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MEDITERRANEAN ACTION PLAN

GEF

Thirteenth Ordinary Meeting of the Contracting Parties to the Convention for the Protection of the Mediterranean Sea against Pollution

Catania (Italy), 11-14 November 2003

STRATEGIC ACTION PROGRAMME

DRAFT REGIONAL PLAN

REDUCTION OF THE GENERATION OF HAZARDOUS WASTE FROM INDUSTRIAL INSTALLATIONS

UNEP/MAP
Athens, 2003

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Meeting of MAP National Focal Points

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UNEP/MAP
Athens, 2003

Regional Plan for the Reduction by 20% by 2007 of the generation of hazardous waste from industrial installations in the MAP countries

Final Report

02 June 2003

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Executive Summary

Introduction

The Regional Activity Centre for Cleaner Production (RAC/CP) of the Mediterranean Action Plan (MAP), has been commissioned to prepare this Regional Plan on hazardous waste reduction. This is done within the framework of the GEF Project Determination of priority actions for the further elaboration and implementation of the Strategic Action Programme for the Mediterranean Sea (SAP MED).

The main goal of this Regional Plan is the reduction by 20% by 2007 of the generation of hazardous waste from industrial installations in the MAP countries. In order to achieve this target, the priority flows of hazardous wastes have been identified and the required actions at regional and national level are proposed.

The main source of information has been a questionnaire provided to RAC/CP National Focal Points. However, the availability of quantitative data is limited due to the lack of completeness in answering the questionnaires, only 15 of 20 countries have responded and the degree of fulfilment is rather varying. One of the key methodological problems of this Regional Plan is the lack of a common classification of hazardous waste in the Region.

General principles

A set of general principles to prevent pollution generated by hazardous wastes in the Mediterranean Region has been proposed:

- Pollution prevention
- Ranking of waste management options (priority for minimization)
- Protection of the environment and human health
- Generator's responsibility
- Regional collaboration
- Integration

Status and trends of hazardous waste generation

Despite the difficulties encountered in the collection of information from all the MAP countries, and the fact that some may be inaccurate, **general trends** in relation to hazardous waste generation have been identified:

- The estimated total amount of hazardous wastes generated by the 20 MAP countries is in the range of **20 millions of tonnes per**

year. The key contributors are the European Mediterranean countries, due to their major industrial development.

- Hazardous waste generation data has been reported both according to the type of waste generated, and to the industrial sector generating them. The **main types** of hazardous wastes in quantitative terms are the ones resulting from **mining activities (18%), organic chemical processes industry (11%), mineral oils (10%) and surface treatment processes (9.5%)**.
- The analysis of reported data shows that the **main industrial sectors** generating hazardous wastes are the **metal industry** (as it includes several types of wastes), mining activities, and oil refining.
- According to the answers to the questionnaires from the MAP countries, **the metal industry sector** is the main source of **environmental impact** due to its hazardous waste generation.
- The **metal industry, oil refining activities and the textile industry** are the industrial sectors identified as the main **sources of pollution for the marine environment**. The industrial concentration on the coastal zone is the main cause of their impact, particularly in southern countries.

Legal and management framework

According to reported data, half the countries of the Region are still developing their industrial and hazardous waste legal and management framework. Hence, they are far from establishing the Hazardous Waste National Plans.

The Northern western countries of the region have stricter legal and management frameworks to prevent pollution on the Mediterranean environment. The Eastern countries, except Greece and Israel, are in general developing the overall legal framework. Among the southern countries of the Region, Egypt and Tunisia appear to be the most advanced in the development of their national legal and management frameworks.

In general, it can be observed that all the countries are adopting a waste hierarchy that gives major priority to prevention of the generation of wastes, in their legal and management framework.

Current waste minimization practices

From the reported answers to questionnaires, it is possible to see that about 40% of countries have incorporated **plans or targets related to waste minimization** in their legal or management framework. However, this does not imply that these principles have been put in practice in terms of specific actions.

It is difficult to highlight **the main sectors that incorporate actions** to reduce the generation of hazardous wastes, since depending on the country different priorities prevail. Nevertheless, there are some recurrent industrial activities in which different countries are taking measures, such as **the chemical, metal, cement and oil refining**.

The instruments to carry out hazardous waste minimization are diverse but the following have been repeatedly reported: **process optimisation, good housekeeping practices, product re-design and on-site recycling.**

Flows of hazardous wastes with a major priority to be reduced

With the limited available data, it has been possible to detect priorities at national and regional level. Taking into consideration a set of country specific criteria (hazardous waste generation, industrial activity, environmental conditions, etc.), the analysis performed would indicate the following:

- **The metal industry** is the sector that is more commonly identified as a **priority sector** in most of the MAP countries, together with the chemical industry and oil refining activities.
- **The priority types of wastes are used mineral oils** and wastes **from surface treatment,** according to the answers in the questionnaires from the countries of the Region.
- An industrial sector like **mining**, accounting for the second largest total generation of hazardous wastes, has only been found as a priority sector in a couple of countries. This is because mining accounts for a large generation of wastes in a single country, Spain, but does not have a significant activity in other countries, or at least this has not been reported.

Towards 20% reduction of hazardous wastes in the Mediterranean Region

Reduction of **20%** of hazardous wastes is approached in this Plan **as a relative target**. This means that the target is aimed at reducing an overall 20% of the hazardous waste generation in relation to industrial activity. That is, tonnes of hazardous wastes per unit of industrial activity (in monetary units), or, in other words, reducing an overall 20% of the "**Waste Generation Factor**". This has been considered to be the most reasonable approach in terms of pursuing the continuous improvement of the industrial sector in the Mediterranean Region.

As result of the identification of the available waste minimisation options and the successful case studies for hazardous waste reduction in the top priority industrial sectors, it has been seen that **significant**

reductions in the waste generation factor can be achieved, in many cases above 20%.

Nevertheless, potential reductions on hazardous waste generation can only be properly identified in each specific country, to take into consideration the different technological, legal and economic frameworks. Consequently, there is not enough information at Regional level to determine a different allocation of the target between MAP countries. Therefore, it is approached in this Plan that each MAP country adopts the overall target in terms of 20% reduction of its National Waste Generation Factor, that is, tonnes of hazardous wastes per unit of industrial activity (industrial GDP, in €).

Proposals

In order to reduce 20% of hazardous wastes generation in the overall Mediterranean Region by 2007, this Regional Plan basically proposes the following approach:

- To reduce 20% of current **Waste Generation Factors** (tonnes of hazardous waste per unit of industrial activity), through the adoption of Cleaner Production techniques and Best Available Techniques.
- To achieve an overall target reduction of 20% through an **equal allocation among MAP countries.**
- To include the reduction target into **National Plans,** this will be elaborated in each MAP country.

Accordingly, at **regional level**, the following actions are proposed:

1. To establish a coordinating unit to promote the required actions and follow-up the development of the Regional Plan.
2. To undertake specific waste minimization oriented studies for priority industrial sectors and sectors that have not been studied yet, in order to provide reference information to the countries.
3. To provide assistance to countries in the development of national legal and management frameworks.
4. To promote technical capacity building on cleaner production and dissemination of information, paying special attention to end users, in particular small and medium enterprises.
5. Follow up of the implementation of the Plan and final overall review, to check reductions in Waste Generation Factors.

Actions at **national level** are the key ones to effectively achieve a relative 20% overall reduction by 2007, and are proposed to be developed in the following way:

1. To undertake a National Diagnosis to better determine the current waste generation factor and priority flows of hazardous wastes to be reduced.
2. To ensure the development of a national strategy for hazardous waste management, that takes into account hazardous waste minimization.
3. Development of National Plans, taking into account, legal, social, technological and economic concerns, and incorporating the target to reduce 20% of the Waste Generation Factor.
4. To establish and promote a set of mechanisms to encourage the adoption of cleaner production actions leading to reduction of hazardous wastes: capacity building and dissemination of information, voluntary agreements, hazardous waste minimization plans, integrated pollution prevention control, economic instruments, etc.

PART A

Regional Plan for the Reduction of Hazardous Wastes in the MAP countries

1. Introduction

1.1 Background

The Regional Activity Centre for Cleaner Production (RAC/CP) of the Mediterranean Action Plan (MAP) [3], has been commissioned by MAP to prepare the Regional Plan for the reduction by 20% by 2007 of the generation of hazardous waste from industrial installations in the MAP countries, in close collaboration with Enviros Spain.

This Plan is developed within the framework of the GEF Project Determination of priority actions for the further elaboration and implementation of the Strategic Action Programme for the Mediterranean Sea (SAP MED) [5]. SAP MED is aimed at facilitating the implementation of SAP and will result in the elaboration of National Plans in all MAP countries. The present Regional Plan responds to the target set by SAP “to reduce as far as possible by 20% the generation of hazardous waste from industrial installations” (Section 5.2.6 of SAP).

The ultimate objective of the present Plan is to facilitate the implementation of both the Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources and Activities (LBS Protocol) [4] and the Protocol on the Prevention of Pollution of the Mediterranean Sea by Transboundary Movements of Hazardous Wastes and their Disposal [2].

The elaboration of this Regional Plan builds on the MAP Draft Regional Plan for the Management of Hazardous Waste [1], which is being developed in response to the SAP objective of preparing a Mediterranean Strategy for the Management of Hazardous Wastes, based on the principles of prevention, reduction and reuse.

1.2 Objectives

The main goal of this Regional Plan is the reduction by 20% by 2007 of the generation of hazardous waste from industrial installations in the MAP countries. This goal is approached in terms of relative reduction of hazardous waste generation in relation to industrial activity (tonnes of HW / unit of industrial activity), that is, reduction of the Waste Generation Factor.

In order to elaborate this Regional Plan the following specific objectives have been sought:

a) To analyse the status and trends of hazardous waste generation, legal and management framework, and waste minimization practices in the MAP countries.

b) To identify the flows of hazardous wastes with a major priority to be reduced.

c) To propose a set of actions to be undertaken at regional and national level

1.3 Scope

According to the general objective indicated above, the scope of this Plan can be defined as follows:

- Geographic scope: the countries integrated into the Mediterranean Action Plan (MAP) [3]. That is, Albania, Algeria, Bosnia and Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Monaco, Morocco, Slovenia, Spain, Syria, Tunisia, and Turkey. In this report, the term "Mediterranean Region" refers to the MAP countries.

- Hazardous wastes: only industrial hazardous wastes are considered. Hazardous wastes from agriculture, household or sanitary activities are out of the scope of this Plan.

- Reduction of hazardous wastes: actions to reduce waste relate to waste minimization actions. It means reduction at source and internal recycling at industrial facilities (also referred to as cleaner production). External recycling and recovery of wastes are not considered in this Plan.

1.4 Methodology

In order to achieve the objectives indicated above, the following methodology has been adopted.

- Preliminary review and analysis of existing data on hazardous waste generation in MAP countries: all the information already available by Enviros and the RAC/CP was collected and analysed, in order to identify the main data gaps and also potential sources of information.
- Identification of reference organizations and actors: for each of the MAP countries, the main organizations and actors were identified in order to find out potential sources of information. These institutions included basically organizations for the cleaner production and waste minimization, and public authorities and agencies in the area of waste management.
- Collection of information: In order to obtain the required information to elaborate this Plan, a questionnaire was developed and sent to the Cleaner Production National Focal Points in MAP countries (see Annex 5). This information was used to determine the

generation of hazardous waste, the main industrial sectors generating hazardous waste, the legal and management framework and current initiatives on hazardous waste minimization. The availability of data is limited due to the lack of completeness in answering the questionnaires in various countries, like Libya, Tunisia, Monaco, and Slovenia. France only provided quantitative data whilst other countries, like Turkey and Egypt, did not report quantitative data.

Besides the questionnaire, information was collected from regional and national reports, usually available at the web sites of the main regional and national organisations on hazardous waste and cleaner production.

Special attention was paid to the collection and analysis of quantitative data regarding the generation of hazardous wastes, as this has been used as one of the main criteria to prioritize types of wastes to be reduced.

- Analysis and integration of information. All the information collected through the different methods explained above, was analysed, and aggregated results were generated for the whole Mediterranean Region.
- Identification of priority types to be reduced. Both types of wastes and industrial sectors generating hazardous wastes were prioritized according to a set of criteria, like total amount of hazardous waste generated, impact on the environment and the Mediterranean Sea, or industrial expected growth.
- Analysis of options to reduce hazardous waste generation by 20%. For the top priority industrial sectors generating hazardous wastes, potential actions to reduce the generation of hazardous wastes were identified.
- Elaboration of the Regional Plan. From the results generated, the Regional Plan was developed. This Regional Plan contains basically a compendium of the status and trends of hazardous waste generation and management in the MAP countries, priority flows of hazardous wastes to be reduced, along with a set of proposals at regional and national level.

1.5 Definition and classification of hazardous waste

Defining hazardous waste is a complex task per se. Waste products which are normally considered to be hazardous are those listed in the annex or annexes of the corresponding legal documents e.g. the Izmir Protocol on the Prevention of Pollution of the Mediterranean Sea by Transboundary Movements of Hazardous Wastes and their Disposal, signed in 1996 [2], or the Basel Agreement on the same subject [7].

For the present Plan, the definition of hazardous waste considered in the Izmir Protocol has been adopted. As stated in Article 3, the Izmir Protocol applies to:

a) Wastes that belong to any category in Annex I of the Protocol.
b) Wastes that are not covered under paragraph (a) above but are defined as, or are considered to be, hazardous wastes by the domestic legislation of the State of export, import or transit.
c) Wastes that possess any of the characteristics contained in Annex II of the Protocol.
d) Hazardous substances that have been banned or are expired, or whose registration has been cancelled or refused through government regulatory action in the country of manufacture or export for human health or environmental reasons, or have been voluntarily withdrawn or omitted from the government registration required for use in the country of manufacture or export.

Accordingly, the preliminary classification adopted in this Plan relates to Annex I of the Izmir Protocol (the Y-Codes), which is equivalent to the one used in the Basel Convention, and also to the one used to elaborate the Hazardous Waste Inventory in the Mediterranean Region prepared by the MAP [41]. This classification is presented in **Annex 1**. It is worth noting that this classification presents some problems for data collection due to the fact that many countries either use their own national classification or the European Waste Catalogue, which are different from Y-codes classification. Moreover, several types of wastes included in the EWC are not considered in the Y-Codes. In order to consider these types of wastes in the present study, a classification list combining Y-codes with the EWC codes has been developed. This classification has posed some practical problems that will be dealt with further below.

1.6 Hazardous wastes and pollution of the environment and the Mediterranean Sea

As a first step to analyse the impact of hazardous waste, it is necessary to consider how it affects the environment and the Mediterranean Sea. As indicated by the Strategic Action Programme [5], hazardous wastes may affect the Mediterranean marine environment in the following situations [5]:

- Through direct discharges of raw waste products into the sea.
- Through indirect discharges of hazardous wastes: discharges into the rivers of the Mediterranean basin, or pollution of soils and

groundwater of coastal aquifers due to spills or inadequate stockpile of wastes.

- Through releases into the atmosphere or into water of pollutants which may be generated in the process of disposal or treating these waste products.

As it will be shown further on, the second main source of pollution of the marine environment is related to the lack of sound management practices of hazardous wastes, which is the current situation in some MAP countries.

1.7 Cleaner production and hazardous wastes

"Cleaner Production" (CP) can be broadly defined to cover concepts such as pollution prevention, waste minimisation, reduction at source, eco-efficiency, or energy efficiency. UNEP defines[1] CP as:

"Cleaner Production is the continuous application of an integrated, preventive strategy to processes, products and services to increase efficiency and reduce risks to humans and the environment"

Cleaner Production is not merely a technical fix and is therefore different from "clean technology". Instead, it refers to the ways in which goods and services are produced with the minimum environmental impact under present technological and economic limits. In this sense, CP contributes to the decoupling of economic growth and environmental pollution.

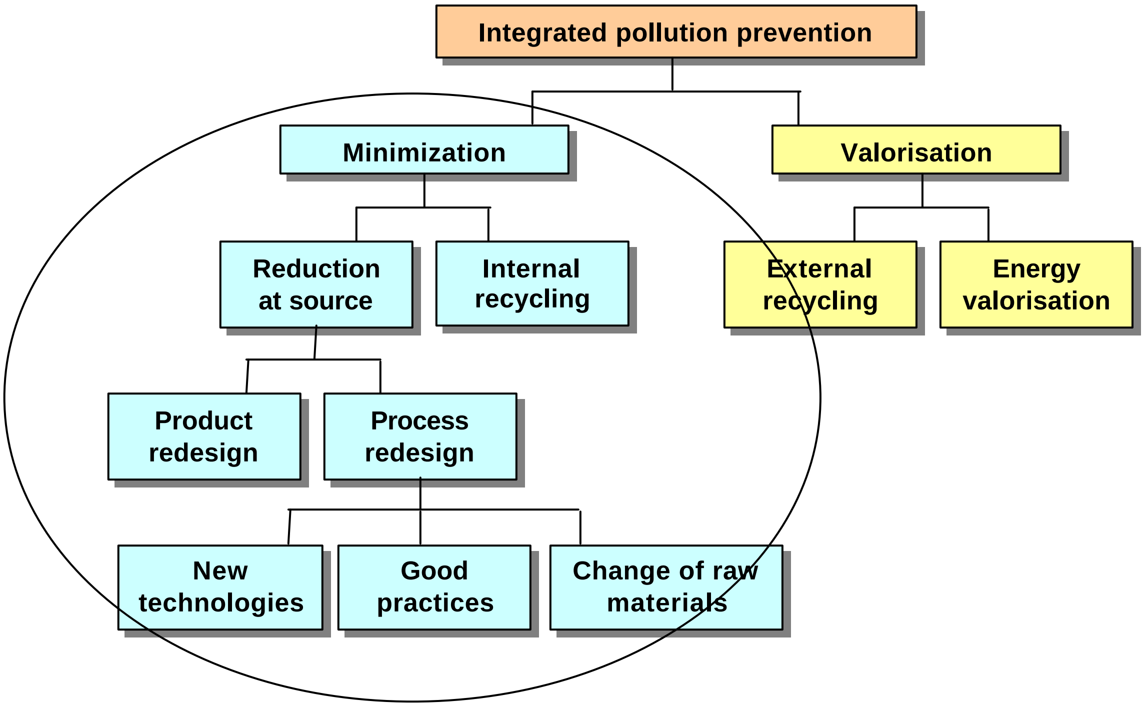
Cleaner Production is a strategic tool of business policy, which integrates the environment in the global management of the company. Furthermore, CP enables companies to maintain or improve competitiveness within a framework of environmental sustainability.

Hence, **Cleaner Production allows for the reduction in quantity and hazardousness of waste** (= hazardous waste minimization or reduction), which is the main objective of this Plan. Waste minimization can be achieved through reduction of the generation of wastes at source, or through internal recycling. Reduction at source can be achieved by redesigning both products and processes. In the case of processes, this new redesign covers the introduction of good practices, new and more efficient technologies lessening waste generation, and the change of raw materials to decrease the toxicity of wastes.

Figure 1-1 shows all the potential actions to minimize hazardous wastes in relation to the integrated pollution prevention strategy (minimization + waste valorisation).

[1] http://www.uneptie.org/pc/cp/understanding_cp/home.htm

Figure 1-1 Cleaner production actions (in circle) leading to reduction of hazardous wastes.



1.8 Structure of the Plan

The structure of the present Plan reflects the methodology followed to achieve the established objectives. In order to improve the illustration and understanding of the information collected and analysed, the document has been split into two parts, **Part A** and **Part B**.

Part A includes constitutes the core of the Regional Plan: after an introduction which includes the background and framework of the Plan, the general principles to prevent pollution from hazardous wastes in the Mediterranean Region are presented. Then, a synthesis of the current situation in terms of hazardous waste generation and management framework is synthesized both at regional and national levels. After that, this information is used to identify the priority flows of hazardous wastes to be reduced and the main industrial sectors generating them. Finally, according to the adopted approach, actions to implement this Regional plan are proposed and scheduled.

Part B includes an exhaustive compendium with all the information collected from the different MAP countries, in relation to hazardous waste generation, legal and management framework, and current waste minimization practices. The analysis of this information is also included in Part B, along with a collection of available information on waste minimization options for priority flows of hazardous wastes identified at Regional level.

2. General principles to prevent pollution generated by hazardous wastes in the Mediterranean Region

Planning hazardous waste reduction is rooted in a set of general principles which are in accordance with international and national waste management strategies and regulations, and may be adapted to the context of the Mediterranean Region. The principles proposed for this Plan are:

- **Pollution prevention**. The adoption of preventive policies is the optimal approach to avoid pollution in the Mediterranean marine environment. This principle should be considered firstly, in the authorization of new industrial activities (integrated pollution prevention control), secondly, in the promotion of products that encourage waste reduction, do not contain hazardous properties and substances or enhance its recyclability (integrated product policy), and finally, in the development of enhanced industrial processes that minimize hazardous wastes generation (cleaner production). Pollution prevention should lead to the de-coupling of economic growth from hazardous waste generation.
- **Ranking waste management options.** Minimization of hazardous wastes, both in quantity and hazardousness, should be the first option recommended in the hierarchy of waste management legislation and management framework. All the MAP countries should adopt this principle in the definition of their national framework. The adoption of this principle should lead to major efforts in cleaner production and to ensure the required financial sources to undertake this task.
- **Protection of the environment and human health.** In the Mediterranean Region, the protection of the environment and human health should be considered as a key principle when prioritising hazardous waste minimization both at regional and national levels. Special attention should also be paid to prevent the pollution of the marine environment, in order to minimize its transboundary effects.
- **Generator's responsibility.** Those who generate hazardous wastes should deal with the costs of waste minimization activities. Generators should also have the responsibility to undertake minimization plans to reduce the generation of hazardous wastes.
- **Regional collaboration**. Countries should collaborate in the collection of data, the definition of priority actions, and the exchange of information concerning their current waste minimization practices. This should lead to the enhancement of

knowledge and technology transfer between countries in the Mediterranean Region.

- **Integration.** This Plan should integrate the current efforts that the different countries in the Mediterranean Region are already undertaking through their national plans. At the same time, the Plan should be integrated in the MAP Regional Plan for the Management of Hazardous Waste (draft version dated June 2002) [1], as the waste minimization strategy needs to be coordinated with waste recycling and treatment strategies.

3. Status and trends of hazardous waste generation and management in the Mediterranean Region

In this Section an overview of the status and trends in relation to hazardous waste generation and management in the Mediterranean Region is presented. The information presented below is a synthesis of the analysis carried out with the available data from the different MAP countries, which has been mainly provided by the Cleaner Production National Focal Points, and is presented in detail in **Part B** of this Regional Plan.

3.1 Overview of hazardous waste generation

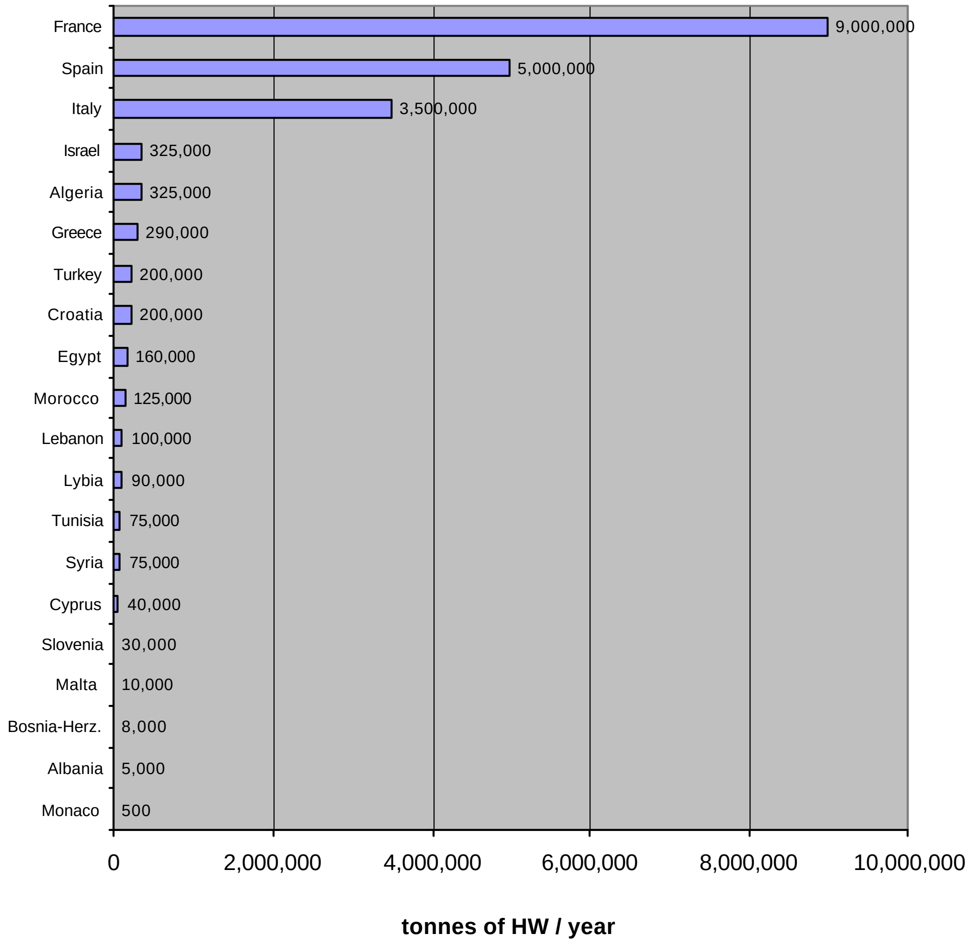
3.1.1 Total hazardous waste generation in the Mediterranean Region

Despite difficulties that usually arise when doing an inventory of hazardous waste generation (lack of reliable data, different classifications, etc.), all available information from all the MAP countries has been collected in order to obtain an overview of the main types of hazardous wastes and the industrial sectors generating them.

It has been estimated that the total amount of hazardous wastes generated by the MAP countries is in the range of **19,558,500 tonnes per year**. This figure results from the aggregation of the data associated to each of the 20 MAP countries. The information sources that have been used are mainly the questionnaires to National Focal Points, but also other international hazardous waste inventories available for the Mediterranean Region [41] or the European Union ([42] and [43]), and finally national inventories.

Using these sources of information, the best estimation for each country has been made. **Error! Reference source not found.** shows how this nearly 20 millions of tonnes per year are distributed among countries.

Figure 3-1 Estimated hazardous waste generation in the MAP countries



In relation to the profile of total generation of hazardous waste in the MAP countries, it must be considered that:

- The key contributors are mainly European Mediterranean countries (France, Spain, Italy), due to their major industrial development.

- Although only single country, France, accounts for nearly 50% of the total generation of hazardous waste, its relative contribution in the French Mediterranean Region is smaller, considering the dimensions and industrial distribution of this country.

3.1.2 Main types of hazardous wastes generated

It has not been possible to collect data on hazardous waste generation by type for all countries. Accordingly, while the estimated total amount of hazardous waste generated in MAP countries is close to 20 millions of tonnes per year, when analysing hazardous waste generation by type, from data reported in the questionnaires, the result is only

11,125,872 millions of tonnes. Therefore, it has only been possible to determine about **57%** of total estimated generation.

According to the available data, the main types of hazardous wastes generated in the Mediterranean Region are the following:

1. Wastes resulting from exploration, mining, quarrying and physical and chemical treatment of minerals
2. Wastes from organic chemical processes
3. Waste mineral oils unfit for their originally intended use
4. Wastes resulting from surface treatment of metals and plastics
5. Wastes from thermal processes
6. Wastes not otherwise specified in the list
7. Wastes from shaping and physical and mechanical surface treatment of metals and plastics
8. Wastes from inorganic chemical processes
9. Waste tarry residues arising from refining, distillation and any pyrolitic treatment
10. Wastes from the production, formulation and use of organic solvents
11. Residues arising from industrial waste disposal operations

These types of wastes account for 90% of the investigated data.

It can be observed that wastes resulting from mining activities occupy the first position. According to reported data by NFP, these wastes are basically generated in a single country, Spain, and they are mainly generated in the Northern region. Instead, other types of wastes such as wastes from organic chemical processes, waste mineral oils, waste from surface treatments, or wastes from oil refining are more representative of the types of wastes generated in the MAP countries.

3.1.3 Industrial sectors generating hazardous wastes

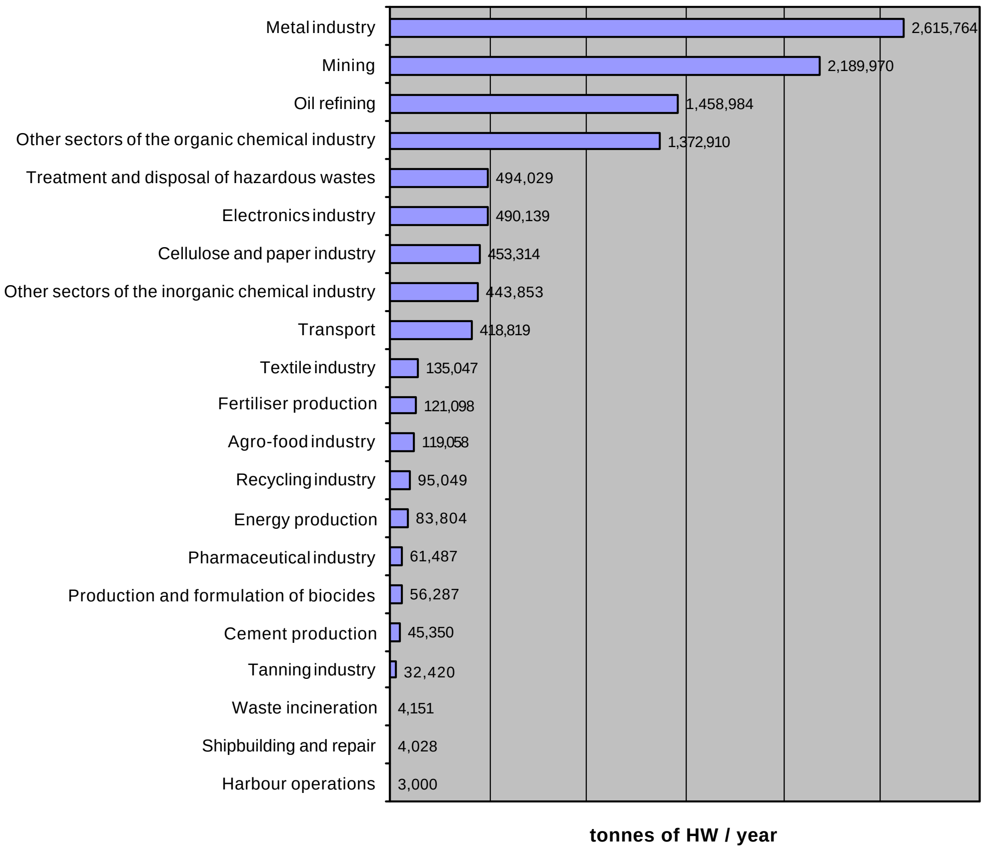
The main industrial sectors generating hazardous wastes have also been identified, considering data provided by the National Focal Points and the MAP inventory of hazardous wastes in the Mediterranean [41]. Again, data on the generation of hazardous waste by industrial sectors is not available for all countries. As a result the total amount of hazardous wastes classified per industrial sectors accounts for approximately **10,700,000 tonnes per year**, while the total estimated amount of hazardous wastes is close to 20 millions of tonnes. Therefore, it has only been possible to determine about **55%** of total generation.

The main industrial sectors generating hazardous wastes (see **Error! Reference source not found.**) are the following:

1. Metal industry
2. Mining
3. Oil refining
4. Organic chemical industry
5. Treatment and disposal of hazardous wastes

These five sectors account for 76% of total reported generation. As indicated in the previous section, mining accounts for a significant proportion of industrial sectors generating hazardous wastes, mainly due to the generation of this type of waste in Spain. However, the other key industrial sectors generating hazardous wastes, like metal industry, oil refining and organic chemical industry, are more representative of the generation in the rest of the MAP countries.

Figure 3-2 Industrial sectors generating hazardous in the MAP countries



3.1.4 Environmental impact of hazardous waste generation

In order to assess the **environmental impact** caused by hazardous waste generation in the MAP countries, and specifically on the Mediterranean Sea, the National Focal Points were requested through the Questionnaire to indicate the industrial sectors accounting for the major impacts and the main causes. Despite the fact that the data available is mainly qualitative and that information was not provided by all countries, some trends have been identified.

As a result of the analysis, it has been observed that metal industry is the sector that has been reported by the MAP countries as the main source of environmental impact due to hazardous waste generation. Other sectors with significant impact on the environment are the chemical industry, oil refining, and textile.

Information for industrial sectors regarding the main causes of environmental impact has also been collected. National Focal Points were requested to indicate which of the following causes of impact were the most important for the sectors of concern. Although this analysis was aimed to obtain just the qualitative perception of NFP, the available responses would indicate the following:

- Hazardousness of wastes is the main reported cause of impact on the environment, while generation of large amount of wastes and lack of proper management have been reported equally important.
- Hazardousness of wastes is the main cause of impact for pharmaceutical, metal and chemical industry.
- Generation of large amount of hazardous wastes is the main cause of impact for oil refining and agro-food industry.
- Lack of proper management is the main cause of impact for textile industry, being also significant for metal industry.
- As a general trend, countries from the Southern Mediterranean Region (Morocco, Algeria, Egypt) indicate the lack of proper management as the main cause of impact whereas in Northern countries (Spain, Italy,…) hazardousness and large amount of wastes are reported as the main causes of environmental impact.

Despite the scarce information gathered regarding the **impact of hazardous waste generation specifically on the Mediterranean Sea**, some trends can also be observed. In this sense, responses form the NFP indicate that the textile industry is one of the sectors, along with metal industry and oil refining, with a major number of responses pinpointing it as one of the main sources of pollution for the marine environment. Chemical industry (organic and inorganic) is also significant for a number of countries. It should also be noted that sectors such as mining, which were found to have significant environmental impact have no influence on the Mediterranean Sea.

Information has also been collected regarding the main causes of impact on the Mediterranean Sea. The available data from the questionnaires would indicate that:

- Concentration of industrial activities on the coastal zone is the main cause of impact, particularly in Southern countries.

- For oil refining and chemical industry, the main cause of impact on the Mediterranean Sea is their concentration on the coastal zone, while for metal and textile industry discharge activities are the main cause of environmental impact.

3.1.5 Trends in hazardous waste generation

Prospective studies carried out by the Blue Plan Regional Activity Centre [34] indicate that the industrialization gap between Northern countries and Southern and Eastern Mediterranean countries (SEMC) could generate a demand to expand highly polluting industrial sectors like oil refineries, chemical and metallurgical products. Assuming that waste generation is not decoupled from economic growth, hazardous waste generation in the Mediterranean will increase even at a higher pace than industrial growth if such an expected growth takes place without incorporating cleaner production actions. In November 2002, the European Topic Centre on Waste, in Copenhagen [44] organised a seminar where European environmental experts discussed how to de-couple resource use and waste generation from economic growth.

In the coming years, the concentration of industry on coastal zones could increase due to the creation of the Euro-Mediterranean free-trade area and relocation of certain activities from North to South. These changes concern particularly the production sectors oriented towards domestic demand, such as cement, petroleum products, cardboard, metal products and steel, all of which involve water consumption and are potential sources of pollution [33]. Furthermore, some of these sectors, like metal industry and oil refining, are the main generators of hazardous wastes in the Mediterranean Region.

3.2 Legal and management framework

3.2.1 International and regional framework

Aware of the risk of degradation of the Mediterranean marine environment, the coastal countries adopted the Mediterranean Action Plan (MAP) in 1975 and the Convention for the Protection of the Mediterranean Sea against Pollution (Barcelona Convention) in 1976. Since then, six protocols for the application of the Barcelona convention have been adopted, and support structures (regional activity centres) as well as technical and financial tools have been set up. The level of implementation of these legislative texts differs from one country to another according to specific social, economic and political circumstances [31].

The main international legal and management instruments addressing prevention of pollution and hazardous waste management in the Mediterranean Region are the following:

- The Barcelona Convention for the Protection of the Mediterranean Marine and Coastal Environment.
- The Mediterranean Action Plan (MAP) Phase II
- Protocol on the Prevention of Pollution of the Mediterranean Sea by Transboundary Movements of Hazardous Wastes and their Disposal (Izmir Protocol)
- Land-Based Sources (LBS) Protocol
- Strategic Action Programme (SAP) for the Mediterranean Sea
- Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal
- European Union framework
- MAP Regional Plan for the Management of Hazardous Waste

All these instruments are described in detail in **Part B** of this Regional Plan.

The MAP Regional Plan for the Management of Hazardous Wastes (draft version dated June 2002) [1], gives response to the targets established in the SAP, including the reduction by 20% of the generation of hazardous wastes from industrial installations.

The proposed regional plan for the management of hazardous waste is being elaborated on the basis of the assessment of management status and inventories of hazardous wastes in the Mediterranean region [41] and regional considerations.

According to the draft version of the MAP Regional Plan for the Management of Hazardous Waste, the elaboration and implementation of **national management plans for hazardous waste** will be the cornerstone for the implementation of the regional plan.

This Plan has been considered as the closest framework for the development of the Regional Plan for the Reduction of Hazardous Wastes. Hence, its main guidelines have been incorporated in the proposals made in the present Regional Plan.

3.2.2 National overview

In **Part B** of this Regional Plan an abstract of the legal situation and management framework for industrial and hazardous wastes in each country is presented. Here is provided an overview of the situation in the different countries, as summarised in Table 2-1.

Table 3-1 Situation of the legal and management framework of industrial and hazardous wastes in the MAP countries (NA: not available; UD: under development; D: developed; ND: not developed).

Country	Legal framework of industrial waste	Legal framework of hazardous waste	Hazardous waste National Plan

Country	Legal framework of industrial waste	Legal framework of hazardous waste	Hazardous waste National Plan
ALBANIA	UD	UD	ND
ALGERIA	UD	UD	UD
BOSNIA&HERZ.	UD	UD	UD
CROATIA	UD	UD	UD
CYPRUS	UD	UD	D
EGYPT	D	D	UD
FRANCE	D	D	NA
GREECE	D	D	UD
ISRAEL	D	D	UD
ITALY	D	D	D
LEBANON	UD	UD	UD
LIBYA	NA	NA	NA
MALTA	UD	UD	UD
MONACO	UD	UD	NA
MOROCCO	UD	UD	ND
SLOVENIA	D	D	UD
SPAIN	D	D	D
SYRIA	UD	UD	ND
TUNISIA	D	D	D
TURKEY	UD	UD	UD

It can be observed that several countries have not yet elaborated a Hazardous Waste National Plan, as they are still developing their industrial and hazardous waste legal and management framework. Most Northern countries have developed national frameworks and hazardous waste management plans, and some of them, like Spain, are even reviewing these plans. Eastern countries are in general developing the overall framework, except Greece and Israel, which have well developed instruments. Southern countries, like Egypt and Tunisia, appear to be the most advanced in the development of their national legal and management frameworks.

In general, it can be observed that national legal and management frameworks tend to adopt a waste management hierarchy, where priority is given to the principle of prevention.

3.3 Current hazardous waste minimization practices

According to the data provided by the questionnaires, the overall situation regarding waste minimisation practices in the Mediterranean is relatively positive. In brief, about 40% of the MAP countries have undertaken actions related to cleaner production in the management or legal framework of hazardous wastes.

It is difficult to identify the main sectors that incorporate actions to reduce the generation of hazardous wastes, since it depends on the different countries. In spite of this, there are some recurrent industrial activities such as the chemical, the metallurgic, the cement and the oil refining in which different countries are taking measures to minimise waste generation.

The instruments to carry out hazardous waste minimization are diverse and include: process optimisation, good housekeeping practices, product re-design and on-site recycling.

The detailed analysis of current hazardous waste minimization practices in each country is provided in **Part B**.

4. Flows of hazardous wastes with a major priority to be reduced

4.1 Criteria to define priority flows

One of the key goals of the present Plan is to identify priority flows of hazardous wastes to be reduced. In order to identify these priority wastes, a set of criteria has been identified and applied to both industrial sectors generating hazardous wastes and to specific types of waste.

This prioritisation analysis has been undertaken at the national level, considering that industrial activities and their distribution in the different countries vary. These differences lead to different profiles of hazardous waste generation and therefore different priorities. It is important to take the national factor into account because the reduction of hazardous waste will necessarily be undertaken through national plans, which need to be adapted to domestic socio-economic conditions and specific requirements. Through the analysis at the national level, it is possible to prioritise key sectors and waste types at Regional level, which will be those that are common to the greatest number of MAP countries.

4.2 Identification of priority industrial sectors

The criteria used to identify **priority industrial sectors** generating hazardous wastes have been the following:

- Total amount of hazardous wastes generated.
- Environmental impact of the industrial sector due to hazardous waste generation.
- Impact of the industrial sector on the Mediterranean Sea due to hazardous waste generation.
- Growth prospect of the industrial sector.

The results for each of the countries with available data to perform the priorization analysis are shown in detail in **Part B** of this Regional Plan. The main priority sectors of each country have been aggregated for all countries, and the results indicate that **metal industry** is the industrial sector that is more commonly identified as a priority sector, namely in 14 of the 16 countries analysed. Other wastes that are also commonly prioritised are inorganic chemical industry, oil refining, and the organic chemical industry. Transport, agro-food, energy production, electronics and textile industry are also important in several countries.

If these results are compared with the total amount of hazardous wastes generated in the MAP countries (see **Error! Reference source not found.**), it can be observed that a sector like mining, accounting for the second largest total generation of hazardous wastes, has only been found as a priority sector in a couple of countries. This is because of the differences in industrial activity between countries. Thus, mining accounts for a large generation of wastes in Spain, but does not have a significant activity in other countries, or at least this has not been reported.

On the contrary, industrial sectors accounting for the lowest total amounts of hazardous wastes, like textile, agro-food, or energy production, are identified as priority sectors in several countries. Again, the reason is the difference between national industrial profiles, and the consideration of other criteria like environmental impact.

4.3 Identification of priority types of wastes

Regarding the identification of **priority types of wastes**, considering the available data, the only criteria which can be applied in a systematic way is the total amount generated. As a result of the analysis performed (See **Part B**), priority types of wastes have been identified for each country with available information, on the basis of the total amount generated.

As in the previous case, these main national priority waste types have been aggregated for the total of countries. Through this analysis it has been observed that **used mineral oils** and **wastes from surface treatment** are the most commonly identified as priority wastes in the analysed countries. Other priority types of wastes commonly identified are waste tarry residues from oil refining and waste from thermal processes.

This indicates that, on the basis of its total generation, the priority types of wastes are those that are generally occurring in a variety of sectors, like used mineral oils, and those generated in sectors typically generating large amount of hazardous wastes, like **metal industry** (surface treatment, thermal processes –metallurgy-, waste oils/water mixtures –cutting fluids-, organic solvents, wastes from shaping of metal,…), **oil refining** (waste tarry), and **chemical industry** (inks and dyes, acidic solutions, organic solvents, resins, etc.).

Again, if these results are compared with the total amount of each type of waste generated in the MAP countries (see **Part B**), it can be observed that wastes from mining activities, accounting for the first largest total generation, has only been found as a priority type of waste in a couple of countries. It has already been indicated that this is a result of the large amount of mining wastes reported by a single country, Spain. The same trend occurs for wastes from organic chemical processes, accounting for the second largest total generation, when it has only been identified as a priority type of waste in single country, Italy.

Other wastes accounting for a large total generation are also commonly identified as priority waste types, like used mineral oils and wastes from surface treatment.

5. Towards 20% reduction of hazardous wastes in the Mediterranean Region

5.1 Reducing the Waste Generation Factor

As it has been indicated in the introduction of this Plan, the target of 20% reduction of the generation of hazardous wastes from industrial installations has been set in framework of the Strategic Action Programme for the Mediterranean Sea (SAP) [5]. Nevertheless, this target needs to be further defined, as depending on how it is approached, potential implications are different. That is, reducing a 20% of hazardous waste generation as stated in the SAP could mean the following:

1. **Reduction of 20% of the baseline**. A first approach is to establish a fixed total amount of hazardous wastes that can be generated in the Mediterranean Region (similar to what the Kyoto Protocol proposes for greenhouse gases). For example, if we consider year 2003 as the baseline, with total amount of about 20 millions of tonnes of hazardous wastes generated per year (Mt/y), in the year 2007 the total generation could not be above 16 millions of tonnes, regardless the evolution (economic growth) of the industrial sector.

2. **Reduction of a fixed amount of hazardous wastes**. This would mean to estimate the total amount to be reduced by 2007, leading to a reduction of 20% in relation to the baseline, regardless the contribution of this amount to total generation in year 2007 in a business as usual scenario. For example, if the target reduction is 4 millions of tonnes per year (20% of 20 Mt/y), but in 2007 the business-as-usual scenario for industry would lead to a generation of 30 millions of tonnes per year, final generation would be of 26 Mt/y. Thus only a reduction of 15% would be achieved.

3. **Reduction of 20% as a relative target**. Finally, a third approach is to reduce an overall 20% of the hazardous waste generation in relation to the industrial activity, that is, tonnes of HW / unit of industrial activity (in tonnes, €,…), or, in other words, reducing an overall 20% of the "**Waste Generation Factor (WGF)**".

