HASHEMITE KINGDOM OF JORDAN
AGABA SPECIAL ECONOMIC ZONE AUTHORITY

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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Contributors

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CONTENT

Glossary/Abbreviations

°C	Degree Celsius
µg	microgram (10-6 grams)
A	Annum
ASEZ	Aqaba Special Economic Zone
ASEZA	Aqaba Special Economic Zone Authority
BAT	Best Available Techniques
BE	Best Estimate
BEP	Best Environmental Practice
DWT	Dead Weight Tonnage
ECD	Ethylene Chlorine or 1,2-dichloroethane
FBC	Fluidized Bed Combustor
G	gram
GJ	Gigajoule (109 Joules)
GWh	Gigawatt hour
HFO	Heavy Fuel Oil
IMO	International Maritime Organisation
JISM	Jordanian Institution for Standards and Meteorology
JOD	Jordanian Dinar
JPMC	Jordan Phosphate Mines Company
KEMAPCO	Kemira Arab Potash Company
Kg	kilogram (103 grams)
MJ	Megajoule (106 joules)
MOEnv	Ministry of Environment
MOH	Ministry of Health
MSW	Municipal Solid Waste
Mt	Megaton (106 tons)
MW	Medical Waste
NA	Not Applicable
NAFETH	Privet Company responsible for trucks entrance to Aqaba
ND	No Data
Ng	nanogram (10-9 grams)
Nm^3	Normal cubic meter (Temp. = 0 °C, Pressure = 1 atmosphere)
PCB	Polychlorinated Biphenyls
PCDD	Polychlorinated dibenzo-p-dioxins
PCDD/F	Polychlorinated dibenzo-p-dioxins & Polychlorinated dibenzo-p-furans
PCDF	Polychlorinated dibenzo-p-furans
PCP	Pentachlorophenol
Pg	picogram (10-12 grams)
PJ	Petajoule (1015 joules)
POPs	Persistent Organic Pollutants
PVC	Polyvinyl Chloride
Ro-Ro	Roll-on Roll-off
TCDD	Tetrachlorodibenzo-p-dioxin
TEF	Toxicity Equivalency Factor
TEQ	Toxic Equivalent
TJ	Terajoule (1012 Joules)

UNEP	United Nations Environment Programme
VCM	Vinyl Chloride Monomer
VOCs	Volatile Organic Compounds

SUMMARY

This study provides a national inventory of polychlorinated dibenzo-p-dioxin (PCDD) and polychlorinated dibenzofuran (PCDF) emissions to air, water and land from known sources. The reference date for this inventory is the year 2008.

This inventory was established according to the Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases Edition 2.1 December 2005.

Sources of PCDDs and PCDFs to the environment for which annual estimates of emissions and releases have been attempted were:

Medical waste incineration

Animal carcasses burning

Thermal wire reclamation

Fossil fuel power plants

Biomass power plants

Domesting heating - Fossil fuels

4-Stroke engines

2-Stroke engines

Diesel engines

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

Dry cleaning residues

Tobacco smoking

Sewage/sewage treatment

Open water dumping

Table ES1 presents summary dioxin emission estimates for each category included in the inventory

Category 2 (Ferrous and Non-Ferrous Metal Production), category 4 (Production of Mineral Products), and category 7 (Production and Use of Chemicals and Consumer Goods) were not considered in this study since they are not carried out in Aqaba (except for category 2, which has been discussed more extensively as we shall see in a page 19).

Certain sources, for example municipal solid waste incineration and smoke houses, were not considered also in the current study since they are not carried out in Aqaba.

The category with the highest estimated emission is the transport sector (i.e. Diesel engines). Transport sector is estimated to contribute to nearly 64.3% of total emissions to air. Port activities and ships consumed around 4869552 ton/a (the amount of diesel consumed by the ships was obtained from the Jordanian Maritime Authority).

Aqaba is considered a high attraction for tourists, receiving 66% of the tourists entering Jordan. There was no enough data about the tourist buses came to Aqaba.

The port of Aqaba, located at the north end of the Gulf of Aqaba, is the sole port in Jordan serving as a base to import daily necessities and export phosphate, potash, and fertilizer, among others. Aqaba receive different types of trucks loading and unloading miscellaneous goods, the majority of these trucks came from outside Aqaba, therefore the estimated distance traveled by each truck inside Aqaba will be no more than forty kilometers for each trip.

Waste incineration contributes to nearly 29.2% of total emissions to air. However, in Aqaba, there is only one late model waste incinerator. This incinerator no longer meets recommended practice standards and is situated too close to other buildings. As for the rest of the Zone's clinical waste, despite sorting efforts, the waste is indifferently disposed off in the Aqaba City Landfill, without any treatment whatsoever. An agreement between

ASEZA and Royal Medical Services (RMS) was signed, ASEZA will take the role of collecting these medical wastes from the generator and the RMS will transfer it to one of their incinerator outside the zone. The haulage of the waste will stop the release of dioxin from the medical waste incinerator and this will reduce the annual release of dioxin to air and residue.

Heat and Power Generation contribute to nearly 5.6% of the total emission to air, the amount of diesel consumed by the boilers (industrial and non industrial) and power generators is 5588.6 ton/a and the amount of heavy fuel used in Heavy fuel fired power boilers and power generators is 214237 ton/a

The power generation in Aqaba has turned to natural gas instead of heavy fuel, this will lead to decrease the dioxin emission to air, the flair which are connected to the pipeline of the imported natural gas was included in this section with an amount of 793581.7 ton/a.

Disposal and land filling is estimated to be the only source of dioxin emissions to water and highest estimated emission to residues with annual release of 0.007 to water and 0.110 to residues.

Sewage/sewage treatment contributes to nearly 43% of the total emission to water and 98% to residue. Open water dumping contributes to nearly 57% of the total emission to water.

No estimate of leachate emissions to groundwater in Aqaba was identified. Aqaba has an extremely dry weather, the total annual rainfall for Aqaba for the year 2008 is 1.5 mm was obtained from the Jordanian Bureau of Meteorology Aqaba landfill doesn't have any collection system for the leachate and the volume of the landfill is very small around 4 ha with a depth of 3 m.

Open Burning Processes is estimated to be the only significant source of dioxin emission to land through the 77 accidental fires in houses and factories, and 50 accidental fires in vehicles which annually release 0.003 g TEQ/a .

Table ES1 Summary of Best Estimate Dioxin Emissions to Air, Water and Land in Aqaba for 2008

Cat.	Source Categories	Annual Releases (g TEQ/a)				
		Air	Water	Land	Product	Residue
1	Waste Incineration	0.220	0.000	0.000	0.000	0.001
2	Ferrous and Non-Ferrous Metal Production	0.000	0.000	0.000	0.000	0.000
٣	Heat and Power Generation	0.042	0.000	0.000	0.000	0.000
4	Production of Mineral Products	0.000	0.000	0.000	0.000	0.000
5	Transportation	0.485	0.000	0.000	0.000	0.000
6	Open Burning Processes	0.011	0.000	0.008	0.000	0.000
7	Production of Chemicals and Consumer Goods	0.000	0.000	0.000	0.000	0.000
8	Miscellaneous	0.000	0.000	0.000	0.000	0.002
9	Disposal	0.000	0.007	0.000	0.000	0.110
10	Identification of Potential Hot-Spots				0.000	0.000
1-9	**Total**	**0.759**	**0.007**	**0.008**	**0.000**	**0.112**
	Grand Total			**1**		

Table ES2 summarizes the information from Table ES1 by subcategory. Only 14 emitters are included in Table ES2 as the emissions produced by the remaining subcategories become insignificant.

Table ES2 Emission Estimates by Subcategory

Source Category	Annual Estimated Release TEQ/a						
	Air	Water	Land	Product	Residue	Bottom Ash	Total"
Medical waste incineration	0.220	0.000	0.000	0.000	0.000	0.001	0.221
Animal carcasses burning	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Thermal wire reclamation	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fossil fuel power plants	0.042	0.000	0.000	0.000	0.000	0.000	0.041

Biomass power plants	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Domesting heating - Fossil fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4-Stroke engines	0.002	0.000	0.000	0.000	0.000	0.000	0.002
2-Stroke engines	0.001	0.000	0.000	0.000	0.000	0.000	0.001
Diesel engines	0.482	0.000	0.000	0.000	0.000	0.000	0.482
Fires, waste burning, landfill fires, industrial fires, accidental fires	0.011	0.000	0.008	0.000	0.000	0.000	0.009
Dry cleaning residues	0.000	0.000	0.000	0.000	0.002	0.000	0.002
Tobacco smoking	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sewage/sewage treatment	0.000	0.003	0.000	0.000	0.110	0.000	0.113
Open water dumping	0.000	0.004	0.000	0.000	0.000	0.000	0.004
Total	0.758	0.007	0.008	0.000	0.112	0.001	0.886

Figure ES1 show the estimated dioxin emissions from each category included in the inventory to air, water, land, product, residue and bottom ash respectively.

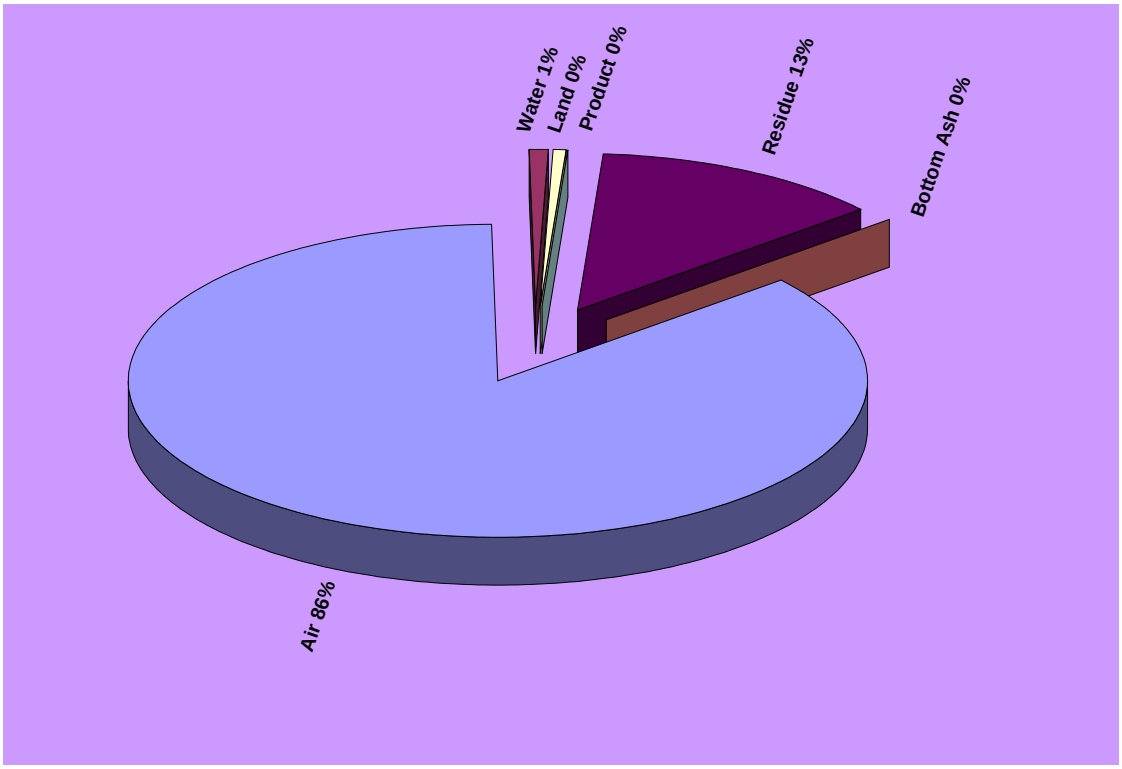


Figure ES1 estimated dioxin emissions

1INTRODUCTION

Jordan's marine coastline is only 27 km long. It forms the north eastern corner of the Gulf of Aqaba, and stretches from the border with Israel at Eilat 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.

Since the environmental resources of Jordan are among its most important assets, the ASEZ Master Plan addressed the need for strong environmental protection. Since 2001, ASEZA has built up a strong regime of environmental protection, including a risk-based environmental clearance mechanism for new industries as well as monitoring and enforcement of standards on the existing activities. One important aspect of ASEZA's regime is the prohibition of any discharges to the marine environment. This 'zero discharge policy' was designed to ensure that only cooling water, which is of the same quality of the Gulf itself, brine from desalination works, and storm water, are discharged to the Gulf. No wastewater treatment discharges, or other industrial discharges are permitted. The Aqaba Marine Park was also established as a specially protected marine reserve. Activities are strictly controlled along this 7 km stretch of coastline.

The pressure on Jordan's coastline demands that constant vigilance be observed, and an ongoing evaluation of proposals for developments and activities which could impinge on the marine environment.

Jordan's marine resources are fragile and important enough to require ASEZA to maintain strong regulation of activities and enforcement of environmental management. Overall, it is the responsibility of AZEZA to ensure that the need for economic development is balanced with the need to protect the environmental resources.

