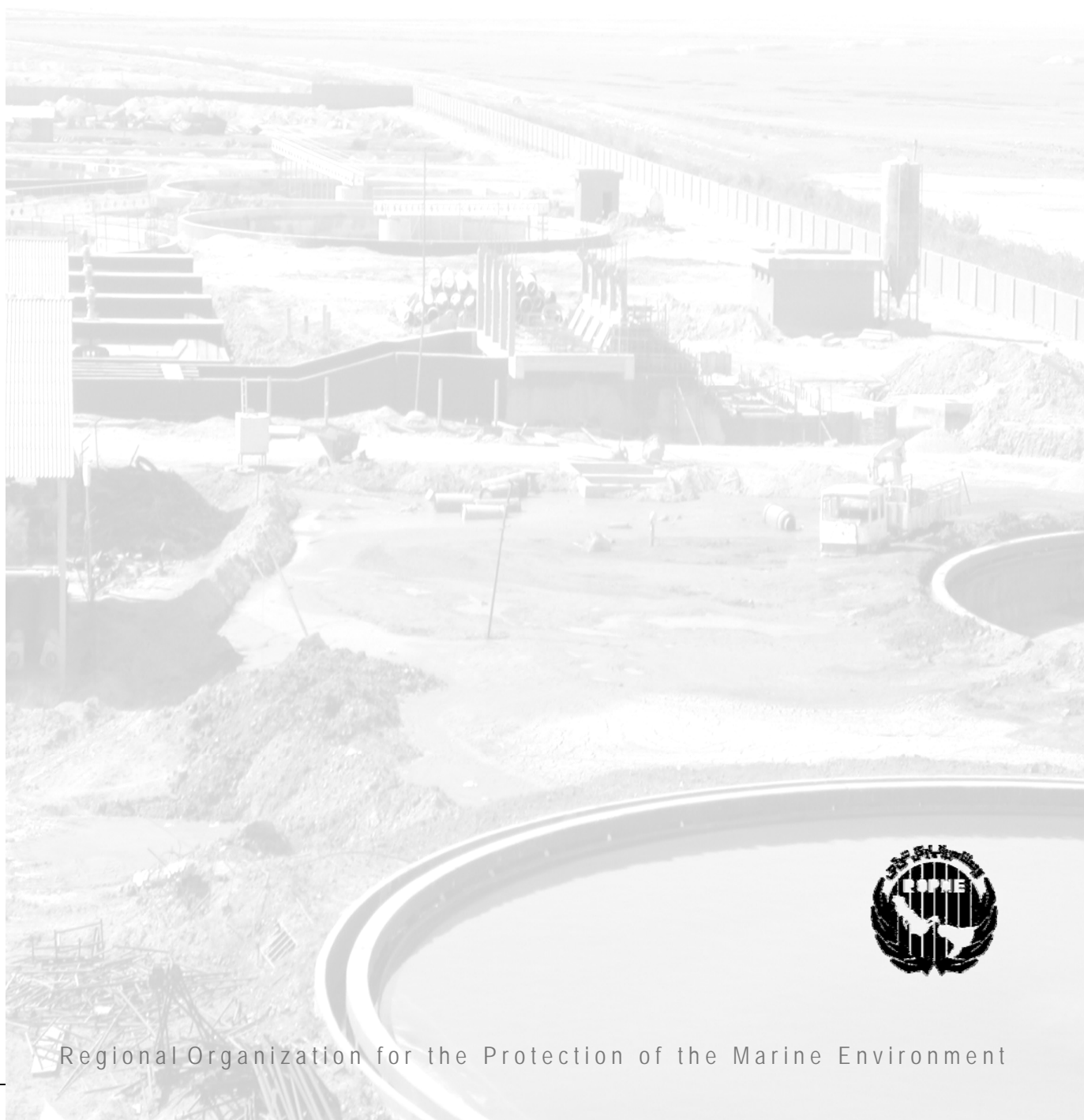


Guidelines for the Management of Industrial Wastewater for the ROPME Region



Regional Organization for the Protection of the Marine Environment

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Foreword

Of the many critical approaches to protecting the marine environment, judicious management of effluents from land-based activities is an important aspect of high priority. In the ROPME Sea Area (RSA), the closed nature of the marine environment poses natural restriction to circulation, which in turn simulates an amplified effect of pollutants on the biota by longer time of residence. Thus, it is imperative that we evolve context specific guidelines for the discharge of land-based effluents into the coastal waters and develop appropriate methods of waste treatment that would minimize pollution and environmental degradation. ROPME is constantly reminded of the grim scenarios that may emerge if the discharges from land-based activities into the RSA are not properly regulated. This has been the background to the efforts made by ROPME in the recent times to collect and collate the essential information on LBA for the management of discharges into the coastal waters as a first step towards mitigation of emerging problems. This document on guidelines epitomizes our collective efforts.

ROPME received generous support from UNEP/GPA in this important endeavour and a Memorandum of Understanding between our institutions guided the activities leading to the document. Under the provisions of the Memorandum, ROPME enlisted the services of a project consultant, Mr. Dimitrios Tsotsos, who completed the difficult task of compiling the text of the draft 'Guidelines' within a short time. A meeting was held in Doha, Qatar during late June 2005 to discuss in detail the draft guidelines and I acknowledge the guidance provided by the representatives of Member States and the inclusions they suggested. With all these, I sincerely hope that the serious and genuine attempt on behalf of ROPME and UNEP/GPA would be considered a landmark and a new beginning on the path of environmental protection in the Region.

ROPME hopes to receive constructive feedback from Member States and other concerned entities on the document, enabling timely revision and further development of the guidelines in the efforts towards mitigating the avoidable negative effects of land-based activities.



Dr. Abdul Rahman Al-Awadi
Executive Secretary, ROPME

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1. INTRODUCTION

1.1 Scope of the document

The scope of this document is to provide useful and practical information to those who are responsible for industrial wastewater management in the ROPME Region, in order to apply the state-of-the-art methods and techniques needed to minimize the harmful effects caused by uncontrolled discharge of industrial effluents into coastal waters.

In the Protocol for the Protection of the Marine Environment against Pollution from Land Based Sources of the Kuwait Convention (Appendix I), it is stated that discharges of effluents into the sea must be controlled and reduced. Special provisions are mentioned for pollution abatement through source control, which means that, for industrial discharges, methods for the reduction of pollution generation within an industrial installation have to be applied. In this regard, particular attention will be given but not limited to the following factors:

- a) Curtailment and/or regulation of import, transportation, manufacturing or processing of certain harmful substances
- b) Change of raw materials
- c) Change of manufacturing processes
- d) Good operating and housekeeping practices
- e) Segregation of waste streams and minimization of pollutant dilution prior to treatment
- f) Recovery, re-use and recycling

In this context, the application of **the integrated pollution prevention approach** in industrial installations (waste minimization/recycling techniques, segregation of waste streams, etc.) is crucial for the effective control of industrial effluent discharges into coastal waters, since it helps avoiding the generation of large wastewater quantities and consequently the necessity to construct and operate large end-of-pipe treatment plants. Therefore, it is important to formulate guidelines for industrial wastewater treatment and disposal and for the application of environmentally sound technologies in industry as well as for the development of environmental management and audit schemes.

Having these aspects in mind, a document formulating the **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 realize the already widespread applicable possibilities to effectively minimize industrial pollution. It can be seen as a guide for the application of pollution control measures within an industrial facility, in order to minimize to the widest possible extent the wastewater quantities to be finally treated by off-site treatment plants.

This document provides a framework serving this scope but, by no means, is a **catalogue** of practices and techniques to be applied in the various industrial branches. The **objectives** of this document can be summarized 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

Questions about joint treatment of industrial effluents or combined municipal/industrial wastewater treatment are not dealt within this document.

1.2 Target groups

The **target groups** to mainly use this document 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.

1.3 Structure of the document

The document is structured in six chapters with an "INTRODUCTION" as **Chapter 1**. **Chapter 2** presents the most common problems encountered in the management of industrial pollution, so that the decision makers and planners become familiar with the magnitude of the issues to be tackled. In **Chapter 3**, the "core" of the document, good practices/techniques for the minimization of industrial effluents and management tools are briefly described, that may inspire about already applicable waste minimization methods, and the various environmental management tools. In **Chapter 4**, requirements needed to successfully implement those minimization programs by industrial managers are suggested. **Chapter 5** describes the program for the monitoring and control of industrial effluents to be applied by the inspecting authorities. Finally, **Chapter 6** deals with financial aspects/incentives associated with the promotion and introduction of pollution control systems. In Appendices III and IV a short presentation of the existing industrial effluent standards into receiving waters and of the main industrial activities in the ROPME Region are presented respectively thus giving an insight into the existing situation in this area.

2. MAJOR PROBLEMS FOR THE CONTROL OF INDUSTRIAL WASTEWATERS

2.1 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 2.1). This is the case not only for effluents originating from major industrial units producing chemical products but also from smaller enterprises (e.g. electroplating industries, tanneries, textiles), which generate harmful wastes 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 2.1) However, direct discharge of industrial effluents into water bodies is often encountered especially in cases when industrial installations are located in remote, isolated areas or when the construction of long collection pipelines to municipal collection systems is prohibitive due to geo-morphological conditions. In this case, stricter regulations must be put into force to avoid dramatic deterioration of the quality of the water recipient.

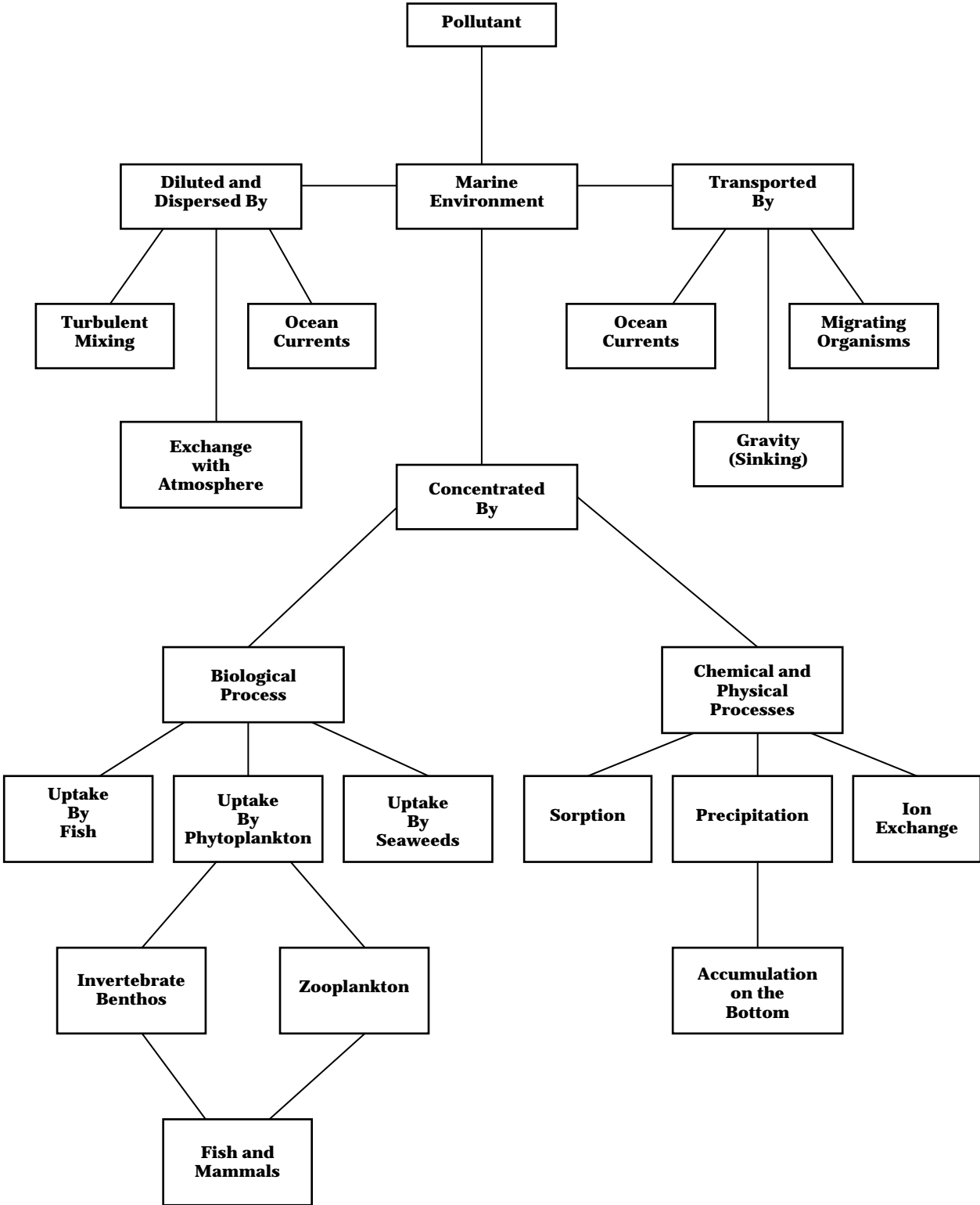
Table 2.1 Contaminants of industrial wastewaters

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, POPs (e.g. phenols, pesticides etc.)	Adverse effect on aquatic life & on biological treatment methods, contamination of sewage sludge for final disposal
	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

Source:

- The wastewater treatment handbook, Commission of the European Communities, DG for Regional Policies – DG for the Environment (produced by AMBER)
- ROPME expert meeting on technical guidelines for the management of land-based activities (Qatar, 25-27.6.05)

Figure 2.1 Processes determining the fate of a pollutant reaching the marine environment



Source: 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 water bodies (semi-closed estuaries, gulfs, oceans) 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 increased volumes of wastewaters discharged into the water recipients.

