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STRATEGIC ACTION PROGRAMME

GUIDELINES

FOR THE MANAGEMENT OF INDUSTRIAL WASTEWATER

FOR THE MEDITERRANEAN REGION

In cooperation with

WHO

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EXECUTIVE SUMMARY

Effluents from industrial activities contain a variety of substances, which can be harmful to the final water recipients and, in some cases, also toxic to human health. Throughout the recent years an increase of the discharge of industrial liquid waste into the Mediterranean Sea has been observed in terms of volumes and content: new chemical substances are being used in industrial processes, which, inevitably, reach the final effluent streams, whereas the overall development of industrial production processes is generating increases volumes of wastewaters discharged into the water recipients.

Both concerned parties, industrial enterprises as well as controlling/inspecting authorities, are facing several burdens in their attempt to avoid the discharge of untreated effluents into the receiving waters due to limited knowledge of the particular conditions and requirements needed for their control. International and national legislation is in place for years with rather strict effluent standards also promoting the introduction of waste prevention/minimization techniques.

Several methods and practices have been developed, which, due to their successfully proven practical application and demonstrative character, can act as guides to industrial managers for adoption of similar “tools” required for industrial pollution control. They can be applied in industrial plants at various production processes targeting the relevant pollution problem after a thorough pollution source inventory and segregation of waste streams. Frequently a combination of several techniques (substitution of chemicals, recycling of waste, recovery of by-products etc.) within an industrial process is feasible, in order to obtain the best possible result (process integrated measures). Within this context, the knowledge of the technical, economical and environmental characteristics of the environmentally **Best Available Techniques (BAT)** in each industrial sector is needed. A few industrial sectors **(tanning, metal finishing, food processing, textiles)** are selected for the description of the relevant BATs, which are typical for the Mediterranean Region: small/medium enterprises, widespread in many North and South Mediterranean countries. These BAT demonstrate the environmental but also the economic benefits arising from their application, so that they can be inspirative to industrial managers to also apply them in similar branches/cases.

Management tools also presented, which, in order to improve industrial environmental performance, new concepts and management systems are being developed by governments and the industry. The basic tools for action currently in operation (ISO, EMAS) and examples of diagnostic tools (EIA, LCA etc.) are summarized.

Any final discharge of industrial effluents has to follow certain requirements, in order to reduce to the minimum possible extent any environmental pollution. There are two main options available for industrial effluents, which are collected from all production units and transferred into a final collection pit: pre-treatment/discharge into the municipal sewer, full treatment. They can be applied in cases of previous installation of prevention/recycling systems as well as final treatment method without any prior intervention in the production process. In case of discharge of industrial effluents into the municipal sewer system of the nearest municipality, these effluents must be pre-treated up to the level of untreated municipal effluents (BOD5 < 300-350 mg/l, absence of toxic substances such as heavy metals, phenols, neutral pH etc.). For any industrial discharge directly into coastal/inland waters full treatment is needed (up to 90-97% of BOD/COD removal).

The conditions needed to be considered when a wastewater minimization program has to be conducted in an industrial plant have also to be defined. The necessary methodological steps to be followed by an industrial/environmental manager, in order to plan, design and successfully implement the program are presented. These steps start with the overall planning/organization of the programme, include the assessment of the possible

technical options and the relevant feasibility analysis and end with the programme's implementation phase and the requirements for capacity building (in-plant training, awareness campaign).

The organizational requirements for an effective wastewater management programme cover a wide range of activities, which have to be undertaken, in order to achieve practical results with the least expenditure of resources. These requirements contain some important elements such as the functions of a coastal pollution control authority, the procedures for setting effluent standards and the conduction of pollution source inventory programmes.

Various economic aspects have to be considered in connection with the decision on new waste minimization systems to be introduced in an industrial plant. They mostly deal with the capital costs needed for the relevant investment but also with the annual operating costs and the expected benefits in monetary terms. This second part of economic consideration are frequently overlooked when decision have to be taken neglecting the fact that they are dominant for the prediction of the investment's pay- back period and the financial burden to be covered annually.

A short overview of economic instruments (environmental taxes/charges), which are usually centrally planned, is also given.

PREAMBLE

Special provisions for the reduction of the pollution caused by industrial activities are, amongst others, explicitly mentioned in the Land Based Sources (LBS) Protocol:

- the general provision mentioned in Article 1 asks the Contracting Parties to take all possible measures to prevent, abate, combat and eliminate pollution of the Mediterranean Sea caused from land-based sources and activities giving priority to inputs of toxic and persistent substances. This provision is further on specified in Article 4 (par.1a) to discharges originating from land-based point sources and activities reaching the Mediterranean Sea through coastal disposals, outfalls, canals etc.
- the necessity for the application of best available techniques (BAT) and best environmental practices is mentioned in Article 5 (par.4), whereas the general framework for the establishment of guidelines, standards and criteria is described in Article 7 (separate treatment of effluents, quantities and concentration of substances in effluents, methods of discharge)
- the assessment of the levels of pollution and the setting-up of inspection systems are mentioned in Articles 8 and 6 respectively.

This ambitious objective, namely to effectively combat pollution originating from industrial activities, would lose its final target if provisions for the development of assistance mechanisms would not have been considered: in Article 10, the formulation of technical assistance programmes is foreseen, where international organisations can and will play a catalytic role.

In accordance with the LBS Protocol, the Contracting Parties to the Barcelona Convention agreed to take all appropriate measures to prevent, abate, combat and eliminate to the fullest possible extent the pollution of the Mediterranean Sea from rivers, coastal establishments or outfalls. They have also agreed to elaborate and implement national and regional action plans and programmes containing measures and timetables for their implementation.

Within this context, the **Strategic Action Programme (SAP)** has been adopted with the main objective to support Mediterranean countries for the formulation, adoption and implementation of relevant national plans. Within SAP targets, the elimination to the fullest possible extent of **industrial pollution** caused by industrial development is a key activity for the forthcoming years by proposing ambitious quantitative targets and asking relevant regional and national authorities to prepare the relevant programmes. Additionally, the formulation of guidelines for industrial wastewater treatment and disposal and for the application of environmentally sound technologies in industry are key activities to be undertaken at regional level as well as the support for the development of environmental management and audit schemes.

Having these aspects in mind, a document formulating **principles** needed for the preparation of action plans for the reduction of pollution discharged by industrial effluents can be a good starting point for **national/local authorities** and **industrial managers**, in order to realise the already widespread applicable possibilities to effectively minimise industrial pollution.

This document provides a systematic framework serving this scope but, by no means, is a **catalogue** of practices and techniques to be applied in the various industrial branches of the Mediterranean region: these technical documentation can be found in several documents prepared within the UNEP/ MAP framework, in various technical literature references and in respective databases. The **objectives** of this document can be summarised as follows:

- to point out the most often encountered problems for industry and authorities to control and reduce pollution coming out from wastewaters
- to provide a guide of Good Practice for the control/reduction of wastewaters
- to define a framework for authorities for effective control and inspection

The **target groups** to mainly use this documentation are authorities responsible for industrial pollution control (inspectors), decision makers/planners of pollution control measures and industrial managers responsible for issuing/implementing environmental protection measures in their own industrial units:

- **Authorities**
  to understand the nature and complexity of matters dealing with the control/inspection of industrial wastewaters
- **Decision makers/planners**
  to set up the framework of their policies and legislative requirements towards industrial activities on the basis of a solid knowledge of the various aspects of industrial pollution control
- **Environmental managers in industry**
  to avoid confrontation with the controlling authorities having a common understanding on the whole chain of pollution prevention, collection and treatment of the final effluents.

The document is structured as follows: chapter 2 presents the most common problems encountered in the management of industrial pollution, chapter 3 gives examples of legislative measures applicable on national and European Union (EU) level in the field of industrial pollution control, in chapter 4, the “core” of the document, good practices/techniques for the minimisation of industrial effluents and management tools are briefly described, whereas in chapters 5 and 6 requirements needed to successfully implement those minimisation programmes are suggested aiming at the awareness of industrial managers as well as of authorities. Chapter 7 deals with financial aspects/incentives associated with the promotion and introduction of pollution control systems.

1. INTRODUCTION

Effluents from industrial activities contain a variety of substances, which can be harmful to the final water recipients and, in some cases, also toxic to human health (Figure 1) This is the case not only for effluents originating from major industrial units producing chemical products, even smaller enterprises, which are widespread around the Mediterranean basin (e.g. electroplating industries, tanneries, textiles) generate harmful effluents reaching coastal and inland waters.

Usually, wastewaters from industrial processes are discharged into the central municipal sewerage system mostly following quality standards set by the authorities issuing the relevant permits These standards aim primarily at the protection of the sewer system and the subsequent municipal wastewater treatment system from the various contaminants contained in industrial effluents (Table 1). Direct discharge of industrial effluents into water bodies is often encountered especially in Southern Mediterranean countries. In this case, stricter regulations are or must be put into force to avoid dramatic deterioration of the quality of the water recipient.

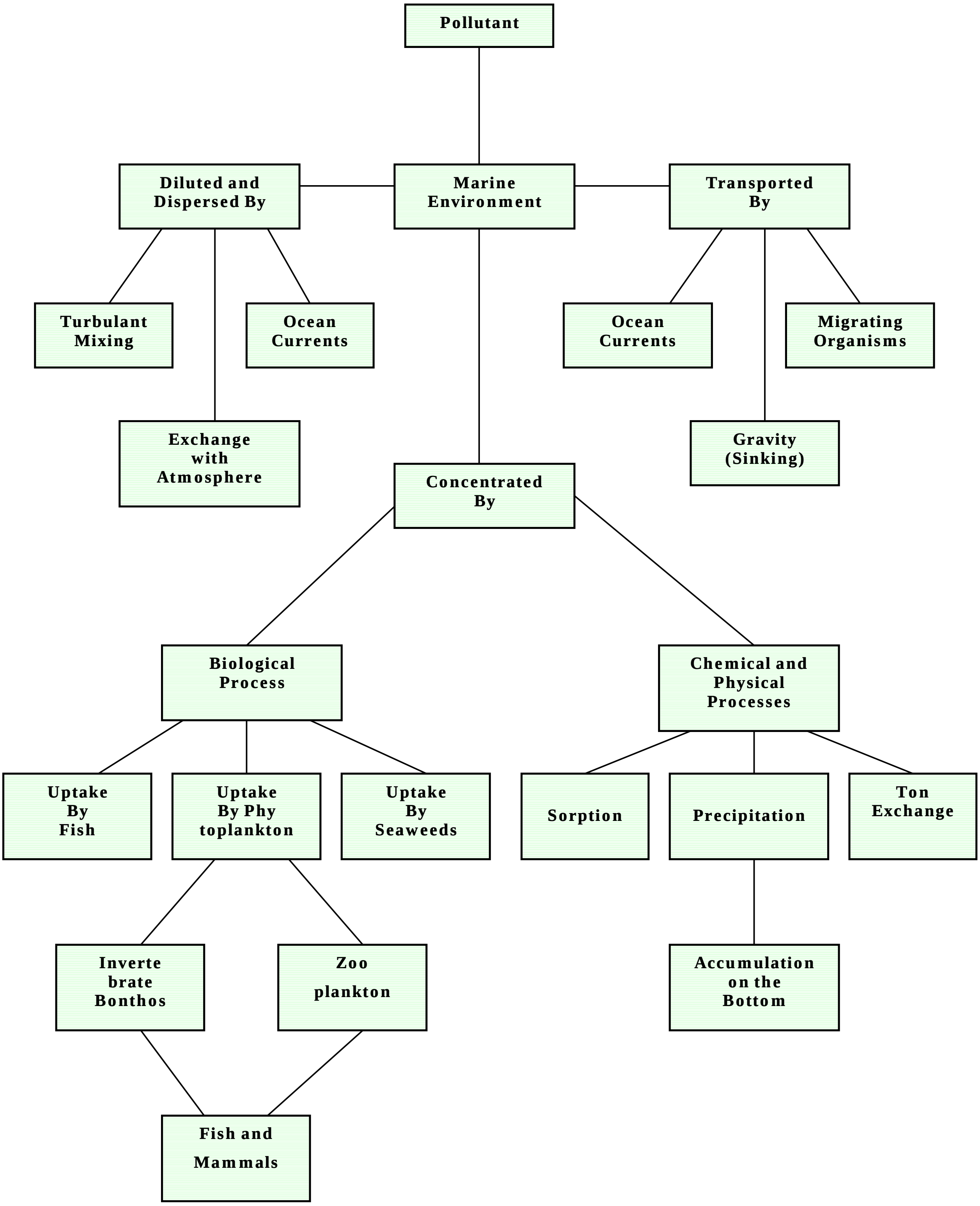
Table 1

Contaminants of industrial wastewaters

Nature of contaminant	Contaminant	Potential effect(s)
Physical	Suspended solids	Lead to development of sludge deposits & anaerobic conditions, mechanical problems (clogging)
	Settleable solids	
Chemical	Biodegradable organics	Lead to depletion of oxygen and the development of septic conditions
	Nutrients (compounds of nitrogen & phosphorous)	Eutrophication
	Surfactants, phenols, pesticides	Resist biological treatment methods
	Heavy metals	Adverse effect on aquatic life & on biological treatment methods, contamination of sewage sludge for final disposal
	Dissolved inorganic solids	To be removed if wastewater has to be reused
	Acids, dyes	Corrosion of pipelines & inhibition of biological treatment processes

<u>Source</u>: the wastewater treatment handbook, Commission of the European Communities, DG for Regional Policies – DG for the Environment (produced by AMBER)

Figure 1 Processes determining the fate of a pollutant reaching the marine environment



<u>Source</u>: Code of practice for environmentally sound management of liquid waste discharge in the Mediterranean Sea, UNEP/MAP – PAP/RAC, 1990

Throughout the recent years an increase of the discharge of industrial liquid waste into the Mediterranean Sea has been observed in terms of volumes and content: new chemical substances are being used in industrial processes, which, inevitably, reach the final effluent streams, whereas the overall development of industrial production processes is generating increases volumes of wastewaters discharged into the water recipients.

In comparison to oceans, the Mediterranean Sea is a semi-closed body with limited possibilities for water circulation and exchange. It receives wastewaters from settlements, tourist resorts, industry and agricultural run – off. A rough estimation of the contribution of industrial sources to the overall pollution load in the Mediterranean basin is given in Table 2.

Table 2
Annual pollution load from industrial sources

Pollutant	Industrial wastewaters **(t/year)**	**Total load (t/year)**	**Ratio industrial/ total (%)**
Volume	6×10^3	430×10^9	1.4
Organic matter (BOD)	409×10^3	2900×10^3	14.0
Nutrients			
Phosphorous	5×10^3	360×10^3	1.4
Nitrogen	25×10^3	1000×10^3	2.5
Phenols	11×10^3	12×10^3	91.7
Metals			
Mercury	7	130	5.4
Lead	1400	4800	29.2
Chromium	950	2800	33.9
Zinc	5000	25000	20.0
Suspended matter	2.8×10^6	350×10^6	0.8

Source:
- **Treatment and discharge of industrial wastewater in the Mediterranean area, Report on a WHO Workshop, World Health Organization (Regional Office for Europe), 1986**
- **Regional Plan for the reduction of input BOD by 50% by the year 2005 from industrial sources, UNEP/MAP, 2002**

The most heavily polluting industries in the Mediterranean region are, besides the major enterprises such as refineries, basic steel industries, cement production and energy production plants, several medium/small sized tanneries, textiles, electroplating and food processing industries. Especially these small enterprises are facing major organisational problems concerning their environmental performance, which mostly are based on limited expertise and restricted availability of resources.