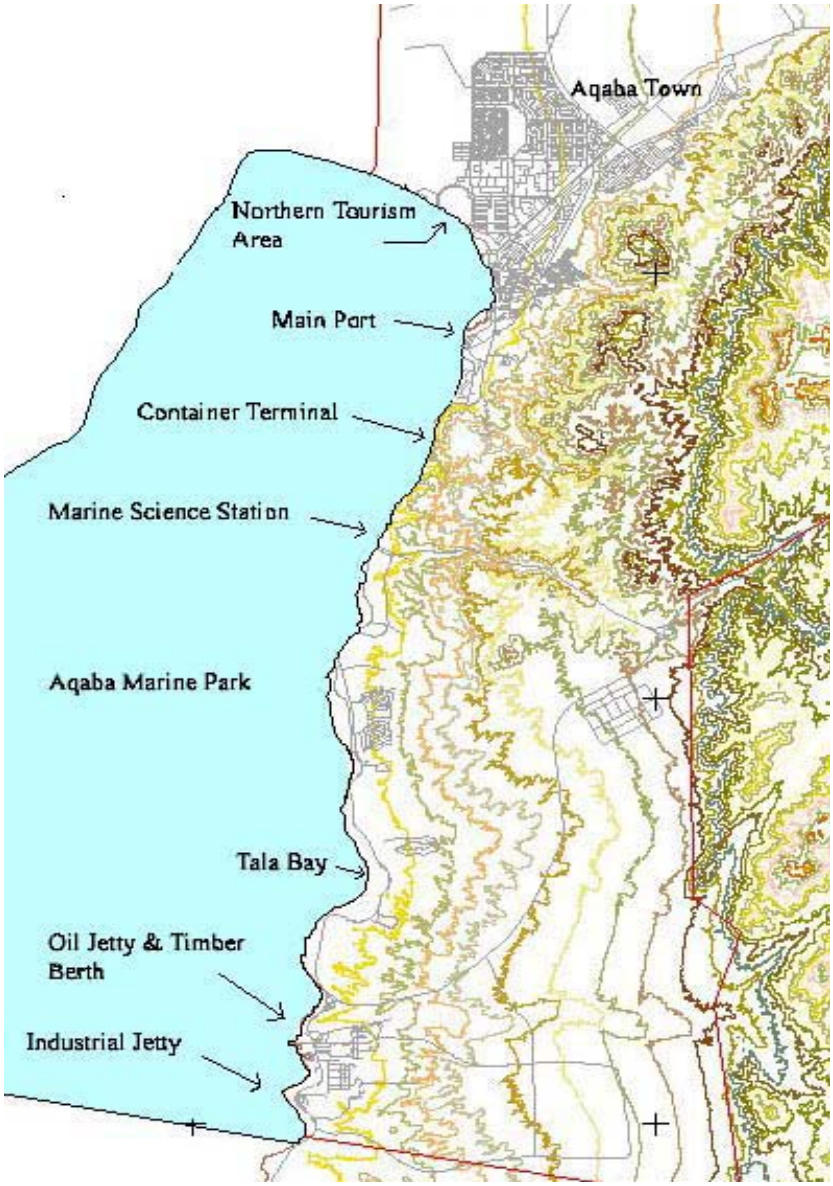
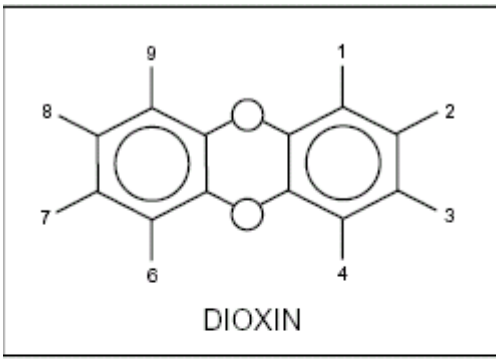


Figure 1.1 The key coastline features

1.1 Background information on dioxins

A dioxin is any compound containing the dibenzo-p-dioxin nucleus, while a furan is any compound containing the dibenzofuran nucleus. The general formula for each of these compounds is presented in Figure 2.1.



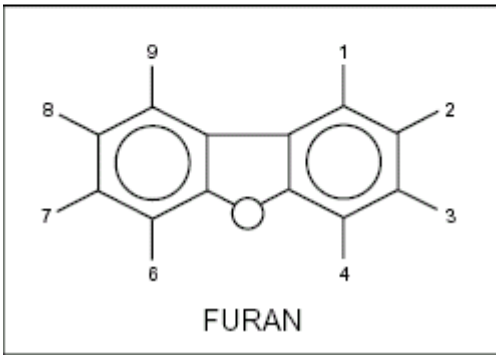


Figure 2.1 General Formulae of Dioxins and Furans

Each of the positions numbered 1 through 4 and 6 through 9 can be substituted with a chlorine atom. Each individual compound resulting from this is referred to as a congener. Each specific congener is distinguished by the number and position of chlorine atoms around the aromatic nucleus. In total, there are 75 possible polychlorinated dibenzo-p-dioxin (PCDD) congeners and 135 possible polychlorinated dibenzo-p-furan (PCDF) congeners.

Each PCDD/F congener has different physical, chemical and toxicological properties. Of the 210 PCDD/F congeners, 17 have been identified as posing significant risk to human health, with 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) being identified as the most toxic compound.

PCDDs and PCDFs are not produced intentionally, but are released to the environment from a variety of industrial discharges, combustion processes and by-products in various chemical formulations (Buckland et al, 2000). Almost all 210 individual congeners have been identified in emissions from thermal and industrial processes and consequently PCDD/PCDF are found as mixtures of individual congeners in environmental matrices such as soil, sediment, air, and plants and lower animals (UNEP, 1999). PCDD/PCDF, particularly the higher chlorinated, are poorly soluble in water, have a low volatility, and adsorb strongly to particles and surfaces (UNEP, 1999). Thus, PCDD/PCDF can hardly be identified in water and are immobile in soils (UNEP, 1999). Especially, the 2,3,7,8-

chlorine substituted PCDD/PCDF are extremely stable in the environment and bioaccumulation in fatty tissues of animals and humans (UNEP, 1999).

Historically the production and use of chloro-organic chemicals have been major sources of PCDDs and PCDFs in the environment (UNEP, 1999; Buckland et al, 2000). However, the main source of emissions identified in many industrialized countries in recent years is combustion processes, particularly poorly controlled or uncontrolled combustion sources (UNEP, 1999; Hayes and Marnane, 2000). It is generally accepted that dioxins and furans can be formed in thermal processes where chlorine containing substances are burned together with carbon and a suitable catalyst in the presence of excess air or oxygen (UNEP, 1999). Dioxin and furan formation also tends to occur in the zone when combustion gases cool from about 450 to 250 °C (de novo synthesis) and not in the combustion chamber (UNEP, 1999).

Human exposure to background contamination with PCDD/PCDF is possible via several routes (UNEP, 1999):

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

In 1990, a WHO working group concluded that 90% of the daily dioxin intake (from background contamination) results from ingestion, though it is thought that most dioxins enter the food chain from the air (UNEP, 1999).

2.1 Toxicity Equivalency Concepts

Many regulatory agencies have developed so-called Toxicity Equivalency Factors (TEF) for risk assessment of complex mixtures of PCDD/F. The TEFs are based on acute toxicity values from in vivo (inside a living organism) and in vitro (outside a living organism) studies. This approach is based on the evidence that there is a common, receptor-mediated mechanism of action for these compounds. However, the TEF approach has its limitations due to a number of simplifications. Although the scientific basis cannot be considered as solid, the TEF approach has been developed as an administrative tool and allows conversion of quantitative analytical data for individual PCDD/F congeners into a single Toxic Equivalent (TEQ). TEF particularly aid in expressing cumulative toxicity of complex PCDD/F mixtures as one single TEQ value. It should be noted that TEFs are interim values and administrative tools for order of magnitude estimates. They are based on present state of knowledge and should be revised as new data becomes available. (UNEP, 2005).

Today there are two schemes applied: the older one are the TEFs established by a NATO/CCMS Working Group on Dioxins and Related Compounds as International

Toxicity Equivalency Factors (I-TEF) (NATO/CCMS, 1988; Kutz et al., 1990) and the most recent scheme established by a WHO/IPCS working group, who re-evaluated the I-TEFs and established a new scheme (UNEP, 2005). The two schemes are presented in Table 2.1. Only the TEFs for human and mammalian risk assessment are shown although the WHO/IPCS group also included non-ortho and mono-ortho substituted polychlorinated biphenyls (PCB) into the TEF and established separate TEFs for fish and birds (UNEP, 2005).

Table 2.1 International Toxicity Equivalency Factors (1-TEF's) for dioxins. a,b,c,d

Compound	I-TEF	WHO-TEF
2,3,7,8-TCDD	1	1
1,2,3,7,8-PeCDD	0.5	1
1,2,3,4,7,8-HxCDD	0.1	0.1
1,2,3,6,7,8-HxCDD	0.1	0.1
1,2,3,7,8,9-HxCDD	0.1	0.1
1,2,3,4,6,7,8-H CDD	0.01	0.01
OCDD	0.001	0.0001
2,3,7,8-TCDF	0.1	0.1
1,2,3,7,8-PeCDF	0.05	0.05
2,3,4,7,8-PeCDF	0.5	0.5
1,2,3,4,7,8-HxCDF	0.1	0.1
1,2,3,6,7,8-HxCDF	0.1	0.1
1,2,3,7,8,9-HxCDF	0.1	0.1
2,3,4,6,7,8-HxCDF	0.1	0.1
1,2,3,4,6,7,8-H CDF	0.01	0.01
1,2,3,4,7,8,9-HpCDF	0.01	0.01
OCDF	0.001	0.0001

a Source: UNEP (2003)

b T - Tetra (four chlorine atoms attached)

Pe - Penta (five chlorine atoms attached)

Hx - I-lexa (six chlorine atoms attached)

Hp - Hepta (seven chlorine atoms attached)

Octa (eight chlorine atoms attached)

CDD - Chlorinated Dibenzo-p-Dioxins

CDF - Chlorinated Dibenzo-p-Furans

c For all non-2,3,7,8-substituted congeners, no TEF has been assigned

d Numbers in bold represent TEFs which have been changed by WHO from I-lEFs

In this emissions inventory, source strengths are estimated as annual mass flow rates of dioxins expressed in grams TEQ of PCDD and PCDF released per annum. Most concentrations of PCDD/F in the published literature and limit values in legislation are presented as I-TEQ (International Toxic Equivalents) using the NATO toxicity equivalency factors (I-TEF) established in 1988 (NATO/CCMS, 1988). The Stockholm Convention, however, requires utilizing state-of-the-art Toxic Equivalency Factors, which presently are the WHO-TEFs. The UNEP Toolkit states the difference between the I-TEFs and mammalian WHO-TEFs are minor and insignificant for the purposes of the Toolkit for estimating PCDD and PCDF emissions (UNEP, 2005). As previously mentioned this inventory addresses emissions of PCDD and PCDF only and does not include emissions from dioxin-like PCB. Furthermore, the emission factors and estimates presented in this inventory and in the UNEP Toolkit represent order of magnitude release estimates. Therefore, the difference between the I-TEFs and WHO TEFs for PCDD and PCDF are insignificant.

2. METHODOLOGY

There are five steps included in the application of the UNEP Toolkit are as follows:

Application of a screening matrix to identify main source categories.

Checking of subcategories to identify existing activities and sources in the country.

Gathering of detailed information on the processes and classifying processes into similar groups by applying the Standard Questionnaire.

Quantification of identified sources with default emission factors.

Establish full inventory and report results using guidance given in the standard format.

Table 3.1 provides an overview of the UNEP main source and subcategories.

The methodology used to compile this inventory follows the UNEP Toolkit guidelines and was performed as follows:

Dioxin emission sources to air, water and land were identified in accordance with the classification provided in the UNEP Toolkit

Activity data were collected (e.g. material throughput, production data) from publicly available information sources for each emission source category

Dioxin emissions were estimated based on default UNEP emission factors.

Default emission estimates and report sections were supplied to industry peak bodies and government agencies for review and comment.

Estimated dioxin emissions were updated based on the response from industry peak bodies and government agencies.

Information was requested from selected industrial peak bodies and facilities on activity and emissions statistics for 2008. As the information was requested on a voluntary basis, this relied heavily on the cooperation of the industrial peak bodies and facilities.

Where emissions data were made available, revised emission estimates were calculated based on these data the UNEP Toolkit based estimates are used in the final total estimated dioxin emissions for 2008.

Prior to the completion of the report, Excerpts of the report were provided to the following representative:

Hotels

Aqaba Thermal Power Plant.

Jordan chemical complex.

Aqaba International laboratories

Aqaba landfill

Aqaba Civil Defense

Al-Fajr Egyptian Jordanian Company

Nippon Jordan Fertilizer Company

KEMAPCO

Industry bodies were requested to respond with any specific comments on the inventory for their given industry sector. In particular, industry bodies were requested to confirm activity data used in the emission estimates.

A draft of the calculations was sent to the international expert before preparing the draft format of the report.

A draft of the report was reviewed by the project committee which includes the following representatives:

Ministry of Environment.

National project coordinator.

Aqaba Thermal Power Plant.

Jordan chemical complex.

Aqaba International Laboratories.

After the reviewing of the committee and their final approval the final report was sent to PERSGA the for the compilation of all the countries reports in one regional report, those countries are Egypt, Jordan, the Kingdom of Saudi Arabia, Sudan and Yemen.

Table 3.1 UNEP Main Source Categories and Subcategories

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
l-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

3. RELEASE ESTIMATES INTO MAIN SOURCE CATEGORIES

3.1 MAIN CATEGORY 1 – WASTE INCINERATION

Waste incineration is the combustion of waste materials in a furnace and does not apply to open or domestic burning (UNEP, 2003). Waste incineration is described by the following UNEP subcategories:

3.1.1 Municipal solid waste incineration

This activity does not exist in Jordan coastline

3.1.2 Hazardous waste incineration

This activity does not exist in Jordan coastline

3.1.3 Light fraction shredder waste incineration

This activity does not exist in Jordan coastline

3.1.4 Sewage sludge incineration

This activity does not exist in Jordan coastline

3.1.5 Waste wood and waste biomass incineration

This activity does not exist in Jordan coastline

3.1.6 Animal carcass incineration

This activity does not exist in Jordan coastline

3.1.6.1 General information

The UNEP Toolkit describes three classes of emission factors ranging from Class 1 (older furnaces, batch type operation with no or very little air pollution control equipment) to Class 3 (modern state of the art facilities that are continuous and have good technology air pollution control equipment).

3.1.6.2 Activity data

The animal carcass incinerator identified in Aqaba slaughterhouse is newly installed with some air pollution control, the UNEP Class 2 emission factors have been chosen to estimate dioxin.