Each of these three approaches has advantages and disadvantages. The first one would be certainly desirable, but hardly possible to be achieved unless the industrial sector decreases or at least does not grow further. Because industrial activities will probably increase in the next 5 years (the creation of the Euro-Mediterranean free-trade area should be considered), a complete de-coupling between economic growth and hazardous waste generation would be necessary in order to achieve the 20% target. The second approach would not be a good option if hazardous waste generation greatly increases by 2007 as it would not be relevant in environmental terms. Furthermore, it poses significant methodological problems to measure a reduction of a fixed amount of wastes in relation to the business as usual scenario.

The third approach, although it also poses some methodological problems, could be the most reasonable approach, as it pursues the continuous improvement of the industrial sector through the adoption of cleaner production actions to reduce hazardous waste generation in relation to industrial activity (waste generation factor), and consequently increases its competitivity.

5.2 Feasibility to achieve 20% reduction of the Waste Generation Factor

In **Part B** of this Regional Plan, several options for hazardous waste minimization of the priority flows identified in the Mediterranean Region have been illustrated. Potential reductions through different waste minimization techniques, including best environmental practices, are identified, as well as several case studies in different countries of the Region, leading to significant reductions.

It has been found that some of the case studies analysed and waste minimisation options reported, indicate that significant reductions on hazardous waste generation can be achieved, in some cases far above 20% to actual generation. Besides, payback periods of the investments required to achieve these reductions, are very reasonable. Moreover, these opportunities for hazardous waste reduction have been identified in key sectors like the metal industry.

Therefore, prospects for 20% reduction on the waste generation factor could be feasible. However, potential reductions will clearly vary among countries, industrial sectors, and even will depend on the minimisation potential of each specific industrial facility.

Accordingly, despite the fact that significant reductions on hazardous waste generation can be achieved, each country will need to further identify the feasibility to undertake waste minimization actions in the different industrial sectors, taking into account technological, economic, and legal considerations.

5.3 National approach

As the overall goal of this Plan is to reduce 20% of hazardous waste generation from industrial sources in the Mediterranean Region, it is approached in this Plan that each MAP country adopts this target in terms of 20% reduction of its Waste Generation Factor, that is, tonnes of hazardous wastes per unit of industrial activity (industrial GDP, in €).

As indicated above, this national approach is required on the basis that potential reductions on hazardous waste generation need to be identified in each country, to take into consideration the different technological, legal and economic frameworks. Consequently, there is not enough information at Regional level to determine a different allocation of the target between MAP countries.

Each country will need to undertake a **National Diagnosis** to determine which flows of hazardous waste present a major feasibility to be reduced. It is recommended that each country, on the basis of its National Diagnosis, design a **National Plan** to reduce hazardous waste generation in the different industrial sectors, taking in consideration a set of criteria, as for example:

- **Priority industrial sectors**. Higher efforts should be dedicated to industrial sectors with a major priority for hazardous waste reduction (because of their total generation, environmental impact, regional distribution, etc.). The information on priority flows of hazardous waste provided in **Part B** for each country can be used as a first step.

- **Potential for waste minimization.** Available waste minimization options for different industrial sectors are presented in **Part B**. Nevertheless, each country will need to assess the possibilities to undertake the available techniques in its country, taking into consideration the technological, economical and legal framework.

- **Environmental best practices.** Minimum reductions can be achieved in all industrial sectors, considering that potential reductions can be achieved if only good environmental practices were applied.

- **Hazardousness.** Although all wastes in this Plan are considered as hazardous wastes, some sectors generate more toxic wastes than others. This is the case of the pharmaceutical industry and production of biocides, where major efforts to reduce wastes should be undertaken.

This national approach implies that to follow-up the achievement of the goal of the Regional Plan, each country will need to do the following:

- To determine the waste baseline (hazardous waste generation in 2003, in tonnes)
- To determine the economic baseline (industrial GDP in 2003, in €)
- To determine the Waste Generation Factor in 2003 (tonnes of HW / million € of industrial GDP).
- To determine Waste Generation Factor in 2007: in order to get the relative reduction.

Considering the above approach, a set of actions at Regional and National level have been proposed for the implementation of this Regional Plan, which are presented in next Section.

6. Proposals

The proposals established in this Plan have taken into account the following preliminary considerations:

- Mission statement: **reduction of 20% of hazardous waste generation as a relative target (reduction of the Waste Generation Factor),** through an equal allocation among MAP countries, as presented in the previous Section. All proposals and actions have been set for the achievement of this target.

- Framework: The overall framework to define proposals has been the Draft Regional Plan for the Management of Hazardous Wastes [1], the Mediterranean Hazardous Waste Protocol (Izmir Protocol) [2], the Strategic Action Programme for the implementation of the LBS Protocol [5], and the Basel convention and its Strategic Plan [8].

- Development of National Plans. Taking into account framework identified above, and in particular the SAP and the Draft Regional Plan for the Management of Hazardous Wastes, the implementation of National Plans is the cornerstone for the achievement of the goals of the regional strategy. Accordingly, it is proposed that each country incorporates the target reduction in its National Plan.

- Time frame: **5 years** (2003 – 2007). It is not expected that all actions proposed in this Plan will necessarily be concluded by all MAP countries within the time-frame indicated. Since several countries have initiated plans and actions on cleaner production and minimization of hazardous wastes, it is proposed to integrate the objectives and actions of this plan into their own ones.

The process to implement the proposals and actions of this Regional Plan shall follow the steps indicated in Figure 6-1 **Error! Reference source not found.**:

In particular, the following phases are suggested at the regional Level:

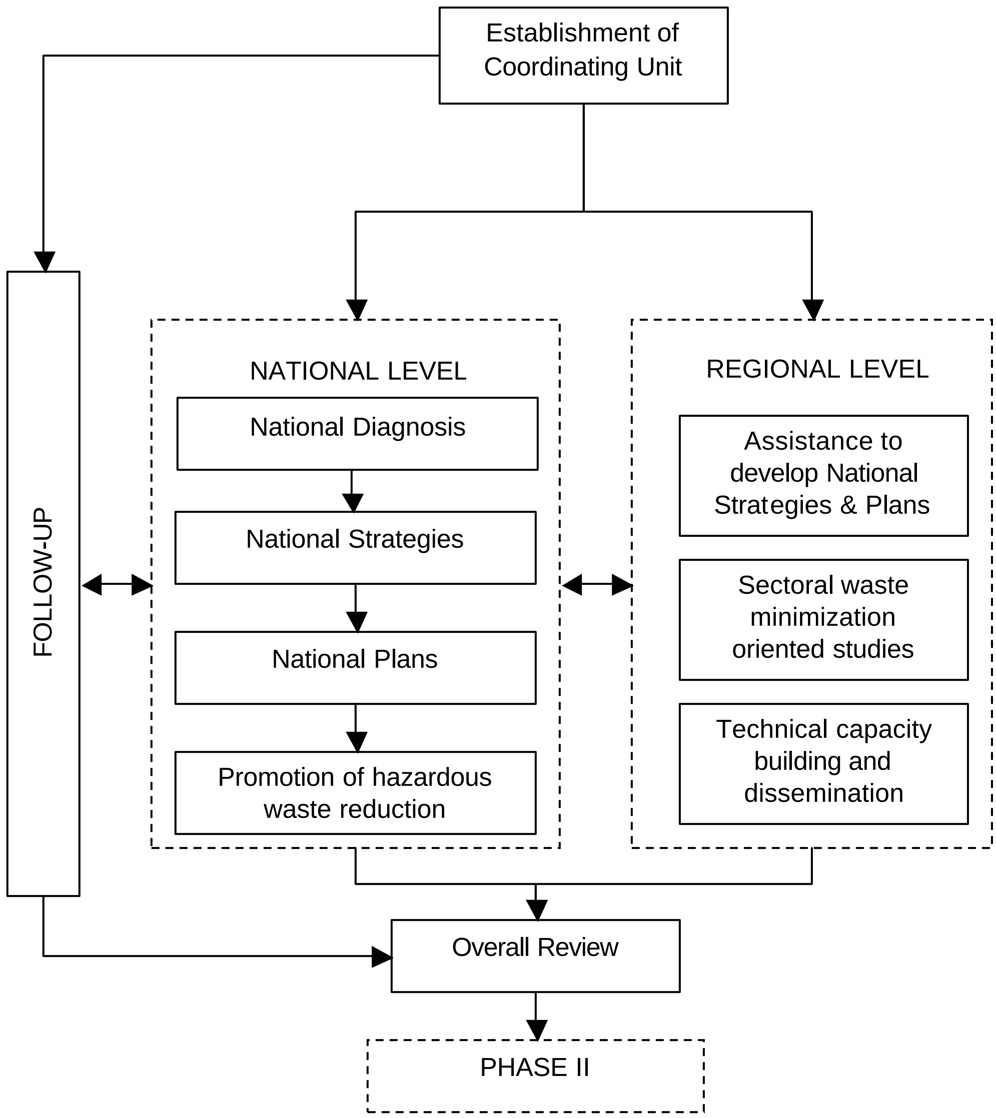
1. Establishment of a coordinating unit for the implementation of the Regional Plan.
2. Assistance to develop National Strategies and Plans
3. Development of sectorial waste minimization studies
4. Technical capacity building and dissemination
5. Follow-up of the Regional Plan
6. Overall review

At the National Level, the following phases are proposed:

1. Development of a National Diagnosis.
2. Development of National Strategies
3. Development of National Plans
4. Development and Promotion of hazardous waste reduction

After the final overall review of the present Plan, a second phase of the plan (Phase II) would be expected.

Figure 6-1. Process to implement the Regional Plan



Specific recommendations as well as a proposed **schedule** and **indicators** for each proposal are established in the section below.

6.1 Proposals at regional level

6.1.1 Establishment of a coordinating unit

Time frame	*2003*
Background	*The Draft Regional Plan for the Management of Hazardous Waste [1] proposes the establishment of a central office/institution in order to facilitate the achievement of its targets. In a similar way, a coordinating unit is required to undertake the coordination of this Regional Plan for the Reduction of Hazardous Wastes. This unit would be responsible for following up the implementation of national plans, coordinate action with national agencies, and could also have functions related to technology transfer, training, consulting, awareness raising and information.*
Initiatives / projects	• *Identification of core functions required for the coordination unit* • *Agreement with National Focal Points and MAP coordinating unit* • *Establishment of the coordination unit*
Action by	• *Regional Activity Centre on Cleaner Production* • *MAP coordinating unit*
Partners	• *National Focal Points on Cleaner Production*
Outcome	• *Establishment of the coordination unit*
Indicators	• *Establishment by 2004 of the coordination unit*

6.1.2 Assistance in the development of national framework for cleaner production and reduction of hazardous wastes

Time frame	*2003 - 2006*
Background	*There are several countries which have not yet incorporated into their national legislation and management framework the required mechanisms to allow for a reduction of hazardous wastes. These countries would benefit from guidance on how to prepare a National Strategy on hazardous wastes based on the principles of prevention, reduction and reuse, and on how to promote the adoption of cleaner production.*
Initiatives / projects	• *Preparation of guidelines for the drafting of national strategy and management framework and provision of*

	advice on this matter. • *Preparation and assistance in the use of guidelines, on specific issues like undertaking inventories, identification of priority hazardous wastes, promotion of cleaner production actions, attracting investment, etc.*
Action by	• *Coordinating Unit of the Regional Plan* • *UNEP*
Partners	• *National authorities on hazardous wastes* • *National Focal Points on Cleaner Production*
Outcome	• *The guidelines are prepared and used by countries* • *Hazardous waste and cleaner production policy, legal and management framework is established at national level with multistakeholders involvement*
Indicators	• *All the MAP countries have ratified Basel Convention and Izmir Mediterranean Hazardous Waste Protocol.* • *All MAP countries support the International Declaration on Cleaner Production (UNEP)* • *All the MAP countries have designated national competent authorities on hazardous wastes* • *The majority of countries have an effective legislation and management framework in place, addressing hazardous waste reduction.*

6.1.3 Sectoral waste minimization oriented studies

Time frame	*2003 - 2004*
Background	*Options to reduce the generation of hazardous wastes can be better identified through specific studies on the industrial sectors and waste types of concern. These studies will aim at identifying specific opportunities and constraints at regional and national level to achieve the target reduction for each industrial sector in hazardous waste generation. It is highly recommended that the industrial sectors covered in this Plan undertake specific studies to analyse options to achieve its respective targets, especially those identified with a major priority for hazardous waste reduction (metal industry, chemical industry, oil refining), and those where no specific studies have been found (electronics industry, transport, energy production, mining).*
Initiatives / projects	• *Elaboration of sectorial studies concerning hazardous waste sources and generation* • *Elaboration of technical guidelines for hazardous waste reduction in each sector*

	• *Dissemination of results*
Action by	• *Coordinating Unit of the Regional Plan / experts engaged by the coordinating unit.* • *RAC/CP*
Partners	• *National Focal Points on Cleaner Production* • *Industry / business regional and national organizations* • *National authorities on hazardous wastes*
Outcome	• *Detailed studies on hazardous waste sources and generation* • *Typical waste generation factors in the different sectors, and desirable waste generation factors, according to Best Available Techniques (BAT).* • *Technical Guidelines with opportunities for hazardous waste minimization* • *Data on costs of implementing identified opportunities*
Indicators	• *Number of studies and guidelines elaborated*

6.1.4 Technical capacity building and dissemination

Time frame	*2003 – 2007*
Background	*In order to enhance the adoption of cleaner production actions oriented to the reduction of hazardous wastes, cooperation for training and technology transfer between cleaner production centres and similar institutions having experience and expertise in areas related to the minimization and management of hazardous wastes is needed, for the purpose of sharing information and knowledge. It is also of crucial importance to facilitate that this information arrives to end users, that is, industry, and in particular small and medium enterprises (SME) operating in the different MAP countries.*
Initiatives / projects	• *Capacity building and assistance in technical matters: strategies for the practical implementation of minimization; appropriate tools, measures and incentives, etc.* • *Provision of scientific and technical know-how* • *Development of methodologies adapted to SME requirements* • *Development of dissemination mechanisms (web site on hazardous waste prevention, newsletter,…)* • *Development and dissemination of the RAC/CP*

	databases on technologies and experts on cleaner production • *Identification of mechanisms to transfer knowledge and technology to industry* • *Technical workshops with experts and representatives from industry and other stakeholders* • *Collection and dissemination of information on existing examples (case studies), in particular in developing countries*
Action by	• *Coordinating Unit of the Regional Plan*
Partners	• *National Focal Points on cleaner productions* • *Industry / Business regional and national organizations* • *UNIDO, UNEP DTIE* • *National Focal Points on Cleaner Production* • *National authorities on hazardous wastes*
Outcome	• *Practical training materials for national authorities, practitioners and industry are available and used.* • *Database containing information on experts and on available clean technologies for reduction of hazardous wastes* • *Technical skills are enhanced with regard to environmental sound management on hazardous wastes* • *Awareness and technical capability towards cleaner production is enhanced*
Indicators	• *Elaborated materials and case studies (such as MedClean files)* • *Number of workshops carried out* • *Number of participants from industry and other stakeholders at the training activities* • *Number of visits at the web-site*

6.1.5 Follow-up of the Regional Plan

Time frame	*2004 – 2007*
Background	*This Plan requires a periodic assessment of the level of implementation of proposals and a final review of the achievements in hazardous waste reduction at national and regional level. All the indicators defined in the different proposals of this Plan should be reviewed periodically so as to analyse if strategies an efforts being carried out at national and regional level need to be modified. Finally, an overall revision in 2007 will be necessary to determine the reductions in hazardous waste generation achieved in the Mediterranean Region, in terms of reduction of the waste*

	generation factor achieved in each MAP country.
Initiatives / projects	• *To define the set of indicators that will be periodically reviewed.* • *To implement indicators* • *Periodic review of results* • *Final review: comparison of the waste generation factors in 2003 and 2007, and check the reductions achieved.*
Action by	• *Coordinating Unit of the Regional Plan*
Partners	• *MAP coordinating unit / MEDPOL* • *National Focal Points on Cleaner Production* • *National authorities on hazardous wastes*
Outcome	• *Reports with assessments of the achievement of the targets set in this Regional Plan* • *Report of the final review*
Indicators	• *Indicators are reviewed* • *Assessment reports are produced periodically* • *Final review report is produced*

6.2 Proposals at national level

6.2.1 Establishing the baseline: development of a National Diagnosis

Time frame	*2003 - 2004*
Background	*A preliminary National Diagnosis on hazardous waste generation and management in each MAP country is provided in this Regional Plan. Nevertheless, it is worth mentioning that, a significant lack of data, both qualitative and quantitative, have been identified, in most of the countries. In order to take appropriate decisions at national level and adopt appropriate strategies leading to a reduction of the 20% of the national waste generation factor, further efforts are needed to improve the analysis of hazardous waste generation and also the identification of priority flows to be minimized. On the other hand, waste generation factors need to be calculated, in order to relate hazardous waste generation with industrial activity. Current initiatives for establishing the "baseline budget" in relation to hazardous waste generation, currently coordinated by the MEDPOL Programme (according to the SAP), should be integrated in the elaboration of the National Diagnosis required for this Regional Plan. A key issue will be to*

	establish the hazardous waste classification to be used by the National Plan, whether the Basel classification (Y-codes), the European Waste Catalogue (EWC), or a mixture of both classifications. In principle the EWC would be recommendable, as it covers more categories of hazardous wastes, and refers to the industrial sector generating each type of waste.
Initiatives / projects	• *Estimation of the hazardous waste generation baseline and waste generation factor in each country, using when possible the information of the Baseline Budget.* • *Identification of priority flows to be minimized, taking into consideration environmental, technological, economic and legal issues.*
Action by	• *National authority on hazardous waste*
Partners	• *National Focal Points on Cleaner Production* • *MAP coordinating unit / MEPOL Programme* • *Representatives of the industrial sector*
Outcome	• *Detailed analysis of hazardous wastes generation in each country* • *Waste Generation Factor (t HW / unit industrial activity), in each country* • *Priority flows of hazardous wastes to be reduced*
Indicators	• *The totality of countries have collected enough data to calculate National Waste Generation Factors.* • *% of sources of hazardous wastes identified in relation to total estimated generation.*

6.2.2 Development of a national strategy

Time frame	*2003 – 2004*
Background	*Several countries in the Mediterranean Region need to bring hazardous waste minimization onto the political agenda. This poses difficulties depending on the priorities of the country (investment and employment, other environmental priorities,…), hence opportunities posed by cleaner production and reduction of hazardous wastes must be highlighted: reduction of risks (health and environment) and economic benefits (efficiency of industrial processes, cost of waste management, clean-up). It is necessary to integrate the reduction of hazardous waste in the general strategy of hazardous waste management of each country.*

Initiatives / projects	• *Preparation of a National Strategy on hazardous wastes based on the principles of prevention, reduction and reuse, which incorporates the national strategies for the achievement of the 20% reduction target of the waste generation factor.*
Action by	• *National authorities on environmental affairs* • *National authorities on hazardous wastes* • *Multi-stakeholder forum involving other ministries, industrial representatives, NGOs, etc.*
Partners	• *UNEP: Secretary of Basel Convention* • *National focal points on cleaner production* • *Coordinating Unit of the Regional Plan* • *RAC/CP*
Outcome	• *A National Strategy on Hazardous Wastes*
Indicators	• *All the MAP countries have elaborated their Strategy* • *All the MAP countries have ratified and applied the Hazardous Waste Protocol and the related programmes and plans.*

6.2.3 Development of national plans

Time frame	*2004 – 2005*
Background	*Once a National Strategy on Hazardous Wastes has been adopted, National Plans for the Management of Hazardous Wastes, taking into account social, technological and economic concerns, should be elaborated. The National Plans should include the results of the National Diagnosis, with an evaluation of the quantities of hazardous wastes generated, and specific actions for the reduction of the waste generation factor. National Plans may include National Programmes for specific industrial sectors or wastes.*
Initiatives / projects	• *To prepare National Plans for the Management of Hazardous Wastes, with specific targets for waste minimization, according to priorities identified in the National Diagnosis.*
Action by	• *National authorities on environmental affairs* • *National authorities on hazardous wastes* • *Working groups involving other ministries, industrial representatives, NGOs, etc.*
Partners	• *UNEP: Secretary of Basel Convention* • *National focal points on cleaner production* • *Coordinating Unit of the Regional Plan*

	• *RAC/CP*
Outcome	• *A National Plan for the Management of Hazardous Wastes*
Indicators	• *All the MAP countries have elaborated their Management Plans*

6.2.4 Development and promotion of hazardous waste reduction

Time frame	*2004 – 2007*
Background	*In order to achieve reduction targets of hazardous wastes, MAP countries will need to identify how to* ***promote waste prevention and compliance****. On the basis of an* ***integrated approach****, countries should develop and promote a set of mechanisms and tools to enhance the adoption of cleaner production in industry leading to a reduction of hazardous waste generation. All these mechanisms should be considered in their National Plans.*
Initiatives / projects	• *To develop specific* ***regulatory provisions****.* • *To establish* ***voluntary agreements****. Through environmental voluntary agreements authorities, producers and users commit themselves to the reduction of hazardous waste on the basis of a reduction plan.* • ***Mandatory Hazardous Waste Minimization Plans****. The development of a hazardous waste minimization plan as a mandatory procedure for those industries generating hazardous wastes.* • ***Integrated Pollution Prevention and Control****. To develop authorization mechanisms of new industrial activities with special consideration to reduction of hazardous wastes. To ensure enforcement and develop inspection programmes.* • ***Integrated Product Policy****. To promote eco-design of products in order to substitute hazardous substances, and enlarge life of products.* • ***Economic instruments****. Taxes on final disposal of hazardous wastes, grants for adoption of cleaner production, etc.*

	• ***Environmental Management Systems****. To promote the adoption of environmental management systems.* • ***Capacity building****. To ensure that employees in public organisations and in industry acquire the necessary skills.* • *These mechanisms should be adapted to domestic conditions, especially to Small and Medium Enterprises.*
Action by	• *National authorities on environmental affairs* • *National authorities on hazardous wastes* • *Other ministries, industrial representatives, NGOs, etc.*
Partners	• *UNEP: Secretary of Basel Convention* • *National focal points on cleaner production* • *Coordinating Unit of the Regional Plan* • *RAC/CP*
Outcome	• *Implementation of the above instruments*
Indicators	• *Reported mechanisms that have been implemented*

6.3 Specific considerations for economies in transition

Some special considerations are highlighted for developing countries adopting the above proposals:

- Waste management in rapidly expanding economies and even in developing economies can involve changes in industrial activities, which may lead to changes in the type and amount of hazardous wastes generated. Thus, any strategy to be applied in these countries must be flexible and include mechanisms to adapt to changing situations.

- Apart from integrated approaches, the introduction of mandatory schemes should be adopted; it is necessary to integrate other issues such as providing the facilities, financial mechanisms, ensuring availability of proper skills, etc.

- Sustainability principle: it is necessary to de-couple economical growth from hazardous waste generation. Here cleaner production plays a key role. This aim is valid both for developed and developing countries.

- Objectives and targets should be a compromise between ambition and realism.

- When learning from other experiences or in case of technology transfer, it is necessary to carefully consider local conditions and circumstances.

6.4 Economic considerations

It is very difficult to carry out an estimation of the costs of implementing the actions proposed above. First, costs for proposals at regional level will depend on the number of actions that are finally decided to undertaken. On the other hand, the major investments will occur at national level. Unfortunately, it is not possible to make an economic estimation of proposals at national level within the scope of this study, because:

- It is very difficult to estimate budgets of public bodies allocated to hazardous waste reduction in each country. Furthermore, costs will be different in those countries where cleaner production has already been adopted and therefore, which are already advanced at institutional level.

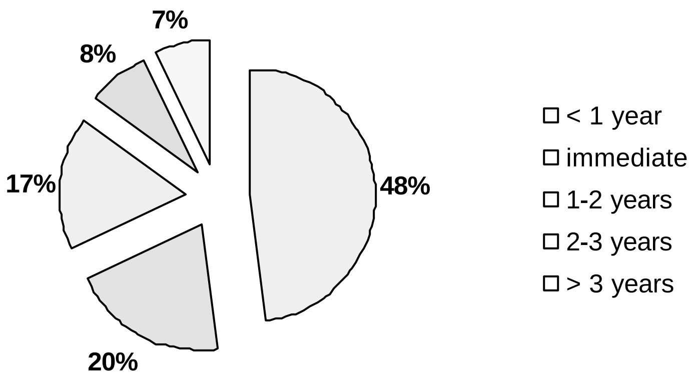
- An economic estimation will strongly depend on the actions that each country decides to undertake at national level. Key actions with a major impact on costs would be those related with the establishment of economic incentives (grants, modification of taxes…), and financing of research and technology development projects within the scope of cleaner production.

- Costs associated with the adoption of cleaner production by industrial sectors will also vary among countries, as they are strongly dependent on costs associated with consumption of raw materials, natural resources, fossil fuels, electricity, wastewater and solid waste management, etc.

Nevertheless, it is clear that the key costs and investments would be those derived from the implementation of alternatives for hazardous waste reduction in the different industrial sectors, in order to achieve the goals of this Plan. Although calculating these costs is extremely difficult at Regional Level, it should be noted that the payback period of adopting alternatives for waste minimization can be very short. As shown in **Error! Reference source not found.**, the payback periods of the alternatives implemented in 44 case studies of different industrial sectors in the Mediterranean Region (Medclean case studies: [15]), were found to be less than a year in nearly 50% of all cases. This can be considered as a strength for the industrial sector and therefore, it is important to make industries aware of this gain.

Furthermore, considering that Cleaner Production can be defined as a "strategy for improving the efficiency of natural resources use while concurrently minimizing the generation of waste, pollution and risks to human health and the environment" [18], it can be said that Cleaner Production is a synonym of efficient management and good business.

Figure 6-2 Medclean case studies: payback period of the alternatives implemented. Source: RAC/CP.



Following from the definition, it can be presumed that there are a number of economic advantages, both at micro level (i.e. companies) and macro level (i.e. countries), to adopt CP practices to reduce hazardous wastes:

- Micro/Company level:
  - "Doing more with less": CP leads to better production efficiency, thus fewer raw materials; less energy, etc. are required.
  - Better competitivity: higher quality output
  - Cost reduction of environmental management issues: less waste generation implies less taxes for waste management, residual effluents with lower contaminant loads means lower costs for water treatment, etc.
  - Less environmental risk: Costs related to accidents, emergencies, etc. are avoided.

- Macro/Country level
  - Better competitivity and economic growth of the country.
  - Reduction of costs related with decontamination and management of areas affected by environmental accidents.
  - Enhancement of skills and competence of civil society through training and education.

There are some basic constraints that are currently limiting the adoption of CP practices and should be explicitly considered for the application of this Regional Plan [18]. Thus, although investments in CP can have attractive economic benefits due to the reduction of input costs for raw materials, reduced expenditures on waste management, etc., companies may have difficulties to make CP investments because of two main reasons:

- Financial aspects:

  - Inability of financial institutions and industrial authorities to assess the technical and financial merits of CP investment proposals.
  - Lack of credit schemes for CP investments.

- Contextual aspects:

  - The legal and management framework of the country can have a key influence over any other existing reason.
  - Basically, in countries with few or unenforced environmental regulations, under-priced or free natural resources or either with little consumer interest in products produced in a proper manner, or which lack facilities for a proper waste management, CP and environmental management in general are less likely to be economically attractive.

In summary, it can be said that the main investments to implement this Regional Plan will necessarily be made by industrial sectors, but it is also true that the adoption of cleaner production practices implies significant benefits and advantages at micro and macro level. Nevertheless, strategies must be undertaken to overcome financial constraints for CP and environmental management.

PART B

Analysis of data and review of options to reduce priority flows of hazardous waste

1. Hazardous Waste Generation in the Mediterranean Region

In this Section an overview of the status and trends in relation to hazardous waste generation and the related environmental impact is presented, both at regional and national level (except for Libya, as information on this country is not available). The main source of information has been the data collected through the questionnaires provided by the National Focal Points.

1.1 Hazardous waste generation

1.1.1 Total hazardous waste generation in the Mediterranean Region

A first step that has been carried out in the analysis to elaborate this Regional Plan has been to estimate the current total amount of hazardous waste that is generated in the MAP countries.

Nevertheless, it is well known that quantifying waste generation is extremely difficult. According to the hazardous waste inventory carried out by the European Environment Agency [42] and reports from European countries [81], statistics on hazardous waste generation are often scarce. The lack of data is generally more significant in non European countries, where national inventories have not yet been developed.

Besides the lack of valid quantitative data, an additional problem is waste classification. As previously indicated a unique classification on the basis of the international Basel Convention and the Izmir Hazardous Waste protocol has proved unsuccessful because many countries report their data according to other classifications, either international (like the European Waste Catalogue) or national. Accordingly, and in order to facilitate the comparison of data, original data has been adapted to the classification used in this plan.

Despite these difficulties, the main analysis has focused on the collection of quantitative information from all the MAP countries in order to obtain an overview of the main types of hazardous wastes and the industrial sectors generating them.

It has been estimated that the total amount of hazardous wastes generated by the MAP countries is in the range of **19,558,500 tonnes per year**. This figure results from the aggregation of the data associated to each of the 20 MAP countries. The information sources that have been used are the following:

- Questionnaire to National Focal Points: data on types of wastes generated
- Questionnaire to National Focal Points: data on industrial sectors generating hazardous wastes
- MAP Hazardous waste inventory in the Mediterranean Region [41]
- European Environmental Agency hazardous waste inventory [42]
- European Topic Centre on Waste [43]
- Blue Plan: regional and national reports
- National sources

For those countries where there was no data available from any of the above sources, data has been estimated according to their industrial activity. For this estimation, economical data has been collected from the World Bank [31] and CIA [32] databases, in order to calculate the Industrial Added Value to the Gross Domestic Product of each country. Relating the total generation of hazardous wastes to the industrial activity, a ratio indicating the tonnes of hazardous wastes per million € of industrial GDP has been obtained. **Error! Reference source not found.** shows this indicator for the different countries. Because the results are quite different between countries, an average of **13.04 ± 9.43 tonnes of HW per M€ of industrial GDP** has been considered as a reference value in order to adjust the best estimation in certain countries, like Croatia (initially over-estimated), or to estimate the generation of waste in Libya (where no data were available).

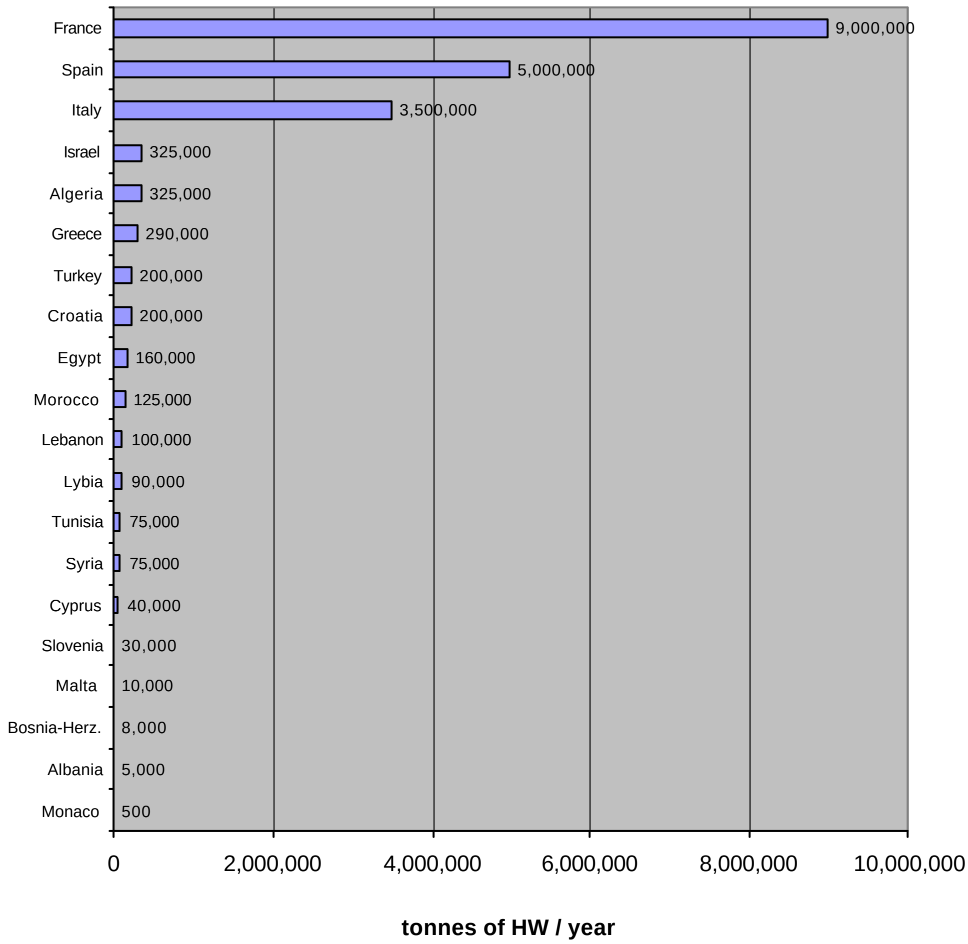
Table 1-1 Estimated hazardous waste generation in the MAP countries (t HW), per million of € of Industrial Gross Domestic Product

Country	t HW / y	M€ GDP Ind	t HW/ M€ GDP Ind
Albania	5,000	1,121	4.46
Algeria	325,000	40,116	8.10
Bosnia-Herz.	8,000	1,461	5.48
Croatia	200,000	6,391	31.29
Cyprus	40,000	1,811	22.09
Egypt	160,000	33,612	4.76
France	9,000,000	337,206	26.69
Greece	290,000	29,475	9.84
Israel	325,000	44,030	7.38
Italy	3,500,000	315,757	11.08
Lebanon	100,000	3,625	27.59
Lybia	90,000	18,800	4.79
Malta	10,000	1,517	6.59
Monaco	500		
Morocco	125,000	10,636	11.75
Slovenia	30,000	6,930	4.33
Spain	5,000,000	170,607	29.31
Syria	75,000	5,313	14.12
Tunisia	75,000	5,752	13.04
Turkey	200,000	39,309	5.09

The variation of the values of this indicator between the different countries may be the result of inaccurate statistics on waste generation or different classification methods. However, it is very likely that this variation is highly influenced by the differences in the distribution of industrial activity, as not all industries generate the same amount of hazardous wastes.

Once the best estimation for each country has been made, **Error! Reference source not found.** shows how this nearly 20 millions of tonnes per year are distributed among countries.

Figure 1-1 Estimated hazardous waste generation in the MAP countries



In relation to the profile of total generation of hazardous waste in the MAP countries, it must be considered that:

- The key contributors are mainly European Mediterranean countries (France, Spain, Italy), due to their major industrial development.

- Although only single country, France, accounts for nearly 50% of the total generation of hazardous waste, its relative contribution in the French Mediterranean Region is smaller, considering the dimensions and industrial distribution of this country.

1.1.2 Main types of hazardous wastes generated

As indicated before, some countries have classified their hazardous waste under the European Waste Catalogue (EWC) instead of the Yzmir Protocol (Y-code) used in the Basel Convention. In this case, the Y-codes which had a direct correspondence with the EWC classification have been identified by both codes, while waste types classified according to the EWC, which do not correspond to any code of Izmir Protocol, have been included in the list and identified by the EWC code.

It has not been possible to collect data on hazardous waste generation by type for all countries. Thus, no data has been obtained for Egypt, Libya, Monaco, and Turkey. In some cases, like France, it has not been possible to integrate the reported data neither with the Y-Codes nor with the EWC. For those countries that have not reported data in the Questionnaire, the MAP inventory has been used.

The specific generation of hazardous waste by types for the different countries is presented in the following sections.

While the estimated total amount of hazardous waste generated in MAP countries is close to 20 millions of tonnes per year, when analysing hazardous waste generation by type, from data reported in the questionnaires, the result is only **11,125,872 millions of tonnes**. Therefore, it has only been possible to determine about **57%** of total estimated generation.

Error! Reference source not found. presents the aggregated results of waste generation by type. According to these data, the main types of hazardous wastes generated are the following:

12. Wastes resulting from exploration, mining, quarrying and physical and chemical treatment of minerals
13. Wastes from organic chemical processes
14. Waste mineral oils unfit for their originally intended use
15. Wastes resulting from surface treatment of metals and plastics
16. Wastes from thermal processes
17. Wastes not otherwise specified in the list
18. Wastes from shaping and physical and mechanical surface treatment of metals and plastics
19. Wastes from inorganic chemical processes
20. Waste tarry residues arising from refining, distillation and any pyrolitic treatment
21. Wastes from the production, formulation and use of organic solvents
22. Residues arising from industrial waste disposal operations

These types of wastes account for 90% of the investigated data. There are some wastes whose generation has not been reported, like organic cyanides or ether. These types of waste may be too specific to be considered in national statistics.

Table 1-2 Types of wastes generated by the MAP countries

Waste Types	IZMIR	EWC	HW generation (t/y)	%
Wastes resulting from exploration, mining, quarrying and physical and chemical treatment of minerals		01 00	2,064,512	18.6%
Wastes from organic chemical processes		07 00	1,276,458	11.5%
Waste mineral oils unfit for their originally intended use	Y8	13 00	1,145,596	10.3%
Wastes resulting from surface treatment of metals and plastics	Y17	11 00	1,065,439	9.58%
Wastes from thermal processes		10 00	1,037,916	9.33%
Wastes not otherwise specified in the list		16 00	623,693	5.61%
Wastes from shaping and physical and mechanical surface treatment of metals and plastics		12 00	615,391	5.53%
Wastes from inorganic chemical processes		06 00	606,883	5.45%
Waste tarry residues arising from refining, distillation and any pyrolitic treatment	Y11	05 00	505,214	4.54%
Wastes from the production, formulation and use of organic solvents	Y6	14 00	491,072	4.41%
Residues arising from industrial waste disposal operations	Y18	19 00	485,168	4.36%
Wastes from production, formulation and use of inks, dyes, pigments, paints, lacquers, varnishes	Y12	08 00	286,358	2.57%
Basic solutions or bases in solid form	Y35		223,876	2.01%
Acidic solutions or acids in solid form	Y34		182,505	1.64%
Waste oils/water, hydrocarbons/water mixtures, emulsions	Y9		137,658	1.24%
Waste packaging: absorbents, wiping cloths, filter materials and protective clothing not otherwise specified		15 00	125,070	1.12%
Wastes from production, formulation and use of photographic chemicals and processing materials	Y16	09 00	86,306	0.78%
Wastes from leather, fur and textile industries		04 00	50,538	0.45%
Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing, food preparation and processing		02 00	32,461	0.29%
Wastes from wood processing and the production of panels and furniture, pulp, paper and cardboard		03 00	26,917	0.24%
Organic solvents excluding halogenated solvents	Y42		13,498	0.12%
Wastes from production, formulation and use of resins latex, plasticizers, glues/adhesives	Y13		10,144	0.09%
Waste pharmaceuticals, drugs and medicines	Y3		8,147	0.07%
Lead, lead compounds	Y31		4,124	0.04%
Wastes of an explosive nature not subject to other legislation	Y15		3,754	0.03%

Waste Types	IZMIR	EWC	HW generation (t/y)	%
Wastes from the production and preparation of pharmaceutical products	Y2		3,510	0.03%
Arsenic, arsenic compounds	Y24		3,083	0.03%
Wastes from the production, formulation and use of biocides and phytopharmaceuticals	Y4		2,059	0.02%
Zinc compounds	Y23		1,661	0.01%
Asbestos (dust and fibres)	Y36	6 00	1,568	0.01%
Mercury; mercury compounds	Y29		1,161	0.01%
Hexavalent chromium compounds	Y21		1,070	0.01%
Phenols, phenolic compounds	Y39		707	0.006%
Wastes from manufacturing, formulation and use of wood preserving chemicals	Y5		660	0.006%
Inorganic cyanides	Y33		510	0.005%
Halogenated organic solvents	Y41		432	0.004%
Copper compounds	Y22		284	0.003%
Cadmium; cadmium compounds	Y26		212	0.002%
Inorganic fluorine compounds	Y32		132	0.001%
Waste substances and articles containing or contaminated with PCB, PCT and/or PBB	Y10		120	0.001%
Organic phosphorus compounds	Y37		3	0.000%
Organohalogen compounds other than substances referred to in this Annex (e.g. Y39, Y41, Y42, Y43, Y44)	Y45		2	0.000%
Waste chemical substances arising from research and development or teaching activities which are not identified and/or are new and whose effects on man and/or the environment are not known	Y14		1	0.000%
TOTAL			**11,125,872**	**100.000%**

Wastes resulting from mining activities occupy the first position. According to reported data by NFP, these wastes are basically generated in a single country, Spain, and they are mainly generated in the Northern region. Instead, other types of wastes such as wastes from organic chemical processes, waste mineral oils, waste from surface treatments, or wastes from oil refining are more representative of the types of wastes generated in the MAP countries.

1.1.3 Industrial sectors generating hazardous wastes

The main industrial sectors generating hazardous wastes have also been identified, considering data provided by the National Focal Points and the MAP inventory of hazardous wastes in the Mediterranean [41]. The list of industrial sectors corresponds to the priority industrial sectors as defined in the Strategic Action Programme to address pollution from land-based activities [5].

Data on the generation of hazardous waste by industrial sectors is not available for all countries. No data have been reported from Egypt, Libya, Monaco, Slovenia, Tunisia and Turkey. As a result the total amount of hazardous wastes classified per industrial sectors accounts for approximately **10,700,000 tonnes per year**, while the total estimated amount of hazardous wastes is close to 20 millions of tonnes. Therefore, it has only been possible to determine about **55%** of total generation.

The main industrial sectors generating hazardous wastes (see **Error! Reference source not found.**) are the following:

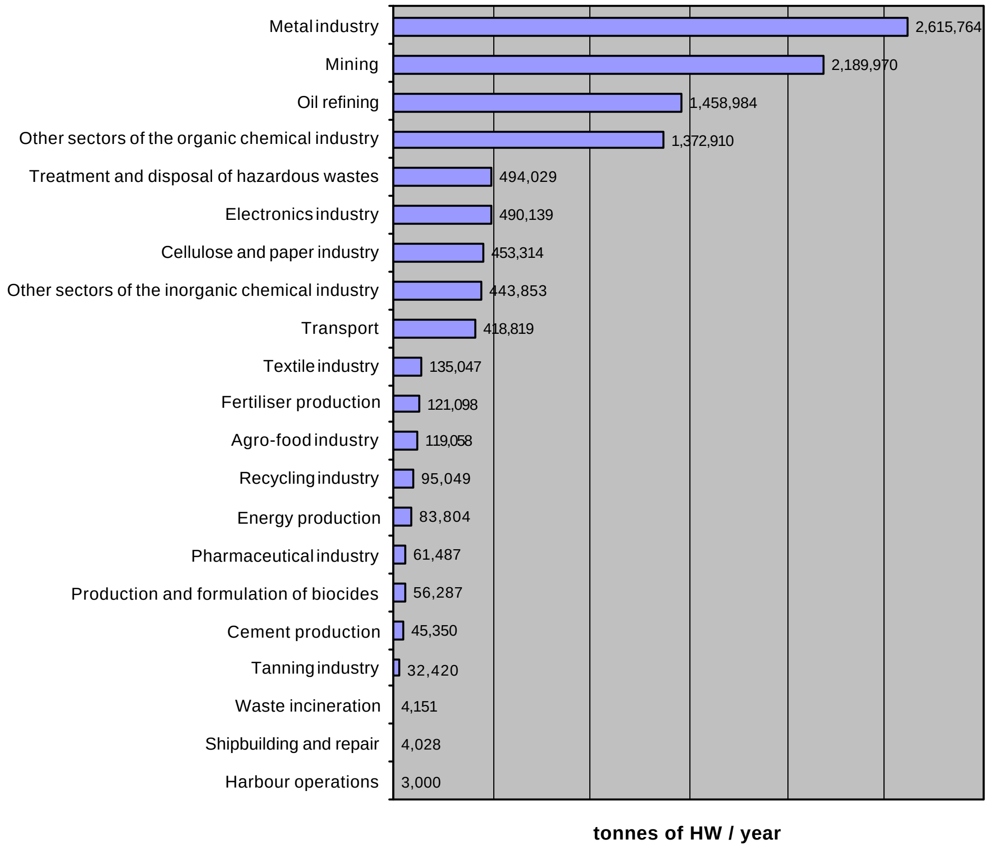
6. Metal industry
7. Mining
8. Oil refining
9. Organic chemical industry
10. Treatment and disposal of hazardous wastes

These five sectors account for 76% of total reported generation. As indicated in the previous section, mining accounts for a significant proportion of industrial sectors generating hazardous wastes, mainly due to the generation of this type of waste in Spain. However, the other key industrial sectors generating hazardous wastes, like metal industry, oil refining and organic chemical industry, are more representative of the generation in the rest of the MAP countries.

Other industrial sectors that also account for significant amounts of hazardous wastes are the electronics industry, cellulose and paper industry, inorganic chemicals, and transport. Other sectors are less significant in quantitative terms, but need also to be considered because of the toxicity of their wastes, like fertiliser production, pharmaceutical industry, or production of biocides. Shipbuilding and repair should also be considered despite its low reported generation of hazardous waste, due to the high risk of polluting the marine environment. Wastes generated by these industrial sectors can contain persistent and toxic substances (PTS), which are of especial concern on the Mediterranean Region, as reported in [48].