2. MAJOR PROBLEMS FOR THE CONTROL OF INDUSTRIAL WASTEWATERS

2.1 Introduction

Both concerned parties, industrial enterprises as well as controlling/inspecting authorities, are facing several burdens in their attempt to avoid the discharge of untreated effluents into the receiving environmental media (coastal/inland/underground waters). These burdens mostly originate from a limited knowledge of the particular conditions and requirements, which have to be met for effective pollution reduction. This is the case because both sides try to organise their pollution reduction activities and measures on the basis of **minimum costs** and **efforts.** There is a common approach mostly adopted by industrial managers concerning environmental protection: implementation of those minimal measures, which are needed just for **compliance with legal/regulatory requirements**, since any other measures with long-term perspective, e.g. recycling of by-products, will have an immediate effect on the enterprise's cost balance and should not be financed. The compliance with the legal requirements is naturally also the predominant perception of the authorities responsible for issuing the necessary permits and controlling the industries' environmental performance. Within this context, however, several elements valuable for effective pollution control as well as for sustainable use of materials/resources can get lost.

In this chapter a review of existing practices will be presented, in order to allocate those common problems reflecting the above, so that the necessary improvement measures can schematically evolve from this description. Therefore this chapter forms the framework, on which the following chapters describing in details the necessary **good practices** will be based.

2.2 Problems in industry

There are 2 major components within an industrial enterprise, which affect its overall environmental performance, namely the **industrial process** itself and the **environmental management**. The analysis of these components is focussing on aspects relative to industrial effluents only, by no means it will expand to the overall enterprise's environmental performance (air emissions, solid waste management etc.). In chapter 4, the suggested good practices, which usually are applicable to industrial environmental management as a whole (e.g. waste minimisation programmes, ISO 14001) can guide interested readers to several aspects associated with all environmental issues relevant to industrial processes.

2.2.1 Deficits in industrial process

Raw materials and **chemicals** used in the production of industrial goods are mostly purchased by industrial managers on the basis of the cheapest possible prices whereas ecologically compatible materials are usually more expensive. This approach, widely adopted especially by small – medium enterprises having limited financial resources, is causing in most of the cases an environmentally complex composition of the relevant industrial effluents and complicates the efforts of pollution reduction thus requiring advanced and more expensive treatment systems. Therefore this "least-cost" purchase of raw materials/chemicals is cost effective on a short-term basis only.

Additionally, other resources needed for the industrial process, especially **water**, are often used in an unsustainable way causing increased volumes of wastewaters to be collected and treated. This usually happens in cases where the enterprises do not have to pay for water use, e.g. by extracting water from their own wells.

In the production process itself, a detailed inventory of inputs/outputs, the so called **material balance,** for each industrial unit operation is often missing, so that unnecessary amounts of materials get lost. This is particular the case by the use of resources such as energy and water, which seldom are precisely measured and used according to the actual needs. The problem of unsustainable water use for industrial purposes is of particular importance for the following reasons:

- the constantly growing demands for water to be used in industrial processes and the subsequent intensive extraction from relevant sources (aquifers, natural/artificial reservoirs) is gradually affecting fresh water quality and quantity particularly in countries with poor hydrological cycle and possibilities for water renewal (e. g. most of the Mediterranean countries)
- increased water use has as consequence increased wastewater quantities, which have to be collected, treated and discharged.

2.2.2 Deficits in environmental management

Well-defined and planned concepts for integrated environmental management in industries are usually not frequently implemented by industries. These concepts require the design and application of precise management measures with focus on environmental protection, the appointment of an environmental manager, the allocation of financial means for pollution control measures etc. Mostly large industrial plants (e.g. oil refineries, chemical plants etc.) apply concepts such as ISO 14001, environmental management and audit schemes (EMAS) etc., whereas small and medium enterprises generally avoid adopting them due to lack of financial and human resources. As it was said in the introduction of this chapter, the overall approach of these industrial managers is to finally comply with the minimal legal/regulatory requirements set by the national/local environmental authorities without developing and applying a concept for successful environmental management. As a matter of fact, regarding industrial effluents, the various waste streams deriving from the various industrial production processes and containing excessive amounts of wasted raw materials and chemicals are simply mixed together in central wastewater collection wells where streams from industrial and municipal (toilets) activities are discharged and transferred to a municipal sewer or to the industry's wastewater treatment plant according to set regulations. As a consequence, any possibilities for recovery of valuable by-products and/or recycling of waste streams cannot be explored, since for any of those possibilities a **segregation** of waste streams is needed. Additionally, various unwanted side effects such as uncontrolled chemical reactions and corrosion of sewers' pipelines can take place by these environmentally unsound measures.

2.3 Problems in the planning/monitoring system

A differentiation must be made between the **planning** institutions/authorities, which design the overall environmental policy in a country and the **inspectorates**, which are responsible for the routine control of standards set: the level of responsibility and the perspectives for successful implementation of practical measures are closely linked with the direction and content of the general policy, which, in most countries, is designed on central level (Ministries) and implemented by regional/local authorities. Therefore, the frequently encountered difficulties to successfully assess and control industrial pollution have to be tracked back to the prescriptions and requirements set up in the centrally planned environmental policy.

2.3.1 Planning authorities

By designing a policy aiming at industrial pollution control, various deficits are frequently encountered, in particular regarding the right balance between **industrial development** and **environmental protection**: a predominant perception that exaggerations in the implementation of pollution reduction measures lead to unbearable costs, which, then, will slow down industrial development, often leads to a distrust of industry towards environmentalists. This long-lasting policy issue is crucial and decisive when environmental regulations and legislative requirements have to be approved on central/national level. During this first planning process, a controversial phase, even between Ministries (Environment, Industry, Economy) within the same government is unavoidable: different perceptions and interests of those responsible for each topic (environment, industry) are frequently intensified by **lobbying** activities of environmental/industrial associations, economical institutions etc. The outcome of this phase is the decisive factor, which determines the direction, content and requirements of the environmental policy to be applied regarding industrial pollution control and reduction.

It must be pointed out, that this controversial process can be productive and is always needed, since it allows both sides not only to understand each other's position but also to find those solutions needed to overcome any bottlenecks. It starts to be a problem affecting the effective pollution control when, as it frequently happens, in the name of economic development, the "lightest" possible measures are adopted. In the case of industrial effluents, **the permit to discharge mixed waste streams into the municipal sewer after minimal treatment**, is the most widely adopted measure especially for small/medium enterprises. Potentials for application of recycling/reuse measures are then neglected and, consequently, not reflected in relevant policy documents.

In some cases, regulations applicable in other countries (e.g. effluent quality standards) are simply adopted without analysing the prevailing national/local conditions (e.g. receiving water quality criteria, assimilative capacity of the marine environment, other similar activities in the region etc.). As a consequence the set expectations are not or partially met.

Lack of adequate information and experience in designing an environmental control policy often leads to the development of a legislative framework, which can cause severe difficulties to those regional/local authorities entrust with the inspection/controlling work: if legislation, development of effluent standards and permit conditions are not clear and unambiguous to both, the industrial managers and the regulatory agency, enforcement of regulations will become difficult, if not impossible. This usually happens when the policy planning decisions relevant to pollution control are taken on central governmental level **without consultation/feedback with/from the inspecting authorities and the industry itself.**

Resource constraints for the implementation of an effective environmental policy can also be decisive in the planning process: existing lack of financial means, manpower etc. on the level of the inspectorates and any missing perspectives for improvement inevitably limit the conditions of the environmental policy framework (inventory of polluting activities, frequency of inspections, extent of effluent sampling/analysis etc.) to be finally implemented. Often the central authorities, which design the relevant policy are not aware or neglect this fact with the consequence that ambitious pollution control programmes can only partially be implemented.

Adaptation of these programmes after a certain period of implementation and taking into consideration any feedback from the controlling authorities according to the achieved results, is not the most common encountered case: the planning "exercise" stops once the relevant policy is approved on governmental level, so that the authorities responsible for the practical pollution control are being left to perform their work on the basis of their own perceptions and limitations. This is usually the case in most Mediterranean countries, it often happens in the framework of States' institutions (e.g. European Union), where an **evaluation of policy effectiveness** has not been yet incorporated in the policy planning/implementation process. One of the possible reasons for this is an ineffective reporting mechanism but also the subsequent involvement of policy planners in other emerging planning activities.

2.3.2 Inspectorates

Some of the problems, which local inspection authorities (inspectorates) are facing, are directly deriving from the insufficient precautions encountered in the policy planning process as stated above (unclear/ambiguous policy content and standards, ambitious monitoring programmes). "Classical", often encountered problems on regional/local level are:

1. "mixing" of responsibilities between authorities
2. lack of equipment needed for sampling/analysis
3. limited availability of skilled/experienced personnel to undertake the inspections
4. tight time schedules for the accomplishment of monitoring programmes
5. limited inventory of pollution sources in the region
6. lack of monitoring concept.

Whereas the 3 first problems are easily understandable, a focus will furthermore be given to the 3 last ones, which sometimes are overlooked even in cases where adequate resources and time for the accomplishment of a monitoring programme are available. These problems are closely interrelated and have the following characteristics:

- Lack of concept for pollution inventory means that the inspectors only randomly organise the monitoring programme, usually according to geographical conditions (distance to the authority's premises, easy accessibility etc.), to size/sectors or by selecting those enterprises to be inspected on the basis of complaints of neighborhood, of governmental orders etc. As a consequence, most of the time period to execute a meaningful monitoring programme is spent in this kind of activities, so that the inspectorates cannot really focus on the actual pollution problems.
- The inventory as such has frequently a limited scope (checking the final sewer well) following the minimum requirements of the set permits. This task is also randomly done by spending some minutes for taking the relevant samples from the well. This perception neglects that industrial effluents are often intermittently discharged according to the conditions of each unit in the production process (e.g. some chemicals are added at certain time intervals and flashed out during a washing process) and therefore the sample taken at certain time can seldom be representative of the whole process.

These constraints endanger the implementation of the envisaged pollution control programmes and the assessment of the achieved results, whereas it can lead to tensions between the authorities and the industry.

3. EXAMPLES OF INTERNATIONAL AND NATIONAL LEGISLATION

3.1 Introduction

In this chapter some examples of international and national legislation are given, which can be used by interesting environmental authorities in the Mediterranean region for the development, improvement or modification of their own legislative framework. By no means there are **proposals/recommendations** to be followed, these examples should be seen as a list of principles, which, on the basis of locally prevailing conditions, experience and capabilities, can be useful as a **guide** to decision makers.

It is assumed that all legislative/regulatory measures adopted by MAP- contracting parties are known, therefore the various Protocols, Plans etc. are not repeated again.

3.2 Policy/legislation of the European Union (EU)

3.2.1 Waste Strategy

A Community Strategy for Waste Management was initially adopted by the European Commission in 1989. The strategy sets out four strategic guidelines: prevention, re-use and recovery, optimization of final disposal and regulation of transport, together with a number of recommended actions. This general principles can be applicable also for industrial discharges, since it is a strategy and not a concrete legislative action (e.g. EU Directive).

3.2.2 Directive for Integrated Pollution Prevention and Control (IPPC)

The IPPC Directive 96/61/EC lays down a framework requiring Member States to issue operating permits for certain installations carrying on industrial activities. The Directive applies to new or substantially changed installations with effect from October 1999 and no later than October 2007 for existing installations. These permits must contain conditions based on best available techniques (BAT) to achieve a high level of protection of the environment as a whole. Its philosophy is based on the introduction of the **waste prevention principle**, by which waste generation is linked with concrete production technologies of preventing nature (BAT) so that the final quantities to be treated should be kept to a technically achievable minimum.

3.2.3 Directive for municipal wastewater treatment and disposal (91/271/EEC)

This Directive provides the framework for the collection, treatment and disposal of municipal wastewaters into water recipients but it also contains prescriptions for the proper discharge of industrial effluents either directly or via the municipal sewers into water bodies.

3.2.4. Directive on dangerous substances discharged into the aquatic environment (76/464/EEC)

By this Directive the discharge of dangerous substances into the aquatic environment is regulated aiming at a “zero” emissions into ground waters.

3.3 National legislation

Usually national authorities define the permitting procedures, limit values and monitoring programmes for each industry on the basis of the local conditions (e.g. water quality standards) and their own requirements. Therefore, a single method for setting standards applicable for all effluents discharged into the aquatic environment cannot and should not be recommended, since it would lead to misunderstandings. A more uniform approach is generally adopted by many countries for the acceptance of pollutants into the public sewerage system where the protection of health of personnel working in sewers and manholes as well as the protection of the operation of collection pipes and treatment plants has to be guaranteed. Within this context, the pre-treatment of industrial effluents up to the level of untreated municipal wastewaters, namely with all toxic/dangerous substances removed, is a generally accepted rule.

The examples presented here give an indication of effluent standards in use in selected countries (Table 3). They should not be seen as a prescriptive guide to be necessarily followed by any Mediterranean authority, they only indicate some crucial effluent parameters to be considered by setting effluent permits and the relevant quantitative values. Additionally a short overview, based on available data, of applied practices in the Mediterranean region is also presented (Tables 4, 5 and 6). The tables are compiled from a short survey of existing national information and information from the Regional Activity Centre for Cleaner Production (CP/RAC).