3.1.6.3 Emission factors

The emission factors used to estimate dioxin emissions from Animal carcasses incineration are presented in Table 4.4

Table 4.4 UNEP Toolkit Emission Factors – Animal carcass incineration

Class	Sub-categories	Potential Release Route (µg TEQ/t)					
		Air	Water	Land	Product	Residue	
						Fly Ash	Bottom Ash
	Animal carcasses burning						
	Old furnaces, batch, no/little APCS	500		NA	NA		ND
1	Updated, continuously, some APCS	50		NA	NA		ND
2	State-of-the-art, full APCS	5		NA	NA		ND
٣							

3.1.6.4 Results

The revised dioxin emission estimate for Animal carcass incineration is provided in Table 4.5

Table 4.5 UNEP Toolkit Estimate of Emissions – Animal carcass incineration

Class	Sub-categories	Production t/a	Annual release					
			g TEQ/a Air	g TEQ/a Water	g TEQ/a Land	g TEQ/a Product	g TEQ/a Fly ash	g TEQ/a Bottom Ash
	Waste incineration							
	Animal carcasses burning	0.200	0.000	0	0	0	0.000	0.000
1	Old furnaces, batch, no/little		0.000				0.000	

	APCS							
2	Updated, continuously, some APCS	0.200	0.000				0.000	
3	State-of-the-art, full APCS		0.000				0.000	

3.1.6.5 Incomplete information

There are no incomplete data.

3.1.7 Medical waste incineration

3.1.7.1 General information

Medical waste (MW) incineration is the combustion of all wastes generated from medical activity including but not limited to, hospitals, medical doctor, dentist or any other physician (UNEP, 2003). A MW incinerator generally has two chambers for combustion, the primary chamber where waste is heated and volatilized and a secondary chamber where combustion is completed (Unilabs, 2001).

Medical waste includes both infectious and non-infectious wastes. These medical wastes are typically incinerated for the following reasons:

To render the waste innocuous

A reduction in the waste volume

To reduce the mass of the waste.

The composition of medical waste can vary considerably, resulting in highly variable emissions. The three main types of medical waste incinerators are:

1. controlled-air incinerators (also known as starved-air)

2. excess-air incinerators

3. Rotary kiln incinerators.

Due to its fast growing economy, the Zone's population is also rapidly growing. In 2004, the Zone's population reached 86 000 with the Jordanian Southern Governorate comprising of approximately 110 000 people (only 36 000 in 1979 and forecasted to grow to 144 000 in 2010). Consequently, ASEZ's population is expected to be more than double in the near future, given its pace of economic development (2005 Zone GDP at 6363 USD was already more than double Jordan's at 2372 GDP per inhabitant) and the Zone's massive announced or ongoing real estate development projects. (Tala Bay,

Saraya, Ayla. New Aqaba). (Aqaba Annual Report, Special Economic Zone Authority 2004-6)

In step with population growth and higher living standards, demand on health care is growing, with two of the Zone's three hospitals announcing or having 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. This will be later explored.

However, in Aqaba, there is only one late model waste incinerator at the Islamic Hospital. This incinerator no longer meets recommended practice standards and is situated too close to other buildings. As for the rest of the Zone's clinical waste, despite sorting efforts, the waste is indifferently disposed of in the Aqaba City Landfill, without any treatment whatsoever. Further, the waste is subject to rummaging by informal gatherers or through other potential diseases spreading vectors such as birds, rodents, etc. thereby creating a significant medical risk to ASEZ and its population.

Clearly, the Zone should urgently remediate its lacuna in hazardous clinical waste and ICW treatment and disposal practices.

3.1.7.2 Activity Data

The total activity data provided by the Health sector and Aqaba slaughter house are provided in Table 4.1.

Table 4.1 Waste incineration activity data

Waste type	Quantity (ton/a)
Medical waste	5.5
Animal carcasses	0.2

The UNEP Toolkit describes four classes of emission factors ranging from Class 1 (uncontrolled batch type combustion with no air pollution control systems) to Class 4 (high technology, continuous combustion with sophisticated air pollution control systems).

The only medical waste incinerator found by the project team was identified as uncontrolled batch type combustion, the UNEP Class 1 emission factors have been chosen to estimate dioxin

3.1.7.3 Emissions Factors

The emission factors used to estimate dioxin emissions from medical waste incineration are presented in Table 4.2

Table 4.2 UNEP Toolkit Emission Factors – Medical Waste Incineration

Class	Sub-categories	Potential Release Route (µg TEQ/t)					
		Air	Water	Land	Product	Residue Fly Ash	Residue Bottom Ash
	Waste incineration						
	Medical waste incineration						
1	Uncontrolled batch combustion, no APCS	40,000		NA	NA		200
2	Controlled, batch, no or minimal APCS	3,000		NA	NA		20
3	Controlled, batch comb., good APCS	525		NA	NA	920	ND
4	High tech, continuous, sophisticated APCS	1		NA	NA	150	

3.1.7.4 Results

The revised dioxin emission estimate for medical waste incineration is provided in Table 4.3

Table 4.3 UNEP Toolkit Estimates of Emissions – Medical Waste Incineration

Class	Sub-categories	Production t/a	Annual release g TEQ/a Air	g TEQ/a Water	g TEQ/a Land	g TEQ/a Product	g TEQ/a Fly ash	g TEQ/a Bottom Ash

	Waste incineration							
	Medical waste incineration	5.500	0.220	0	0	0	0.000	0.001
1	Uncontrolled batch combustion, no APCS	5.500	0.220				0.000	0.001
2	Controlled, batch, no or minimal APCS		0.000				0.000	0.000
٣	Controlled, batch comb., good APCS		0.000				0.000	
4	High tech, continuous, sophisticated APCS		0.000				0.000	0.000

3.1.7.5 Incomplete information

There are no incomplete data**.**

3.2 MAIN CATEGORY NO 2 – FERROUS AND NON-FERROUS METAL PORDUCTION

This category concerns the recovery of metals from ores and/or scrap. Primary metal production is considered to be those processes that obtain metal for the original ore and secondary metal production is considered to be those operations that obtain a refined metal from scrap.

These industries are not present in Aqaba, the only sub category may be present in Aqaba is Thermal wire reclamation, but there are no records about it, some investigations were conducted by the project team about methodology used to extract the copper. The team found that the copper was taken by peeling the wire. So we feel that this subcategory could be neglected.

3.2.1 Iron ore sintering

This activity does not exist in Jordan coastline.

3.2.2 Coke production

This activity does not exist in Jordan coastline.

3.2.3 Iron and steel production

This activity does not exist in Jordan coastline.

3.2.4 Copper production

This activity does not exist in Jordan coastline.

3.2.5 Aluminum production

This activity does not exist in Jordan coastline.

3.2.6 Lead production

This activity does not exist in Jordan coastline.

3.2.7 Zinc production

This activity does not exist in Jordan coastline.

3.2.8 Brass and bronze production

This activity does not exist in Jordan coastline.

3.2.9 Magnesium production

This activity does not exist in Jordan coastline.

3.2.10 Thermal non-ferrous mental production

This activity does not exist in Jordan coastline.

3.3 MAIN CATEGORY 3 – HEAT AND POWER GENERATION

3.3.1 Fossil Fuel Power Plants

1.3.1.1 General information

This subcategory covers fossil fuel electricity generation for distribution through the national grid and also fuel usage in boilers for industrial heating and processing.

3.3.1.2 Activity Data

Activity data relating quantity of fuel used in boilers of hotels, industries, asphalt mixer…etc. was sourced from the different sectors through field visits.

The estimated 2008 activity data for fossil fuel power plants are presented in Table 6.1

Table 6.1 Activity Data for Fossil Fuel Power Plants

NAME	liter / month	liter/year	kg / year	TJ / year	source strength for air	source strength - residue	type
days Inn Hotel	2166.66	25999.92	22099.932	0.98344697	0.491723487		Diesel
Movenpick Hotel - south coast	22500	270000	229500	10.21275	5.106375		Diesel
Radison SAS hotel	11291	135492	115168.2	5.1249849	2.56249245		Diesel
movenpick Hotel - Aqaba city	62530	750360	637806	28.382367	14.1911835		Diesel
Aqaba Gulf Hotel	2400	28800	24480	1.08936	0.54468		Diesel
Royal Diving Club	625	7500	6375	0.2836875	0.14184375		Diesel
Captain Hotel	0	0	0	0	0		Diesel
Marina Plaza Hotel	6990	83880	71298	3.172761	1.5863805		Diesel
Golden Tulip Hotel	2310	27720	23562	1.048509	0.5242545		Diesel
Intercontinental Hotel		339215	288332.75	12.8308074	6.415403688		Diesel
Kemapco			6600000	273.9	684.75		Heavy oil
Industrial complex			32000000	1328	3320		Heavy oil
Industrial complex			3640000	161.98	80.99		Diesel
Thermal Station			20000	0.89	0.445		Diesel
Thermal Station			174000000	7221	18052.5		Heavy oil
Thermal station			793121754	38069.8442	19034.9221		Natural gas
Red Sea Wood Factory			437000	18.1355	45.33875		Heavy oil
Red Sea Wood Factory			280000	4.2	210	63	Wood
Asphalt Mixer #1			255000	11.3475	5.67375		Diesel
Asphalt Mixer #2			255000	11.3475	5.67375		Diesel

3.3.1.3 Estimate of Emissions

The UNEP Toolkit provides specific emission factors for dioxin releases to air based on the type of fuel combusted. No emission factors are presented for water emissions as this release route is expected to be insignificant. The UNEP Toolkit presents a dioxin emission factor for solid residues from Heavy fuel fired power boilers equals 2.5 µg/TJ and 0.5 µg/TJ from Light fuel oil/natural gas fired power boilers. The solid residue emission factor is used to estimate the total emissions to land from fossil fuel power plants.

The UNEP dioxin emission factors are presented in Table 6.2.

Table 6.2 Emission Factors - Fossil Fuel Power Plants

Sub-categories	Potential Release Route (µg TEQ/TJ)				
	Air	Water	Land	Product	Residue
Heat and Power Generation					
Fossil fuel power plants					
Fossil fuel/waste co-fired power boilers	35	ND	NA	NA	ND
Coal fired power boilers	10	ND	NA	NA	14
Heavy fuel fired power boilers	2.5	ND	NA	NA	ND
Shale oil fired power plants	1.5	ND	NA	NA	ND
Light fuel oil/natural gas fired power boilers	0.5	ND	NA	NA	ND

3.3.1.4 Results

Table 6.3 provides the Toolkit emission estimate for releases to air, water and land.

Table 6.3 UNEP Toolkit Estimate of Emissions – Fossil Fuel Power Plants

Sub-categories	Production	Annual release				
	TJ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
Heat and Power Generation		Air	Water	Land	Product	Residue
Fossil fuel power plants	47,209	0.041	0	0	0	0.0
Fossil fuel/waste co-fired power boilers		0.000				
Coal fired power boilers		0.000				0.000

Heavy fuel fired power boilers	8890.8355	0.022				
Shale oil fired power plants		0.000				
Light fuel oil/natural gas fired power boilers	38,319	0.019				

3.3.1.5 Incomplete information

There is no incomplete information

3.3.1.6 The Southern Industrial Zone

The Southern Industrial Zone consists of two adjacent areas – Wadi 1 and Wadi 2 which are located 22 km south of the Main Port and outside the Municipal boundary. These zones are both linked by the Back Road to the Amman Route and have been designated for heavy industrial use. At present, water is supplied to the Zone from the Disi aquifer. The emission sources currently located within the zone include:

Jordan phosphate mines company / industrial complex (6.1.1)

Red Sea Timber Industries Company(6.1.2)

Aqaba Thermal Power Plant(6.1)

Al-Fajr Egyptian Jordanian Company(6.1.3)

Nippon Jordan Fertilizer Company(6.1.4)

KEMAPCO produce potassium nitrate (NOP), dicalcium phosphate dihydrate (DCP), and nitric acid to be used as raw material in the processes. (6.1.5)

3.3.1.6.2 Jordan phosphate mines company / industrial complex

The Jordan Phosphate Mining Company was established in 1949 for the purpose of mining and exporting of phosphate rock via Aqaba main port. In 1982 the fertilizers complex was established and started operation. JPMC facilities in Aqaba contain three major components: Jordan chemical complex, industrial port and Phosphate company branch at the main port.

The complex includes four main units i.e. phosphoric acid unit, Aluminum fluoride unit, DAP unit and the utilities unit. The complex was designed to produce fertilizers and chemicals according to the following capacities:-

DAP	740,000 ton/year
Phosphoric Acid	415,000 ton/year
Aluminum Fluoride	20,000 ton/year
Sulfuric Acid	1,200,000 ton/year

Fluorosilisic Acid 25,000 ton/year

3.3.1.6.2. 3 Phosphoric Acid Production

Phosphate rock is transported by trucks from the phosphate mining site at Al-Shidiya. It is stored in a main warehouse and transported to the process by a conveyer belt system. The phosphate rock is grounded and weighed.

By acidulation with Sulfuric Acid, Phosphate rock is converted to Phosphoric Acid and Gypsum is a by product.

3.3.1.6.3 Sulfuric Acid

Elemental Sulfur is imported from different countries to Aqaba port and then transported from the port to the storage warehouse using a conveyer belt system.

Sulfur is melted by hot steam then filtered to remove the impurities. Melted Sulfur is then burned to Sulfur dioxide (SO2). SO2 is cooled down and transferred to SO3 using Vanadium Pentoxide as a catalyst. Te SO3 is then hydrolyzed to Sulfuric Acid.

3.3.1.6.4 Aluminum Fluoride Unit

Aluminum Hydroxide is brought to the warehouse by trucks then transported to the process unit using bucker elevator and skew conveyers. Fluorosilisic acid is transported by pipes where Aluminum Hydroxide is dried using hot air produced by a diesel burner. Aluminum Hydroxide and Fluorosilisic acid are mixed and Silica is produced and later on being separated.

3.3.1.6.5 Di-Ammonium Phosphate Production

Ammonia is transported through the industrial port into the storage tanks via pipes. The process starts by mixing Phosphoric acid with anhydrous Ammonia to produce slurry. The slurry is then spread onto a bed of recycled solids in a rotating granulator and Ammonia is sparged into the bed from underneath. Granules pass to a rotary dryer followed by a rotary cooler. It is solidified using a special heavy oil burner.

Wastewater treatment Unit: Domestic wastewater at the plant is treated biologically using an activated sludge treatment system. It consists mainly of an aeration tank and a sedimentation tank. The treated effluent is pumped to an evaporation lagoon.