The most heavily polluting industries are major enterprises such as refineries, petrochemicals, desalination plants, basic steel industries, cement production and energy production plants, as well as several medium/small sized tanneries, textiles, electroplating and food processing industries. These small enterprises are particularly facing major organizational problems concerning their environmental performance, which mostly are based on limited expertise and restricted availability of resources.

Both concerned parties, industrial enterprises as well as inspecting authorities, are facing several burdens in their attempt to avoid the discharge of untreated effluents into the 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 organize 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, that is the implementation of those minimal measures, which are needed just for **compliance with legal/regulatory requirements**. Other measures with long-term perspective, e.g. recycling of by-products, will have an immediate effect on the enterprise's cost balance, and is often avoided. 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 (i.e. waste prevention actions, rational use of raw materials).

In this chapter, a review of existing practices is 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

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 and other sources.

In the production process itself, a detailed inventory of inputs/outputs for each industrial unit operation, **the material balance**, is often missing, so that unnecessary amounts of materials get lost. This is particularly the case by the use of resources such as energy and water, which seldom are precisely measured and used according to the actual needs of the industrial production processes. 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
- 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 are usually not frequently applied 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), 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 an integrated concept for successful environmental management. As a matter of fact, various waste streams deriving from 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 authorities**, which design the overall environmental policy in a country and the **inspectors** that 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 at 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 National 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 can lead to unbearable costs, which, then, will slow down industrial development, often is causing 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 authorities (environmental, industrial, economical) 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 and 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 analyzing 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 are 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 entrusted with the inspection/controlling work (inspectorates). 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 at 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. at 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 programs can only partially be implemented.

Adaptation of these programs after a certain period of implementation and taking into consideration any feedback from the inspectorates according to the achieved results, is not the most commonly encountered case. The planning "exercise" stops once the relevant policy is approved at 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.

A differentiation between **new** and **existing** installations is sometimes neglected, so that strict effluent standards, normally foreseen for new installations, are also applied for existing industries with the result that the latter are not able to meet them. As a matter of fact, new installations can better apply new environmental technologies and methods, which are needed for meeting strict standards due to the fact that crucial issues such as purchase of equipment, space requirements etc. can better be addressed. The application of **environmental assessment** procedures, which will show how and to which extent the environment will be affected by existing and/or new industrial installations in a region, is a powerful tool needed for the necessary differentiation in the planning procedure between existing and new installations. A good solution for existing installations is either to apply simple on-site good housekeeping measures or to plan the removal of these units in an industrial complex where a central physical/chemical/biological treatment plant can treat the effluents of industries of similar nature (i.e. textiles, tanneries etc.).

Environmental assessment is a procedure that ensures that the environmental implications of projects and programs are taken into account before the decisions are made. The process involves an analysis of the likely effects on the environment, recording those effects in a report, undertaking a public consultation exercise on the report, taking into account the comments and the report when making the final decision and informing the public about that decision afterwards.

In principle, environmental assessment can be undertaken for individual projects such as a dam, motorway, airport or factory ('**Environmental Impact Assessment**') or for plans, programmes and policies ('**Strategic Environmental Assessment**').

The purpose of Strategic Environmental Assessment is to ensure that environmental consequences of certain plans and programs are identified and assessed during their preparation and before their adoption. The public and environmental authorities can give their opinion and all results are integrated and taken into account in the course of the planning procedure. After the adoption of the plan or program the public is informed about the decision and the way in which it was made.

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 programs). "Classical", often encountered problems at the 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 programs
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 program are available. These problems are closely interrelated and have the following characteristics:

- Lack of concept for pollution inventory means that the inspectors only randomly organize the monitoring program, 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 program 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 programs and the assessment of the achieved results, whereas it can lead to tensions between the authorities and the industry.

3. SUGGESTED PRACTICES FOR THE MANAGEMENT OF INDUSTRIAL EFFLUENTS

3.1 Introduction

In this chapter an overview of existing 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.

An additional objective of this chapter is to inspire the inspecting authorities to adopt their monitoring programs 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 minimization techniques (clean technologies, recovery/reuse/recycling methods, good housekeeping)
- management tools

3.2 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.

3.2.1 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**). Figures 3.1 & 3.2 show the principle on which material balance has to be prepared.

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:

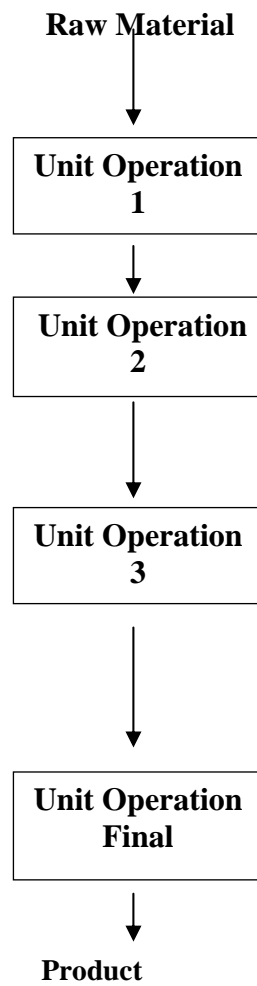
- exactly know the consumption of raw materials, chemicals and resources (water, energy) for each production unit and thus avoid “wasting”
- estimate the precise operational costs of each unit operation and plan the purchase of materials, etc.
- assess the volume, concentration and environmental “importance” 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 be collected and analyzed. The following potential information sources can be used:

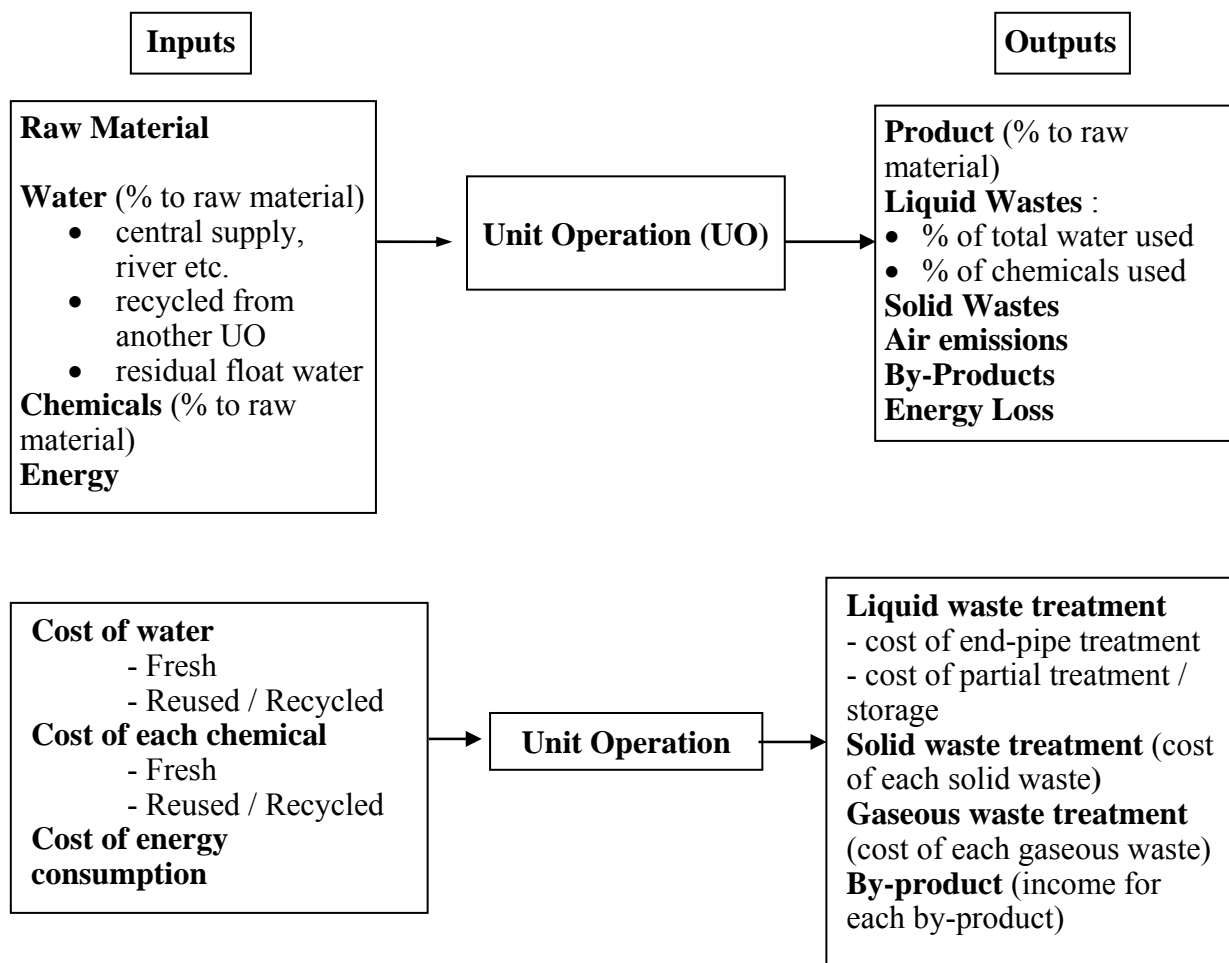
1. samples, analyses and flow measurements of feed stocks, products and waste streams
2. raw material purchase records
3. material inventories
4. emission inventories
5. equipment cleaning and validation procedures
6. batch make-up records
7. product specifications
8. design material balances
9. production records
10. standard operating procedures and manuals

Figure 3.1 Industrial production process (sequence of unit operations)



Source: Preparation of a decision support tool for the textile industry, Commission of the European Union, LIFE program (1997)

Figure 3.2 Material/mass balance principle



Source: Preparation of a decision support tool for the textile industry, Commission of the European Union, LIFE program (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 minimization 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 easily assess the potential for the introduction of innovative clean technologies/waste minimization practices.

This kind of “integrated” mass balance process allows 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).

3.2.2 Segregation of waste streams

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 **prioritization** 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:

- 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 prioritization 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

3.3 Waste minimization techniques

The term **waste minimization** is generally used to define all methods used to reduce pollution loads within a plant. It includes pollution prevention techniques (e.g. cleaner production methods), recovery, reuse and recycling of waste components, as well as simple and good

housekeeping measures (e.g. reuse of rinsing/cooling water). 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 hazard 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.

Quantitative information about BAT focuses on the environmental benefits expected (e.g. degree of recycling of materials and water) and in some cases on the relevant cost savings when each BAT is applied. However, whereas the environmental benefits can be clearly described, the cost figures should be carefully taken into consideration, since they strongly depend on local conditions.

The European Union has issued the Directive for Integrated Pollution Prevention and Control (IPPC), which asks the major industrial activities to apply BATs for each industrial production process. 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 can be found in <http://eippcb.jrc.es>. Within UNEP/MAP, the Regional Center for Cleaner Production (CP/RAC) has also a comprehensive set of information about sectoral studies and methodology manuals (<http://www.cema-sa.org>).

3.4 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.

