCDD molecule (left) and structure of PCDF molecule (right)

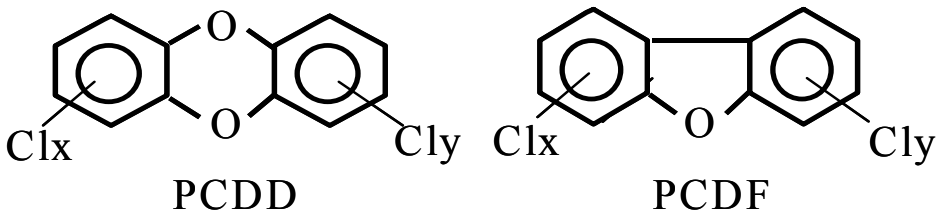


Figure1: structures of Dioxins and Furans

Dioxins are group of tricyclic aromatic chemicals, of which 17 have significant toxicity. Neither PCDDs nor PCDFs are produced commercially, and they have no known use. They are formed essentially as unintentional by-products in a number of chemical processes as well as in almost every combustion process.

1.1.1 Some properties of Dioxins:

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

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

3. ***Bioaccumulation and biomagnitude***: The persistence, combined with high partition coefficients (up to 8.20 for OCDD) provides the necessary conditions for these compounds to bioconcentrate in organisms. A bioconcentration factor of 26,707 has been reported in rainbow trout exposed to 2,3,7,8-TCDD. They can accumulate in fatty tissues of animals such as birds, fish, shellfish, marine mammals, and domestic animals and in people.

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

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

4. Poison humans and wildlife: PCDD/PCDF are toxic compounds and act as endocrine distruptors and immuno suppressors. Advers effects of PCDD/PCDF includes e.g. developmental neurotoxicity, reproductive toxicity, immunotoxicity, endometriosis and cancer.

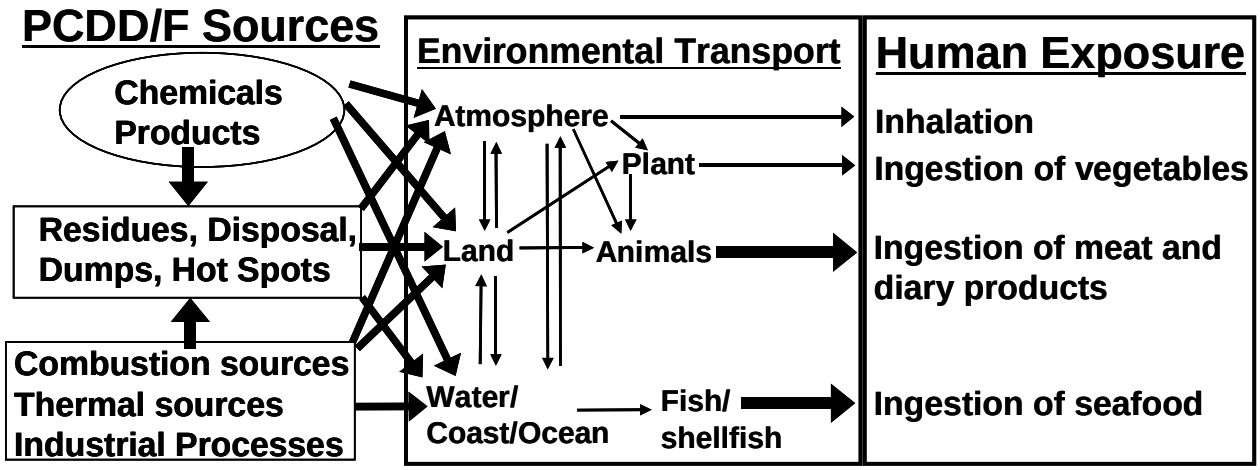


Figure 2: Sources, environmental transport and major human exposure pathways of PCDD/PCDF

All POPs listed in the Stockholm Convention require "continuing minimization and, where feasible, ultimate elimination" (SC 2001). The Convention requires the development and implementation of an action plan to identify characterize and address the releases of these chemicals. The action plan includes the development and maintenance of source inventories and release estimates, which serve then as a base for priority setting and as a measure for evaluation and documentation of the progress of the emission reduction.

This report presents the estimation of current release of PCDDs/PCDFs in Sudanese Red Sea Coast by determining the main emission sources of PCDDs/PCDFs. For this purpose the dioxin

task team screened all emission sources listed in the UNEP toolkit (including all source categories identified in Annex C of the Stockholm Convention) for PCDD/PCDF release and evaluated their relevance in the area.

As method it was decided to follow the methodology explained in the UNEP toolkit for the development of this PCDD/PCDF inventory.

1.2 Country and coastline Profile

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.

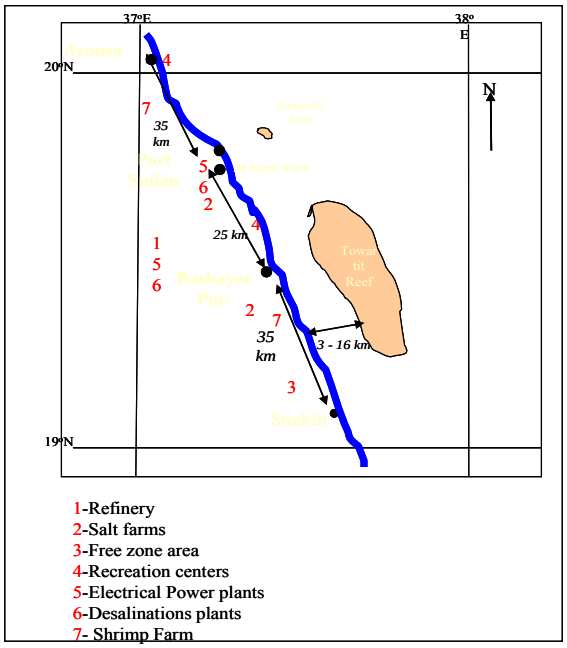
Sudanese Red Sea coastline is some 750Km long, not including all embayment and inlets. Numerous islands are scattered along the coast, the majority of which have no water or vegetation. The dominant coastal forms are silty beaches, rocky headlands and salt marches, commonly boarded with mangroves.

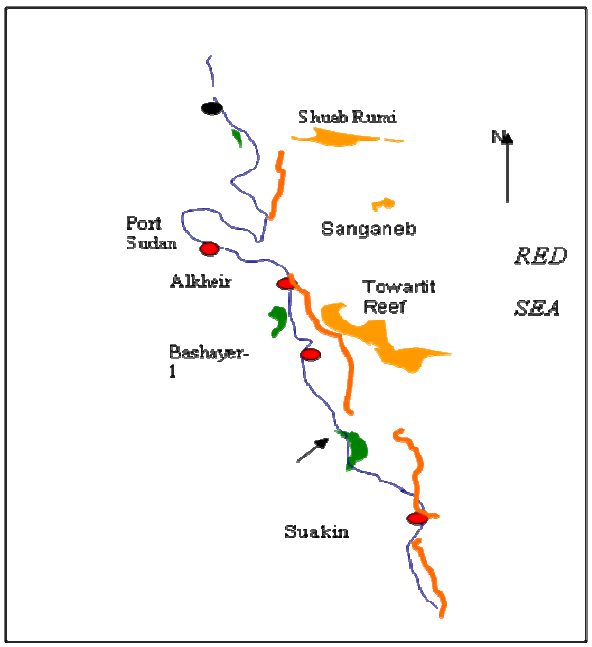
The principal environmental issues are

- Costal 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.