Table 3

Standards for emissions of BOD, COD, TSS and nutrients

Parameter	**Emission limit for discharge into surface water in milligrams per liter (mg/L)***											
	Turk	**Egypt**[1]	**Italy**	**B&H**	**Alger**	**Croat**	**Maroc**[2]	**Israël**	**Malta**	**Cypr**	**Tunis**	**France**
BOD_5	50	60	40	20[3]	40	40[4]	100	1,200	300-350	10	30	25
COD	180	100	160	40	120	200	500	2,000	600	30	90	125
TSS	60	60	80	100	30	50	50	1,000	500	10	30	35
Total Nitrogen	20	40	NH4:15 NO2:20 NO3:20	[5]	40	25	30	-	100	10	30	12
Total Phosphorus	2	5	10		-	4	10	-	-	2	0,1	2

[1] Emissions in sea
[2] standards are not adopted yet (draft regulation only)
[3] IV class
[4] IV class
[5] limits available for particular nitrogen compounds (nitrites (0.5), ammoniac(0.5) nitrates(15)

Table 4

Environmental best techniques and practices applied in Mediterranean countries

Environmental practices	**Turkey**		**Egypt**		**Italy**	
ISO 14000	X		X		X	
EMAS					X	
Cleaner production	X		X			
Best Available Techniques					X	
Good housekeeping			X			
Recycling			X			
Source reduction measures						
Process integrated measures						
Other (please specify)						

Environmental practices	**Algeria**		**Croatia**		**Morocco**		**Israel**		**France**	
ISO 14000			X		X		X		X	
EMAS										
Cleaner production	X		X		X		X		X	
Best Available Techniques							X			
Good housekeeping	X		X		X		X		X	
Recycling	X		X		X		X		X	
Source reduction measures	X		X		X		X		X	
Process integrated measures			X		X		X			
Other (please specify)										

Environmental practices	**Malta**		**Cyprus**		**Tunisia**	
ISO 14000	X		X		X	
EMAS	X					
Cleaner production	X		X		X	
Best Available Techniques	X		X			
Good housekeeping	X		X		X	
Recycling	X		X		X	
Source reduction measures	X		X		X	
Process integrated measures			X		X	
Other (please specify)						

Table 5

Technological institutions in MAP countries for support of BATs and BEPs

Type of infrastructure for BATs promotion	Turk	Egyp	Italy	B&H	Algeria	Croatia	Morocco	Israel
Industry specific technical centers	X	X					X	X
Public environmental technology centers	X	X	X		X		X	
Private environmental technology centers	X			X			X	
Business associations		X			X		X	X
Chambers of commerce	X					X	X	
NGOs	X	X	X	X	X	X	X	
University	X	X	X		X		X	
Other (Research Institutes)	X		X		X			

Type of infrastructure for BATs promotion	Malta	Cyprus	Tunisia	France
Industry specific technical centers			X	X
Public environmental technology centers	X		X	X
Private environmental technology centers		X		X
Business associations		X	X	X
Chambers of commerce		X	X	X
NGOs		X	X	
University	X		X	X
Other (Research Institutes)			X	X

Table 6

Summary of legal instruments in MAP countries

	Water pollution control regulation	Environmental Impact Assessment	Voluntary agreements	Legal provision for CP, BATs and BEPs
Albania	•	□	□	□
Algeria	•	•	□	□
Bosnia&Herzeg.	•	•	□	Δ
Cyprus	•	•	•	Δ
Croatia	•	•	•	•
Egypt	•	•	•	□
Spain	•	•	•	•
France	•	•	•	•
Greece	•	•	•	•
Israel	•	•	•	□
Italy	•	•	•	•
Lebanon	•	□	□	□
Libya	•	□	□	□
Malta	•	•	•	Δ
Monaco	•	•	•	Δ
Morocco	•	•	□	□
Slovenia	•	•	□	□
Syria	•	□	□	□
Tunisia	•	•	□	Δ
Turkey	•	•	•	Δ
•legislation in place, **Δ under preparation,** **□ no legislation**				

4. SUGGESTED PRACTICES FOR THE MANAGEMENT OF INDUSTRIAL EFFLUENTS

4.1 Introduction

In this chapter an overview of existing good techniques, methods, practices and tools for the management of effluents, which are applicable in many industrial enterprises, is presented. It is by no means exhaustive and should not be seen as a “catalogue” where interested readers can find any “turn-key” solutions. It mainly contains **examples** of methods/practices, which, due to their successfully proven practical application and demonstrative character, can act as guides to industrial managers for adoption of similar “tools” required for industrial pollution control. These examples should be seen more as “demonstrative cases” of concepts and methods and less as a “manual” for application. Therefore, the description/listing of any detailed technicalities (e.g. technical specifications of equipment, quantities of raw materials/chemicals used etc.) is beyond the scope of this document.

The overall focus of this chapter is given to waste prevention options, however a short section is devoted to “classical” wastewater treatment, which is still an alternative preferred in many Mediterranean regions (end-of-pipe treatment).

An additional objective of this chapter is to inspire the inspecting authorities to adopt their monitoring programmes to the particular conditions associated with the characteristics of these methods, so that an improved level of control mechanisms can be created and applied. It is expected that these authorities will be helped to move away from the classical approach, namely to just inspect and randomly take samples from the final sewer and adopt a more comprehensive and in-depth investigation of the prevailing conditions in each industrial branch regarding wastewater generation and management. In particular, terms used in the waste minimization “jargon” such as “waste segregation”, “substitution of chemicals” etc. should become familiar to them.

The suggested practices for industries described in this chapter are presented according to their nature as follows:

- methods for the assessment of pollution loads
- waste minimisation techniques (clean technologies, recovery/reuse/recycling methods, good housekeeping)
- management tools

For the selection of the methods/practices the following criteria were applied:

- adequate information available
- simplicity of the method
- demonstrative character (full scale application)
- reproduction potential (clear technological and economical benefits)

For the preparation of this chapter information was collected from various well recognized sources (Commission of the European Union, UNEP, U.S.EPA). Within UNEP/MAP substantial work is currently performed by the Regional Activity Centre for Cleaner Production (CP/RAC). CP/RAC carries out studies and produces methodology manuals, which identify the pollution prevention options in specific industrial sectors. It also introduces management tools to improve business efficiency and produces in-depth studies on subjects of interest within the Mediterranean region.

4.2 Methods for the assessment of pollution loads

This is the first essential step needed, in order to introduce any new techniques aiming at waste minimization within an industrial plant. In doing so, a detailed analysis of the various unit operations of the industrial production processes has to be elaborated, in order to allocate the various waste streams generated and, therefore, the potential for the application of those techniques.

4.2.1 Inventory of pollution sources

The most important prerequisite to estimate the potential for the introduction of pollution reduction methods/techniques is the precise knowledge of the waste streams generated during an industrial production process. In doing so, the assessment of the flows of materials, chemicals, energy and water for each unit operation in an industrial plant has to be precisely and carefully undertaken. This inventorial activity starts from the purchase and use for raw materials and chemicals, continues with the measurement of energy and water consumption and ends with the analysis of the composition of the effluents generated **(material/mass balance)**. The following Figures 2 and 3 show the principle on which material balance has to be prepared.

These material/mass balance sheets have to be prepared for each industrial unit operation of an industrial plant, in order to rationalize the use of input materials, water etc. but also to better estimate the wastewater quantities discharged. This analysis of **inputs/outputs** has a multiple beneficial effect in the industrial process as a whole since it enables industrial managers to:

- exactly know the consumption of raw materials, chemicals and resources (water, energy) for each production unit and thus avoiding “wasting”
- estimate the precise operational costs of each unit operation and plan the purchase of materials etc.
- assess the volume, concentration and environmental “importance” of each waste stream generated
- identify important process steps and sources where wastes are generated (environmental “weak” spots)
- understand the potential for application of waste minimization methods/techniques on each stage of the industrial production process
- plan/design the necessary process modifications needed for the introduction of these methods and estimate the relevant capital and operational costs
- define the “baseline” for tracking progress of subsequent waste minimization efforts
- compile data for the evaluation of the unit’s economic performance

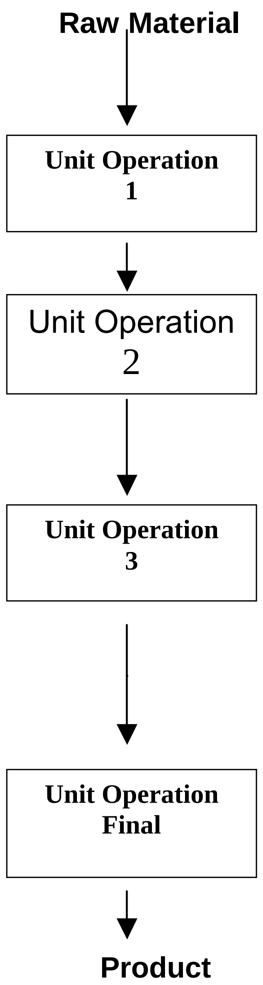
Furthermore, the preparation of material balances can assist in determining concentrations of waste components where analytical test data is missing or limited as well as in cases where fugitive losses are occurring (e.g. difference of outputs to inputs can give an estimate of solvent’s evaporation).

By preparing a material/mass balance all data/information sets available in the plant have to collected and analysed. The following potential information sources can be used:

1. samples, analyses and flow measurements of feed stocks, products and waste streams

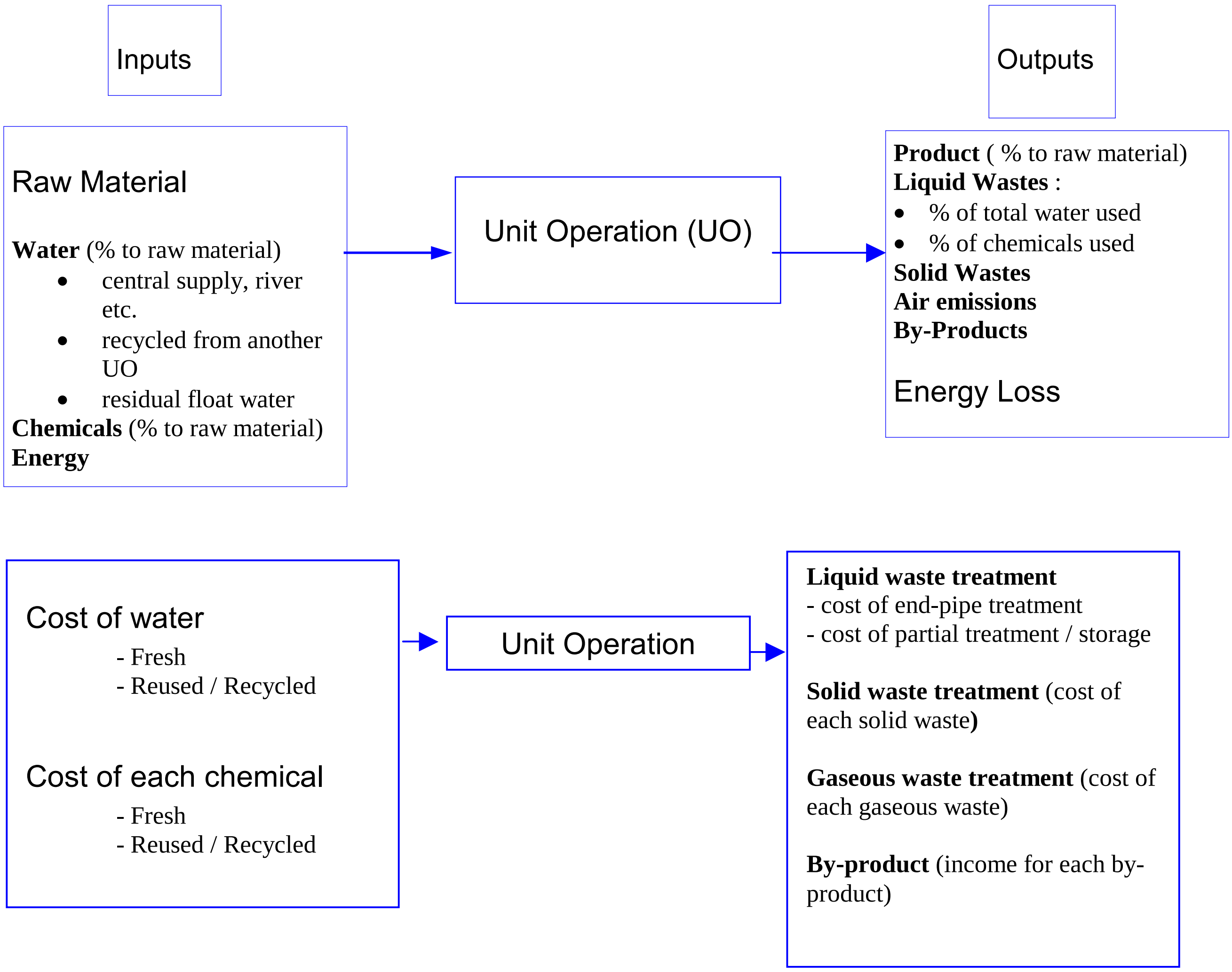
2. raw material purchase records
3. material inventories
4. emission inventories
5. equipment cleaning and validation procedures
6. batch make-up records
7. product specifications
8. design material balances
9. production records
10. standard operating procedures and manuals

Figure 2 Industrial production process (sequence of unit operations)



Source: Preparation of a decision support tool for the textile industry, Commission of the European Union, LIFE programme (coordinator: National Technical University of Athens) - 1997

Figure 3 Material/mass balance principle



Source: Preparation of a decision support tool for the textile industry, Commission of the European Union, LIFE programme (coordinator: National Technical University of Athens) - 1997

Material balances constructed over the duration of a complete production cycle are typically easier to prepare and are reasonably accurate compared to those over a shorter time span, which require more accurate and frequent stream monitoring.

Measuring waste mass flows and compositions should be done periodically, in order to track seasonal flow variations, intermittent waste discharges etc. In any case material balances have to be prepared before ("baseline" for comparison) and after the introduction of waste minimisation systems

There are several projects/products dealing with a systematic development of the elements needed for a material balance mostly in computerized form, in order to simultaneously incorporate, calculate and assess the complexity of inputs/outputs.

Concerning material balances designed for industrial pollution control, a classical flow diagram of inputs/outputs has to be expanded to incorporate elements of clean technologies, recycling methods and good housekeeping measures such as technical characteristics, expected environmental benefits (expressed as reduction of wastewater quantities and/or of released pollutants in comparison to the "baseline" case), related costs and required process modifications for the introduction of the new methods. It seems rather complex but this kind of analysis is needed, in order not only to define the losses of resources occurring during the production process but also to easier assess the potential for the introduction of innovative clean technologies/waste minimization practices.

These kind of "integrated" mass balances allow the user to:

- assess existing production processes and determination of "weak" spots in the process flow chart through material and cost balance reports
- define Best Available Techniques (BATs) suitable for the production process (technical - economical characteristics, environmental performance)
- compare existing legislation with the actual effluent concentration of industries
- select one of the suggested BATs per unit operation and modify the production process flow chart accordingly
- simulate the production process using the new "green" recipes (integration of BATs in the production replacing the existing traditional production recipes used so far by the industry).

4.2.2 <u>Segregation of waste streams</u>

After the assessment of all unit operations of an industrial production process and of the relevant waste streams, a detailed picture of pollution loads generated can be formed. This knowledge allows the **prioritisation** of those streams contributing to the overall pollution load of the industrial plant. As a consequence, a **segregation** of each of these streams is necessary for the following reasons:

- targeted use of amelioration measures (treatment systems, clean technologies) to wastes with environmental "importance", so that cost effectiveness can be achieved
- recycling measures can be easier applied for each of the segregated streams, since the composition and quantities of recycled products cannot be "diluted" by other components coming from streams mixing
- harmful effects such as emission of dangerous substances caused by mixing of streams can be avoided

For the most effective prioritisation of waste streams the following elements must be taken into consideration:

- wastewater quantities
- compliance with current and future regulations
- environmental and safety liability
- hazardous properties (toxicity, flammability, corrosivity, reactivity of components)
- safety hazards e.g. to employees
- potential for introduction of waste minimization options
- possibilities for recovery of valuable by-products

4.3 Waste minimisation techniques

The term **waste minimisation** is generally used to generally define all methods used to reduce pollution loads in-situ (within a plant). It includes pollution prevention techniques (e.g. cleaner production methods), recovery, reuse and recycling of waste components, as well as simple good housekeeping measures. All these methods, if successfully applied, can lead to

- savings in the consumption of raw materials, water and energy
- reduction of final wastewater treatment/disposal costs
- reduction/replacement of hazardous materials
- reduction of the quantities and hazardousness of waste and emissions

Frequently a combination of several techniques (substitution of chemicals, recycling of waste, recovery of by-products etc.) within an industrial process is feasible, in order to obtain the best possible result (process integrated measures). Within this context, the knowledge of the technical, economical and environmental characteristics of the environmentally **Best Available Techniques (BAT)** in each industrial sector is needed. The term best should not be misinterpreted as the only one, it refers to all those techniques, which are practically feasible and substantially contribute in pollution reduction.

Information/documentation provided by various sources have been used for the preparation of this chapter: BATs for the purposes of the EU Directive for Integrated Pollution Prevention and Control (IPPC)*, UNEP (Industry/Environment Office, MAP-CP/RAC)**, documentation from national environmental authorities. It must be pointed out, that these BATs are not the only existing means for the reduction of industrial pollution: each industrial manager can use his own intelligent approach tailored to each specific process by using simple good housekeeping measures or techniques, which are not described elsewhere. The BAT examples given below are indicative and act as “inspirators” for actions of this kind.