It can also be observed that some of the industrial sectors typically perceived as contributing to increase risk, particularly those related to water pollution, like the textile, agro-food or tanning, do not generate as many hazardous wastes as other sectors, although they significantly contribute to BOD. Cement industry, which poses also other kind of environmental concerns, do not generate either significant amounts of hazardous wastes. Actually, the characteristics of its industrial processes can be used to eliminate hazardous wastes by combustion.

Figure 1-2 Industrial sectors generating hazardous in the MAP countries



1.1.4 Environmental impact of hazardous waste generation

In order to assess the **environmental impact** caused by hazardous waste generation in the MAP countries, and specifically on the Mediterranean Sea, the National Focal Points were requested through the Questionnaire to indicate the industrial sectors accounting for the major impacts and the main causes. Despite the fact that the data available is mainly qualitative and that information was not provided by all countries, some trends have been identified. The detailed information for each country is presented in the corresponding sections of this chapter.

As a result of the analysis, it has been observed that metal industry is the sector that has been reported by the MAP countries as the main source of environmental impact due to hazardous waste generation.

Other sectors with significant impact on the environment are the chemical industry, oil refining, and textile.

Information for industrial sectors regarding the main causes of environmental impact has also been collected. National Focal Points were requested to indicate which of the following causes of impact were the most important for the sectors of concern:

- Generation of large amount of hazardous wastes
- Hazardousness[2] of wastes
- Lack of proper management

Although this analysis was aimed to obtain just the qualitative perception of NFP, the available responses would indicate the following:

- Hazardousness of wastes is the main reported cause of impact on the environment, while generation of large amount of wastes and lack of proper management have been reported equally important.
- Hazardousness of wastes is the main cause of impact for pharmaceutical, metal and chemical industry.
- Generation of large amount of hazardous wastes is the main cause of impact for oil refining and agro-food industry.
- Lack of proper management is the main cause of impact for textile industry, being also significant for metal industry.
- As a general trend, countries from the Southern Mediterranean Region (Morocco, Algeria, Egypt) indicate the lack of proper management as the main cause of impact whereas in Northern countries (Spain, Italy,…) hazardousness and large amount of wastes are reported as the main causes of environmental impact.

Despite the scarce information gathered regarding the **impact of hazardous waste generation specifically on the Mediterranean Sea**, some trends can be observed. In this sense, responses form the NFP indicate that the textile industry is one of the sectors, along with metal industry and oil refining, with a major number of responses pinpointing it as one of the main sources of pollution for the marine environment. Chemical industry (organic and inorganic) is also significant for a number of countries. It should also be noted that sectors such as mining, which were found to have significant environmental impact have no influence on the Mediterranean Sea.

Information has also been collected regarding the main causes of impact on the Mediterranean Sea. The following causes have been reported for each of the sectors of concern:

- Concentration of industrial activities on the coastal zone
- Discharge activities (direct or to river basins)

[2] This cause of impact was indicated in the questionnaire as 'toxicity'.

- Pollution of coastal groundwater

The available data from the questionnaires would indicate that:

- Concentration of industrial activities on the coastal zone is the main cause of impact, particularly in Southern countries.
- For oil refining and chemical industry, the main cause of impact on the Mediterranean Sea is their concentration on the coastal zone, while for metal and textile industry discharge activities are the main cause of environmental impact.

1.1.5 Trends in hazardous waste generation

Prospective studies carried out by the Blue Plan Regional Activity Centre [34] indicate that the industrialization gap between Northern countries and Southern and Eastern Mediterranean countries (SEMC) could generate a demand to expand highly polluting industrial sectors like oil refineries, chemical and metallurgical products. Assuming that waste generation is not decoupled from economic growth, hazardous waste generation in the Mediterranean will increase even at a higher pace than industrial growth if such an expected growth takes place without incorporating cleaner production actions. In November 2002, the European Topic Centre on Waste, in Copenhagen [44] organised a seminar where European environmental experts discussed how to de-couple resource use and waste generation from economic growth.

In the coming years, the concentration of industry on coastal zones could increase due to the creation of the Euro-Mediterranean free-trade area and relocation of certain activities from North to South. These changes concern particularly the production sectors oriented towards domestic demand, such as cement, petroleum products, cardboard, metal products and steel, all of which involve water consumption and are potential sources of pollution [33]. Furthermore, some of these sectors, like metal industry and oil refining, are the main generators of hazardous wastes in the Mediterranean Region.

2. Legal and management framework

2.1 International and regional framework

Aware of the risk of degradation of the Mediterranean marine environment, the coastal countries adopted the Mediterranean Action Plan (MAP) in 1975 and the Convention for the Protection of the Mediterranean Sea against Pollution (Barcelona Convention) in 1976. Since then, six protocols for the application of the Barcelona convention have been adopted, and support structures (regional activity centres) as well as technical and financial tools have been set up. The level of implementation of these legislative texts differs from one country to another according to specific social, economic and political circumstances [31].

2.1.1 The Barcelona Convention for the Protection of the Mediterranean Marine and Coastal Environment

The Barcelona Convention provides a general framework for environmental action in the Mediterranean. It establishes that the Contracting Parties shall take individually or jointly all appropriate measures provided for in the convention for preventing, reducing, combating and eliminating pollution in the Mediterranean region and for protecting and improving the marine environment with a view to contributing to its sustainable development. For this purpose, they shall apply the principle of precaution, the "polluter pays" principle and undertake studies of the impact of projects on the environment that may cause extensive damage to the marine environment. Furthermore, they shall cooperate and exchange information about projects that may have an impact on the marine environment in other countries in the region. In application of the Barcelona Convention and its protocols, the Contracting Parties shall use the best available techniques and the best environmental practices and promote access and transfer of safe environmental technologies, including cleaner production technologies, taking into account social, economic, and technological conditions.

2.1.2 The Mediterranean Action Plan (MAP) Phase II

The Action Plan for the Protection of the Marine Environment and the Sustainable Development of the Coastal Areas of the Mediterranean (MAP Phase II), was adopted in 1995. MAP Phase II states that actions should be taken to encourage and facilitate the use of appropriate industrial procedures and cleaner technologies, to facilitate its transfer, adaptation and control among Mediterranean countries, to consolidate and accelerate the introduction of programmes for the control and reduction of industrial pollution and to strengthen and expand programmes for the reduction and management of industrial waste. At national level, it recommends formulating and implementing national action programmes or plans based on the precautionary approach, to prevent and eliminate pollution from land-based activities.

2.1.3 Protocol on the Prevention of Pollution of the Mediterranean Sea by Transboundary Movements of Hazardous Wastes and their Disposal (Izmir Protocol)

Being one of the protocols of the Barcelona Convention, the Izmir Protocol provides a specific framework of action for the Mediterranean region regarding hazardous waste and the reduction of their inputs into the marine environment.

The importance of this text is crucial because until recently, the issue of managing hazardous wastes had not still been incorporated in a specific way into the national strategies and policies of many Mediterranean countries.

As a general obligation (Art. 5), the text states that the Parties shall take appropriate measures for preventing, combating and eliminating pollution that may be caused by cross-border movements and the elimination of hazardous waste and for reducing its production to a minimum. Furthermore, the Parties shall cooperate in the scientific and technological sphere, particularly in the application and development of new methods of reduction and elimination of hazardous waste through cleaner production methods.

A list of categories of waste subject to the provisions of the protocol is included as Annex I of the protocol. It is similar to the list set up under the provisions of the Basel Convention [7].

2.1.4 Land-Based Sources (LBS) Protocol

As a general obligation, the Contracting Parties (COP) commit themselves to eliminate pollution created by land-based sources and activities [4]. For this purpose, they shall write and apply the appropriate national plans and programmes containing the measures and schedules to be put into practice, taking into account the best available techniques, the best environmental practices and cleaner production technologies. The Protocol foresees that the COP will progressively formulate and adopt, in cooperation with international organizations, the directives and criteria related to the progressive control and replacement of products, facilities and industrial processes causing widespread pollution of the marine environment.

The LBS Protocol states that the COP shall cooperate in the scientific and technological sphere, particularly in research into the effects of pollutants, and the development of new method for treatment, reduction or elimination as well as the development of cleaner production procedures. For this purpose, the Parties shall endeavour to exchange of scientific and technical information, coordinate their research programmes and promote access to, and transfer of environmentally sound technologies including cleaner production technologies.

2.1.5 Strategic Action Programme (SAP) for the Mediterranean Sea

The Strategic Action Programme (SAP) [5] was elaborated and adopted to facilitate the implementation by the Contracting Parties of the LBS Protocol. Therefore it is designed to assist Parties in taking actions individually or jointly within their respective policy priorities and resources which will lead to the prevention, reduction, control and/or elimination of the degradation of the marine environment.

The SAP states that among the 30 priority sectors of activity that are listed in Annex I to the LBS Protocol, 21 of them are industrial. **Industrial sectors** have been picked out of the list in Annex I to the LBS Protocol in order to determine those being major industrial sources of hazardous waste.

In a similar way, in terms of **pollutants**, priority is given to substances that are toxic, persistent and susceptible to bio-accumulation (TPBs) due to their effects on health, biodiversity and ecosystems. These substances are composed of organic matter or persistent organic pollutants (POPs) and inorganic matter such as certain heavy metals and organo-metallic compounds. Other heavy metals, organo-halogen compounds, radioactive substances, nutrients and suspended solids and hazardous wastes are also considered target industrial pollutants. The SAP proposes schedules for reducing priority pollutants and recommends, wherever possible, the use of best available techniques, best environmental practices and cleaner production technology approaches.

The issue of **hazardous wastes** is addressed in the SAP, amongst others, as a source of degradation of the marine environment through direct or indirect discharges of raw waste products into the sea or through the releases into the atmosphere or into water of pollutants which may be generated in the process of disposal or treating these waste products.

The SAP proposed targets concerning hazardous wastes are:

- By the year 2025, to dispose all hazardous wastes in a safe and environmentally sound manner and in conformity with the provisions of the LBS Protocol and other international agreed provisions.

- **Over a period of 10 years, to reduce as far as possible by 20% the generation of hazardous waste from industrial installations.**
- By the year 2010, to dispose of 50% of the generated hazardous waste, in a safe and environmentally sound manner and in conformity with the provisions of the LBS Protocol and other internationally agreed provisions.

These targets would be reached through a set of **regional and national activities** on the basis of a regional strategy for the management of hazardous waste, elaborated on the basis of environmentally sound management processes.

According to the SAP, these activities shall address hazardous wastes with special attention to obsolete chemicals (safe disposal), used lubricating oils (recycling) and batteries (reduction of generation).

2.1.6 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal

The Basel Convention that was adopted in 1989 and entered into force on 5 May 1992 [7], strictly regulates the transboundary movements of hazardous wastes and provides obligations to its Parties to ensure that such wastes are managed and disposed of in an environmentally sound manner when moved across national boundaries.

The so-called Ban Amendment to the Basel Convention bans the export of hazardous wastes for final disposal and recycling from Annex VII countries (Basel Convention Parties that are members of the EU, OECD and Liechtenstein) to non-Annex VII countries.

Recently, the Strategic Plan for the implementation of the Basel Convention (2000-2010) has been approved by the Sixth Conference of the Parties to the Basel Convention, held in Geneva last 9-14 December 2002 [8]. In this Strategic Plan several actions have been defined to address the minimization of hazardous wastes.

2.1.7 European Union framework

In the European Union, the Sixth Environment Action Programme [10] for 2001-2010 lists sustainable use of natural resources and management of wastes as one of its key priorities. Regarding waste, the goal is to achieve a “significant overall reduction in the volumes of waste generated through improved waste prevention initiatives, better resource efficiency, and a shift to more sustainable consumption patterns." Waste prevention is considered to be a key element of an integrated product policy approach.

One of the headline objectives of the EU Strategy for Sustainable Development [9] of 2001 is to "break the links between economic growth, the use of resources and the generation of waste." Some specific measures envisaged include developing an Integrated Product Policy in co-operation with business to reduce resources use and the environmental impacts of waste; and instituting a system of resources productivity measurement to be operational by 2003.

European Union's Waste Management Hierarchy, according to the Community Strategy for Waste Management [11] states that waste management strategies must aim primarily to prevent the generation of waste and to reduce its harmfulness. Where this is not possible, waste materials should be reused, recycled or recovered, or used as a source of energy. Only as a final resort, waste should be disposed of safely (e.g. by incineration, or in landfill sites).

According to the Integrated Pollution Prevention and Control Directive (96/61/EEC), industrial installations must be operated in such a way that all appropriate preventive measures against pollution must be taken, in particular through the application of Best Available Techniques. Other requirements of the IPPC Directive are that no significant pollution shall be caused, waste generation should be avoided (the waste management hierarchy should be followed) and energy used efficiently.

The key legal instrument dealing with hazardous wastes at European Union level is the Directive of 12 December 1991 on hazardous wastes (91/689/EEC). The object of this Directive is to approximate the laws of the Member States on the controlled management of hazardous waste. This Directive also establishes those general provisions to be adopted by Member States for the proper management of hazardous waste.

In the past, classifications of hazardous wastes in the European Union have been continuously modified, which proves the complexity in establishing a unique list. The first hazardous waste list, produced as a result of Directive 91/689, was published in 1994 (Commission Decision 94/3/EC). In 2000, a replacement hazardous waste list was introduced (Commission Decision 2000/532/EC), which came into force on 1 January 2002. So far, this replacement waste list has been amended three times.

It should be mentioned that the European classification of hazardous wastes is different from the one established in the Basel Convention and the Izmir Protocol.

2.1.8 MAP Regional Plan for the Management of Hazardous Waste

The aforementioned plan (draft version dated June 2002) [1], gives response to the above indicated SAP targets.

The proposed regional plan for the management of hazardous waste is being elaborated on the basis of the assessment of management status and inventories of hazardous wastes in the Mediterranean region [41] and regional considerations.

According to the draft version of the MAP Regional Plan for the Management of Hazardous Waste, the elaboration and implementation of national management plans for hazardous waste will be the cornerstone for the implementation of the regional plan.

In case some Mediterranean countries may already have a national plan regarding environmental issues (and more specifically, hazardous waste), the draft version of the regional plan suggests integrating the elements of the plan into the national action plans of the MAP countries.

This Plan has been considered as the closest framework for the development of the Regional Plan for the Reduction of Hazardous Wastes. Hence, its main guidelines have been incorporated in the proposals made in the present Regional Plan. Nevertheless, it should be noted that the version used was a draft dated June 2002, which might have undergone significant changes.

2.2 National overview

In the following sections an abstract of the legal situation and management framework for industrial and hazardous wastes in each country is presented. Before that, Table 2-1 shows an overview of the situation in the different countries, according to the data collected through the questionnaires provided by the National Focal Points.

It can be observed that several countries have not yet elaborated a Hazardous Waste National Plan, as they are still developing their industrial and hazardous waste legal and management framework. Most Northern countries have developed national frameworks and hazardous waste management plans, and some of them, like Spain, are even reviewing these plans. Eastern countries are in general developing the overall framework, except Greece and Israel, which have well developed instruments. Southern countries, like Egypt and Tunisia, appear to be the most advanced in the development of their national legal and management frameworks.

In general, it can be observed that national legal and management frameworks tend to adopt a waste management hierarchy, where priority is given to the principle of prevention.

Table 2-2, provides a list of national authorities responsible for hazardous waste planning and management. Normally, these authorities belong to the Ministry of the Environment or a designated national authority. Where no information was available through the questionnaire, designated authority established in the Basel Convention has been indicated.

Table 2-1 Situation of the legal and management framework of industrial and hazardous wastes in the MAP countries (NA: information not available; UD: under development; D: developed; ND: not developed).

Country	Legal framework of industrial waste	Legal framework of hazardous waste	Hazardous waste National Plan
ALBANIA	UD	UD	ND
ALGERIA	UD	UD	UD
BOSNIA&HERZ.	UD	UD	UD
CROATIA	UD	UD	UD
CYPRUS	UD	UD	D
EGYPT	D	D	UD
FRANCE	D	D	NA
GREECE	D	D	UD
ISRAEL	D	D	UD
ITALY	D	D	D
LEBANON	UD	UD	UD
LIBYA	NA	NA	NA
MALTA	UD	UD	UD
MONACO	UD	UD	NA
MOROCCO	UD	UD	ND
SLOVENIA	D	D	UD
SPAIN	D	D	D
SYRIA	UD	UD	ND
TUNISIA	D	D	D
TURKEY	UD	UD	UD

Table 2-2 List of national authorities in charge of hazardous waste (HW) management in the MAP countries

Country	HW National Authority
ALBANIA	**Ministry the Environment** Rruga e Durresit Nr 27 Tirana
ALGERIA	**Ministry of Physical Planning and Environment** Les quatre cannons 16000 Alger
BOSNIA-HERZEGOVINA	**Federal Ministry of Physical Planning and Environment** Marsala Tita 9a, 71000 Sarajevo. e-mail: fmpuio@fbihvlada.gov.ba
CROATIA	**Ministry of Environmental Protection and Physical Planning** Ul.grada Vukovara 78 1000 Zagreb
CYPRUS	**Environment Service, Ministry of Agriculture, Natural Resources and Environment** Environment Service, Ministry of Agriculture, Natural Resources and Environment, Nicosia, 1411
EGYPT	**Egyptian Environmental Affairs Agency** 30 Misr-Helwan road Maadi , Cairo
FRANCE	**Direction de la prévention des pollutions et des risques** Sous-direction des produits et des déchets Ministère de l'Ecologie et du Développement Durable 20, avenue de Ségur 75302 Paris 07 SP, France
GREECE	**Ministry of Environment, Physical Planning and Public Works** 147 Patission Street Athens 112 51
ISRAEL	**Hazardous Substances Devision, the Ministry of the Environment** P.O Box 34033 Jerusalem 91340
ITALY	**Ministry of the Environment and Physical Planning** Via Cristoforo Colombo, n. 44 00147 - Rome
LEBANON	**Ministry of Environment** Antelias, PO Box: 70-1091
LIBYA	[Does not exist a designated authority by the Basel Convention]

Country	HW National Authority
MALTA	**Malta Environment and Planning Authority** Environment Protection Directorate PO BOX 200, La Valletta
MONACO	**Le Ministre Plenipotentiaire** Chargé de la Coopération Internationale pour l'Environnement et le Développement 16, Boulevard de Suisse MC 98000, Monaco
MOROCCO	**Department of the Environment** 36, Al Abtal Agdal, Rabat
SLOVENIA	**Nature Protection Authority** Ministry of Environment and Regional Planning Vojkova 1b 1000 Ljubljana
SPAIN	**Ministry of the Environment** Plaza San Juan de la Cruz, s/n 28071 Madrid
SYRIA	**Ministry of State for Environment** Tolyani Street Damascus, Syrian Arab Republic
TUNISIA	**Ministère de l'Environnement et de l'Aménagement du Territoire** Centre Urbain Nord Building I.C.F. 2080 Ariana
TURKEY	**Ministry of Environment** Eskisehir Yolu 8. km 06530 Ankara

3. Current hazardous waste minimization practices

In this section, the state of the art regarding cleaner production and hazardous waste minimization approaches in the MAP countries is presented.

According to the data provided by the questionnaires, the overall situation regarding waste minimisation practices in the Mediterranean is relatively positive. In brief, out of the twenty countries that integrate the study, eight of them have reported to have specific plans or targets regarding industrial or hazardous waste minimization in the legal and management framework (see Table 3-1), whereas seven countries have not yet developed any aspect related to hazardous waste reduction. There is no data available from five of the countries, which affects the overall analysis of the situation.

Table 3-1 Countries with specific plans or targets in their legal and management framework, regarding industrial or hazardous waste minimization

Country	Plans or targets?
Albania	YES
Algeria	YES
Bosnia-Herz.	NO
Croatia	YES
Cyprus	YES
Egypt	YES
France	N/A
Greece	NO
Israel	YES
Italy	YES
Lebanon	NO
Libya	N/A
Malta	NO
Monaco	N/A
Morocco	NO
Slovenia	N/A
Spain	YES
Syria	NO
Tunisia	N/A
Turkey	NO

N/A: No answer available from the NFP questionnaire.

Table 5-1 shows that 40% of the MAP countries have undertaken actions related to cleaner production in the management or legal framework of hazardous wastes. This percentage is by no means negligible. Accordingly, the regulatory framework could play an important role in pushing the industrial sector to adopt changes in their production and management processes in order to move from the traditional end-of-pipe solutions to environmentally sound management.

In many cases it seems difficult to translate the regulatory framework into concrete actions, and most of the measures are focused on the promotion of municipal waste minimization. It is clearly necessary that those countries lacking a national policy on cleaner production develop it, especially in the area of industrial and hazardous wastes which is the least advanced.

It is difficult to identify the main sectors that incorporate actions to reduce the generation of hazardous wastes, since it depends on the different countries. In spite of this, there are some recurrent industrial activities such as the chemical, the metallurgic, the cement and the oil refining in which different countries are taking measures to minimise waste generation.

The instruments to carry out hazardous waste minimization are diverse and include: process optimisation, good housekeeping practices, product re-design and on-site recycling.

A summary of the available information on waste minimization practices in each country is presented below. Nevertheless, a more comprehensive review on the cleaner production status in the MAP countries is presented in the report ‘State of the Cleaner Production in the MAP countries’ [12], which is currently being updated by the RAC/CP.

3.1 Albania

According to the information provided by the questionnaire, there are specific plans regarding hazardous waste minimization in Albania. These plans are mainly oriented towards the rehabilitation of “hot spots”, most of which are historical industrial ones. The different projects and actions carried out in this area are indicated in Table 3-2

Table 3-2 Industrial sectors already taking action to reduce the generation of its hazardous wastes in Albania

Industrial Sector	Actions aimed at reducing hazardous waste
Chemical fertilizer plant in Fier	Project :Removal of 800 m3 arsenical solution: actually is prepared the Tender Dossier
Chemical industrial plant in Durres	Project: Remediation plan for chemical plant in Durres: actually are prepared for the Project
Marine Oil field in Patos	APC (Albanian Petroleum Company which administer the field) is taking measures for proper management and pollution reduction through new investments.
Chlorine alkali and PVC plant in Vlora	Project: Reinvestment study for rehabilitation of hot-spot in Vlora
For all hazardous waste	``CARDS`` 2003-2004 Project: Secure hazardous waste landfill site development: has already been approved

3.2 Algeria

According to the questionnaire, the minimization of hazardous wastes in Algeria is addressed through the following instruments:

- The National Plan for the Management of Hazardous Wastes, which is being developed.
- The creation of the National Agency for Hazardous Wastes

In order to address environmental pollution problems, industries from different sectors have started to sign up contracts with the Ministry for Land Planning and the Environment to enhance environmental performance and reduce the generation of hazardous wastes. These contracts are managed by the Ministry for Land Planning and the

Environment. The priority sectors to be engaged by this instrument are the following:

- Cement
- Mechanics
- Siderurgy
- Agro-food

3.3 Bosnia and Herzegovina

According to the information provided by the questionnaire, in Bosnia and Herzegovina there are no specific plans regarding hazardous waste minimization. Consequently, there is not a specific cleaner production related policy or planning framework. However, there are some practices aimed at reducing hazardous wastes in specific sector ssuch as the metal industry, as indicated in Table 5-3.

Table 3-3 Industrial sectors already taking action to reduce the generation of its hazardous wastes in Bosnia-Herzegovina

Industrial Sector	**Actions aimed at reducing hazardous waste**
Metal industry (“Aluminijum” Mostar)	Filter replacing, reducing air emission
Metal industry (“Galvanizacija” Konjic)	Cleaner production, pollution prevention on source, minimization of wastewater discharge.

3.4 Croatia

In Croatia, according to the questionnaire, the minimization of hazardous wastes is addressed in the following plans and strategies:

- National Strategy of Environmental protection (2000),
- National Environmental Action Plan (2000),
- National Strategy for Hazardous Waste Management is in preparation phase

On the one hand, the Physical Planning Programme (1997) of Croatia includes a chapter on environmental protection, waste reduction and pollution prevention.

On the other hand, Croatia has a specific centre related with cleaner production since 2000,. This fact has favoured the development of initiatives and awareness programmes of cleaner production. In particular, in the field of hazardous wastes, different actions addressed to the oil refining and the energy production sectors have been carried out, as shown in Table 5-4.. All refineries and facilities subjected to cleaner production projects are certified under ISO 14001.

Table 3-4 Industrial sectors already taking action to reduce the generation of its hazardous wastes in Croatia

Industrial Sector	Actions aimed at reducing hazardous waste
Oil refining (in refineries in Rijeka and Sisak and in lubricant plant in Mlaka)	An ongoing Cleaner Production/HW minimisation project related with process optimisation, housekeeping practises and on-site recycling
Energy production (three thermal power plant)	An ongoing cleaner production project related to waste oils/PCB (transformers, capacitors)

3.5 Cyprus

With regard to cleaner production, Cyprus developed the bill on the Management of Solid and Hazardous Wastes which fully transposes the relevant EU legislation on industrial and hazardous waste minimization.

According to the information provided by the questionnaire, there are different projects oriented to cleaner production, indicated in Table 5-5.

Table 3-5 Industrial sectors already taking action to reduce the generation of its hazardous wastes in Cyprus

Industrial Sector	Actions aimed at reducing hazardous waste
Cement industry	Waste minimization
Energy production	Good housekeeping practices
Transport	Recycling of drained car batteries
Waste oils	Recycling of oil wastes

3.6 Egypt

In Egypt, the Egyptian Environmental Affairs Agency (EEAA), under the Ministry of Environment is responsible for cleaner production promotion. The main focal sectors considered include the textile, food processing, petroleum, chemical industry, leather industries, paper and pulp industries, cement industry, edible oil and soap manufacturing.

The most relevant cleaner production projects are:

- The Egyptian Pollution Abatement Project (EPAP)
- The industrial Modernization Program (IMP) at the industrial Modernization Centre (IMC)
- The Energy Conservation and Environmental Protection Project (ECEP)
- The Environmentally Friendly Industrial Cities Program is one leading initiative of the Ministry of State Environmental Affairs (MSEA)

According to the questionnaire provided by the focal point, some industrial sectors are taking actions to reduce the generation of hazardous wastes.

Table 3-6 Industrial sectors already taking action to reduce the generation of its hazardous wastes in Egypt

Industrial Sector	**Actions aimed at reducing hazardous waste**
Petroleum	Process optimization
Textile	Life Cycle Analysis
Fertilizers	Good housekeeping practices
Food	Good housekeeping practices

3.7 France

ADEME (Agency for the Environment and Energy-Management Directorates for Industry and Planning) is responsible for the promotion of cleaner production [67]. Since 1993, regulatory instruments for cleaner technology implementation as well as pollution prevention legislation were enacted,. ADEME has created a decision tool (DIADEME) oriented to the reduction of industrial wastes at source.

3.8 Greece

According to the information provided by the questionnaire, there are not specific targets regarding hazardous waste minimisation in Greece. However, actions are regularly undertaken to minimise all hazardous waste generated through the use of clean technologies as well as recycling, reuse and regeneration. The aim is to follow the IPPC Directive of the European Union.

3.9 Israel

Since 1999, the Ministry of the Environment has been funding industries to carry out projects aimed at reducing hazardous wastes which would otherwise be sent to Ramat-Hovav. The Ministry finances up to 40% of the investment cost of the project and up to NIS 200,000 (nearly 40,000€), with prioritising plans in which waste or waste toxicity is reduced at source. During 1999-2000, thirteen plants received one million shekels worth of grants that allowed them to reduce their H.W by 3,656 tonnes per year and to save nearly 10 million shekels per year. The project has increased the industries' awareness of the importance of minimizing hazardous waste generation.

In 2001 11 projects were approved (9 facilities), resulting in an estimated reduction of 7,000 tonnes of hazardous wastes.

The Israeli Cleaner Production Centre provides information, guidance services and financial aid to carry out a diagnose with the aim to recommend technologies to reduce hazardous waste generation at source.

3.10 Italy

According to the information provided by the questionnaire, in Italy there is a specific plan regarding hazardous waste minimization. Law 445/88 outlines measures for waste reduction, materials recovery and innovative technologies. Besides, the Environment Report released in 1996 prioritized minimization of waste generation.

The ministry of Environment has developed voluntary agreements with certain production sectors aimed at encouraging the use of cleaner technology and waste minimization in particular. According to the information provided by the questionnaire, the sectors that are taking actions aimed at reducing the generation of hazardous wastes are the chemical industry, the ceramics industry, the food industry and the energy production. All these industrial sectors are employing mitigation technologies for specific processes/sectors which, due to their specificity, can not be generalized. Examples of waste minimisation which are common to all sectors are:

- Selective waste collection to increase the efficiency of recycling processes and waste disposal;
- Improvement of sewage related parameters (sludge production).

Some specific examples for industrial sectors are:

- Mitigation technologies applied in the Chemical sector: evaporation and concentration plant for recycling of sodium chloride.
- Responsible Care: is a voluntary agreement international programme applied in the chemical sector (Industrial groups).

- Mitigation technologies applied in the energy production sector: filter for oil recycling in turbine

The Ministry of the Environment and Territory has elaborated the "Strategy for the Reorientation of industrial process/product systems" on the basis of regional programmes under EU Structural Funds 2000-2006 Programme. Therefore, enterprises will be able to access EC funding through the presentation of projects which may include the following actions:

- Introduction of environmental management systems
- Modification of process technologies
- Improvement of emission abatement systems
- Pursuing energy efficiency and waste generation reduction
- Environmental product innovation

3.11 Lebanon

According to the information provided by the questionnaire, in Lebanon there is not a specific plan regarding hazardous waste minimisation. However, some sectors have developed actions aimed at reducing the impact due to the generation of these kinds of wastes. The main actions are oriented at treatment or disposal.

Table 3-7 Industrial sectors already taking action to reduce the generation of its hazardous wastes in Lebanon

Industrial Sector	**Actions aimed at reducing hazardous waste**
Chemical	physical-chemical (partial treatment)
Waste oil	physical-chemical (partial treatment)
Pesticide container	Export for disposal

The lack of financial resources to implement sound environmental management plans is the main factor which hinders the elaboration and implementation of these plans and which contributes to the slow enforcement of legislation. However, the severity of the problem may decrease slightly once petroleum storage facilities between Dora and Antelias (north of Beirut) are relocated to 275,000m² of land to be claimed from the sea (Linord's project), provided appropriate safeguards are followed and emergency response capabilities are put in place. Construction of nine planned sewage treatment plants along the coast will mitigate pollution in the Mediterranean, especially if secondary treatment plants are built. Moreover, the closure of the Borj-Hammoud dumpsite (North Beirut) and the rehabilitation of Tripoli dump site (protected by a sea dike since 1996) will eliminate the release of solid waste and debris into the sea.

3.12 Malta

According to the information provided by the questionnaire, in Malta there is not a specific plan regarding hazardous waste minimisation. Nevertheless, some sectors described in Table 3-8 have taken actions aimed at reducing the generation of hazardous wastes.

Table 3-8 Industrial sectors already taking action to reduce the generation of its hazardous wastes in Malta

Industrial Sector	Actions aimed at reducing hazardous waste
Ship repair	Implementation of Good House Keeping and Process Optimization
Transport servicing	Recycling
Electronics	Product Re-design and On-site Recycling
Metal products	Products Re-design and CP

Malta has a Cleaner Technology Centre that was set up in 1993 by the Environment Protection Department, the Department of Industry and hosted by the University of Malta. The focal sectors are metal finishing, refrigeration, packaging, tourism and construction.

3.13 Monaco

The Direction of the Environment, Urbanism and Construction in Monaco aims to promote the best available techniques (BAT) and in this context, the implementation of ISO 14000 is encouraged. Furthermore, different actions are also promoted: rational use of energy, promotion of recycling; the reduction of the production losses; use of eco-technologies and waste reduction.

3.14 Morocco

This country has not developed a plan to minimize hazardous wastes. According to the information provided by the questionnaire, some sectors have taken actions to reduce the generation of this kind of wastes, as shown in Table 3-9:

Table 3-9 Industrial sectors already taking action to reduce the generation of its hazardous wastes in Morocco

Industrial Sector	Actions aimed at reducing hazardous waste
Mechanics industry	Solid waste treatment : thermic regeneration of toxic sands (Projet supported by Fonds de Dépollution Industrielle)
Metallurgical industry	Solid waste treatment : thermic regeneration of toxic sands (Projet supported by Fonds de Dépollution Industrielle)
Electric and Electronic industry	Solid waste treatment : thermic regeneration of toxic sands (Projet supported by Fonds de Dépollution Industrielle)

Morocco has developed the integrated programme ‘Strengthening Industrial Competitiveness’ addressed to industries. The programme aims to promote exports and to improve technological and institutional infrastructure, by encouraging sustainable industrial development through cleaner production.

In 1994 the National Cleaner Production Centre, hosted by the Ministry of Environment was created. Its main focal sector is agro industry.

3.15 Slovenia

Data for Slovenia is not available.

3.16 Spain

According to the data provided by the questionnaire, Spain has a specific plan regarding minimization of hazardous wastes. This is the ‘Special Prevention Programme’ included in the draft of the hazardous waste National Plan (2002-2008). The specific target of this programme is the reduction of the generation of hazardous wastes by 15%. In this regard, the Ministry of Environment facilitates information, promotes waste minimisation practices and technologies, encourages research, develops environmental diagnostics aimed at waste minimisation at source, pollution prevention projects, demonstration projects, publishes minimisation case sheets, training schemes, attention to concrete consultations by enterprises and press releases.

3.17 Syria

In Syria, according to the questionnaire, the industrial and hazardous waste management plan will integrate specific targets regarding the minimization of wastes. At present, the main actions are addressed at encouraging the use of clean technologies, the application of environmental management systems and the promotion of good housekeeping practices.

Due to the active role of the Ministry of Environment, environmental audits have been carried out in several industrial sectors. As a result, control measures to prevent the pollution in the Damascus and Aleppo tanneries, in the cement industry Adda in Damascus, in the textile industry of the country and in the fertilizer plant in Horms have been proposed.

As a drawback, the scarce promotion of cleaner technologies among the sectors that have an impact on the Mediterranean Sea should be highlighted.

3.18 Tunisia

Since 1996, the National Cleaner Production Centre is hosted by the Tunis International Centre for Environmental Technologies (CITET), which holds responsibility for the promotion of clean technologies in the country. The focal sectors are tanneries, electronics, and electrical and mechanical industries, batteries manufacturing, paper and metal industry. The Code on Investment Incentives and various texts applying its dispositions set eligibility criteria and procedures to use incentives targeted on the basis of current priorities in terms of reducing pollution and managing, reusing and disposing of waste.

In Tunisia, a set of regulatory measures as well as economic and financial tools and action programs have been set up to provide incentives for firms to take environmental issues into consideration and also to encourage cleaner production. One of the most relevant initiatives is the capacity building program carried out in different industrial activities in 1998. The CITET also implemented programs aimed at promoting eco-technologies in industry (especially in the areas of resource conservation and protection, waste treatment, recycling and soil decontamination).

3.19 Turkey

In Turkey, according to the questionnaire, there is yet no plan to reduce the generation of hazardous wastes nor have actions been taken in specific industrial sectors of the country.
In 1997 the Energy Systems & Environment Research Institute (ESERI), hosted by Scientific and Technical Research Council of Turkey, Marmara Research Centre was set up. The focal sectors are olive oil manufacturers, electroplating and tanning. The Ministry of Environment, Ministry of industry and Trade and ministry of Finance provide funding to the institute.

4. Flows of hazardous wastes with a major priority to be reduced

4.1 Criteria to define priority flows

One of the key goals of the present Plan is to identify priority flows of hazardous wastes to be reduced. In order to identify these priority wastes, a set of criteria has been identified and applied to both industrial sectors generating hazardous wastes and to specific types of waste.

This prioritisation analysis has been undertaken at the national level, considering that industrial activities and their distribution in the different countries vary. These differences lead to different profiles of hazardous waste generation and therefore different priorities. It is important to take the national factor into account because the reduction of hazardous waste will necessarily be undertaken through national plans, which need to be adapted to domestic socio-economic conditions and specific requirements. Through the analysis at the national level, it is possible to prioritise key sectors and waste types at Regional level, which will be those that are common to the greatest number of MAP countries.

The criteria used to identify **priority industrial sectors** generating hazardous wastes have been the following (see Table 4-1):

- Total amount of hazardous wastes generated.
- Environmental impact of the industrial sector due to hazardous waste generation.
- Impact of the industrial sector on the Mediterranean Sea due to hazardous waste generation.
- Growth prospect of the industrial sector.

Table 4-1 Criteria used to identify priority industrial sectors.

Criteria	***Priority***		
	1 (low)	***2 (medium)***	***3 (high)***
Amount (% of total generation)	*< 5%*	*5% - 20%*	*> 20%*
Environmental Impact (ranking of industrial sectors in the questionn.)	*Not reported in the questionnaire*	*3-5 ranked sectors in the questionnaire*	*1-2 ranked sectors in the questionnaire*
Impact on Mediterranean (ranking of industrial sectors in the questionn.)	*Not reported in the questionnaire*	*3-5 ranked sectors in the questionnaire*	*1-2 ranked sectors in the questionnaire*
Growth prospect (as reported in the questionn.)	*C (expected to decrease)*	*B (remains equal)*	*A (expected to increase)*

Each of the criteria has been ranked between 1 and 3, from less (1) to major (3) priority. The data used to assign the different values have been obtained through the questionnaires reported by National Focal Points (See **Annex 5**). Thus, the different criteria have been ranked as shown in Table 4-1.

The results for each of the countries with available data to perform the priorization analysis are shown in detail in **Annex 3**.

Regarding the identification of **priority types of wastes**, considering the available data, the only criteria which can be applied in a systematic way is the total amount generated. Other potential criteria (hazardousness, recyclability, cost of waste treatment, etc.) are extremely difficult to translate into ranking parameters, considering the vast quantity of waste types to be considered, and the lack of information to derive these parameters.

As a result of the analysis performed, priority types of wastes have been identified for each country with available information, on the basis of the total amount generated. The result of this analysis is presented in **Annex 4**.

4.2 Identification of priority industrial sectors

It has been possible to identify priority industrial sectors in most of the MAP countries, except for Libya, Monaco, Tunisia and Slovenia. The results of the analysis for each of the 16 countries are presented in **Annex 3**. For each country, the main five sectors regarding the priority for waste reduction have been identified (see Table 4-2).

Table 4-2 Top five priority industrial sectors identified in the MAP countries.

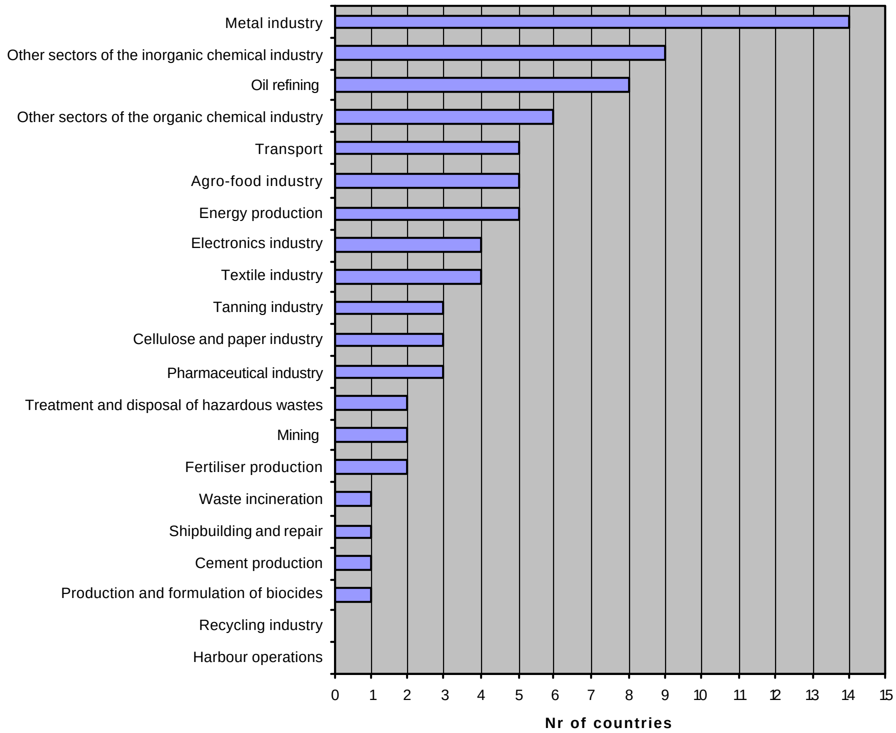
Country	Top 5 priority sectors
ALBANIA	• Inorganic chemical industry • Oil refining • Organic chemical industry • Metal industry • Energy production
ALGERIA	• Inorganic chemical industry • Organic chemical industry • Oil refining • Metal industry • Mining
BOSNIA-HERZEGOVINA	• Metal industry • Mining • Oil refining • Inorganic chemical industry

Country	Top 5 priority sectors
	• Organic chemical industry
CROATIA	• Oil refining • Transport • Energy production • Metal industry • Cellulose and paper industry
CYPRUS	• Tanning industry • Treatment hazardous waste • Energy production • Metal industry • Pharmaceutical industry
EGYPT	• Textile industry • Pharmaceutical industry • Metal industry • Fertiliser production • Agro-food industry
FRANCE	• Oil refining • Metal industry • Cellulose/paper industry • Electronics industry • Transport
GREECE	• Fertiliser production • Metal industry • Oil refining • Cellulose and paper industry
ISRAEL	• Inorganic chemical industry • Production biocides • Transport • Electronics industry • Treatment and disposal of hazardous waste
ITALY	• Organic chemical industry • Metal industry • Inorganic chemical industry • Electronic s industry • Treatment and disposal of hazardous waste
LEBANON	• Oil refining • Metal industry • Inorganic chemical industry • Agro-food industry • Textile industry
LIBYA	
MALTA	• Shipbuilding and repair

Country	Top 5 priority sectors
	• Transport • Metal industry • Energy production • Agro-food industry
MONACO	
MOROCCO	• Inorganic chemical industry • Metal industry • Agro-food industry • Electronics industry • Tanning industry
SLOVENIA	
SPAIN	• Inorganic chemical industry • Organic chemical industry • Pharmaceutical industry • Treatment and disposal of hazardous waste • Mining
SYRIA	• Cement production • Agro-food industry • Inorganic chemical industry • Tanning industry • Metal industry
TUNISIA	
TURKEY	• Metal industry • Energy production • Oil refining • Textile industry • Waste incineration

These 'top five' priority sectors of each country have been aggregated for all countries, and the results obtained are presented in Figure 4-1. It can be observed that **metal industry** is the industrial sector that is more commonly identified as a priority sector, namely in 14 of the 16 countries analysed. Other wastes that are also commonly prioritised are inorganic chemical industry, oil refining, and the organic chemical industry. Transport, agro-food, energy production, electronics and textile industry are also important in several countries.

Figure 4-1 Aggregation of the 5 priority industrial sectors identified in each of the 16 MAP countries analysed.



If these results are compared with the total amount of hazardous wastes generated in the MAP countries (see **Error! Reference source not found.**), it can be observed that a sector like mining, accounting for the second largest total generation of hazardous wastes, has only been found as a priority sector in a couple of countries. This is because of the differences in industrial activity between countries. Thus, mining accounts for a large generation of wastes in Spain, but does not have a significant activity in other countries, or at least this has not been reported.

On the contrary, industrial sectors accounting for the lowest total amounts of hazardous wastes, like textile, agro-food, or energy production, are identified as priority sectors in several countries. Again, the reason is the difference between national industrial profiles, and the consideration of other criteria like environmental impact.

4.3 Identification of priority types of wastes

As indicated above, priority types of hazardous of wastes have been identified for each country only on the basis of their generation. In this case, also 16 countries have been analysed, except Egypt, Libya, Monaco, and Turkey. **Annex 4** shows the results of this analysis. For each country, the top three and top five types of wastes accounting for a major generation have been identified, hence with a major priority for reduction (see Table 4-3).

Table 4-3 Top five priority waste types identified in the MAP countries.

Country	Top 5 priority waste types
• ALBANIA	• From production of biocides • Arsenic compounds • Inorganic fluorine compounds • From production, of inks, dyes, pigments, paints, lacquers and varnishes • Hexavalent chromium compounds
• ALGERIA	• Waste tarry • Mineral oils • Other not specified • From thermal processes • From inorganic chemical processes
• BOSNIA-HERZEGOVINA	• Waste tarry • Waste mining • Oil and-hydrocarbons/water mixtures, emulsions • Mineral oils • Other not specified
• CROATIA	• Waste tarry • Mineral oils • Oil and-hydrocarbons/water mixtures, emulsions • From production of inks, dyes, pigments, paints, lacquers and varnishes • From production of organic solvents
• CYPRUS	• From production of inks, dyes, pigments, paints, lacquers and varnishes • Surface treatments • Lead • From manufacturing of wood preserving chemicals • Mineral oils
EGYPT	
• FRANCE	• .From production of organic solvents • Acidic solutions waste • Basic solutions waste • Mineral oils • Oil and-hydrocarbons/water mixtures, emulsions
• GREECE	• Shaping and physical surface treatment • Other not specified • Waste tarry • Surface treatment • From thermal processes

Country	Top 5 priority waste types
• ISRAEL	• Basic solutions waste • Organic solvents excluding halogenated • Acidic solutions waste • Arsenic compounds • Mercury compounds
• ITALY	• From organic chemical processes • Mineral Oil • Thermal processes • Shaping and physical surface treatment • Surface treatment
• LEBANON	• Waste tarry • Waste packaging • Acidic solutions waste • Basic solutions waste • From production of organic solvents
LIBYA	
• MALTA	• Mineral oils • Oil and-hydrocarbons/water mixtures, emulsions • Surface treatments • From industrial waste disposal operations • From production of resins, latex
MONACO	
• MOROCCO	• From inorganic chemical processes • Agriculture waste • Leather and fur waste • From wood processing • Shaping and physical surface treatment
• SLOVENIA	• From production of resin/latex • From pharmaceutical industry • Organic solvents excluding halogenated • Explosive wastes • Acidic solutions waste
• SPAIN	• Mining waste • Surface treatment • From thermal processes • Mineral oils • Other not specified
• SYRIA	• From thermal processes • Agriculture waste • Leather and fur waste • From inorganic chemical processes

Country	Top 5 priority waste types
	• Surface treatment
• TUNISIA	• Mineral oils • Surface treatments • From pharmaceutical industry • From production of resins, latex • Waste tarry
TURKEY	

These 'top five' national priority waste types have been aggregated for the total of countries, and the results obtained are presented in Table 4-4. Only wastes that have been identified as priority in any of the countries are shown on the table. It can be observed that **used mineral oils** and **wastes from surface treatment** are the most commonly identified as priority wastes in the analysed countries. Other priority types of wastes commonly identified are waste tarry residues from oil refining and waste from thermal processes.