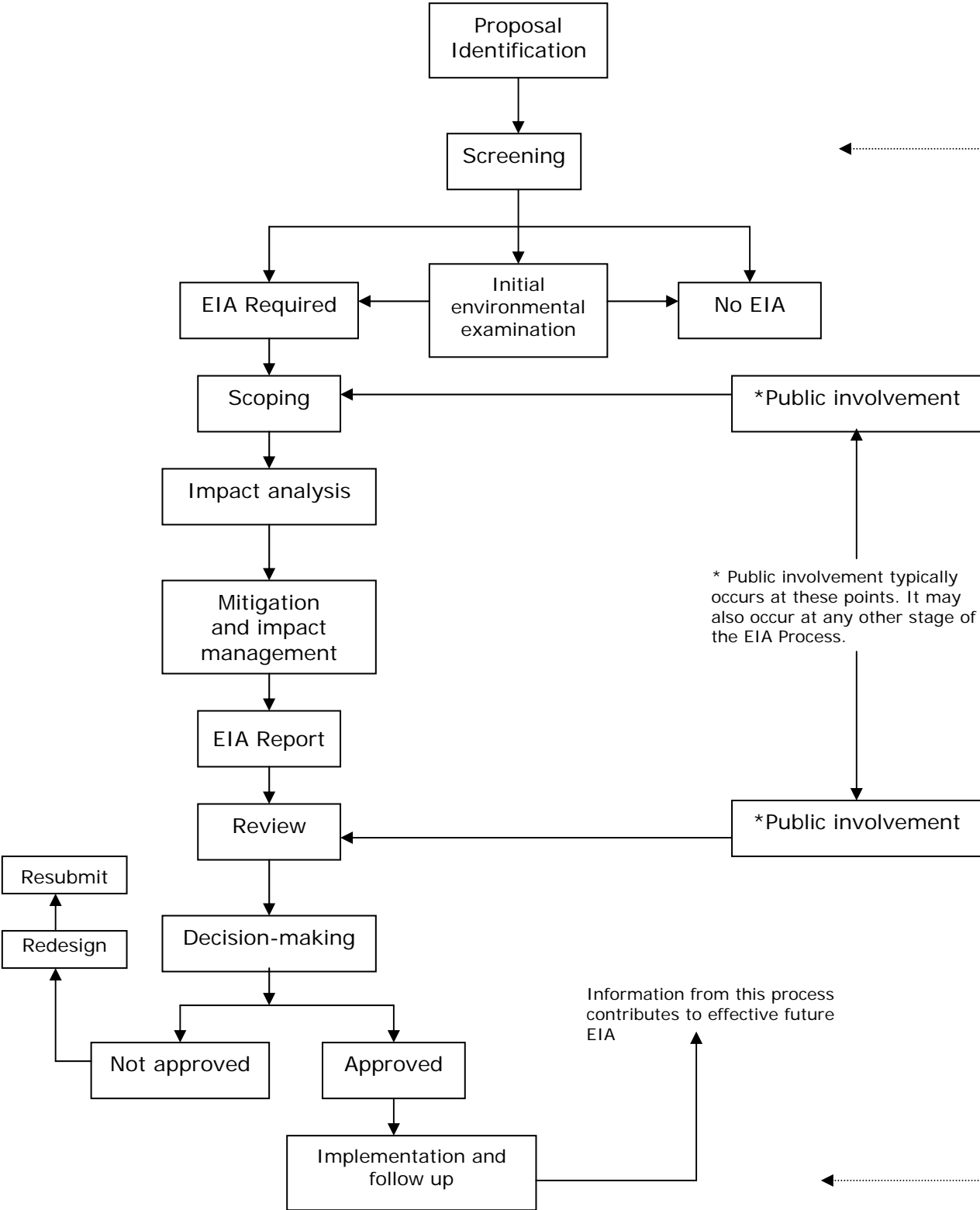
Management tools can be categorized according to their nature and objectives as tools for **analysis** and tools for **action** and, although overlapping of contents and outcomes cannot be avoided, a very rough distinction can be made. Tools for analysis are diagnostic instruments and aim at the assessment 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 summarized below.

3.4.1 Tools for analysis

3.4.1.1 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 3.3).

Figure 3.3 Environmental Impact Assessment

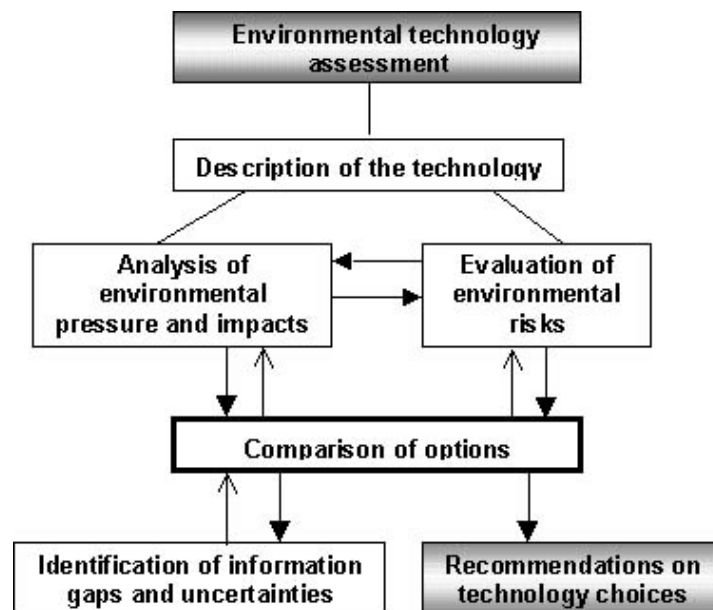


3.4.1.2 Environmental Technology Assessment

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 as any associated risks (Figure 3.4).

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

Figure 3.4 Environmental Technology Assessment



3.4.1.3 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 (Figure 3.5).

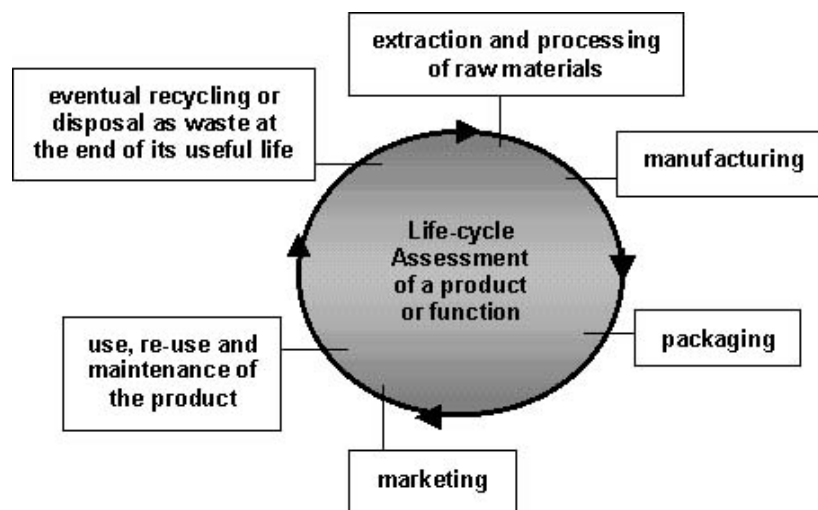
3.4.2 Tools for action

The term tools for action mean **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. Some of the key principles of such a system to be considered by industrial managers are the following:

- recognize and rank environmental management amongst 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 3.5 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 of ISO 14001, which contains requirements that may be objectively audited for certification purposes and the European eco-management and audit scheme (EMAS).

3.4.2.1 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.

3.4.2.2 EMAS

This European Union 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.

3.5 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 programs) 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.

3.6 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 and 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.

3.6.1 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), land farming of oily sludge or at specific sites in cases of hazardous

content. It is the responsibility of the industries to either pre-treat this sludge up to an “inert” level and then transport it to landfill sites or to directly transport it to hazardous waste disposal sites.

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.

3.6.2 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 water's 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 calls for substantial investment/operational costs and for industrial area availability.

3.7 ROPME Region: Examples of industrial activities

3.7.1 Desalination plants

Many desalination plants are operating in the ROPME Region, mainly in the Gulf Cooperation Council countries (GCC), thus covering the growing demands for drinking water supply in the area (Table 3.1).

Table 3.1 Installed Desalination Capacities in the GCC countries

Country	Population (millions)	Annual population change (%)	Area (km ²)	GNP/per capita (\$)	Total installed desalination capacity (m ³ /d)	Total installed desalination capacity (liters per capita)
Bahrain	0,651	2.17	707	11,130	516,059	792.7
Kuwait	2,044	3.46	17,818	18,270	2,181,026	1,067.00
Oman	2,452	2.93	309,500	7,600	334,879	136.6
Qatar	0,598	1.54	11,427	27,415	762,932	1,275.80
Saudi Arabia	21,408	2.92	2,240,000	8,460	6,569,172	306.9
U.A.E	3,488	1.94	77,700	22,666	5,532,777	1586.2
Total	28,189		2,657,152		15,896,845	

Source: 2004 IDA Worldwide Desalting Plants Inventory Report No. 18, 31, 2003

Methods/processes

There are 2 major groups of desalination processes namely distillation and membrane processes with the following characteristics:

Distillation processes (seawater is heated in a vessel)

- Multistage Flash Distillation (MSF)
- Multi-Effect Distillation (ME)
- Vapor Compression Distillation (VC)

Membrane processes (selective movement of salts through a membrane)

- Electrodialysis (ED)
- Reverse Osmosis (RO)

Discharges into the marine environment

All desalination plants use chemicals as part of the pre- treatment process of the feed water or source water, as well as for the post- treatment process of the product water. Most chemicals are mainly used as biocides, antiscalants, antifoulants and antifoaming agents and ultimately affect the concentrate composition. The presence of certain metals, which are derived as corrosion products from the system, also affects the concentrate composition.

1. Chemicals

- Corrosion products (heavy metals)
- Antiscalants (to reduce scale deposits on industrial equipment)
- Antifoulants
- Antifoaming additives

2. Concentrate

3. Backwash of membranes discharges in RO plants (cleaning with acid/alkaline solutions)

There are various negative environmental effects caused by desalination plants, which are summarized in Table 3.2.

Table 3.2 Adverse environmental impacts associated with desalination processes

Adverse Impact	Impact Level	Source of Impact	Mitigation Techniques
Thermal pollution: <ul style="list-style-type: none"> • reduction of dissolved oxygen in receiving waters • harmful effects to thermal tolerant species 	Medium Medium	Hot brine	Mixing of brine with cold water before discharge into retention ponds
Increased salinity: harmful effects to salt intolerant species	Medium	Concentrated brine	Dilution of brine before discharge, salts recovery, proper selection of the plant outfall location for maximum mixing and dispersion
Disinfectants	High	Chlorine and its compounds	Use of other disinfectants (UV)
Heavy metals: toxicity	Medium	Corrosion of plant equipment	Proper design and selection of plant equipment by using materials resistant to corrosion
Chemicals: <ul style="list-style-type: none"> • eutrophication of receiving waters • toxicity • pH increase 	High Low Low	Anticorrosion and antiscalant additives	Reduce the use of chemicals to minimum level, use of environmentally friendly additives

Source: UNEP/MAP, Sea water desalination in the Mediterranean, assessment and guidelines, Technical Reports Series No. 139, 2003

In Table 3.3 a classification of the environmental impacts of the main desalination technologies (RO, MSF, ED) is presented.

Table 3.3 Environmental impacts of desalination technologies

Effect	RO	MSF	ED
Noise	H	M	L
Water effluent	M	H	M
Toxic material	M	H	M
Air Pollution	L	H	M
Industrial Risk	L	H	M

H = high, M = medium, L = low

Source: UNEP/MAP, Sea water desalination in the Mediterranean, assessment and guidelines, Technical Reports Series No. 139, 2003

Information concerning a typical desalination plant in the ROPME Region is presented in Table 3.4.

Table 3.4 RO plant performance and environmental data for Fujairah SWRO, UAE

Parameter	Fujairah SWRO
Rated capacity, m ³ /d	9000
Product water TDS, mg/l	450
Water conversion, %	35
Membrane configuration	Spiral wound
Seawater temperature, °C	27
Energy consumption, kWh/m ³	7.75
Seawater temperature rise, °K	0.65
Inlet seawater flow, kg/s	306.5
Seawater TDS, %	4.2
Brine flow, kg/s	199.3
Brine TDS, %	6.46
Chemical dosing, mg/l:	
Sulphuric acid	30
Chlorine	2.2
Sodium bisulphite	9.9

SWRO = Sea Water Reverse Osmosis

Source: Morton, A., J. et al., Environmental Impacts of Seawater distillation and reverse osmosis process, *Desalination*, (8):1-10. In: Proceeding of desalination and the Environment Oct. 20-23, 1996

3.7.2 Oil refineries

3.7.2.1 Processes

The major categories of refinery installations are listed below:

Physical separation processes

- Atmospheric distillation
- Vacuum distillation
- High pressure distillation
- Aromatics extraction
- De-waxing/de-asphalting
- Gas separation plant

Processes which bring about chemical conversions

- Isomerisation
- Alkylation
- Etherification
- Reforming
- Catalytic cracking
- Hydrocracking
- Thermal cracking/visbreaking
- Petroleum coking
- Asphalt blowing

Purification or treating processes

- Desalting
- Hydrotreating/hydrodesulphurisation (HDS)/hydrofinishing
- Sour gas concentration (Acid gas removal)
- Sulphur recovery from hydrogen sulphide
- Sour water treatment

Lubricating oil refining

Utilities and General facilities

- Steam and/or power supply
- Refinery liquid/gas fuel system
- Flare system for disposal of vapor releases
- Water, Air, Hydrogen, Nitrogen supply
- Cooling water system
- Wastewater and hydrocarbon slops treatment

Blending, storage and loading facilities

Environmental Controls

- Aqueous effluent treatment
- Combustion and other air emission controls
- Waste disposal
- Odor and noise control

3.7.2.2 Effluents

An overview of effluents generated by the various processes is presented in Table 3.5.