1.3 Legislation

The Interim National Constitution, 2005 stated that: the State shall not pursue any policy, or take or permit any action, which may adversely affect the existence of any species or animal or vegetation life, their natural or adapted habitat. Also the Sudan Environment Act, 2001, which is the basic environmental law, provides definitions and clarifications regarding natural resources management, sources of pollution and pollutants and endorses the principal of the "polluter pay". The law gives right to each State in coordination with the Interim Constitution and the national Environment Act to issue their state environment act. So far appropriate and up to date legislation and guidance is lacking for the direction of various authorities. No limit for POPs releases in the environment at all country states.

2 METHODOLOGY

The inventory has been conducted according to steps developed in "Toolkit for Identification of Dioxin and Furan Releases" published by UNEP chemicals in 2005. The methodology in it helps countries just developing their inventories to estimate releases of PCDD/PCDF. The Toolkit's goal is to guide the inventory makers within a country in the techniques and stages of the inventory development by giving examples and check parameters for classification. It is designed as a simple and standardized methodology and accompanying database to enable assembly of consistent national and regional PCDD/PCDF inventories.

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

The Standardized Toolkit gives a 5-step approach, which are followed in the course of this inventory

1. Apply Screening Matrix of the Standardized Toolkit to identify Main Source Categories
2. Check subcategories to identify existing activities and sources in the inventories area
3. Gather detailed information on the processes and classify processes into similar groups by applying the Standard Questionnaire
4. Quantify identified sources with default/measured emission factors
5. Apply nation-wide to establish full inventory and report results using guidance given in the standard format.

The PCDD/PCDF task team members were provided a 2 days training course on PCDD/PCDF inventory which including introduction of the UNEP toolkit on how to undertake the inventory.

2.1 Step 1: Screening Matrix: Main Source Categories

In the first step ten main source categories are identified for each release vectors as shown in the table 2-1

Table: 2-1: Main Source Categories

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				

2.2 Step 2: Subcategories Identification

In the second step, subcategories within each Main Source Category are identified. For comparability, each of the ten Main Source Categories has been divided by the UNEP Toolkit into a series of subcategories. The list of subcategories gives the summary matrix of the Dioxin Source Inventory, which were compiled.

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

For ten Main Source Categories shown in the above table the subcategories that identified in Sudanese Red Sea Coast were presented in Table 2-Table 11:

Table 2-2: Subcategories Waste Incineration

This activity not existe

Table 2-3: Subcategories Ferrous and Non-Ferrous Metal Production

			Potential Release Route				
No.		**Subcategories of Main Category**	**Air**	**Water**	**Land**	**Product**	**Residues**
2		**Ferrous and Non-Ferrous Metal Production**	**X**				**X**

	d	Copper production	X				x
	e	Aluminium production	X				x

Table 2-4: Subcategories Heat and Power generation

			Potential Release Route				
No.		**Subcategories of Main Category**	**Air**	**Water**	**Land**	**Product**	**Residues**
3		**Heat and Power generation**	**x**		**(x)**		**X**
	a	Fossil fuel Power Plants	x				x
	d	Household heating and cooking (biomass)	x		(x)		X

Table 2-5: Subcategories Production of Mineral Products

			Potential Release Route				
No.		**Subcategories of Main Category**	**Air**	**Water**	**Land**	**Product**	**Residues**
4		**Production of Mineral Products**	**X**				**X**
	f	Asphalt production	X			x	x

Table 2-6: Subcategories Transport

			Potential Release Route				
No.		**Subcategories of Main Category**	**Air**	**Water**	**Land**	**Product**	**Residues**
5		**Transport**					
	a	4-stroke engines	X				
	b	2-stroke engines	X				
	c	Diesel engines	X				(x)

Table 2-7: Subcategories Open Burning Processes

			Potential Release Route				
No.		**Subcategories of Main Category**	**Air**	**Water**	**Land**	**Product**	**Residues**
6		**Open Burning Processes**	**X**				**X**
	a	Biomass burning	X	(x)	X		(x)
	b	Waste burning and accidental fires	X	(x)	X		(X)

Table 2-8: Subcategories Production and Use of Chemicals and Consumer Goods

			Potential Release Route				
No.		**Subcategories of Main Category**	**Air**	**Water**	**Land**	**Product**	**Residues**
7		**Production and Use of Chemicals and Consumer Goods**	**X**	**X**		**X**	**X**
	e	Leather Refine		x		x	

Table 2-9: Subcategories Miscellaneous

			Potential Release Route				
No.		**Subcategories of Main Category**	**Air**	**Water**	**Land**	**Product**	**Residues**
8		**Miscellaneous**	**X**	**X**	**X**	**X**	**X**
	e	Tobacco smoking		x			

Table 2-10: Subcategories Disposal

			Potential Release Route				
No.		**Subcategories of Main Category**	**Air**	**Water**	**Land**	**Product**	**Residues**
9		**Disposal**		**X**	**X**		**X**
	c	Open water dumping		x			

Table 2-11: Subcategories Identification of Potential Hot-Spots

			Potential Release Route				
No.		**Subcategories of Main Category**	**Air**	**Water**	**Land**	**Product**	**Residues**
10		**Identification of Potential Hot-Spots**			**X**		
	g	Dumps of wastes/residues from categories 1-9	x	X	X		x

2.3 Step 3: 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:

- State Ministry of Industry, Industrial Statistic Department
- State Ministry of Environment

- Central Statistic Bureau
- Civil Defence Department
- State Ministry of Finance
- State Ministry of Health
- Sea Ports Corporation
- Etc….

Information needed to classify process and subcategories were obtained by questionnaire pre-designed for each source category by the Toolkit.

Complete highly detailed databases containing all activities potentially related to the release of PCDD/PCDF were established on individual sites for each source through direct visits and contact of responsible authorities.

2.4 Step 4: Process Classification and Source Quantification

In this step processes listed, as subcategories were classified and appropriate emission factors identified and used in calculations. Since there is no local measured data for processes release PCDD/PCDF in the country the default emission factors in the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases were applied for quantification.

The annual releases for all vectors, namely air, water, land, product, residue, from a source or a source category are calculated as follow:

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

This means for the source five calculations has to be made, i.e.

Source Strength

(PCDD/PCDF released per year) $= \sum$ Emission Factor $_{Air}$ X Activity Rate

$+ \sum$ Emission Factor $_{Water}$ X Activity Rate

$+ \sum$ Emission Factor $_{Land}$ X Activity Rate

$+ \sum$ Emission Factor $_{Product}$ X Activity Rate

$+ \sum$ Emission Factor $_{Residue}$ X Activity Rate

Emission factor is the amount of PCDD/PCDF (in µg I-TEQ) that is released to any of the five vectors per unit feed material or product produced.

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 identified.

2.5 Step 5: Compilation of Inventory

Annual emissions from all identified subcategories in the Sudanese Red Sea Coast are added to give the releases for the five potential vectors for the ten Main Sources outlined above.

3 RELEASE ESTIMATES INTO MAIN SOURCE CATEGORIES

3.1 Main Category 1- Waste Incineration

3.1.1 Municipal Solid Waste Incineration

No Municipal Solid Waste Incinerators exist in Sudanese Red Sea Coast at present time. Solid wastes are often treated by open burning.

3.1.2 Hazardous Waste Incineration

Since there is no hazardous waste management and classification in Sudan Red Sea Costal Area, their management by incineration or any special mean do not exist.

3.1.3 Light-Fraction Shredder Waste Incineration

This activity is not practiced in Sudanese Red Sea Coast. Separation of e.g. waste car and refrigerators are usually done manually by hand and the materials are then sold as scrap.

3.1.4 Sewage Sludge Incineration

This activity is not practiced in Sudanese Red Sea Coast. In fact there is no sewage system existed in all towns at the coastline.