3.3.1.6.6 Aqaba Thermal Power Plant

The station is situated approximately 1 km inland and east of the shoreline of the Gulf of Aqaba, some 19 km south of the port of Aqaba in the industrial zone adjacent to the fertilizer complex. It has been in operation since 1986. An extension is built and

started operating in 1998. The generation capacity was increased from 260 MW (two units) up to 650 MW (five units).

3.3.1.6.6.2 Production

Each unit includes a steam generator, a steam turbine-generator, and a surface condenser cooled by sea water and seven stage regenerative feed water heating system. The cooling water system includes a common intake system for all five units and two outfall systems, one for each stage. It starts with producing steam in the boilers at an average temperature of 1300 c using natural gas. The superheated steam expands through the high pressure section of the steam turbine, flows back to the boiler and is reheated to its initial temperature, then expands through intermediate and low pressure sections of the turbine into the underslung condenser where it is condensed. The condensate is pumped from the condenser through four low pressure surface type feed water heaters into a direct contact deaerator heater and into the deaerator feed water storage tank. Feed water is pumped from the storage tank by a booster and main boiler feed water pumps through two high pressure feed water heaters into the economizer section of the boiler. The condensate and feed water is heated in the feed water heaters and deaerator by steam extracted from the steam turbine.

Air from the forced draught fans passes through the air preheater, where it is heated by the hot gases leaving the boiler en route to the chimney using heat exchange elements. The combustion air leaves the air heater and passes to the air registers on each burner to provide the air necessary for combustion. The resulting flue gases would then pass through the boiler super heater, reheater and economizer, through the air heater and then discharged from the chimney.

The water required for cooling is sea water abstracted from the sea, used once only, and returned to the sea (Gulf of Aqaba) at a rate of 8300 m3/hr for stage I and II. It is mainly used to condensate steam. Auxiliary cooling water will be taken from the cooling water supply to the closed circuit cooling water heat exchangers which remove heat from the distillate that removes heat from the generator air coolers, the turbine lubricating oil coolers and other coolers and the outlet culvert. The cooling water whether fresh or sea water does not come into contact with any process fluids in the course of its use.

3.3.1.6.6.3 Liquid Wastes

The wastewater system of ATPP was designed to be zero discharge system with evaporation ponds and reuse of water on site for irrigation. It includes chemical cleaning effluents, boiler blow down, softener deionization waste, boiler and air heater wash water, drainage water and chemicals from the oil separator unit, as well

as domestic sewage. Added to that, sea water for cooling purposes is deposited back into the gulf at a rate of 83000 m3/hr. It is analyzed at the laboratory of ATPP.

Chemical cleaning is usually necessary to remove scale from the boiler tubes. It is done once every 5-10 years as well as before commissioning of new boilers. The amount of wastewater resulting from this process is about 1200 m3/boiler. Boiler blowdown amounts and quality depend on the purity of the feed water as well as the age of the boilers. Boiler and air heaters are usually washed once a year during maintenance periods.

On the other hand, sewage from the plant is treated in the activated sludge treatment unit, before discharging to the evaporation pond designed for such waste. It is usually used for irrigation purposes within the plant area.

3.3.1.6.6.4 Red Sea Timber Industries Company

Red Sea Timber Industries (RSTI) is a timber processing plant that has a workforce of over 250 employees, located in Aqaba, in the Hashemite Kingdom of Jordan.

Our mission is the manufacturing of high quality Sawn Timber, Block Board, Particle Board, Plywood, Lamination Board, Pallets and Furniture, from carefully selected timber obtained mostly from the forests of Russia, Canada and the Far East.

First rate and highly specialized equipment coupled with precise quality control checks made it possible for RSTI to become one of the most reputable timber plants in the world.

Being the only timber plant in the region and among a limited, 40 plants worldwide of this size, we export sizeable quantities of processed timber to the Middle East constantly opening new markets beyond the region. Our location in the southern coastal town of Aqaba by the Red Sea makes importing the timber and exporting our product extremely efficient and fast.

6.1.4 Al-Fajr Egyptian Jordanian Company

Figure 6.1 The Arab Gas Pipeline

The Arab Gas Pipeline (Figure 6.1) is a pipeline that exports Egyptian natural gas to the Middle East and possibly to Europe, with a further extension. When completed, it will have a total length of 1,200 kilometers (750 mi) at a cost of US$ 1.2 billion.

3.3.1.6.6.5 Nippon Jordan Fertilizer Company

NJFC is the first joint venture company between Japan and Jordan to produce high quality fertilizers with the participation of two Jordanian companies (JPMC, APC) as well as four Japanese companies. It is situated about 26 km from Aqaba city at southern coast. The plant was mechanically completed at the end of December 1996 as scheduled, followed by commissioning activities startup, then the commercial production at the beginning of May 1997.

The production design capacity of the plant is 300,000 MT/ year for producing compound fertilizers consisting of 4 grades in addition to DAP.

Liquid Waste: Wastewater produced from the reactor cleaning as well as wet scrubbers installed at the stack system make the liquid waste from the plant. These liquids are collected in a special closed pit to be reused.

3.3.2 Biomass power plants

This activity does not exist in Jordan coastline

3.3.3 Landfill biogas combustion

This activity does not exist in Jordan coastline

3.3.4 Household heating and cooking with biomass

This activity does not exist in Jordan coastline

3.3.5 Household heating and cooking with fossil fuels.

This activity does not exist in Jordan coastline

3.3.6 Domestic Heating and Cooking (Fossil Fuels)

3.3.6.1 General information

This subcategory covers all residential heating and cooking using coal, oil and natural gas as the fuel. Information on the domestic consumption of charcoal was taken from ASEZA customs.

3.3.6.2 Activity Data

The total charcoal imported to Aqaba in the year 2008 was 208 ton. Heating in Aqaba is neglected due to the moderate weather temperature in winter, the only type of fuel used is the butane gas, and emission estimate for the cooking gas was according to class 4 Natural gas fired stoves (1.5 μg TEQ/TJ). The total activity data provided by ASEZA customs and Aqaba refinery storage tanks was calculated in TJ and provided in Table 6.4.

Table 6.4 Fuel Consumption Activity Data for Domestic Heating and Cooking (Fossil Fuels)

Fuel	Energy Consumed (TJ/a)
Coal	1
Oil	Not used
LPG	154
Natural Gas*	22.1

flare of the Jordanian Egyptian Fajr for Natural Gas Transmission & Supplies Company

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 form 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.

3.3.6.3 Estimate of Emissions

The UNEP Toolkit dioxin emission factors to air, water and land are presented in Table 6.5.

Table 6.5 Emission Factors- Domestic Heating and Cooking

Sub-categories	Potential Release Route (µg TEQ/TJ)				
	Air	Water	Land	Product	Residue
Domesting heating - Fossil fuels					µg TEQ/t Ash
High-chlorine coal fired stoves	12,000	ND	NA	NA	30,000
Coal fired stoves	100	ND	NA	NA	5,000
Oil fired stoves	10	ND	NA	NA	NA
Natural gas fired stoves	1.5	ND	NA	NA	NA

3.3.6.4 Results

Table 6.6 provides the Toolkit emission estimate for releases to air, water and land.

Table 6.6 UNEP Toolkit Estimate of Emissions – Domestic Heating and Cooking

Sub-categories	Production	Annual release				
	TJ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
Heat and Power Generation		Air	Water	Land	Product	Residue
Domesting heating - Fossil fuels	155	0.000	0	0	0	0.0
High-chlorine coal fired stoves		0.000				0.000
Coal fired stoves	1	0.000				0.010
Oil fired stoves		0.000				
Natural gas fired stoves	154	0.000				

3.3.6.5 Incomplete information

There is no incomplete information

3.4 MAIN CATEGORY NO 4 – PRODUCTION OF MINERAL PRODUCTS

3.4.1 CEMENT KILNS

This activity does not exist in Jordan coastline

3.4.2 LIME

This activity does not exist in Jordan coastline

3.4.3 BRICK

This activity does not exist in Jordan coastline

3.4.4 GLASS

This activity does not exist in Jordan coastline

3.4.5CERAMICS

This activity does not exist in Jordan coastline

3.4.6 SPHALT MIXING

This activity does not exist in Jordan coastline

3.4.7 OIL SHALE PROCESSING

This activity does not exist in Jordan coastline

3.5 MAIN CATEGORY NO 5 – TRANSPORT

Transportation network in Aqaba

Transportation network in Aqaba has been upgraded over the years to serve the growing activities within Aqaba and to link the Jordanian Port City with the rest of the Kingdom. The circulation network within the Zone is divided into five main categories of roadways: national, primary, secondary, neighborhood, and local. Whereas national highways lead to Amman, primary roads are major dual-carriage ways between significant points and secondary roads are dual carriage-roads defining and connecting development areas.

Neighborhood streets on the other hand are within development zones, and local streets provide access to individual parcels within a development area. Also as part of Aqaba's transportation network is Aqaba Railway System, which currently operates as a single product (phosphate) closed loop railroad

Ports of Aqaba

The Aqaba Ports Corporation (APC) is the port authority for the Port of Aqaba. The APC is responsible for developing, managing, maintaining, promoting, and securing the safety for the port and its customers. The Port of Aqaba covers a total area of two million square meters, including 1.7 million square meters of land and 380.8 square meters of sea. The port also contains an additional 178.1 thousand square meters for the oil refinery, grain silos, free zones, and military fridge. The main Port of Aqaba covers one million square meters.

At a strategic location between the continents of Asia, Europe, and Africa, the Port of Aqaba plays a vital role in Jordan's economy. It is the country's only seaport, handling 78% of Jordan's exports and 65% of the country's imports. The Port of Aqaba contains three main areas: the main port zone, the containers port zone, and the industrial port zone.

The Port of Aqaba's Main Port Zone, near the town of Aqaba, contains 12 berths with a total length of 2120 meters. The berths are used for handling general cargoes and grain, exporting phosphate, and supporting roll-on/roll-off and lighter traffic.

The General Cargo Port includes nine berths of 1510 meters with alongside depth of 13 meters that can accommodate vessels to 70 thousand DWT. Each berth includes a 35-meter wide apron, a transit shed, partly-covered shed, and open storage. Berth 1 is dedicated to imported grain, with capacity to move about a thousand tons per hour from vessels by conveyor belt to the grain silos.

Also in the Port of Aqaba's General Cargo Port are the local craft mid-basin and slipway containing three berths used for mooring pilot boats, tugs, lighters, and small ships less than 100 meters long with maximum draft of six meters. The phosphate loading station contains Berth A, 220 meters long with alongside depth of 11 meters, to accommodate vessels to 30 thousand DWT. In addition to loading/unloading up to a thousand tons per hour, the berth accommodates ships for bunkering, including

those that import mineral and vegetable oils. Phosphate Berth B is 180 meters long with alongside depth of 14.4 meters. It can accommodate vessels to 120 thousand DWT and can load/unload up to 4400 tons per hour.

The Port of Aqaba's Containers Port Zone is located five kilometers south of the main port area and contains seven berths of a total one thousand meters in length. The Mo'ta Berth, a floating berth 150 meters long with alongside depth of 23 meters, can accommodate vessels to 53 thousand DWT. Located to the north of the Container Terminal, the Mo'ta Berth supports the rice-processing plant and is also used for livestock.

The Containers Port Zone's Moshterak Berth, a dolphin berth, is 120 meters long with alongside depth of 11 meters. It can accommodate vessels to 100 thousand DWT carrying cement exports and imports of vegetable oil and livestock.

The Container Terminal includes three berths of a total 540 meters in length with alongside depth of 15 meters that can accommodate vessels to 84 thousand DWT. The roll-on/roll-off berth is 40 meters long with alongside depth of 10 meters.

The Yarmouk Berth contains the Port of Aqaba's Passenger Terminal. The floating berth is 150 meters long with alongside depth of 23 meters and is used for both passengers and roll-on/roll-off ships to 19 thousand DWT with draft of 9 meters. Built in 1986 by joint contributions from Jordan, Iraq, and Egypt, the Passenger Terminal provides a vital link between the east and west sides of the Gulf of Aqaba.

The Port of Aqaba Industrial Port Zone is located 18 kilometers south of the Main Port Zone. With a total length of 640 meters, they were created to handle oil, timber, and industrial products. The Oil Jetty, a four-dolphin berth, is used for export and import of oil and oil products. It is 150 meters long with alongside depth of 24 meters and can accommodate oil tankers to 406 thousand DWT. Supporting cargoes of livestock and timber, the Timber Berth is 80 meters long with alongside depth of 7 meters and can accommodate vessels to 14 thousand DWT.

The Port of Aqaba's four Industrial Berths were built in 1981. The handle imports and exports of fertilizers, salt, sulfur, chemicals, and potash. Accommodating vessels to 70 thousand DWT, the west berth is 220 meters long with alongside depth of 15 meters. The west berth handles potash, sulfur, potash, salt, and dry bulk cargoes. The east berth is 190 meters long with alongside depth of 11 meters. Accommodating vessels to 40 thousand DWT, the east berth handles bulk fertilizers, ammonia, and chemical products.

The Port of Aqaba contains a variety of storage facilities. It contains 62 thousand square meters of closed storage, 41.2 thousand square meters of covered storage, 245 thousand square meters of open storage, and refrigerated storage with capacity for 500 tons of cargo. Storage facilities for specific cargoes include facilities for phosphate (310 ton capacity), grain (silos with capacity for 150 thousand tons), potash (150 thousand tons), rice (55 thousand tons), and cement (30 thousand tons).

In 2008, the Port of Aqaba welcomed over three thousand vessel calls. Of these, 1.8 thousand ships carried passengers, including 103 cruise ships. The remaining 1336 cargo vessels included 362 container vessels and vessels carrying dry bulk (347), liquid bulk (202), roll-on/roll-off cargoes (195), general cargo (93), and miscellaneous cargoes (34). The Port of Aqaba served 1.2 million passengers in 2008. It handled 17 million tons of cargo, including 9.2 million tons of imports and 7.8 million tons of exports

Railway

Jordan Railways history started from the begging of last century. Work started in building track link between the Northern and southern parts of Jordan in 1900.

The part of track is considered part of the main track which links Turkish land with AL-Median passing through the capital city of Amman.