Table 3.5 Pollutants in oil refinery effluents

Process	Oil	H ₂ S (RSH)	NH ₃ (NH ₄ ⁺)	Phenols	BOD COD TOC	CN ⁻	TSS
Distillation Units	XX	XX	XX	X	XX	-	XX
Hydrotreatment	XX	XX(X)	XX(X)	-	X(X)	-	-
Visbreaker	XX	XX	XX	XX	XX	X	X
Catalytic	XX	XXX	XXX	XX	XX	X	X
Cracking	XX	XXX	XXX	-	X	-	-
Hydrocracking	XX	X	X	-	XX	-	-
Lube oil	XX	XX	-	XXX	XXX	X	X
Spent caustic	X	-	-	X	X	X	X
Ballast water	-(x)	-	-	-	X	-	-
Utilities (Rain)	-	-	X	-	X	-	XX
Sanitary/Domestic							

X < 50 mg/l, XX= 50 – 500 mg/l, XXX > 500 mg/l

Source: Best Available Techniques to reduce emissions from refineries, CONCAWE, 1999

A rough estimation of the loads of the main pollutants from oil refineries is presented in Table 3.6.

Table 3.6 Specific loads of oil refinery pollutants

Parameter	Composition after pretreatment by API, CPI, SWS (mg/l)		Effluent composition (mg/l) of wastewater treatment plants (annual average)	Specific load (t/Mt feedstock)
	average	maximum		
Oil	40	100	0.05 – 9.8	0.01 – 4.5
COD	300	700	30 - 225	3 - 125
BOD	150	400	2 - 50	0.5 - 25
SS	10 - 20	75	2 - 80	1 - 50
Phenols	12	40	0.03 - 1	0.01 – 0.25
Sulphide	5	15	0.01 - 1	
Kjendahl nitrogen	25	50	5 - 35	
Total N	25	50	1.5 - 100	1 - 100
Phosphate	5	20	0.1 – 1.5	
Fluoride	0 - 30	60	1 - 20	
Cyanide	0 - 3	5	0.03 - 1	
Chromium		100	0.1 – 0.5	
Lead		10	0.2 – 0.5	

Source: European Commission, Reference Document on Best Available Techniques for Mineral Oil and Gas Refineries, 2003

Oil is the main contaminant to be found in the effluents. It usually originates from process, steam and wash water coming in contact with process fluids. Other wastewater streams

possibly containing oil/hydrocarbons are cooling waters (in cases of leakages) and rainwater from process areas, which are oil-polluted.

There are some end-of-pipe treatment technologies, which can be applied for its reduction namely:

1. Gravity separation (API separator, parallel plate/corrugated plate interceptor, break tanks, oil skimmers)
2. Flotation (dissolved air/induced air flotation)
3. Filtration (mixed media filters, continuous sand washed filters, gravity filters)

Biological treatment systems are applicable to remove the contaminants from all refinery effluents as well as **membrane systems** (reverse osmosis, electro dialysis) whereas **sour water strippers** are used to remove dissolved H₂S and ammonia.

3.7.2.3 BAT for the reduction of wastewater discharges

There are some simple steps to be undertaken for the reduction of pollution originating from refinery wastewaters, namely:

- Reduction of the use of fresh water and reuse of cleaned water as much as possible
- Segregation of contaminated, low-contaminated and non-contaminated water (including process water, rain water, ballast water, cooling water, etc.), which can be mixed for final treatment after they have been pretreated
- Avoidance of oil leakage into cooling systems
- Implementation of a good management system for the maximum reuse of spent caustic solutions, etc.

A detailed reference of the many BATs is beyond the scope of this document, especially for the very complex nature of the many unit operations included in a refinery. The information can be found in the relevant literature (9, 18).

4. DEVELOPMENT OF A WASTEWATER MINIMIZATION PROGRAM IN AN INDUSTRY

4.1 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 4.1, 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.

4.2 Planning and organization

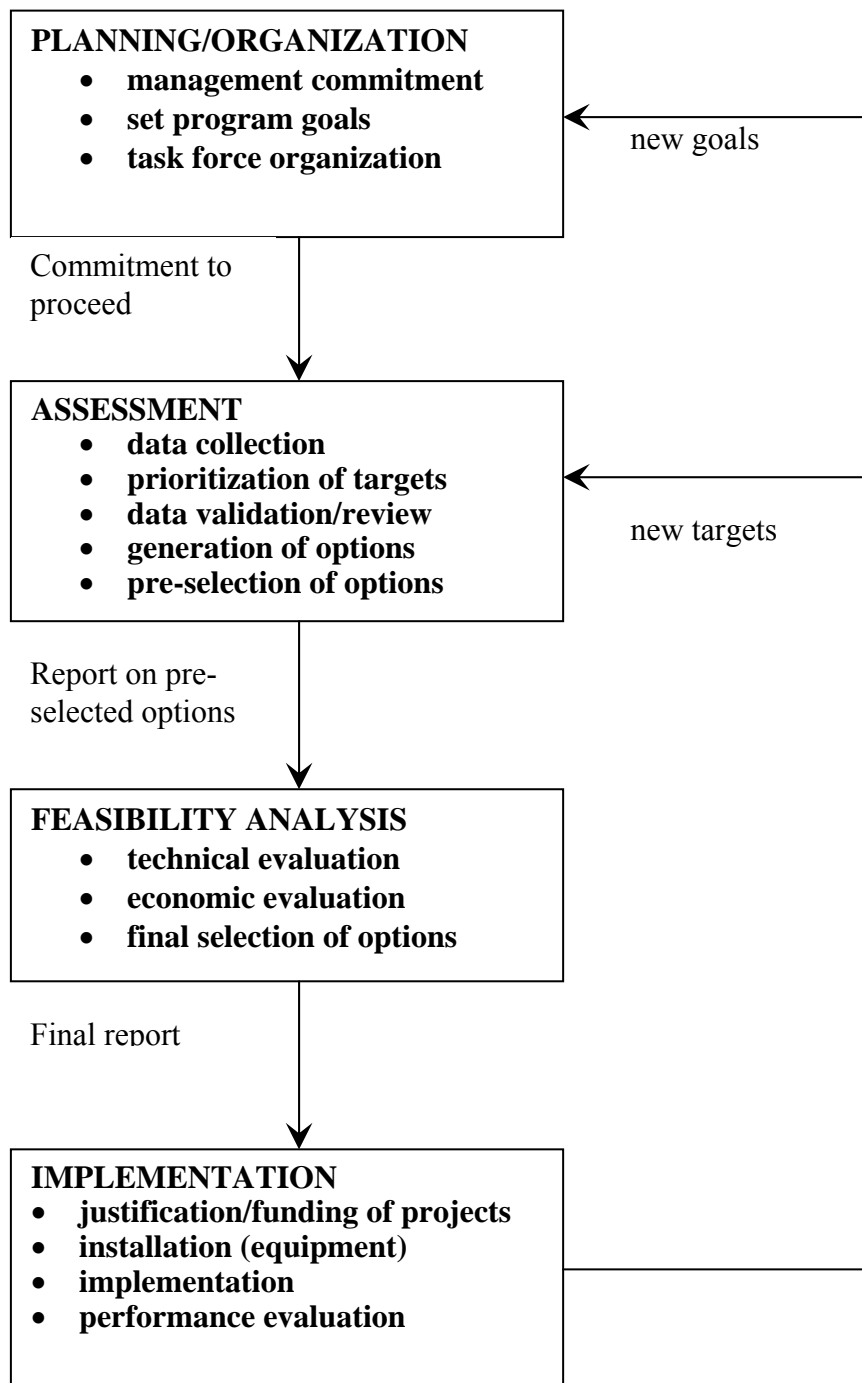
4.2.1 Management commitment

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 3.4.2.2).

4.2.2 Program goals

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

Figure 4.1 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.

4.2.3 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.

4.3 Assessment

4.3.1 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 and monitoring 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 updated picture of the overall situation. An example of waste stream records is presented in Appendix II.

4.3.2 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

4.3.3 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 end-of-pipe-treatment systems, pre-treatment of wastewater up to the level of untreated domestic wastewaters (BOD < 500 mg/l) is usually the favorable option.

4.4 Feasibility analysis

4.4.1 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

4.4.2 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 4.1.

Table 4.1 Capital and operating costs/savings

Capital cost	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.

4.4.3 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

4.5 Implementation

4.5.1 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 prioritized 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.

4.5.2 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, m³ 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)

4.6 Capacity building

Any waste minimization/prevention program cannot be successful on long-term 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 program'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.

4.6.1 In-plant training

These are short-term practical seminars usually conducted by professional trainers hired by the company. The participants can be managers, engineers and technicians involved in running the overall environmental management program. 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 authorization.

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, such as 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.

4.6.2 Awareness/training

Several non-governmental organizations, national/local authorities and educational institutions often promote various initiatives on 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 programs 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 necessary information to those interested, namely to industrial associations, planning authorities etc.

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

5.1 Introduction

The organizational requirements for an effective wastewater management program 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

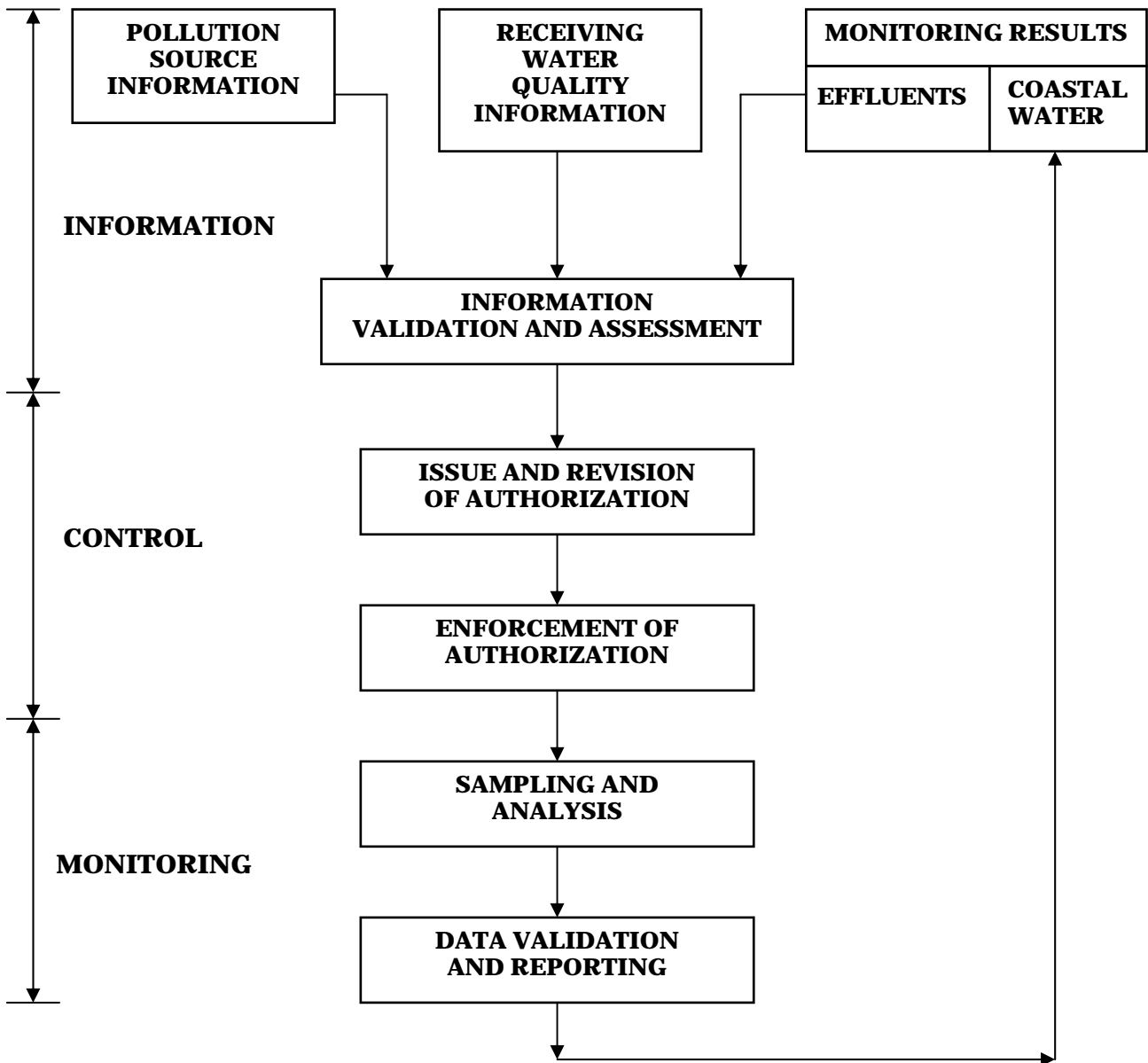
This chapter is focusing entirely on those elements needed to enable controlling authorities to implement an effective monitoring program of industrial effluents. These elements are practically dealing with the “classical” work of inspecting authorities, namely with **information collection/validation** 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.