Quantitative information, if available, has been focusing on the environmental benefits expected (e.g. degree of recycling of materials and water). A few industrial sectors **(tanning, metal finishing, food processing, textiles)** are selected for the description of the relevant BATs, which are typical for the Mediterranean Region: small/medium enterprises, widespread in many North and South Mediterranean countries. In Table 7 an indication of the main wastewater characteristics in these industrial branches are summarized. The description of each BAT is inevitably brief, more details can be found in the literature references. They are classified as examples of clean technologies, recovery/reuse/recycling measures and good housekeeping practices.

Table 7

Wastewater characteristics of selected industries

INDUSTRY	**WASTEWATER CHARACTERISTICS**	PARAMETERS OF CONCERN
Tanning	lime, salt, suspended solids, chromium, sulphides	BOD, COD, Cr, TSS< TDS, S
Metal finishing	acids, metals, other toxic substances	TSS, pH, CN, Pb, Cr, Zn, Ni, Cd, Cu, Fe
Food processing	proteins, fats, dissolved & suspended solids	BOD, COD, TSS, TDS, pH
Textiles	alkaline, suspended solids, spent dyes, temperature	BOD, COD, pH, TSS

Source: Code of Practice for environmentally sound management of liquid waste discharge in the Mediterranean Sea, UNEP/MAP (PAP/RAC), 1990

***** *The relevant BATs for the IPPC Directive are being gradually investigated and published by the European Integrated Pollution Prevention and Control Bureau (EIPPCB), which has been established and hosted by the EU Joint Research Center – Institute for Prospective Technological Studies (JRC – IPTS) in Seville (Spain). Information about these BATs : http://eippcb.jrc.es/pages/FActivities.htm*

** *Information about CP/RAC activities, sectoral studies, methodology manuals can be found in: http://www.cema-sa.org*

4.3.1 Industry's profile

4.3.1.1 Tanning (leather production)

The tannery operation consists of converting the raw hide or skin into leather, which can be used in the manufacture of a wide range of products. The whole process is "pollution-intensive" and involves a sequence of complex chemical reactions. The environmental effects to be considered are associated with the discharge of classical pollutants (BOD, COD, suspended solids) and the use of certain chemicals such as biocides, surfactants, organic solvents and chromium (III) salts (major tanning chemical used).

The following processes are typically carried out in a tannery, most of them generate substantial amounts of liquid, solid and gaseous waste streams:

- beamhouse operations (soaking, unhairing, liming, fleshing, splitting)
- tanyard (deliming, bating, pickling, tanning)
- post-tanning (samming, shaving, retanning)
- finishing (dyeing, fatliquoring, drying)

4.3.1.2 Metal finishing (electroplating)

Metal finishing may cover a potentially vast number of operations in which metals are cleaned, prepared, treated and coated, the coatings themselves having a variety of compositions. Most of these operations cause significant environmental impacts on account of the metals, chemicals and processes they involve.

The nature, composition of chemicals used strongly depend on the actual coating process, i.e. which coating metal will be selected. A general sequence of operations is usually followed till the final coating process:

- surface preparation (grinding, pre-cleaning/stripping, degreasing)
- surface activation (pickling, fluxing, drying)
- metallic coating (plating with copper, nickel, chrome, zinc etc.)
- after – treatment (cooling, greasing)

4.3.1.3 Food processing industry

The most commonly used processing techniques and unit operations in the food and drink industry are given below. The raw materials used by the food and drink industry are natural products, which may vary from season to season and from year to year. It may therefore be necessary to adapt production processes to accommodate the changes in characteristics of the raw materials. This list of processing techniques is clearly not exhaustive but indicative of the most common processes used in an industrial sector with such a variety of raw materials and products.

Raw materials, reception and preparation
Materials handling, unpacking, storage
Sorting, screening, grading, dehulling, trimming
Peeling
Washing
Size reduction, mixing, forming
Cutting, slicing, chopping, mincing, pulping
Mixing, blending, homogenization
Grinding, milling
Forming, moulding, extruding
Separation techniques
Extraction
Deionization
Fining
Centrifugation/sedimentation
Filtration
Membrane separation
Crystallisation
Neutralization (removal of fatty acids)
Bleaching
Deodorization by stream stripping
Decolourization
Distillation
Product processing technology
Soaking
Dissolving
Solubilization
Fermentation

Coagulation
Germination
Brining, curing
Smoking
Hardening
Sulphitation
Carbonatation
Carbonation
Coating, spraying, enrobing, agglomerization, encapsulation
Ageing
Heat processing
Melting
Blanching
Cooking, boiling
Baking
Roasting
Frying
Tempering
Pasteurization, sterilization
Concentration by heat
Evaporation (liquid to liquid)
Drying (liquid to solid)
Dehydration (solid to solid)
Processing by removal of heat
Cooling, chilling
Freezing
Freeze drying, lyophilization
Post processing operations
Packing, filling
Gas flushing
Utility processes
Cleaning/sanitization
Energy generation/consumption
Water treatment (incoming process water)
Vacuum generation
Refrigeration

Several of these industrial plants are seasonally operated, namely when raw materials (e.g. specific fruits, tomatoes) are harvested.

Food industrial wastewater is notable for its extreme variability in composition. Typically food process wastewater is high both in chemical oxygen demand (COD) and in biochemical oxygen demand (BOD). It is normally 10 - 100 times stronger than domestic wastewater.

The BOD content of the main food constituents is:
kg BOD/ kg food constituent
Carbohydrate 0.65
Fats 0.89
Protein 1.03

Suspended solids concentration varies from negligible to as high as 120000 mg/l. Wastewater from some sub-sectors (e.g. dairy, meat) has high concentrations of fats and oils. Food processing wastewaters vary from the highly alkaline (pH 11) to the highly acidic (pH 3.5).

The industry has traditionally been a large user of water as an ingredient, cleaning agent, means of conveyance and feed to utility systems. Large food processing installations will use several hundred cubic meters of water a day. Most of the water not used as an ingredient ultimately appears in the wastewater stream. In the fruit and vegetable sub-sector, for example, in the order of 10 m^3 of wastewater is generated for every ton of raw material processed.

Wastewater flow rates may be very variable on a diurnal, weekly or seasonal basis. The wastewater profile is largely dependent on production patterns and when cleaning, which is often the largest water use, takes place.

4.3.1.4 Textiles

The textile industry is one of the longest and most complicated industrial chains in manufacturing industry. It is a fragmented and heterogeneous sector dominated by a majority of small and medium enterprises widespread in the Mediterranean region.

The textile and clothing chain is composed of a wide number of sub-sectors covering the entire production cycle from the production of raw materials (man-made fibers) to semi-processed (yarns, woven and knitted fabrics with their finishing process) and final/consumer products (carpets, home textiles, clothing and industrial use textiles).

The complexity of the sector is also reflected in the difficulty of finding a clear-cut classification system for the different activities involved. The old nomenclature system (old NACE 1995) still classified textile industry's activities as follows:

- man-made fibers industry
- wool
- cotton
- silk
- flax/jute
- knitting
- finishing
- carpets
- other textiles
- household linen.

The new nomenclature system (NACE 1997) identifies the following categories:

- yarn and thread
- woven fabric
- textile finishing
- home textiles
- industrial & other textiles (which includes Carpets and Wool Scouring)
- knitted fabrics & articles

A rough categorization of textile processes gives the following picture:

- wool scouring mills
- mills finishing yarn and/or floc
- mills finishing knitted fabric
- mills finishing woven fabric
- carpet industry

The textiles industry has always been regarded as a water-intensive sector. The main environmental concern is therefore about the amount of water discharged and the chemical load it carries. Usually the various streams coming from the different processes are mixed together to produce a final effluent whose characteristics are the result of a complex combination of factors such as:

- the types of fibers involved
- the types of make-ups processed
- the techniques applied
- the types of chemicals and auxiliaries used in the process.

Furthermore, since the production may vary widely not only during a year (because of seasonal changes and fashion), but also over a single day (according to the production program), the resulting emissions are even more difficult to standardize and to compare.

The removal of contaminants present on raw wool fiber leads to the discharge of an effluent in which the main polluting contributors are:

- highly concentrated organic material in suspension and in solution, along with dirt in suspension
- micro-pollutants resulting from the veterinary medicines applied to protect sheep from external parasites.

There are also detergents in the discharged water, which contribute to the increase of the chemical oxygen demand of the effluent.

Water-polluting substances in dyeing processes may originate from:

- the dyes themselves (e.g. toxicity, metals, color)
- auxiliaries contained in the dye formulation
- basic chemicals (e.g. alkali, salts, reducing and oxidizing agents) and auxiliaries used in
  dyeing processes
- contaminants present on the fiber when it enters the process sequence.

In the various finishing processes (the term "finishing" covers all those treatments that serve to impart to the textile the desired end-use properties), residues of concentrated liquors are reused, if the finishing auxiliaries applied show sufficient stability. However, too often these liquors are drained and mixed with other effluents. Although the volumes involved are quite small when compared with the overall wastewater volume produced by a textile mill, the concentration levels are very high, with active substances contents in the range of 5 – 25 % and COD of 10 to 200 gO_2/litre.

4.3.2 Cleaner production methods (clean technologies)

In accordance to a definition given by UNEP/MAP Regional Activity Center for cleaner production (RAC/CP), **cleaner production** is "the continuous application of an integrated environmental prevention strategy in processes, products and services with the aim to reduce the risks for humans and the environment, to increase company's competitiveness and guarantee its economic viability".

4.3.2.1 <u>Tanning</u>

Examples of successfully applied clean technologies are **the substitution of substances** and **the increased efficiency of used chemicals.**

Substitution of chemicals
- use of less persistent/toxic biocides instead of halogenated organic compounds
- processing of fresh (unsalted) hides will reduce the chloride load reaching the effluents by approx. 90%
- use of high-exhausting dyestuffs and fatliquoring systems
- use of enzymes in the unhairing process can reduce the consumption of sulphides

Increased efficiency of used chemicals
- by careful control of process parameters the conventional chrome tanning efficiency can be increased up to 80% and the chromium content of the effluents accordingly reduced
- modification of tanning agents to enhance chromium (III)-salt uptake can considerably reduce the chromium content of the effluents (approx. by 95%)

4.3.2.2 <u>Metal finishing</u>

Examples of clean technologies are **the substitution of chemicals** and **change/modification of processes.**

Substitution of chemicals
- zinc and copper baths can replace the most environmentally dangerous cyanide baths in the zinc and copper coating processes respectively without any significant impact on the final product's quality
- the development of highly corrosion-resistant zinc plating has eliminated the necessity to use, for the same purpose (corrosion protection), the highly toxic cadmium
- chromium (III) can replace the toxic chromium (VI) in making up baths for chrome plating

Change/modification of processes
- the development from deep pickling tanks to turbulent pickling (spraying of acid directly onto the strip) leads to increased process efficiency and reduction of pickling loss by 20-30%
- replacement of the traditional hot-dip galvanization by a closed circuit system can lead to a substantial reuse of process water and to a reduction of hazardous waste flows by approximately 70 - 80%

4.3.2.3 <u>Food processing industry</u>

As clean technologies are defined those **process changes** usually applicable for the minimization of water consumption and wastewater generation.

Process changes
- use dry peeling techniques in the fruit/vegetable processing
- convert from water to steam blanching
- use of dry mechanical transport instead of transport by water
- application of ultra-filtration techniques for protein standardization in cheese production increases the cheese yield of the processed milk unit and leads to reductions in whey and wastewater quantities

- minimizing phosphorous emissions into wastewater by using citric acid instead of phosphoric acid for separating phospholipids in the vegetable fat industry

4.3.2.4. Textiles

Clean technologies refer to **substitution of chemicals** and **modification of processes.**

Substitution of chemicals

- mineral oil-based lubricants in the spinning process, which cannot be fully degraded in biological treatment plants and can also contain hazardous substances (poly - aromatic hydrocarbons) have now largely been replaced with formulations based on glycols
- use of biodegradable washing agents in the various washing processes can reduce BOD load by 25 – 35%

Modification of processes

- bleaching after dyeing the cotton fabric with reactive dyes lead to water savings by more than 15%
- use of a new jet technology (AFS airflow system) allows optimum penetration of dyestuffs and chemicals in the fabric, so that water consumption can be decreased by 50%

4.3.3 Recovery/reuse/recycling of waste components/water

These terms are frequently used in a confused manner (recovery: separation of a material from a process, reuse: use of a recovered material in a production process as raw material/chemical, recycling: re-introduction of a material in the same production process), in the context of waste management they all reflect the selective treatment and separation of components from waste streams and their renewed application in the industrial process cycle. The relevant practices differ from the clean technologies, which have a **preventive** character and aim at the modification of the industrial production process, they usually deal with the waste streams as such without any substantial influence in the process.

4.3.3.1 Tanning

The most known example is the **recovery/reuse/recycling of chromium:** chrome tanning effluents are collected, chromium is recovered through precipitation and separation, re-dissolved and re-introduced in the tanning process by replacing 20-35% of the “fresh” added chrome tanning salt. This process leads to a substantial reduction of the chromium content of the effluents to be finally treated.

4.3.3.2 Metal finishing

There are numerous examples of reuse/recycling practices in the electroplating industry according to the specific requirements and nature of each process (coating material, use of specifically composed baths etc.). The examples mentioned here outline the general features of reuse/ recycling, which have a “cross cutting” character, namely they can be applied in most similar cases with the necessary modifications. They focus on **the regeneration of baths** after several production cycles, **the minimization of the consumption of water and the recovery/reuse of chemicals.** These measures can substantially reduce the wastewater quantities to be finally treated and disposed of.

Regeneration of baths

- filtration/centrifugation of various baths (alkaline cleaning, degreasing, chromating, phosphating etc.) removes bath impurities and separates highly concentrated wastes, which, otherwise, would have reached the effluents
- grease and oil removal from degreasing baths with "in situ" cleaning by bacteria ("biological degreasing") can keep unlimited bath's life time
- freezing of copper cyanide may be used to concentrate and separate dissolved impurities

Minimization of the consumption of water

- the installation of counter – current rinse cascade can dramatically reduce the water consumption (up to 90%) without changing the rinsing effect
- spray or jet rinse in zinc, copper or nickel plating helps decreasing the water consumption

Recovery/reuse of chemicals

- in galvanizing processes spent hydrochloric acid from combined pickling and stripping with high concentrations of iron and zinc can be processed and recovered like a flux bath
- spent flux baths can be recycled, the salts in the spent flux solution can be reused for flux agent production

4.3.3.3 Food processing

The **recovery** of various materials from wastewater streams and their use as useful by-products in other branches is the most commonly used method in the food processing industry. Additionally parts of the enormous **fresh water** quantities used in this branch are **recycled** in the same or other process, in order to minimize its consumption and the generation of relevant wastewater quantities.