It can be observed, that on the basis of its total generation, the priority types of wastes are those that are generally occurring in a variety of sectors, like used mineral oils, and those generated in sectors typically generating large amount of hazardous wastes, like **metal industry** (surface treatment, thermal processes –metallurgy-, waste oils/water mixtures –cutting fluids-, organic solvents, wastes from shaping of metal,…), **oil refining** (waste tarry), and **chemical industry** (inks and dyes, acidic solutions, organic solvents, resins, etc.).

Table 4-4 Aggregation of the 5 priority types of wastes identified in each of the 16 MAP countries analysed.

Waste type	Nr of countries
Waste mineral oils unfit for their originally intended use	9
Wastes resulting from surface treatment of metals and plastics	7
Waste tarry residues arising from refining, distillation and any pyrolitic treatment	6
Wastes from thermal processes	5
Waste oils/water, hydrocarbons/water mixtures, emulsions	4
Wastes from production, formulation and use of inks, dyes, pigments, paints, lacquers, varnishes	4
Acidic solutions or acids in solid form	4
Wastes not otherwise specified in the list	4
Wastes from the production, formulation and use of organic solvents	3

Waste type	Nr of countries
Wastes from production, formulation and use of resins latex, plasticizers, glues/adhesives	3
Wastes from inorganic chemical processes	3
Wastes from shaping and physical and mechanical surface treatment of metals and plastics	3
Arsenic, arsenic compounds	2
Basic solutions or bases in solid form	2
Organic solvents excluding halogenated solvents	2
Wastes resulting from exploration, mining, quarrying and physical and chemical treatment of minerals	2
Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing, food preparation and processing	2
Wastes from leather, fur and textile industries	2
Wastes from the production and preparation of pharmaceutical products	1
Waste pharmaceuticals, drugs and medicines	1
Wastes from the production, formulation and use of biocides and phytopharmaceuticals	1
Wastes from manufacturing, formulation and use of wood preserving chemicals	1
Wastes of an explosive nature not subject to other legislation	1
Residues arising from industrial waste disposal operations	1
Hexavalent chromium compounds	1
Mercury; mercury compounds	1
Lead, lead compounds	1
Inorganic fluorine compounds	1
Wastes from wood processing and the production of panels and furniture, pulp, paper and cardboard	1
Wastes from organic chemical processes	1
Waste packaging: absorbents, wiping cloths, filter materials and protective clothing not otherwise specified	1

Again, if these results are compared with the total amount of each type of waste generated in the MAP countries (see **Error! Reference source not found.**), it can be observed that wastes from mining activities, accounting for the first largest total generation, has only been found as a priority type of waste in a couple of countries. It has already been indicated that this is a result of the large amount of mining wastes reported by a single country, Spain. The same trend occurs for wastes from organic chemical processes, accounting for the second largest total generation, when it has only been identified as a priority type of waste in single country, Italy.

Other wastes accounting for a large total generation are also commonly identified as priority waste types, like used mineral oils and wastes from surface treatment.

5. Options to reduce priority flows of hazardous waste

5.1 Introduction

The objective of this Section is to provide a review of the current available options to reduce the generation of hazardous wastes. This information is not exhaustive but can be used by the different MAP countries when designing their National Plans to reduce their priority flows of hazardous wastes. To this end, the top three priority industrial sectors for hazardous waste reduction, according to the results obtained in the previous section, have been identified and analysed:

- Metal industry
- Chemical industry
- Oil refining

For each of these sectors and given the information available in the literature, the following aspects have been analysed:

- Sources of hazardous wastes
- Waste minimization options
- Case studies

The main references used in this Section have been the sectorial guidelines on pollution prevention, edited by the RAC/CP, as they have been elaborated within the scope of the Mediterranean Region, and the Reference Documents on Best Available Techniques (BREFs), published by the Joint Research Centre.

On the basis that all industrial sectors should undertake efforts to reduce hazardous wastes, waste minimization options for other industrial sectors have also been identified. The sectors analysed have been those where sectorial studies and case studies were available within the scope of the Mediterranean Region:

- Textile
- Tanning
- Food and dairy
- Paper and cellulose

Waste minimization options have also been identified for used oils, which are the main specific type of hazardous waste generated in most of the countries because it is generated by a variety of industrial sectors.

5.2 Metal industry

The prioritization of industrial sectors and hazardous wastes types identified in the previous section has shown that a priority sector is metal industry, where cleaner production actions should be addressed.

This conclusion is based on four main reasons:

- Metal industry has been identified as the industrial sector accounting for the major total generation of hazardous wastes in the Mediterranean region.
- Metal industry has been identified as a priority industrial sector in 14 out of the 16 countries analysed considering the following criteria: total amount, environmental impact, impact on Mediterranean Sea and growth prospect.
- Four out of the 'top five' priority hazardous waste types identified are generated by metal industry: waste mineral oils, wastes resulting from surface treatment, wastes from thermal processes and waste oils/water mixtures –emulsions-.
- Metal industry generates the greatest variety of types of hazardous wastes identified in the Mediterranean region: in addition to the four belonging to the 'top five', wastes from shaping and physical and mechanical surface treatment of metals, wastes from the production, formulation and use of organic solvents and organic solvents excluding halogenated solvents are significantly generated by metal industry and its subsectors.

As metal industry includes several subsectors, activities and processes, cleaner production options have been identified for the three main activities with the major environmental impact: metal shaping, cleaning and surface preparation, and surface treatment.

Among them, three priority types of hazardous waste have been identified and the cleaner production actions -internal recycling, product redesign, good practices, new technologies and change of raw materials- have been developed where information was available.

Finally, some case studies have been analysed in order to assess real benefits related with cleaner production actions already developed.

5.2.1 Subsectors and specific hazardous wastes to be minimised

5.2.1.1 Metal shaping

Metal shaping operations convert raw materials to their intermediate or final form [13]. Primary shaping typically converts the metal into a sheet, bar, or plate. Secondary shaping alters the metal into an intermediate or final form by stamping, turning, drilling, cutting, grinding, or other processes. Metalworking fluids are typically used to cool the part, aid lubrication, provide a good finish, wash away chips, and inhibit corrosion.

In general, two types of wastes are generated in the metal shaping processes. These wastes are scrap metal and spent metalworking fluids and oils. The metalworking fluids can become contaminated or spoiled after use and reuse. This fluid waste may be considered hazardous due to the oil content, contamination by metals like cadmium and lead, or if the oils contain chemical additives like sulphides and chlorine. Typically, the scrap metal and metalworking fluids are disposed of or recycled. Due to the nature of the process, metal shavings and oils are mixed together, making recycling difficult.

5.2.1.2 Cleaning and Surface preparation

The surface preparation phase is undertaken to remove unwanted surface materials, or to alter the chemical or physical characteristics of the metal [13]. Parts may have been contaminated with machining oils, fingerprints, or grease that need to be removed before the part is coated. Surface preparation usually consists of one or a combination of the following methods:

- Solvent vapour degreasing
- Solvent baths
- Aqueous degreasers or baths
- Mechanical cleaning

Solvent degreasing can generate air emissions, solvent-bearing wastewaters, and solid wastes. Aqueous degreasing operations can still have some solvent content and may also generate high pH wastes, oil wastes, or metal wastes. Chemical treatment operations result in wastes containing metals from the cleaned part and can generate high or low pH wastes. Water rinses are usually necessary after chemical treatment baths and this water usage varies widely depending on the industry. Mechanical cleaning generates spent media along with metals. It is important to note that a non-hazardous cleaner can become hazardous when it is mixed with the metal and contaminants being cleaned. A common sight in many plants is a parts washer station. The wastes from these stations are often collected by the solvent supplier, or can be distilled on or off-site.

5.2.1.3 Surface treatment

A wide variety of materials and processes are used to clean, etch, and plate metallic surfaces [13]. The materials include acids and bases for etching, and solutions of metal salts and other compounds to plate a finish onto the metal. Physical, chemical, and electrochemical processes are all used to finish the pieces. Finishing may be performed to improve appearance or to change the surface properties of the metal. Metal deposition activities include anodizing, conversion coatings, electroless coatings, electroplating, and etching. Anodizing is an electrochemical process which converts the metal surface to a coating of an insoluble oxide.

Formation of oxide occurs when the parts are made anodic in dilute sulphuric or chromic acid solutions. Conversion coatings include any operation that uses chromating, phosphatizing, metal colouring, or passivating. Electroless plating consists of the chemical deposition of a metal coating on a part in immersion when electricity is not involved. Electrocoating produces a thin surface coating of metal on another by electrodepositing. Ferrous and non-ferrous materials are typically coated with copper, nickel, chromium, brass, zinc, and cadmium among other metals. Chemical etching dissolves the surface of a metal to provide a specific surface appearance. All of these metal deposition finishing operations take place using plating baths with cleaning and rinsing baths typically upstream and downstream of the metal deposition procedure.

The metal deposition operations typically result in solid and liquid waste streams containing chemicals and metals. Liquid wastes come from rinsing operations and spent process baths. Plants involved in this field have centralized water treatment plants that result in wastewater treatment sludges.

5.2.2 Waste minimization options

5.2.2.1 Waste organic solvents

Cleaner Production Actions

Among organic solvents, halogenated solvents are those accounting for the major environmental impact due to their toxicity, persistence and bioaccumulation.

Waste halogenated solvents are mainly generated in cleaning operations in metal industry; however, they are also generated by other industrial activities such as: formulation of pharmaceutical products, inorganic and other organic chemical processes, production of paints, varnishes and lacquers, etc.

- The first proposal aimed at reducing halogenated solvent wastes, should be to reduce or eliminate the use of solvents at source [13]:

  Avoid the need to clean

  In some cases, upstream or downstream processes can be eliminated or altered to avoid cleaning. It may be necessary to work with suppliers in order to assess this option.

  Employee training

  Industries should consider training employees in good operating practices when cleaning. The training should not only illustrate the "how-to" of good operating practices, but should also explain how these practices can save money and lessen environmental impacts.

- If solvents cannot be eliminated from the process, the second option is to recycle or reuse the wastes that are generated in an environmentally sound management (waste minimization).

  Extend the life span of the solvent

  Industries can recover spent solvents through the use of an outside recycler, or recycle solvents on-site using their own equipment.

  Small batch distillation units allow the solvent to be reused several times at an additional capital, operating, energy, and maintenance cost. However, this can be cost effective compared to buying pure solvent and producing more hazardous wastes. In-line filters may also extend the life of the solvent at a minimal cost.

- When raw material substitution is mandatory, like CFC's and 1, 1, 1-trichloroethane, among others, in EU Mediterranean countries (EC Regulation 2037/2000 on substances that deplete the ozone layer), alternatives to chlorinated solvent use in metal parts cleaning have been developed [14].
  The main identified alternatives are: aqueous and semi- aqueous cleaning, vacuum de-oiling and dry ice blasting:

  Aqueous Cleaning

  Aqueous cleaning solutions use water as the primary solvent. A combination of water conditioners, detergents and surfactants are added to promote better cleaning of the metal object. In addition, special additives such as builders, pH buffers, inhibitors, saponifiers, emulsifiers and deflocculants can be added to meet the desired cleaning requirements.

Semi-Aqueous Cleaning

Semi-aqueous cleaning products have demonstrated their efficiency to remove waxes, heavy greases, tar and baked on organic materials. Generally semi-aqueous cleaners are effective at room temperature and they possess a very low evaporation rate which infers low use cost and low VOC emissions.
The most common semi-aqueous cleaners are:

- Terpenes: no toxic, biodegradable, available substitute for 1, 1, 1-trichloroethane and CFC's
- HFE (hydro fluor ether): good moistener and surfactant, low toxicity, thermal and chemical stability and low viscosity.

Vacuum De-oiling

A new process on the market is vacuum de-oiling, an operation that removes surface oils from parts without using ozone-depleting or hazardous chemicals, water or detergents. Thermal and vacuum technology removes the oil residue on parts through vaporization but at a certain energetic cost.

Dry Ice Blasting

This technology uses solid pellets of carbon dioxide as a blasting medium for cleaning metal parts. This process uses dry ice pellets which return to their gaseous state on impact.

Case Studies

A pollution prevention case study focusing on a company which manufactures metal parts with high-precision cuts is reported in MEDCLEAN files [15]:

SASONIA DE CORTE FINO, S.A. (La Roca del Vallès, Spain)

The raw material (metal strip coils) is passed through a roller straightening machine to straighten it and is then cut in the press. To facilitate the cut, the material is impregnated with a thin oil layer. Afterwards, to eliminate the rough edges originated, the parts are smoothed with abrasive bands and metal brushes, and cut oils are also used as cooling agents.

The parts without rough edges are totally impregnated with oil. This means that the parts have to be washed and degreased. The company used trichloroethylene that had to be periodically renewed. Consequently, wastes containing trichloroethylene were generated (and externally treated) as well as sludge containing metal dust and oil residues that were valorised with scrap.

The actions carried out by the company have consisted in installing a new cleaning machine at the end of every line that eliminates rough edges. These machines use a non-hazardous water-based cleaning agent (96% deionised water).

Cleaning machines include a system to separate oils (from the cutting stage) and metal dust (from the stage aimed at eliminating rough edges). Thus, the cleaning agent may be recycled and after being used in the cleaning stage may be re-used in the stage aimed at eliminating rough edges.

<u>Balances:</u>

	Old process	**New process**
Balances of material		
Trichloroethylene consumption	9,600 kg/y	0 kg/y
Consumption of cooling oil	6,500 kg/y	0 kg/y
Consumption of the new cleaning agent	0 l/y	700 l/y
Economic balances		
Trichloroethylene consumption	6,058€ /y	0 €/y
Consumption of cooling oil	7,813 €/y	0 €/y
Trichloroethylene management	4,788 €/y	0 €/y
Management of sludge containing trichloroethylene	847 €/y	0 €/y
Consumption of the new cleaning agent	0 €/y	3,142 €/y
Total savings		16,364 €/y
Investment		79,393 €
Payback period		4.85 years

As a result of redesigning the process, the management of trichloroethylene and sludge containing trichloroethylene was totally eliminated and the investment made had a payback period of 4.85 years.

5.2.2.2 Metalworking fluids and oils

Cleaner Production Actions

Cleaner production specific actions to reduce waste metalworking fluids can be classified into three main actions: internal recycling, good practices and new technologies [16] (see Table 5-1)

Table 5-1 Waste metalworking fluids minimization options

CLEANER PRODUCTION ACTIONS	SPECIFIC ACTIONS
Internal recycling	Centrifuge
	Blower
	Vibration equipment
	Compacting equipment
Good practices	Defining responsibilities
	Compatibility of products
	Training
	Control plan of metalworking fluid
	Quality control of water when added to the concentrated solution
	Disinfection of distribution circuit when replaced
	Airing metalworking fluid
	Involving supplier in the cleaner production process
New technologies	Dry shaping
	MQL technology
	Central distribution tank
	Maintenance units

An overview of the different specific actions is described below:

Dry shaping

Dry shaping is new technology consisting of a dry process which involves hard, resistant machines, tools and materials. Metalworking fluid is totally avoided and so is the waste cutting fluid.

Minimum Quantity Lubrication (MQL)

The metalworking fluid is dosed in the minimum quantity needed to ensure operation conditions. The consumption of metalworking fluid can be reduced by 95%.

Maintenance units

It consists of maintenance systems which avoid pollutants in the bath such as particles (solid removers) or oils (oil removers). These units improve bath quality and therefore, extend its operating life.

Control plan

The implementation of monitoring plans which analyse the relevant state parameters of the metalworking fluid allows the design of an adequate maintenance plan which will extend its operating life. It is estimated that the waste metalworking fluids can decrease in 60%.

Auxiliary separation equipments

Pieces and shavings are means of metalworking fluid dissipation due to drag out. There are several available techniques which can lead to a 50% reduction of drag out.

- Centrifuge
- Blower
- Vibration equipment
- Compacting equipment

Storage emplacement

An adequate emplacement can minimize cleaning operations and ease waste management.

Case Studies

According to the case studies reported by IHOBE [16], the potential reductions of waste metalworking fluids generation in companies implementing different cleaner production actions include:

New technologies:

- The construction of a central distribution tank has reduced waste generation between 25 and 70% depending on companies.
- The implementation of maintenance units has led to a 56-90% reduction of waste metalworking fluids.
- A case study in which MQL technology has been implemented reported a 100% reduction of metalworking fluids.

Good practices:

- Establishing a control plan has reduced waste in 41-90%.
- Through defining responsibilities in metalworking fluid management, it has been reported a 30% of waste reduction.

Two pollution prevention case studies focused at metal shaping companies, have been reported in MEDCLEAN Files [15]:

LAMINADOS DE ALUMINIO ESPECIALES, S.A. (LAE). (Rubí, Spain)

LAE manufactures evaporators for refrigeration devices from aluminium cylindrical shells of 6mm of thickness.

The modification consisted of the installation of a 3,000 litres underground tank where the recirculated cutting-oil and the spills from manufacturing processes are stored by gravity. After filtering, the cutting-oil is sent to a central distribution tank for reuse.

When the cutting-oil is considered to be faulty, it is directly sent from the collection tank to a vertical tank with a capacity for 25,000 litres. This vertical tank feeds an automatic tangential microfiltration unit constituted by 2 filtering modules with ceramic membranes, which have a filtering capacity of 2,900 litres/week. This unit separates water, which can then be reused given its high quality, from oils which are no longer reusable and which must be managed as waste.

Balances:

	Old process	**New process**
Waste Generation	200,000 l/year	10,000 l/year
Expenses		
Waste Treatment	13,333 €/year	667 €/year
Waste Transport	3,333 €/year	333 €/year
Energy	400 €/year	1,333 €/year
Personnel	4,000 €/year	4,000 €/year
Total Cost	21,067 €/year	6,333 €/year
Investment		34,067 €/year
Pay-back		2,3 years

The implementation of a central tank and microfiltration of cutting oil reduced waste generation (cutting oil) from 200,000 l/year in the old process to 10,000 l/year in the new process, which involves a 95 % reduction. The investment had a pay-back period of 2,3 years.

COMPONENTES MECÁNICOS, S.A. (COMESA) (Barcelona, Spain).

COMESA makes gear boxes and rear axles for industrial vehicles.
The initiative consisted of installing a vacuum evaporation unit which, after filtration, treats the following waste: cutting oils (drilling fluids), spent part rinsing baths and dirty water from the floor and line washes. This unit generates two effluents. One is a concentrate (5% of the starting volume) and is subsequently managed by an outside company. The other is a distillate and corresponds to the water contained in the waste. This water is taken to two 1000 litre tanks where it is stored for its subsequent use as water in the auxiliary cleaning process and in the rinsing baths of the parts.

Balances

	Old process	New process
Comparison of material Water consumption Liquid waste to be treated	 634,000 l/year 654,000 l/year	 118,000 l/year 33,000 l/year
Economic comparison Water consumption cost Liquid waste management cost Energy and unit maintenance cost	 2,193.7 €/year 149,363.5 €/year -	 781.3 €/year 7,861.2 €/year 7,843.2 €/year
Savings and costs Water consumption saving Liquid waste management saving Energy and maintenance costs		 1,412.5 €/year 141,502.3 €/year 7,843.2 €/year
Total savings **Investment in facilities** **Payback period**		135,071.6 €/year 82,078.9 €/year 0.61 years = 7months

Due to internal recycling actions, the liquid waste to be treated was reduced by 95%. The economic balance concludes that the investment in facilities only had a payback period of 7 months.

5.2.2.3 Spent process baths and metal sludges

Cleaner Production Actions

Prior minimization options are described as follows [13], [16], [17]:

Extending bath operating life

Maintenance and replacement of leaking tanks, piping, valves, and seals along with good housekeeping in general are critical to reducing wastes.

Bath maintenance and cleaning operations lead to two significant environmental targets: first, they avoid generation of spent baths by achieving a longer life of the bath and second, they enable the return of dragged electrolyte to the bath.

Common operations are: filtration, active carbon treatment, selective electrolysis, etc.

As for degreasing baths, the main techniques are: oil removers (oil skimmers), centrifuge and ultrafiltration.

Minimizing drag-out

If the drag-out is minimized, the charge of pollutants in wastewater is reduced and, therefore, the amount of metal sludges. It is also possible to reduce rinse water.

The main recommended action is to increase drainage time. The design of racks and drums and the collocation of the parts will contribute to this target.

Optimizing cleaning techniques

It is necessary to know the required quality of the cleaning water and the possible techniques according to the number of positions available.

Returning dragged bath or electrolyte

The return can be direct or indirect:

- Direct: it can be either continuous, if the cleaning technique (flows) has been optimized, or discontinuous through recovery tanks (a recovery of 85% can be achieved)

- Indirect: A complete recovery is achievable but auxiliary equipments are needed such as evaporators.

Recovering Metals

In the past, for most plating lines, it was not cost-effective to recover metals from wastewater or spent process baths. Recovered metals can be returned to baths, sold or returned to suppliers. Technologies for recovering metals and metal salts include evaporation, reverse osmosis, ion exchange, electrolytic recovery, and electrodialysis. The volume of waste, concentration of metals, potential for reuse, and treatment and disposal costs all have an influence on the viability of these options.

Using Low Concentrations

Keeping the chemical concentration at the lowest acceptable operating level will reduce the loss of process chemicals due to drag-out. To find out this level, the plater may need to perform trial and error reductions of chemical amounts from that specified by the supplier. At some point, quality will be affected and the concentration must be kept at a high enough level to ensure product integrity. Monitoring baths should be an ongoing process to allow for continued use of low chemical concentration baths.

Raw Material Substitution or Product Elimination

Some industries have eliminated the use of plating materials including cyanide and cadmium. This has either been done by material substitution or elimination of a product line:

- **Plating chrome process:** there is a current trend to switch from hexavalent baths to trivalent chromium in decorative plating as the latter is considerably less toxic. However, in most cases, the most appropriate a substitute for hard plating chrome has not yet been found to achieve the desired quality of the product .
- **Copper bath:** the most common option is the alkaline cyanide bath which can be substituted by alkaline or acidic bath without cyanide in some concrete applications.
- **Cadmium bath:** it can be substituted by other materials depending on the coating target: zinc when high corrosion resistance is required, zinc alloys for automotive industry or aluminium for decorative plating.
- **Zinc process:** the alkaline cyanide bath is progressively being substituted by alkaline or acidic bath without cyanide.
- **Brass, silver bath:** no alternatives to cyanide bath have been found.
- **Gold bath:** the metal from the spent baths is recovered completely due to its high cost. Cyanide compounds are oxidized in the electrolytic tank where gold is deposited, hazardous waste is, therefore minimized.

Case Studies

Five pollution prevention case studies focused at metal plating companies, have been reported in MEDCLEAN Files [15]:

SANDOVAL, S.L (L'Hospitalet de Llobregat, Spain)
Its operations involve the zinc electrocoating of metal parts in drums and racks.

Sandoval, S.L. adopted the principles of pollution prevention policy and progressively applied various waste and emission minimisation actions, in which particular attention was paid to good professional practices. As a result, Sandoval S.L. substantially improved its performance. The main actions were:

a. Increased drainage time of parts on racks and increased drum spinning duration, achieving a 65% reduction in drag-out.

b. Changes in some processes, with a 20-50% increase in the average operating life of pickling, degreasing and passivating baths.
c. Segregation of effluents according to their characteristics and various improvements in purification systems, achieving a 70% drop in purifying chemicals consumption and a significant reduction (as yet impossible to calculate) in sludge generation.

Balances:

	Old process	**New process**
Water Consumption Bath Salt Consumption Treatment Plant Chemical Consumption	35,000 m3/year 23 t/year 50 t/year	25,000 m3/year 13 t/year 20 t/year
Water Expenses Bath Salt Expenses	37,333 €/year 10,000 €/year	26,667 €/year 5,667 €/year
Treatment Plant Chemical Expenses Sewage Tax	6,667 €/year 6,667 €/year	2,667 €/year 5,167 €/year
Total Cost **Annual Savings** **Investment** **Pay-back**	60,667 €/year	40,167 €/year 20,500 €/year 6,667 €/year 4 months

The total amount of investment will be paid back in only 4 months.

ECZACIBASI YAPI GEREÇLERI A.S. (Artema Armatur Grubu, Turkey).
This company produces chromium and copper plated sanitary fittings since 1983.

In 1993 a new fully automated electroplating plant was installed. Some differences between the old and new processes are:
a. In this new process cyanide copper plating was eliminated.
b. In plating and degreasing sections, solution vapours were collected by a push-pull system and were discharged to the atmosphere after wet filtration.
c. Recirculation water system was also included. This system cleans the polluted water by means of cation and anion exchange columns. Clean water is pumped to plating line to be used in rinsing tanks and polluted water from rinsing tanks is collected and discharged in a recirculation tank to be cleaned and reused again in plating line. With this action the amount of used water has been reduced by 1/6.

d. In 1997-1998, the cleaning tanks after chromium and nickel tanks were converted to economy tanks to reuse chrome and nickel solution. With this modification chemicals carried by plated pieces from plating tanks were reduced more than 80% and the quality of plated surfaces was not affected.
e. In this new process, new filter press and sludge dryer systems for wastewater treatment section were introduced. Thus, water content of filter press sludge decreased from more than 80% to less than 65% and water content of dried sludge is less than 15%.

With the introduction of these pollution prevention opportunities, the benefits achieved were:

- **Reduction of the volume of effluents to be treated. Total wastewater treated in the sewage treatment plant was reduced by the ratio of 1/6 in comparison with the old plating process.**
- **Reduction of used chemicals and generated sludge. In concrete, the total amount of used chemicals in plating plant and in the sewage treatment plant was reduced by 50% and sludges were reduced by 70%.**
- **Total elimination of the cyanide copper plating process because of the risk problem to surroundings and employees.**

<u>Balances:</u>

Pollution prevention opportunities	**Investment**	**Annual savings**	**Pay-back**
Fully automated plating plant	1,800,000 €	590,000 €/y	3 years
Filter press and sludge dryer	120,000 €	50,000 €/y	2,4 years
Chrome economy tank	2,000 €		1 month
Nickel economy tank	2,000 €		1 month
Total Annual Savings Total Investment	1,924,000 €	683,000 €/y	

The different investments had payback periods between 1 month and 3 years.

ZINCATS INDUSTRIALS CANOVELLES, S.L. (Vallès Oriental. Spain)

Surface treatment company whose operations involve zinc coating of metal pieces.

In order to replace the cyanided alkaline zinc bath with an alkaline zinc bath without cyanide, the company exhausted the cyanided zinc bath, and proceeded to treat the remaining in the company's wastewater treatment plant.

The alkaline zinc bath without cyanide was then brought into operation and, in order to guarantee the good functioning of the new bath, an auxiliary tank for the chemical zinc solution that feeds the treatment bath was installed. It has not been necessary to make any other process modification in the zinc-plating line.

Balances:

	Old process	New process
Balances of material		
Sodium hypochlorite	50 t/year	0 t/year
Soda	30 t/year	26 t/year
Total sewage sludge production	13 t/year	8.5 t/year
Process costs		
Bath replacement costs	7,580 €/year	3,860 €/year
Environmental costs		
Wastewater treatment costs	19,050 €/year	11,265 €/year
Sludge sewage management costs	2,910 €/year	1,380 €/year
Total Cost	29,540 €/year	16,505 €/year
Annual Savings		13,034 €/year
Investment		22,580 €/year
Pay-back		1.7 years

Due to process redesign and change of raw materials, the total sewage sludge production decreased by approximately 35%. The investment made had a payback period of 1.7 years.

ST MICROELECTRONICS Ltd. (Malta)

The company assembles and tests a wide range of semi-conductor products in major high technology sectors. The company's environmental programme to reduce water consumption aimed at recycling electroplating wastewater was completed in 1998.

The wastewater recycling system required the segregation of the different types of process wastewaters in order to use the appropriate technology to recover them. Four drains were found to be necessary, and therefore, four streams were obtained: acid concentrate containing copper, acid concentrate containing tin and lead, rinse waters containing copper, and rinse waters containing tin and lead. The drains were installed on all electroplating machines. The main results were:

The two drains for concentrates were sent directly into storage tanks from where they were circulated into electrowinners and subjected to plate out of metals for recovery. Copper and tin metals were sold to a metal recovery firm. The acid generated by electrolytic removal of the metals was collected and reused for regeneration of scavenger resins. The steams of rinsing operations were then passed into scavenger ion-exchange resins for the removal of heavy metals before being passed into a reverse osmosis unit, whose product was further processed by ion-exchange resins for removal of all other traces of salts. The resulting deionised water was conveyed back to the electroplating machines to be used once again as rinse water.

Balances:

Water recycling and metal recovery system reduced water and chemical consumption. Due to these savings, the initial investment of 919,548 € had a payback period of 4.8 years.

The adoption of these cleaner production options, the recovery of heavy metals and ulterior selling to a metal recovery firm, and the reuse of acid generated by metals electrolytic removal, contributed to reduce the generation of hazardous sludge containing heavy metals.

CONSTRUCCIONES MECÁNICAS DOMÈNECH (Olot, Spain).

It manufactures machines and assembles power transmission components.

The company replaced the cyanide salts with a hydrocarbon (methyl alcohol). The reductive gas is produced by a hydrocarbon controlled drip system that, when ignited within a furnace chamber (oven), produces the cementation or reductive atmosphere. This replacement involved the redesign and replacement of the cementation ovens, of their heating system and of the tubing and control units.

Once the required cementation depth has been attained, the part goes on to the production line.

Balances:

	Old process	New process
Balances of material		
Consumption of cyanide salts	3,349 kg/year	0 kg/year
Consumption of methyl alcohol	0 l/year	820 l/year
Generation of special wastes associated with this stage	2,850 kg/year	0 kg/year
Electrical consumption of cementation	465,150 kwh/year	118,200 kwh/year
Consumption of natural gas	0 m3/year	18,725 m3/year

Economic balances		
Cost of cyanide salts	11,072.3 €/year	0 €/year
Cost of methyl alcohol	0 €/year	1,652.8 €/year
Cost of cyanide waste management	8,173.8 €/year	0 €/year
Cost of electrical consumption	50,736.8 €/year	8,882.2 €/year
Cost of natural gas	0 €/year	10,127.1 €/year
Cost of facility maintenance	8,392.3 €/year	2,424.9 €/year
Total Savings		37,694.5 €/year
Investment in facilities		186,185 €
Pay-back		3.3 years

Due to process redesign and exchange of raw materials, generation of special wastes associated with this stage was totally eliminated. The investment in facilities had a payback period of 3.3 years.

5.3 Chemical industry

According to the prioritization of industrial sectors that has been presented previously, inorganic chemical industry is the second industrial sector in which the generation of hazardous wastes should be reduced. Organic chemical industry occupies the fourth place in the ranking. Consequently, chemical industry as a whole has been considered as the second priority industrial sector where minimisation options should be further encouraged.

The two main reasons are:

- Inorganic and organic chemical industry have been identified as priority industrial sectors in nine and six, respectively, out of the 16 countries analysed, considering the following criteria: total amount, environmental impact, impact on Mediterranean Sea and growth prospect.

- Some priority hazardous waste types identified are mainly generated by chemical industry: wastes from formulation and use of inks, dyes, pigments, paints, lacquers and varnishes; acidic solutions or acids in solid form; wastes from the production, formulation and use of organic solvents and wastes from the production, formulation and use of resin latex, plasticizers, glues/adhesives.

5.3.1 Types of specific hazardous wastes to be minimised

It is difficult to distinguish hazardous from non hazardous wastes generated by chemical industrial operations because of the variety of chemical compounds that are likely to participate in chemical processes. As a result, the same waste type can display different hazardous properties or lack of hazardousness depending on the concentration of dangerous substances according to Annex III to Council Directive 91/689/EEC.

Nevertheless, according to the European Waste Catalogue the general types of hazardous wastes associated with chemical industry are:

<u>Hazardous wastes originated by inorganic chemical industry</u>, they are classified according to the specific dangerous compounds (acids, metals, anions, salt, etc) which they contain:

- Sulphuric acid and sulphurous acid
- Hydrochloric acid
- Phosphoric and phosphorous acid
- Nitric and nitrous acid
- Calcium hydroxide

- Ammonium hydroxide
- Sodium and potassium hydroxide
- Solid salts and solutions containing cyanides
- Solid salts and solutions containing heavy metals
- Wastes containing arsenic
- Wastes containing mercury
- Sludges from on-site effluent treatment containing dangerous solutions
- Wastes containing asbestos from electrolysis
- Activated carbon from chlorine production
- Waste containing dangerous silicones
- Etc.

As for organic chemical industry, the most common types of hazardous wastes can be summarised as follows:

- Aquous washing liquids and mother liquors
- Organic halogenated solvents, washing liquids and mother liquors
- Other organic solvents, washing liquids and mother liquors
- Halogenated still bottoms and reaction residues
- Other still bottoms and reaction residues
- Halogenated filter cakes and spent absorbents
- Other filter cakes and spent absorbents
- Sludges from on-site effluent treatment containig dangerous substances
- Wastes from additives containing dangerous substances
- Solid wastes containing dangerous substances
- Etc.

Thus, wastes from organic chemistry have been mainly classified according to their source while wastes resulting from inorganic chemistry have been mainly classified according to their chemical properties.

From the point of view of waste minimisation, hazardous wastes are classified according to their source. For instance, following BREF [19], the following hazardous wastes have been identified:

- Off-specification raw materials

- Spent catalyst and catalyst support

Catalysts may be spent because of chemical desactivation, physical degradation or fouling. The composition of catalysts varies greatly and is often subject to a high level of confidentiality. Many catalysts are based on expensive, exotic metals and this provides an economic incentive for catalyst regeneration (either on or off site).

- Wastes on shutdown (e.g. organic residues)

- Corrosion and erosion products inside equipment (e.g. oxides of iron and other metals)

- Spent purification media

A variety of media are used to purify the product of impurities such as water or unwanted side products (e.g. activated carbon, molecular sieves, filter media, desiccants, ion exchange resins). Where possible , media is regenerated.

- Unwanted by-products

- Process residues

Heavy organic residues from distillation columns (e.g. tars and waxes) and vessels sludge.

- Spent reagents (e.g. organic solvents)

- Off-specification products

- Waste packaging which have contacted dangerous substances

- Adsorbents used for spill clean-up

- Solids produced by the abatement of air pollutants (e.g. dust from electrostatic precipitators, bag filters)

- Solids produced by the abatement of water pollutants (e.g. catalyst solids settled from waste water, filter cake).

- Ashes

- Soots from furnaces, heaters and other combustion equipment

- Spent cleaning agents (e.g. phosphoric acid)

- Spent oils (lubrication, hydraulic etc)

- Spent heat transfer fluids.

5.3.2 Waste minimization options

The integration of environmental protection into process design has spawned the terms ‘green synthesis’ and ‘green chemistry’. Green chemistry has been defined as “the utilisation of a set of principles that reduces or eliminates the use or generation of hazardous substances in the design, manufacture, and application of chemical products” ([Anastas & Warner, 1998 #44] in [19])

The goal of green chemistry is to reduce the inherent hazards associated with products and processes, whilst maintaining the improvements to the quality of life that the industry has brought. It is not a radical new approach since it builds upon factors that have always been part of process design, but it integrates environmental considerations into the heart of decision making. Green Chemistry has been summarised into twelve principles (Table 5-2). These should be incorporated into the design of any new chemical process, and whenever major modifications of existing processes provide suitable opportunities.

Table 5-2 Principles of Green Chemistry [20]

1. It is better to prevent than to treat or clean up waste after it is formed.
2. Synthetic methods should be designed to maximise the incorporation of all materials used in the process into the final product.
3. Wherever practicable, synthetic methodologies should be designed to use and generate substances that possess little or no toxicity to human health and the environment.
4. Chemical products should be designed to preserve efficacy of function while reducing toxicity.
5. The use of auxiliary substances (e.g. solvents, separation agents) should be made unnecessary wherever possible and, innocuous when used.
6. Energy requirements should be recognised for the environmental and economic impacts and should be minimised. Synthetic methods should be conducted at ambient temperature and pressure.
7. A new material feedstock should be renewable rather than depleting wherever technically and economically practicable.
8. Unnecessary derivisation (*use of derivatives*) (blocking group, protection/de-protection, temporary modification or physical/chemical processes) should be avoided whenever possible.
9. Catalytic reagents (as selective as possible) are superior to *un-catalysed* reagents.
10. Chemical products should be designed so that at the end of their function they do not persist in the environment and (that they) break down into innocuous degradation products.
11. Analytical methodologies need to be further developed to allow for real-time, in-process monitoring and control prior to the formation of hazardous substances.
12. Substances and the form of a substance used in the chemical process should be chosen so as to minimise the potential for chemical accidents, including releases, explosions and fires.

5.3.2.1 Product Changes

While beyond the immediate scope of European IPPC Directive, if the actual product from a process has significant environmental impact, then operators and regulators should question the need for its production and examine the viability of alternatives. If it is possible to produce a more environmentally benign product that fulfils the same purpose, has an equivalent specification and a similar production cost, then the presumption should be for the substitute. Drivers for product changes may come increasingly from customers, banks and insurance companies who require more attention to be paid to the overall Life Cycle of the product.

It may also be possible to reformulate or re-specify the product in order to reduce the quantity of waste arising from its production (e.g. by relaxing the product specification it may be possible to obviate a separation stage). However, there may be strong economic and technical constraints to such changes as they require agreement from customers (who will have their own waste minimisation concerns).

5.3.2.2 Input material changes

The synthesis of either an organic or inorganic compound typically begins with the selection of the starting material and this choice has a significant influence on the environmental impact of a process. The selection should not only consider the hazardous properties of raw materials and the downstream design implications, but also the environmental impact of how they have been produced. The aim should be to minimise these environmental impacts through substitution with more benign raw materials.

- Auxiliary <u>chemical reagents</u> used in a process can pose environmental issues, either directly from their hazardous properties, or indirectly from downstream processing that they necessitate (e.g. separation from the product).
- <u>Organic solvents</u> are widely used reagents in the production of organic chemical industry and processes should be appraised to determine if the solvent is absolutely necessary (e.g. can water be used as an alternative?). Where the use of an organic solvent cannot be avoided then there should be consideration of replacing it with a solvent of lower volatility and lower environmental impact. After optimisation of these parameters, efforts should then concentrate on reducing the overall use and loss of solvents.
- Impurities in raw materials and auxiliary chemicals will introduce <u>unwanted chemical species</u> into a process. These chemicals usually end up as contaminants in the product and this necessitates a separation stage followed by treatment/disposal of the waste stream. This may be avoided by using the highest possible specification for raw materials and auxiliary chemicals and by using reaction inhibitors to prevent the formation of unwanted by-products.
- The use of regenerative <u>filters and adsorbents</u> or the implementation of mechanics elements in the filtration extend filter's life and reduce waste generation.

The minimisation options concerning imput material changes are generally difficult to implement due to economic causes for example the use of regenerative filters or the introduction of raw materials with a higher purity.

Some potential problems and their approaches concerning input material changes have been identified and are illlustrated in Table 5-3)

Table 5-3 Potential problems and possible approaches regarding input material changes.

Potential Problem	Possible approach
Non-reactant materials (e.g. solvents, adsorbents) create wastes. Each chemical (including water) employed within the process introduces additional potential waste sources and the composition of generated wastes tends to become more complex.	• Evaluate unit operations or technologies that do not require the addition of solvents or other non-reactant chemicals.
Non-regenerative treatment systems result in increased waste (compared with regenerative systems).	• Regenerative fixed beds or desiccants (e.g. aluminium oxide, silica, activated carbon, molecular sieves) generate less solid and liquid waste than non-regenerative units (e.g. calcium chloride, activated clay). However the activation and regeneration of beds can cause significant pollutants.
By-product formation, incomplete conversion and less-than-perfect yield	• Use a more selective catalyst that will reduce the yield of undesired by-products. • Improve reactor mixing/contacting to increase catalyst efficiency • Increase activity of the catalyst by means of a higher concentration of active components and/or increased surface area. • Develop a thorough understanding of reaction to allow optimisation of the process. Include catalyst consumption and by-product yield.
The presence of heavy metals in catalysts can result in contaminated waste water, waste gases, waste or (by)products	• Use catalysts comprised of noble metals or non-toxic metals. Both on-site and off-site re-claimers generally recycle catalysts containing noble metals. • Use a more robust catalyst or support in case of heterogeneous catalysts
Short catalyst life	• Use catalyst which is less sensitive • Avoid conditions which promote thermal or chemical deactivation • By extending catalyst life, emissions associated with catalyst handling and regeneration are minimised.
Impurities may produce unwanted by-products and waste. Toxic impurities, even in trace amounts, can make a waste	• Use higher purity raw materials. • Purify materials before use and re-use if

Potential Problem	Possible approach
hazardous.	practicable • Use inhibitors to prevent side reactions. Note that inhibitors may have environmental impact themselves.
Impurities may poison catalyst prematurely, resulting in increased wastes due to yield loss and more frequent catalyst replacement	• Install guard beds to protect catalyst.
Hazardous or toxic compounds are found in the waste streams.	• Evaluate which process conditions, routes or reagents (e.g. solvent, catalysts) can be substituted or changed to reduce or eliminate hazardous or toxic compounds.

5.3.2.3 Technology changes

Technology changes involve modifications to existing process equipment, or the use of a fundamentally new process to produce the same product. Since technology changes are concerned with process hardware there is often a need for design, expenditure approval and construction that may slow their implementation. New technologies, especially catalytic processes, may also be patented and this may hinder widespread adoption.

<u>Production process changes:</u> Expenditure on raw materials is usually the largest cost in producing organic chemicals. For commercial reasons, operators therefore aim to maximise the reaction yield and selectivity by applying effective processes that use high performance, selective catalysts and well-designed reactors. This approach typically ensures that environmental emissions are also minimised.

Catalytic reagents are generally better to un-catalysed reagents on environmental grounds and on process efficiency, although catalysts can themselves create environmental issues. In the design of catalysts it is undesirable to have a low yield per pass of reactants as this necessitates a substantial recycle that is costly and uses power. However, a low conversion per pass often produces a high selectivity, and so there is an economic balance between improved feedstock consumption and energy cost for recycles.

There are often practical obstacles to attain the yield that is theoretically achievable from reaction kinetics or stoichiometry. The following factors should therefore be considered in deciding the optimal yield:

- energy consumption can increase as the maximum yield is approached and this has associated costs and combustion emissions

- safety considerations may become limiting (e.g. explosion limits)
- in equilibrium reactions secondary products may accumulate and require removal (for example by recycling within the process).

However, it is possible for a reaction to have 100 % yield and yet still generate substantial quantities of waste. For this reason, it is suggested ([Anastas & Warner, 1998 #44] in [19]) that a better measure of reaction economy is ‘atom efficiency’ (the ratio of the molecular weight of desired product to the molecular weight of all material generated by a reaction). On the basis of atom efficiency, substitution and elimination reactions are undesirable because they generate stoichiometric quantities of unwanted by-products and waste. By contrast, addition reactions show high atom efficiency because they incorporate all the starting materials into the final product.

Biotechnology enables the production of chemicals by means of the synthesising powers of micro-organisms or by using their purified enzymes as biocatalysts. It therefore avoids the use of toxic catalysts, organic solvents and extreme process conditions, although it may generate different waste streams. At present, biotechnology experience is mainly limited to fine chemicals, but it is expected to have increasing application to organic chemical industry. At the moment, the main disadvantages are economic and technical.

<u>Changes to equipment, layout or piping</u>: The ultimate aim is for closed processes with no release points to the environment, but this is rarely practicable and the aim is to minimise the number of releases. Operators should aim to reduce equipment-related inefficiencies using such techniques as better seals on pumps to prevent leaks (ingress and egress), and vapour recovery lines to return VOCs to the process.

<u>Additional automation</u>: Additional monitoring and alarm equipment is desirable since it improves the data on process variables and hence enables better process control. Increased automation of process control reduces the likelihood of human error, although this should not be at the expense of operator understanding of process control.

<u>Process Optimisation</u>: There are many process specific changes that can be made to process variables (flow, pressure, temperature, residence time) that optimise production and minimise wastes.