5.2 Functions of a coastal pollution control authority

In Figure 5.1 the major functions of a coastal pollution control inspectorate 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 5.1 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

5.3 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.

The major parameters to be considered by setting effluent standards are presented in Table 5.1.

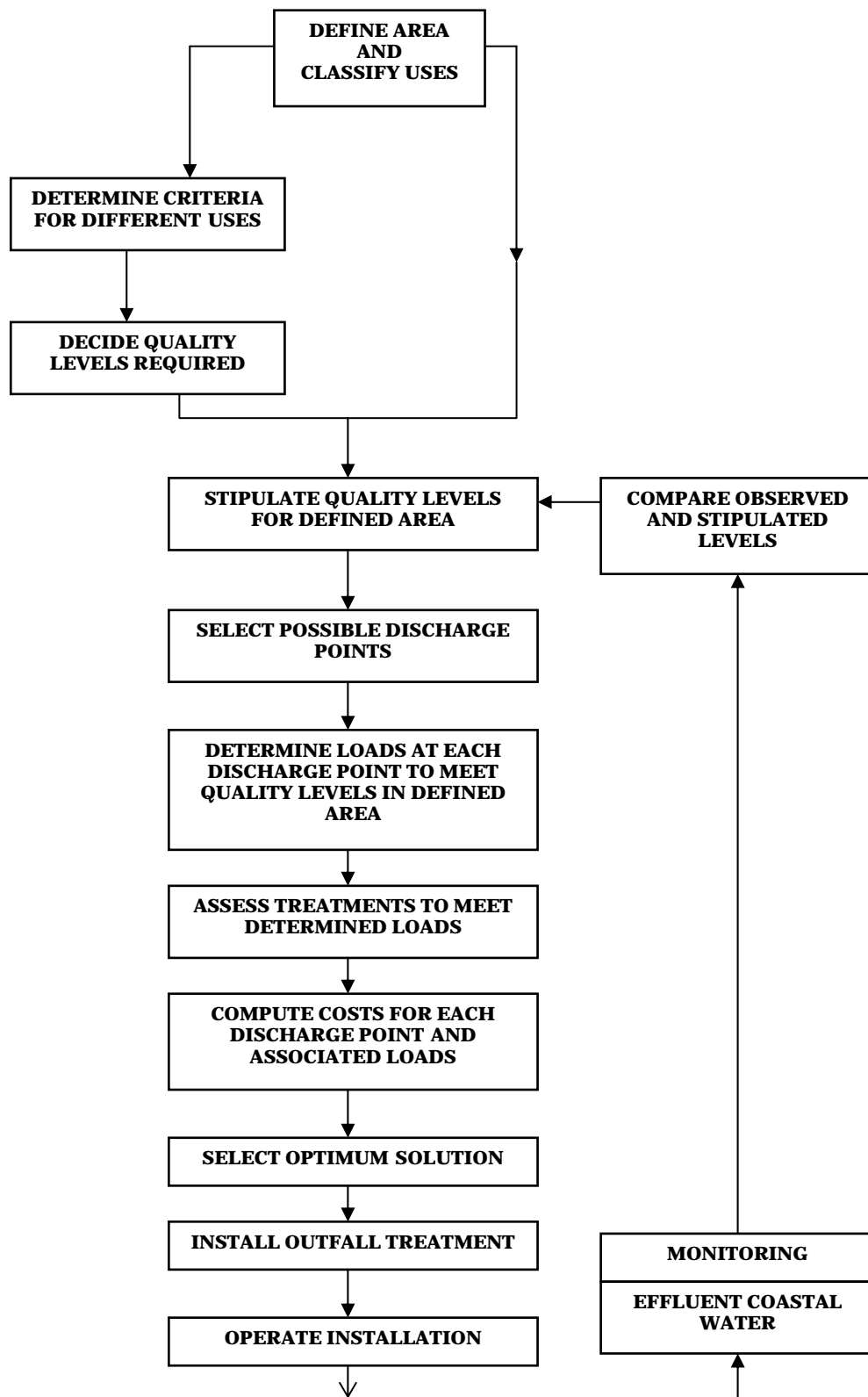
**Table 5.1 Major parameters for effluent standards formulation
(direct discharge into receiving waters)**

Parameter	Suggested standard (mg/l)
BOD₅	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

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 5.2.

Figure 5.2 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

5.4 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. It enables 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:

$$WQ_j = A_j \times WF$$

Where:

WQ_j = quantity (kg/year) of each pollutant generated by the production process j

A_j = 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

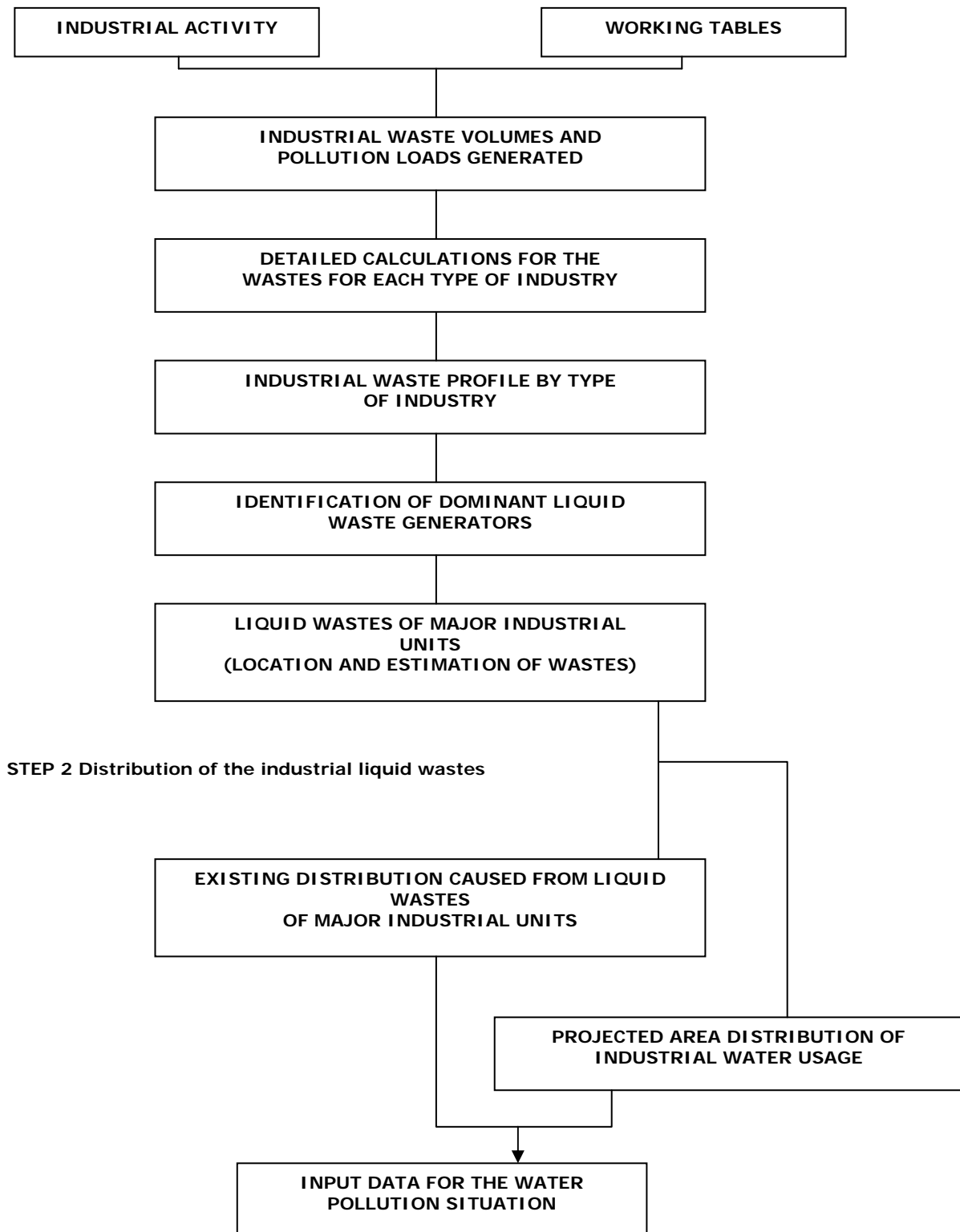
Having defined each waste factor, the waste quantities from similar plants and industrial operations can be calculated if the quantities of raw materials used in the relevant production process are known.

Rapid assessment (Figures 5.3 & 5.4) 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

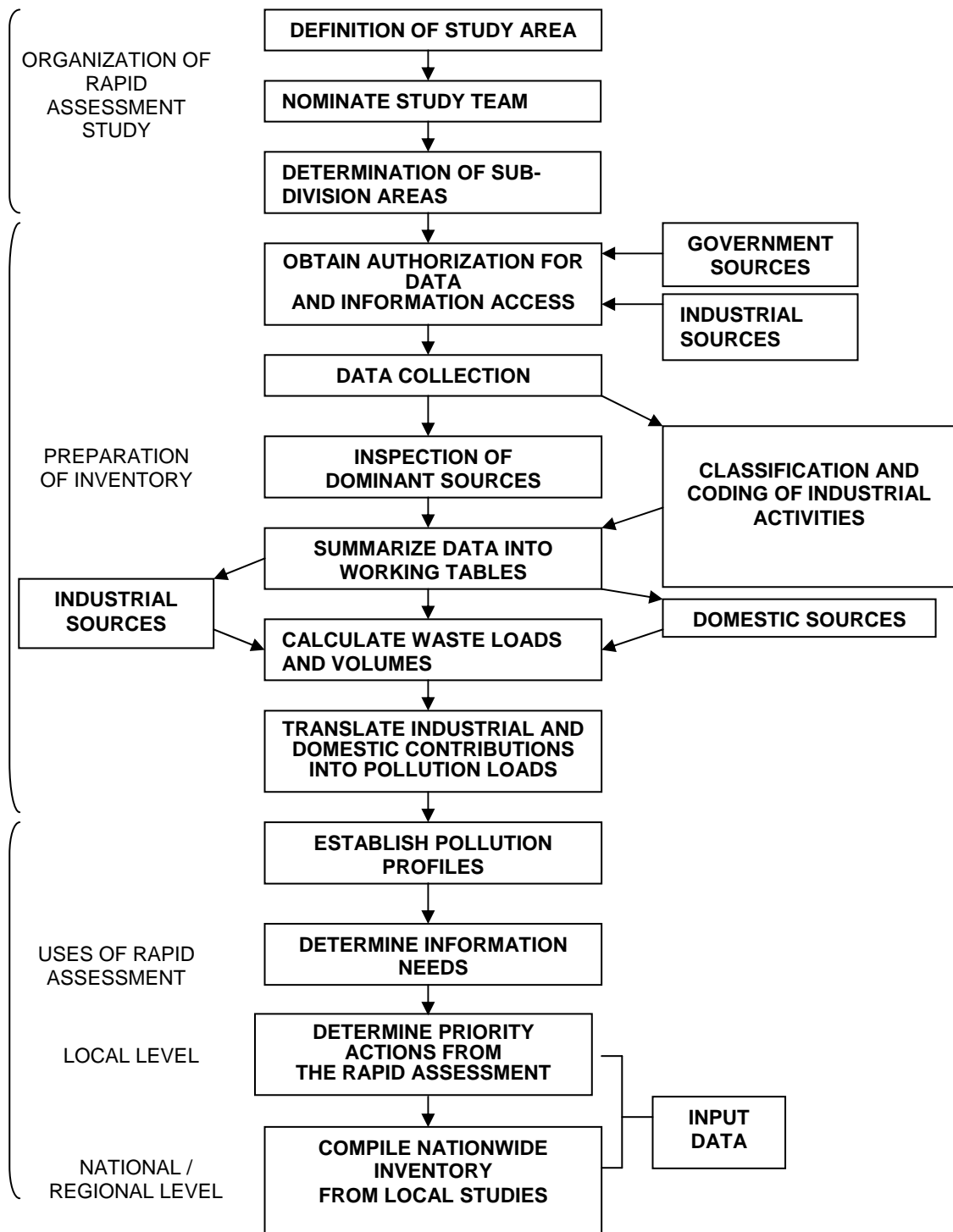
Figure 5.3 Analysis of industrial effluents

STEP 1 Calculation of industrial waste volumes and pollution loads



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

Figure 5.4 Rapid assessment flow diagram



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

This “condensed” inventory program 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, a “pilot” inventory of representative plants from selected industrial branches will be prepared. 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/analyzed 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 focused 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 analyzed 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.