3.1.5 Waste Wood and Waste Biomass Incineration

This activity is not practiced in Sudanese Red Sea Coast. The woods generated from industries mainly furniture are used for cooking. Wood from construction or demolitions is usually separated and used for cooking or disposes off with municipal solid wastes

3.1.6 Animal Carcasses Burning

Animal carcasses rejected from slaughterhouses for health reasons and the remains separated during slaughting process are collected and dispose off with municipal waste. .

3.1.7 Medical Waste Incineration

The problem of medical waste is well known and of high concern to the local authorities. 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 is mixed with municipal solid waste for disposal

3.2 MAIN CATEGORY NO 2- FERROUS AND NON-FERROUS PRODUCTION

3.2.1 Iron Ore Sintering

This activity was not realized in Sudanese Red Sea Coast.

3.2.2 Coke Production

No coke was produced in Sudanese Red Sea Coast.

3.2.3 Iron and Steel Production and Foundries

3.2.3.1 Steel production:

There is no facility for steel production exists in Sudanese Red Sea Coast.

3.2.3.4 Foundries:

There is no foundry engaged in metal recycling located in Sudanese Red Sea Coast.

3.2.4 Copper Production

3.2.4.1 General information

Only one foundry engaged in copper smelting from scrap materials. The foundry use cold air cupola furnace without any air pollution control system.

3.2.4.2 Activity data

Total annual production of this foundry is one ton annually. The foundry is located at the Sea Ports Corporation.

3.2.4.3 Emission factors

Potential releases to air using an Emission Factor of 800µg TEQ/t is

1 * 800 = 800 µg TEQ/a

= **0.0008 g TEQ/a**

Potential releases to residue using an Emission Factor of 630µg TEQ/t is

1 * 630 = 630 µg TEQ/a

= **0.00063 g TEQ/a**

3.2.4.4 Result

Copper Plants	Production (t/a)	E.F. to Air µg TEQ/t	Releases to Air µg TEQ/a	E.F. to Residues µg TEQ/t	Releases to Residues µg TEQ/a
capacity	1	800	800	630	630
Grand Total	**0.00143 g TEQ/a**				

3.2.4.5 Incomplete information

There are no incomplete information

3.2.5 Aluminum Production

3.2.5.1 General information

Two local foundries re-melt aluminum scraps. 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.

3.2.5.2 Activity data

Aluminum Production:

Total annual production is 4.9 t

3.2.5.3 Emission factors

Potential releases to air using an Emission Factor of 100µg TEQ/t is

4.9 * 100 = 490 µg TEQ/a

= **0.00049g TEQ/a**

Potential releases to residue using an Emission Factor of 200µg TEQ/t is

4.9 *200 = 980 µg TEQ/a

= 0.00098 g TEQ/a

3.2.5.4 Result

3. Table 3-4 Emission from Aluminum Production

Aluminium Plants	Production (t/a)	E.F. to Air µg TEQ/t	Releases to Air µg TEQ/a	E.F. to Residues µg TEQ/t	Releases to Residues µg TEQ/a

capacity	4.9	100	490	200	980
Grand Total	**0.00147 g TEQ/a**				

3.2.5.5 Incomplete information

There are no incomplete information

3.2.6 Lead Production:

No lead is produced or recycled in Sudanese Red Sea Coast.

3.2.7 Zinc Production

No zinc is produced in Sudanese Red Sea Coast.

3.2.8 Brass and Bronze Production

No brass and bronze production in Sudanese Red Sea Coast

3.2.9 Magnesium Production

No magnesium is produced in Sudanese Red Sea Coast.

3.2.10. Other non-ferrous Production

None of non-ferrous metal is produced in Sudanese Red Sea Coast.

3.2.11 Shredders

This activity is not practiced in Sudanese Red Sea Coast. Separation of e.g. waste car and refrigerators are usually done manually by hand and the materials are sold as scrap.

3.2.12 Thermal Wire Reclamation

There is no organized thermal wire reclamation to recover copper or aluminum identified during the inventory despite we believe that this activity is practiced by some individuals. The personnel who conducted this inventory tried hardly to locate possible places where this activity is performed but unfortunately they failed, even the information about the quantity of copper which may be recovered by this process is not available. So there is no data to make any kind of assumption.

Tires are burned to remove iron wire which is used in building construction. This process is taking place in open sites. The process was banned in residential and industrial areas, but still in some areas outside the city the process is practiced. No information available about the amount burn

3.3 MAIN CATEGOEY NO 3- HEAT AND POWER GENERATION

3.3.1 Fossil Fuel Power Plants

3.3.1.1 Electrical Power Station

3.3.1.1.1 General information

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

3.3.1.1.2 Activity data

1- Light fuel Oil/Diesel fuel consumption per year is 4015 t

2- Diesel Oil consumption per year is 660088.32 t

3.3.1.1.3 Emission factors

1- Emission of light /Diesel fuel

4015 * 44500

= 178667500 MJ/a

= 178.67 TJ/a

Potential releases to air

178.67 * 2.5

= 446.66 µg TEQ/a

= **0.000446 g TEQ/a**

2- Emission of Diesel oil

1460 * 45500

= 66430000 MJ/a

= 66.43 TJ/a

Potential releases to air

66.43 * 2.5

= 166.075 µg TEQ/t

= **0.000166 g TEQ/t**

3.3.1.1.4 Result

The total consumption of different fuel type and the releases from these stations are shown in the table below:

Table 3-5 Emission from Fossil Fuel Power Plants

Type of Fuel	Consumption t/a	Consumption TJ/a	E.F. to air µg TEQ/t	Releases to Air g TEQ/a
Heavy fuel fired power boiler	4015	178.67 TJ/a	2.5	**0.000446**
Light fuel oil	1460	66.43 TJ/a	0.5	**0.000166**
Grand Total	**0.0006 g TEQ/a**			

3.3.1.5 Incomplete information

There are no incomplete information

3.3.1.2 Industrial Power Generation

No industrial power boilers use fossil fuel found during the inventory

3.3.2 Biomass power plant

This activity is not realized in Sudanese Red Sea Coast

3.3.3 Landfill/Biogas Combustion:

This activity is not realized in Sudanese Red Sea Coast

3.3.4 Household Heating and Cooking with Biomass:

3.3.4.1 General information

Like many cities in Sudan, biomass in coastline cities is not a primary source of energy. Wood charcoal used for cooking is of limited amount.

3.3.4.2 Activity data

The amount consumed annually in Port Sudan city is 8 tons. Heating value used in calculation is obtained from the National Energy Corporation.

For this inventory no data available for use of wood as fired stove despite of its use in household cooking especially in rural area.

3.3.4.3 Emission factors

.

1- Wood charcoal consumption per year is 8 tons

8 * 28.9 * 1000 = 231200 MJ

= 0.2312

3.3.4.4 Result

Potential releases to air 0.2312 * 100 = 23.12 µg TEQ/a

= **0.00002312 g TEQ/a**

Potential releases to residue .0.2312 * 10 = 2.312 µg TEQ/a

= **0.00000231 g TEQ/a**

3.3.4.5 Incomplete information

There is no incomplete information

3.3.5 Domestic Heating and Cooking with Fossil Fuels

3.3.5.1 General information

According to the nature of the climate at Red Sea Coast residents do not require heating at home. However, LPG, wood and wood charcoal are used for cooking. LPG is used in urban areas for cooking, whereas wood and wood charcoal is mainly used in rural areas.