Recovery of materials

- starch from high starch waste water streams in fruit/vegetable processing
- utilization of whey for protein recovery and/or in animal food production in the dairy industry
- a quantity of meat juice can be collected from the bottom of transport containers and, rather than emptying this juice into the sewer and therefore increasing the pollution of the wastewater, it can be used in the manufacturing of processed meat products

Water recycling

- peeling and/or sterilization water can be used for pre-washing of raw materials in fruit/ vegetable processing
- reuse of final rinse water from cleaning for the initial rinse of the next cleaning
- reuse of washing water (from tins and jars) in the peeling process
- reuse of the condensate created during the concentration of fruit and vegetables juices for mixing or diluting the end-product

4.3.3.4 Textiles

One of the main recycling activities in textile processing finishing is dealing with **water recycling** and the **reuse of chemicals**

Water recycling

- water reuse (e.g. reuse of final rinsing baths, dye bath reuse, use water for pre-washing carpets in after-washing, counter-current flows in continuous washing)

- reuse of cooling water as process water (also heat recovery)
- reuse of wastewater during the mercerising process results in reduction of wastewater quantities by up to 85% and of the polluting load of NaOH and COD by 72% and 55% respectively
- a separated collection and treatment of effluents from dyeing/rinsing process and reuse of hot water for rinsing allows considerable reductions of wastewater volume and the contained quantities of NaOH and COD by 62%, 53% and 88% respectively

Reuse of chemicals

- collection of dye baths and reuse on other products can save fresh water by 25% and reduce wastewater quantities by 30%

4.3.4 Good housekeeping

This term means the application of simple measures, in order to reduce mainly the water and energy consumption in an industrial plant without extensive modifications of the production process and the wastewater collection and treatment systems.

4.3.4.1 Tanning

- “batch” instead “running water” wash can reduce the water consumption and consequently the effluent quantity by 50%
- use of short floats
- screening to remove coarse material from effluents can reduce by up to 40% the content of suspended solids in the final wastewater stream

4.3.4.2 Metal finishing

- progressive reuse of cleaning solutions from the rear of a series of baths to the front of the sequence
- covering of phosphating/chromating baths reduces the relevant chemicals consumption
- optimization of the rinsing quality of the baths, e.g. by agitation of the rinse water, results in reduction of water consumption
- allowing sufficient dripping time for treated work pieces over the plating bath or using an additional drag-out tank is one of the simplest and cost-efficient method for the reduction of spent chemicals
- the control pf the rinsing time and the quantity of water used can reduce water consumption by at least 50%
- the use of static rinse tanks instead of flow rinsing arrangements the drag-out accumulates in the tanks and can therefore be recovered

4.3.4.3 Food processing

- "chlorinated" effluents can be used for cleaning floors and process plants
- separation of cooling water, storm water and process effluents of different origins in order to permit appropriate treatment options
- flow measurement and control techniques can reduce material waste and effluent generation in food and drink processing (e.g. by 20% in dairies)
- installing level controls on water storage tanks, balance tanks and high-use equipment to monitor water consumption
- utilizing high pressure water for cleaning floors and open equipment

- utilizing alternative water sources, e.g. by using rain water or river water for feeding evaporative condensers

4.3.4.4 Textiles

- process optimization by improved control of process parameters such as temperature, chemical feed, dwell times, moisture (for dryers), etc.
- use of high-quality water (where needed) in wet processes in order to avoid/reduce the use of chemicals to prevent side effects caused by the presence of impurities
- avoiding/ minimizing any kind of surplus of applied chemicals and auxiliaries (e.g. by automated dosing and dispensing of chemicals)
- optimizing scheduling in production (e.g. in dyeing: dyeing dark shades after pale shades reduces water and chemicals consumption for machine cleaning)
- giving preference to low add-on devices for chemicals
- combination of different wet treatments in one single step (e.g. combined scouring and desizing, combined scouring/desizing and bleaching).

4.4 Management tools

In order to improve industrial environmental performance, new concepts and management systems are being developed by governments and the industry, which are considered as instruments to support information management and decision-making. They are used by companies to:

- evaluate and improve their processes and operations (e.g. environmental audits and cleaner production assessments)
- design more environmentally sound products (e.g. life-cycle/risk assessment)
- support communication with company's stakeholders, customers and suppliers (e.g. environmental reporting)
- monitor/benchmark the progress achieved so far
- improve the eco-efficiency of used resources and achieve considerable cost savings (e.g. by using cleaner production/waste minimization assessments and cost/benefit analysis)

Most of these management systems are systematically structured, in order to respond to actually encountered problems of industrial environmental performance, they can be used by large companies (corporate audits) as well as by medium sized enterprises. They deal with each industrial unit and the industrial plant as a whole.

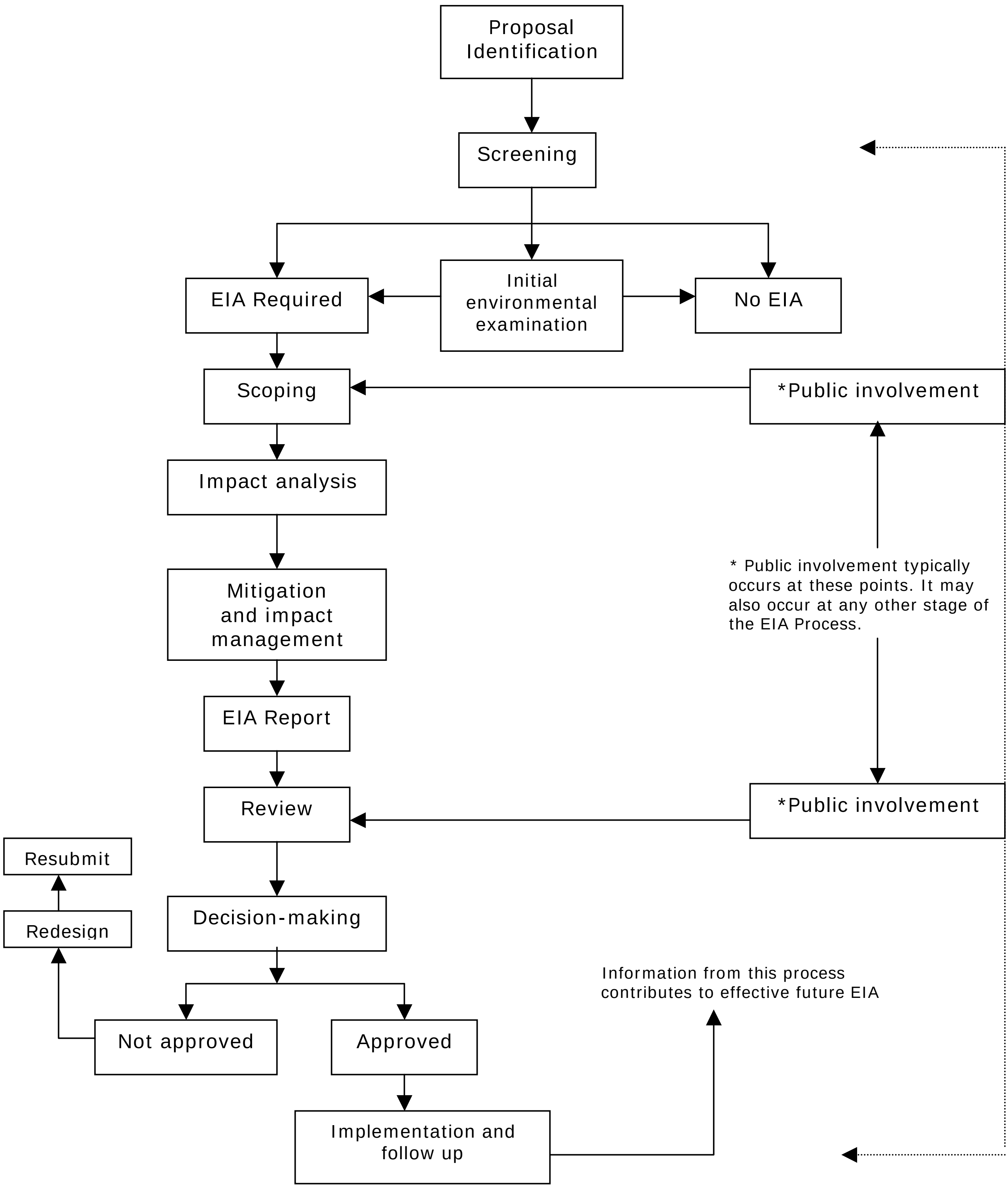
Management tools can be categorized according to their nature and objectives as tools for **analysis** and tools for **action** and, although overlapping of contents and outcomes cannot be avoided, a very rough distinction can be made: tools for analysis are diagnostic instruments and aim at the assessment of the company's existing situation, those for action are used during the business routine by evaluating the actual performance according to set quantitative policy targets (e.g. degree of pollution reduction). The basic tools for action currently in operation (ISO, EMAS) and examples of diagnostic tools are here summarized.

4.4.1 Tools for analysis

4.4.1.1 Environmental impact assessment

Environmental impact assessment (EIA) describes a technique and a process by which information about the environmental effects of a project/technology is collected, evaluated and validated, in order to allow the company itself, governmental authorities and other interested parties (stakeholders, general public) to decide whether those impacts can be tolerated. It is a rather interactive process (dialog between the company and the other parties) where the identification of potential environmental problems occurs and amelioration procedures are proposed.

Figure 4 Environmental Impact Assessment

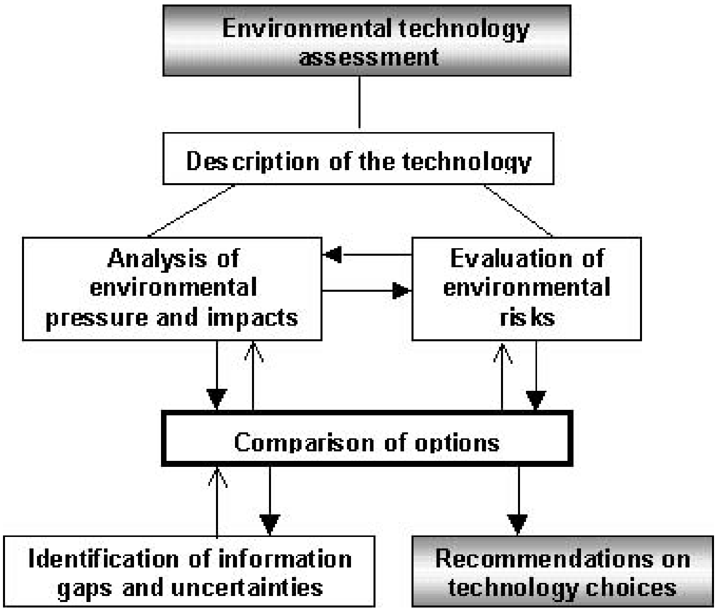


4.4.1.2 Environmental Technology Assessment

Environmental Technology Assessment (ETA) is a tool to help decision-makers understand the likely impact of the use of a new or existing technology. The assessment process looks at the costs of the technology, the monetary benefits, its environmental, social and political impacts as well any associated risks.

The goal of ETA is to assist in making informed choices on technologies that are compatible with sound environmental performance.

Figure 5 Environmental Technology Assessment



4.4.1.3 Life Cycle Assessment

Life Cycle Assessment (LCA) is a tool for the systematic evaluation of the environmental aspects of a product or service system through all stages of its life cycle. It is an objective process to evaluate the environmental burdens/risks associated with a product, process or activity by identifying and quantifying energy/materials used and wastes released into the environment. It includes the entire life cycle of a product etc. by analyzing extraction and processing of raw materials, manufacturing, transportation, recycling and final disposal.

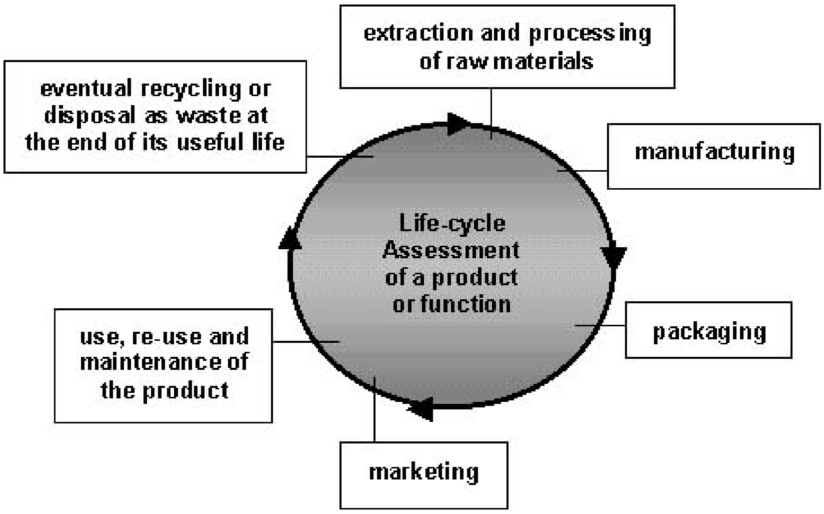
4.4.2 Tools for action

As tools for action are meant **the environmental management systems,** which are integral part of a company's overall management plan describing the organizational structure, responsibilities, practices, procedures, processes and resources for the implementation and maintenance of the environmental management. Some of the key principles of such a system to be considered by industrial managers are the following:

- recognize and rank environmental management among the high priorities of a company
- establish a dialogue with internal and external interested parties
- determine the legislative requirements and environmental aspects associated with the company's activities, products and services

- develop management and employee commitment to environmental protection with clear assignment of responsibility and accountability
- encourage environmental planning throughout the product/process life cycle
- provide appropriate and sufficient human and financial resources to achieve set environmental performance targets on a continuous basis
- assess environmental performance against appropriate policies, objectives and targets and seek continuous improvement where appropriate
- establish a management process to review and audit the environmental management system
- coordinate the environmental management system with other systems (e.g. health and safety, quality, finance) applicable in the company

Figure 6 Life Cycle Assessment



These general principles are needed, in order to define, plan and finally implement an environmental management system for all aspects determining the company's overall management. Concerning pollution reduction, the **preventive approach** should be the specific principle to be followed aiming at **waste minimization at source.** This principle can be reflected in the management system in the promotion of the use of **cleaner production methods** and the best possible **eco-efficiency of used resources.**

There are several serious attempts to introduce environmental management systems in industrial plants. The purpose of the relevant standards is to provide organizations with the elements of an effective environmental management system, which can be integrated with other management requirements, in order to assist these organizations to achieve technical, economic and environmental goals. These include the specification ISO 14001, which contains requirements that may be objectively audited for certification purposes and the European eco-management and audit scheme (EMAS).

4.4.2.1 ISO-14001

There is a whole "family" of ISO-14000 standards (14001: environmental management systems – specification, 14004: environmental management systems – general guidelines on principles, systems and supporting techniques, 19011: guidelines on quality and/or environmental management systems auditing etc.), which are being developed with the following key principles in mind:

- they should promote the broad interests of the public and the users of the standards
- they should be cost effective, non-prescriptive, and flexible, to allow them to meet the differing needs of organizations of any size
- they should be suitable for internal or external verification

ISO 14001 is today the most widely implemented environmental management system standard in the world. To be certified in conformity with this standard, a company/organization has to maintain regulatory compliance and provide evidence for continuous improvement of its environmental performance.

The key elements of an ISO-14001 are:

Environmental Policy
- the environmental policy and the requirements to pursue this policy via objectives, targets, and environmental programs

Planning
- the analysis of the environmental aspects of the organization (including its processes, products and services as well as the goods and services used by the organization);

Implementation and operation
- implementation and organization of processes to control and improve operational activities that are critical from an environmental perspective (including both products and services of an organization)

Checking and corrective action
- checking and corrective action including the monitoring, measurement, and recording of the characteristics and activities that can have a significant impact on the environment

Management Review
- review of the environmental management system by the organization's top management to ensure its continuing suitability, adequacy and effectiveness

Continual improvement
- the concept of continual improvement is a key component of the environmental management system; it completes the cyclical process of plan, implement, check, review and continually improve.