This called Hejaz, -Railway. This track was linked by a sub-line to Ras -EL-Naqab in 1942 to carry phosphates from mines to Ras – EL-Naqab station then by tracks to Aqaba port.

Due to the importance of phosphate to the Jordan National income, it has become very necessary to find an economic and high capacity, means of transport.

For this reason, the concerned government officials had taken the decision to construct a railway line to connect phosphate mines with Aqaba port.

Work had started to strengthen the part of Hejazi Railway from EL-Hasa mines to Batn-EL-Ghoul.

A new line was constructed to connect Batn EL-Ghoul to Aqaba port in Nov 1972 and officially opened in 14/11/1975 a new organization called Aqaba Railways corporation has been named to manage this Railway a new line was added to join phosphate mines in EL-Abiad 22 KM . The total lines reached 293.34 Km. Figure 7.1 shows a train carrying phosphate.

Figure 7.1 A Phosphate train

3.5.1 4-Stroke Engines

3.5.1.1 General information

4-stroke engines are commonly used in passenger cars and in medium and large engine.

Some of the cars in Aqaba are modern and fitted with catalytic converter but most are without catalytic converter.

3.5.1.2 Activity Data

Activity data for the amount of petrol fuel consumed in 4-stroke internal combustion engines were sourced from the Aqaba Traffic Division for the 2008 records. All gasoline fuel combusted by the transportation sector in Jordan since 2007 was unleaded petrol. The total fuel consumed was 24309 ton.

3.5.1.3 Estimate of Emissions

The UNEP Toolkit suggest an emission factor to air of 2.2 µg TEQ/ton fuel combusted in leaded fuelled vehicles and 0.1 µg TEQ/ton of fuel combusted in unleaded fuelled vehicles without catalysts and 0 µg TEQ/ton of fuel combusted in unleaded vehicles with catalysts.

No emission factors are provided for releases to water or land, as these release routes are negligible.

Table 7.1 presents the UNEP Toolkit dioxin emission factors for 4-stroke engine combustion in the transportation sector.

Table 7.1 UNEP Toolkit Emission Factors – 4-Stroke engines

Class	Sub-categories	Potential Release Route (µg TEQ/t)				
		Air	Water	Land	Product	Residue
	Transport					
	4-Stroke engines					
1	Leaded fuel	2.2	NA	NA	NA	NA
2	Unleaded fuel without catalyst	0.1	NA	NA	NA	NA
٣	Unleaded fuel with catalyst	0.00	NA	NA	NA	NA

3.5.1.4 Results

The dioxin emission factors used to estimate emissions from 4-stroke petrol fuelled vehicles are presented in Table 7.2. The estimate dioxin emission factor is taken to be the second class the unleaded fuel without catalyst emission factors.

Table 7.2 UNEP Toolkit Estimates of Emissions - 4-Stroke engines

Class	Sub-categories	Consumption	Annual release				
		t/a *	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
	Transport		Air	Water	Land	Product	Residue
	4-Stroke engines	24,309	0.002	0	0	0	0
1	Leaded fuel		0.000				
2	Unleaded fuel without catalyst	24,309	0.002				
3	Unleaded fuel with catalyst		0.000				

3.5.1.5 Incomplete information

There is no incomplete information

3.5.2 2-Stroke Engines

3.5.2.1 General information

2-stroke petrol powered internal combustion engines are commonly used in small boats, motorcycles, lawnmowers and other small machinery.

3.5.2.2 Activity Data

For the purposes of this study it was assumed that all petrol consumed in motorcycles and off-road vehicles provided by the Traffic Division, was consumed in 2-stroke internal combustion engines. The total petrol combusted was 324 ton/annum.

There is a degree of uncertainty associated with this estimate. Therefore, a margin since there is no records for the small boats, and other small machinery.

3.5.2.3 Estimate of Emissions

The UNEP Toolkit provides a default dioxin emission factor to air of 2.5 µg TEQ/ton of fuel combusted.

Dioxin emissions to water and land are expected to be negligible and hence no dioxin emission factors are provided in the UNEP Toolkit.

The default UNEP emission factor to air is used to estimate dioxin emissions from 2-stroke engines.

Table 7.3 presents the UNEP Toolkit dioxin emission factors for 2-stroke engine combustion in the transportation sector.

Table 7.3 UNEP Toolkit Emission Factors - 2-Stroke engines

Class	Sub-categories	Potential Release Route (µg TEQ/t)				
		Air	Water	Land	Product	Residue
	Transport					
	2-Stroke engines					
1	Leaded fuel	3.5	NA	NA	NA	NA
2	Unleaded fuel without catalyst	2.5	NA	NA	NA	NA

3.5.2.4 Results

The dioxin emissions estimate presented is based on the second class: the unleaded fuel without catalyst as shown in Table 7.4

Table 7.4 UNEP Toolkit Estimates of Emissions - 4-Stroke engines

Class	Sub-categories	Consumption t/a *	Annual release g TEQ/a	g TEQ/a	G TEQ/a	g TEQ/a	g TEQ/a
	Transport		Air	Water	Land	Product	Residue
	4-Stroke engines	24,309	0.002	0	0	0	0
1	Leaded fuel		0.000				
2	Unleaded fuel without catalyst	24,309	0.002				
٣	Unleaded fuel with catalyst		0.000				
	2-Stroke engines	324	0.001		0	0	0
1	Leaded fuel		0.000				
2	Unleaded fuel without catalyst	324	0.001				

3.5.2.5 Incomplete information

There is no incomplete information

3.5.3 Diesel Engines

3.5.3.1 General information

Diesel engines are commonly used in heavy trucks, light trucks, buses, heavy construction equipment, boats and a smaller proportion of passenger cars.

3.5.3.2 Activity Data

Activity data for the amount of diesel fuel consumed in Aqaba for the diesel engine is shown in Table 7.5

Table 7.5 Diesel fuel consumed in Aqaba for the Diesel Engine

No	item	No of unit	Total no per year	source of data	Diesel consumed per

					year (ton)
1	Ships	220 per month	2640	Jordan maritime authority	4819800
2	Train	5 per day	1800	Aqaba railway corporation	330
3	Buses licensed from aqaba	250 per year	250	Traffic Division	1151
	Tourist buses	No records	No records	No records	No records
4	Trucks	62000	62000	NAFETH	1054
5	Small vehicle	No records	No records	No records	No records

3.5.3.3 Estimate of Emissions

The recommended UNEP Toolkit emission factor to air for diesel fuel combustion is 0.1 µg TEQ/ton of fuel combusted.

Emissions to water are expected to be negligible. However, particulate emissions from diesel engines are expected to contain dioxins. Dioxin emissions from diesel engines in the form of particulate would be expected to be a land emission. However, there is no data available to estimate a dioxin emission factor.

The recommended dioxin emission factor of 0.1 µg TEQ/ton of fuel combusted is used to estimate emissions from diesel combustion in the transportation sector, Table 7.6

Table 7.6 UNEP Toolkit Emission Factors - 2-Stroke engines

	Sub-categories	Potential Release Route (µg TEQ/t)				
Class		Air	Water	Land	Product	Residue
	Transport					
	Diesel Engines	0.1	NA	NA	NA	NA

3 .5.3.4 Results

3.5.3.4.1 Ships

There are about 220 ships enter the ports of Aqaba per month, in addition to one anchored vessel – Jerash (Oil Tanker) which engine is running 24 hours per day. These whole ships consume about 4819800 tons of diesel per year during there

presence in Aqaba ports, noting that the ships are forced to turn to diesel engine during their presence in Aqaba, the use the heavy oil are allowed only outside the Territorial waters.

The UNEP Toolkit shows that there is only one class of emission factor for Diesel engines. The toolkit Estimates of Emissions for ships is shown in Table 7.7

Table 7.7 UNEP Toolkit Estimates of Emissions - ships

Class	Sub-categories	Consumption t/a	Annual release g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
	Transport (ships)		Air	Water	Land	Product	Residue
	Diesel engines	4819800	0.482	0	0	0	0
1	Diesel engines	4819800	0.482				
			0.482	0	0	0	0

3.5.3.4.2 Railways

The dioxin emissions estimate presented is based on the records from the Aqaba real ways corporation taking into consideration the route of the train inside Aqaba and their residence time in Aqaba. Table 7.8 shows the Toolkit Estimates of Emissions for trains.

Table 7.8 UNEP Toolkit Estimates of Emissions - trains

Class	Sub-categories	Consumption t/a	Annual release g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
	Transport (ships)		Air	Water	Land	Product	Residue
	Diesel engines	330	0.000	0	0	0	0
1	Diesel engines	330	0.000				

			0.000	0	0	0	0

3.5.3.4.3 Trucks

The dioxin emissions estimate presented is based on the records from NAFETH.

As mentioned in section all the trucks will come to Aqaba through:

the Desert Highway and Amman Road via the back road

or through the Dead Sea Highway and Airport Road via Ashelaleh road.

The calculations consider the distance that the truck moves inside Aqaba while coming and leaving. Table 7.9 shows the Toolkit Estimates of Emissions for trucks.

Table 7.9 UNEP Toolkit Estimates of Emissions - trucks

Class	Sub-categories	Consumption t/a	Annual release g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
	Transport (ships)		Air	Water	Land	Product	Residue
	Diesel engines	1054	0.000	0	0	0	0
1	Diesel engines	1054	0.000				
			0.000	0	0	0	0

3.5.3.4.4 Buses

The dioxin emissions estimate presented is based on the records from the Traffic Division and the Investment Directorate (transportation section) and the Aqaba visitor Eid survey carried by the Health Directorate.

The total Diesel consumption of Buses was estimated to two types of buses:

buses registered in Aqaba and work in Aqaba

tourist buses which are not registered in Aqaba

Table 7.10 shows the Toolkit Estimates of Emissions for buses.

Table 7.9 UNEP Toolkit Estimates of Emissions - buses

	Sub-categorie	Consumption	Annual release

Class	s	t/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
	Transport (ships)		Air	Water	Land	Product	Residue
	Diesel engines	1151	0.000	0	0	0	0
1	Diesel engines	1151	0.000				
			0.000	0	0	0	0

3.5.3.5 Incomplete information

3.5.3.6 There is no incomplete information

3.6 MAIN CATEGORY NO 6 – OPEN BURNING PRODUCTION

This category covers all combustion activity that does not occur in controlled devices such as incinerators, stoves or boilers. Uncontrolled combustion processes have been broken up into the following categories:

3.6.1 Biomass Burning

This subcategory covers the burning of biomass occurring in the open areas, this includes forest fires, as well as burning of grassland and harvest residues. Biomass burning in not carried out in Aqaba.

3 .6.2 Waste Burning and Accidental Fires

This subcategory includes landfill fires, accidental fires in houses and factories, uncontrolled domestic waste burning, accidental fires in vehicles and open burning of wood (construction/demolition).

3.6.2.1 Landfill Fires

Regulation for the Protection of the Environment in the Aqaba Special Economic Zone (Regulation No. 21 of Year 2001), issued under Aqaba Special Economic Zone Law (No. 32 of Year 2000) prohibits open burning of the waste.

Even though some of the scavengers burn the tires in order to recover its metallic content, burning of tires are not considered a source of dioxin since the sulfur is the binding atom not the chlorine.

3.6.2.1.2 Uncontrolled Domestic Waste Burning

No activity data were available for uncontrolled domestic waste burning. It is noted previously that ASEZA Banned domestic waste burning

.

3.6.2.1.3 Accidental Building Fires

The total number of fires in structures (domestic, commercial and industrial buildings) was sourced for Aqaba civil defense records. The estimated number fires in structure for the 2008 as in Table 8.1

Table 8.1 total number of fires

Type	Number
Industries	2
Houses	75

The mass of combustible material consumed in fires can be estimated based on the size of the fire. Based in assumption the civil defense classifies fires in the following manner:

Small fires, consuming 100 - 250 kg of materials per fire

Moderate fires, consuming 1 - 2.5 tons of materials

This methodology was applied to fire statistics for Aqaba. The material consumed in the fires is **shown in Table 8.2**

Table 8.2 material consumed in the fires

Type	NO of fires	Size	Total mass of combustible material in tons
Industries	2	Moderate	2 – 5
Houses	75	Small	7.5 – 18.75
Total	77		9.5 – 23.75
Average			16.625

3.6.2.1.4 Accidental Vehicle Fires

3.6.2.1.4.1 General information

The total number of vehicle fires was sourced from Aqaba civil defense. Therefore, the total number of vehicle fires were estimated based on the number of fires reported for the estimated number of vehicle fires in Aqaba for the year 2008 was 50.

3.6.2.1.4.2 Activity data

The UNEP Toolkit provides a default emission factor to air of 1,000 µg TEQ/ton of material burnt for landfill fires. Using data from the Swedish study that the emission factor is based on and, assuming that the rate of landfill fires is directly proportional

to population between countries, the 1,000 µg TEQ/ton of material burnt is equivalent to 4.0 µg TEQ/person.

The UNEP Toolkit assigns a default emission factor for accidental fires on houses and factories of 400 µg TEQ/ton of material burnt. The default emission factor to land for accidental fires in houses and factories is also 400 µg TEQ/ton of material burnt.

The default UNEP emission factor to air for uncontrolled domestic waste burning is 300 µg TEQ/ton of waste burnt and the default emission factor to land is 600 µg TEQ/ton of material burnt.

3.6.2.1.4.3 Emission factors

The UNEP Toolkit provides an emission factor to air of 94 µg TEQ/vehicle fire and 18 µg TEQ/vehicle fire for emissions to land.

The UNEP Toolkit provides a default emission factor to air of 60 µg TEQ/ton of material burnt and 10 µg TEQ/ton of material burnt.

The UNEP Toolkit emission factors to air, water and land are outlined in Table 8.3.

Table 8.3 UNEP Toolkit Emission Factors – Waste Burning and Accidental Fires

Class	Sub-categories	Potential Release Route (µg TEQ/t)				
		Air	Water	Land	Product	Residue
	Fires, waste burning, landfill fires, industrial fires, accidental fires					
1	Landfill fires	1,000	ND	600	NA	600
2	Accidental fires in houses, factories	400	ND	400	NA	400
٣	Uncontrolled domestic waste burning	300	ND	600	NA	600
4	Accidental fires in vehicles (per vehicle)	94	ND	18	NA	18
5	Open burning of wood (construction/demolition)	60	ND	10	NA	10

3.6.2.1.4.4 Results

Table 8.4 provides the revised emission estimate for releases to air, water and land.