3.3.5.2 Activity data

Total amount of LPG used for cooking is 323.994 tons per year

3.3.5.3 Emission factors

323.994 * 46 * 1000 = 14903724 MJ

= 14.904 TJ

3.3.5.4 Result

Potential releases to air 14.904 * 1.5 = 22.356 µg TEQ/a

= **0.000022356 g TEQ/a**

3.3.5.5 Incomplete information

There are no incomplete information

3.4 MAIN CATEGORY NO 4 PRODUCTION OF MINERAL PRODUTION

3.4.1 Cement Production

No cement factory for cement production is existed in Sudanese Red Sea Coast

3.4.2 Lime production

No lime is produced in Sudanese Red Sea Coast

3.4.3 Brick Production

No brick is produced in Sudanese Red Sea Coast.

All bricks produced by pressing wet mixture of cement and sand with certain proportion. No heating is involved in this process.

4.4.4 Glass Production:

No glass production process exist in Sudanese Red Sea Coast

3.4.5 Ceramic Production:

No ceramic production process exist in Sudanese Red Sea Coast

3.4.6 Asphalt Mixing

3.4.6.1 General information

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.

3.4.6.2 Activity data

The total annual capacity of three of them is 175000 tons.

3.4.6.3 Result

Table 3-6 Emission from Asphalt Mixing

Plant	Production (t/a)	E.F. to Air (μg TEQ/t)	Releases to Air (μg TEQ/a)
Port Sudan asphalt mixing facilities	175000	0.07	12250
Grand Total	**0.01225 g TEQ/a**		

3.4.6.4 Incomplete information

No information about the amount produced by the fourth company which works only upon request.

3.4.7 Oil Shale Processing:

This activity is not existed in Sudanese Red Sea Coast.

3.5 MAIN CATEGORY NO 5 – TRANSPORT

Number of private, public and goods vehicles used in transportation which are registered in the Red Sea State is 87557. The number of trucks and farm equipments are 222. Fuels types consume by these sectors are gasoline and diesel. Calculations of PCDD/PCDF releases to air by all types of fuels used in this sector have been based on the total amount of consumption per year. The data from the Petrol and Transport Directorate at the Ministry of Finance are used to estimate the emission from each type of fuels consumed by the specified engine. Fortunately all gasoline used in the country is unleaded type. Some of this fuel is consumed outside the coastline but it is extremely difficult to estimate the amount.

3.5.1 4-Stroke Engines:

3.5.1.1 Result

Table 3-7 Emission from 4-Stroke Engines

Classification	Total amount consumed t/a	E.F to Air **µg TEQ/t**	Releases to Air **µg TEQ/a**
Unleaded fuel without catalyst	30075	0.1	3007.5
Total	**0.0030g TEQ/a**		

3.5.1.2 Incomplete data

There is no incomplete information

3.5.2 2-Stroke Engines:

The fuel consumed by this sub-category is difficult to estimate. Hence the calculation for this activity is not performed.

3.5.3 Diesel Engines:

3.5.3.1 Result

Table 3-13 Emission from Diesel Engines

Classification	Total amount consumed t/a	E.F to Air **µg TEQ/t**	Releases to Air **µg TEQ/a**
Diesel engines	15392.44	0.1	1539.244
Total	**0.00154 g TEQ/a**		

3.5.3.2 Incomplete information

There is no incomplete information

3.5.4 Heavy Oil Fired Engines:

3.5.4.1 Activity data

According to the estimation provided by the Red Port Corporation the quantity of heavy fuel oil used by ships is about 7200 ton per year

3.5.4.2 Result

Classification	Total amount consumed t/a	E.F to Air **μg TEQ/t**	Releases to Air **μg TEQ/a**
Heavy fuel oil	7200	4	28800
Total	**0.0288 g TEQ/a**		

3.5.4.3 Incomplete information

There is no incomplete information

3.6 MAIN CATEGORY NO 6 – OPEN BURNING PRODUCTION

3.6.1 Biomass Burning

3.6.1.1 Forest Fires

No forest at the coastline, however scatter trees of *maskee*t trees covering small area are sometimes removed by burning the lower part of the tree. No data available about the limited number of trees which is burned annually.

3.6.1.2 Grass and moor fires

Grass and moor fires does not occur in Sudanese Red Sea Coast.

3.6.1.3 Agricultural residues burning (in the field) impacted, poor conditions

Average precipitation in the coastal area is extremely low, ranging from 36 mm per year at Halaib in the north to 164 mm per year at Suakin in the south, so that the desert extends right to the tide mark. The only exception is the Tokar delta, which receives substantial runoff seasonal streams originating in Ethiopian and Eritrean highland. Subsequently agricultural activities in the red sea state is limited to Toker (40000 feddans) where sorghum, millets are the main crops. The stalks of both crops are mainly used as fodder for animals as there are no other sources of fodder in the area. Arbaat another agricultural area where in the past about 30000 are annually cultivated but recently and due to construction of small dam to preserve water for human use the cultivated area dropped to less than 1000 feddans. Both in Tokar and Arbaat crop residues are not burned but used for animals and building of small native huts

3.6.1.4 Agricultural residues burning (in the field) not impacted

The same situation in 4.6.1.3 applied for this subcategory.

3.6.2 Waste Burning and Accidental Fires

3.6.2.1 Landfill fires

The waste collected from Port Sudan city is openly burned in certain location around the city.

3.6.2.2 Accidental fires in houses, factories

3.6.2.2.1 General information.

It is worth to mention that there may be many incidents occurred thought out the coast but usually will not be reported. This is the case especially in the rural areas where usually there is no presence of and reporting to the Civil Defense Department.

3.6.2.2.2 Activity data

Data from Civil Department reported in 2009 that 183 accidental fires in houses, factories, shops and government facilities have been occurred.

3.6.2.2.3 Emission factors

Potential releases to air	165 * 400	= 66000μg TEQ/a
		= **0.066 g TEQ/a**
Potential releases to residue	183 * 400	= 73200 μg TEQ/a
		= **0.066 g TEQ/a**

3.6.2.2.4 Incomplete information

There are no information on the magnitude of damage in tons emission factor of 400 μg TEQ/item is used

3.6.2.3 Uncontrolled domestic waste burning\

3.6.2.3.1 General information

The case of Port Sudan illustrates the solid waste management problems that exist throughout the country. The city has several uncontrolled waste disposal sites on its fringes. The largest by far is located along the banks of a broad *wadi*, approximately six kilometers from the city center.

The boundaries of the site are difficult to determine, as open dumping takes place along the access routes and in vacant and common land. In total it is estimated not less than 5Km^2 are covered with a layer of mixed waste ranging from 0.1 to 1m in thickness.

The site is virtually uncontrolled and presents obvious health and environmental hazards. Waste is burned or sorted by resident group of waste scavengers who live in terrible conditions on sites. Animal observed feeding on the waste including dogs, goat and camels.

The types of waste dumped on site include clinical waste (syringes, catheters, blood packs, drugs and bandages), plastic and papers, drums and other metal scraps, abattoirs, and food wastes, and septic tanks solid and liquids.

All municipal and medical waste in Port Sudan city is managed by local municipal authority and private company. Domestic and medical waste collected every day from household, markets, hospitals and private clinics are disposed off in certain area outside the city.

3.6.2.3.2 Activity data

This waste is burned in open at different frequencies. The amount collected and burned annually is 40396 tons.

3.6.2.3.2.3 Emission factors

Potential releases to air	40369* 1000	= 40369000 µg TEQ/a
		= 40.359 g TEQ/a
Potential releases to residue	40369*600	=24221400 µg TEQ/a
		=24.22 g TEQ/a

3.6.2.3.2.4 Result

Total release **=64.58 g TEQ/a**

4.6.2.4 Accidental fires in vehicles

3.6.2.4.1 Activity data

According to Civil Defense Department the total number of vehicles fires accidentally are 18.