Some potential problems and their approaches concerning technology changes have been identified as follows (see Table 5-4):

Table 5-4 Potential problems and possible approaches regarding technology changes

Potential Problem	Possible approach
Numerous processing steps create	• Keep it simple. Make sure all operations

Potential Problem	Possible approach
wastes and opportunities for errors	are entirely necessary.
Intermediates may contain toxic constituents or have characteristics that are harmful to the environment, under both normal or upset conditions	• Modify process to reduce amount or change composition of intermediates • Use equipment design and process control to reduce emissions
Process inefficiencies and increased emissions of batch processes	• Use continuous process where possible • Sequence the addition of reactants and reagents to optimise yields and lower emissions
Wastes are generated as part of the process.	• Determine what changes of process conditions would lower waste generation or toxicity. • Determine if wastes can be recycled into the process
Shutdowns and start-ups generate waste and releases	• Preferably use continuous processes • Optimise on-line run-time • Optimise shutdown interlock inspection frequency • Identify safety and environment critical instruments and equipment • Improve on-line controls • Use automatic start-up and shut down • On-line vibration analysis • Use ‘consensus’ systems (e.g. shutdown trip requires 2 out of 3 affirmative responses).
Leaks to soil and groundwater, leaking losses	• Design equipment layout to minimise pipe run length. • Eliminate underground piping or design with cathode protection • Welded fittings. • Reduce number of flanges and valves. • Use all welded pipe. • Use spiral wound gaskets. • Use plugs and double valves for open-end-lines. • Change metallurgy • Use lined pipe • Monitor for corrosion and erosion. • Paint to prevent external corrosion

5.3.2.4 Good operating practices

Good operating practices are techniques involving management, organisation or personnel that can be used to minimise waste (i.e. software changes). They can often be implemented very quickly, at little cost, and bring efficiency savings with a high return on investment.

Management practices: Management systems may include staff training, suggestion schemes to encourage waste minimisation, and a clear specification to employees of what a good practice actually entails. Although more of an issue for batch processes, production scheduling is also important to minimise the need for vessel opening and cleaning.

Materials handling: Process wastes are often just damaged final products, spill residues or outof-date / off-specification raw materials. Significant waste reductions can therefore be conferred by inventory control (e.g. reducing the inventory size, increasing turnover, and consolidating chemical use) and material controls (reducing raw material and product loss, and preventing damage during handling / storage).

Waste segregation: Waste streams should be kept separate to reduce the volume of mixed wastes and hence facilitate re-use and treatment

Cost accounting: The full costs of waste treatment and disposal should be allocated to all process activities so that each production unit is aware of the economic implications of waste generation.

Control of operating conditions such as temperature, pressure, time of residence, etc. and materials or reagents addition.

Spill and leak prevention: Precautionary modifications should be made to ensure that spills and leaks do not occur, and that they are dealt with promptly when they do arise. The following techniques may be applicable:

- identify all hazardous substances used or generated in a process
- identify all the potential sources / scenarios of spillage and leakage
- assess the risks posed by spills and leaks
- review historical incidents and remedies
- implement hardware (e.g. containment, high level alarms) and software (e.g. inspection and maintenance regimes) to ameliorate the risks
- establish incident response procedures
- provide appropriate clean-up equipment (e.g. adsorbents for mopping up spills after small leaks or maintenance works)
- establish incident reporting procedures (both internally and externally)

- establish systems for promptly investigating all incidents (and near-miss events) to identify the causes and recommend remedial actions
- ensure that agreed remedial actions are implemented promptly
- disseminate incident learning, as appropriate, within the process, site, company or industry to promote future prevention.

The vast majority of good operating practices are highly viable economically and technically.

Some potential problems and their approaches concerning good operating practices have been identified as follows (see Table 5-5):

Table 5-5 Potential problems and possible approaches regarding good practices

Potential Problem	Possible approach
Leaking losses from equipment	• Minimise operating pressure. Equipment operating under vacuum is not a source of fugitives; however, leaks into the process require control when system is degassed. • Reduce leaking losses by control measures
Material contamination occurs from corrosion products. Equipment failures result from spills, leaks and increased maintenance costs	• Avoid corrosivity of materials contacting equipment. • Neutralise corrosivity of materials contacting equipment. This may generate waste. • Improve metallurgy or provide lining or coating of equipment • Use corrosion inhibitors. This may generate waste.
Waste generated by cleaning/purging of process equipment between production batches	• Use materials with low viscosity. Minimise equipment roughness. • Optimise product manufacturing sequence to minimise washing operations and cross-contamination of subsequent batches.
Large inventories can lead to spills, inherent safety issues and material expiration.	• Minimise inventory by just-in-time delivery.?
Small containers increase handling frequency which increases changes of material releases and waste residues from shipping containers	• Use bulk supply, or ship by pipeline. • Pack the product in the same containers that the raw materials were supplied in. • Use returnable containers or drums

Potential Problem	Possible approach
Characteristics and sources of waste are unknown.	• Document sources, quantities and quality of waste streams prior to pollution prevention assessment
Environmental fate and waste properties are not known or understood.	• Evaluate waste characteristics using the following type properties: corrosivity, flammability, reactivity, energy content, biodegradability, aquatic toxicity and bio-accumulation potential of the waste and its degradable products, and whether it is a solid, liquid or gas.
Ability to treat and manage hazardous and toxic wastes unknown or limited.	• Consider and evaluate all onsite and offsite recycle, re-use, treatment, and disposal options available. Determine availability of facilities to treat or manage wastes generated.
Leaks to soil and groundwater	• Reduce unnecessary purges, transfers and samplings • Use drip pans where necessary • Water stops • Embedded metal planes • Epoxy, or other, impervious
Leaks and emissions during cleaning	• Design equipment for cleaning • Design for minimum rinsing • Design for minimum sludge • Provide vapour enclosure • Drain to process water system or sump • Use drip pans for maintenance activities • Re-use cleaning solutions
Contaminated materials due to tubes leaking at tube sheets	• Use welded tubes or double tube sheets with inert purge. • Operate the least critical medium at a slight overpressure. • Mount vertically. • Steam heating can reduce decomposition and fouling (but may be less efficient than direct firing).
Leaking losses from shaft seal leaks	• Use pressure transfer to eliminate pump. • Mechanical seal instead of packing. • Double mechanical seal with inert barrier fluid vented to control device. • Seal-less pump (canned motor magnetic drive). • Use vertical pump.

Potential Problem	Possible approach
	• Seal installation practices. • Monitor for leaks.
Residual 'heel' of liquid during pump maintenance	• Low point drain on pump housing • Flush housing to process sewer for treatment • Increase running time pump by selecting proper sealing materials, good alignment, reduced pipe-induced stress, maintaining seal lubrication
Leaking losses	• Vent to control or recovery equipment? • Monitor for leaking losses (particularly after the valve has discharged) • Monitor for control efficiency
Waste generation due to samples (from disposal, containers, leaks, fugitives)	• Reduce number and size of samples needed • Sample at the lowest possible temperature • Cool before sampling • Use in-line in-situ analysers • System for return to process • Closed loop • Drain to sump or process water system

5.3.2.5 Recycling

Where it is not possible to prevent waste arising through source reduction techniques, then opportunities to recycle wastes, off-specification products and by-products should be investigated.

Use and re-use: It may be possible to return the waste material back to the originating process as a substitute for an input material. The waste may also be re-used in another process, possibly utilising the waste exchange services that exist in many countries. The potential for re-use of a waste will be determined by its effect on the process; its economic value, and the supply (availability and consistency of composition).

Reclamation: Rather than direct re-use, reclamation involves waste processing to recover the resource value. Reclamation depends on the ability to segregate the desired material from the waste stream. Examples include the recovery of the chlorine content of chlorinated VOCs by incineration and absorption, and solvent cleaning by distillation. The energy value of VOCs can also be reclaimed by their use as fuel.

Some potential problems and their approaches concerning recycling techniques have been identified and are illustrated in Table 5-6):

Table 5-6 Potential problems and possible approaches regarding recycling

Potential Problem	Possible approach
High conversion with low yields results in wastes	• Recycle operations generally improve overall use of raw materials and chemicals, thereby increasing the yield of desired products while also reducing the generation of wastes. For example, operating at a lower conversion rate per reaction cycle (by reducing catalyst consumption, temperature or residence time) can result in a higher selectivity to the desired products. The net effect upon recycle of unreacted reagents is an increase in product yield, reduced quantities of spent catalyst and less desirable by-products.
Waste by-product formation)	• Provide separate reactor for converting recycle streams to usable products • Optimise reaction conditions (e.g. temperature, pressure)

5.3.3 Case Studies

Four pollution prevention case studies focused on chemical industries, have been reported in MEDCLEAN Files [15]:

HERBOS d.d (Sisak, Croatia)

This company produces herbicides and discharges wastewater higly contaminated with herbicide Atrazine.
Two main cleaner production measures were implemented:

a. Increase of raw material exhaustion (for 1%) was performed by better control of the process, improved housekeeping and slight process modification.
b. Reduction of wastewater pollution. Adding more tenzide in the Atrazine synthesis process, filterability of the suspension was much better, the filtration of total mixture was easier and faster and no decantation phase (the main source of water pollution) was needed.

These measures did not require any capital investments.

After some initial investigative work of Atrazine synthesis, the process control was improved. The raw materials exhaustion was increased for 1% and by adding more tenzide, the filterability of product suspension was better. The financial savings were obtained by the reduction of: consumption of raw materials, final product lost, and wastewater discharge fee the investments for wastewater treatment plant.

Savings

Raw material	101 tonnes/year
Final product	21 tonnes/year
COD	54 tonnes O_2/year

Financial Savings
215.000 € /year

Fertilizers and Chemicals LTD (Haifa, Israel)

This is a medium-size chemical company that produces liquid fertiliser formulations, water treatment chemicals and organic intermediates.

The filter cake of raw acidic nitration product is soaked with sulphuric and nitric acids. The filter cake is not washed before dissolution for purification because the wet cake hardens and then becomes very difficult to peel off. As a result, large quantities of these acids end up in wastewater and must be neutralised. After concentration, large amounts of concentrate are also generated and need to be disposed of at high cost.

The process conditions at the precipitation step following nitration were modified in such a way that it now yields significantly larger crystals than previously. This allows for washing of the acid crude filter cake without the last one hardening.
The short washing step introduced (actually displacement of the acid associated with the filter cake) is the performed on the centrifuge at the filtration stage.

Consequently waste water acidity is now very low, requiring only a small amount of base for neutralisation. The generation of sludge to be incinerated has significantly decreased.

Savings

Generation of sludge	1,000 tonnes/year
Consumption of neutralisation material	90 tonnes/year

Total investment	204,000 €
Annual savings	250,000 €/year

HIPERTIN, S.A. (Barberà del Vallès, Spain)

The company manufactures cosmetics (production of peroxide hair dye).
A Minimisation Opportunities Environmental Diagnosis (MOED) was carried out in order to find alternatives that would enable the following goals to be reached:

- Reduction of water consumption, both in the reactor cleaning processes and in the refrigeration circuit.
- Reduction of final product losses due to incomplete draining of the reactor and its oxidation after its contact with the air.
- Reduction of pollutant load discharged and the volume of effluent to be treated.

The actions taken were:

- The drainage system has been improved by keeping the mixer working during the operation and by raising temperature. This favours evacuation of the product, which can be recovered and consequently, does not reach wastewater.
- The cleaning system is now being carried out immediately after draining in order to avoid excessive oxidation by using high temperature and high pressure systems.
- As for the water used for final cleaning, it is stored in order to be used as raw materials in other stages of the cleaning process. As a consequence, water consumption has been reduced further.
- The water circuit has been closed thanks to the installation of cold equipment

Balances:

	Old process	**New process**
Water consumption	2,177.7 m^3/y	40 m^3/y
Production per unit of raw material	97/100 t/t	99/100 t/t
Wastewater generation	2,177.7 m^3/y	0 m^3/y
Savings in water consumption		13,688.05 €
Productivity increase and reduction of losses		54,091.09 €
Savings in waste treatment cost		13,674.23 €
Investment		66,111.33 €

INACSA (Industrias del Acetato de Celulosa, S.A.) La Batllòria, Spain
This is a textile and chemical company which manufactures and manipulates cellulose thread.

The project consists of reintroducing dope waste (solid waste generated by the distillation of acetone used during the cleaning phase, and thread remains) in the manufacturing process. Each type of waste must be previously conditioned:

- Dope waste can be used in the manufacturing of black thread. Thus, only mixing with pure dope adding colouring agent is required.
- Acetone used for cleaning the facilities is distilled and collected as raw material. Regarding the waste produced by acetone distillation (i.e. acetate, colouring and acetone), it is also used for the manufacturing of black thread, through an evaporator allowing the recycling of the product.
- Thread remains are separated in various categories depending on their characteristics: bright or matt, coloured or black, pasted or derived from a mixture of acetate with other types of fibres. They are then dissolved and filtered
- The remains of bright thread are dissolved in a mixer with acetone and used as raw material in the manufacture of dope
- The solution containing black and coloured residual thread serves as raw material for manufacturing black thread.

<u>Balances:</u>

	Old process	**New process**
Waste generated	23,000 kg/y	3,000 kg/y
Process costs: Cellulose acetate Acetone Energy Water Labour force	 2.75 M €/y 88,955 €/y 0 €/y 0 €/y 0 €/y	 2.64 M €/y 85,313 €/y 282 €/y 258 €/y 32,508 €/y
Waste management	2,464 €/y	390.6 €/y
Treatment of wastewater	0 €/y	158.3 €/y
Total costs	**2.84 M €/y**	**2.76 M €/y**
Savings	**82,509 €/y**	
Investment	**144,543 €**	

As a result, the company has achieved a 87% reduction of the generated waste whilst 85% of the remaining waste is recycled within the industrial process, with a positive impact on raw material consumption.

5.4 Oil refining industry

Oil refining industry occupies the third place according to the prioritization of industrial sectors developed previously. Nine out of the eighteen countries analysed considered it as a priority sector. Furthermore, the main type of hazardous waste generated by this sector (Waste tarry residues arising from refining, distillation and any pyrolitic treatment) occupies the third place in the classification of priority hazardous waste types.

5.4.1 Types and sources of hazardous waste to be minimised

Refineries are industrial sites that manage huge amounts of raw materials and products. They are also intensive consumers of energy and water [21]. From storage and from the refining process, they generate emissions to the atmosphere, to water and soil.

Table 5-7 shows a summary of the impact on the different media from the different activities found within refineries. As it can be observed; wastes are generated in several processes or functional units.

Nevertheless, the amount of waste generated by refineries is small if it is compared with the amount of raw materials and products that they process [21].

Table 5-7 Environmental account of refinery processes

Process/Functional unit	Environmental compartment						
	Air	Waste water	Waste	Substances and energy	Waste heat	Noise	Safety
Fundamental processes							
Delivery	—	—	—	—	—	0	X
Loading	X	—	—	—	—	X	X
Storage	X	0	X	0	0	—	X
Process furnaces	X	—	0	X	X	0	X
Separation processes							
Crude oil atmospheric distillation unit	X	X	0	X	X	0	X
Vaccum distillation unit	X	X	0	X	X	0	X
Gas separation unit	X	0	0	0	0	0	X
Conversion processes							
Thermal cracking, visbreaking	X	X	0	X	X	0	X
Delayed coking	X	X	X	X	X	X	X
Catalytic cracking	X	X	X	X	X	0	X
Hydrocracking	X	X	X	X	X	0	X
Bitumen blowing	X	X	X	X	X	0	X
Reforming	X	X	X	X	X	0	X
Isomerisation	X	X	X	X	X	0	X
MTBE production	X	X	X	X	0	0	X
Alkylation	X	0	X	X	0	0	X
Refining processes							
Hydrodesulphurisation	X	X	X	X	X	0	X
Sweetening	X	X	X	X	0	0	X
Gas washing	X	0	X	X	0	0	X
Lubricating oil production	X	X	X	X	0	0	X
Extractions							
- with solvents	X	0	0	X	0	—	X
- with molecular sieves	X	—	X	X	0	—	X
Other processes							
Sulphur plant	X	X	0	0	0	0	X
Flare	X	X	0	0	0	X	X
Cooling tower	X	X	0	0	0	0	0
Waste water treatment	X	X	X	X	0	—	0
Blending units	X	X	0	0	0	—	X
Off-gas clean up (Exhaust gas recovery unit)	X	X	X	0	0	0	X
X: high account		0: small account		—: very small or no account			

An important issue when considering refinery wastes is that there are still many differing definitions between countries, which makes comparisons of waste even more difficult.

Oil refinery waste normally covers three categories of materials:

- ***Sludges*** are defined as emulsions of oil in water, stabilised by the presence of solids. In refineries a number of different types of sludges are generated at the following sources: crude and product tanks bottoms, desalters, alkylation units, boiler feed water preparation, biotreaters, the cleaning of heat exchanger bundles and equipment, oil spills and soil remediation. In terms of volume oily sludges represent the largest waste category from refineries. Partly this is due to the presence of basic sediment and water in the crude, which can vary from crude to crude. Bio-sludge production takes place only if a refinery operates a biotreater.

- ***Other refinery wastes*** including miscellaneous liquid, semi-liquid or solid wastes (e.g. contaminated soil, spent catalysts from conversion processes, oily wastes, incinerator ash, spent caustic, spent clay, spent chemicals, acid tar) are generated from many of the refining processes, petroleum handling operations and waste water treatment. Both hazardous and non-hazardous wastes are generated.
- Spent catalysts originate from reformers, catalytic crackers, hydrocrackers, hydrodemetallisation, hydrodesulphurisation and hydrotreating units. The regeneration of catalysts is a well established technique.

Table 5-8 shows a summary of the main types of solid wastes generated in a refinery and their sources.

Table 5-8 Main solid wastes generated by refineries

Type of waste	**Category**	**Source**
Oiled materials	Oily sludges	Tank bottoms, biotreatment sludges, interceptor sludges, waste water treatment sludges, contaminated soils, desalter sludges
	Solid materials	Contaminated soils, oil spill debris, filter clay acid, tar rags, filter materials, packing, lagging, activated carbons
Non-Oiled materials	Spent catalyst (excluding precious metals)	Fluid catalytic cracking unit catalyst, hydrodesulphurisation / hydrotreatment catalyst, polymerisation unit catalyst, residue conversion catalyst
	Other materials	Resins, boiler feed water sludges, desiccants and absorbents, neutral sludges from alkylation plants, FGD (Flue Gas Desulphurisation) wastes
Drums and containers		Metal, glass, plastic paint
Radioactive waste (if used)		Catalysts, laboratory waste
Scales		Leaded / unleaded scales, rust
Construction / demolition debris		Scrap metal, concrete, asphalt, soil, asbestos, mineral fibres, plastic/wood
Spent chemicals		Laboratory, caustic, acid, additives, sodium carbonate, solvents, MEA/DEA (mono / di-ethanol amine), TML / TEL (tetra methyl / ethyl lead)
Pyrophoric wastes		Scale from tanks / process units
Mixed wastes		Domestic refuse, vegetation
Waste oils		Lube oils, cut oils, transformer oils, recovered oils, engine oils

The amount of sludge generated depends on the types of processes and the availability of incineration. As a common figure, the generation rate of solid waste and sludges is normally less than 0.5 % of crude processed, but in some refineries is less than 0.3 %. According to the World Bank, 80 % of those solid wastes may be considered hazardous because of the presence of toxic organics and heavy metals ([101, World Bank, 1998] in [21]).

The refinery waste generation was covered in a report ([82, CONCAWE, 1995] in [21]) representing the 1993 European refinery waste situation (see Table 5-9). A summary of the waste generated in a refinery is as follows: 45 % sludge, 35 % non-refining wastes and 20 % other refining wastes. However, it is likely that there are differences in percentages for each type of waste between refineries in no European Mediterranean countries and the data reported in Table 5-9).

Table 5-9 Percentage of each type of waste in a refinery

Type of Waste	Percentage (% w/w)
Sludges	
API/DAF/IAF sludges	41.8
WWTP biosludge	30.2
Boiling fresh water preparation sludge	13.0
Tank bottom sludge	7.1
Miscellaneous sludge	6.7
Desalter sludge	0.8
Acid alkylation sludge	0.3
Non-refining wastes (Construction/Demolition and Domestic Wastes)	
Domestic	43.8
Rubble	41.9
Scrap metal	14.3
Other refining wastes production	
Contaminated soil	26.3
FCCU catalyst	19.4
Other wastes	15.5
Miscellaneous oily wastes	8.9
Incinerator ash	6.0
Spent caustic	6.0
Other catalysts	4.7
Desulphurisation catalyst	3.2
Spent clay	2.7
Tank scales	2.4
Sorbents	1.9
Flue gas desulphurisation	1.3
Spent chemicals	1.2
Reformer catalyst	0.4
Acid tar	0.2

Sludges come from stabilisation processes (4.7 % of the total sludge generated after treatments), waste water sludges (39.8 %) and sludges with no treatment (55.5 %). The total amount of identified other refining wastes which are specific to the refining process (e.g. spent catalysts, tank scales, contaminated soils, etc.) generated in 1993 by the 89 European refineries reporting was 201,983 tonnes (i.e. 0.04 % w/w of the total refinery throughput). Data provided by 16 EU+ refineries show that the specific production of waste ranges from 133 to 4200 t/Mt of crude. Table 5-10 shows an example of the waste production of a refinery. However, as mentioned previously, probable differences in percentages for each type of waste between refineries in no European Mediterranean countries and the data shown in Table 5-10 might be found.

Table 5-10 Waste generation of an European refinery

	Non-Hazardous waste 1997 (t)	Hazardous waste 1997 (t)	Sum 1997 (t)
Landfill	7362	1109	8471
Material recycling and thermal treatment	202	2401	2603
Biological treatment	1003	57	1060
Chem./phys, treatment	21	13	34
Total	8588	3580	12168
Note: Waste includes waste generated by storage tanks			

Waste generation trends during the last ten years show that oily sludge production is declining, mainly through housekeeping measures, (i.e. oil retained in sludges or other type of wastes represents a loss of product and, where possible, efforts are made to recover such oil); whereas biological sludge generation has increased as a result of increased biotreatment of refinery effluent. Spent catalysts production is also increasing through the installation of new hydrocrackers, hydrotreatment facilities and catalytic cracker dust collectors. For all these waste categories increased use is made of third party waste contractors for off-site treatment and disposal.

5.4.2 Waste minimisation options

For each type of waste, the minimisation options have been developed. Few actions based on reduction at source (process redesign, product redesign, change of raw materials) have been found. They are mainly focused at recovery and recycling either in site or off site.

5.4.2.1 Sludges

According to [CONCAWE, in 1993] in [21], 44 % of the European refinery sludges were incinerated, 9 % was land farmed and 30 % land filled. It is foreseen that land filling and land farming of sludges will be increasingly prohibited by forthcoming EU legislation, which means that the scope for sludge prevention reduction but also for incineration at third parties will increase in the future.

Dewatering / de-oiling

The purpose of sludge treatment by dewatering or drying is to reduce the volume and the residual hydrocarbon content in order to save costs in subsequent processing or disposal:

The principle of mechanical dewatering by decanters is based on centrifugal forces and on the density difference between water, oil and solids. Decanter centrifuges are widely used in sludge dewatering and deoiling applications throughout the (refining) industry, either as fixed facilities or as a mobile service rendered by contractors.
Dewatered biological and oily sludges can be further processed using drying and/or incineration techniques resulting into virtually oil free residues for which useful applications are available.

De-oiling/dewatering of sludges gives small volume of solid, low solvent waste, (centrifuging or filtration).

Steam dryers

They are almost exclusively applied to biosludge and function often as a pre-treatment step for incineration. Drying is currently hardly employed by refineries due to safety risks.

Applicability

Because of its high cost, waste reduction or recycling are prefered, as minimisation option, to waste incineration.

5.4.2.2 Spent solid catalysts

The use of catalytic processes in refineries is significantly increasing. This increase is mainly due to the introduction of catalytic residue conversion processes such as heavy oil residue cracking, hydrocracking and residue hydroconversion, hydrodemetallisation and hydrofinishing and also hydrogen production. Since 1980 a significant expansion of the hydrotreating and hydrodesulphurisation capacity as well as of sulphur recovery units and associated tail gas treatment has taken place,. Traditional catalytic processes such as fluid catalytic cracking, catalytic reforming and isomerisation are also generators of spent catalysts.

The purpose of spent catalyst management is to minimise environmental and health impacts. To achieve this goal spent catalysts are carefully handled, safely removed, carefully packed and sent for reactivation or metal reclamation. Metal recovery aims at conversion of spent catalysts into useful products, which can be recycled and re-used with minimum impact on the environment.

The principle of spent catalyst management is a scheduled, strictly regulated and safe handling of the materials involved, usually executed by specialised contractors during plant turn-arounds.

Regeneration of hydroprocessing catalysts is usually possible 3 or 4 times. The ultimate spent catalysts are almost exclusively reworked by third parties into commercial metal oxides or metal salt solutions. Although a regeneration process has been developed for spent FCC (Fluidized-bed Catalytic Cracking) catalysts, this process is hardly used due to the availability of cheaper alternatives. The catalyst carrier (alumina and/or silica) can sometimes be converted into products or is disposed of otherwise.

Spent catalysts are distinguished by type, process, composition and recyclability. Some of these catalysts are indicated below:

Co/Mo catalysts are typically used in hydrodesulphurisation, hydrocracking, hydrotreating. Extensive regeneration and reclamation options are available.

Ni/Mo catalysts are typically used in hydrotreaters and hydrocracking units. Regeneration and reclamation capacity is available.

Ni/W catalysts are used in lube oil hydrofinishing. This category experiences limitations to dispose off in view of the high Tungsten content (24 % w/w).

FCC (Fluidized-bed Catalytic Cracking) spent catalysts, also including heavy oil and residue cracking spent catalysts (RCC), are the largest catalyst waste category in refineries. Outlets in road building are becoming available.

Reformer and Isomerisation catalysts are exclusively reprocessed by the suppliers of the fresh catalysts. Replacement contracts have been concluded since the introduction of these processes due to the very expensive noble Pt metal involved.

Hydrodemetallisation catalysts typically have high vanadium contents (10 - 20 %) and are currently alumina based (used to be silica). Direct disposal to the steel industry is possibly the most cost-effective option.

Zn containing beds from H_2 plants are typically recycled to the Zn-industry where ZnS ores are processed. Amounts are some 50 t/yr.

The applied regeneration processes are based on pyrometallurgical techniques (roasting-, calcinations, smelting-, sintering- and reduction furnaces) for thermal destruction of the inorganic matrix and on hydrometallurgical methods (aqueous/acid extraction, crystallisation, precipitation, separation and drying) for recovery/purification of metal salts either in dry form or as liquid metal concentrates.

Reclamation facilities are typically operated in batch mode and contain many different unit operations. From the total spent catalysts only some 5 % pure products are produced. The remainder is either ferro-alloy feed or ceramic raw material. Facilities usually process relatively small batches. Spent hydroprocessing catalysts can vary considerably in composition. Hence, facilities have limited process automation.

Economics

Cost for processing and metal recovery depends strongly on the composition of the spent catalyst concerned. For high metal waste even a recovery fee will be paid to the waste generator. Current processing costs for an average HDS (Hydrodesulphurisation) catalyst could be in the order of € 500/tonne. Recent stringent internationally accepted legal procedures, amongst which special packaging (for rent 2 m3 containers at EUR 5/day), labelling and acceptance requirements as well as transportation costs could add considerably to these costs. As a result, on-site processing of spent catalysts is expensive for a refinery.

Spent FCC (Fluidized-bed Catalytic Cracking) catalysts with limited V/Ni concentrations are accepted with consent of authorities, by raw material suppliers to the road building industry. The material is sometimes used in cement and as asphalt filler.

5.4.2.3 Heavy residues

Heavy residues generated by refineries are the heaviest fractions from the different units (distillation, conversion), have no application for products and are typically re-used within the refinery. Those residues have a calorific value that can be exploited. A list of treatments that may be applied to reduce the amount of those residues is shown below.

1. Methods to increase the hydrogen content (hydrogenation)

- **Catalytic hydrogenation** as Resid Fining, RCD UNIBON, Unicracking, HYVAHL-ASVAHL hydrotreatment, AUROBAN, H-Oil, LCFining, HYCON.
- **Non catalytic hydrogenation** as Hydrovisbreaking, Dynacracking, Donor Solvent Visbreaking.

2. Methods to increase the C-content

- **Catalytic cracking** as Reduced Crude Cracking (RCC), Heavy Oil Cracking, VEBA combi cracking (VCC), Deep catalytic cracking (DCC).

- **Non catalytic cracking** as Delayed Coking, Fluid Coking, Flexicoking, LR-Coking, Deasphalting: DEMEX, Rose-Technology, Visbreaking, Thermal Cracking, Partial Oxidation.

5.4.2.4 Oils from oily sludges

Because oily sludges make up a large portion of refinery solid wastes, any improvement in the recovery of oil from the sludges can significantly reduce the volume of waste. There are a number of technologies currently in use to mechanically separate oil, water and solids, including: belt filter presses, recessed chamber pressure filters, rotary vacuum filters, scroll centrifuges, disc centrifuges, shakers, thermal dryers and centrifuge-dryer combinations.

5.4.2.5 Filtration clay

Clay from refinery filters must periodically be replaced. Spent clay often contains significant amounts of entrained hydrocarbons and, therefore, must be designated as hazardous waste. Techniques that may be applied are:

- Back washing spent clay with water or steam can reduce the hydrocarbon content to levels so that it can be re-used or handled as a no hazardous waste.
- Another method used to regenerate clay is to wash the clay with naphtha, dry it by steam heating and then feed it to a burning kiln for regeneration.
- In some cases clay filtration can be replaced entirely with hydrotreating.

5.4.2.6 Off specification products

It is customary in refineries to have dedicated tankage (so-called “slops”) for the collection of hydrocarbon streams/intermediate products that cannot be blended into final products for the market. These slops are generally reprocessed, often by injection into the crude oil feedstock to the crude distilling unit or to the coker. Often segregation is practised between wet and dry slops. The wet slops tank is equipped with facilities to separate (drain) water from oil. (to prevent slugs of water coming into the crude distiller). In some refineries separate slops processing (distillation) facilities are installed ([259, Dekkers, 2000] in [21]).

Streams from water treatment units (e.g. oil/water mixtures from interceptors) can be routed to the wet slops tank. Oil from sludge thickeners (centrifuges/decanters) can be routed to the slops tanks. In that way also the oil in sludges from DAF (Dissolved Air Flotation) units can be recovered ([259, Dekkers, 2000] in [21]).

5.4.2.7 Waste lubes

Waste lubes can be re-used within the refinery as fuel component or as feedstock for re-refining. Waste lubricating oils are generally undefined and may contain all kind of additives and contaminants (even PCB’s). Inclusion of contaminated waste lubes into commercial fuel oil would expose the customer to high risks. Inclusion of this waste in refinery fuel poses a safety risk.

Only by application of well-controlled pretreatment techniques, the treated waste oil can be upgraded to a fuel component. Such a pretreatment activity is normally not compatible with refinery operations and is done outside the refinery by specialized companies, which also do the collection of the waste oils. The only exception to the use of waste lubes as fuel component is for waste lube oil that is generated in the refinery itself and of which its composition is beyond any doubt. ([259, Dekkers, 2000] in [21]).

5.4.2.8 Lab samples

Lab samples can be recycled to the oil recovery system.

5.4.2.9 Recycle / Re-use outside the installation

Some options to reduce the waste generation is to recycle or re-use. Some examples that can be considered as good environmental practices are:

- catalysts for metal recovery (reforming, desulphurisation)
- waste lubes: re-refining
- drums/containers: reconditioning
- spent caustic can be used
- alkylation process: CaF_2
    - for HF production
    - as a fluxing agent (steel industry)
- resale of polymerisation plant catalyst as a fertiliser
- sale of gypsum or sulphuric acid from flue gas desulphurisation units
- dust: in the regenerative flue gas desulphurisation process according to Welmann Lord NH_3 is injected to prevent the formation of SO_3. Therefore up to 80 % of the ash consists of $(NH_4)_2SO_4$, which can be used as a fertilizer or as a basic material for NH_3 production ([250, Winter, 2000] in [21])
- paper, wood, glass, scrap metal
- construction/demolition debris:
    - concrete to a crusher, for use in road building etc.
    - asphalt scrapings re-used, e.g. in road building

It has to be mentioned that re-use of waste fractions/residues outside the company is an option, if these waste fractions meet certain criteria (such as concentration of pollutants in a fertiliser) and do not alter the original product characteristics (e.g. when using gypsum in the cement industry).

No case studies dealing with hazardous waste reduction have been identified in the reviewed bibliography.

5.5 Reduction of hazardous waste in other industrial sectors

Hazardous waste minimisation options in other sectors have been classified according to the type of pollution prevention action (new technologies, process changes, substitution of raw materials, internal recycling) and the sector to which they belong.

The main hazardous wastes generated by other industrial sectors have been identified as follows:

5.5.1 Hazardous waste in other industrial sectors

5.5.1.1 Textiles dyeing, printing and finishing

The textiles sector encompasses a wide diversity of activities [22]. However, dyeing, printing and finishing subsectors are considered the most relevant activities in the Mediterranean basin since they have significant effects on the environment, due to both resource consumption, especially water, and generation of pollution, especially wastewater.

The most common waste types generated by the textile dyeing and printing industries are not a result of such processes but auxiliary activities and may be classified as generic or repeated waste from all processes. Their hazardousness will depend on the extent to which they contain dangerous substances.

There is a wide range of waste products, which are identified below:

- Obsolete (out of fashion) and out of date dyes
- Paper sacks
- Containers for bulk products
- Metal drums
- Plastic bags and drums
- Metal rings
- Yarn cones (broken or discarded)
- Dye trays and supports (broken or discarded)
- Used oils and lubricants
- Exhausted cleaning solvents
- Plastic and paper packaging waste
- End products that do not meet specifications
- Rejected textile raw materials
- Spilled solid/liquid products.

Others:

• Sludge and sediment from chemical precipitations and mechanical separations (sedimentation, filtration)
• Sludge Remains of containers of products used in such treatment

Waste minimisation options related to the aforementioned wastes often involve the implementation of new technologies.

5.5.1.2 Tanning sector industry

Tanning is the process through which rawhides and skins are converted into leather as a final usable and sellable product [23]. The latter is used afterwards, as the basic raw material for the production of various leather commodities (i.e. shoes, bags, etc.).

As there is no single or general procedure for leather production; the techniques available vary considerably according to the original raw material (hides, skins…) and the final product needed. Tanning is usually performed through a series of batch processes that could last from as short as a few minutes or hours to as long as several months for some kinds of vegetable tanning techniques. Hide and skin tanning, is a process divided into a series of stages, in which the pelts are treated with different chemical and non-chemical agents, as well as passing through different mechanical operations.

The tanning process is usually divided into the following phases:
- Beamhouse (Preparation Phase);
- Tanyard (Tanning Phase);
- Re tanning - and finishing activities

The most common wastes are: organic solid waste, fibers, wastes coming from leather finishing and organic matter containing chrome. Only the last one is considered to be hazardous.

Hence, hazardous waste minimisation options will be applied basically to Beamhouse and Tanyard.

5.5.1.3 Food and dairy industry

The main waste types arising from food industry are organic, they originate from rejected product (raw material, semi-finished product, final product) and are often recycled to produce food for animal consumption [28]. Other wastes may come from packaging and auxiliary activities such as maintenance, laboratory and cleaning.

Hence, the most common waste types generated by food industry are not hazardous. Hazardous wastes arising from food industry are generic wastes in all industrial sectors such as used oils, packaging from dangerous substances, batteries, etc. These wastes can be minimised through good housekeeping practices.

5.5.2 New technologies

Some options and examples for reducing generation of hazardous wastes in the textile, tanning and cellulose and paper sectors through new technologies are presented below. No cases were found for food and dairy industry due to the reasons mentioned in the previous section.

5.5.2.1 Textiles dyeing, printing and finishing

[22] Using colorite software

Traditional problem

Usually, the manufacturer of finished fabric must provide his clients with samples of the fabric, in the colours requested by the client.

On other occasions, physical models of some sizes must be produced before the client decides to purchase a consignment. This involves a highly complex process of dyeing, printing and finishing of small yardages and garment-by-garment sewing, which lead to the consumption of resources and the generation of proportionally more effluents and waste products than those which are generated by larger consignments.

Alternative technique

Colorite is a computer programme which allows to visualise the true colour of a sample on the screen and on different textures. It is possible to send this information via e-mail to any other part of the world with full guarantees that wherever it is sent, it will be seen in exactly the same colour (true colour).

Field of application

Adaptable to any operational company that works with colour communication: dry cleaners', dressmakers, designers, etc.

Production benefits

The most significant benefits are:

• Reduction in terms of time and cost associated with sending samples

• Greater facility in the communication of the right colour

• A reduction in defective consignments given the visual control of the colour via a monitor

Environmental benefits

The need for fewer samples has the knock-on effect of eliminating waste (remains of dyes and test auxiliaries, finishing remains, print paste remains, etc.) and the wastewater generated in the preparation of samples.

Economic parameters

Although the application of this technology requires an initial purchase cost, this is quickly paid-back given the savings made on expenses associated wtih sending samples, and the making of disposable samples or samples that are finally discarded.

More and more companies have introduced this new communications technique. Among them are:

• USA: Wal-Mart, Burlington, Burke Mills, Fruit of the Loom, Guilford Mills.
• Europe: Oaxley Threads, Penn Nyla, Marks & Spencer, Textured Jersey, Triumph, Courtalds.

<u>Recovery and reuse of printing pastes</u>

Traditional problem
The printing paste that remains in the rotary printing system after the printing process finished is eliminated during the cleaning of the different elements of the equipment: moulds, scraper systems, conduits, drums, etc. This involves a great loss of dyes and printing paste, with all the chemical products that are necessary, and the corresponding wastewater pollution.

The loss in production as a result of the time needed to wash the whole system should also be mentioned. If there are no paste recovery facilities, , it is estimated that approximately 2.8 kg of printing paste are lost in a narrow machine and 3.8 kg of printing paste in a wide machine for each colour printed. When this amount is multiplied by the number of colours that a design may have (8-9) and by the number of printing changes that may take place in the course of a year (approx. 6,000), it can be seen that on an annual basis, between 134 and 205 t of printing pastes are lost in wastewater or, in the best of cases, are partially segregated as waste.

Alternative technique
The new patented technology (the system was developed by Stork Brabant, Boxmeer, the Netherlands) is capable of cleaning and recovering the printing paste from the print system's conduits.

With this paste recovery system, it is estimated that remains would be 1.1 kg of paste in the narrow machine and 1.8 kg in the wide machine. The recovered paste (between 60 and 75%) could be reused as a component for later printing pastes if colorimetric equipment is available and the software suitable, or it could be managed as waste.

Field of application
This technique may be applied in most rotary printing machines by means of microperforated cylinders and, preferably in the Stork printing machines.

Production benefits
The production benefits derive from lower consumption of printing dyes and pastes given the recovery that is achieved.

Environmental benefits
Paste recovery permits:

• A reduction in the wastewater pollutant load generated in the cleaning of printing equipment
• The correct management, as a waste product, of the recovered pastes that have not been reused
• A reduction in the consumption of water for cleaning operations
• A reduction in the consumption of reactive and energy in the treatment of wastewater

Economic parameters
Although the installation for the recovery of pastes requires an initial investment, annual savings could be up to 48,000€.

Samples by digital printing

Traditional problem
The process, from buying a design, which is generally on paper, until the printed products enter the market, is extraordinarily long and costly.

Habitually, the manufacturer of printed fabric must provide his clients with fabric samples in the colour combinations that have been proposed and, occasionally, they should be even ready to wear garments. This involves a highly complicated process of printing of small yardages, garment-by-garment dressmaking, etc., which involves resource consumption and the generation of effluents and proportionally higher quantities of waste than are generated with larger consignments.

Furthermore, cylinders must be engraved, which are sometimes only used for the preparation of the aforementioned samples with the consequent expense to the company.

Alternative technique
Given the new technique of digital stamping, samples of the designs created for printing can be made on the fabric without the need to engrave and create cylinders, and with no need to carry out the physical process of printing, as it will be done later in the factory.

By connecting one or several CAD (computer aided design) systems to a digital printer printing on fabric, it is possible to carry out samples with different types of dyes: reactive, acid, disperse and pigment dyes. This means that it is possible to obtain reproducibility with the results that are going to be obtained with the traditional method. The digital printer is controlled by a printing server (RIP) which permits the storage of the work and the optimisation of its functioning.

Each type of combination of fibres in the fabric (knit or open weave) requires a different process for the preparation of the fabric and a suitable set of dyes with affinity to the fabric. In most cases, the fabric which has been dyed must be dried and then the dyes must be fixed on the fibre in a suitable machine. Later, the fabric must be washed and finished.

Field of application

The printing of cotton, polyester, silk and wool fabrics (prepared for printing).

The possibility of creating exclusive combinations of small yardages. This technique may be applied on a small or large scale by simply increasing the number of digital printers. Depending on the sample volume more than one unit shall be necessary. The required space for the installation will depend on the number of printers (size 210 cm wide approx.) More and more companies are implementing this technique on a level of sample production. In Italy, there are several plants in which several in-line printers work on silk in order to do high-resolution prints.

Process benefits

This technique allows the rapid response to market demands given that it permits a faster visualisation of the design created on different fabrics. Moreover, it makes small productions possible, without going through traditional production channels.

Nevertheless, digital printing machines produce between 100 and 200 m^2 per hour, which is a significantly lower production than that which may be obtained using the traditional system.

However, certain operations are avoided compared to the traditional printing process.

Environmental benefits

A reduction in the generation of printing paste remains, in water consumption in cleaning operations of the aforementioned remains and of the wastewater pollutant load.

Economic parameters

Depending on the printer to be installed, the price range of the investment varies, and amortisation is fast for the user since all expenses incurred in the engraving of cylinders and moulds are saved.

The cost of the machine may be offset by the increased availability for the production of samples.

(Ferraz Pinto, SIVT, Zenith, STOF, Grupo Perrin in [22])

5.5.2.2 Tanning industry

Introducing green fleshing [23]

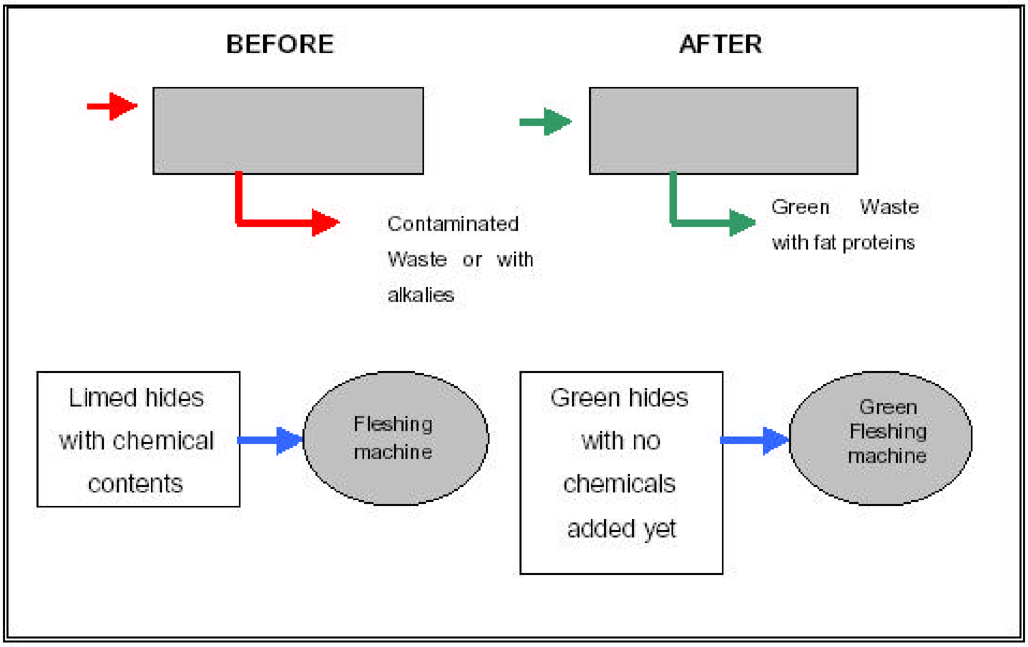
Process Stage: Pre-liming.

Description
Fleshing the pelts at earlier stages of the tanning process will reduce the overall weight of the pelts and consequently reduce the quantities of necessary chemicals and water needed for the subsequent processes. This eliminates 14-18% of the weight of the pelts.

Procedure
Green fleshing is the application of fleshing just after soaking. This procedure has many advantages; it will result in the production of acceptable fleshing for the production of fats (triglycerides) and proteins for composting and meat meal. Also it will improve the penetration level of chemicals in the pelt, leading to a positive influence on the pollution load (by reducing the chemicals used) and on the quality of the finished leather (finer grain and increased area).

Issues to consider when selected
This process has to be carefully conducted as it can cause some mechanical damages to the skin of small animals. If the machine pressure is not properly adjusted or skins which have not been thoroughly washed and have dung stuck to them are defleshed.

Figure 5-1 Introducing green fleshing



Environmental Benefits

- Reduction in water consumption;
- Reduction in wastewater generation;
- Reduction in the level of chemicals found in effluents;
- Reduction in hazardous solid waste

Hair Recovery from Liming Process

Process Stage: Liming.