Example of application of waste factors

Two textile plants

The plant **TEX1** is a manufacturing plant only (cotton) with a production of 10,000 Kg of cotton/day. The plant **TEX2** is a finishing/dyeing plant (acrylic/wool) with a production of 7,000 Kg wool and 18,000 Kg acrylic per day. Both textile plants operate for 280 days per year.

BOD₅ –load calculation

According to literature (19), the BOD₅ emission factor (cotton, no dyeing) is 23 kg BOD₅/10³ kg fabric, for the bleaching operation 10 kg BOD₅/10³ kg fabric, for wool dyeing 21 kg BOD₅/kg fabric, for acrylic finishing 60 kg BOD₅/kg fabric and for acrylic dyeing 26 kg BOD₅/kg fabric. Therefore the total BOD₅ load is as follows:

TEX1 (cotton, no dyeing):

Washing and wetting 10,000 Kg/day fabric X 23 Kg BOD₅/10³ Kg fabric = **230 Kg BOD₅**
Bleaching 10,000 Kg/day fabric X 10 Kg BOD₅/10³ Kg fabric = **100 Kg BOD₅**

TOTAL BOD₅ of TEX1 = 230 + 100 = 330 Kg BOD₅/day and if the water consumption for the 2 unit operations of this plant is 100 m³/day, then the assumed final BOD₅ concentration (before any treatment) for the 2 operations is 330,000,000 mg BOD₅/100,000 liters = 3300 mg/l

330 Kg BOD₅ X 280 days/year = 92,400 Kg / year

TEX2 (wool / acrylic, finishing, dyeing):

Wool

Dyeing 7,000 Kg fabric/day X 21 Kg BOD₅/10³ Kg fabric = 147 Kg BOD₅

Acrylic

Finishing 18,000 Kg/day fabric X 60 Kg BOD₅/10³ Kg fabric = 1,800 Kg BOD₅

Dyeing 18,000 Kg/day fabric X 26 Kg BOD₅/10³ Kg fabric = 468 Kg BOD₅

TOTAL BOD₅ of TEX2 = 147 + 1,800 + 468 = 2,415 Kg BOD₅

If the water consumption of these unit operations is 250 m³/day, then the assumed final BOD₅ concentration is 2,415,000,000 mg BOD₅/250,000 liters = 9660 mg/l

2,415 Kg BOD₅ X 280 days/year = 676,200 Kg/year

Therefore, by applying this method, a good estimation of the pollution loads can be achieved (i.e. by 80-85% accuracy).

6. ECONOMIC ANALYSIS FOR INDUSTRIAL ENVIRONMENTAL MANAGEMENT

6.1 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 programs 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.

6.2 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.

Here a “checklist” of key factors needed for managers to estimate the costs associated with pollution control measures is presented.

6.2.1 Essential information for cost estimation

There are some basic economic considerations to be analyzed 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.

6.2.2 Capital (investment) – operational costs

6.2.2.1 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, labor 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, labor, 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

6.2.2.2 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

6.3 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.

6.3.1 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 are also various types of charges which frequently overlap such as:

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

Some examples of these taxes are presented in Table 6.1.

Table 6.1 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

Source: 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.

7. 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 behavior 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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9. APPENDICES

9.1 APPENDIX I

PROTOCOL FOR THE PROTECTION OF THE MARINE ENVIRONMENT AGAINST POLLUTION FROM LAND BASED SOURCES

THE CONTRACTING STATES

BEING PARTIES to the Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment from Pollution;

RECOGNIZING the danger posed to the marine environment and to human health by pollution from land-based sources and the serious problems resulting therefrom in coastal waters of many Contracting States, principally due to the release of untreated, insufficiently treated and/or inadequately disposed of domestic or industrial discharges;

NOTING that existing measures to prevent, abate and combat pollution caused by discharges from land-based sources need to be strengthened on a national and a regional basis;

BEING AWARE of Articles 194, 207, 212 and 213 of the United Nations Convention on the Law of the Sea (1982); and the Montreal Guidelines for the Protection of the Marine Environment against Pollution from Land-Based Sources (1985); and

DESIROUS to strengthen the implementation of Article III, paragraph (b) and Article VI of the Convention;

HAVE AGREED AS FOLLOWS:*

ARTICLE I

DEFINITIONS

For the purpose of this Protocol:

1. "Combined Treatment" means common treatment of industrial effluents along with domestic sewage;
2. "Competent State Authority" means the Authority designated by the Contracting State for the purpose of this Protocol;

* A Meeting of the Plenipotentiaries was held in Kuwait on 21 February 1990 for signing the Protocol concerning the Protection of the Marine Environment against pollution from Land-Based Sources.

3. "Contracting State" means any State which has become a party to this Protocol;
4. "Convention" means the Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment from Pollution;
5. "Council" means the organ of the Organization as referred to in subparagraph (i) of paragraph (b) of Article XVI of the convention;
6. "Freshwater Limit" means the place in watercourses where, at low tide and in a period of low freshwater flow, there is an appreciable increase in salinity due to the presence of sea-water;
7. "Joint Pretreatment/Treatment" means common pretreatment/treatment of the effluent from more than one industrial source;
8. "Land-based Sources" means municipal, industrial or agricultural sources, both fixed and mobile on land, discharges from which reach the Marine Environment, as outlined in Article III of this Protocol;
9. "Marine Environment" means the Protocol Area as defined in Article II of this Protocol;
10. "Organization" means the Regional Organization for the Protection of the Marine Environment established in accordance with Article XVI of the convention;
11. "Pollution" means "Marine Pollution" as defined in paragraph (a) of Article 1 of the Convention;

ARTICLE II AREA OF APPLICATION

The area to which this Protocol applies (hereinafter referred to as the "Protocol Area") shall be the Sea Area as defined in Article II, paragraph (a) of the Convention, together with the waters on the landward side of the baselines from which the breadth of the territorial sea of the Contracting States is measured and extending, in the case of watercourses, up to the freshwater limit and including intertidal zones and salt-water marshes communicating with the sea.

ARTICLE III SOURCES OF POLLUTION

This Protocol shall apply to discharges reaching the Protocol Area from land-based sources within the territories of the Contracting States, in particular:

- a) from outfalls and pipelines discharging into the sea;
- b) through rivers, canals or other watercourses, including underground watercourses;

- c) from fixed or mobile offshore facilities serving purposes other than exploration and exploitation of the sea bed, its subsoil and the continental shelf; and
- d) from any other land-based sources situated within the territories of the Contracting States, whether through water, through the atmosphere or directly from the coast.

ARTICLE IV SOURCE CONTROL

1. The Contracting States undertake to implement the action programmes based on source control as outlined in Annex I to this Protocol. To this end, they shall develop and implement, jointly or individually, as appropriate, the necessary programmes and measures.
2. The programmes and measures and the timetables for their implementation aimed at reducing pollution from land-based sources, shall be fixed by the Contracting States and periodically reviewed and revised, if necessary every two years, in accordance with the provisions of Article XIV of this Protocol.

ARTICLE V JOINT AND/OR COMBINED EFFLUENT TREATMENT

1. The Contracting States in their endeavour not to inhibit the development of new industries, and especially that of small industrial operations, and recognizing the economic and technical difficulties often encountered by such operations in properly treating their effluent individually undertake to implement, to the extent possible, industrial location planning programmes as outlined in Annex II to this Protocol. To this end, they shall develop and implement, jointly and/or individually, as appropriate, the necessary programmes and measures.
2. The Regional guidelines and criteria along with programmes and measures and the time-tables for their implementation, aimed at reducing pollution from land-based sources through joint and/or combined effluent treatment, shall be fixed by the Contracting States and periodically reviewed and revised, if necessary every two years, in accordance with the provisions of Article XIV of this Protocol.

ARTICLE VI REGIONAL AND LOCAL REGULATIONS/PERMITS FOR RELEASE OF WASTES

1. As outlined in Annex III to this Protocol, the Contracting States shall progressively develop and adopt, in cooperation with competent Regional and International Organizations as appropriate:

- a) Regional guidelines, standards or criteria, as appropriate, for the quality of seawater used for specific purposes that is necessary for the protection of human health, living resources and ecosystems;
- b) Regional regulations for the waste discharge and/or degree of treatment for all significant types of land-based sources;
- c) Stricter local regulations for waste discharge and/or degree of treatment for specific sources based on local pollution problems and desirable water usage considerations.

Stricter regulations for specific sources serve the purpose of preserving the quality of seawater required for the intended use. In developing such regulations the local ecological, geographical and physical characteristic, as well as, the level of existing pollution in the Marine Environment shall be taken into consideration.

- 2. The programmes for the implementation of the above measures shall be adopted and shall take into account, for their progressive application, the cost of measures involved, the capacity to modify existing installations, the economic capacity of the Contracting States and their need for sustainable development.
- 3. Polluters shall be required to obtain a permit to discharge from the Competent State Authorities. Such permits shall allow for review and modification of discharge conditions reflecting the periodic update of regulations.
- 4. Guidelines, standards or criteria, as well as, regulations, programmes and measures shall be developed and adopted in accordance with the provisions of Article XIV of this Protocol and periodically updated, if necessary every two years, to reflect the increasing information through the monitoring programme described in Article VII of this Protocol, the changes in the industrial and other human activities and possible advances in Science and the pollution control technologies.

ARTICLE VII MONITORING AND DATA MANAGEMENT

- 1. The Contracting States, within the framework of the provisions of Article X of the Convention, shall carry out monitoring activities, if necessary in co-operation with the competent Regional and International Organizations, in order to:
 - a) collect data on natural conditions of the Protocol Area as regards its physical, biological and chemical characteristics;
 - b) collect data on inputs of substances or energy that cause or potentially cause pollution from land-based sources, including information on the distribution of sources and the quantities of pollutants introduced to the Protocol area;

- c) assess systematically the levels of pollution within their internal and territorial waters, in particular with regard to the substances that may have a potential significant impact on the Marine Environment. For the selection of the sampling locations and substances to be measured, information available, inter alia, from source inventories, discharge outfalls and marine environment characteristics shall be considered; and
 - d) evaluate the effectiveness of measures taken under this Protocol in meeting the environmental objectives.
2. Contracting States shall collaborate jointly or collectively to establish comparable monitoring programmes, as well as analytical quality control programmes and to promote data storage, retrieval and exchange.

ARTICLE VIII

ENVIRONMENTAL IMPACT ASSESSMENT

1. The Contracting States shall require on priority basis an assessment of the potential environmental impacts during the planning and implementation stages of selected development projects within their territories, particularly in the coastal areas, which may cause significant risks of pollution from land-based sources to the Protocol Area, in order to ensure that appropriate measures are taken to prevent or mitigate such risks.
2. The Contracting States shall develop, with the assistance of the Organization, technical and other guidelines concerning the assessment of the potential environmental impacts of development projects referred to in paragraph 1, including possible transboundary effects. The assessment should, where appropriate, contain inter alia the following:
 - a) A description of the geographical location of the activities to be carried out;
 - b) A description of the initial ecological state of the marine environment and the coastal area which may be effected by the activities;
 - c) An indication of the nature, aims and scope of the proposed activities;
 - d) A description of the methods, installations and other means to be used;
 - e) A description of the foreseeable direct and indirect long-term and short-term effects of the activities on the Marine Environment, including fauna, flora and the ecological balance;
 - f) A statement setting out the measures proposed to reduce to the minimum the risk of pollution by carrying out the activities and, in addition, possible process and pollution abatement alternatives to such measures;

- g) An indication of the measures to be taken for the protection of the Marine Environment from pollution during and, as appropriate, at the end of the proposed activities;
 - h) Definition of commitments to ongoing environmental management and monitoring;
 - i) Cost-benefit analysis as appropriate;
 - j) A brief summary of the assessment;
3. The implementation of the selected projects referred to in paragraph 1 should be made subject to a prior written authorization from the Competent State Authorities which takes fully into account the findings of the environmental impact assessment.
4. The Contracting States shall co-operate with the Organization to develop procedures for the dissemination to all Contracting States of the reports on the results of such assessment with a view to enable the Contracting States which may be affected by the environmental impacts of the development projects to consult with the Contracting State concerned.

ARTICLE IX SCIENTIFIC AND TECHNOLOGICAL CO-OPERATION

The Contracting States, in conformity with Article X of the Convention, shall co-operate in scientific and technological fields related to pollution from land-based sources, particularly research on inputs, pathways and effects of pollutants and on the development of new methods for their treatment, reduction or elimination. To this end, the Contracting States shall, in particular, endeavour to:

- a) exchange scientific and technical information;
- b) co-ordinate their research programmes of common nature.