ISO-14001 has started being widely adopted by companies worldwide together with ISO-9000 (quality control). It is accepted and recognized as a most useful tool for the best possible planning, implementation and monitoring of a company's environmental performance.

4.4.2.2 <u>EMAS</u>

This EU regulation is encouraging the voluntary participation of companies in an environmental management and audit scheme, in order to promote and improve their environmental performance and provide necessary information to the public and other interested parties. EMAS has similar philosophy, approach and background to ISO-14001, both can be applied by large as well as by small/medium enterprises. However EMAS contains the following specific elements, which are fundamental for its application:

- an environmental statement, in which the achievements of the company against its targets and objectives are described

- an initial review of the company's activities, products and services, which will be the basis for the implementation of an environmental management system with particular focus on the company's compliance with existing environmental legislation
- a full section is devoted to the auditing, verification and accreditation procedures

EMAS is considered to be a more stringent environmental standard: its requirement for issuing an environmental statement may render a company liable for environmental damages in front of the general public. It is mainly implemented in the European Union region.

4.5 Waste minimization initiatives

There are some initiatives undertaken by individual industries, governmental institutions and local authorities in recent years aiming at the initiation of activities on small (e.g. in an industrial plant) or large (e.g. national/regional programmes) scale, which will further encourage the introduction of waste minimization techniques. They are usually based on voluntary agreements and aim at the raising of awareness of industrial managers to endorse the application of clean technologies in their enterprises. Examples of these initiatives can be the establishment of subsidy schemes promoting waste prevention activities in a limited number of companies, demonstration of the financial benefits of reducing waste at source by applying of demonstration waste minimization techniques etc.

4.6 Treatment of industrial effluents

There are two main options available for industrial effluents, which are collected from all production units and transferred into a final collection pit: pre-treatment/discharge into the municipal sewer, full treatment. They can be applied in cases of previous installation of prevention/recycling systems as well as final treatment method without any prior intervention in the production process.

4.6.1 Pre-treatment/discharge into municipal sewer

There is a general regulatory rule in many countries that, in case of discharge of industrial effluents into the municipal sewer system of the nearest municipality, these effluents must be pre-treated up to the level of untreated municipal effluents (BOD5 < 300-350 mg/l, absence of toxic substances such as heavy metals, phenols, neutral pH etc.). This rule is enforced, in order to protect the sewer material from adverse impacts like corrosion as well as to avoid any malfunctioning of the subsequent municipal wastewater treatment installation, which can be caused by intoxication of the activated sludge.

As a matter of fact, this solution is mostly applied by small-medium enterprises, which are not able to install new recycling systems into the respective production cycle due to lack of expertise and resources, however, also larger units apply the same principle preferred as a simple solution.

Pre-treatment methods are some simple operations like neutralization, screening/sedimentation of coarse materials. The sediments are transported as "sludge" out from the plant and disposed either in municipal solid waste disposal sites (landfills, incineration plants) or at specific sites in cases of hazardous content.

When more complex waste streams are generated during the production process like those with high content in heavy metals, BOD/COD etc., the pre-treatment methods to be applied, besides those mentioned above, include physical/chemical treatment where with the addition of chemicals a higher degree of removal can be achieved. In most cases even high BOD content can be reduced up to raw municipal wastewater content.

4.6.2 Full treatment

For any industrial discharge directly into coastal/inland waters full treatment is needed (up to 90-97% of BOD/COD removal) for the protection of the receiving waters quality. This imposes, according to the content of the effluents to be discharged:

- physical/chemical treatment (removal of heavy metals, toxic substances, suspended solids, substantial BOD reduction)
- biological treatment (final BOD/COD reduction, removal of suspended solids)

The case of full effluent treatment is usually counter-productive, since it asks for substantial investment/operational costs and for industrial area availability.

5. DEVELOPMENT OF A WASTEWATER MINIMIZATION PROGRAMME IN AN INDUSTRY

5.1 Introduction

This chapter deals with the description of the conditions, which need to be considered when a wastewater minimization program has to be conducted in an industrial plant. It systematically lists the necessary methodological steps to be followed by an industrial/environmental manager, in order to plan, design and successfully implement this program provided that the company's management has agreed on a comprehensive corporate environmental policy to be implemented and all waste minimization options have to be explored.

The content of this chapter is organized according to 4 major elements usually applicable during the elaboration of this kind of processes:

- planning/organization
- assessment
- feasibility analysis
- implementation

In Figure 7 these elements are schematically summarized.

It must be pointed out that these steps have to be considered as methodological guidance for the successful implementation of a waste minimization program especially in cases where the management/ownership of larger companies is not clearly aware of the environmental implications linked with the related production processes. It is also helpful for the elaboration of most of the previously described waste minimization measures (clean technologies, mass balances, segregation of waste streams etc.). In any case, going through these phases, the obvious economic benefits potentially arising from any waste minimization program (waste is "wasting of resources") can be clearly identified, described and quantified, so that final decisions can easier be made. Additionally, a waste minimization program is the core on which an environmental management system (ISO- 14001, EMAS) can be based.

5.2 Planning and organization

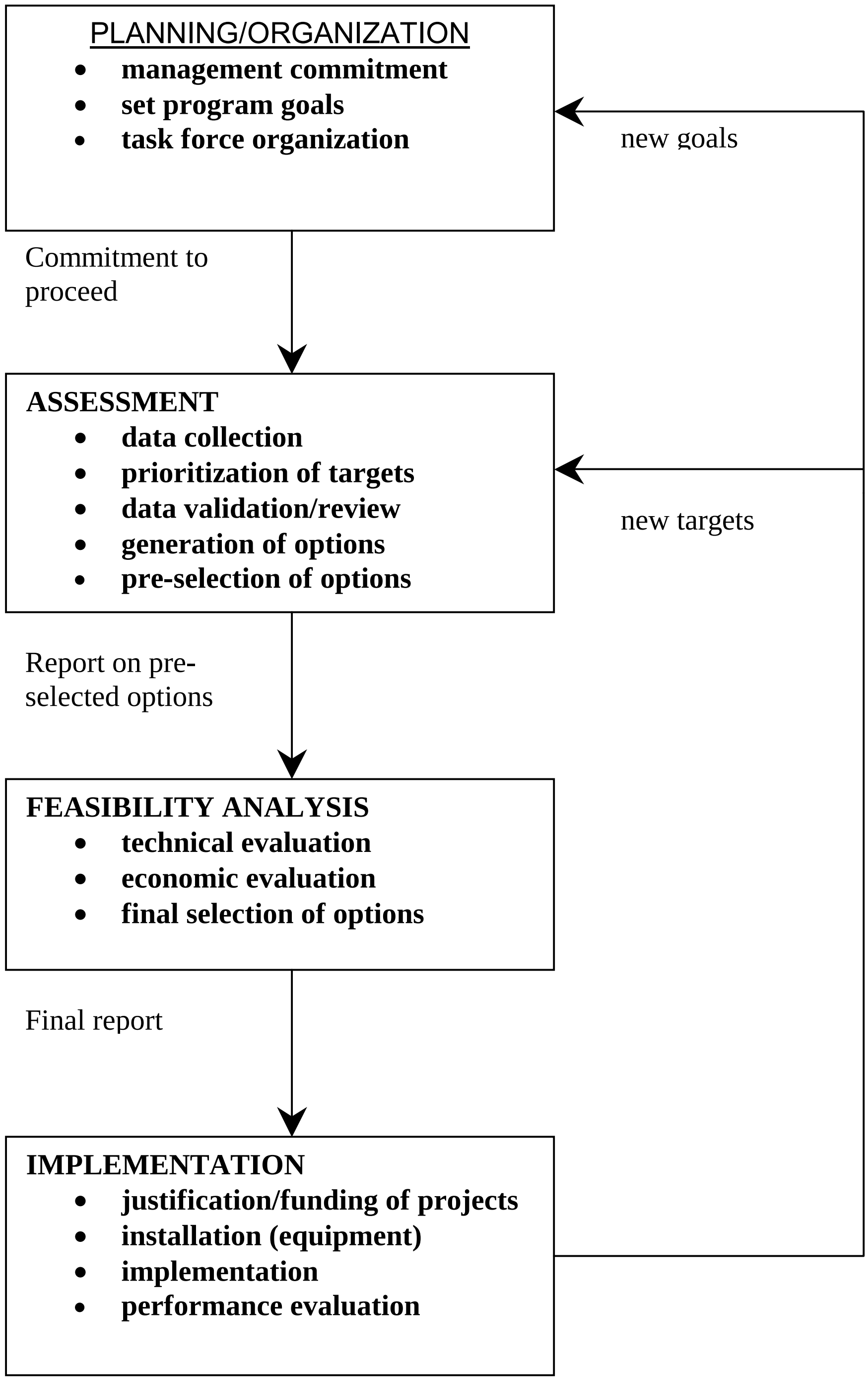
5.2.1 Management commitment

The management of a company can support a waste minimization program if it is convinced that the expected benefits (economic/competitive advantages, compliance with regulations, reduced environmental impacts, improved public image) will compensate the related costs for its execution. This management support can be reflected in a company's **policy statement**, similar to that described in the EMAS regulation (chapter 4.4.2.2.).

5.2.2 Program goals

Goals must be quantifiable, since, otherwise, they can be interpreted ambiguously (example: "a significant reduction of emissions of dangerous substances into the environment"). Quantifiable goals (example: "zero discharge of chromium into wastewaters") establish a clear guide to the degree of success of the program.

Figure 7 Waste minimization assessment procedure (phases)



Source: U.S.EPA Waste minimization opportunity assessment manual, 1988

The goals have to be periodically reviewed and modified according to the process of evaluation of the program during its implementation phase.

5.2.3 Task force

A team has to be established and accordingly organized for the preparation, planning, design and implementation of the program. Members of each company's department affected by the waste minimization program should participate in the task force team. This has not to be so formal in small enterprises, where the production manager can set up a small team of 2-3 persons to conduct the necessary inventories, or sub – contract specialized consultancy firms.

5.3 Assessment

5.3.1 Data collection, validation and review

Data can be obtained from any possible source, in order to compile the necessary mass/material balances needed as basis for the assessment of pollution loads. In doing so, information sources such as design manuscripts, environmental studies, production records etc. can provide the necessary data sets. This information forms the basis for focusing on the more problematic areas in the plant but it has always to be combined with a detailed site inspection for obtaining an integrated and up – dated picture of the overall situation.

5.3.2 Target setting

It is understood that a prioritization of waste streams and of pollution reduction targets is needed, in order to make the best economic and environmental profit from this program. This prioritization has to follow the following criteria:

- compliance with environmental regulations
- potential for economic benefits (e.g. recovery of by – products from concentrated waste streams)
- investment needed for the installation of necessary equipment to meet the set targets and the related operational costs
- company's existing financial capabilities

5.3.3 Pre-selection of options

The process for identifying options should follow a hierarchy in which source reduction options should be explored first before recycling, whereas treatment possibilities should be considered after all waste minimization techniques have been identified.

Searching for waste minimization options can start with the simple good housekeeping measures and continue with pollution source reduction of concentrated waste streams where a high potential of by -products recovery can be explored. For the selection of unavoidable treatment systems, pre–treatment of wastewater up to the level of untreated domestic wastewaters (BOD < 500 mg/l).

5.4 Feasibility analysis

5.4.1. Technical evaluation

The technical evaluation of options determines whether it will work in the prevailing specific conditions in an industrial plant. The following criteria have to be followed:

- safety for workers
- maintenance of product quality

- compatibility of new equipment/installations with existing production operating procedures
- requirements for additional labor/expertise and space
- expected environmental benefits

5.4.2 Economic evaluation

Each company has its own economic criteria for selecting projects for implementation. Generally various costs and savings must be considered, they are summarized as capital and operating costs in Table 8.

Table 8

Capital and operating costs/savings

Capital costs	**Operating costs/savings**
Direct Site development Process equipment Materials Connections to existing facilities Construction/installation Other non-process equipment **Indirect** Engineering, procurement Power, fuel etc. Contractor's fees Permitting costs Start-up costs Training	Material purchase Insurance-liability Utilities Operation-maintenance Overhead Revenues from production Revenues from by-products Costs/savings from quality control Waste management (treatment, disposal, transportation)

Source: U.S.EPA Waste minimization opportunity assessment manual, 1988

Additional factors to be considered when a project has to be economically evaluated are the pay-back period (capital investment per annual operating cost savings), return on investment and net present value.

5.4.3 Final selection of options

A final report has to be prepared and submitted to company's management with a clear proposal of the final waste minimization options to be adopted. This report should contain:

- a clear description of the technical and economic characteristics of each option as well as the expected environmental benefits
- the required resources and how they will be obtained
- estimated construction period
- estimated changes in the production cycle and relevant implications (production downtime, lowering of production rate etc.)
- how the project's performance can be evaluated after its implementation

5.5 Implementation

5.5.1 Funding

Despite the fact that waste minimization options generally lead to improvements in process efficiency and reductions in waste management costs, a sincere effort to convince the company's management has to be undertaken mainly due to the fact that, frequently, existing resources are prioritised towards future revenues (e.g. expanding plant's capacity). Therefore a special focus of the feasibility final report should be given to the exploration of possibilities for funding such as bank loans, sponsoring etc.

5.5.2 Implementation/evaluation

After project's approval and obtaining funding the "classical" implementation phases have to be followed trying to avoid major disturbances of the production process. These phases are:

- planning
- design
- procurement
- construction

The evaluation of the project's performance follows the start - up and a reasonable initial phase (6 months). In doing so, the actual waste reduction results and cost savings should be benchmarked to those predicted and estimated during the assessment and feasibility analysis phase (recording of raw materials and waste quantities before/after project implementation). The following **indicators** best fit into this evaluation process:

- waste quantities per production rate (e.g. kg BOD/kg raw material, m^3 of effluents/ kg of raw material)
- savings in chemicals (e.g. kg dyes/kg raw material)
- concentrations of pollutants in final effluents (e.g. mg BOD/ml)
- pay - back period (years)

5.6 Capacity building

Any waste minimization/prevention programme cannot be long-term successful if the human factor applying it, namely the industry's responsible personnel, is not adequately educated and trained on all issues to be addressed during the programme's implementation. This educational activity can either be performed on the company's own initiative or in cooperation with local authorities, non-governmental organizations, which are specifically set up for raising awareness on sustainability, promote new initiatives etc.

5.6.1 In-plant training

These are short-term quick practical seminars usually conducted by professional trainers hired by the company. As participants are included managers, engineers and technicians involved in running the overall environmental management programme. This is usually the case when the company is applying for any environmental standard permit (ISO, EMAS) where those involved are trained to assess all those elements needed for the final authorisation.

Additionally, in cases of installation of new waste minimization systems, the responsible personnel is accordingly trained on the system's features. Outside plant training is conducted (participation in workshops, seminars) when specific knowledge must be obtained on items of interest: new techniques/BAT, prospects of raising environmental performance in the branch, discussion on eco-design etc. These events should usually be visited by those experts having a “strategic” position in the company, in order to assure that any new ideas/proposals would be incorporated in the company’s overall strategy and development.