3.6.2.4.2 Emission factors

Potential emission to air	18 * 94	= 1692 µg TEQ/item
		= **0.001692 g TEQ/item**
Potential emission to residue	18 * 18	= 324 µg TEQ/item
		= **0.000324 g TEQ/item**

3.6.2.4.3 Result

Total release

=0.00202 g TEQ/a

3.6.2.5 Open burning of wood (construction/demolition)

Wood from construction or demolitions usually separated and used for cooking or dispose off with municipal solid wastes.

3.7 MAIN CATEGORY NO 7- PRODUCTION OF CHEMICALS AND CONSUMER GOODS

3.7.1 Pulp and Paper Production:

There are no pulp and paper mills in Sudanese Red Sea Coast.

3.7.2 Chemical Industry:

3.7.2.1 Chlorine production:

There is no chlorine chemical industry is practiced in Sudanese red Sea coast.

No other potential relevant chemical industry mentioned in the toolkit was discovered.

3.7.3 Petroleum Industry

The first and oldest refinery situated at Port Sudan city was closed down since 1999. The refinery design is not suitable for refining of the crude oil produced in Sudan at present. At the time of its operation the catalyst used is re-exported to original company for activation. No plan to operate it in near future.

3.7.4 Textiles Production

This industry is not practiced in Sudanese Red Sea Coast

3.7.5 Leather Refining

Only one tannery identified during the inventory. It produces about 2600 pieces of leather from both sheep and cows. Tanning process involved chromium sulphate that impart blue green colour to the leather. In this process PCP is not used before or at any stage of the process, therefore it is unlikely this tanning process produces any PCDD/PCDF emission.

3.8 MAIN CATEGORY NO 8 – MISCELLANEOUS

3.8.1 Drying of biomass

This activity is not practiced in Port Sudan city which is the main and biggest city at the coastline.

3.8.2 Crematoria

Sudan is a Muslim country hence this activity is not known in any part of it.

3.8.3 Smoke Houses

This activity is not practiced in Sudanese Red Sea Coast.

3.8.4 Dry Cleaning

A dry cleaning service is not found in all cities at Red Sea State.

3.8.5 Tobacco Smoking:

3.8.5.1 General information

Information about the exact amount tobacco consumed annually is not available and the following assumption is made

Assumption: Number of population in the costal is 1,300,000. 10% of these population smokes 5 cigarette per individual/ day and the weight of each cigarette is one gram.

3.8.5.2 Activity data

Therefore the amount of cigarettes consumed per year is 47.45 ton.

3.8.5.2.3 Emission factors

Using emission factor of 0.1pg T-TEQ the emission from this sub-category is negligible.

According to information from Custom Department (Illegal Trade Section) the amount of shiesha in the year is about 25 Kg. Assuming that this amount represent only 0.1% of the real amount entering Port Sudan. Using this assumption the total amount used in the year is 25 ton. Applying emission factor of 0.3pg T-TEQ,

3.8.5.2.4 Result

The emission to air from this sub-category is negligible.

3.8.5.2.5 Incomplete information

Information about the exact amount tobacco consumed annually is not available and the following assumption is made.

3.9 MAIN CATEGORY NO 9 - DISPOSAL

3.9. 1 Landfill and Waste Dumps

For the purposes of the toolkit, landfill is a controlled engineered waste storage site where as a dump is a largely dump site contains mixed waste that was disposed of without any pollution prevention devices. In all cities at Red Sea State disposal sites are unmanaged and can be classified as open disposal sites. Most are close to the residential areas.

The passage of water in rainy season through waste cause leachates escaping in uncontrolled manner. Since the rainfall has a large variation and the area of waste disposal is difficult to estimate, the PCDD/PCDF emission from this subcategory cannot be calculated.

3.9.2 Sewage and Sewage Treatment

Sewer 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

The 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.).

3.9.3.2 Activity data

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 and we assume that the number of capita members is 5.

3.9.3.3 Emission factors

The releases to water from this sub-category using emission factor 0.5pg TEQ/L will be:

500000/5*60*365*.5 = 1095000 µg TEQ/L

=1.095 g TEQ/L

3.9.3.4 Result

=1.095 g TEQ/a

3.9.3.5 Incomplete information

There is no incomplete information

3.9.4 Composting

This activity is not practiced at Red Sea State.

3.9.5 Waste oil Treatment

No recycling plant or process for the used lubricating oil collected from car and other motors. Part of it is used in septic tanks for mosquito control. Large amount is dispose off as waste in open area.

In restaurant and canteens the oil is totally consumed and therefore no waste oil result from food businesses.

3.10 MAIN CATEGORY NO 10 – INDENTIFICTION OF POTENTIAL HOPTS SPOTS

3.10.1 Production sites of Chlorinated Organics

There is no production of chlorinated organic chemicals in Sudanese Red sea Coast.

3.10.2 Production Sites of Chlorine

This activity is not practiced before at Red Sea state.

3.10.3 Formulation Sites of Chlorinated Phenols

No formulation of chlorinated phenols is done in Red Sea State.

3.10.4 Application Sites of Chlorinated Phenols

Chlorinated phenols are not applied in Sudanese Red Sea Coastal area,

3.10.5 Timber manufacture and Treatment Sites

Woods that are locally produced for construction are not treated by any chemicals.

4.10.6 PCB-filled Transformers and Capacitors

During the inventory no site identified which is at present or formally used for PCB-filled Transformers and Capacitors.

3.10.7 Dump of Wastes/Residues from Categories 1-9

Municipal solid waste and waste water are openly disposed.

3.10.8 Sites of relevant accidents:

No site of relevant accident identified during this inventory.

3.10.9 Dredging of sediments

No information about such activities in the coastline.

3.10.10 Kaolinic or ball clay sites

No Koalinic or ball clay site identified in the coastline.