Description
Removing the hair prior to the liming stage would substantially reduce the amount of pollution related to hair (i.e. suspended solids, BOD…) found in the wastewater generated. This initiative would also permit an easier recycling of wastewater.

Procedure

The operation consists of the following phases:

1. Immunization. Treatment of skins soaked in an alkaline solution of lime and NaOH for 45-50 minutes.
2. Chemical shaving. Sodium sulphydrate is added (this attacks the roots) for 20 minutes, after which the immunized hair falls out whole.
3. Bath recirculation. By passing through a 1-mm filter, the wet hair debris is eliminated with 75% humidity. The hair constitutes 17-20% of the skin's weight.
4. Attack of the epidermis. Sodium sulphide is added to attack and dissolve the queratine in the epidermis.
5. Liming. Lime is added to bring about controlled alkaline swelling.

Other procedures:
- Mechanical removal of hair from pelts using advanced methods (e.g. The Eastern Regional Research Centre (ERRC) process) reduces the total amount of wastewater generated during liming
- Sulphur-free processes may also be used (e.g. dehairing with glycolates, using aminos as dehairing agents or enzymes in dehairing.

Issues to consider when selected
- Methods might require additional supervision and control;
- Avoid dissolving hair in chemicals by making a proper choice of chemicals and using mechanical screens to remove hair from wastewater

Figure 5-2 Hair recovery from liming process

Before	After
Soaking→ Rinsing→ Liming→	Soaking→ Rinsing→ Mechanical Hair→ Removal→ Liming→

Environmental Benefits

- Reduction in water consumption;
- Reduction in wastewater generation;
- Reduction in the level of chemicals found in effluents;
- Reduction in hazardous solid wastes

<u>High chrome exhaustion techniques</u>

Process Stage: Chrome Tanning.

Description

Chrome fixation can be raised by a combination of practices leading to a reduction in chrome residuals in the wastewater to minimum levels.

Procedure

Using shorter floats, maintaining optimum initial temperatures of the floats, increasing the tanning time, optimizing the pH and raising the temperature towards the end of tanning will always favour a high chrome fixation. In addition, a continuous monitoring of the pH level will assure maximum levels of exhaustion, thus limiting the final chrome residuals in the effluents.

Issues to consider when selected

- The use of a portable pH meter as well as a thermometer will help monitor the chrome tanning process. However the tanners should make sure that their equipment is in good operating condition and that all readings are accurate. One way of doing so is by a regular maintenance and check-ups of the measuring equipment.

Environmental Benefits

- Reduction in water consumption;
- Reduction in wastewater generation;
- Reduction in the level of chemicals found in effluents;
- Reduction in hazardous solid wastes

5.5.2.3 Cellulose and paper industry

A case study is presented below:

MANIPULADOS DEL TER, S.A. (Sarrià de Ter, Spain) is a company that produces adhesive and pasted papers and films [15].

The composition of the adhesives and glues used is very different and depends on the use of the final product. Waste from adhesives and glues has a double source: residues of glue from the gluing process, and wastewater from cleaning tanks and glue lines, carrying a certain amount of glue. Those cleaning operations had to be carried out every time there was a change in product production, since all types of glue were introduced into the process by the same line.

The company decided to launch an alternative that would minimise the waste type of glues consisting of replacing the single line introducing all types of glue into the process with seven parallel lines (one for each type of glue). Thus, intermediate cleaning operations, required each time the type of glue was changed, were eliminated. By applying this alternative, it is estimated that there will be a reduction in the generation of glue waste of approximately 45%.

Balances:

	Old process	**New process**
Balance of materials Annual generation of glue waste (kg)	860,000	473,000
Economic balance Waste management costs (€/year)	65,570.42	36,060.73
Savings Savings in waste management (€/year) Savings in water consumption (€/year)		 29,509.69 7,212.15
Investment in installation (€)		3,005.006
Payback period		Immediate

5.5.3 Change of raw materials

An example for reducing generation of hazardous wastes in the tanning sector through change of raw materials is presented below.

5.5.3.1 Tanning industry

Reducing Ammonium usage in deliming process [23]

Process Stage: Deliming.

Description
Through the substitution of ammonium salts the level of ammonia in the wastewater are reduced.

Procedure

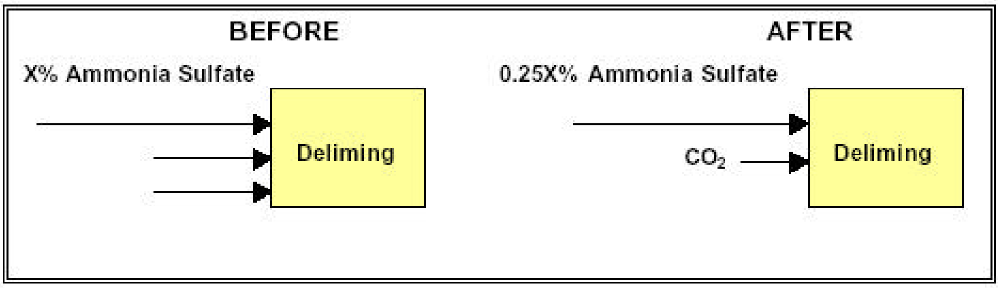
A number of alternatives could be adopted to limit the usage of ammonium salts, thus improving the final quality as well as reducing the level of nitrogen in the effluents.

Boric acid, magnesium lactate, organic acids, such as lactic acid, formic acids, etc. can be used to substitute the ammonium used. Another new technique would be to use of carbon dioxide in deliming to limit the use of ammonium salts. Such operation would allow a reduction of close to 75% in ammonia nitrogen [22]. In addition to the nitrogen reductions, the chrome tanning agents work better on skins delimed with the carbonic gas than with the salts which reduces the quantity of the chrome residues in the tanning effluents ([25].in [23]) CO2 forms carbonic acids which dissolves the residual lime.

Issues to consider when selected

- Avoid intermittent gas inputs, which form carbonate;
- Add bisulphate to avoid H_2S formation

Figure 5-3 Reducing ammonium usage in deliming process



Environmental Benefits

- Reduction in the level of chemicals found in effluents;
- Reduction in hazardous solid wastes;
- Reduction of noxious odour

5.5.4 Internal recycling

Some options for reducing generation of hazardous wastes in the tanning sector through internal recycling are presented below:

5.5.4.1 Tanning industry

<u>Chrome precipitation and recovery [23]</u>

Process Stage: Chrome Tanning.

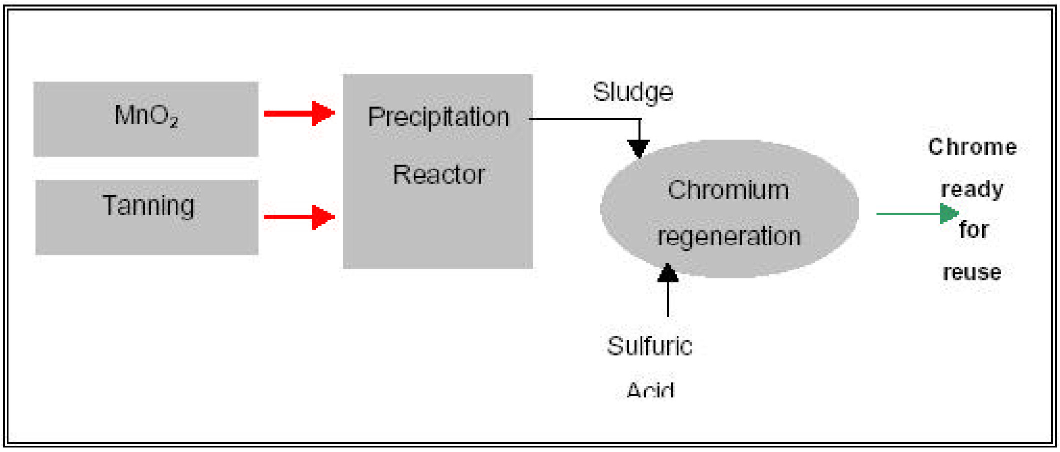
Description

The purpose of this option is to collect the chrome bearing liquors for treatment with alkali, precipitating the chromium as hydroxide, before its final re-usage.

Procedure
Two possible means to recover the chrome are ([26] in [23]):
1. Alkali - NaOH or MgO- is added to the chrome liquor, up to pH 8.5-9. The hydroxide sludge may be passed after thickening to a filter press or belt, the cake so formed then being re-dissolved with sulphuric acid and re-used.
2. The liquor is left undisturbed overnight. Virtually "chrome-free" supernatant can then be drawn off and discharged to the effluent system. The remaining settled hydroxide sludge is re-dissolved with acid in situ and reused.
The alkali utilized for precipitation depends on the subsequent recycling system.

Issues to consider when selected
- The first method is very expensive and might require lots of space;
- The second method although cheaper requires a strict process control since a small mistake could ruin the quality of the end products.

Figure 5-4 Chrome precipitation and recovery



Environmental Benefits
- Reduction in the level of chemicals found in effluents
- Reduction in chemicals used;
- Reduction in hazardous solid waste

Chrome Recovery and Recycling in the Leather Industry (Greece)

Background
The following case study is taken from an EP3 project ([27] in [23]).
The project was carried out with the aim of enabling a tanning facility located near Athens in Greece to comply with discharge standards for

trivalent chromium (Cr^{3+}) as recent limits for discharge to the environment have limited Cr^{3+} discharge to levels as low as 2mg/liter in wastewater.
The audited facility produces good quality upper leather from cattle hides, processing 2200 tonnes per year.

Cleaner Production Principle
Recovery, reuse and recycle of Cr^{3+}

Cleaner Production Application
The technology developed involves the recovery of Cr^{3+} from the spent tannery liquors and its reuse.

Tanning of hides is carried out with basic chromium sulphate, $Cr.(OH)SO_4$, at a pH of 3.5-4.0. After tanning, the solution is discharged by gravity to a collection pit. The liquor is sieved during this transfer to remove particles and fibres that have come from the hides. The liquor is then pumped to the treatment tank and a calculated quantity of magnesium oxide is added with stirring until the pH reaches at least 8. The stirrer is switched off and the chromium precipitates as a compact sludge of $Cr.(OH)_3$. After settling, the clear liquid is decanted off. The remaining sludge is dissolved by adding a calculated quantity of concentrated sulphuric acid (H_2SO_4) until a pH of 2.5 is reached.
The liquor now contains $Cr(OH)SO_4$ and is pumped back to a storage tank for reuse.

In conventional chrome tanning processes, 20-40% of the used chrome is discharged into wastewater. In the new process, 95-98% of the waste Cr^{3+} can be recycled.

Environmental and Economic Benefits
The project benefits include:
- More consistent product quality;
- Reduced chromium content of effluent waters.

Costs
For the audited tannery, which has a chrome recycling capacity of 12m3/day, the approximate costs were as follows:
- Capital Investment 35,280 €
- Operating cost 26,636.4 €
- Total 61,916.4 €

Savings
Savings 65,047.5 €
The payback period was 12/ (66,047/61,916.4)= 11 months.

Constraints
This technology is expected to be economical only for chrome recovery plants processing more than 1.7m3/day.

<u>Re-Use of Chromium in Leather Tanning (Tunisia)</u>

Background

The following case study is taken from an EP3 project ([27]. In [23])
The audited facility is a tannery in Tunisia, which produces leather from sheep and goatskins.

At the time of the cleaner production (CP) assessment, a number of pollution problems existed at the facility, including the generation of sulphide, excessive chromium discharge, excessive effluent volume, inefficient chromium fixation and inefficient use of dye chemicals. In addition, the company's wastewater pre-treatment station was not functioning adequately, resulting in the discharge of wastewater exceeding the required norms.

Cleaner Production Principle

- Recovery, reuse and recycle;
- Process modification;
- Good Housekeeping

Cleaner Production Application

The CP assessment identified four solutions that would bring significant environmental and economic benefits. The solutions, which are now being implemented, are:

- to recycle chromium effluent with the addition of one third of the initial requirements to reduce chromium discharge into wastewater. This is done by constructing a holding pit into which the used tanning bath is pumped after having been screened. The solution can be used five times before discharging it;
- to recycle used black dye solution, with the addition of half of the initial requirements to reduce the dye discharged into the wastewaters. This is done by installing tanks, plumbing and filters needed for recycling.
- to raise temperature and control pH of the tanning baths to increase chromium fixation on the hides. This is done by repairing the boiler to pre-heat the tanning bath, and by installing continuous, digital temperature and pH probes for each bath;
- to segregate the liming and washing wastewaters from other acidic waste waters to eliminate sulphide generation. This is done by constructing a sump that intercepts wastewater from the liming and washing operations. The sulphides are oxidized.

Environmental and Economic Benefits

The CP solutions reduce the quantity of toxic chemicals released. The amount of wastewater to be treated is reduced by 8.5 percent (2,000 m3 per year); the loading of toxic chromium salts by 55 percent and of dye baths by 25 percent. Isolating incompatible waste streams for separate treatment enables the pre-treatment station to operate more efficiently, and avoids the generation of foul smelling and toxic hydrogen sulphide gas.

Costs & Savings

Overall, the implementation of the CP project will result in an annual saving of 86,436 € for a total investment of about 22,050 €. Specifically, recycling used chromium effluent is expected to result in a financial benefit in the first year of 37,044 €, requiring a total investment of just 4,410 €. The implementation of the solutions will also result in improved productivity and increased quality of products.

Constraints
No constraints are reported.

5.5.5 Good practices

Good Housekeeping Practices are better environmental practices than the present ones or better than the most common ones [30]. Good Housekeeping Practices (GHPs) are the whole group of personal and collective habits that lead to correct environmental management as the result of each individual's actions in an organisation. This practice reveals the principle of overall sustainability as well as the individual sustainability of the company itself.

An illustration of a series of Good Housekeeping Practices from a pilot project carried out in different sectors of industry in Catalonia [30] is described. It is worth mentioning that these practices were considered to be of general interest:

Communication: Good Housekeeping Practices consist mainly of considering and assessing the effect of any decision or action on the generation of waste, wastewater and emissions. It is thus important for everybody in the company to work together and to share the information necessary for carrying out their usual tasks and thus contribute to the overall objective of prevention.

Established procedures: Establishing written procedures for undertaking tasks and their compliance can help to save raw materials, avoid the generation of products that do not comply with specifications, minimise the risk of accidents and prevent pollution.

Cleaning: Efficient cleaning processes save resources and cleaning agents. They also prevent the generation of waste, waste water and emissions.

Tool and installation upkeep: Equipment suffers from wear due to intensive use and a preventative maintenance programme may help to minimise wear and its consequences. The goal is to prevent breakdowns before they cause losses in production or before pollution is generated.

Everything in its place: Everything in its place and a place for everything. Certain operations often need to be undertaken in different areas of the indlustry which have specific conditions and equipment to minimise risks to the environment.

Turn off and clean up: Leakages and spills are relatively frequent in most companies. Turning off and cleaning up equipment enables pollution to be reduced, helps in the valuation of spilt products and minimises the need for water and/or cleaning products. Overall, it involves reductions in the volume and pollution load of the wastewater generated.

The stores location and its maintenance: A well-managed, orderly stores location reduces the generation of waste and therefore reduces the cost associated with waste elimination.

Handling and transportation: By taking the necessary precautions in the handling, transportation and transfer or decanting of products, leakages, spills or other emissions can be avoided and pollution and environmental costs reduced.

Waste segregation: Waste segregation facilitates minimisation, it enables the most appropriate treatment to be given to each waste material, it increases waste valorisation and reduces the economic costs associated with management.

Applying such good practices leads to hazardous waste reduction. Two examples of application of good practices in the dairy and food industry are presented below:

Misr Company for Dairy and Food (Egypt) is one of the largest producers of dairy products in Egypt [15].
An industrial audit was conducted in this company in order to identify pollution prevention opportunities.

The audit identified a series of environmental considerations to take into account, mainly due to the following reasons:

- Different solid wastes were stored randomly in open areas and roads, constituting a fire risk and impairing the general appearance of the premises.
- Considerable amounts of milk were wasted due to overflow during the filling of storage and service tanks.
- Milk leakages occurred in the milk packaging and refrigeration units.
- Oil used in the car and truck maintenance facilities was drained to factory sewers, encouraging drain blockage and consequent development of foul odours.
- Excessive consumption of mazot in the boiler house, due to poorly turned boilers. This also resulted in excessive air emissions being discharged from the boiler stacks.

The following actions and achievements were put into practice:

1. With low cost, firstly, improvement of the cleanliness of the factory premises was achieved, secondly, a monthly accumulation of 0.75 tonnes of used garage oil was sold at 81.4 per ton, thereby reducing the strength of wastewater, and preventing blockage of sewers and overflow, and thirdly, an efficient removal of solid wastes from the site was achieved with additional economic benefits.
2. By means of the boiler tune-up and upgrade, mazot consumption was reduced by 60 tonnes/year. In addition, energy consumption reduction was also achieved. With the restoration of the softening unit, a 16% increase in boiler efficiency was achieved.
3. The installation of a refrigeration system permitted the temperature to be fully controlled, the relocation of the packaging unit from a restricted area to near the refrigeration facility which prevents handling losses. Furthermore, production capacity, process efficiency and quality control were improved, and a reduction of 3.3 tonnes/month of milk losses was achieved.
4. By reusing permeate in the cheese packaging stage, a 50% drop in the organic load generated from the white cheese unit was achieved, and 2,200 m^3 of water were saved on an annual basis.
5. By installing level controls and control valves, daily savings of 350 kg of milk were obtained and pollution loads were reduced, thus improving cleanliness and hygiene.

Balances:

Options	**Environmental Benefits**	**Investment (€)**	**Savings (€/year)**	**Payback period (months)**
Good housekeeping	• Prevention of blockage of sewers and overflow • Overall improvement of the factory's image and cleanliness	3,997	36,245	1.3
Boiler upgrade and softening unit restoration	• Increase in boiler efficiency • Reduction of mazot consumption and gas emissions	592	10,924	< 1
Increase in milk refrigeration efficiency	• Increase in production capacity, process efficiency and quality control • Reduction of reject rates of the final product	7,861	11,741	8
Permeate reuse	• 50% drop in organic load generated from the white cheese unit • Water savings	None	612	Immediate

Options	Environmental Benefits	Investment (€)	Savings (€/year)	Payback period (months)
Installation of milk tank level controls and food quality valves	• Milk savings • Pollution loads reduction • Improvement of hygiene and safety	21,951	37,266	7

Sila Edible Oil Company (Fayoum, Egypt)

This company processes seeds, mainly sunflower, corn, soybean and cotton, producing first grade edible oil. The main by-products include dried meal (packaged in sacks and sold as animal feed) and soapstock and gums (separated by highspeed centrifuge).

By means of an industrial audit of the company carried out by the SEAM Project, the following pollution prevention opportunities were initially identified:

a. Reduction of steam losses as a result of damaged lines and valves and inadequate insulation.
b. Reuse of broken seeds and hulls in the oil extraction process in the seed-receiving unit.
c. Reduction of mazout leaks and spills.
d. Segregation and reuse of the refinery wastewater, which has the highest organic load.
e. Reduction of oil losses in the refinery due to leakage, in the storage unit and in the packaging area and losses of process chemicals in the refinery unit.

The following measures were put into practice:

1. Good housekeeping:
• Preventive Maintenance Programme (In-factory servicing of the expeller, modification of the packing of the cooling towers and steam trap modifications, repair of leaking or broken valves, damaged water pipes and damaged steam pipes, etc.)
• Collection and recycling of split oil in the packaging unit, pumping it to a collection tank, where the oil is recycled to the refinery for reprocessing.

2. Process modification:
• Reuse of fines from the preparation unit. The plant was originally designed to recycle sunflower seed fines back to the expeller. This step was modified to direct these fines immediately to the extraction plant, allowing a higher throughput of fresh seed in the expeller.

3. Material substitution:
• Use of caustic soda solution instead of caustic soda when neutralising. Thus losses of caustic soda are reduced.

4. Water and energy conservation:

• Upgrade steam network, rehabilitating the steam lines, tuning the boiler and improving the treatment of boiler feedwater, recycling the steam condensate, replacing faulty/broken valves, replacing/repairing steam traps and pipes and insulating hot water and steam pipes.

5. Reuse and recycling:
• Recovery of hulls and broken seeds. They were originally collected and sold as animal feed. The process has now been modified so that they are collected using a screw conveyor and transferred to the preparation unit, where they are further processed.
• Recovery of 10% of fatty matter from the final effluent. Fat is collected from the refinery effluent by a scraper, acidulated, split and then transferred to soapstock storage tanks.

6. Wastewater segregation:
• Segregating of process effluents coming from the refinery. The remaining effluent generated by the company is used for land reclamation activities within the factory.

Balances:

Options	**Benefits**	**Savings (t/year)**	**Investment (€)**	**Savings (€/year)**	**Payback period (months)**
Preventive Maintenance Programme	Reduction of steam and warm water losses and process optimization	34	4,500	9,000	6
Oil recycling	Further production	13.92	750	10,500	<1
Reuse of fines	Crushing capacity has been increased	120	3,000	36,000	1
Use of liquid caustic soda	Daily neutralisation costs dropped by 47%, reduced losses of caustic soda, reduced levels of corrosion, improved soapstock quality, better working conditions		None	75,000	Immediate
Upgrade steam network	Steam consumption reduction	3,600			
	One boiler has been taken off the line (savings of mazout usage)	1,728	9,000	165,888	<1
	Water consumption and maintenance costs reduction	28,800			
Recovery of broken seeds	Extra of oil	78	2,700	138,975	<1

Options	Benefits	Savings (t/year)	Investment (€)	Savings (€/year)	Payback period (months)
	Extra of meal produced	595			
Fat recovery	Recovery of soapstock and reduced strength	29	1,500	4,320	4
Wastewater segregation	Reduction of effluent to be disposed off-site	13,464	None	5,400	Immediate

Significant benefits were achieved through the implementation of these low or no-cost measures:
Maintenance costs were reduced by 10%
Water consumption was reduced by 46%
Wastewater treatment requirements were reduced by 66%
Boiler fuel consumption was reduced by 48%

Annual recovery of oil, soapstock and metal was valued at 207,795 €.

5.6 Reducing generic hazardous wastes: used mineral oils

5.6.1 Sources of used mineral oils

Used mineral oil can be defined as any industrial oil that has become unsuitable for the use to which it was initially assigned [29]. This definition especially includes used oils from combustion engines, transmission systems, turbines and hydraulic systems, the different sectors of the car industry and industrial shipping activities.

Used mineral oils are classified according to current European regulations as hazardous waste due to the effects that they can have both on health and the environment.

Direct effects on the environment that stand out include the following:

- The pollution of soils, rivers and the sea due to their low biodegradability.
- On coming into contact with water, they produce a film that prevents oxygen circulation.
- Uncontrolled combustion can lead to the emission of chlorine, lead and other gas elements into the atmosphere, with the corresponding effects.

In view of these effects, guidance is given on actions to be carried out regarding the reprocessing, minimisation at source of this type of waste: industrial oils used in hydraulic systems can be reused by both the company itself and the same hydraulic system after the oil has been put through a cleaning process. This treatment prolongs the life cycle of the oil in question.

Mineral oils that are used and then become spent or used oils are made up of base lubricants and additives that have been developed specifically for lubrication that give special characteristics to the oil. Base lubricants are mostly hydrocarbons whereas the additives, which make up between 15% and 20% of the oil, contain organic compounds derived from sulphur and nitrogen that contain metals.

After the oil has been used and has turned into used oil, the constituent pollutants that can be found are shown in Figure 5-5.

Figure 5-5 Pollutant compounds in used oils

POLLUTANTS	EXAMPLES	ORIGIN
Polynuclear aromatic hydrocarbons		Petroleum - Base Lubricant
Mononuclear aromatic hydrocarbons	Alkyl benzene	Petroleum - Base Lubricant
Dinuclear aromatic hydrocarbons	Naphthalene	Petroleum - Base Lubricant
Chlorinated Hydrocarbons	Trichloretane	Use of contaminated oil
Metals	Barium	In Additives
	Aluminium	In engines
	Lead	In fuel
	Zinc, Chrome	
Inorganic acids derived from chlorine, sulphur and nitrogen		
Organic compounds such as aldehydes, acids, etc.		

5.6.2 Minimisation processes at source: the reprocessing of used mineral oils

For used oils, the main actions to prevent and reduce pollution at source are directed towards reprocessing used oils. However, these actions are very incipient and are not generally used as a treatment system in industry.

Reprocessing involves the recovery of used oils and their reconversion into top quality oils that can be used in production processes. Through undertaking this action achieves the following three objectives are achieved:

- There is a considerable reduction in the quantity of used oil (i.e. waste)
- In business terms, important savings are made in the purchase of new oils.
- The life cycle of the oil is extended with reprocessed oil being re-introduced into the same production cycle.

Processes for achieving minimisation at source are based on the following stages:

1. Vacuum distillation: a dehydration and degassing stage, during which other volatile pollutants are also eliminated.
2. Ultrafiltration: a stage where the used oil is subjected to sedimentation and filtration processes to eliminate metal particles and other solids contained in the oil.
3. Readditivation: additives are added throughout this process in order to obtain clean oil with the desired characteristics.

Chemical analyses are carried out prior to the oil being introduced into the system in order to firstly, establish the condition of the used oil and secondly, to be able to define the intensity of treatment and additivation that will be necessary to obtain the required end characteristics.

5.7 Available resources for hazardous waste minimization on the internet

Some cleaner production resources available on the internet have been collected in order to provide database, specific guideline and examples of their application in different industrial sectors, including the priority ones indicated above. These web sites provide further information on how to reduce hazardous wastes.

General sources

Pollution Prevention Resource Exchange.
Information on specific industries or topics
http://www.p2rx.org

Pollution Prevention Resources on the Internet.
Search database by product or industry.
http://www.p2gems.org/Category.cfm?subj=PI

Cleaner Production
Resources for Business Managers.
http://www.cleanerproduction.com/

European environment Agency.
A guide to information sources.
http://www.eea.eu.int/

European Topic Centre on Waste and Material Flows. Topic Centre of European Environment Agency

http://waste.eionet.eu.int/prevention

United Nations Environment Programme. Environment for development

http://www.unep.org/

EPA. Waste Reduction Resource Centre.
Information by industry.
http://wrrc.p2pays.org/industry/indsector.htm

Enviroene
Provides information and databases
http://es.epa.gov/

Environment Canada. Canadian Pollution Prevention Information Clearinghouse. Search information by sector.
http://www.ec.gc.ca/cppic/search/en/sector.cfm

Sector guidelines

Sectorial studies
Regional Activity Centre for Cleaner Production.

http://www.cema-sa.org/car/eng/

Reference Documents on Best Available Techniques
Institute for Prospective Technological Studies
http://www.jrc.es/pub/english.cgi/0/733169

Cleaner production activities
UN Environment Programme - Production and Consumption Branch
http://www.unepie.org/pc/cp/home.htm

Case Studies

MEDCLEAN Files.
Regional Activity Centre for Cleaner Production.
http://www.cema-sa.org/car/eng/medclean.htm#3

Examples and case studies by industry type.
Environment Australia. Industry Eco-efficiency and cleaner production
http://www.ea.gov.au/industry/eecp/

Canadian Success Stories classified according to cleaner production actions
Environment Canada.
http://www.ec.gc.ca/pp/index.cfm?language=en

Technical case studies classified according to manufacture activities
Environmental Management Centre.
http://www.emcentre.com/unepweb/tec_case/index.htm

Cases and measures by sectors.
Green Profit.
http://www.greenprofit.net/measures.html

Examples by industry.
Cleaner Production Germany
http://www.cleaner-production.de/wwwcpg/htmlneu/index.html

Case Studies in Environmental Management
International Network for Environmental Management.

http://www.inem.org/htdocs/inem_casestudies.html

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Annex 1. Hazardous waste classification

CATEGORIES OF WASTES SUBJECT TO THE BASEL CONVENTION AND THE IZMIR PROTOCOL (Y-CODES)

A. HAZARDOUS WASTES

Y0 All wastes containing or contaminated by radionuclides, the radionuclide concentration or properties of which result from human activity

Y1 Clinical wastes from medical care in hospitals, medical centres and clinics

Y2 Wastes from the production and preparation of pharmaceutical products

Y3 Waste pharmaceuticals, drugs and medicines

Y4 Wastes from the production, formulation and use of biocides and phytopharmaceuticals

Y5 Wastes from manufacturing, formulation and use of wood preserving chemicals

Y6 Wastes from the production, formulation and use of organic solvents

Y7 Wastes from heat treatment and tempering operations containing cyanides

Y8 Waste mineral oils unfit for their originally intended use

Y9 Waste oils/water, hydrocarbons/water mixtures, emulsions

Y10 Waste substances and articles containing or contaminated with polychlorinated biphenyls (PCBs) and/or polychlorinated terphenyls (PCTs) and/or polybrominated biphenyls (PBBs)

Y11 Waste tarry residues arising from refining, distillation and any pyrolytic treatment

Y12 Wastes from production, formulation and use of inks, dyes, pigments, paints, lacquers, varnishes

Y13 Wastes from production, formulation and use of resins, latex, plasticizers, glues/adhesives

Y14 Waste chemical substances arising from research and development or teaching activities which are not identified and/or are new and whose effects on man and/or the environment are not known

Y15 Wastes of an explosive nature not subject to other legislation

Y16 Wastes from production, formulation and use of photographic chemicals and processing materials

Y17 Wastes resulting from surface treatment of metals and plastics

Y18 Residues arising from industrial waste disposal operations

Wastes having as constituents:

Y19 Metal carbonyls

Y20 Beryllium; beryllium compounds

Y21 Hexavalent chromium compounds

Y22 Copper compounds

Y23 Zinc compounds

Y24 Arsenic; arsenic compounds

Y25 Selenium; selenium compounds

Y26 Cadmium; cadmium compounds

Y27 Antimony; antimony compounds

Y28 Tellurium; tellurium compounds

Y29 Mercury; mercury compounds

Y30 Thallium; thallium compounds

Y31 Lead; lead compounds

Y32 Inorganic fluorine compounds excluding calcium fluoride

Y33 Inorganic cyanides

Y34 Acidic solutions or acids in solid form

Y35 Basic solutions or bases in solid form

Y36 Asbestos (dust and fibres)

Y37 Organic phosphorus compounds

Y38 Organic cyanides

Y39 Phenols; phenolic compounds including chlorophenols

Y40 Ethers

Y41 Halogenated organic solvents

Y42 Organic solvents excluding halogenated solvents

Y43 Any congener of polychlorinated dibenzo-furan

Y44 Any congener of polychlorinated dibenzo-p-dioxin

Y45 Organohalogen compounds other than substances referred to in this Annex (e.g. Y39, Y41, Y42, Y43, and Y44)

Annex 2. Industrial sectors of concern

A list of priority industrial sectors as defined in the SAP (Strategic Action Programme to address pollution from land-based activities) is provided below. This list can be used as a guideline to consider the main industrial sectors generating hazardous wastes in your country:

1. Energy production;
2. Fertiliser production;
3. Production and formulation of biocides;
4. Pharmaceutical industry;
5. Oil refining;
6. Cellulose and paper industry;
7. Cement production;
8. Tanning industry;
9. Metal industry;
10. Mining;
11. Shipbuilding and repair;
12. Harbour operations;
13. Textile industry;
14. Electronics industry;
15. Recycling industry;
16. Other sectors of the organic chemical industry;
17. Other sectors of the inorganic chemical industry;
18. Agro-food industry;
19. Treatment and disposal of hazardous wastes;
20. Waste incineration;
21. Transport.

Annex 3. Identification of priority industrial sectors

Priority industrial sectors have been identified by applying defined criteria at a national level. The data corresponding to the 16 analysed countries are in the following tables:

Albania
Algeria
Bosnia-Herzegovina
Croatia
Cyprus
Egypt
France
Greece
Israel
Italy
Lebanon
Malta
Morocco
Spain
Syria
Turkey

Albania									
Industrial sector	**tonnes/y**	**%**	**Amount**	**Env Imp**	**Med Imp**	**Growth prosp**	**Priority**	**Top 3**	**Top 5**
Energy production	501	16.14%	2	1	1	2	4	0	1
Fertiliser production	0	0.00%	1	1	1	1	1	0	0
Production and formulation of biocides	0	0.00%	1	1	1	1	1	0	0
Pharmaceutical industry	0	0.00%	1	1	1	1	1	0	0
Oil refining	706	22.74%	3	3	2	3	54	1	1
Cellulose and paper industry	0	0.00%	1	1	1	1	1	0	0
Cement production	0	0.00%	1	1	1	1	1	0	0
Tanning industry	0	0.00%	1	1	1	1	1	0	0
Metal industry	284	9.15%	2	2	2	2	16	0	1
Mining	83	2.67%	1	1	1	2	2	0	0
Shipbuilding and repair	0	0.00%	1	1	1	1	1	0	0
Harbour operations	0	0.00%	1	1	1	1	1	0	0
Textile industry	0	0.00%	1	1	1	1	1	0	0
Electronics industry	0	0.00%	1	1	1	1	1	0	0
Recycling industry	0	0.00%	1	1	1	1	1	0	0
Other sectors of the organic chemical industry	129	4.15%	1	3	3	2	18	1	1
Other sectors of the inorganic chemical industry	1,402	45.16%	3	3	3	2	54	1	1
Agro-food industry	0	0.00%	1	1	1	1	1	0	0
Treatment and disposal of hazardous wastes	0	0.00%	1	1	1	1	1	0	0
Waste incineration	0	0.00%	1	1	1	1	1	0	0
Transport	0	0.00%	1	1	1	1	1	0	0
TOTAL	3,105	100.00%							

Algeria									
Industrial sector	**tonnes/y**	**%**	**Amount**	**Env Imp**	**Med Imp**	**Growth prosp**	**Priority**	**Top 3**	**Top 5**
Energy production	1,694	0.66%	1	1	1	3	3	0	0
Fertiliser production	0	0.00%	1	1	1	1	1	0	0
Production and formulation of biocides	0	0.00%	1	1	1	1	1	0	0
Pharmaceutical industry	213	0.08%	1	1	1	3	3	0	0
Oil refining	110,486	43.19%	3	3	1	3	27	1	1
Cellulose and paper industry	600	0.23%	1	1	3	1	3	0	0
Cement production	5,350	2.09%	1	1	1	3	3	0	0
Tanning industry	0	0.00%	1	1	1	1	1	0	0
Metal industry	7,397	2.89%	1	2	3	3	18	0	1
Mining	43,721	17.09%	2	1	1	2	4	0	0
Shipbuilding and repair	0	0.00%	1	1	1	1	1	0	0
Harbour operations	0	0.00%	1	1	1	1	1	0	0
Textile industry	11,781	4.61%	1	2	2	1	4	0	1
Electronics industry	246	0.10%	1	1	2	1	2	0	0
Recycling industry	0	0.00%	1	1	1	1	1	0	0
Other sectors of the organic chemical industry	36,860	14.41%	2	3	3	3	54	1	1
Other sectors of the inorganic chemical industry	36,860	14.41%	2	3	3	3	54	1	1
Agro-food industry	614	0.24%	1	1	1	3	3	0	0
Treatment and disposal of hazardous wastes	0	0.00%	1	1	1	1	1	0	0
Waste incineration	0	0.00%	1	1	1	1	1	0	0
Transport	0	0.00%	1	1	1	1	1	0	0
TOTAL	255,822	100.00%							

Bosnia									
Industrial sector	**tonnes/y**	**%**	**Amount**	**Env Imp**	**Med Imp**	**Growth prosp**	**Priority**	**Top 3**	**Top 5**
Energy production	100	9.07%	2	1	1	2	4	0	0
Fertiliser production	0	0.00%	1	1	1	2	2	0	0
Production and formulation of biocides	0	0.00%	1	1	1	2	2	0	0
Pharmaceutical industry	0	0.00%	1	1	1	2	2	0	0
Oil refining	120	10.89%	2	3	1	2	12	1	1
Cellulose and paper industry	100	9.07%	2	1	1	2	4	0	0
Cement production	0	0.00%	1	1	1	2	2	0	0
Tanning industry	6	0.54%	1	1	1	2	2	0	0
Metal industry	80	7.26%	2	2	3	2	24	1	1
Mining	480	43.56%	3	3	1	2	18	1	1
Shipbuilding and repair	0	0.00%	1	1	1	2	2	0	0
Harbour operations	0	0.00%	1	1	1	2	2	0	0
Textile industry	6	0.54%	1	1	2	2	4	0	0
Electronics industry	0	0.00%	1	1	1	2	2	0	0
Recycling industry	0	0.00%	1	1	1	2	2	0	0
Other sectors of the organic chemical industry	90	8.17%	2	3	1	2	12	0	1
Other sectors of the inorganic chemical industry	90	8.17%	2	3	1	2	12	0	1
Agro-food industry	30	2.72%	1	1	1	2	2	0	0
Treatment and disposal of hazardous wastes	0	0.00%	1	1	1	2	2	0	0
Waste incineration	0	0.00%	1	1	1	2	2	0	0
Transport	0	0.00%	1	1	1	2	2	0	0
TOTAL	1,102	100.00%							

Croatia

Industrial sector	tonnes/y	%	Amount	Env Imp	Med Imp	Growth prosp	Priority	Top 3	Top 5
Energy production	10,000	4.53%	1	2	2	2	8	1	1
Fertiliser production	0	0.00%	1	1	1	2	2	0	0
Production and formulation of biocides	100	0.05%	1	1	1	2	2	0	0
Pharmaceutical industry	150	0.07%	1	1	1	2	2	0	0
Oil refining	180,000	81.54%	3	3	3	2	54	1	1
Cellulose and paper industry	3,000	1.36%	1	1	1	2	2	0	1
Cement production	0	0.00%	1	1	1	2	2	0	0
Tanning industry	500	0.23%	1	1	1	2	2	0	0
Metal industry	7,000	3.17%	1	1	1	2	2	0	1
Mining	0	0.00%	1	1	1	2	2	0	0
Shipbuilding and repair	2,000	0.91%	1	1	1	2	2	0	0
Harbour operations	3,000	1.36%	1	1	1	2	2	0	0
Textile industry	0	0.00%	1	1	1	2	2	0	0
Electronics industry	0	0.00%	1	1	1	2	2	0	0
Recycling industry	0	0.00%	1	1	1	2	2	0	0
Other sectors of the organic chemical industry	0	0.00%	1	1	1	2	2	0	0
Other sectors of the inorganic chemical industry	0	0.00%	1	1	1	2	2	0	0
Agro-food industry	0	0.00%	1	1	1	2	2	0	0
Treatment and disposal of hazardous wastes	0	0.00%	1	1	1	2	2	0	0
Waste incineration	0	0.00%	1	1	1	2	2	0	0
Transport	15,000	6.80%	2	3	1	2	12	1	1
TOTAL	220,750	100.00%							

Cyprus

Industrial sector	tonnes/y	%	Amount	Env Imp	Med Imp	Growth prosp	Priority	Top 3	Top 5
Energy production	7,720	22.28%	3	1	1	2	6	1	1
Fertiliser production	0	0.00%	1	1	1	1	1	0	0
Production and formulation of biocides	968	2.79%	1	1	1	2	2	0	0
Pharmaceutical industry	43	0.12%	1	3	1	2	6	0	1
Oil refining	158	0.46%	1	1	1	2	2	0	0
Cellulose and paper industry	0	0.00%	1	1	1	1	1	0	0
Cement production	0	0.00%	1	1	1	1	1	0	0
Tanning industry	11,500	33.19%	3	3	1	1	9	1	1
Metal industry	1,260	3.64%	1	3	1	2	6	0	1
Mining	2,000	5.77%	2	1	1	2	4	0	0
Shipbuilding and repair	0	0.00%	1	1	1	1	1	0	0
Harbour operations	0	0.00%	1	1	1	1	1	0	0
Textile industry	0	0.00%	1	1	1	1	1	0	0
Electronics industry	0	0.00%	1	1	1	1	1	0	0
Recycling industry	0	0.00%	1	1	1	1	1	0	0
Other sectors of the organic chemical industry	0	0.00%	1	2	1	2	4	0	0
Other sectors of the inorganic chemical industry	0	0.00%	1	2	1	2	4	0	0
Agro-food industry	0	0.00%	1	1	1	1	1	0	0
Treatment and disposal of hazardous wastes	11,000	31.75%	3	1	1	3	9	1	1
Waste incineration	0	0.00%	1	1	1	1	1	0	0
Transport	0	0.00%	1	1	1	1	1	0	0
TOTAL	34,649	100.00%							

Egypt

Industrial sector	tonnes/y	%	Amount	Env Imp	Med Imp	Growth prosp	Priority	Top 3	Top 5
Energy production	0	0.00%	2	1	1	1	2	0	0
Fertiliser production	0	0.00%	2	1	2	3	12	0	1
Production and formulation of biocides	0	0.00%	2	1	1	1	2	0	0
Pharmaceutical industry	0	0.00%	2	2	2	3	24	1	1
Oil refining	0	0.00%	2	1	1	3	6	0	0
Cellulose and paper industry	0	0.00%	2	1	3	1	6	0	0
Cement production	0	0.00%	2	1	1	3	6	0	0
Tanning industry	0	0.00%	2	1	1	1	2	0	0
Metal industry	0	0.00%	2	3	1	2	12	1	1
Mining	0	0.00%	2	1	1	1	2	0	0
Shipbuilding and repair	0	0.00%	2	1	1	1	2	0	0
Harbour operations	0	0.00%	2	1	1	1	2	0	0
Textile industry	0	0.00%	2	3	3	2	36	1	1
Electronics industry	0	0.00%	2	1	1	1	2	0	0
Recycling industry	0	0.00%	2	1	1	1	2	0	0
Other sectors of the organic chemical industry	0	0.00%	2	1	1	1	2	0	0
Other sectors of the inorganic chemical industry	0	0.00%	2	1	1	1	2	0	0
Agro-food industry	0	0.00%	2	2	1	3	12	0	1
Treatment and disposal of hazardous wastes	0	0.00%	2	1	1	1	2	0	0
Waste incineration	0	0.00%	2	1	1	1	2	0	0
Transport	0	0.00%	2	1	1	1	2	0	0
TOTAL	1	100.00%							

France									
Industrial sector	**tonnes/y**	**%**	**Amount**	**Env Imp**	**Med Imp**	**Growth prosp**	**Priority**	**Top 3**	**Top 5**
Energy production	0	0.00%	1	2	2	2	8	0	0
Fertiliser production	0	0.00%	1	2	2	2	8	0	0
Production and formulation of biocides	0	0.00%	1	2	2	2	8	0	0
Pharmaceutical industry	0	0.00%	1	2	2	2	8	0	0
Oil refining	984,808	42.73%	3	2	2	2	24	1	1
Cellulose and paper industry	346,752	15.04%	2	2	2	2	16	1	1
Cement production	0	0.00%	1	2	2	2	8	0	0
Tanning industry	0	0.00%	1	2	2	2	8	0	0
Metal industry	409,856	17.78%	2	2	2	2	16	1	1
Mining	72,759	3.16%	1	2	2	2	8	0	0
Shipbuilding and repair	0	0.00%	1	2	2	2	8	0	0
Harbour operations	0	0.00%	1	2	2	2	8	0	0
Textile industry	12,458	0.54%	1	2	2	2	8	0	0
Electronics industry	186,905	8.11%	2	2	2	2	16	0	1
Recycling industry	0	0.00%	1	2	2	2	8	0	0
Other sectors of the organic chemical industry	29,612	1.28%	1	2	2	2	8	0	0
Other sectors of the inorganic chemical industry	42,616	1.85%	1	2	2	2	8	0	0
Agro-food industry	55,338	2.40%	1	2	2	2	8	0	0
Treatment and disposal of hazardous wastes	0	0.00%	1	2	2	2	8	0	0
Waste incineration	0	0.00%	1	2	2	2	8	0	0
Transport	163,744	7.10%	2	2	2	2	16	0	1
TOTAL	2,304,848	100.00%							

Greece									
Industrial sector	**tonnes/y**	**%**	**Amount**	**Env Imp**	**Med Imp**	**Growth prosp**	**Priority**	**Top 3**	**Top 5**
Energy production	0	0.00%	1	1	1	1	1	0	0
Fertiliser production	85,000	33.58%	3	3	1	2	18	1	1
Production and formulation of biocides	0	0.00%	1	1	1	1	1	0	0
Pharmaceutical industry	0	0.00%	1	1	1	1	1	0	0
Oil refining	38,850	15.35%	2	2	1	3	12	1	1
Cellulose and paper industry	9,000	3.56%	1	1	1	2	2	0	1
Cement production	0	0.00%	1	1	1	1	1	0	0
Tanning industry	0	0.00%	1	1	1	1	1	0	0
Metal industry	120,300	47.52%	3	2	1	2	12	1	1
Mining	0	0.00%	1	1	1	1	1	0	0
Shipbuilding and repair	0	0.00%	1	1	1	1	1	0	0
Harbour operations	0	0.00%	1	1	1	1	1	0	0
Textile industry	0	0.00%	1	1	1	1	1	0	0
Electronics industry	0	0.00%	1	1	1	1	1	0	0
Recycling industry	0	0.00%	1	1	1	1	1	0	0
Other sectors of the organic chemical industry	0	0.00%	1	1	1	1	1	0	0
Other sectors of the inorganic chemical industry	0	0.00%	1	1	1	1	1	0	0
Agro-food industry	0	0.00%	1	1	1	1	1	0	0
Treatment and disposal of hazardous wastes	0	0.00%	1	1	1	1	1	0	0
Waste incineration	0	0.00%	1	1	1	1	1	0	0
Transport	0	0.00%	1	1	1	1	1	0	0
TOTAL	253,150	100.00%							