Table 8.4 UNEP Toolkit Estimate of Emissions – Waste Burning and Accidental Fires

Class	Sub-categories	Production t/a	Annual release g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
	Open Burning Processes		Air	Water	Land	Product	Residue
	Fires, waste burning, landfill fires, industrial fires, accidental fires	67	0.011	0	0.008	0	0
1	Landfill fires		0.000		0.000		
2	Accidental fires in houses, factories	17	0.007		0.007		
٣	Uncontrolled domestic waste burning		0.000		0.000		
4	Accidental fires in vehicles (per vehicle)	50	0.005		0.001		
5	Open burning of wood (construction/demolition)		0.000		0.000		

3.6.2.1.4.5 Incomplete information

There is no incomplete information

3.6.2.1.5 Open Burning of Construction Wood

No activity data were available for the open burning of construction wood.

9. MAIN CATEGORY NO 7 – PRODUCTION OF CHEMICALS AND CONSUMER GOOD

3.7.1 PULP AND PAPER MILLS

This activity does not exist in Jordan coastline

3.7.2 CHEMICAL INDUSTRY

This activity does not exist in Jordan coastline

3.7.3 PETROLUM REFINRIES

This activity does not exist in Jordan coastline

3.7.4 TEXTILE PLANTS

This activity does not exist in Jordan coastline

3.7.5 LEATHER PLANTS

This activity does not exist in Jordan coastline

MAIN CATEGORY NO 8 – MISCELLAEOUS

Miscellaneous is used to quantify all emission sources that do not fit into any of the categories described elsewhere.

The following categories are included in the miscellaneous category:

Drying of biomass

Crematoria

Smoke Houses

Dry cleaning

Tobacco smoking

3.8.1 Drying Of Biomass

The UNEP Toolkit indicates that dioxin emissions can occur from the drying of biomass if contaminated wood is used as fuel. The drying of biomass using combustion does not take place in Aqaba .

Furthermore, the combustion of contaminated wood does not occur in Aqaba. Therefore, dioxin emissions from the drying of biomass are insignificant.

3.8.2 CREMATORIA

Crematoria are used to reduce human bodies to ash for the purposes of burial. Islamic way is to bury the bodies so this part is not applicable in Aqaba.

3.8.3 Smoke Houses

Smoke houses use the combustion of biomass to produce smoke in a closed chamber to preserve food. Dioxin emissions to air from the combustion products of biomass and to land from ash disposal are possible. No smoke houses are present in Aqaba.

3.8.4 Dry Cleaning

3.8.4.1 General information

The main source of dioxins from the dry cleaning process is from the actual textile being cleaned, which may have dioxin contamination due to manufacturing methods.

The dry cleaning process itself does not generate any dioxins. During the dry cleaning process, dioxins can be extracted from contaminated textiles and transferred into the solvent. The solvent is distilled for recovery and reuse and consequently dioxins can be concentrated in the residues

3.8.4.2 Activity Data

There are main two laundries in Aqaba as provided in Table 9.1

Table 9.1 Dry Cleaning Activity Data

NO.	Hotel Name	Quantity of Textile (Ton\a)	Type of Textile
1	Tala Bay Resort	15	Normal textiles
2	Moevenpick Resort & Residence Aqaba	19.2	Normal textiles

3.8.4.3 Estimate of Emissions

The UNEP Toolkit describes two classes of emission factors ranging from Class 1: Heavy Textile to Class 2: Normal Textile as shown in Table 9.2. The Class 2 dioxin emission factors have been chosen to estimate dioxin emissions from these Laundries since Aqaba is considered a tourist place and due to its hot weather.

Table 9.2 UNEP Toolkit Emission Factors – Dry Cleaning

Class	Sub-categories	Potential Release Route (µg TEQ/t)				
		Air	Water	Land	Product	Residue
	Miscellaneous					
	Dry cleaning residues					
1	Heavy textiles, PCP-treated, etc.	NA	NA	NA	NA	3,000
2	Normal textiles	NA	NA	NA	NA	50

3.8.4.4 Results

Table 9.3 provides the emission estimate for dry cleaning.

Table 9.3 UNEP Toolkit Estimates of Emissions - Dry Cleaning

Class	Sub-categories	Production t/a	Annual release				
			g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
	Miscellaneous		Air	Water	Land	Product	Residue
	Dry cleaning residues	34	0	0	0	0	0.002
1	Heavy textiles, PCP-treated, etc.						0.000
2	Normal textiles	34					0.002

3.8.4..5 Incomplete information

There is no incomplete information

3.8.5 Tobacco smoking

3.8.5.1 General information

Tobacco smoking is regarded as a minor source of dioxin emission to air, with the smoker normally regarded as the most exposed individual due to inhalation of smoke.

3.8.5.2 Activity Data

For the 2008 period the Aqaba Customs estimated number of cigarettes imported to Aqaba as 146 million cigarettes. Aqaba is a free customs area so the price of cigarettes in Aqaba is lower than the around regions. Note that not all the imported cigarettes to Aqaba will be consumed in Aqaba, despite that the whole quantity were included in the calculation since there is no accurate records for the cigarettes sold out side of Aqaba.

3.8.5.3 Estimate of Emissions

The default UNEP Toolkit emission factor of 0.1 pg TEQ/cigarette is used to estimate dioxin emissions to air from cigarette smoking. The range of activity data estimates is used to estimate the range of dioxin emissions.

In theory there would be an emission to land through cigarette ash. However, it is likely that the contribution to land would be insignificant. Therefore, dioxin emissions to land are assumed to be negligible.

The UNEP emission factors to air, water and land are outlined in Table 9.4

Table 9.4 UNEP Toolkit Emission Factors – Tobacco smoking

Class	Sub-categories	Potential Release Route (µg TEQ/t)				
		Air	Water	Land	Product	Residue
	Miscellaneous					
	Tobacco smoking					
1	Cigar (per item)	0.3	NA	NA	NA	NA
2	Cigarette (per item)	0.1	Na	NA	NA	NA

3.8.5.4 Results

Table 9.5 provides the emission estimate for tobacco smoking.

Table 9.5 UNEP Toolkit Estimates of Emissions - Tobacco smoking

Class	Sub-categories	Production t/a	Annual release				
			g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
	Miscellaneous		Air	Water	Land	Product	Residue
	Tobacco smoking	146,000,000	0.0000	0	0	0	0
1	Cigar (per item)		0.0000				
2	Cigarette (per item)	146,000,000	0.0000				

3.8.5.5 Incomplete information

There is no incomplete information

3.9 MAIN CATEGORY 9 – DISPOSAL

3.9.1 LAND FILL LEACHATE

No estimate of leachate emissions to groundwater in Aqaba was identified. Aqaba has an extremely dry weather; the total annual rainfall for Aqaba for the year 2008 is 1.5 mm according to the Jordanian Bureau of Meteorology.

Aqaba landfill doesn't have any collection system for the leachate and the volume of the landfill is very small around 4 ha with a depth of 3 m.

3.9.1.1 Landfills and Waste Dumps

Landfills and waste dumps are places where waste is disposed of by burying in the ground or piling on the surface. A landfill is considered a controlled engineered waste storage site with respect to inputs/types of wastes, location of different types of wasteland management (gas and water collection etc.).

3.9.2 Sewage and Sewage Treatment

3.9.2.1 General information

Sewage in this case is the wastewater arising from human sanitation and any associated industrial wastes that are treated in the same systems. Sludge describes the solid component of the wastewater that is often extracted during the sewage treatment process.

3.9.2.2 Activity Data

Wastewater

The Aqaba water Company estimates that for the year 2008, a 5475000 m3 wastewater was received in the Aqaba waste water treatment plant Sludge

The Aqaba water Company estimates that for the year 2008, a total quantity of sludge was 1095 ton generated. All the sludge generated is still stored in the drying bonds for 10-12 years before removing it.

3.9.2.3 Emission factors

Table 10.1 Emission Factors – Sewage and sewage treatment

Class	Sub-categories	Potential Release Route (µg TEQ/t)				
		Air	Water	Land	Product	Residue
	Disposal		µg TEQ/m³			µg TEQ/m³
	Sewage/sewage treatment					
1	Industrial, mixed domestic with chlorine relevance	NA				
	No sludge removal	NA	0.005	NA	NA	1,000
	With sludge removal	NA	0.0005	NA	NA	1,000
2	Urban environments	NA				
	No sludge removal	NA	0.002	NA	NA	100
	With sludge removal	NA	0.0005	NA	NA	100
٣	Remote and residential or modern treatment plant	NA	0.0001	NA	NA	10

3.9.2.4 Results

Table 10.2 provides the emission estimate for releases.

Table 10.2 UNEP Toolkit Estimate of Emissions – Sewage and sewage treatment

	Sub-categories	Production	Annual release

Class			g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	
	Disposal		Air	Water	Land	Product	Residue	
	Landfill leachate	0	0	0.000	0	0	0	
1	Hazardous waste *			0.000			0	
2	Non-hazardous waste *			0.000		0	0	
	Sewage/sewage treatment	5,475,000		0.003	0	0	0.110	Please enter mass of sludge (t/a)
1	Industrial, mixed domestic with chlorine relevance	0		0.000	0	0	0.000	
	No sludge removal			0.000			0.000	
	With sludge removal			0.000			0.000	
2	Urban environments	5,475,000		0.003	0	0	0.110	
	No sludge removal			0.000			0.000	
	With sludge removal	5475000		0.003			0.110	1,095
3	Remote and residential or modern treatment plant			0.000			0.000	

3.9.2.5 Incomplete information

There is no incomplete information

3.9.3 Open water dumping

3.9.3.1 General information

This subcategory relates to discharges from households, offices and other small businesses as well as run-off from contained land.

3.9.3.2 Activity Data

Open water dumping were sourced from Aqaba Thermal Power Plant and Arab Fertilizers and Chemicals Industries as provided in Table 10.3

Table 10.3 Open water dumping Activity Data

NO.	Industry	Quantity of water (m^3\a)
1	Aqaba Thermal Power Plant	No records
2	Arab Fertilizers and Chemicals Industries	876000

3.9.3.3 Estimate of Emissions

The UNEP Toolkit provides three emission factors for open water dumping as follows:

Class 1: Mixed domestic and industrial water dumping (5 pg TEQ/L)

Class 2: Urban environments (0.2 pg TEQ/L)

Class 3: Remote environments or where controls are in place for open water dumping (0.1 pg TEQ/L)

The Class 1 and Class 3 emission factors are used to estimate the range of dioxin emissions from open water dumping whereas the Class 2 emission factor is used to generate the best estimate of dioxin emissions from open water dumping, Table 10.4.

Table 10.4 Emission Factors – Open water dumping.

Class	Sub-categories	Potential Release Route (µg TEQ/t)				
		Air	Water	Land	Product	Residue
	Disposal		µg TEQ/m^3			µg TEQ/m^3
	Open water dumping					
1	Mixed domestic and industrial inputs	NA	0.005	NA	NA	NA
2	Urban environments	N	0.0002	NA	NA	NA

٣	Remote environments or input control	A N A	0.0001	NA	NA	NA

3.9.3.4 Results

Table 10.5 provides the emission estimate for releases.

Table 10.5 UNEP Toolkit Estimate of Emissions – Open water dumping

Class	Sub-categories	Production	Annual release				
			g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
	Disposal		Air	Water	Land	Product	Residue
	Open water dumping	876,000	0	0.004	0	0	0
1	Mixed domestic and industrial inputs	876,000		0.004			
2	Urban environments			0.000			
3	Remote environments or input control			0.000			

3.9.3.5 Incomplete information

There is no incomplete data.

3.9.3.6 Solid Waste Dumping

The Aqaba Special Economic Zone (ASEZ) of Jordan is currently populated by 90 000 inhabitants. ASEZ's population grows significantly during summer and other tourist seasons.

Due to economic expansion, the zone's population and economic activity are growing rapidly from 5% to 10 % per year. This growth is expected to continue, given the zone's current ongoing or announced multi-billion JOD construction projects. ASEZ, beyond tourism, is also an import transit port for cargo to Jordan and Iraq. This trend is expected to continue. The zone further has a fast growing duty free manufacturing sector.

A private company is responsible for: street cleaning, solid waste management, parks and landscaping, roads and bridges, service to public buildings, planning, etc.

From ASEZA estimates, 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.

As ASEZ is an important tourist centre, authorities place particular importance on cleanliness of the zone's streets and open areas and promptness for waste removing services. Consequently, waste is removed daily with some areas undergoing 24 hour per day cleaning and collection. Further, except for industrial solid waste producers, all waste, including bulky items, is promptly removed without charge.

At present, ASEZA strategically places waste collection points near homes and businesses. Residents and businesses then place waste in the nearest available collector or receptacle. In turn, the waste collectors are picked-up daily or more often for disposal. Bulky waste is generally placed on the nearest curb side where they are picked up within 24 hours by special crews. The system has the advantage of concentrating waste collection points which then enjoy daily disposal.

With the exception of four outlining towns, ASEZ's urban areas are relatively compact, with most people living in small apartment complexes and businesses located in business districts and centers.

The Port of Aqaba has solid waste receptacles in the port areas and provides a daily garbage collection service via barge to ships anchored offshore. The Port of Aqaba collects some 3 tons of garbage each day, as compared to 100 tons/day collected from Aqaba homes and businesses.

No systematic recycling is currently practiced. Used tires constitute a special environmental problem, since there are approximately 100,000 used tires lying about.

ASEZA has only recently undergone significant economic expansion, in that most of the zone has excellent roads and infrastructure. A new landfill has also been recently opened this solid waste dumpsite is located to the east of the Southern Coastal Zone. The site is far away from the collection centers. The disposal site is in the south near the industrial area in an upland wadi, east of the planned South Coast Tourism Zone. The round trip from Aqaba Town to this site is approximately 36 km. The disposal method at the site consisted of burying. The site was not properly maintained.