4. Assessment of the inventory results:

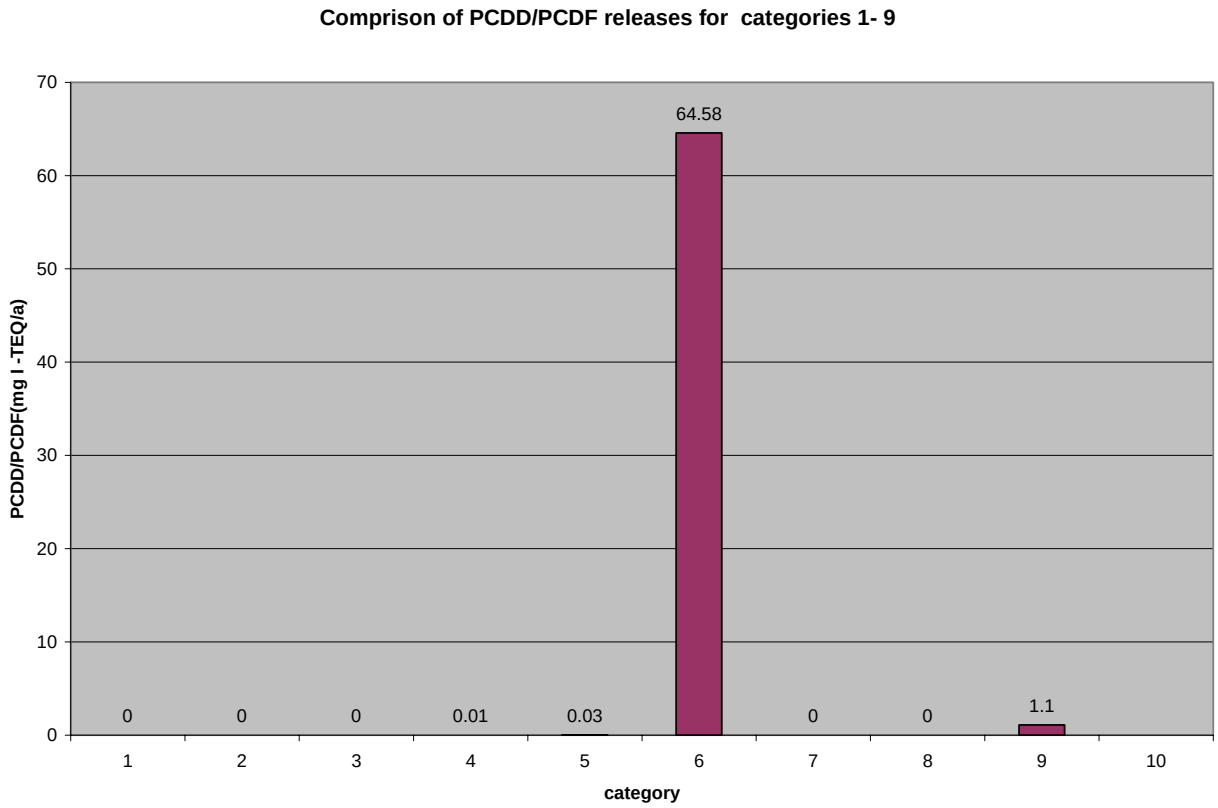
The quantities of dioxin and furan releases from all categories are summarized in Table 4-1. An estimated 65.64 g TEQ of PCDD/PCDF was released into the environments of coastline. Uncontrolled combustion processes had the largest impact with an emission of 64.58 g TEQ/a, which is 98.4% of total emission followed by disposal/landfill 1.1g TEQ/L, transport (0.0333; 0.05% of total releases) and ferrous and non-ferrous metal production and production of mineral products (each 0.02%).

The releases to the five compartments/media – air, water, land, residues and products – were assessed. According to the toolkit approach, the main emission vectors were to air (40.4165 g; 61.58% of total releases) and residues (24.2216 g; 36.90% of total releases) and water (1.1g ; 1.6%) with no releases to land, product and water. However since PCDD/PCDF are semi-volatile compounds and can transgress from one media to another (Figure 2), the emission vectors only give an idea of the direct releases from the sources and not of the final contamination. For example the main emission source of the coastline is uncontrolled waste burning with a direct release of 24.22g (36.90% of total releases) to residues. However, this can also be viewed as a direct contamination of land since the residues of uncontrolled waste combustion are just scattered all over the land and mixed with soil and additionally distributed by the wind. Furthermore this widely distributed contaminated residues/soil/land has the potential to directly contaminate water by wash out via rain.

Table 4-1 Summery of PCDD/PCDF Releases

Cat	Source Categories	Annual Releases (**g TEQ/a)**						
		Air	Water	Land	Products	Residues	Total	%
1	Waste Incineration	0.000	0.000	0.000	0.000	0.000	0.000	0.00
2	Ferrous and Non-Ferrous Metal Production	0.0013	0.000	0.000	0.000	0.0016	0.0029	0.00
3	Power Generation and Heating	0.0006	0.000	0.000	0.000	0.000	0.0006	0.00
4	Production of Mineral Products	0.0123	0.000	0.000	0.000	0.000	0.0123	0.02
5	Transportation	0.0333	0.000	0.000	0.000	0.000	0.0333	0.05
6	Uncontrolled Combustion Processes	40.369	0.000	0.000	0.000	24.22	64.58	98.39
7	Production of Chemicals and Consumer Goods	0.000	0.000	0.000	0.000	0.000	0.000	0.00
8	Miscellaneous	0.000	0.000	0.000	0.000	0.000	0.000	0.00
9	Disposal/Landfills	0.000	1.10	0.000	0.000	0.000	0.000	1.67
10	Identification of Potential Hot-Spots							
1-9	**Total**	**40.4165**	**1.10**	**0.000**	**0.000**	**24.2216**	**65.6381**	

	%	**61.58**	**1.6**	**0.00**	**0.00**	**36.90**		



Key:

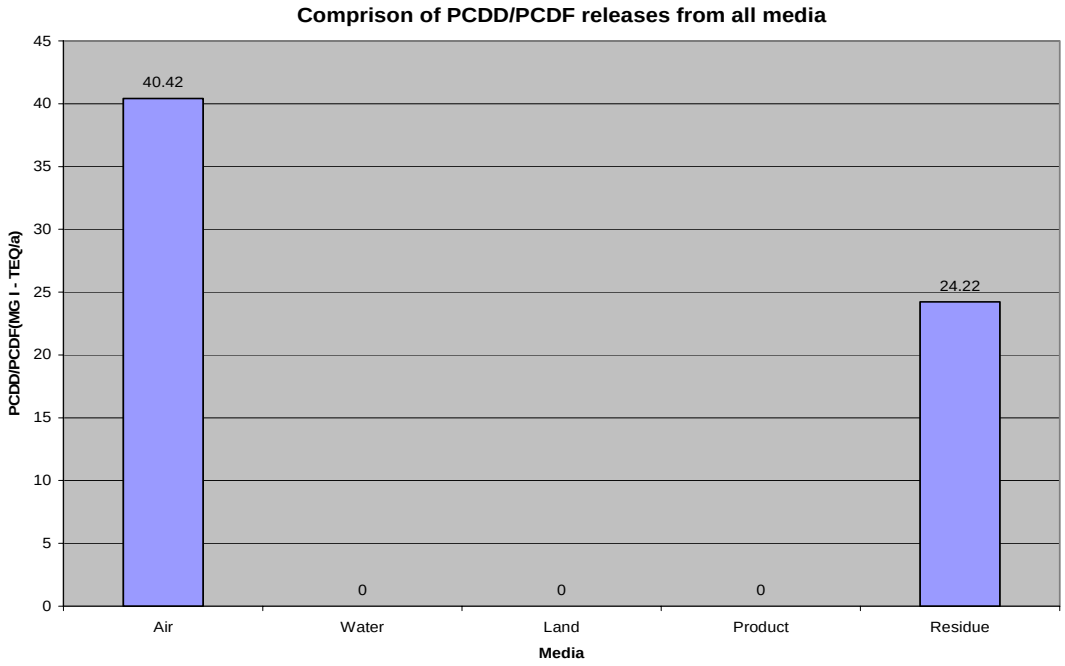
1= Waste incineration 2= Ferrous and Non-ferrous metal production

3=Power generation and heating 4= Production of mineral products

5= Transportation 6= Uncontrolled combustion processes

7= Production of chemicals and consumer goods 8=Miscellaneous

9= Disposal/landfills



A few emission sources could not be estimated and included in this inventory due to a lack of information. These were:

- Accidental fires in houses and shops: incidents may occur throughout the coastline but usually are not being reported. This is the case especially in the rural areas where usually there is no presence of and reporting to the Civil Defence Department.
- Forest fires: No information available about the limited activities for trees removal.
- Open water dumping: Some industries discharge their wastewater on land or open dumping. No compiled data exist for such discharge. Household wastewater in urban areas is disposed of in open pit latrines and in septic tanks. Also no figures were available for the percentage of domestic wastewater or sludge treated by different systems (septic tanks, pit latrines etc.). In rural areas wastewater is disposed of directly on land. Also no compiled data exist for such discharge.

Finally it is expected that the findings of the dioxin and furan inventory shall have an impact on the environmental policy in general (e.g. waste management).

Furthermore, it is believed that the need to introduce a basic monitoring program is essential

- For the verification of the data and results of the PCDD/PCDF inventory,
- For the assessment of (environmental) contamination and identification of hot spots, and
- For priority setting and guidance of the action plan.