Israel									
Industrial sector	**tonnes/y**	**%**	**Amount**	**Env Imp**	**Med Imp**	**Growth prosp**	**Priority**	**Top 3**	**Top 5**
Energy production	968	0.29%	1	1	2	2	4	0	0
Fertiliser production	3,652	1.11%	1	1	2	2	4	0	0
Production and formulation of biocides	55,219	16.81%	2	3	2	2	24	1	1
Pharmaceutical industry	12,354	3.76%	1	1	2	2	4	0	0
Oil refining	7,794	2.37%	1	1	2	2	4	0	0
Cellulose and paper industry	114	0.03%	1	1	2	2	4	0	0
Cement production	0	0.00%	1	1	2	2	4	0	0
Tanning industry	0	0.00%	1	1	2	2	4	0	0
Metal industry	14,110	4.29%	1	1	2	2	4	0	0
Mining	0	0.00%	1	1	2	2	4	0	0
Shipbuilding and repair	0	0.00%	1	1	2	2	4	0	0
Harbour operations	0	0.00%	1	1	2	2	4	0	0
Textile industry	0	0.00%	1	1	2	2	4	0	0
Electronics industry	27,755	8.45%	2	2	2	2	16	0	1
Recycling industry	3,341	1.02%	1	1	2	2	4	0	0
Other sectors of the organic chemical industry	11,568	3.52%	1	2	2	2	8	0	1
Other sectors of the inorganic chemical industry	131,586	40.05%	3	3	2	2	36	1	1
Agro-food industry	0	0.00%	1	1	2	2	4	0	0
Treatment and disposal of hazardous wastes	16,782	5.11%	2	1	2	2	8	0	0
Waste incineration	4,151	1.26%	1	1	2	2	4	0	0
Transport	39,163	11.92%	2	3	2	2	24	1	1
TOTAL	328,556	100.00%							

Italy									
Industrial sector	**tonnes/y**	**%**	**Amount**	**Env Imp**	**Med Imp**	**Growth prosp**	**Priority**	**Top 3**	**Top 5**
Energy production	58,911	1.95%	1	1	2	2	4	0	0
Fertiliser production	0	0.00%	1	1	2	2	4	0	0
Production and formulation of biocides	0	0.00%	1	1	2	2	4	0	0
Pharmaceutical industry	0	0.00%	1	1	2	2	4	0	0
Oil refining	0	0.00%	1	1	2	2	4	0	0
Cellulose and paper industry	76,841	2.55%	1	1	2	2	4	0	0
Cement production	0	0.00%	1	1	2	2	4	0	0
Tanning industry	5,601	0.19%	1	1	2	2	4	0	0
Metal industry	867,921	28.76%	3	2	2	2	24	1	1
Mining	11,135	0.37%	1	1	2	2	4	0	0
Shipbuilding and repair	0	0.00%	1	1	2	2	4	0	0
Harbour operations	0	0.00%	1	1	2	2	4	0	0
Textile industry	79,301	2.63%	1	1	2	2	4	0	0
Electronics industry	269,634	8.94%	2	1	2	2	8	0	1
Recycling industry	91,708	3.04%	1	1	2	2	4	0	0
Other sectors of the organic chemical industry	1,110,049	36.79%	3	3	2	2	36	1	1
Other sectors of the inorganic chemical industry	15,358	0.51%	1	3	2	2	12	1	1
Agro-food industry	21,801	0.72%	1	1	2	2	4	0	0
Treatment and disposal of hazardous wastes	218,752	7.25%	2	1	2	2	8	0	0
Waste incineration	0	0.00%	1	1	2	2	4	0	0
Transport	190,386	6.31%	2	1	2	2	8	0	1
TOTAL	3,017,398	100.00%							

Lebanon									
Industrial sector	**tonnes/y**	**%**	**Amount**	**Env Imp**	**Med Imp**	**Growth prosp**	**Priority**	**Top 3**	**Top 5**
Energy production	0	0.00%	1	1	1	1	1	0	0
Fertiliser production	0	0.00%	1	1	1	1	1	0	0
Production and formulation of biocides	0	0.00%	1	1	1	1	1	0	0
Pharmaceutical industry	0	0.00%	1	1	1	1	1	0	0
Oil refining	39,566	39.53%	3	3	3	3	81	1	1
Cellulose and paper industry	8,516	8.51%	2	1	1	3	6	0	0
Cement production	0	0.00%	1	1	1	1	1	0	0
Tanning industry	0	0.00%	1	1	1	1	1	0	0
Metal industry	11,856	11.84%	2	3	3	3	54	1	1
Mining	0	0.00%	1	1	1	1	1	0	0
Shipbuilding and repair	0	0.00%	1	1	1	1	1	0	0
Harbour operations	0	0.00%	1	1	1	1	1	0	0
Textile industry	8,681	8.67%	2	2	2	3	24	0	1
Electronics industry	4,411	4.41%	1	1	1	3	3	0	0
Recycling industry	0	0.00%	1	1	1	1	1	0	0
Other sectors of the organic chemical industry	0	0.00%	1	1	1	1	1	0	0
Other sectors of the inorganic chemical industry	11,312	11.30%	2	3	3	3	54	1	1
Agro-food industry	9,036	9.03%	2	2	2	3	24	0	1
Treatment and disposal of hazardous wastes	0	0.00%	1	1	1	1	1	0	0
Waste incineration	0	0.00%	1	1	1	1	1	0	0
Transport	6,724	6.72%	2	1	1	3	6	0	0
TOTAL	100,102	100.00%							

Malta									
Industrial sector	**tonnes/y**	**%**	**Amount**	**Env Imp**	**Med Imp**	**Growth prosp**	**Priority**	**Top 3**	**Top 5**
Energy production	550	8.77%	2	2	1	3	12	0	1
Fertiliser production	0	0.00%	1	2	1	1	2	0	0
Production and formulation of biocides	0	0.00%	1	2	1	1	2	0	0
Pharmaceutical industry	0	0.00%	1	2	1	1	2	0	0
Oil refining	0	0.00%	1	2	1	1	2	0	0
Cellulose and paper industry	306	4.88%	1	2	1	1	2	0	0
Cement production	0	0.00%	1	2	1	1	2	0	0
Tanning industry	0	0.00%	1	2	1	1	2	0	0
Metal industry	922	14.70%	2	2	1	3	12	1	1
Mining	0	0.00%	1	2	1	1	2	0	0
Shipbuilding and repair	2,028	32.33%	3	2	3	1	18	1	1
Harbour operations	0	0.00%	1	2	1	1	2	0	0
Textile industry	0	0.00%	1	2	1	1	2	0	0
Electronics industry	258	4.11%	1	2	1	3	6	0	0
Recycling industry	0	0.00%	1	2	1	1	2	0	0
Other sectors of the organic chemical industry	146	2.33%	1	2	1	2	4	0	0
Other sectors of the inorganic chemical industry	146	2.33%	1	2	1	2	4	0	0
Agro-food industry	314	5.01%	2	2	1	3	12	0	1
Treatment and disposal of hazardous wastes	0	0.00%	1	2	1	1	2	0	0
Waste incineration	0	0.00%	1	2	1	1	2	0	0
Transport	1,602	25.54%	3	2	1	2	12	1	1
TOTAL	6,272	100.00%							

Morocco									
Industrial sector	**tonnes/y**	**%**	**Amount**	**Env Imp**	**Med Imp**	**Growth prosp**	**Priority**	**Top 3**	**Top 5**
Energy production	0	0.00%	1	1	1	2	2	0	0
Fertiliser production	0	0.00%	1	1	1	2	2	0	0
Production and formulation of biocides	0	0.00%	1	1	1	2	2	0	0
Pharmaceutical industry	0	0.00%	1	1	1	2	2	0	0
Oil refining	0	0.00%	1	1	1	2	2	0	0
Cellulose and paper industry	0	0.00%	1	1	1	2	2	0	0
Cement production	0	0.00%	1	1	1	2	2	0	0
Tanning industry	1,700	1.43%	1	2	2	2	8	0	1
Metal industry	10,100	8.49%	2	3	3	2	36	1	1
Mining	0	0.00%	1	1	1	2	2	0	0
Shipbuilding and repair	0	0.00%	1	1	1	2	2	0	0
Harbour operations	0	0.00%	1	1	1	2	2	0	0
Textile industry	5,700	4.79%	1	2	2	2	8	0	0
Electronics industry	930	0.78%	1	2	3	2	12	0	1
Recycling industry	0	0.00%	1	1	1	2	2	0	0
Other sectors of the organic chemical industry	44,320	37.28%	3	1	1	2	6	0	0
Other sectors of the inorganic chemical industry	44,320	37.28%	3	3	2	2	36	1	1
Agro-food industry	9,630	8.10%	2	2	3	2	24	1	1
Treatment and disposal of hazardous wastes	0	0.00%	1	1	1	2	2	0	0
Waste incineration	0	0.00%	1	1	1	2	2	0	0
Transport	2,200	1.85%	1	1	1	2	2	0	0
TOTAL	118,900	100.00%							

Spain									
Industrial sector	**tonnes/y**	**%**	**Amount**	**Env Imp**	**Med Imp**	**Growth prosp**	**Priority**	**Top 3**	**Top 5**
Energy production	3,360	0.08%	1	1	1	2	2	0	0
Fertiliser production	32,386	0.82%	1	1	2	2	4	0	0
Production and formulation of biocides	0	0.00%	1	1	1	1	1	0	0
Pharmaceutical industry	48,727	1.23%	1	3	3	3	27	1	1
Oil refining	94,996	2.40%	1	1	3	2	6	0	0
Cellulose and paper industry	8,085	0.20%	1	1	1	2	2	0	0
Cement production	0	0.00%	1	1	1	1	1	0	0
Tanning industry	3,113	0.08%	1	1	1	1	1	0	0
Metal industry	1,157,678	29.22%	3	1	1	3	9	0	0
Mining	2,059,792	51.98%	3	3	1	1	9	0	1
Shipbuilding and repair	0	0.00%	1	1	1	1	1	0	0
Harbour operations	0	0.00%	1	1	1	1	1	0	0
Textile industry	13,120	0.33%	1	2	2	2	8	0	0
Electronics industry	0	0.00%	1	1	1	1	1	0	0
Recycling industry	0	0.00%	1	1	1	1	1	0	0
Other sectors of the organic chemical industry	140,136	3.54%	1	3	3	3	27	1	1
Other sectors of the inorganic chemical industry	149,113	3.76%	1	3	3	3	27	1	1
Agro-food industry	4,295	0.11%	1	1	1	2	2	0	0
Treatment and disposal of hazardous wastes	247,495	6.25%	2	2	1	3	12	0	1
Waste incineration	0	0.00%	1	1	1	1	1	0	0
Transport	0	0.00%	1	1	1	1	1	0	0
TOTAL	3,962,296	100.00%							

Syria									
Industrial sector	**tonnes/y**	**%**	**Amount**	**Env Imp**	**Med Imp**	**Growth prosp**	**Priority**	**Top 3**	**Top 5**
Energy production	0	0.00%	1	2	2	2	8	0	0
Fertiliser production	60	0.07%	1	2	2	2	8	0	0
Production and formulation of biocides	0	0.00%	1	2	2	2	8	0	0
Pharmaceutical industry	0	0.00%	1	2	2	2	8	0	0
Oil refining	1,500	1.64%	1	2	2	2	8	0	0
Cellulose and paper industry	0	0.00%	1	2	2	2	8	0	0
Cement production	40,000	43.66%	3	2	2	2	24	1	1
Tanning industry	10,000	10.92%	2	2	2	2	16	0	1
Metal industry	7,000	7.64%	2	2	2	2	16	0	1
Mining	0	0.00%	1	2	2	2	8	0	0
Shipbuilding and repair	0	0.00%	1	2	2	2	8	0	0
Harbour operations	0	0.00%	1	2	2	2	8	0	0
Textile industry	4,000	4.37%	1	2	2	2	8	0	0
Electronics industry	0	0.00%	1	2	2	2	8	0	0
Recycling industry	0	0.00%	1	2	2	2	8	0	0
Other sectors of the organic chemical industry	0	0.00%	1	2	2	2	8	0	0
Other sectors of the inorganic chemical industry	11,050	12.06%	2	2	2	2	16	1	1
Agro-food industry	18,000	19.65%	2	2	2	2	16	1	1
Treatment and disposal of hazardous wastes	0	0.00%	1	2	2	2	8	0	0
Waste incineration	0	0.00%	1	2	2	2	8	0	0
Transport	0	0.00%	1	2	2	2	8	0	0
TOTAL	91,610	100.00%							

Turkey									
Industrial sector	**tonnes/y**	**%**	**Amount**	**Env Imp**	**Med Imp**	**Growth prosp**	**Priority**	**Top 3**	**Top 5**
Energy production	0	0.00%	2	3	2	3	36	1	1
Fertiliser production	0	0.00%	2	1	1	1	2	0	0
Production and formulation of biocides	0	0.00%	2	1	1	1	2	0	0
Pharmaceutical industry	0	0.00%	2	1	1	3	6	0	0
Oil refining	0	0.00%	2	3	2	2	24	1	1
Cellulose and paper industry	0	0.00%	2	1	1	2	4	0	0
Cement production	0	0.00%	2	1	1	3	6	0	0
Tanning industry	0	0.00%	2	1	1	2	4	0	0
Metal industry	0	0.00%	2	3	3	3	54	1	1
Mining	0	0.00%	2	1	1	1	2	0	0
Shipbuilding and repair	0	0.00%	2	1	1	1	2	0	0
Harbour operations	0	0.00%	2	1	1	1	2	0	0
Textile industry	0	0.00%	2	2	1	3	12	0	1
Electronics industry	0	0.00%	2	1	1	1	2	0	0
Recycling industry	0	0.00%	2	1	1	1	2	0	0
Other sectors of the organic chemical industry	0	0.00%	2	1	1	1	2	0	0
Other sectors of the inorganic chemical industry	0	0.00%	2	1	1	1	2	0	0
Agro-food industry	0	0.00%	2	1	1	1	2	0	0
Treatment and disposal of hazardous wastes	0	0.00%	2	1	1	1	2	0	0
Waste incineration	0	0.00%	2	2	1	3	12	0	1
Transport	0	0.00%	2	1	1	1	2	0	0
TOTAL	1	100.00%							

Annex 4. Identification of priority types of wastes

Priority types of wastes have been identified at a national level according to the amount criteria. The data have been collected in the following tables which correspond to each of the 16 analysed countries:

Albania
Algeria
Bosnia-Herzegovina
Croatia
Spain
Greece
Malta
Cyprus
Italy
Israel
Lebanon
Morocco
France
Slovenia
Syria
Tunisia

Albania

Waste type	Y-CODE	EWC	tonnes/y	%	Amount	Priority	Top 3	Top 5
Wastes from the production and preparation of pharmaceutical p	Y2		0.00	0.00%	1	8	0	0
Waste pharmaceuticals, drugs and medicines	Y3		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of biocides and	Y4		1,000.00	45.76%	3	24	1	1
Wastes from manufacturing, formulation and use of wood prese	Y5		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of organic solv	Y6	14 00	0.00	0.00%	1	8	0	0
Wastes from heat treatment and tempering operations containin	Y7		0.00	0.00%	1	8	0	0
Waste mineral oils unfit for their originally intended use	Y8	13 00	0.00	0.00%	1	8	0	0
Waste oils/water, hydrocarbons/water mixtures, emulsions	Y9		0.00	0.00%	1	8	0	0
Waste substances and articles containing or contaminated with	Y10		0.00	0.00%	1	8	0	0
Waste tarry residues arising from refining, distillation and any pyı	Y11	05 00	0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of inks, dyes, pigm	Y12	08 00	98.49	4.51%	1	8	0	1
Wastes from production, formulation and use of resins latex, pla	Y13		30.40	1.39%	1	8	0	0
Waste chemical substances arising from research and developm	Y14		0.00	0.00%	1	8	0	0
Wastes of an explosive nature not subject to other legislation	Y15		0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of photographic ch	Y16	09 00	0.00	0.00%	1	8	0	0
Wastes resulting from surface treatment of metals and plastics	Y17	11 00	0.00	0.00%	1	8	0	0
Residues arising from industrial waste disposal operations	Y18	19 00	0.00	0.00%	1	8	0	0
Metal carbonyls	Y19		0.00	0.00%	1	8	0	0
Beryllium; beryllium compounds	Y20		0.00	0.00%	1	8	0	0
Hexavalent chromium compounds	Y21		41.88	1.92%	1	8	0	1
Copper compounds	Y22		3.64	0.17%	1	8	0	0
Zinc compounds	Y23		9.90	0.45%	1	8	0	0
Arsenic, arsenic compounds	Y24		840.00	38.44%	3	24	1	1
Selenium; selenium compounds	Y25		0.00	0.00%	1	8	0	0
Cadmium; cadmium compounds	Y26		0.00	0.00%	1	8	0	0
Antimony; antimony compounds	Y27		0.00	0.00%	1	8	0	0
Tellurium; tellurium compounds	Y28		0.00	0.00%	1	8	0	0
Mercury; mercury compounds	Y29		0.00	0.00%	1	8	0	0
Thallium; thallium compounds	Y30		0.00	0.00%	1	8	0	0
Lead, lead compounds	Y31		13.90	0.64%	1	8	0	0
Inorganic fluorine compounds	Y32		131.60	6.02%	2	16	1	1
Inorganic cyanides	Y33		15.00	0.69%	1	8	0	0
Acidic solutions or acids in solid form	Y34		0.00	0.00%	1	8	0	0
Basic solutions or bases in solid form	Y35		0.00	0.00%	1	8	0	0
Asbestos (dust and fibres)	Y36	6 00	0.00	0.00%	1	8	0	0
Organic phosphorus compounds	Y37		0.00	0.00%	1	8	0	0
Organic cyanides	Y38		0.00	0.00%	1	8	0	0
Phenols, phenolic compounds	Y39		0.60	0.03%	1	8	0	0
Ethers	Y40		0.00	0.00%	1	8	0	0
Halogenated organic solvents	Y41		0.00	0.00%	1	8	0	0
Organic solvents excluding halogenated solvents	Y42		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-furan	Y43		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-p-dioxin	Y44		0.00	0.00%	1	8	0	0
Organohalogen compounds other than substances referred to in	Y45		0.00	0.00%	1	8	0	0
Wastes resulting from exploration, mining, quarring and physical and cher		01 00	0.00	0.00%	1	8	0	0
Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fis		02 00	0.00	0.00%	1	8	0	0
Wastes from wood processing and the production of panels and furniture,		03 00	0.00	0.00%	1	8	0	0
Wastes from leather, fur and textile industries		04 00	0.00	0.00%	1	8	0	0
Wastes from inorganic chemical processes		06 00	0.00	0.00%	1	8	0	0
Wastes from organic chemical processes		07 00	0.00	0.00%	1	8	0	0
Wastes from thermal processes		10 00	0.00	0.00%	1	8	0	0
Wastes from shaping and physical and mechanical surface treatment of m		12 00	0.00	0.00%	1	8	0	0
Waste packaging; absorbents, wiping cloths, filter materials and protective		15 00	0.00	0.00%	1	8	0	0
Wastes not otherwise specified in the list		16 00	0.00	0.00%	1	8	0	0
TOTAL			2,185.41	100.00%				

Algeria

Waste type	Y-CODE	EWC	tonnes/y	%	Amount	Priority	Top 3	Top 5
Wastes from the production and preparation of pharmaceutical p	Y2		0.00	0.00%	1	8	0	0
Waste pharmaceuticals, drugs and medicines	Y3		211.00	0.06%	1	8	0	0
Wastes from the production, formulation and use of biocides and	Y4		0.00	0.00%	1	8	0	0
Wastes from manufacturing, formulation and use of wood prese	Y5		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of organic solv	Y6	14 00	267.00	0.08%	1	8	0	0
Wastes from heat treatment and tempering operations containin	Y7		0.00	0.00%	1	8	0	0
Waste mineral oils unfit for their originally intended use	Y8	13 00	61,094.00	18.80%	2	16	1	1
Waste oils/water, hydrocarbons/water mixtures, emulsions	Y9		0.00	0.00%	1	8	0	0
Waste substances and articles containing or contaminated with	Y10		0.00	0.00%	1	8	0	0
Waste tarry residues arising from refining, distillation and any pyı	Y11	05 00	110,708.00	34.07%	3	24	1	1
Wastes from production, formulation and use of inks, dyes, pigm	Y12	08 00	3,403.00	1.05%	1	8	0	0
Wastes from production, formulation and use of resins latex, pla	Y13		0.00	0.00%	1	8	0	0
Waste chemical substances arising from research and developm	Y14		0.00	0.00%	1	8	0	0
Wastes of an explosive nature not subject to other legislation	Y15		0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of photographic ch	Y16	09 00	0.00	0.00%	1	8	0	0
Wastes resulting from surface treatment of metals and plastics	Y17	11 00	18,403.00	5.66%	2	16	0	0
Residues arising from industrial waste disposal operations	Y18	19 00	17,121.00	5.27%	2	16	0	0
Metal carbonyls	Y19		0.00	0.00%	1	8	0	0
Beryllium; beryllium compounds	Y20		0.00	0.00%	1	8	0	0
Hexavalent chromium compounds	Y21		0.00	0.00%	1	8	0	0
Copper compounds	Y22		0.00	0.00%	1	8	0	0
Zinc compounds	Y23		0.00	0.00%	1	8	0	0
Arsenic, arsenic compounds	Y24		0.00	0.00%	1	8	0	0
Selenium; selenium compounds	Y25		0.00	0.00%	1	8	0	0
Cadmium; cadmium compounds	Y26		0.00	0.00%	1	8	0	0
Antimony; antimony compounds	Y27		0.00	0.00%	1	8	0	0
Tellurium; tellurium compounds	Y28		0.00	0.00%	1	8	0	0
Mercury; mercury compounds	Y29		0.00	0.00%	1	8	0	0
Thallium; thallium compounds	Y30		0.00	0.00%	1	8	0	0
Lead, lead compounds	Y31		0.00	0.00%	1	8	0	0
Inorganic fluorine compounds	Y32		0.00	0.00%	1	8	0	0
Inorganic cyanides	Y33		0.00	0.00%	1	8	0	0
Acidic solutions or acids in solid form	Y34		0.00	0.00%	1	8	0	0
Basic solutions or bases in solid form	Y35		0.00	0.00%	1	8	0	0
Asbestos (dust and fibres)	Y36	6 00	0.00	0.00%	1	8	0	0
Organic phosphorus compounds	Y37		0.00	0.00%	1	8	0	0
Organic cyanides	Y38		0.00	0.00%	1	8	0	0
Phenols, phenolic compounds	Y39		0.00	0.00%	1	8	0	0
Ethers	Y40		0.00	0.00%	1	8	0	0
Halogenated organic solvents	Y41		0.00	0.00%	1	8	0	0
Organic solvents excluding halogenated solvents	Y42		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-furan	Y43		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-p-dioxin	Y44		0.00	0.00%	1	8	0	0
Organohalogen compounds other than substances referred to in	Y45		0.00	0.00%	1	8	0	0
Wastes resulting from exploration, mining, quarring and physical and cher		01 00	4,240.00	1.30%	1	8	0	0
Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fis		02 00	87.00	0.03%	1	8	0	0
Wastes from wood processing and the production of panels and furniture,		03 00	20.00	0.01%	1	8	0	0
Wastes from leather, fur and textile industries		04 00	3,466.00	1.07%	1	8	0	0
Wastes from inorganic chemical processes		06 00	26,005.00	8.00%	2	16	0	1
Wastes from organic chemical processes		07 00	6,071.00	1.87%	1	8	0	0
Wastes from thermal processes		10 00	28,486.00	8.77%	2	16	0	1
Wastes from shaping and physical and mechanical surface treatment of m		12 00	829.00	0.26%	1	8	0	0
Waste packaging: absorbents, wiping cloths, filter materials and protective		15 00	828.00	0.25%	1	8	0	0
Wastes not otherwise specified in the list		16 00	43,747.00	13.46%	2	16	1	1
TOTAL			324,986.00	100.00%				

Bosnia-Herzegovina

Waste type	Y-CODE	EWC	tonnes/y	%	Amount	Priority	Top 3	Top 5
Wastes from the production and preparation of pharmaceutical p	Y2		0.00	0.00%	1	8	0	0
Waste pharmaceuticals, drugs and medicines	Y3		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of biocides and	Y4		0.00	0.00%	1	8	0	0
Wastes from manufacturing, formulation and use of wood prese	Y5		110.00	4.85%	1	8	0	0
Wastes from the production, formulation and use of organic solv	Y6	14 00	0.00	0.00%	1	8	0	0
Wastes from heat treatment and tempering operations containin	Y7		0.00	0.00%	1	8	0	0
Waste mineral oils unfit for their originally intended use	Y8	13 00	140.00	6.17%	2	16	0	1
Waste oils/water, hydrocarbons/water mixtures, emulsions	Y9		140.00	6.17%	2	16	1	1
Waste substances and articles containing or contaminated with	Y10		0.00	0.00%	1	8	0	0
Waste tarry residues arising from refining, distillation and any pyr	Y11	05 00	830.00	36.56%	3	24	1	1
Wastes from production, formulation and use of inks, dyes, pigm	Y12	08 00	30.00	1.32%	1	8	0	0
Wastes from production, formulation and use of resins latex, pla	Y13		0.00	0.00%	1	8	0	0
Waste chemical substances arising from research and developm	Y14		0.00	0.00%	1	8	0	0
Wastes of an explosive nature not subject to other legislation	Y15		0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of photographic ch	Y16	09 00	0.00	0.00%	1	8	0	0
Wastes resulting from surface treatment of metals and plastics	Y17	11 00	90.00	3.96%	1	8	0	0
Residues arising from industrial waste disposal operations	Y18	19 00	0.00	0.00%	1	8	0	0
Metal carbonyls	Y19		0.00	0.00%	1	8	0	0
Beryllium; beryllium compounds	Y20		0.00	0.00%	1	8	0	0
Hexavalent chromium compounds	Y21		0.00	0.00%	1	8	0	0
Copper compounds	Y22		0.00	0.00%	1	8	0	0
Zinc compounds	Y23		0.00	0.00%	1	8	0	0
Arsenic, arsenic compounds	Y24		0.00	0.00%	1	8	0	0
Selenium; selenium compounds	Y25		0.00	0.00%	1	8	0	0
Cadmium; cadmium compounds	Y26		0.00	0.00%	1	8	0	0
Antimony; antimony compounds	Y27		0.00	0.00%	1	8	0	0
Tellurium; tellurium compounds	Y28		0.00	0.00%	1	8	0	0
Mercury; mercury compounds	Y29		0.00	0.00%	1	8	0	0
Thallium; thallium compounds	Y30		0.00	0.00%	1	8	0	0
Lead, lead compounds	Y31		0.00	0.00%	1	8	0	0
Inorganic fluorine compounds	Y32		0.00	0.00%	1	8	0	0
Inorganic cyanides	Y33		0.00	0.00%	1	8	0	0
Acidic solutions or acids in solid form	Y34		0.00	0.00%	1	8	0	0
Basic solutions or bases in solid form	Y35		0.00	0.00%	1	8	0	0
Asbestos (dust and fibres)	Y36	6 00	0.00	0.00%	1	8	0	0
Organic phosphorus compounds	Y37		0.00	0.00%	1	8	0	0
Organic cyanides	Y38		0.00	0.00%	1	8	0	0
Phenols, phenolic compounds	Y39		0.00	0.00%	1	8	0	0
Ethers	Y40		0.00	0.00%	1	8	0	0
Halogenated organic solvents	Y41		0.00	0.00%	1	8	0	0
Organic solvents excluding halogenated solvents	Y42		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-furan	Y43		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-p-dioxin	Y44		0.00	0.00%	1	8	0	0
Organohalogen compounds other than substances referred to in	Y45		0.00	0.00%	1	8	0	0
Wastes resulting from exploration, mining, quarring and physical and cher		01 00	480.00	21.15%	3	24	1	1
Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fis		02 00	0.00	0.00%	1	8	0	0
Wastes from wood processing and the production of panels and furniture,		03 00	100.00	4.41%	1	8	0	0
Wastes from leather, fur and textile industries		04 00	12.00	0.53%	1	8	0	0
Wastes from inorganic chemical processes		06 00	13.00	0.57%	1	8	0	0
Wastes from organic chemical processes		07 00	70.00	3.08%	1	8	0	0
Wastes from thermal processes		10 00	125.00	5.51%	2	16	0	0
Wastes from shaping and physical and mechanical surface treatment of m		12 00	0.00	0.00%	1	8	0	0
Waste packaging; absorbents, wiping cloths, filter materials and protective		15 00	0.00	0.00%	1	8	0	0
Wastes not otherwise specified in the list		16 00	130.00	5.73%	2	16	0	1
TOTAL			2,270.00	100.00%				

Croatia

Waste type	Y-CODE	EWC	tonnes/y	%	Amount	Priority	Top 3	Top 5
Wastes from the production and preparation of pharmaceutical p	Y2		0.00	0.00%	1	8	0	0
Waste pharmaceuticals, drugs and medicines	Y3		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of biocides and	Y4		0.00	0.00%	1	8	0	0
Wastes from manufacturing, formulation and use of wood prese	Y5		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of organic solv	Y6	14 00	1,800.00	0.75%	1	8	0	1
Wastes from heat treatment and tempering operations containin	Y7		0.00	0.00%	1	8	0	0
Waste mineral oils unfit for their originally intended use	Y8	13 00	30,000.00	12.56%	2	16	1	1
Waste oils/water, hydrocarbons/water mixtures, emulsions	Y9		25,000.00	10.46%	2	16	1	1
Waste substances and articles containing or contaminated with	Y10		100.00	0.04%	1	8	0	0
Waste tarry residues arising from refining, distillation and any py	Y11	05 00	180,000.00	75.35%	3	24	1	1
Wastes from production, formulation and use of inks, dyes, pigm	Y12	08 00	2,000.00	0.84%	1	8	0	1
Wastes from production, formulation and use of resins latex, pla	Y13		0.00	0.00%	1	8	0	0
Waste chemical substances arising from research and developm	Y14		0.00	0.00%	1	8	0	0
Wastes of an explosive nature not subject to other legislation	Y15		0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of photographic ch	Y16	09 00	0.00	0.00%	1	8	0	0
Wastes resulting from surface treatment of metals and plastics	Y17	11 00	0.00	0.00%	1	8	0	0
Residues arising from industrial waste disposal operations	Y18	19 00	0.00	0.00%	1	8	0	0
Metal carbonyls	Y19		0.00	0.00%	1	8	0	0
Beryllium; beryllium compounds	Y20		0.00	0.00%	1	8	0	0
Hexavalent chromium compounds	Y21		0.00	0.00%	1	8	0	0
Copper compounds	Y22		0.00	0.00%	1	8	0	0
Zinc compounds	Y23		0.00	0.00%	1	8	0	0
Arsenic, arsenic compounds	Y24		0.00	0.00%	1	8	0	0
Selenium; selenium compounds	Y25		0.00	0.00%	1	8	0	0
Cadmium; cadmium compounds	Y26		0.00	0.00%	1	8	0	0
Antimony; antimony compounds	Y27		0.00	0.00%	1	8	0	0
Tellurium; tellurium compounds	Y28		0.00	0.00%	1	8	0	0
Mercury; mercury compounds	Y29		0.00	0.00%	1	8	0	0
Thallium; thallium compounds	Y30		0.00	0.00%	1	8	0	0
Lead, lead compounds	Y31		0.00	0.00%	1	8	0	0
Inorganic fluorine compounds	Y32		0.00	0.00%	1	8	0	0
Inorganic cyanides	Y33		0.00	0.00%	1	8	0	0
Acidic solutions or acids in solid form	Y34		0.00	0.00%	1	8	0	0
Basic solutions or bases in solid form	Y35		0.00	0.00%	1	8	0	0
Asbestos (dust and fibres)	Y36	6 00	0.00	0.00%	1	8	0	0
Organic phosphorus compounds	Y37		0.00	0.00%	1	8	0	0
Organic cyanides	Y38		0.00	0.00%	1	8	0	0
Phenols, phenolic compounds	Y39		0.00	0.00%	1	8	0	0
Ethers	Y40		0.00	0.00%	1	8	0	0
Halogenated organic solvents	Y41		0.00	0.00%	1	8	0	0
Organic solvents excluding halogenated solvents	Y42		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-furan	Y43		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-p-dioxin	Y44		0.00	0.00%	1	8	0	0
Organohalogen compounds other than substances referred to in	Y45		0.00	0.00%	1	8	0	0
Wastes resulting from exploration, mining, quarring and physical and cher		01 00	0.00	0.00%	1	8	0	0
Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fis		02 00	0.00	0.00%	1	8	0	0
Wastes from wood processing and the production of panels and furniture,		03 00	0.00	0.00%	1	8	0	0
Wastes from leather, fur and textile industries		04 00	0.00	0.00%	1	8	0	0
Wastes from inorganic chemical processes		06 00	0.00	0.00%	1	8	0	0
Wastes from organic chemical processes		07 00	0.00	0.00%	1	8	0	0
Wastes from thermal processes		10 00	0.00	0.00%	1	8	0	0
Wastes from shaping and physical and mechanical surface treatment of m		12 00	0.00	0.00%	1	8	0	0
Waste packaging; absorbents, wiping cloths, filter materials and protective		15 00	0.00	0.00%	1	8	0	0
Wastes not otherwise specified in the list		16 00	0.00	0.00%	1	8	0	0
TOTAL			238,900.00	100.00%				

Cyprus

Waste type	Y-CODE	EWC	tonnes/y	%	Amount	Priority	Top 3	Top 5
Wastes from the production and preparation of pharmaceutical p	Y2		5.00	0.01%	1	8	0	0
Waste pharmaceuticals, drugs and medicines	Y3		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of biocides and	Y4		400.00	0.89%	1	8	0	0
Wastes from manufacturing, formulation and use of wood prese	Y5		550.00	1.22%	1	8	0	1
Wastes from the production, formulation and use of organic solv	Y6	14 00	11.00	0.02%	1	8	0	0
Wastes from heat treatment and tempering operations containin	Y7		0.00	0.00%	1	8	0	0
Waste mineral oils unfit for their originally intended use	Y8	13 00	520.00	1.16%	1	8	0	1
Waste oils/water, hydrocarbons/water mixtures, emulsions	Y9		0.00	0.00%	1	8	0	0
Waste substances and articles containing or contaminated with	Y10		0.00	0.00%	1	8	0	0
Waste tarry residues arising from refining, distillation and any pyr	Y11	05 00	0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of inks, dyes, pigm	Y12	08 00	37,500.00	83.45%	3	24	1	1
Wastes from production, formulation and use of resins latex, pla	Y13		500.00	1.11%	1	8	0	0
Waste chemical substances arising from research and developm	Y14		0.00	0.00%	1	8	0	0
Wastes of an explosive nature not subject to other legislation	Y15		0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of photographic ch	Y16	09 00	54.00	0.12%	1	8	0	0
Wastes resulting from surface treatment of metals and plastics	Y17	11 00	3,000.00	6.68%	2	16	1	1
Residues arising from industrial waste disposal operations	Y18	19 00	0.00	0.00%	1	8	0	0
Metal carbonyls	Y19		0.00	0.00%	1	8	0	0
Beryllium; beryllium compounds	Y20		0.00	0.00%	1	8	0	0
Hexavalent chromium compounds	Y21		0.00	0.00%	1	8	0	0
Copper compounds	Y22		0.00	0.00%	1	8	0	0
Zinc compounds	Y23		0.00	0.00%	1	8	0	0
Arsenic, arsenic compounds	Y24		0.00	0.00%	1	8	0	0
Selenium; selenium compounds	Y25		0.00	0.00%	1	8	0	0
Cadmium; cadmium compounds	Y26		0.00	0.00%	1	8	0	0
Antimony; antimony compounds	Y27		0.00	0.00%	1	8	0	0
Tellurium; tellurium compounds	Y28		0.00	0.00%	1	8	0	0
Mercury; mercury compounds	Y29		0.00	0.00%	1	8	0	0
Thallium; thallium compounds	Y30		0.00	0.00%	1	8	0	0
Lead, lead compounds	Y31		2,399.00	5.34%	2	16	1	1
Inorganic fluorine compounds	Y32		0.00	0.00%	1	8	0	0
Inorganic cyanides	Y33		0.00	0.00%	1	8	0	0
Acidic solutions or acids in solid form	Y34		0.00	0.00%	1	8	0	0
Basic solutions or bases in solid form	Y35		0.00	0.00%	1	8	0	0
Asbestos (dust and fibres)	Y36	6 00	0.00	0.00%	1	8	0	0
Organic phosphorus compounds	Y37		0.00	0.00%	1	8	0	0
Organic cyanides	Y38		0.00	0.00%	1	8	0	0
Phenols, phenolic compounds	Y39		0.00	0.00%	1	8	0	0
Ethers	Y40		0.00	0.00%	1	8	0	0
Halogenated organic solvents	Y41		0.00	0.00%	1	8	0	0
Organic solvents excluding halogenated solvents	Y42		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-furan	Y43		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-p-dioxin	Y44		0.00	0.00%	1	8	0	0
Organohalogen compounds other than substances referred to in	Y45		0.00	0.00%	1	8	0	0
Wastes resulting from exploration, mining, quarring and physical and cher		01 00	0.00	0.00%	1	8	0	0
Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fis		02 00	0.00	0.00%	1	8	0	0
Wastes from wood processing and the production of panels and furniture,		03 00	0.00	0.00%	1	8	0	0
Wastes from leather, fur and textile industries		04 00	0.00	0.00%	1	8	0	0
Wastes from inorganic chemical processes		06 00	0.00	0.00%	1	8	0	0
Wastes from organic chemical processes		07 00	0.00	0.00%	1	8	0	0
Wastes from thermal processes		10 00	0.00	0.00%	1	8	0	0
Wastes from shaping and physical and mechanical surface treatment of m		12 00	0.00	0.00%	1	8	0	0
Waste packaging; absorbents, wiping cloths, filter materials and protective		15 00	0.00	0.00%	1	8	0	0
Wastes not otherwise specified in the list		16 00	0.00	0.00%	1	8	0	0
TOTAL			44,939.00	100.00%				

France

Waste type	Y-CODE	EWC	tonnes/y	%	Amount	Priority	Top 3	Top 5
Wastes from the production and preparation of pharmaceutical products	Y2		0.00	0.00%	1	8	0	0
Waste pharmaceuticals, drugs and medicines	Y3		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of biocides and phytopl	Y4		0.00	0.00%	1	8	0	0
Wastes from manufacturing, formulation and use of wood preserving che	Y5		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of organic solvents	Y6	14 00	297,955.00	31.00%	3	24	1	1
Wastes from heat treatment and tempering operations containing cyanid	Y7		0.00	0.00%	1	8	0	0
Waste mineral oils unfit for their originally intended use	Y8	13 00	106,622.00	11.09%	2	16	0	1
Waste oils/water, hydrocarbons/water mixtures, emulsions	Y9		106,622.00	11.09%	2	16	0	1
Waste substances and articles containing or contaminated with PCB, PC	Y10		0.00	0.00%	1	8	0	0
Waste tarry residues arising from refining, distillation and any pyrolitic tre	Y11	05 00	0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of inks, dyes, pigments, pa	Y12	08 00	0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of resins latex, plasticizers	Y13		0.00	0.00%	1	8	0	0
Waste chemical substances arising from research and development or te	Y14		0.00	0.00%	1	8	0	0
Wastes of an explosive nature not subject to other legislation	Y15		0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of photographic chemicals	Y16	09 00	0.00	0.00%	1	8	0	0
Wastes resulting from surface treatment of metals and plastics	Y17	11 00	0.00	0.00%	1	8	0	0
Residues arising from industrial waste disposal operations	Y18	19 00	0.00	0.00%	1	8	0	0
Metal carbonyls	Y19		0.00	0.00%	1	8	0	0
Beryllium; beryllium compounds	Y20		0.00	0.00%	1	8	0	0
Hexavalent chromium compounds	Y21		0.00	0.00%	1	8	0	0
Copper compounds	Y22		0.00	0.00%	1	8	0	0
Zinc compounds	Y23		0.00	0.00%	1	8	0	0
Arsenic, arsenic compounds	Y24		0.00	0.00%	1	8	0	0
Selenium; selenium compounds	Y25		0.00	0.00%	1	8	0	0
Cadmium; cadmium compounds	Y26		0.00	0.00%	1	8	0	0
Antimony; antimony compounds	Y27		0.00	0.00%	1	8	0	0
Tellurium; tellurium compounds	Y28		0.00	0.00%	1	8	0	0
Mercury; mercury compounds	Y29		0.00	0.00%	1	8	0	0
Thallium; thallium compounds	Y30		0.00	0.00%	1	8	0	0
Lead, lead compounds	Y31		0.00	0.00%	1	8	0	0
Inorganic fluorine compounds	Y32		0.00	0.00%	1	8	0	0
Inorganic cyanides	Y33		0.00	0.00%	1	8	0	0
Acidic solutions or acids in solid form	Y34		162,591.00	16.92%	2	16	1	1
Basic solutions or bases in solid form	Y35		162,591.00	16.92%	2	16	1	1
Asbestos (dust and fibres)	Y36	6 00	0.00	0.00%	1	8	0	0
Organic phosphorus compounds	Y37		0.00	0.00%	1	8	0	0
Organic cyanides	Y38		0.00	0.00%	1	8	0	0
Phenols, phenolic compounds	Y39		0.00	0.00%	1	8	0	0
Ethers	Y40		0.00	0.00%	1	8	0	0
Halogenated organic solvents	Y41		0.00	0.00%	1	8	0	0
Organic solvents excluding halogenated solvents	Y42		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-furan	Y43		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-p-dioxin	Y44		0.00	0.00%	1	8	0	0
Organohalogen compounds other than substances referred to in this Anı	Y45		0.00	0.00%	1	8	0	0
Wastes resulting from exploration, mining, quarring and physical and chemical trea		01 00	0.00	0.00%	1	8	0	0
Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing, foc		02 00	0.00	0.00%	1	8	0	0
Wastes from wood processing and the production of panels and furniture, pulp, pa		03 00	0.00	0.00%	1	8	0	0
Wastes from leather, fur and textile industries		04 00	0.00	0.00%	1	8	0	0
Wastes from inorganic chemical processes		06 00	62,377.50	6.49%	2	16	0	0
Wastes from organic chemical processes		07 00	62,377.50	6.49%	2	16	0	0
Wastes from thermal processes		10 00	0.00	0.00%	1	8	0	0
Wastes from shaping and physical and mechanical surface treatment of metals an		12 00	0.00	0.00%	1	8	0	0
Waste packaging: absorbents, wiping cloths, filter materials and protective clothing		15 00	0.00	0.00%	1	8	0	0
Wastes not otherwise specified in the list		16 00	0.00	0.00%	1	8	0	0
TOTAL			961,136.00	100.00%				

Greece

Waste type	Y-CODE	EWC	tonnes/y	%	Amount	Priority	Top 3	Top 5
Wastes from the production and preparation of pharmaceutical p	Y2		0.00	0.00%	1	8	0	0
Waste pharmaceuticals, drugs and medicines	Y3		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of biocides and	Y4		0.00	0.00%	1	8	0	0
Wastes from manufacturing, formulation and use of wood prese	Y5		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of organic solv	Y6	14 00	0.00	0.00%	1	8	0	0
Wastes from heat treatment and tempering operations containin	Y7		0.00	0.00%	1	8	0	0
Waste mineral oils unfit for their originally intended use	Y8	13 00	6,700.00	2.30%	1	8	0	0
Waste oils/water, hydrocarbons/water mixtures, emulsions	Y9		0.00	0.00%	1	8	0	0
Waste substances and articles containing or contaminated with	Y10		0.00	0.00%	1	8	0	0
Waste tarry residues arising from refining, distillation and any pyr	Y11	05 00	33,650.00	11.53%	2	16	1	1
Wastes from production, formulation and use of inks, dyes, pigm	Y12	08 00	0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of resins latex, pla	Y13		0.00	0.00%	1	8	0	0
Waste chemical substances arising from research and developm	Y14		0.00	0.00%	1	8	0	0
Wastes of an explosive nature not subject to other legislation	Y15		0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of photographic ch	Y16	09 00	0.00	0.00%	1	8	0	0
Wastes resulting from surface treatment of metals and plastics	Y17	11 00	27,400.00	9.39%	2	16	0	1
Residues arising from industrial waste disposal operations	Y18	19 00	0.00	0.00%	1	8	0	0
Metal carbonyls	Y19		0.00	0.00%	1	8	0	0
Beryllium; beryllium compounds	Y20		0.00	0.00%	1	8	0	0
Hexavalent chromium compounds	Y21		0.00	0.00%	1	8	0	0
Copper compounds	Y22		0.00	0.00%	1	8	0	0
Zinc compounds	Y23		0.00	0.00%	1	8	0	0
Arsenic, arsenic compounds	Y24		0.00	0.00%	1	8	0	0
Selenium; selenium compounds	Y25		0.00	0.00%	1	8	0	0
Cadmium; cadmium compounds	Y26		0.00	0.00%	1	8	0	0
Antimony; antimony compounds	Y27		0.00	0.00%	1	8	0	0
Tellurium; tellurium compounds	Y28		0.00	0.00%	1	8	0	0
Mercury; mercury compounds	Y29		0.00	0.00%	1	8	0	0
Thallium; thallium compounds	Y30		0.00	0.00%	1	8	0	0
Lead, lead compounds	Y31		1,000.00	0.34%	1	8	0	0
Inorganic fluorine compounds	Y32		0.00	0.00%	1	8	0	0
Inorganic cyanides	Y33		0.00	0.00%	1	8	0	0
Acidic solutions or acids in solid form	Y34		0.00	0.00%	1	8	0	0
Basic solutions or bases in solid form	Y35		0.00	0.00%	1	8	0	0
Asbestos (dust and fibres)	Y36	6 00	900.00	0.31%	1	8	0	0
Organic phosphorus compounds	Y37		0.00	0.00%	1	8	0	0
Organic cyanides	Y38		0.00	0.00%	1	8	0	0
Phenols, phenolic compounds	Y39		0.00	0.00%	1	8	0	0
Ethers	Y40		0.00	0.00%	1	8	0	0
Halogenated organic solvents	Y41		0.00	0.00%	1	8	0	0
Organic solvents excluding halogenated solvents	Y42		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-furan	Y43		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-p-dioxin	Y44		0.00	0.00%	1	8	0	0
Organohalogen compounds other than substances referred to in	Y45		0.00	0.00%	1	8	0	0
Wastes resulting from exploration, mining, quarring and physical and cher		01 00	0.00	0.00%	1	8	0	0
Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fis		02 00	0.00	0.00%	1	8	0	0
Wastes from wood processing and the production of panels and furniture,		03 00	9,000.00	3.08%	1	8	0	0
Wastes from leather, fur and textile industries		04 00	8,400.00	2.88%	1	8	0	0
Wastes from inorganic chemical processes		06 00	7,800.00	2.67%	1	8	0	0
Wastes from organic chemical processes		07 00	2,000.00	0.69%	1	8	0	0
Wastes from thermal processes		10 00	10,000.00	3.43%	1	8	0	1
Wastes from shaping and physical and mechanical surface treatment of m		12 00	108,700.00	37.25%	3	24	1	1
Waste packaging; absorbents, wiping cloths, filter materials and protective		15 00	0.00	0.00%	1	8	0	0
Wastes not otherwise specified in the list		16 00	76,250.00	26.13%	3	24	1	1
TOTAL			291,800.00	100.00%				