The old site area is located on the highway to Amman it does not receive any solid waste it is used now a days for the demolition waste, and for illegal dumping of tires, most of the fire illegal burning by the scavengers are in this site.

3.9.4 Composting

This activity does not exist in Jordan coastline

3.9.5 Waste oil disposal

This activity does not exist in Jordan coastline

3.9.6 Aqaba Water Company

3.9.6.1 History

Before the construction of natural plant in 1987 Aqaba was served by a small activated sludge plant since year 1965. The natured plant replaces the old treatment plant which is now redundant. In Sep 2005, an expansion and upgrading to the existing wastewater treatment system has been established to meet the requirement of the project area till the year 2025 (in low projection), and to meet Jordan's standard specifications for wastewater reuse for agricultures and for industrial requirements. So now we have two treatment plants.

The natural plant (9000 m3/d) produces reclaimed reused water for agriculture farms.

The activated sludge tertiary plant (12000 m3/d) produces reused water for industries and for landscape.

Both wastewater plants consist of different equipments except the head works is same for both.

3.9.6.2 Primary Plant Headwork

The Headwork is designed to accommodate the peak hour flow to both plants of 12,000 m3/d associated with the ultimate 48,000 m3/d average day capacity. The values shown for mechanical treatment are used for the design of the secondary biological process and the tertiary filtration disinfection process

3.9.6.3 Tertiary Plant Oxidation Ditches

There are two oxidation ditches operating in parallel each of 15,817 m3 capacity; each equipped with five brush aerators and six submersible mixers

The Oxidation Ditch is a variation of the Activated Sludge process capable of oxidizing the organic content (usually expressed as BOD's) and the reduced nitrogen which is formed in raw sewage. The reduced nitrogen is found in organic material and as ammonia. The process accomplishes the oxidation by sustaining a mixed population of microorganisms (biomass) that use the organic material and ammonia for energy and growth

3.9.6.4 Clarifiers

Two clarifiers are used to settle fine solids carried over from the oxidation ditches The Mixed Liquor from the oxidation ditches flows to the Clarifier Distribution Chamber that distributes the flow to two circular clarifiers that will be constructed as part of this project The diameter of each clarifier is28 m and has a side water depth of 5 m.

Provisions are made in the design for scum removal so that no floating material will pass to the next process unit.

3.9.6.5 Flocculation and Filtration

The flocculation basins can be operated in series, if a longer retention time is desired, or in parallel, if a shorter retention time proves sufficient. The stirring provided by the vertical flocculates causes the coagulated solids to bind together, creating a larger, denser flock that can be removed easily by the filters.

3.9.6.6 Return Activated Sludge (RAS) and Waste Activated Sludge (WAS) Pump Station

Activated Sludge is withdrawn from the sludge hopper in each clarifier and piped to the wet well of the RAS/WAS pump station. RAS and WAS are drawn from this well independently to satisfy the MLSS requirement of the oxidation ditches and to maintain the desired Solids Residence Time in the process.

3.9.6.7 Disinfection

Despite the high efficiency of removal of suspended material, coli forms, viruses and helminthes by the preceding processes, it is essential that the filtered effluent receive a high degree of disinfection prior to being used for urban irrigation where human contact is probable. This is achieved by exposing the filtered effluent to ultraviolet (UV) light for disinfection.

Following the UV disinfection, a chlorine injector is provided to provide a chlorine residual throughout the URW distribution system.

3.9.8.8 Sludge Drying Beds

Sludge drying beds are provided to dewater the Waste Activated Sludge. There are 64 beds with vertical walls. Each bed has a sand layer supported by a crushed rock layer on a prepared impermeable base sloped to drain to the center of the bed. The bottom of each bed is lined to with HDPE fabric to ensure impermeability

The dried sludge could be composted to make it suitable for reuse, or hauled to a suitable landfill for disposal.

3.9.6.9 Urban Reclaimed Water (URW) Pump Station

The Urban Reclaimed Water System consists of a pump station with4 vertical turbine pumps 2 duties and one standby, a piping system and a reservoir The pumps have a duty of 230 m3/hr. at 108 m head.

The URW pump station discharges into a piping network supplying the various green areas within Aqaba and providing Utility Water for the WWTP, and Supply industries with the treated water Normal operation of the URW pump station is controlled by the level in the reservoir. If the reservoir is full, flow is bypassed to the ARW system.

3.10 MAIN CATEGORY NO 10 – IDENTIFICATION OF POTENTIAL HOTS SPOTS

This activity does not exist in Jordan coastline

4 ASSESSMENT OF THE INVENTORY RESU

Table 11.1 presents a summary of best estimate dioxin emissions for each category included in the inventory.

The category with the highest estimated emission is the transport sector (i.e. Diesel engines). Transport sector is estimated to contribute to nearly 64.3% of total emissions to air. Port activities and ships consumed around 4869552 ton/a (the amount of diesel consumed by the ships was obtained from the Jordanian maritime authority).

Heat and Power Generation contribute to nearly 5.6% of the total emission to air, the amount of diesel consumed by the boilers (industrial and non industrial) and power generators is 5588.6 ton/a and the amount of heavy fuel used in Heavy fuel fired power boilers and power generators is 214237 ton/a

Disposal and land filling is estimated to be the only source of dioxin emissions to water and highest estimated emission to residues with annual release of 0.007 g TEQ/a for water and 0.110 g TEQ/a for residues.

Sewage/sewage treatment contributes to nearly 43% of the total emission to water and 98% to residue. Open water dumping contributes to nearly 57% of the total emission to water.

Open Burning Processes is estimated to be the only significant source of dioxin emission to land through the 77 accidental fires in houses and factories, and 50 accidental fires in vehicles which annually release 0.003 g TEQ/a .

Table 11.2 shows the emission estimates by subcategory.

Table 11.1 Summary of Best Estimate Dioxin Emissions to Air, Water and Land in Aqaba for 2008

Cat.	Source Categories	Annual Releases (g TEQ/a)				
		Air	Water	Land	Product	Residue
1	Waste Incineration	0.220	0.000	0.000	0.000	0.001
2	Ferrous and Non-Ferrous Metal Production	0.000	0.000	0.000	0.000	0.000
٣	Heat and Power Generation	0.042	0.000	0.000	0.000	0.000
4	Production of Mineral Products	0.000	0.000	0.000	0.000	0.000
5	Transportation	0.485	0.000	0.000	0.000	0.000
6	Open Burning Processes	0.006	0.000	0.003	0.000	0.000
7	Production of Chemicals and Consumer Goods	0.000	0.000	0.000	0.000	0.000
8	Miscellaneous	0.000	0.000	0.000	0.000	0.002
9	Disposal	0.000	0.007	0.000	0.000	0.110
10	Identification of Potential Hot-Spots				0.000	0.000
1-9	Total	0.754	0.007	0.003	0.000	0.112
	Grand Total (rounded)	1				

Table 11.2 Emission Estimates by Subcategory

Source Category	Annual Estimated Release TEQ/a						
	Air	Water	Land	Product	Residue	Bottom Ash	Total"
Medical waste incineration	0.220	0.000	0.000	0.000	0.000	0.001	0.221

Animal carcasses burning	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Thermal wire reclamation	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Fossil fuel power plants	0.041	0.000	0.000	0.000	0.000	0.000	0.041
Biomass power plants	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Domesting heating - Fossil fuels	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4-Stroke engines	0.002	0.000	0.000	0.000	0.000	0.000	0.002
2-Stroke engines	0.001	0.000	0.000	0.000	0.000	0.000	0.001
Diesel engines	0.482	0.000	0.000	0.000	0.000	0.000	0.482
Fires, waste burning, landfill fires, industrial fires, accidental fires	0.006	0.000	0.003	0.000	0.000	0.000	0.009
Dry cleaning residues	0.000	0.000	0.000	0.000	0.002	0.000	0.002
Tobacco smoking	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sewage/sewage treatment	0.000	0.003	0.000	0.000	0.110	0.000	0.113
Open water dumping	0.000	0.004	0.000	0.000	0.000	0.000	0.004
Total	0.752	0.007	0.003	0.000	0.112	0.001	0.875

Figure 11.1 shows the results percentages for air, water, land, production, residue, and bottom ash.

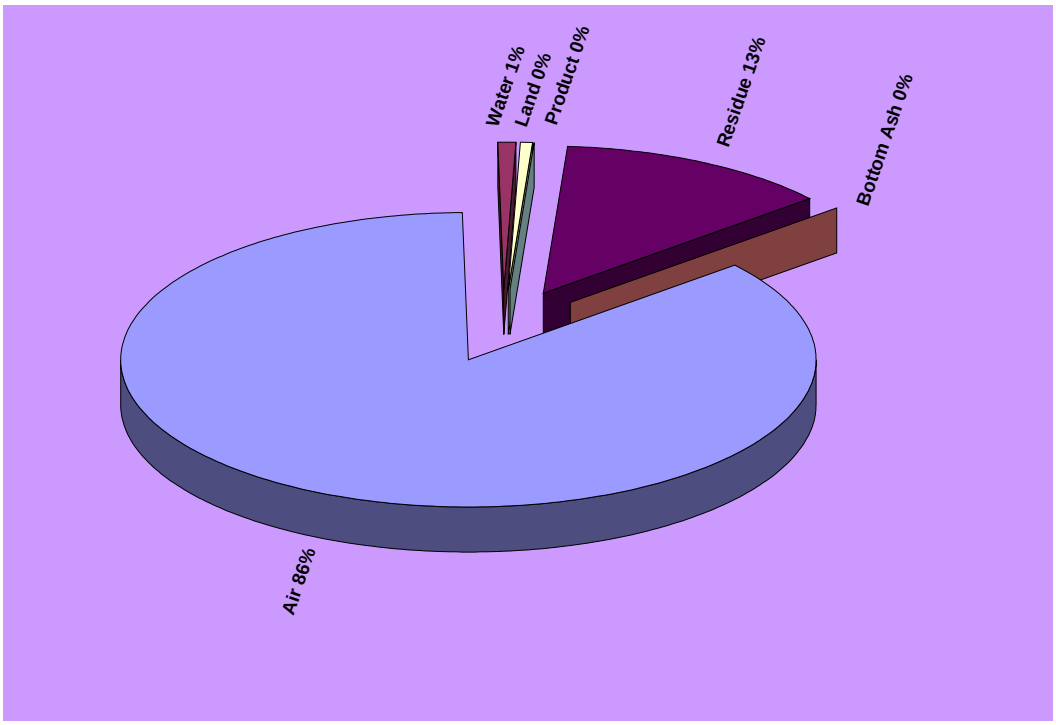


Figure 11.1 Results Percentages

5 PRIORITY SECTOR AND location FOR BAT/BEP INTRODUCTION

There are three main sources or categories where BAT/BET can be implemented; Waste Incineration, Heat and Power Generation, and Transportation.

5.1 Waste Incineration

5.1.1 Medical Incineration

There are two options for reducing emissions: short term (BEP) and long term (BAT).

Short term: transport the wastes out of Aqaba to a medical incinerator or treatment facility. This will eliminate the emissions to air and it will be zero.

Long term: the revised dioxine emission estimates for medical waste incineration in Aqaba

after installing a high technology incinerator will be modified as the following:

Table 13.1 UNEP Toolkit Estimates of Emissions – Medical Waste Incineration (current)

Class	Sub-categories	Production t/a	Annual release g TEQ/a Air	g TEQ/a Water	g TEQ/a Land	g TEQ/a Product	g TEQ/a Fly ash	g TEQ/a Bottom Ash
	Waste incineration							
	Medical waste incineration	5.500	0.220	0	0	0	0.000	0.001
1	Uncontrolled batch combustion, no APCS	5.500	0.220				0.000	0.001
2	Controlled, batch, no or minimal APCS		0.000				0.000	0.000
3	Controlled, batch comb., good APCS		0.000				0.000	
4	High tech, continuous, sophisticated APCS		0.000				0.000	0.000

Table 13.2 UNEP Toolkit Estimates of Emissions – Medical Waste Incineration (after applying BAT)

	Sub-categories	Production t/a	Annual release g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a

Class			Air	Water	Land	Product	Fly ash	Bottom Ash
	Waste incineration							
	Medical waste incineration	5.500	0.000	0	0	0	0.001	0.000
1	Uncontrolled batch combustion, no APCS	0.000	0.000				0.000	0.000
2	Controlled, batch, no or minimal APCS		0.000				0.000	0.000
3	Controlled, batch comb., good APCS		0.000				0.000	
4	High tech, continuous, sophisticated APCS	5.500	0.000				0.001	0.000

Table 4.2 UNEP Toolkit Emission Factors – Medical Waste Incineration

Class	Sub-categories	Potential Release Route (µg TEQ/t)					
						Residue	
		Air	Water	Land	Product	Fly Ash	Bottom Ash
	Waste incineration						
	Medical waste incineration						
1	Uncontrolled batch combustion, no APCS	40,000		NA	NA		200
2	Controlled, batch, no or minimal APCS	3,000		NA	NA		20
٣	Controlled, batch comb., good APCS	525		NA	NA	920	ND
4	High tech, continuous, sophisticated APCS	1		NA	NA	150	

5.2 Heat and Power Generation

The main subcategory in this category is Fossil fuel power plants. There are two alternatives: installing Air Pollution Control Systems (BAT) or shifting from heavy oil fuel to diesel for the industrial companies, and shifting from diesel to LPG (BEP).

Table 13.3 UNEP Toolkit Estimates of Emissions – Fossil Fuel Power Plants (current)

Sub-categories	Production	Annual release				
	TJ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
Heat and Power Generation		Air	Water	Land	Product	Residue
Fossil fuel power plants	47,210	0.041	0	0	0	0.0
Fossil fuel/waste co-fired power boilers		0.000				
Coal fired power boilers		0.000				0.000
Heavy fuel fired power boilers	8891	0.022				
Shale oil fired power plants		0.000				
Light fuel oil/natural gas fired power boilers	38,319	0.019				

Table 13.3 UNEP Toolkit Estimates of Emissions – Fossil Fuel Power Plants (after applying BEP)

Sub-categories	Production	Annual release				
	TJ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
Heat and Power Generation		Air	Water	Land	Product	Residue
Fossil fuel power plants	47,209	0.023	0	0	0	0.0
Fossil fuel/waste co-fired power boilers		0.000				
Coal fired power boilers		0.000				0.000
Heavy fuel fired power boilers		0.000				
Shale oil fired power plants		0.000				
Light fuel oil/natural gas fired power boilers	47,209	0.023				

5.3 Transportation

There are no practical solutions to be carried out to implement BAT or BEP here. There are some ideas to provide the ships in the harbor with electricity from the host port instead of keeping their engines running, but again this solution is difficult to be applied.