5. PRIORETY SECTORS AND LOCATION FOR BAT/BEP INTRODUCTION

With the guidance of the above criteria and in consultation with team who did the survey, the priorities for BAT/BEP implementation were set as follows:

1- Uncontrolled domestic waste burning.

2- Asphalt mixing facilities

3- Copper and Aluminum Production

5.1 Priority locations for BAT/BEP implementation to open burning of waste:

1- Uncontrolled domestic and medical waste burning.

5.2 Criteria for selecting the priority locations:

The main objectives of priority setting are:

- To ensure adequate human health and environmental protection from UP-POPs risks
- To ensure that UP-POPs policies are supporting the overall policy direction and agenda
- Give guidance for the drafting the UP-POPs the implementation plan, specially when dealing with the proposed activities and their finance

Based on the above the priority criteria could be:

1- Location, sensitive areas: these in general refer to the nature and environmental values, what is the direct environmental exposure and thus indirect exposure of the humans.

2- Human exposure: Immediate risks, number of people exposed and the degree of exposure.

3- Legal, formal criteria according to the Stockholm Convention: Elaboration of the necessity to manage and/or phase-out toxic substances according to the criteria set in the SC; identify, remove, eliminate, etc. For the UP-POPs is to reduce or eliminate.

4- Political and public wills and urgency: Potential for release and exposure from contained or non-contained area (e.g. industrial setting, waste site) larger/minor human population groups exposed

Annexes

1 Site visits & Interviews

State Ministry of Environment

Port Sudan City Municipality, Preventive Health

Municipal disposal sites

Foundry of Sea Ports Corporation for Copper and Aluminum production

State Ministry of Finance, Transport Administration

Electrical Power Generation Plants

Asphalt Mixing Plants

Civil Defence Department

Slaughterhouse

Tannery Plant

Forestry Department

State Ministry of Industry

Petroleum Refinery

2 Contact details of the stakeholders contacted in the inventory:

The completed questionnaires are kept with project coordinator.

Ferrous and Non-ferrous metal production:

Sea Ports Corporation

Power Generation and Heating:

1- Kalid Osman Ahmed

Tel. 0912310475

2- Eng. Osman Mohamed Ali

Tel. 0913133531

Production of Mineral

Asphalt Mixing:

1- Al Naser General for Contracts,

Director, Hassan Alam

Production Engineer, Ahmed Al Husiny

2- Sea Ports Engineering Company

Director, Dack Pawlo

Tel. 0912377164,

Engineer, Ashraf Hassan

Tel. 0922819088

3- Al Thger Engineering Company

Tel. 311824592, 8785439670

Fax: 311827902

e-mail: ELTHAGER@hotmail.com

4- Gaser AL Lollow Company

Tel. 0912178111

Transport:

Transport and Petrol Administration,

Hisham Mohamed Al Hassan

Tel. 0912331822

Open Burning Processes

1. Preventive Health Administration, Port Sudan Locality, Ministry of Health,

Health Inspector: Mustfa Mohamed Ohag

Tel. 0912727250

2- Forestry Department

Abdelaziz Sid Ahmed

Tel. 0912708406

3- Port Sudan city, Civil Defense Department

Table 2 Ferrous and Non-ferrous Metal Production

Source Categories	Potential Releases Route (µg TEQ/a					Production t/a	Annual Release (g TEQ/a)				
Category 2. Ferrous and Non-Ferrous Metal Production	Air	Water	Land	Products	Residues		Air	Water	Land	Products	Residues
(a) Iron ore sintering											
1. High waste recycling, incl. Oil contaminant. Materials	20	ND	HD	ND	0.003	0					
2. Low waste use, well controlled plant	5	ND	ND	ND	0.003	0					
3. High technology, emission reduction	0.3	ND	ND	ND	0.003	0					
(b) Coke production											
1. No gas cleaning	3	ND	0.06	ND	ND	0					
2. Afterburner/ dust removal	0.3	ND	0.06	ND	ND	0					
(c) Iron and steel production plants and foundries											
Iron and steel plants											
1. Dirty scrap, scrap preheating, limited	10	ND	ND	NA	15	0					

controls											
2. Clean scrap/virgin iron, afterburner, fabric filter	3	ND	ND	NA	15	0					
3. Clean scrap/virgin ions, BOS furnaces	0.1	ND	ND	NA	1.5	0					
4. Blast furnaces with APC	0.01	ND	ND	NA	ND	0					
Foundries											
1. Cold air cupola or rotary drum, no APCS	10	ND	ND	ND	ND	0					
2. Rotary drum - fabric filter	4.3	ND	ND	NA	0.2	0					
3. Cold air cupola, fabric filter	1	ND	ND	ND	8	0					
4. Blast cupola or induction furnace, fabric filter	0.03	ND	ND	ND	0.5	0					
(a) Hot-dip galvanizing Plants											
1. Facilities without APCS	0.06	NA	NA	NA	ND						
2. Facilities with degreasing step, good APCS	0.05	NA	NA	NA	2,000						
3. Facilities with degreasing step, good APCS	0.02	NA	NA	NA	1,000						
(d) Copper											

production											
1. Sec. Cu - Basic technology	800	ND	ND	ND	630	1	**0.0008**				**0.0006**
2. Sec. Cu - well controlled	50	ND	ND	ND	630	0					
3. Sec. Cu - optimized for PCDD/PCDF control	5	ND	ND	ND	300	0					
4. Smelting and casting of Cu/Cu alloys	0.03	ND	ND	NA	ND	0					
5. Prim. Cu well controlled with some secondary feed materials	0.01	ND	ND	ND	ND	0					
6.Pure prim.Cu smelters with no secondary feed	ND	ND	NA	NA	NA						
(e) Aluminium production 1. Processing scrap Al, minimal treatment of inputs, simple dust removal	150	ND	NA	NA	200	4.9	**0.00049**				**0.0010**
2. Scrap treatment, well controlled, good APCS	35	ND	ND	ND	400	0					
3. scrap	5	ND	NA	NA	100						

treatment, well controlled fabric filter, lime injection											
4. Optimized process, optimized APCS	1	ND	ND	ND		0					
5. Shaving/turnings drying (simple plants)	5	NA	NA	NA	NA	0					
6. Thermal de-oiling, rotary furnace, after burners, fabric filters	0.3	NA	NA	NA	NA						
7. Pure primary Al Plants	ND	NA	NA	NA	ND						
(f) Lead production											
1. Sec. Lead from scrap, PVC battery separator	80	ND	NA	NA	ND	0					
2. SE. from PVC/Cl2 fee scrap, some APCS	8	ND	NA	NA	5	0					
3. Sec. Lead, PVC/Cl2 free scrap in modern furnaces, with scrubber	0.5	ND	NA	NA	ND	0					
4. Pure primary lead production	0.5	ND	NA	NA	ND						