Israel

Waste type	Y-CODE	EWC	tonnes/y	%	Amount	Priority	Top 3	Top 5
Wastes from the production and preparation of pharmaceutical p	Y2		0.00	0.00%	1	8	0	0
Waste pharmaceuticals, drugs and medicines	Y3		635.00	0.83%	1	8	0	0
Wastes from the production, formulation and use of biocides and	Y4		492.00	0.64%	1	8	0	0
Wastes from manufacturing, formulation and use of wood prese	Y5		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of organic solv	Y6	14 00	0.00	0.00%	1	8	0	0
Wastes from heat treatment and tempering operations containin	Y7		0.00	0.00%	1	8	0	0
Waste mineral oils unfit for their originally intended use	Y8	13 00	377.00	0.49%	1	8	0	0
Waste oils/water, hydrocarbons/water mixtures, emulsions	Y9		211.00	0.27%	1	8	0	0
Waste substances and articles containing or contaminated with	Y10		7.00	0.01%	1	8	0	0
Waste tarry residues arising from refining, distillation and any pyr	Y11	05 00	502.00	0.65%	1	8	0	0
Wastes from production, formulation and use of inks, dyes, pigm	Y12	08 00	789.00	1.03%	1	8	0	0
Wastes from production, formulation and use of resins latex, pla	Y13		134.00	0.17%	1	8	0	0
Waste chemical substances arising from research and developm	Y14		1.00	0.00%	1	8	0	0
Wastes of an explosive nature not subject to other legislation	Y15		0.10	0.00%	1	8	0	0
Wastes from production, formulation and use of photographic ch	Y16	09 00	19.00	0.02%	1	8	0	0
Wastes resulting from surface treatment of metals and plastics	Y17	11 00	0.00	0.00%	1	8	0	0
Residues arising from industrial waste disposal operations	Y18	19 00	0.00	0.00%	1	8	0	0
Metal carbonyls	Y19		0.00	0.00%	1	8	0	0
Beryllium; beryllium compounds	Y20		0.00	0.00%	1	8	0	0
Hexavalent chromium compounds	Y21		1,024.00	1.33%	1	8	0	0
Copper compounds	Y22		264.00	0.34%	1	8	0	0
Zinc compounds	Y23		220.50	0.29%	1	8	0	0
Arsenic, arsenic compounds	Y24		2,243.00	2.92%	1	8	0	1
Selenium; selenium compounds	Y25		0.00	0.00%	1	8	0	0
Cadmium; cadmium compounds	Y26		211.50	0.28%	1	8	0	0
Antimony; antimony compounds	Y27		0.00	0.00%	1	8	0	0
Tellurium; tellurium compounds	Y28		0.00	0.00%	1	8	0	0
Mercury; mercury compounds	Y29		1,161.00	1.51%	1	8	0	1
Thallium; thallium compounds	Y30		0.00	0.00%	1	8	0	0
Lead, lead compounds	Y31		0.10	0.00%	1	8	0	0
Inorganic fluorine compounds	Y32		0.00	0.00%	1	8	0	0
Inorganic cyanides	Y33		377.00	0.49%	1	8	0	0
Acidic solutions or acids in solid form	Y34		7,035.00	9.15%	2	16	1	1
Basic solutions or bases in solid form	Y35		50,596.00	65.81%	3	24	1	1
Asbestos (dust and fibres)	Y36	6 00	0.00	0.00%	1	8	0	0
Organic phosphorus compounds	Y37		3.00	0.00%	1	8	0	0
Organic cyanides	Y38		0.00	0.00%	1	8	0	0
Phenols, phenolic compounds	Y39		29.00	0.04%	1	8	0	0
Ethers	Y40		0.00	0.00%	1	8	0	0
Halogenated organic solvents	Y41		309.00	0.40%	1	8	0	0
Organic solvents excluding halogenated solvents	Y42		10,245.00	13.33%	2	16	1	1
Any congener of polychlorinated dibenzo-furan	Y43		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-p-dioxin	Y44		0.00	0.00%	1	8	0	0
Organohalogen compounds other than substances referred to in	Y45		0.00	0.00%	1	8	0	0
Wastes resulting from exploration, mining, quarring and physical and cher		01 00	0.00	0.00%	1	8	0	0
Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fis		02 00	0.00	0.00%	1	8	0	0
Wastes from wood processing and the production of panels and furniture,		03 00	0.00	0.00%	1	8	0	0
Wastes from leather, fur and textile industries		04 00	0.00	0.00%	1	8	0	0
Wastes from inorganic chemical processes		06 00	0.00	0.00%	1	8	0	0
Wastes from organic chemical processes		07 00	0.00	0.00%	1	8	0	0
Wastes from thermal processes		10 00	0.00	0.00%	1	8	0	0
Wastes from shaping and physical and mechanical surface treatment of m		12 00	0.00	0.00%	1	8	0	0
Waste packaging: absorbents, wiping cloths, filter materials and protective		15 00	0.00	0.00%	1	8	0	0
Wastes not otherwise specified in the list		16 00	0.00	0.00%	1	8	0	0
TOTAL			76,885.20	100.00%				

Italy

Waste type	Y-CODE	EWC	tonnes/y	%	Amount	Priority	Top 3	Top 5
Wastes from the production and preparation of pharmaceutical p	Y2		0.00	0.00%	1	8	0	0
Waste pharmaceuticals, drugs and medicines	Y3		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of biocides an	Y4		0.00	0.00%	1	8	0	0
Wastes from manufacturing, formulation and use of wood prese	Y5		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of organic solv	Y6	14 00	58,332.00	1.62%	1	8	0	0
Wastes from heat treatment and tempering operations containin	Y7		0.00	0.00%	1	8	0	0
Waste mineral oils unfit for their originally intended use	Y8	13 00	475,063.00	13.15%	2	16	1	1
Waste oils/water, hydrocarbons/water mixtures, emulsions	Y9		0.00	0.00%	1	8	0	0
Waste substances and articles containing or contaminated with	Y10		0.00	0.00%	1	8	0	0
Waste tarry residues arising from refining, distillation and any py	Y11	05 00	47,537.00	1.32%	1	8	0	0
Wastes from production, formulation and use of inks, dyes, pigm	Y12	08 00	48,236.00	1.34%	1	8	0	0
Wastes from production, formulation and use of resins latex, pla	Y13		0.00	0.00%	1	8	0	0
Waste chemical substances arising from research and developm	Y14		0.00	0.00%	1	8	0	0
Wastes of an explosive nature not subject to other legislation	Y15		0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of photographic ch	Y16	09 00	77,139.00	2.14%	1	8	0	0
Wastes resulting from surface treatment of metals and plastics	Y17	11 00	363,871.00	10.07%	2	16	0	1
Residues arising from industrial waste disposal operations	Y18	19 00	218,752.00	6.06%	2	16	0	0
Metal carbonyls	Y19		0.00	0.00%	1	8	0	0
Beryllium; beryllium compounds	Y20		0.00	0.00%	1	8	0	0
Hexavalent chromium compounds	Y21		0.00	0.00%	1	8	0	0
Copper compounds	Y22		0.00	0.00%	1	8	0	0
Zinc compounds	Y23		0.00	0.00%	1	8	0	0
Arsenic, arsenic compounds	Y24		0.00	0.00%	1	8	0	0
Selenium; selenium compounds	Y25		0.00	0.00%	1	8	0	0
Cadmium; cadmium compounds	Y26		0.00	0.00%	1	8	0	0
Antimony; antimony compounds	Y27		0.00	0.00%	1	8	0	0
Tellurium; tellurium compounds	Y28		0.00	0.00%	1	8	0	0
Mercury; mercury compounds	Y29		0.00	0.00%	1	8	0	0
Thallium; thallium compounds	Y30		0.00	0.00%	1	8	0	0
Lead, lead compounds	Y31		0.00	0.00%	1	8	0	0
Inorganic fluorine compounds	Y32		0.00	0.00%	1	8	0	0
Inorganic cyanides	Y33		0.00	0.00%	1	8	0	0
Acidic solutions or acids in solid form	Y34		0.00	0.00%	1	8	0	0
Basic solutions or bases in solid form	Y35		0.00	0.00%	1	8	0	0
Asbestos (dust and fibres)	Y36	6 00	0.00	0.00%	1	8	0	0
Organic phosphorus compounds	Y37		0.00	0.00%	1	8	0	0
Organic cyanides	Y38		0.00	0.00%	1	8	0	0
Phenols, phenolic compounds	Y39		0.00	0.00%	1	8	0	0
Ethers	Y40		0.00	0.00%	1	8	0	0
Halogenated organic solvents	Y41		0.00	0.00%	1	8	0	0
Organic solvents excluding halogenated solvents	Y42		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-furan	Y43		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-p-dioxin	Y44		0.00	0.00%	1	8	0	0
Organohalogen compounds other than substances referred to in	Y45		0.00	0.00%	1	8	0	0
Wastes resulting from exploration, mining, quarring and physical and cher		01 00	0.00	0.00%	1	8	0	0
Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fis		02 00	0.00	0.00%	1	8	0	0
Wastes from wood processing and the production of panels and furniture,		03 00	4,012.00	0.11%	1	8	0	0
Wastes from leather, fur and textile industries		04 00	1,027.00	0.03%	1	8	0	0
Wastes from inorganic chemical processes		06 00	230,665.00	6.39%	2	16	0	0
Wastes from organic chemical processes		07 00	1,020,243.00	28.25%	3	24	1	1
Wastes from thermal processes		10 00	427,827.00	11.85%	2	16	1	1
Wastes from shaping and physical and mechanical surface treatment of m		12 00	396,966.00	10.99%	2	16	0	1
Waste packaging; absorbents, wiping cloths, filter materials and protective		15 00	0.00	0.00%	1	8	0	0
Wastes not otherwise specified in the list		16 00	242,016.00	6.70%	2	16	0	0
TOTAL			3,611,686.00	100.00%				

Lebanon

Waste type	Y-CODE	EWC	tonnes/y	%	Amount	Priority	Top 3	Top 5
Wastes from the production and preparation of pharmaceutical p	Y2		0.00	0.00%	1	8	0	0
Waste pharmaceuticals, drugs and medicines	Y3		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of biocides and	Y4		159.00	0.16%	1	8	0	0
Wastes from manufacturing, formulation and use of wood prese	Y5		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of organic solv	Y6	14 00	6,278.00	6.25%	2	16	0	1
Wastes from heat treatment and tempering operations containin	Y7		0.00	0.00%	1	8	0	0
Waste mineral oils unfit for their originally intended use	Y8	13 00	0.00	0.00%	1	8	0	0
Waste oils/water, hydrocarbons/water mixtures, emulsions	Y9		0.00	0.00%	1	8	0	0
Waste substances and articles containing or contaminated with	Y10		0.00	0.00%	1	8	0	0
Waste tarry residues arising from refining, distillation and any py	Y11	05 00	31,912.00	31.76%	3	24	1	1
Wastes from production, formulation and use of inks, dyes, pigm	Y12	08 00	5,284.00	5.26%	2	16	0	1
Wastes from production, formulation and use of resins latex, pla	Y13		0.00	0.00%	1	8	0	0
Waste chemical substances arising from research and developm	Y14		0.00	0.00%	1	8	0	0
Wastes of an explosive nature not subject to other legislation	Y15		543.00	0.54%	1	8	0	0
Wastes from production, formulation and use of photographic ch	Y16	09 00	0.00	0.00%	1	8	0	0
Wastes resulting from surface treatment of metals and plastics	Y17	11 00	2,537.00	2.52%	1	8	0	0
Residues arising from industrial waste disposal operations	Y18	19 00	0.00	0.00%	1	8	0	0
Metal carbonyls	Y19		0.00	0.00%	1	8	0	0
Beryllium; beryllium compounds	Y20		0.00	0.00%	1	8	0	0
Hexavalent chromium compounds	Y21		0.00	0.00%	1	8	0	0
Copper compounds	Y22		0.00	0.00%	1	8	0	0
Zinc compounds	Y23		0.00	0.00%	1	8	0	0
Arsenic, arsenic compounds	Y24		0.00	0.00%	1	8	0	0
Selenium; selenium compounds	Y25		0.00	0.00%	1	8	0	0
Cadmium; cadmium compounds	Y26		0.00	0.00%	1	8	0	0
Antimony; antimony compounds	Y27		0.00	0.00%	1	8	0	0
Tellurium; tellurium compounds	Y28		0.00	0.00%	1	8	0	0
Mercury; mercury compounds	Y29		0.00	0.00%	1	8	0	0
Thallium; thallium compounds	Y30		0.00	0.00%	1	8	0	0
Lead, lead compounds	Y31		0.00	0.00%	1	8	0	0
Inorganic fluorine compounds	Y32		0.00	0.00%	1	8	0	0
Inorganic cyanides	Y33		0.00	0.00%	1	8	0	0
Acidic solutions or acids in solid form	Y34		10,653.00	10.60%	2	16	1	1
Basic solutions or bases in solid form	Y35		9,746.00	9.70%	2	16	0	0
Asbestos (dust and fibres)	Y36	6 00	0.00	0.00%	1	8	0	0
Organic phosphorus compounds	Y37		0.00	0.00%	1	8	0	0
Organic cyanides	Y38		0.00	0.00%	1	8	0	0
Phenols, phenolic compounds	Y39		0.00	0.00%	1	8	0	0
Ethers	Y40		0.00	0.00%	1	8	0	0
Halogenated organic solvents	Y41		0.00	0.00%	1	8	0	0
Organic solvents excluding halogenated solvents	Y42		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-furan	Y43		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-p-dioxin	Y44		0.00	0.00%	1	8	0	0
Organohalogen compounds other than substances referred to in	Y45		0.00	0.00%	1	8	0	0
Wastes resulting from exploration, mining, quarring and physical and cher		01 00	0.00	0.00%	1	8	0	0
Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fis		02 00	4,744.00	4.72%	1	8	0	0
Wastes from wood processing and the production of panels and furniture,		03 00	0.00	0.00%	1	8	0	0
Wastes from leather, fur and textile industries		04 00	0.00	0.00%	1	8	0	0
Wastes from inorganic chemical processes		06 00	4,577.00	4.55%	1	8	0	0
Wastes from organic chemical processes		07 00	56.00	0.06%	1	8	0	0
Wastes from thermal processes		10 00	0.00	0.00%	1	8	0	0
Wastes from shaping and physical and mechanical surface treatment of m		12 00	0.00	0.00%	1	8	0	0
Waste packaging; absorbents, wiping cloths, filter materials and protective		15 00	24,005.00	23.89%	3	24	1	1
Wastes not otherwise specified in the list		16 00	0.00	0.00%	1	8	0	0
TOTAL			100,494.00	100.00%				

Malta

Waste type	Y-CODE	EWC	tonnes/y	%	Amount	Priority	Top 3	Top 5
Wastes from the production and preparation of pharmaceutical p	Y2		0.00	0.00%	1	8	0	0
Waste pharmaceuticals, drugs and medicines	Y3		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of biocides an	Y4		0.00	0.00%	1	8	0	0
Wastes from manufacturing, formulation and use of wood prese	Y5		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of organic solv	Y6	14 00	0.00	0.00%	1	8	0	0
Wastes from heat treatment and tempering operations containin	Y7		0.00	0.00%	1	8	0	0
Waste mineral oils unfit for their originally intended use	Y8	13 00	2,500.00	26.32%	3	24	1	1
Waste oils/water, hydrocarbons/water mixtures, emulsions	Y9		2,500.00	26.32%	3	24	1	1
Waste substances and articles containing or contaminated with	Y10		0.00	0.00%	1	8	0	0
Waste tarry residues arising from refining, distillation and any py	Y11	05 00	0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of inks, dyes, pigm	Y12	08 00	0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of resins latex, pla	Y13		1,500.00	15.79%	2	16	0	1
Waste chemical substances arising from research and developm	Y14		0.00	0.00%	1	8	0	0
Wastes of an explosive nature not subject to other legislation	Y15		0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of photographic ch	Y16	09 00	0.00	0.00%	1	8	0	0
Wastes resulting from surface treatment of metals and plastics	Y17	11 00	1,500.00	15.79%	2	16	1	1
Residues arising from industrial waste disposal operations	Y18	19 00	1,500.00	15.79%	2	16	0	1
Metal carbonyls	Y19		0.00	0.00%	1	8	0	0
Beryllium; beryllium compounds	Y20		0.00	0.00%	1	8	0	0
Hexavalent chromium compounds	Y21		0.00	0.00%	1	8	0	0
Copper compounds	Y22		0.00	0.00%	1	8	0	0
Zinc compounds	Y23		0.00	0.00%	1	8	0	0
Arsenic, arsenic compounds	Y24		0.00	0.00%	1	8	0	0
Selenium; selenium compounds	Y25		0.00	0.00%	1	8	0	0
Cadmium; cadmium compounds	Y26		0.00	0.00%	1	8	0	0
Antimony; antimony compounds	Y27		0.00	0.00%	1	8	0	0
Tellurium; tellurium compounds	Y28		0.00	0.00%	1	8	0	0
Mercury; mercury compounds	Y29		0.00	0.00%	1	8	0	0
Thallium; thallium compounds	Y30		0.00	0.00%	1	8	0	0
Lead, lead compounds	Y31		0.00	0.00%	1	8	0	0
Inorganic fluorine compounds	Y32		0.00	0.00%	1	8	0	0
Inorganic cyanides	Y33		0.00	0.00%	1	8	0	0
Acidic solutions or acids in solid form	Y34		0.00	0.00%	1	8	0	0
Basic solutions or bases in solid form	Y35		0.00	0.00%	1	8	0	0
Asbestos (dust and fibres)	Y36	6 00	0.00	0.00%	1	8	0	0
Organic phosphorus compounds	Y37		0.00	0.00%	1	8	0	0
Organic cyanides	Y38		0.00	0.00%	1	8	0	0
Phenols, phenolic compounds	Y39		0.00	0.00%	1	8	0	0
Ethers	Y40		0.00	0.00%	1	8	0	0
Halogenated organic solvents	Y41		0.00	0.00%	1	8	0	0
Organic solvents excluding halogenated solvents	Y42		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-furan	Y43		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-p-dioxin	Y44		0.00	0.00%	1	8	0	0
Organohalogen compounds other than substances referred to in	Y45		0.00	0.00%	1	8	0	0
Wastes resulting from exploration, mining, quarring and physical and cher		01 00	0.00	0.00%	1	8	0	0
Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fis		02 00	0.00	0.00%	1	8	0	0
Wastes from wood processing and the production of panels and furniture,		03 00	0.00	0.00%	1	8	0	0
Wastes from leather, fur and textile industries		04 00	0.00	0.00%	1	8	0	0
Wastes from inorganic chemical processes		06 00	0.00	0.00%	1	8	0	0
Wastes from organic chemical processes		07 00	0.00	0.00%	1	8	0	0
Wastes from thermal processes		10 00	0.00	0.00%	1	8	0	0
Wastes from shaping and physical and mechanical surface treatment of m		12 00	0.00	0.00%	1	8	0	0
Waste packaging; absorbents, wiping cloths, filter materials and protective		15 00	0.00	0.00%	1	8	0	0
Wastes not otherwise specified in the list		16 00	0.00	0.00%	1	8	0	0
TOTAL			9,500.00	100.00%				

Morocco

Waste type	Y-CODE	EWC	tonnes/y	%	Amount	Priority	Top 3	Top 5
Wastes from the production and preparation of pharmaceutical p	Y2		0.00	0.00%	1	8	0	0
Waste pharmaceuticals, drugs and medicines	Y3		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of biocides and	Y4		0.00	0.00%	1	8	0	0
Wastes from manufacturing, formulation and use of wood prese	Y5		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of organic solv	Y6	14 00	0.00	0.00%	1	8	0	0
Wastes from heat treatment and tempering operations containin	Y7		0.00	0.00%	1	8	0	0
Waste mineral oils unfit for their originally intended use	Y8	13 00	0.00	0.00%	1	8	0	0
Waste oils/water, hydrocarbons/water mixtures, emulsions	Y9		0.00	0.00%	1	8	0	0
Waste substances and articles containing or contaminated with	Y10		0.00	0.00%	1	8	0	0
Waste tarry residues arising from refining, distillation and any py	Y11	05 00	0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of inks, dyes, pigm	Y12	08 00	0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of resins latex, pla	Y13		800.00	0.66%	1	8	0	0
Waste chemical substances arising from research and developm	Y14		0.00	0.00%	1	8	0	0
Wastes of an explosive nature not subject to other legislation	Y15		0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of photographic ch	Y16	09 00	0.00	0.00%	1	8	0	0
Wastes resulting from surface treatment of metals and plastics	Y17	11 00	3,900.00	3.21%	1	8	0	0
Residues arising from industrial waste disposal operations	Y18	19 00	0.00	0.00%	1	8	0	0
Metal carbonyls	Y19		0.00	0.00%	1	8	0	0
Beryllium; beryllium compounds	Y20		0.00	0.00%	1	8	0	0
Hexavalent chromium compounds	Y21		0.00	0.00%	1	8	0	0
Copper compounds	Y22		0.00	0.00%	1	8	0	0
Zinc compounds	Y23		0.00	0.00%	1	8	0	0
Arsenic, arsenic compounds	Y24		0.00	0.00%	1	8	0	0
Selenium; selenium compounds	Y25		0.00	0.00%	1	8	0	0
Cadmium; cadmium compounds	Y26		0.00	0.00%	1	8	0	0
Antimony; antimony compounds	Y27		0.00	0.00%	1	8	0	0
Tellurium; tellurium compounds	Y28		0.00	0.00%	1	8	0	0
Mercury; mercury compounds	Y29		0.00	0.00%	1	8	0	0
Thallium; thallium compounds	Y30		0.00	0.00%	1	8	0	0
Lead, lead compounds	Y31		0.00	0.00%	1	8	0	0
Inorganic fluorine compounds	Y32		0.00	0.00%	1	8	0	0
Inorganic cyanides	Y33		0.00	0.00%	1	8	0	0
Acidic solutions or acids in solid form	Y34		0.00	0.00%	1	8	0	0
Basic solutions or bases in solid form	Y35		0.00	0.00%	1	8	0	0
Asbestos (dust and fibres)	Y36	6 00	0.00	0.00%	1	8	0	0
Organic phosphorus compounds	Y37		0.00	0.00%	1	8	0	0
Organic cyanides	Y38		0.00	0.00%	1	8	0	0
Phenols, phenolic compounds	Y39		0.00	0.00%	1	8	0	0
Ethers	Y40		0.00	0.00%	1	8	0	0
Halogenated organic solvents	Y41		0.00	0.00%	1	8	0	0
Organic solvents excluding halogenated solvents	Y42		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-furan	Y43		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-p-dioxin	Y44		0.00	0.00%	1	8	0	0
Organohalogen compounds other than substances referred to in	Y45		0.00	0.00%	1	8	0	0
Wastes resulting from exploration, mining, quarring and physical and cher		01 00	0.00	0.00%	1	8	0	0
Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fis		02 00	9,630.00	7.91%	2	16	1	1
Wastes from wood processing and the production of panels and furniture,		03 00	5,700.00	4.68%	1	8	0	1
Wastes from leather, fur and textile industries		04 00	7,400.00	6.08%	2	16	1	1
Wastes from inorganic chemical processes		06 00	88,640.00	72.85%	3	24	1	1
Wastes from organic chemical processes		07 00	0.00	0.00%	1	8	0	0
Wastes from thermal processes		10 00	0.00	0.00%	1	8	0	0
Wastes from shaping and physical and mechanical surface treatment of m		12 00	5,600.00	4.60%	1	8	0	1
Waste packaging; absorbents, wiping cloths, filter materials and protective		15 00	0.00	0.00%	1	8	0	0
Wastes not otherwise specified in the list		16 00	0.00	0.00%	1	8	0	0
TOTAL			121,670.00	100.00%				

Slovenia

Waste type	Y-CODE	EWC	tonnes/y	%	Amount	Priority	Top 3	Top 5
Wastes from the production and preparation of pharmaceutical produ	Y2		3,360.00	13.46%	2	16	1	0
Waste pharmaceuticals, drugs and medicines	Y3		36.00	0.14%	1	8	0	0
Wastes from the production, formulation and use of biocides and phy	Y4		8.00	0.03%	1	8	0	0
Wastes from manufacturing, formulation and use of wood preserving	Y5		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of organic solvents	Y6	14 00	0.00	0.00%	1	8	0	0
Wastes from heat treatment and tempering operations containing cy	Y7		0.00	0.00%	1	8	0	0
Waste mineral oils unfit for their originally intended use	Y8	13 00	1,981.00	7.93%	2	16	0	0
Waste oils/water, hydrocarbons/water mixtures, emulsions	Y9		225.00	0.90%	1	8	0	0
Waste substances and articles containing or contaminated with PCB	Y10		13.00	0.05%	1	8	0	0
Waste tarry residues arising from refining, distillation and any pyroliti	Y11	05 00	0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of inks, dyes, pigments	Y12	08 00	1,915.00	7.67%	2	16	0	0
Wastes from production, formulation and use of resins latex, plastici:	Y13		3,700.00	14.82%	2	16	1	1
Waste chemical substances arising from research and development	Y14		0.00	0.00%	1	8	0	0
Wastes of an explosive nature not subject to other legislation	Y15		3,211.00	12.86%	2	16	0	1
Wastes from production, formulation and use of photographic chemi	Y16	09 00	117.00	0.47%	1	8	0	0
Wastes resulting from surface treatment of metals and plastics	Y17	11 00	48.00	0.19%	1	8	0	0
Residues arising from industrial waste disposal operations	Y18	19 00	300.00	1.20%	1	8	0	0
Metal carbonyls	Y19		0.00	0.00%	1	8	0	0
Beryllium; beryllium compounds	Y20		0.00	0.00%	1	8	0	0
Hexavalent chromium compounds	Y21		4.00	0.02%	1	8	0	0
Copper compounds	Y22		16.00	0.06%	1	8	0	0
Zinc compounds	Y23		1,431.00	5.73%	2	16	0	0
Arsenic, arsenic compounds	Y24		0.00	0.00%	1	8	0	0
Selenium; selenium compounds	Y25		0.00	0.00%	1	8	0	0
Cadmium; cadmium compounds	Y26		0.00	0.00%	1	8	0	0
Antimony; antimony compounds	Y27		0.00	0.00%	1	8	0	0
Tellurium; tellurium compounds	Y28		0.00	0.00%	1	8	0	0
Mercury; mercury compounds	Y29		0.00	0.00%	1	8	0	0
Thallium; thallium compounds	Y30		0.00	0.00%	1	8	0	0
Lead, lead compounds	Y31		711.00	2.85%	1	8	0	0
Inorganic fluorine compounds	Y32		0.00	0.00%	1	8	0	0
Inorganic cyanides	Y33		118.00	0.47%	1	8	0	0
Acidic solutions or acids in solid form	Y34		2,226.00	8.92%	2	16	0	1
Basic solutions or bases in solid form	Y35		943.00	3.78%	1	8	0	0
Asbestos (dust and fibres)	Y36	6 00	548.00	2.19%	1	8	0	0
Organic phosphorus compounds	Y37		0.00	0.00%	1	8	0	0
Organic cyanides	Y38		0.00	0.00%	1	8	0	0
Phenols, phenolic compounds	Y39		677.00	2.71%	1	8	0	0
Ethers	Y40		0.00	0.00%	1	8	0	0
Halogenated organic solvents	Y41		123.00	0.49%	1	8	0	0
Organic solvents excluding halogenated solvents	Y42		3,253.00	13.03%	2	16	1	1
Any congener of polychlorinated dibenzo-furan	Y43		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-p-dioxin	Y44		0.00	0.00%	1	8	0	0
Organohalogen compounds other than substances referred to in this	Y45		2.00	0.01%	1	8	0	0
Wastes resulting from exploration, mining, quarring and physical and chemical		01 00	0.00	0.00%	1	8	0	0
Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fishing		02 00	0.00	0.00%	1	8	0	0
Wastes from wood processing and the production of panels and furniture, pulp		03 00	0.00	0.00%	1	8	0	0
Wastes from leather, fur and textile industries		04 00	0.00	0.00%	1	8	0	0
Wastes from inorganic chemical processes		06 00	0.00	0.00%	1	8	0	0
Wastes from organic chemical processes		07 00	0.00	0.00%	1	8	0	0
Wastes from thermal processes		10 00	0.00	0.00%	1	8	0	0
Wastes from shaping and physical and mechanical surface treatment of metal:		12 00	0.00	0.00%	1	8	0	0
Waste packaging: absorbents, wiping cloths, filter materials and protective clot		15 00	0.00	0.00%	1	8	0	0
Wastes not otherwise specified in the list		16 00	0.00	0.00%	1	8	0	0
TOTAL			24,966.00	100.00%				

Spain

Waste type	Y-CODE	EWC	tonnes/y	%	Amount	Priority	Top 3	Top 5
Wastes from the production and preparation of pharmaceutical p	Y2		0.00	0.00%	1	8	0	0
Waste pharmaceuticals, drugs and medicines	Y3		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of biocides and	Y4		0.00	0.00%	1	8	0	0
Wastes from manufacturing, formulation and use of wood prese	Y5		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of organic solv	Y6	14 00	126,429.00	2.46%	1	8	0	0
Wastes from heat treatment and tempering operations containin	Y7		0.00	0.00%	1	8	0	0
Waste mineral oils unfit for their originally intended use	Y8	13 00	411,599.00	8.00%	2	16	0	1
Waste oils/water, hydrocarbons/water mixtures, emulsions	Y9		0.00	0.00%	1	8	0	0
Waste substances and articles containing or contaminated with	Y10		0.00	0.00%	1	8	0	0
Waste tarry residues arising from refining, distillation and any py	Y11	05 00	95,305.00	1.85%	1	8	0	0
Wastes from production, formulation and use of inks, dyes, pigm	Y12	08 00	184,663.00	3.59%	1	8	0	0
Wastes from production, formulation and use of resins latex, pla	Y13		0.00	0.00%	1	8	0	0
Waste chemical substances arising from research and developm	Y14		0.00	0.00%	1	8	0	0
Wastes of an explosive nature not subject to other legislation	Y15		0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of photographic ch	Y16	09 00	8,977.00	0.17%	1	8	0	0
Wastes resulting from surface treatment of metals and plastics	Y17	11 00	629,560.00	12.23%	2	16	1	1
Residues arising from industrial waste disposal operations	Y18	19 00	247,495.00	4.81%	1	8	0	0
Metal carbonyls	Y19		0.00	0.00%	1	8	0	0
Beryllium; beryllium compounds	Y20		0.00	0.00%	1	8	0	0
Hexavalent chromium compounds	Y21		0.00	0.00%	1	8	0	0
Copper compounds	Y22		0.00	0.00%	1	8	0	0
Zinc compounds	Y23		0.00	0.00%	1	8	0	0
Arsenic, arsenic compounds	Y24		0.00	0.00%	1	8	0	0
Selenium; selenium compounds	Y25		0.00	0.00%	1	8	0	0
Cadmium; cadmium compounds	Y26		0.00	0.00%	1	8	0	0
Antimony; antimony compounds	Y27		0.00	0.00%	1	8	0	0
Tellurium; tellurium compounds	Y28		0.00	0.00%	1	8	0	0
Mercury; mercury compounds	Y29		0.00	0.00%	1	8	0	0
Thallium; thallium compounds	Y30		0.00	0.00%	1	8	0	0
Lead, lead compounds	Y31		0.00	0.00%	1	8	0	0
Inorganic fluorine compounds	Y32		0.00	0.00%	1	8	0	0
Inorganic cyanides	Y33		0.00	0.00%	1	8	0	0
Acidic solutions or acids in solid form	Y34		0.00	0.00%	1	8	0	0
Basic solutions or bases in solid form	Y35		0.00	0.00%	1	8	0	0
Asbestos (dust and fibres)	Y36	6 00	0.00	0.00%	1	8	0	0
Organic phosphorus compounds	Y37		0.00	0.00%	1	8	0	0
Organic cyanides	Y38		0.00	0.00%	1	8	0	0
Phenols, phenolic compounds	Y39		0.00	0.00%	1	8	0	0
Ethers	Y40		0.00	0.00%	1	8	0	0
Halogenated organic solvents	Y41		0.00	0.00%	1	8	0	0
Organic solvents excluding halogenated solvents	Y42		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-furan	Y43		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-p-dioxin	Y44		0.00	0.00%	1	8	0	0
Organohalogen compounds other than substances referred to in	Y45		0.00	0.00%	1	8	0	0
Wastes resulting from exploration, mining, quarring and physical and cher		01 00	2,059,792.00	40.03%	3	24	1	1
Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fis		02 00	0.00	0.00%	1	8	0	0
Wastes from wood processing and the production of panels and furniture.		03 00	8,085.00	0.16%	1	8	0	0
Wastes from leather, fur and textile industries		04 00	16,233.00	0.32%	1	8	0	0
Wastes from inorganic chemical processes		06 00	175,745.00	3.42%	1	8	0	0
Wastes from organic chemical processes		07 00	185,640.00	3.61%	1	8	0	0
Wastes from thermal processes		10 00	531,478.00	10.33%	2	16	1	1
Wastes from shaping and physical and mechanical surface treatment of m		12 00	103,296.00	2.01%	1	8	0	0
Waste packaging; absorbents, wiping cloths, filter materials and protective		15 00	100,237.00	1.95%	1	8	0	0
Wastes not otherwise specified in the list		16 00	261,550.00	5.08%	2	16	0	1
TOTAL			5,146,084.00	100.00%				

Syria

Waste type	Y-CODE	EWC	tonnes/y	%	Amount	Priority	Top 3	Top 5
Wastes from the production and preparation of pharmaceutical p	Y2		0.00	0.00%	1	8	0	0
Waste pharmaceuticals, drugs and medicines	Y3		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of biocides an	Y4		0.00	0.00%	1	8	0	0
Wastes from manufacturing, formulation and use of wood prese	Y5		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of organic solv	Y6	14 00	0.00	0.00%	1	8	0	0
Wastes from heat treatment and tempering operations containin	Y7		0.00	0.00%	1	8	0	0
Waste mineral oils unfit for their originally intended use	Y8	13 00	0.00	0.00%	1	8	0	0
Waste oils/water, hydrocarbons/water mixtures, emulsions	Y9		0.00	0.00%	1	8	0	0
Waste substances and articles containing or contaminated with	Y10		0.00	0.00%	1	8	0	0
Waste tarry residues arising from refining, distillation and any py	Y11	05 00	1,500.00	1.64%	1	8	0	0
Wastes from production, formulation and use of inks, dyes, pigm	Y12	08 00	0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of resins latex, pla	Y13		0.00	0.00%	1	8	0	0
Waste chemical substances arising from research and developm	Y14		0.00	0.00%	1	8	0	0
Wastes of an explosive nature not subject to other legislation	Y15		0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of photographic ch	Y16	09 00	0.00	0.00%	1	8	0	0
Wastes resulting from surface treatment of metals and plastics	Y17	11 00	7,000.00	7.64%	2	16	0	1
Residues arising from industrial waste disposal operations	Y18	19 00	0.00	0.00%	1	8	0	0
Metal carbonyls	Y19		0.00	0.00%	1	8	0	0
Beryllium; beryllium compounds	Y20		0.00	0.00%	1	8	0	0
Hexavalent chromium compounds	Y21		0.00	0.00%	1	8	0	0
Copper compounds	Y22		0.00	0.00%	1	8	0	0
Zinc compounds	Y23		0.00	0.00%	1	8	0	0
Arsenic, arsenic compounds	Y24		0.00	0.00%	1	8	0	0
Selenium; selenium compounds	Y25		0.00	0.00%	1	8	0	0
Cadmium; cadmium compounds	Y26		0.00	0.00%	1	8	0	0
Antimony; antimony compounds	Y27		0.00	0.00%	1	8	0	0
Tellurium; tellurium compounds	Y28		0.00	0.00%	1	8	0	0
Mercury; mercury compounds	Y29		0.00	0.00%	1	8	0	0
Thallium; thallium compounds	Y30		0.00	0.00%	1	8	0	0
Lead, lead compounds	Y31		0.00	0.00%	1	8	0	0
Inorganic fluorine compounds	Y32		0.00	0.00%	1	8	0	0
Inorganic cyanides	Y33		0.00	0.00%	1	8	0	0
Acidic solutions or acids in solid form	Y34		0.00	0.00%	1	8	0	0
Basic solutions or bases in solid form	Y35		0.00	0.00%	1	8	0	0
Asbestos (dust and fibres)	Y36	6 00	50.00	0.05%	1	8	0	0
Organic phosphorus compounds	Y37		0.00	0.00%	1	8	0	0
Organic cyanides	Y38		0.00	0.00%	1	8	0	0
Phenols, phenolic compounds	Y39		0.00	0.00%	1	8	0	0
Ethers	Y40		0.00	0.00%	1	8	0	0
Halogenated organic solvents	Y41		0.00	0.00%	1	8	0	0
Organic solvents excluding halogenated solvents	Y42		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-furan	Y43		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-p-dioxin	Y44		0.00	0.00%	1	8	0	0
Organohalogen compounds other than substances referred to in	Y45		0.00	0.00%	1	8	0	0
Wastes resulting from exploration, mining, quarring and physical and cher		01 00	0.00	0.00%	1	8	0	0
Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fis		02 00	18,000.00	19.65%	2	16	1	1
Wastes from wood processing and the production of panels and furniture,		03 00	0.00	0.00%	1	8	0	0
Wastes from leather, fur and textile industries		04 00	14,000.00	15.28%	2	16	1	1
Wastes from inorganic chemical processes		06 00	11,060.00	12.07%	2	16	0	1
Wastes from organic chemical processes		07 00	0.00	0.00%	1	8	0	0
Wastes from thermal processes		10 00	40,000.00	43.66%	3	24	1	1
Wastes from shaping and physical and mechanical surface treatment of m		12 00	0.00	0.00%	1	8	0	0
Waste packaging: absorbents, wiping cloths, filter materials and protective		15 00	0.00	0.00%	1	8	0	0
Wastes not otherwise specified in the list		16 00	0.00	0.00%	1	8	0	0
TOTAL			91,610.00	100.00%				

Tunisia

Waste type	Y-CODE	EWC	tonnes/y	%	Amount	Priority	Top 3	Top 5
Wastes from the production and preparation of pharmaceutical p	Y2		145.00	0.19%	1	8	0	0
Waste pharmaceuticals, drugs and medicines	Y3		7,265.00	9.46%	2	16	1	1
Wastes from the production, formulation and use of biocides an	Y4		0.00	0.00%	1	8	0	0
Wastes from manufacturing, formulation and use of wood prese	Y5		0.00	0.00%	1	8	0	0
Wastes from the production, formulation and use of organic solv	Y6	14 00	0.00	0.00%	1	8	0	0
Wastes from heat treatment and tempering operations containin	Y7		0.00	0.00%	1	8	0	0
Waste mineral oils unfit for their originally intended use	Y8	13 00	49,000.00	63.84%	3	24	1	1
Waste oils/water, hydrocarbons/water mixtures, emulsions	Y9		2,960.00	3.86%	1	8	0	0
Waste substances and articles containing or contaminated with	Y10		0.00	0.00%	1	8	0	0
Waste tarry residues arising from refining, distillation and any py	Y11	05 00	3,270.00	4.26%	1	8	0	1
Wastes from production, formulation and use of inks, dyes, pigm	Y12	08 00	2,440.00	3.18%	1	8	0	0
Wastes from production, formulation and use of resins latex, pla	Y13		3,480.00	4.53%	1	8	0	1
Waste chemical substances arising from research and developm	Y14		0.00	0.00%	1	8	0	0
Wastes of an explosive nature not subject to other legislation	Y15		0.00	0.00%	1	8	0	0
Wastes from production, formulation and use of photographic ch	Y16	09 00	0.00	0.00%	1	8	0	0
Wastes resulting from surface treatment of metals and plastics	Y17	11 00	8,130.00	10.59%	2	16	1	1
Residues arising from industrial waste disposal operations	Y18	19 00	0.00	0.00%	1	8	0	0
Metal carbonyls	Y19		0.00	0.00%	1	8	0	0
Beryllium; beryllium compounds	Y20		0.00	0.00%	1	8	0	0
Hexavalent chromium compounds	Y21		0.00	0.00%	1	8	0	0
Copper compounds	Y22		0.00	0.00%	1	8	0	0
Zinc compounds	Y23		0.00	0.00%	1	8	0	0
Arsenic, arsenic compounds	Y24		0.00	0.00%	1	8	0	0
Selenium; selenium compounds	Y25		0.00	0.00%	1	8	0	0
Cadmium; cadmium compounds	Y26		0.00	0.00%	1	8	0	0
Antimony; antimony compounds	Y27		0.00	0.00%	1	8	0	0
Tellurium; tellurium compounds	Y28		0.00	0.00%	1	8	0	0
Mercury; mercury compounds	Y29		0.00	0.00%	1	8	0	0
Thallium; thallium compounds	Y30		0.00	0.00%	1	8	0	0
Lead, lead compounds	Y31		0.00	0.00%	1	8	0	0
Inorganic fluorine compounds	Y32		0.00	0.00%	1	8	0	0
Inorganic cyanides	Y33		0.00	0.00%	1	8	0	0
Acidic solutions or acids in solid form	Y34		0.00	0.00%	1	8	0	0
Basic solutions or bases in solid form	Y35		0.00	0.00%	1	8	0	0
Asbestos (dust and fibres)	Y36	6 00	70.00	0.09%	1	8	0	0
Organic phosphorus compounds	Y37		0.00	0.00%	1	8	0	0
Organic cyanides	Y38		0.00	0.00%	1	8	0	0
Phenols, phenolic compounds	Y39		0.00	0.00%	1	8	0	0
Ethers	Y40		0.00	0.00%	1	8	0	0
Halogenated organic solvents	Y41		0.00	0.00%	1	8	0	0
Organic solvents excluding halogenated solvents	Y42		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-furan	Y43		0.00	0.00%	1	8	0	0
Any congener of polychlorinated dibenzo-p-dioxin	Y44		0.00	0.00%	1	8	0	0
Organohalogen compounds other than substances referred to in	Y45		0.00	0.00%	1	8	0	0
Wastes resulting from exploration, mining, quarring and physical and cher		01 00	0.00	0.00%	1	8	0	0
Wastes from agriculture, horticulture, aquaculture, forestry, hunting and fis		02 00	0.00	0.00%	1	8	0	0
Wastes from wood processing and the production of panels and furniture,		03 00	0.00	0.00%	1	8	0	0
Wastes from leather, fur and textile industries		04 00	0.00	0.00%	1	8	0	0
Wastes from inorganic chemical processes		06 00	0.00	0.00%	1	8	0	0
Wastes from organic chemical processes		07 00	0.00	0.00%	1	8	0	0
Wastes from thermal processes		10 00	0.00	0.00%	1	8	0	0
Wastes from shaping and physical and mechanical surface treatment of m		12 00	0.00	0.00%	1	8	0	0
Waste packaging; absorbents, wiping cloths, filter materials and protective		15 00	0.00	0.00%	1	8	0	0
Wastes not otherwise specified in the list		16 00	0.00	0.00%	1	8	0	0
TOTAL			76,760.00	100.00%				