5.6.2 Awareness/training

Several non-governmental organizations, national/local authorities and educational institutions often promote various initiatives to promote environmentally sound techniques and the overall concept of sustainable development. They also help companies to obtain financing for cleaner production/waste minimization investments, so that a continuous inter-active support can be maintained provided that the companies will positively respond. Within this framework, these organizations often conduct demonstration programmes in an industrial plant by showing, during short seminars, the benefits of new techniques (cost savings, meeting environmental regulations etc.). Important part of these activities is the dissemination of important information to those interested, namely to industrial associations, planning authorities etc.

Within the very busy world of every day’s activities, a company has to appoint responsible persons to deal with awareness/training, which usually has a long-term character and it is seen as “luxury” compared with the acute operational issues to be continuously solved.

6. PLANNING, DESIGN AND IMPLEMENTATION OF A PROGRAM FOR MONITORING/CONTROL OF INDUSTRIAL EFFLUENTS

6.1 Introduction

The organizational requirements for an effective wastewater management programme cover a wide range of activities, which have to be undertaken, in order to achieve practical results with the least expenditure of resources. Some of these requirements are mentioned here:

- establishment of a pollution control inspectorate
- management of industrial and municipal wastewater facilities (collection, treatment and disposal)
- monitoring/control of coastal waters and effluents
- elaboration of research programs to improve the existing technical and organizational capabilities for effluent control

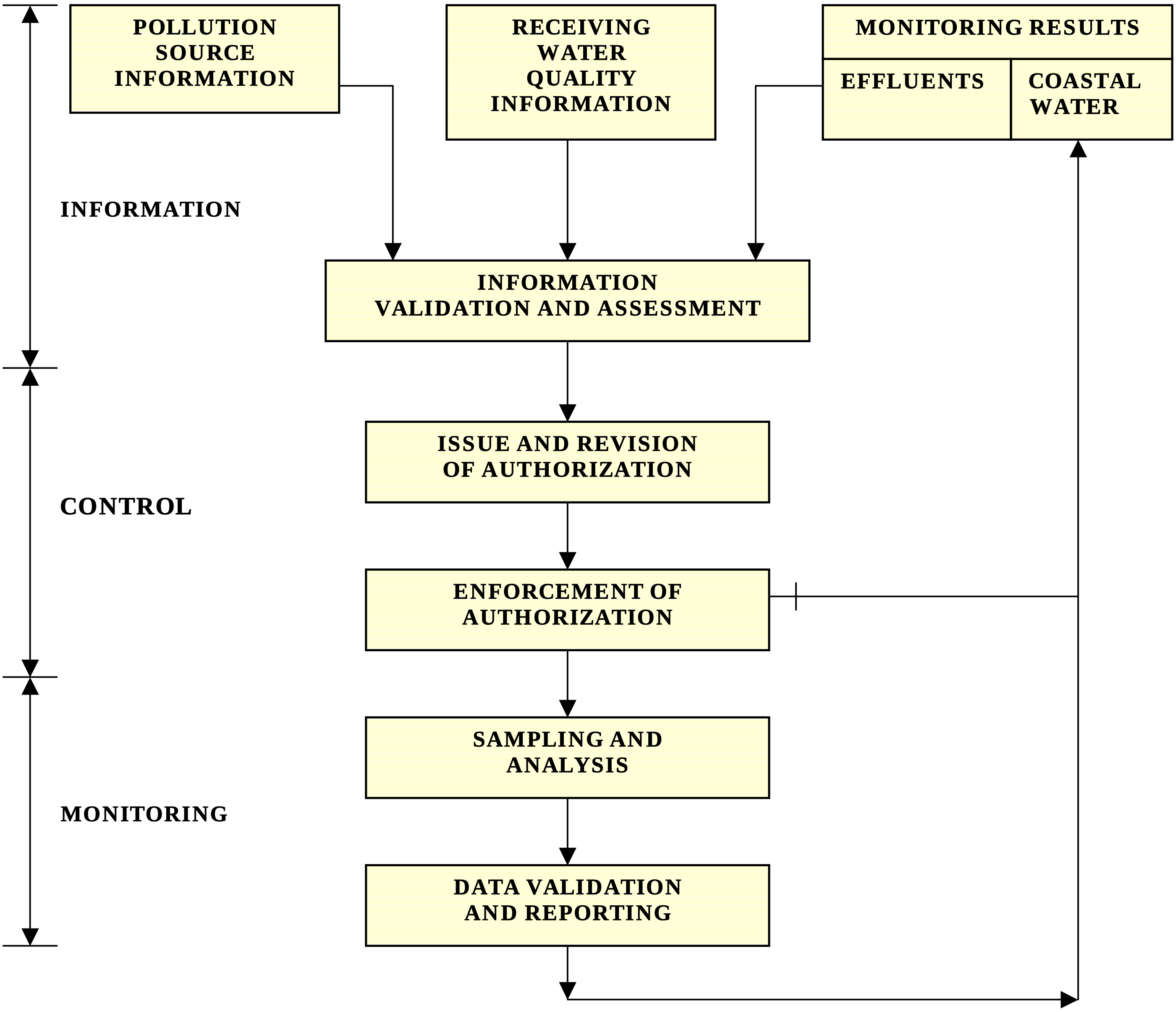
This chapter is focussing entirely on those elements needed to enable controlling authorities to implement an effective monitoring program of industrial effluents. These elements are practically dealing with the “classical” work of inspecting authorities, namely with **information collection/validation** concerning quantity (volume) and quality (concentrations) of final effluents reaching water recipients and especially coastal waters as well as **monitoring** and **control** of both (effluents and receiving water quality). Concerning the other main elements (establishment of an inspectorate, management of facilities and implementation of research programs) they are beyond the scope of this chapter, which is to practically support existing authorities to better monitor and control the discharge of industrial effluents into the coastal environment. This major activity is the backbone for the whole chain of regulation compliance and enforcement as well as for the final evaluation and eventual modification of a pollution control policy. In chapter 2 the major problems encountered by planning and implementing such a policy have been highlighted, where the necessity of feedback from the locally operating inspectorates to the centrally located planners has been pointed out. Therefore the main objective of this chapter is to set up a framework for the implementation of a quick, effective and sustainable monitoring program for industrial effluents.

6.2 Functions of a coastal pollution control authority

In Figure 8 the major functions of a coastal pollution control authority are illustrated.

A regionally/locally operating coastal pollution control authority (inspectorate) has to tackle the problem of effluent discharge into the sea waters in an integrated way, namely by setting the appropriate **water quality standards/objectives** and defining the necessary **effluent standards** to be met by the relevant industries. This is the case when uniform, nationwide standards have not been implied so far. In this context it must be pointed out that this uniform approach can be misleading and should be avoided, since it cannot take into consideration the locally prevailing situation (water quality, accumulation of industries etc

Figure 8 Functions of a coastal pollution control inspectorate



Source: Code of Practice for environmentally sound management of liquid waste discharge in the Mediterranean Sea, UNEP/MAP (PAP/RAC), 1990

6.3 Setting of effluent standards

Various methods have been employed to control the discharge of pollutants into water recipients. The oldest and probably easiest method is the imposition of identical limits to all discharges **(uniform emission standards)**. This method is applicable to industrial discharges into main sewers of municipal wastewaters (pre-treatment up to the level of untreated municipal wastewaters) but in cases of direct discharge into coastal waters it should be avoided since it cannot respond to the differentiation of the locally prevailing conditions of the water recipients.

A more sophisticated method for setting effluent standards has to take into consideration many factors mainly depending on the receiving sea water quality **(environmental quality objectives system)**. It is based on the philosophy of controlling discharges so that the quality of the receiving water body is suitable for its established legitimate uses. As a general rule, the combined load of discharged effluents (municipal + industrial) should never exceed the self-purification capacity of the receiving water. In order to assess this capacity several physical, chemical, biological and microbiological studies have to be elaborated. This procedure for the control of discharges based on environmental quality objectives is illustrated in Figure 9.

The major parameters to be considered by setting effluent standards are presented in Table 9.

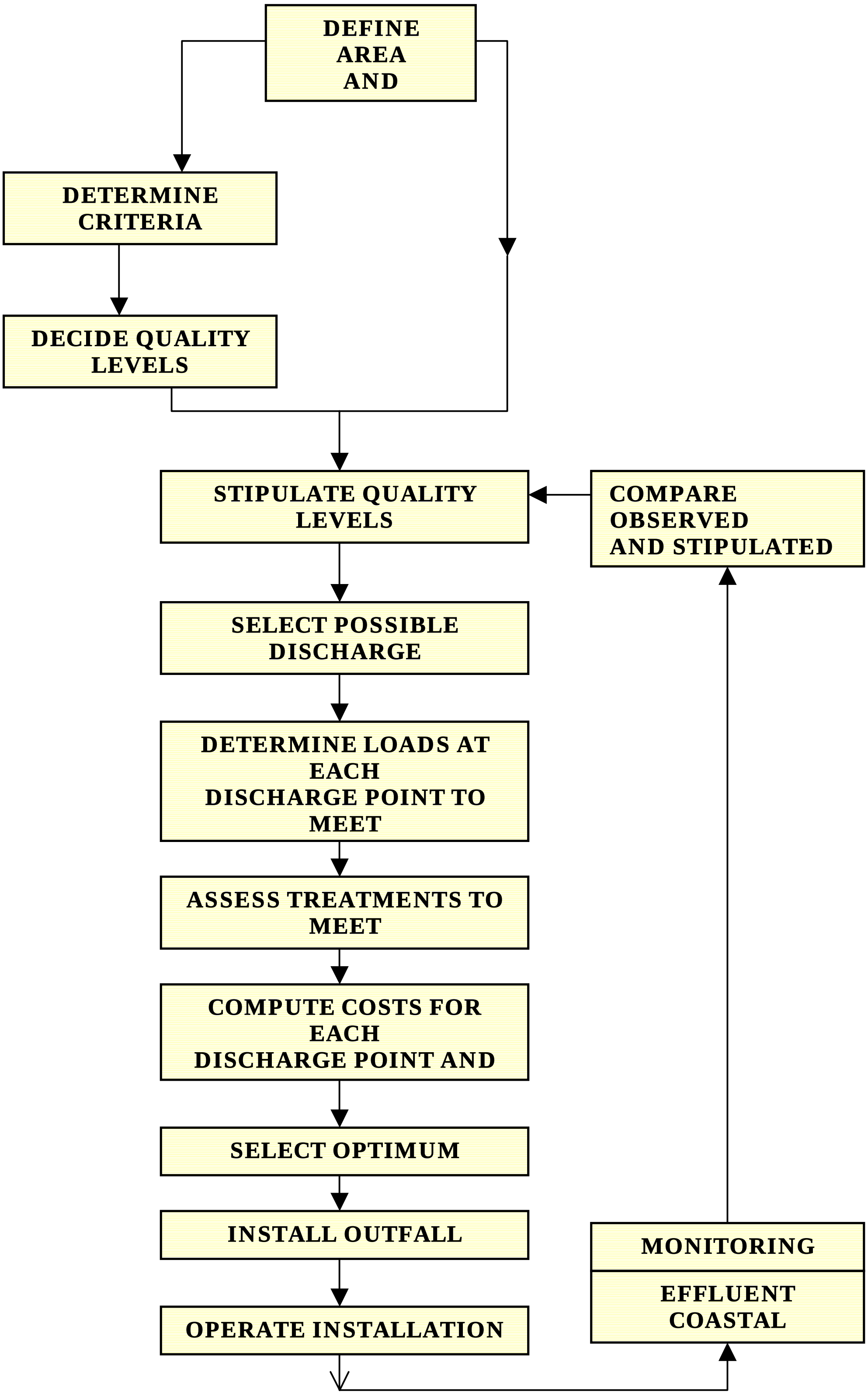
Table 9

General guide for effluent standards formulation
(direct discharge into receiving waters)

Parameter	Suggested standard (mg/l)
BOD_5	10 - 20
COD	30 - 40
Suspended solids (SS)	30 - 50
Dissolved oxygen (DO)	5 (in sea water)

Source: Code of Practice for environmentally sound management of liquid waste discharge in the Mediterranean Sea, UNEP/MAP (PAP/RAC), 1990

Figure 9 Environmental quality objectives system



__Source__: **Code of Practice for environmentally sound management of liquid waste discharge in the Mediterranean Sea, UNEP/MAP (PAP/RAC), 1990**

6.4 Development and organization of an inventory program

Usually inspecting authorities conduct inventories of polluting activities in an area as part of their work of supervision of the compliance of industries with set permits and standards but also as a feedback in the planning process where actually achieved results, reported from monitoring exercises, can contribute to better plan forthcoming pollution control procedures (amelioration measures, new legislation etc.).

These inventories occur on different ways namely on a random basis (selection of an industrial plant, random sampling from various spots and/or from the central sewer) or in a very systematic and detailed way: all industrial plants within an area are visited and inspected. While the first method contains a significant risk of error, the second is associated with an extensive investment of resources and time.

Between these extremes, a more reasonable approach allowing the reliable rapid assessment of the major pollution sources, an easier up-dating of conducted inventory archives and better targeting of pollution reduction procedures is the use of waste factors, which link the waste generators (driving forces) with the actual waste quantities. These factors are derived from the literature and from experimental results and are used as "tools" to assess the waste quantities from industrial production figures (e.g. kg of polluting parameter per kg of raw material). As a consequence, by knowing production figures a calculation of the expected waste quantities is possible enabling a first assessment of pollution loads but also a "dynamic" up - dating of pollution loads on the basis of industrial production figures.

This methodology can be schematically presented by the following equation:

WQj = Aj x WF

Where:

WQj = quantity (kg/year) of each pollutant generated by the production process j
Aj = quantity of raw material (kg/year) used in the production process j
WF = waste factor (kg of pollutant/kg of raw material) associated with the production process j

Having defined each waste factor, the waste quantities from similar plants and industrial operations can be calculated if the quantities of raw materials used in the relevant production process are known.