(g) Zinc production											
1. Kiln with no dust control	1,000	ND	ND	ND	ND	0					
2. Hot briquetting/rotary furnaces, basic control	100	ND	ND	ND	ND	0					
3. Comprehensive control	5	ND	ND	ND	ND	0					
4. Melting (only)	0.3	ND	ND	ND		0					
5. Pure primary Zinc production	ND	ND	NA	NA	ND						
(h) Brass and Bronze production											
1. Thermal de-oiling of turning	2.5	NA	NA	NA	NA	0					
2. Simple melting furnaces	10	ND	NA	NA	ND	0					
3.Mixed scrap, induction furnace, bag filter	3.5	ND	NA	NA	125						
4. Sophisticated equipment, clean inputs, good APCS	0.1	ND	NA	NA	ND						
(i) Magnesium production											
1. Using MgO/C thermal treatment in C12, no	250	9,000	NA	ND	0	0					

effluent treatment, poor APCS											
2. Using MgO/C thermal treatment in C12, comprehensive pollution control,	50	24	NA	ND	9,000	0					
j) Thermal non-ferrous metal production (e.g. Ni)											
1. Contaminated scrap, simple or no dust control	100	ND	ND	ND	ND	0					
2. Clean scrap, good APCS	2	ND	ND	ND	ND	0					
(k) Shredders											
1. Metal shredding plants	0.2	NA	NA	ND	ND	0					
(l) Thermal wire reclamation					ND						
1. Open burning of cable	5,000	ND	ND	ND	ND						
2. Basic furnace with after burner, wet scrubber	40	ND	ND	ND	ND	0					
3. Burning electric motors, brake shoes, etc., afterburner	3.3	ND	ND	ND	ND	0					

Ferrous and non-ferrous metal production							**0.0013**				**0.0016**

Table 3 Heat and Power Generation

Source Categories	Potential Releases Route (µg TEQ/a					Production t/a	Annual Release (g TEQ/a)				
Category 3. Heat and Power Generation	Air	Water	Land	Products	Residues		Air	Water	Land	Products	Residues
(a) Fossil fuel power plants											
1. Fossil fuel/waste co-fired power boilers	35	NA	NA	NA	ND	0					
2. Coal fired power boilers	10	NA	NA	NA	14	0					
3. Heavy fuel fired boilers	2.5	NA	NA	NA	ND	4015	0.00044				

4. Shale oil fired power plants	1.5	ND	NA	NA	ND						
5. Light fuel/oil/natural gas fired power boilers	0.5	NA	NA	NA	ND	1460	0.00017				
(b) Biomass power plants											
1. Mixed biomass fired power boilers	500	NA	NA	NA	ND	0					
2. Clean wood fired power boilers	50	NA	NA	NA	15	0					
(c) Landfill and biogas combustion											
1. Biogas-/landfill gas fired boilers,	8	NA	NA	NA	NA	0					
(d) Household heating and cooking - Biomass											
1. Contaminated wood/biomass fired stoves	1,500	NA	NA	NA	1,000	0					
2. Virgin wood/bio	100	NA	NA	NA	10	0					

mass fired stoves											
(e) Domestic heating - fossil fuels											
1. High-chlorine coal fired stove	12,000	ND	NA	NA	30,000						
2. Coal fired stoves	100	ND	NA	NA	5,000	0					
3. Oil fired stoves	10	NA	NA	NA	NA	0					
4. Natural gas fired stoves	1.5	NA	NA	NA	NA	323.994	0.00002				
Heating and Power generation							**0.00062**				

Table 4 Production of mineral products

Source Categories	Potential Releases Route (µg TEQ/a					Production t/a	Annual Release (g TEQ/a)				
Category 4. Production of mineral products	Air	Water	Land	Products	Residues		Air	Water	Land	Products	Residues
(a) Cement kilns											
1. Shaft kilns	5	NA	Na	ND	ND						
2. Old wet kilns, ESP temperature > 300 ^{o}C	5	NA	ND	ND	NA	0					
3. Wet kilns, ESP/FF temperature 200 to 300 oC	0.6	NA	ND	ND	NA	0					
4. Wet kilns, ESP/FF temperature < 200 oC and all	0.05	NA	ND	ND	NA	0					

types of dry kilns with preheater/precal ciners, T <200ºC											
(b) Lime											
1. Cyclone/no dust control, contaminated or poor fuel	10	ND	ND	ND	ND	0					
2. Good dust abatement	0.07	ND	ND	ND	ND	0					
(c) Brick											
1. Cyclone/no dust control, contaminated or poor fuel	0.2	NA	ND	ND	ND	0					
2. Good dust abatement	0.02	NA	ND	ND	ND	0					
(d) Glass											
1. Cyclone/no dust control, contaminated or poor fuel	0.2	NA	ND	ND	ND	0					
2. Good dust abatement	0.015	NA	ND	ND	ND	0					
(e) Ceramics											
1. Cyclone/no dust control, contaminated or poor fuel	0.2	NA	ND	ND	ND	0					
2. Good dust abatement	0.02	NA	ND	ND	ND	0					
(f) Asphalt mixing											
1. Mixing plant with no gas cleaning	0.07	ND	ND	ND		175,000	0.0123				
2. Mixing plant with fabric filter, wet scrubber	0.007	ND	ND	ND							
Oil shale processing											
1.Thermal	ND	ND	ND	ND	ND						

fractionation											
2. Oil shale pyrolsis	0.003	NA	ND	0.07	2						
Production of mineral products							0.0123				

Table 5 transport

Source Categories	Potential Releases Route (µg TEQ/a					Production t/a	Annual Release (g TEQ/a)				
Category 5. Transport	Air	Water	Land	Products	Residues		Air	Water	Land	Products	Residues
(a) 4-stroke engines											
1. Leaded fuel	2.2	NA	NA	NA	NA	0					
2. Unleaded fuel without catalyst	0.1	NA	NA	NA	NA	30075	0.0030				
3. Unleade	0.0	NA	NA	NA	NA	0					

d fuel with catalyst	0										
(b) 2-stroke engines											
1. Leaded fuel	3.5	NA	NA	NA	NA	0					
2. Unleaded fuel without catalyst	2.5	NA	NA	NA	NA	0					
(c) Diesel engines											
1. Diesel engines	0.1	NA	NA	NA	ND	15,392.44	0.0015				
(d) Heavy oil fired engines											
1. All types	4	NA	NA	NA	ND	7200	0.0288				
Transport							0.0333				

Table 6 Open burning Process

Source Categories	Potential Releases Route (µg TEQ/a					Production t/a	Annual Release (g TEQ/a)				
Category 6. Open burning Process	Air	Water	Land	Products	Residues		Air	Water	Land	Products	Residues
(a) Fires/burning -											

biomass											
1. Forest fires	5	ND	4	NA	ND	0			**0**		
2. Grassland and moor fires	5	ND	4	NA	ND	0			**0**		
3. Agricultural residue burning (in field), impact, poor combustion conditions	30	ND	10	NA	ND	0			**0**		
Agricultural residue burning (in field), not impacted	0.5	ND	10	NA	ND	0			**0**		
(b) Fires, waste burning, landfill fires, industrial fires, accidental fires											
1. Landfill fires	1,000	ND	600	NA	600	40369	40.369				**24.22**
2. Accidental fires in houses, factories	400	ND	400	NA	400	165	0.066				**0.066**
3. Uncontrolled domestic waste burning	300	ND	600	NA	600						
4. Accidental fires in vehicles (per vehcile)	94	ND	18	NA	18	18	0.0017				**0.0003**
5. Open burning of wood (construction/demolition)	60	ND	10	NA	10	0					
Uncontrolled combustion processes							**40.4367**				**24.2863**

4. Assumption methodology

Information about the exact amount tobacco consumed annually is not available and the following assumption is made

Assumption:

Number of population in the costal is 1,300,000. 10% of these population smokes 5 cigarette per individual/ day and the weight of each cigarette is one gram. Therefore the amount of cigarettes consumed per year is 47.45 ton. Using emission factor of 0.1pg T-TEQ the emission from this sub-category is negligible.

According to information from Custom Department (Illegal Trade Section) the amount of shiesha in the year is about 25 Kg. Assuming that this amount represent only 0.1% of the real amount entering Port Sudan. Using this assumption the total amount used in the year is 25 ton. Applying emission factor of 0.3pg T-TEQ, the emission to air from this sub-category is negligible.