ARTICLE X SCIENTIFIC, TECHNICAL AND OTHER ASSISTANCE

1. The Contracting States shall, directly or with the assistance of the Organization or competent Regional and International organizations, co-operate with a view to formulate and implement programmes of assistance, particularly in the fields of science, education and technology, for the prevention, reduction and control of pollution from land-based sources.

2. Such technical assistance shall include, in particular, the training of scientific and technical personnel, as well as the acquisition, utilization, maintenance and production of appropriate equipment.

ARTICLE XI

WATERCOURSES SHARED BY STATES

1. If discharges from a watercourse which flows through the territories of Contracting States are likely to cause pollution of the Protocol Area, the Contracting States in question, in accordance with the provisions of this Protocol in so far as each of them is concerned, are called upon to co-operate with a view to ensuring its full application.
2. A Contracting State shall not be responsible for any pollution originating on the territory of a non-Contracting State. However, the Contracting State shall endeavour to co-operate with such State so as to make possible full application of the Protocol.

ARTICLE XII

EXCHANGE OF INFORMATION

1. The Contracting States shall inform one another directly or through the Organization of measures taken, of results achieved and, if the case arises, of difficulties encountered in the application of this Protocol. Procedures for the collection and submission of such information shall be determined by the Council.
2. Such information shall include *inter alia*:
 - a) Relevant statistical data in accordance with Articles VI and VII of this Protocol;
 - b) Data resulting from monitoring as provided for in Article VII of this Protocol;
 - c) Quantities of pollutants discharged or emitted from their territories;
 - d) Measures taken in accordance with Articles IV, V and VI of this Protocol.

ARTICLE XIII

RESPONSIBILITY AND LIABILITY FOR DAMAGE

1. Contracting States shall ensure that recourse is available in accordance with their legal systems for prompt and adequate compensation or other relief in respect of damage caused by pollution of the Marine Environment by natural or juridical persons under their jurisdiction.
2. Contracting States shall formulate and adopt appropriate procedures for the determination of liability for damage resulting from pollution from land-based sources.

ARTICLE XIV INSTITUTIONAL ARRANGEMENTS

The Council, in accordance with Article XVII of the Convention, shall be responsible for keeping under review the implementation of this Protocol. To this end, the Council shall, *inter alia*:

- a) consider the efficacy of the measures adopted and the advisability of adopting any other measures, in particular in the form of annexes;
- b) revise and amend any annex to this Protocol, as appropriate;
- c) formulate , adopt and review programmes and measures in accordance with Articles IV, V, VI, VII, IX and X of this Protocol;
- d) adopt Regional guidelines, standards or criteria in accordance with Articles IV, V and VI of this Protocol;
- e) formulate procedures for exchange of information in accordance with Articles VIII and XII of this Protocol;
- f) consider information submitted by the Contracting States under Articles VIII and XII of this Protocol;
- g) discharge such other functions as appropriate for the application of this Protocol; and
- h) establish any such institutional mechanism as deemed necessary for the achievement of the objectives of this Protocol.

ARTICLE XV GENERAL PROVISIONS

- 1. The provisions of the Convention relating to any Protocol shall apply to this Protocol.
- 2. Procedures for amendments to Protocols and their Annexes adopted in accordance with Articles XX and XXI of the Convention shall apply to this Protocol.
- 3. The Rules of Procedures and Financial rules adopted pursuant to Article XXII of the Convention, and amendments thereto, shall apply to this Protocol.
- 4. The Annexes form an integral part of this Protocol unless expressly provided otherwise thereto.

ARTICLE XVI
FINAL PROVISIONS

1. This Protocol shall be open for signature in the State of Kuwait from 21 February to 21 May 1990 by any State which is party to the Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment from pollution.
2. This Protocol shall be subject to ratification, acceptance, approval or accession by the States parties to the Convention. Instruments of ratification, acceptance, approval or accession shall be deposited with the Government of Kuwait which shall assume the functions of the Depository.
3. This Protocol shall enter into force on the ninetieth day following the date of deposit of at least five instruments of ratification, acceptance or approval of, or accession to this Protocol by the States as referred to in paragraph 1 of this Article.

In WITNESS WHEREOF the undersigned Plenipotentiaries, being duly authorized by their respective Governments, have signed this Protocol.

DONE AT KUWAIT this twenty-first day of February, in the year one thousand nine hundred ninety in the Arabic, English and Persian languages, the texts being equally authentic.

Annex 1 to the Protocol

POLLUTION ABATEMENT THROUGH SOURCE CONTROL

With regard to the issue of pollution abatement through source control referred to in Article IV of this Protocol, consideration should be given to the control and progressive replacement of products, installations and industrial or other processes causing significant pollution to the Marine Environment. In this regard, particular attention will be given, but not limited, to the following factors:

- a) Curtailment and/or regulation of import, transportation, manufacturing or processing of certain harmful substances.
- b) Change of raw materials.
- c) Change of manufacturing processes.
- d) Good operating and housekeeping practices.
- e) Segregation of waste streams and minimization of pollutant dilution prior to treatment.
- f) Recovery, re-use and recycling.

The programmes, measures and the timetables required for the implementation of source control will be developed and priorities allocated on the basis of the results of on-going assessment studies.

Problem areas of Regional interest, where cost effective measures can be implemented, will receive attention for the purpose of establishing general management schemes. Such areas are, for example, the collection, treatment, and proper disposal of spent lubricating oils, blood and paunch from slaughterhouses, the control of fuel combustion processes and the implementation of source control in selected processes within large industries.

Annex 2 to the Protocol

PROMOTION OF JOINT AND/OR COMBINED EFFLUENT TREATMENT

Without undue prejudice to the multifaceted constraints that often govern the selection of the location of new industries, a programme will be undertaken, as referred to in Article VI of this Protocol, to promote:

- a) agglomeration of industries in a way that enhances the possibility of joint effluent pretreatment and/or treatment, as the need may be;
- b) location within the limits of city sewer systems of certain types of industry so as to enhance combined treatment of industrial and domestic wastes.

Promotion of joint and/or combined effluent treatment, if properly planned, could result in greatly reduced treatment, monitoring and enforcement costs as well as in increased treatment reliabilities. To this end, Regional guidelines and criteria will be developed dealing with topics of common interest, such as:

- the compatibility of effluent from different sources;
- pretreatment requirements prior to discharge into domestic and/or industrial sewer systems;
- cost sharing for the construction and operation of treatment plants.

Such guidelines and criteria will assist Contracting States in developing their own specific programmes and measures. While initial plans may deal with the location problem of new industries, the end objective will be the progressive attraction of existing selected small industries as the infrastructure and facilities are developed in the designated areas.

Annex 3 to the Protocol

GUIDELINES, REGULATIONS AND PERMITS FOR THE RELEASE OF WASTES

1. With a view to guidelines, standards or criteria, as well as to regulations, programmes, measures, and discharge permits for release of wastes referred to in Article VI of this Protocol, particular attention will be given, *inter alia*, to the following factors:
 - a) Regional regulations for the waste discharge and/or degree of treatment should be specific for each kind of source and, if necessary, may be different between existing and new sources. Their development should be based on treatment technology, cost and nature of pollutants considerations, as well as on an overview of the state of environment in the Protocol Area.
 - b) Regional guidelines and, as appropriate, standards or criteria should be developed for the quality of sea water used for specific purposes.
 - c) For areas where the water quality standards for the intended use cannot be achieved through the implementation of the above regional regulations, stricter local regulations for the waste discharge and/or degree of treatment should be developed. Such local regulations will apply to the specific sources in the areas under consideration.
 - d) Regional regulations along with the programmes, measures and the timetables required for the implementation should be developed on a priority basis, *inter alia*, for the following types of wastes:
 - i) Ballast water, slops, bilges and other oily water discharges generated by land-based reception facilities and ports through loading and repair operations.
 - ii) Brine water and mud discharges from oil and gas drilling and extraction activities from land-based sources.
 - iii) Oily and toxic sludges from crude oil and refined products storage facilities.
 - iv) Effluents and emissions from petroleum refineries.
 - v) Effluents and emissions from petrochemical and fertilizer plants.
 - vi) Toxic effluents and emissions from industries such as chlor-alkali, primary aluminum production, pesticides, insecticides, and lead recovery plants.
 - vii) Emissions from natural gas flaring and desulfurization plants.

- viii) Dust emissions from major industrial sources, such as cement, lime, asphalt and concrete plants.
 - ix) Effluent and emissions from power and desalination plants.
 - x) Wastes generated from coastal development activities which may have a significant impact on the Marine Environment.
 - xi) Sewage and solid waste.
- e) As the Diagram 1 attached to this Annex illustrates, pollution abatement is an iterative process. Pollution abatement action will start from high priority measures, which will be selected to be pragmatic cost-effective, while addressing the most critical environmental problems as perceived today. The monitoring programme as specified in Article VII of this Protocol, will be providing the necessary feedback for the required corrective action by yielding the database for accessing the effectiveness of implemented programmes, the current state of the environment and its trends. Corrective action, whenever required, will be taken through periodic updates of the regulations, programmes and measures and review of the conditions in discharge permits, in accordance with the provisions of Articles IV and VI of this Protocol.
2. Provisions for establishing criteria governing the issue of permits for the discharging of waste matter in the Marine Environment, should also take into consideration inter alia the following:
- a) Characteristics and Composition of Waste
 - i) Type and size of waste source, e.g. industrial process.
 - ii) Type of waste (origin, average composition).
 - iii) Form of waste (solid, liquid, sludge, slurry).
 - iv) Total amount (volume discharged, e.g. per year).
 - v) Discharge pattern (continuous, intermittent, seasonally variable, etc.).
 - vi) Concentrations with respect to major constituents.
 - vii) Properties: physical, e.g. solubility and density chemical and biochemical, e.g. oxygen demand, nutrients, and biological, e.g. presence of viruses, bacteria, yeast, parasites.
 - viii) Toxicity

- ix) Persistence: physical, chemical and biological.
 - x) Accumulation and biotransformation in biochemical materials or sediments.
 - xi) Susceptibility to physical, chemical and biochemical changes and interaction in the aquatic environment with other dissolved organic and inorganic materials.
 - xii) Probability of producing taints or other changes reducing marketability of resources, e.g. fish, shellfish, etc.
- b) Characteristics of Discharge Site and Receiving Marine Environment.
- i) Hydrographic, meteorological, geological, biological and topographical characteristics of the discharge site.
 - ii) Location and type of the discharge (outfall, canal, outlet, etc.) and its relation of other areas, e.g. amenity areas, spawning, nursery and fishing areas, shellfish grounds and exploitable resources.
 - iii) Rate of disposal per specific period, e.g. quantity per day, per week and per month.
 - iv) Initial dilution achieved at the point of discharge into the receiving marine environment.
 - v) Methods of packaging and containment, if any.
 - vi) Dispersion characteristics such as effects of current, tides and wind on horizontal transport and vertical mixing.
 - vii) Water characteristics, e.g. temperature, pH, salinity, stratification, oxygen indices of pollution - dissolved oxygen (DO), chemical oxygen demand (COD), biochemical oxygen demand (BOD) - nitrogen present in organic and mineral form including ammonia, suspended matter, other nutrients and productivity.
 - viii) Existence and effects of other discharges which have been made in the discharge site, e.g. heavy metal background levels and organic carbon content.

c) Availability of Waste Technologies

The methods of waste reduction and discharge for industrial effluent as well as domestic sewage should be selected taking into account the availability and feasibility of:

- i) Alternative treatment processes;
- ii) Re-use or elimination methods;
- iii) On-land disposal alternative; and
- iv) Appropriate low-waste technologies.

d) General Considerations and Conditions

- i) Possible effects on amenities, e.g. presence of floating or stranded materials, turbidity, objectionable odour, discoloration and foaming.
- ii) Effects on human health through pollution impact on : Edible marine organisms, bathing waters, aesthetics;, etc.
- iii) Effects on marine ecosystems, in particular living resources, endangered species and critical habitats.
- iv) Possible effects on other uses of the sea, e.g. impairment of water quality for industrial use, underwater corrosion of structure, interference with ship operations from floating materials, interference with fishing or navigation through deposit of waste or solid objects on the sea floor and protection of areas of special importance for scientific or conservations purposes.