Table 13.4 UNEP Toolkit Estimates of Emissions – ships (current)

Class	Sub-categories	Consumption t/a	Annual release g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a	g TEQ/a
	Transport (ships)		Air	Water	Land	Product	Residue
1	Diesel engines	4819800	0.482	0	0	0	0
	Diesel engines	4819800	0.482				
			0.482	0	0	0	0

5.4 Criteria for selecting the priority locations for BAT/BEP implementation

Criteria for selection of priority sites are:

Compatibility with legislation.

Compatibility with national plans.

Compatibility with the outputs of the inventory emission sources of unintentional persistent organic pollutants in Aqaba study.

The possibility of application:

- the financial capabilities.
- the technical capabilities.

How useful the return on the community in the case of the introduction of new technologies.

ANNEXES

Annex A: Sample of Calculations

Hotels

Days Inn hotel

Days Inn Hotel has two boilers, only one is operating usually and the other one is operating for only one month in winter.

Diesel consumption (average for summer and winter) = 2166 liter/month

= 26000 liter/year

= 0.85 * 26000 liter/year [density of diesel: 0.85 kg/liter]

= 22100 kg/year

From Table 96 (Heating values for oil, page 231, PCDD/PCDF Toolkit 2005):

Light fuel oil/ Diesel fuel heating value: 43 – 46 MJ/kg

Taking average value: 44.5 MJ/kg

Activity Rate = 44.5 MJ/kg * 22100 kg/year

= 983450 MJ/year

Source Strength (for air) = Emission Factor * Activity Rate

= 0.5 µg TEQ/TJ * 10-6 TJ/MJ * 983450 MJ/year

= 0.491725 µg TEQ/year

Radison SAS Hotel

Radison SAS Hotel has three boilers, only one is operating in normal conditions. In winter – which last for about three months – the three boilers are operating together.

Diesel consumption (average for summer and winter) = 11291 liter/month

= 135492 liter/year

= 0.85 * 135492 liter/year [density of diesel: 0.85 kg/liter]

= 115168.2 kg/year

From Table 96 (Heating values for oil, page 231, PCDD/PCDF Toolkit 2005):

Light fuel oil/ Diesel fuel heating value: 43 – 46 MJ/kg

Taking average value: 44.5 MJ/kg

Activity Rate = 44.5 MJ/kg * 115168.2 kg/year

= 5124984.9 MJ/year

Source Strength (for air) = Emission Factor * Activity Rate

= 0.5 µg TEQ/TJ * 10-6 TJ/MJ * 5124984.9 MJ/year

= 2.5625 µg TEQ/year

Movenpick Hotel – Aqaba City

Movenpick Hotel – Aqaba City has three boilers with 900 kW each, and two steam boilers with power of three ton and 800 kg respectively.

Diesel consumption (average for summer and winter) = 31666 liter/month

= 380000 liter/year

= 0.85 * 380000 liter/year [density of diesel: 0.85 kg/liter]

= 323000 kg/year

From Table 96 (Heating values for oil, page 231, PCDD/PCDF Toolkit 2005):

Light fuel oil/ Diesel fuel heating value: 43 – 46 MJ/kg

Taking average value: 44.5 MJ/kg

Activity Rate = 44.5 MJ/kg * 323000 kg/year

= 14373500 MJ/year

Source Strength (for air) = Emission Factor * Activity Rate

= 0.5 µg TEQ/TJ * 10-6 TJ/MJ * 14373500 MJ/year

= 7.18675 µg TEQ/year

Aqaba Gulf Hotel

Diesel consumption (average for summer and winter) = 2400 liter/month

= 28800 liter/year

= 0.85 * 28800 liter/year [density of diesel: 0.85 kg/liter]

= 24480 kg/year

From Table 96 (Heating values for oil, page 231, PCDD/PCDF Toolkit 2005):

Light fuel oil/ Diesel fuel heating value: 43 – 46 MJ/kg

Taking average value: 44.5 MJ/kg

Activity Rate = 44.5 MJ/kg * 24480 kg/year

= 1089360 MJ/year

Source Strength (for air) = Emission Factor * Activity Rate

= 0.5 µg TEQ/TJ * 10-6 TJ/MJ * 1089360 MJ/year

= 0.54468 µg TEQ/year

Royal Diving Club

Diesel consumption (average for summer and winter) = 625 liter/month
= 7500 liter/year
= 0.85 * 7500 liter/year [density of diesel: 0.85 kg/liter]
= 6375 kg/year
From Table 96 (Heating values for oil, page 231, PCDD/PCDF Toolkit 2005):
Light fuel oil/ Diesel fuel heating value: 43 – 46 MJ/kg
Taking average value: 44.5 MJ/kg
Activity Rate = 44.5 MJ/kg * 6375 kg/year
= 283687.5 MJ/year
Source Strength (for air) = Emission Factor * Activity Rate
= 0.5 µg TEQ/TJ * 10-6 TJ/MJ * 283687.5 MJ/year
= 0.14184 µg TEQ/year

Marina Plaza Hotel

Diesel consumption (average for summer and winter) = 6990 liter/month
= 83880 liter/year
= 0.85 * 83880 liter/year [density of diesel: 0.85 kg/liter]
= 71298 kg/year
From Table 96 (Heating values for oil, page 231, PCDD/PCDF Toolkit 2005):
Light fuel oil/ Diesel fuel heating value: 43 – 46 MJ/kg
Taking average value: 44.5 MJ/kg
Activity Rate = 44.5 MJ/kg * 71298 kg/year
=3172761 MJ/year
Source Strength (for air) = Emission Factor * Activity Rate
= 0.5 µg TEQ/TJ * 10-6 TJ/MJ * 3172761 MJ/year
= 1.5864 µg TEQ/year

Golden Tulip Hotel

Golden Tulip Hotel has two boilers; one for hot water and the other for heating. The heating boiler works only for three months during the year (in winter).

Diesel consumption (average for summer and winter) = 2310 liter/month
= 27720 liter/year
= 0.85 * 27720 liter/year [density of diesel: 0.85 kg/liter]

= 23562 kg/year

From Table 96 (Heating values for oil, page 231, PCDD/PCDF Toolkit 2005):

Light fuel oil/ Diesel fuel heating value: 43 – 46 MJ/kg

Taking average value: 44.5 MJ/kg

Activity Rate = 44.5 MJ/kg * 23562 kg/year

=1048509 MJ/year

Source Strength (for air) = Emission Factor * Activity Rate

= 0.5 µg TEQ/TJ * 10-6 TJ/MJ * 1048509 MJ/year

= 1.04851 µg TEQ/year

Companies

Kemapco

Kemapco has only one boiler that uses heavy oil, it operates continuously for 24 hour per day and 330 days per year. It consumes 20 ton / day.

Heavy Oil consumption = 20 ton/day * 1000 kg/ton * 330 day/year

= 6600000 kg/year

From Table 96 (Heating values for oil, page 231, PCDD/PCDF Toolkit 2005):

Heavy fuel oil heating value: 40 – 43 MJ/kg

Taking average value: 41.5 MJ/kg

Activity Rate = 41.5 MJ/kg * 6600000 kg/year

=273900000 MJ/year

Source Strength (for air) = Emission Factor * Activity Rate

= 2.5 µg TEQ/TJ * 10-6 TJ/MJ * 273900000 MJ/year

= 684.75 µg TEQ/yea

Industrial Complex

Industrial Complex uses both heavy fuel oil and diesel in its boilers to generate power.

Heavy Oil consumption = 32000 ton/year * 1000 kg/ton

= 32000000 kg/year

From Table 96 (Heating values for oil, page 231, PCDD/PCDF Toolkit 2005):

Heavy fuel oil heating value: 40 – 43 MJ/kg

Taking average value: 41.5 MJ/kg

Activity Rate = 41.5 MJ/kg * 32000000 kg/year

=1328000000 MJ/year

Source Strength (for air) = Emission Factor * Activity Rate

= 2.5 µg TEQ/TJ * 10-6 TJ/MJ * 1328000000 MJ/year

= 3320 µg TEQ/year

Diesel consumption = 3640 ton/year * 1000 kg/ton

= 3640000 kg/year

From Table 96 (Heating values for oil, page 231, PCDD/PCDF Toolkit 2005):

Light fuel oil/ Diesel fuel heating value: 43 – 46 MJ/kg

Taking average value: 44.5 MJ/kg

Activity Rate = 44.5 MJ/kg * 3640000 kg/year

= 161980000 MJ/year

Source Strength (for air) = Emission Factor * Activity Rate

= 0.5 µg TEQ/TJ * 10-6 TJ/MJ * 161980000 MJ/year

= 80.99 µg TEQ/year

Aqaba Thermal Power Plant

Aqaba Thermal Power Plant is using three types of fuel: Natural Gas, Diesel, and Heavy fuel Oil.

It has five boilers operating normally on natural gas, while in shutdown and maintenance – which last for 14 days per year for each boiler – they turning to heavy fuel oil. Diesel is used only in start up.

Heavy Oil consumption = 174000 ton/year * 1000 kg/ton

= 174000000 kg/year

From Table 96 (Heating values for oil, page 231, PCDD/PCDF Toolkit 2005):

Heavy fuel oil heating value: 40 – 43 MJ/kg

Taking average value: 41.5 MJ/kg

Activity Rate = 41.5 MJ/kg * 174000000 kg/year

=7221000000 MJ/year

Source Strength (for air) = Emission Factor * Activity Rate

= 2.5 µg TEQ/TJ * 10-6 TJ/MJ * 7221000000 MJ/year

= 18052.5 µg TEQ/year

Diesel consumption = 20 ton/year * 1000 kg/ton

= 20000 kg/year

From Table 96 (Heating values for oil, page 231, PCDD/PCDF Toolkit 2005):

Light fuel oil/ Diesel fuel heating value: 43 – 46 MJ/kg

Taking average value: 44.5 MJ/kg

Activity Rate = 44.5 MJ/kg * 20000 kg/year

= 890000 MJ/year

Source Strength (for air) = Emission Factor * Activity Rate

= 0.5 µg TEQ/TJ * 10-6 TJ/MJ * 890000 MJ/year

= 0.445 µg TEQ/year

Natural Gas consumption = 793121.754 ton/year * 1000 kg/ton

= 793121754 kg/year

From Table 97 (Heating values for gas, page 232, PCDD/PCDF Toolkit 2005):

Natural Gas heating value: 48 MJ/kg

Activity Rate = 48 MJ/kg * 793121754 kg/year

= 38069844192 MJ/year

Source Strength (for air) = Emission Factor * Activity Rate

= 0.5 µg TEQ/TJ * 10-6 TJ/MJ * 38069844192 MJ/year

= 19034.9221 µg TEQ/year

Nippon Jordan Fertilizers Company

NJFC is using heavy fuel oil in its boilers.

Heavy Oil consumption = 1200 ton/year * 1000 kg/ton

= 1200000 kg/year

From Table 96 (Heating values for oil, page 231, PCDD/PCDF Toolkit 2005):

Heavy fuel oil heating value: 40 – 43 MJ/kg

Taking average value: 41.5 MJ/kg

Activity Rate = 41.5 MJ/kg * 1200000 kg/year

= 49800000 MJ/year

Source Strength (for air) = Emission Factor * Activity Rate

= 2.5 µg TEQ/TJ * 10-6 TJ/MJ * 49800000 MJ/year

= 124.5 µg TEQ/year

Red Sea Wood Factory

Red Sea Wood Factory has two boilers; one is operating on heavy fuel oil and the other on wood.

Heavy Oil consumption = 437 ton/year * 1000 kg/ton

= 437000 kg/year

From Table 96 (Heating values for oil, page 231, PCDD/PCDF Toolkit 2005):

Heavy fuel oil heating value: 40 – 43 MJ/kg

Taking average value: 41.5 MJ/kg

Activity Rate = 41.5 MJ/kg * 437000 kg/year

=18135500 MJ/year

Source Strength (for air) = Emission Factor * Activity Rate

= 2.5 µg TEQ/TJ * 10-6 TJ/MJ * 18135500 MJ/year

= 45.3388 µg TEQ/year

Wood consumption = 280 ton/year * 1000 kg/ton

= 280000 kg/year

From Table 98 (Heating values for wood, page 232, PCDD/PCDF Toolkit 2005):

Wood heating value: varies from 10 to 17 MJ/kg

Taking average value: 15 MJ/kg

Activity Rate = 15 MJ/kg * 280000 kg/year

= 4200000 MJ/year

Source Strength (for air) = Emission Factor * Activity Rate

= 50 µg TEQ/TJ * 10-6 TJ/MJ * 4200000 MJ/year

= 210 µg TEQ/year

Source Strength (for residue) = Emission Factor * Activity Rate

= 15 µg TEQ/TJ * 10-6 TJ/MJ * 4200000 MJ/year

= 63 µg TEQ/year

Asphalt Mixers

There are six asphalt mixers in Aqaba, but only two of them are operating. The two operating mixers are identical. They are both using diesel boilers.

Diesel consumption = 255 ton/year * 1000 kg/ton * 2 (for both)

= 510000 kg/year

From Table 96 (Heating values for oil, page 231, PCDD/PCDF Toolkit 2005):

Light fuel oil/ Diesel fuel heating value: 43 – 46 MJ/kg

Taking average value: 44.5 MJ/kg

Activity Rate = 44.5 MJ/kg * 510000 kg/year

= 22695000 MJ/year

Source Strength (for air) = Emission Factor * Activity Rate

= 0.5 µg TEQ/TJ * 10-6 TJ/MJ * 22695000 MJ/year

= 11.3475 µg TEQ/year

References

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