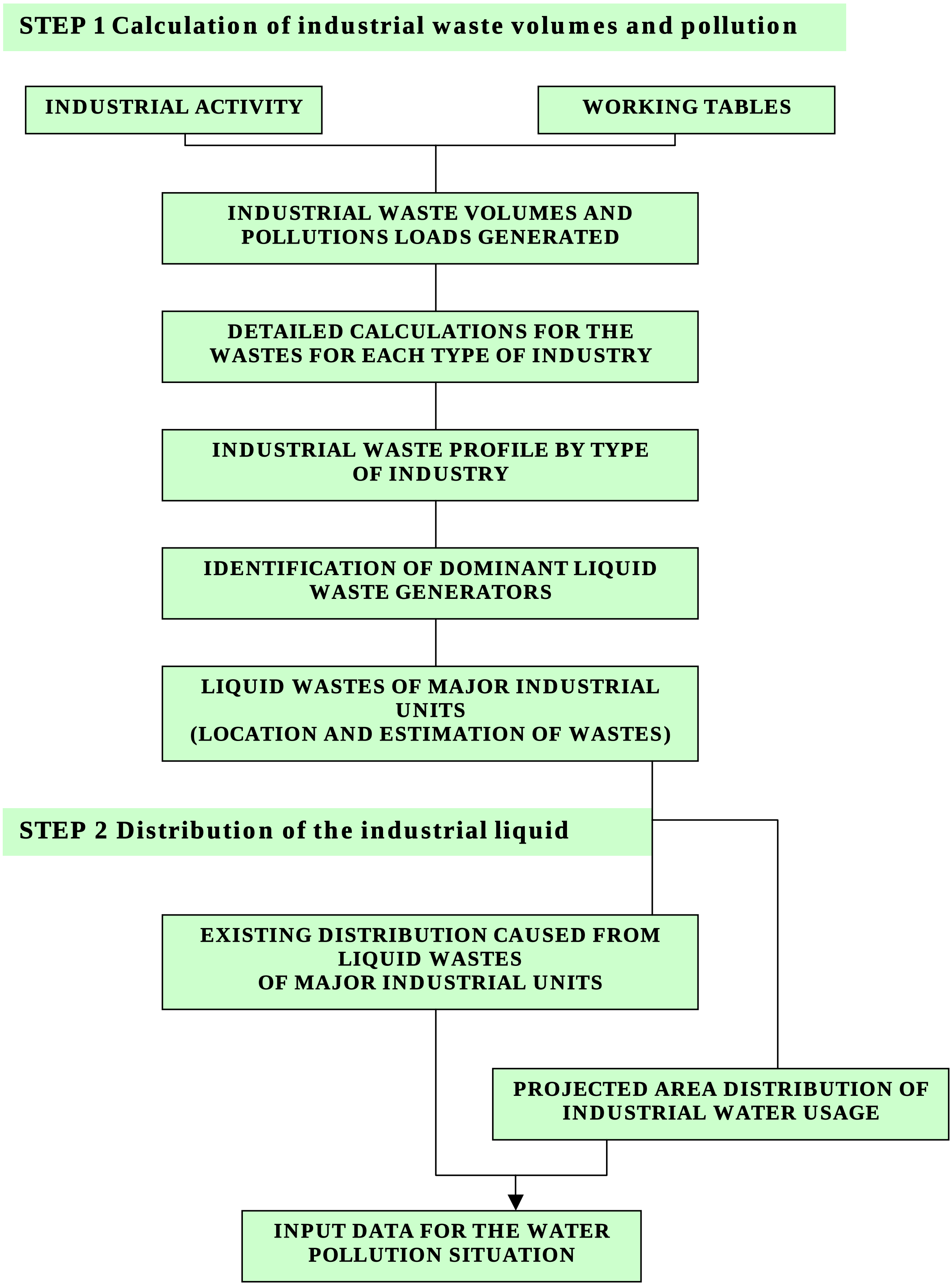
Rapid assessment is the first step needed by an inspectorate to reliably assess the environmental "importance" of an industrial branch in an area, in order to:

- define high priority control actions
- organize subsequent source surveys and monitoring programs
- assess the impact of new industrial development and select proper control measures

In doing so, 2 methodological steps are needed, namely the calculation of industrial waste volumes and pollution loads and a study of the distribution of the industrial effluents in an area.

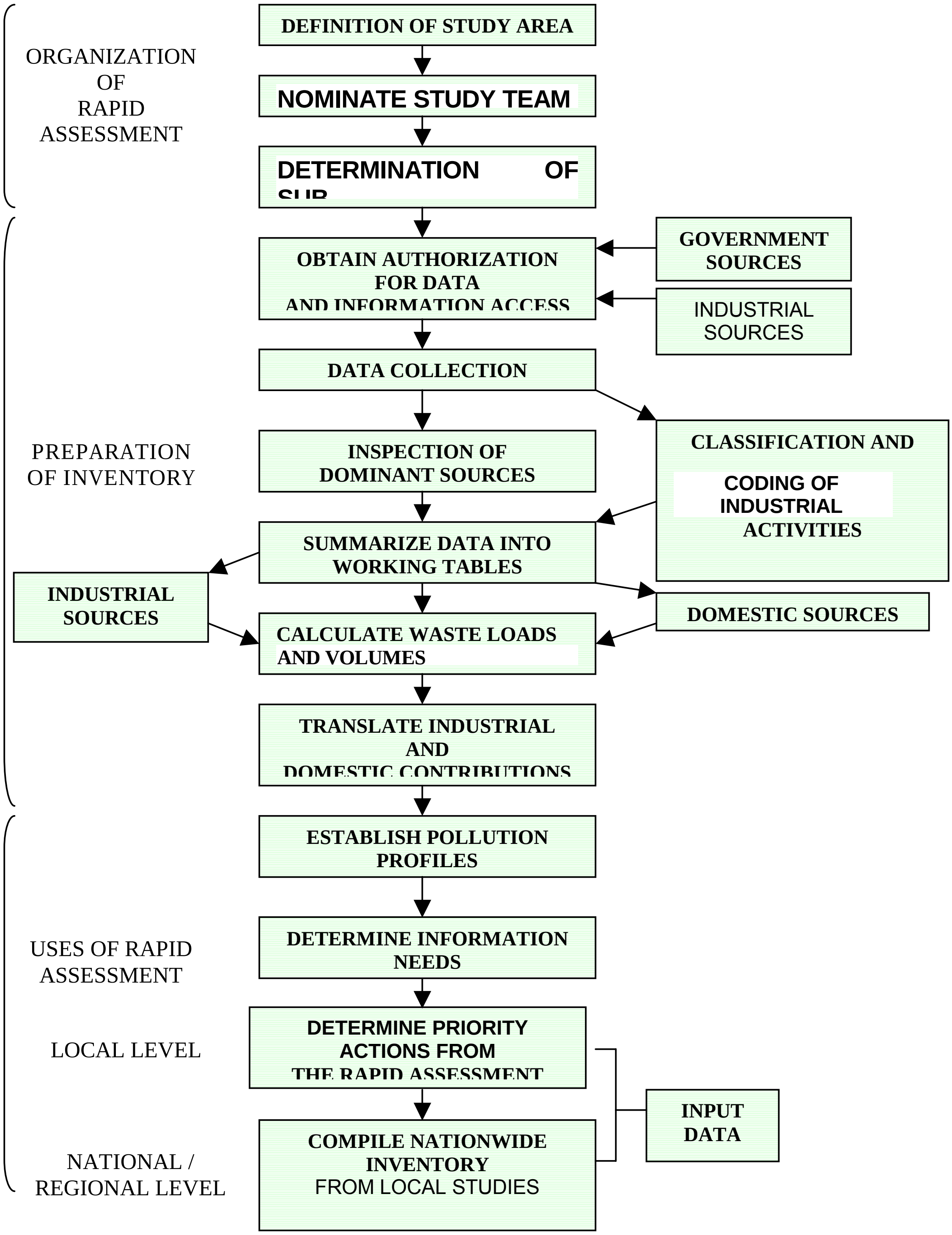
Figures 10 and 11 highlight these steps and the elements of the rapid assessment methods respectively.

Figure 10 Analysis of industrial effluents



<u>Source</u>: **Code of Practice for environmentally sound management of liquid waste discharge in the Mediterranean Sea, UNEP/MAP (PAP/RAC), 1990**

Figure 11 Rapid assessment flow diagram



<u>Source</u>: Code of Practice for environmentally sound management of liquid waste discharge in the Mediterranean Sea, UNEP/MAP (PAP/RAC), 1990

This “condensed” inventory programme of industrial pollution sources has to be executed by well trained and experienced personnel, which has to obtain knowledge on:

- production processes of each industrial branch to be monitored
- assessment of waste quantities to be generated by each industrial unit operation
- targeted sampling of industrial effluents at selected points in an industrial plant

After the development of the above mentioned waste factors will follow a “pilot” inventory of representative plants from selected industrial branches. The following methodological steps are needed for its execution:

1. a few large, medium sized and small plants from each branch are chosen
2. the production details and pollution sources in each branch are studied/analysed based on literature references and experience
3. the environmentally “weak” spots are defined for each plant to be visited
4. a questionnaire customized for each branch and focussed on the areas of interest will be prepared
5. a visit to each plant has to be organized during which, on the basis of the questionnaire, the industrial managers responsible for environmental issues will be interviewed
6. samples from sewers containing waste streams from the “weak” spots will be taken and analysed in the inspectorate’s premises
7. results will be compared with the company’s self-monitoring records, if any, and with literature references
8. the relevant waste factors for each production unit and technology will be prepared on the basis of the combined information from literature references and the obtained experimental results
9. waste quantities from each visited plant will be calculated by using the waste factors
10. a pollution profile for each industrial branch has to be finally prepared linking production figures (quantities of raw materials used) with production technologies and estimated waste quantities.

This kind of inventory of industrial enterprises is the “backbone” of the preparation of a baseline budget of pollutants releases as it is envisaged in SAP as a reference basis needed for benchmarking the progress of pollution reduction in the Mediterranean region in the forthcoming years.

7. ECONOMIC ANALYSIS FOR INDUSTRIAL ENVIRONMENTAL MANAGEMENT

7.1 Introduction

There are various aspects within the whole economic/financial framework associated with industrial pollution control: one major issue is the imposition of taxes ("green taxes"), charges, fees as driving forces for the acceleration of pollution control measures, the other important topic is the whole economic analysis concerning the investment and operation of cleaner production systems, waste prevention programmes etc.

Environmental ("green") taxes have been used for years especially in Europe. They are imposed by the respective national authorities aiming at substantial drops in pollutants release.

For industrial managers, however, most important is the analysis and assessment of all costs relevant to the installation of new systems for pollution reduction since this factor is the exclusively dominant factor for decision making in an industrial plant. Necessarily, this topic will be to a certain extent described here whereas a brief summary, for information purposes, on taxes, fees etc. will also be presented.

This chapter is aiming to help industrial managers to better assess the economic impacts associated with any investment in new systems they intend to make whereas it also can give some inspirations to national authorities for the introduction of environmental taxes.

7.2 Capital/operating costs for pollution abatement technologies

The estimation of costs relevant to the installation and operation of systems for pollution reduction in industry is totally depending on local and site-specific considerations, so that no comparison can be made between organizations, industrial branches and countries. Thus, estimates of costs for similar facilities and control techniques often vary widely reflecting not only the local conditions but also alternative technical/economic assumptions and methodological differences.

This chapter provides a kind of "checklists" of key factors needed for managers to estimate the costs associated with pollution control measures.

7.2.1 Essential information for cost estimation

There are some basic economic considerations to be analysed as part of the final decision making process within an industrial plant, in order to finally decide to install a new pollution control system. The relevant key factors to be defined first are summarized as follows:

1. which pollutant(s) have to be removed and to which level (removal efficiency required)
2. type of installation (new or retrofit)
3. basis year for economic calculations
4. size of facility and annual average facility utilization (e.g. continuous/batch operation of the pollution control system)
5. side effects (e.g. industrial area occupation for system's installation)
6. expected life time (years) of pollution control facility
7. investment costs needed and funds granted
8. estimated annual operational costs
9. interest rate, annual inflation rate
10. pay-back period (years)

11. impacts on industry's product policy/polluter pays principle ("cost of pollution prevention to be reflected in the cost of goods and services causing pollution in production and/or consumption")

This set of factors defines the overall framework to be followed at the stage of final decisions.

7.2.2 Capital (investment) – operational costs

7.2.2.1 Investment costs

For the calculation of these costs the following factors should be considered:

1. expenditure on the construction or acquisition of equipment (equipment/supplies, engineering, labour and supervision, instrumentation, piping, safety/sanitary facilities etc.)
2. expenditure on the construction/acquisition of buildings needed for equipment installation/ operation (excavations, building/storage facilities, roads etc.)
3. expenditure on the acquisition of land needed or value of land already owned
4. expenditure on necessary production modifications
5. start-up running costs (raw materials, chemicals, labour, energy costs etc.)
6. loss of product output during installation/start-up phase of the equipment
7. cost of money (interest rate) over the project's construction/installation period

7.2.2.2 Operational costs

The factors determining the annual operating costs, a cost item sometimes underestimated in decision making, can be summarized as follows:

1. total personnel costs required for system operation
2. maintenance/repair
3. systems administration/management (communication, transportation, expenses connected with management activities)
4. consumables (raw materials, chemicals, energy, water)
5. monitoring/laboratory costs
6. annual cost of interest of the overall investment
7. taxes and insurance

7.3 Revenue collection

The part of revenue collection originating from the operation of a new pollution control system is often underestimated or overlooked by managers, since it is seen as a rather minor side effect of the investment. However it has to be kept in mind that cleaner production and waste prevention/minimization systems aim almost always at materials savings and/or the production of useful by-products, which can be sold. These savings help to substantially cut off the investment's pay-back period.

Some examples of savings are given in section 4.3. (waste minimization techniques).

7.4 Environmental taxes/charges

Environmental taxes are usually seen as effective tools to introduce pollution prevention systems in major parts of the economy. The experience so far has shown that they were quite successful, thus inspiring several countries to introduce them.

The term **taxes and charges** should be understood to cover all compulsory, unrequited payments whether the revenue goes directly to governmental budget or is destined for particular purpose.

There also various types of charges which frequently overlapp such as:

- cost covering charges covering the cost of controlling/monitoring the use of the environment
- incentive taxes intended to change environmentally damaging behaviour
- revenue raising taxes influencing behaviour and still yielding revenues

Some examples of these taxes are presented in Table 10.

Table 10

Environmental taxes/charges

Type	**Sector affected**
Nitrogen taxes	Tax on large power plants/large energy producers
Wastewater charges	Sewage treatment plants/industries – dwellings
Packaging taxes	Container filler or importer when product released for consumption/ fillers - packers
Batteries taxes	Consumer – battery industry
Aggregate taxes	Construction industry
Pesticides taxes/charges	Agriculture/pesticide manufacturers
Landfill taxes	Landfill sites/recycling industry
Water abstraction charges	Water companies

<u>Source</u>: Study on environmental taxes and charges in the European Union – ECOTEC in association with CESAM, CLM, University of Gothenburg, UCD, IEEP, 2001

These and other taxes are generally centrally planned by national authorities and monitored on local level by the relevant inspectorates. Concerning industry, they can provide powerful economic incentives for a better environmental performance on the long term despite the criticism usually made by industrial associations as an additional cost factor.

8. GLOSSARY

- **BAT (Best Available Technique)**
  State of the art of the most effective processes, facilities or methods of operation that indicate the practical suitability of a particular measure for limiting discharges, emissions and waste

- **BEP (Best Environmental Practice)**
  Application of the most appropriate combination of environmental control measures and strategies

- **CP (Cleaner Production)**
  Continuous application of an integrated preventive environmental strategy applied to processes, products and services to increase overall efficiency and reduce risks to humans and the environment.

- **CT (Cleaner Technology)**
  Cleaner Technology may be thought of a subset of Cleaner Production activities with a focus on the actual manufacturing process itself and considers the integration of better production systems to minimize environmental harm and maximize production efficiency from many or all inputs

- **EMS (Environmental Management System)**
  The part of a general business management system which includes the organization structure, the responsibilities, the practices, the procedures, the processes and the resources to determine and carry out the environmental policy of a company

- **Good Housekeeping Practices**
  Attitude or behaviour change helping, by introducing simple management measures, to improve the company's efficiency, its environmental management and its competitiveness.

- **Industrial effluent**
  Liquid waste generated from industrial production facilities excluding effluents from industry's personnel (municipal wastewater)

- **Pre-treatment**
  Any treatment which is needed for partial removal of pollutants from industrial effluents prior to their discharge into a sewer

- **Waste minimization**
  Intervention into waste production cycles by introducing preventive and/or recycling, recovery and reuse measures

- **Waste prevention**
  Avoidance of waste generation

- **Waste recycling**
  Collection of generated waste from a system/facility and re-introduction into the same or similar material production cycle

- **Waste reuse**
  Collection of generated waste as by-product from a system/activity and its use as input into another material production cycle

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