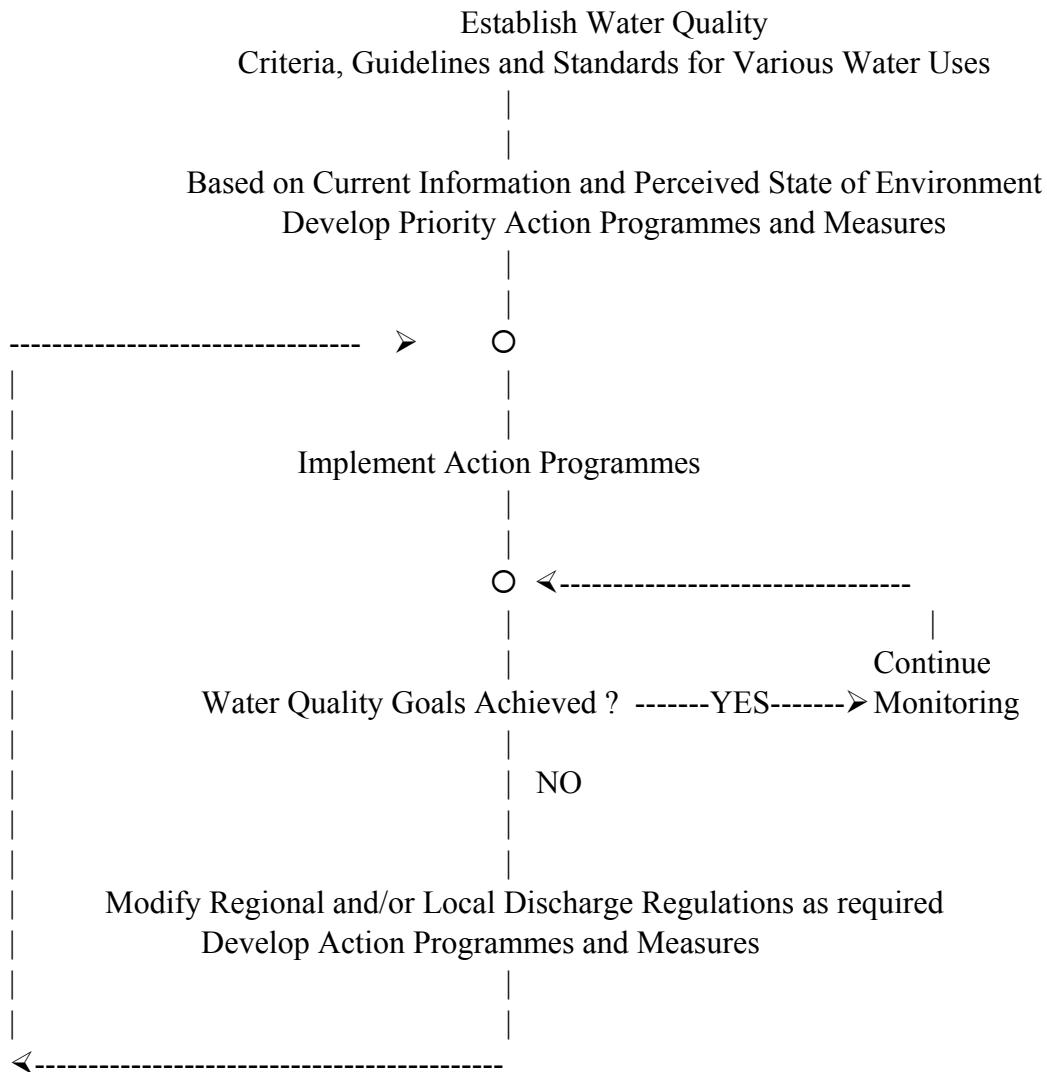


Diagram 1 : Environmental Management Scheme

9.2 APPENDIX II

WORKSHEET I

INDIVIDUAL WASTE STREAM CHARACTERIZATION

1. Waste Stream Name/ID: ----- Stream Number ----
Process Unit/Operation -----

2. Waste Characteristics (attach additional sheets with composition data, as necessary.)
 gas liquid solid mixed phase
Density ----- High Heating Value, Btu/lb -----
Viscosity/Consistency -----
pH ----- Flash Point----- : % Water -----

3. Waste Leaves Process as:
 air emission hazardous waste

4. Occurrence
 continuous -----
 discrete -----
discharge triggered by -----

Type : periodic ----- length of period -----
 sporadic
 non-recurrent

5. Generation Rate
Annual ----- lbs per year
Maximum ----- lbs per -----
Average ----- lbs per -----
Frequency ----- batches per -----
Batch Size ----- average ----- range

**WORKSHEET
III**

**INDIVIDUAL WASTE STREAM
CHARACTERIZATION
(continued)**

Waste Stream -----

7. Management Method

- Leaves site in bulk -----
 roll off bins -----
 55 gal drums -----
 other (describe) -----

Disposal Frequency -----

Applicable Regulations¹ -----

Regulatory Classification² -----

- Managed onsite offsite
 commercial TSDF -----
 own TSDF -----
 other (describe) -----

- Recycling direct use/re-use -----
 energy recovery -----
 redistilled -----
 other (describe) -----

reclaimed material return to site?
 Yes No used by others

residue yield -----
residue disposal / repository -----

¹ list federal, state & local regulations, (e.g., RCRA, TSCA, etc.)
² list pertinent regulatory classification (e.g. RCRA – Listed KO11 waste, etc.)

**WORKSHEET
IV**

**INDIVIDUAL WASTE STREAM
CHARACTERIZATION
(continued)**

Waste Stream -----

8. Management Method (continued)

- Treatment biological -----
 oxidation/reduction -----
 incineration -----
 pH adjustment -----
 precipitation -----
 solidification -----
 other (describe) -----
 residue disposal/repository -----

- Final Disposition landfill -----
 pond -----
 lagoon -----
 deep well -----
 ocean -----
 other (describe) -----

Costs as of ----- (quarter and year)

Cost Element:	Unit Price \$ per -----	Reference / Source:
Onsite Storage & Handling		
Pretreatment		
Container		
Transportation Fee		
Disposal Fee		
Local Taxes		
State Tax		
Federal Tax		
Total Disposal Cost		

WASTE SUMMARY

Attribute	Description¹		
	Stream No. --	Stream No. --	Stream No. --
Waste ID/Name:			
Source/Origin			
Component/or Property of Concern			
Annual Generation Rate (units ---)			
Overall			
Component(s) of Concern			
Cost of Disposal			
Unit Cost (\$ per: -----)			
Overall (per year)			
Method of Management ²			
Notes : 1. Stream numbers, if applicable, should correspond to those used on process flow diagrams. 2. For example, sanitary landfill, hazardous waste landfill, onsite recycle, incineration, combustion with heat recovery, distillation, dewatering, etc.			

9.3 APPENDIX III

INDUSTRIAL EFFLUENT STANDARDS IN THE ROPME REGION

9.3.1 Kingdom of Bahrain

Standards of industrial effluents before releasing to receiving waters

Parameter	Unit	Monthly average*	Maximum value**
Physicochemical			
Floating particles		0	
pH		6-9	
TSS	mg/l	20	35
Temperature	°C	$\Delta T \pm 3$ for receiving water	
Turbidity	NTU	25	75
Biochemical			
BOD	mg/l	25	50
COD	mg/l	150	350
TOC	mg/l	50	
Total Kjeldahl N	mg/l	5	10
Oil & grease	mg/l	8	15
Fluorescent petroleum matters	mg/l	0.1	0.1
Phenols	mg/l	0.5	1
Chemical			
Ammonical N	mg/l	1	3
Residual chlorine	mg/l	0.5	2
CN ⁻	mg/l	0.05	0.1
Nitrite	mg/l	-	10
Nitrate	mg/l	-	1
Sulfide	mg/l	0.5	1
Total phosphate	mg/l	1	2
As	mg/l	0.1	0.5
Cd	mg/l	0.01	0.05
Total Cr	mg/l	0.1	1
Cu	mg/l	0.2	0.5
Pb	mg/l	0.2	1
Hg	mg/l	0.001	0.005
Ni	mg/l	0.2	0.5
Al	mg/l	15	25
Fe	mg/l	5	10
Zn	mg/l	2	5
Biological			
Total coliform	MPN/100 ml	1000	10000

* average reading during 30 days

** maximum value must not be exceeded at any time

9.3.2 Islamic Republic of Iran

D.O.E (Department of the Environment) I.R.Iran, wastewater discharge limiting standards

Discharge limiting parameter	Surface Water	Wells	Agriculture use
BOD	30(50)	30(50)	100
COD	60(100)	60(100)	200
DO	2	-	2
TDS	*	-	100
TSS	40(60)	-	100
SS	0	-	-
PH	6.5-8.5	5-9	6-8.5
TURBIDITY	50	-	50
Color	75	75	75
Coliforms (100ml)	400	400	400
Coliforms (MPN)	1000	1000	1000
Detergents (ABS)	1.5	0.5	0.5
Oil	10	10	10
Zn	2	2	2
V	0.1	0.1	0.1
SO ₄	400(*)	400(**)	500
SO ₃	1	1	1
SH ₂	3	3	3
Se	1	0.1	0.1
Pb	1	1	1
PO ₄	6	6	-
NO ₃	50	10	-
NO ₂	10	10	-
NH ₄	2.5	1	-
Ni	2	2	2
Mo	0.01	0.01	0.01
Mn	1	1	1
Mg	100	100	100
Li	2.5	2.5	2.5
Hg	trace	trace	trace
Fe	3	3	3

Discharge limiting parameter	Surface Water	Wells	Agriculture use
F	2.5	2	2
Cu	1	1	0.2
Cr ₃	2	2	2
Cr ₆	0.5	1	1
Co	1	1	0.05
CN	0.5	0.1	0.1
Phenol (C ₆ H ₅ O)	1	trace	trace
CH ₂ O	1	1	1
Chloride (Cl)	600(*)	600(**)	600
Cl	1	1	0.2
Cd	0.1	0.1	0.05
Ca	75	-	-
Be	0.1	1	0.5
Ba	5	1	1
B	2	1	1
As	0.1	0.1	0.1
Al	5	5	5
Ag	1	0.1	0.1

All the units are mg/l, except Ph, turbidity and colour

* Discharge more than these amounts are permitted if the concentration of chloride (Cl⁻), sulfates (SO₄) and TDS in receiving waters do not increase by more than 10 percent, within (in the) a 200 meters distance.

** Discharge more than these values are permitted if Cl⁻ and SO₄ and TDS concentrations of wastewater to the water used (raw/ natural water used in the industries) do not be more than 10 percent (the ratio between the wastewater and using water).

9.3.3 State of Kuwait

Maximum limits of Pollutants in Industrial Wastewater Permissible to be Discharged into the Sea

Pollutant	Symbol	Unit	Maximum Unit
Colour	-	-	clear
pH	pH	-	6-8
Temperature	-	⁰ C	10*
Biological Oxygen Demand	BOD (5 day, 20 ⁰ C)	mg/L	30
Chemical Oxygen Demand	COD	mg/L	200
Oil / grease		mg/L	10
Total Suspended Solids	TSS	mg/L	10
Total Soluble Solids		mg/L	1500
Phosphate	PO ₄	mg/L	2
Ammonia	NH ₃ -N	mg/L	3
Nitrate	NO ₃	mg/L	30
Total Kaldal Nitrogen		mg/L	5
Total Nitrogen		mg/L	30
Total Recoverable Phenol		mg/L	1
Fluorides	F	mg/L	25
Sulfides	S	mg/L	0.5
Chlorine	Cl ₂	mg/L	0.5
Dissolved Oxygen	DO	mg/L	>2
Turbidity		NTU	50
Floatables		mg/L	Nil
Aluminum	Al	mg/L	5
Arsenic	As	mg/L	0.1
Barium	Ba	mg/L	2
Boron	B	mg/L	0.75
Beryllium	Br	mg/L	0.1
Cadmium	Cd	mg/L	0.01
Cyanides	Cn	mg/L	0.1
Chromium	Cr	mg/L	0.2
Nickel	Ni	mg/L	0.2
Mercury	Hg	mg/L	0.001
Cobalt	Co	mg/L	0.2
Iron	Fe	mg/L	5
Antimony	Sb	mg/L	1.0
Copper	Cu	mg/L	0.2
Manganese	Mn	mg/L	0.2
Zinc	Zn	mg/L	2.0
Lead	Pb	mg/L	0.5
Lithium	Li	mg/L	2.5
Molybdenum	Mo	mg/L	0.01
Vanadium	V	mg/L	0.1
Silver	Ag	mg/L	0.1
All herbicides		mg/L	0.2
Most Probable number of total Coliform		MP/N/100ml	1000

* The subtraction of the external and internal water temperature in water entry and exit point

9.3.4 Sultanate of Oman

Liquid Effluents to the Marine Environment from Land-Based Sources - Maximum Quality Limits at Discharge Point (Mg/L except where otherwise stated)

PARAMETER (in mg/l except pH, temperature, faecal coliform bacteria, viable nematode ova)	Standard
pH	6 - 9
Temperature	<10°C above ambient temp
Biochemical oxygen demand (BOD)	20.0
Chemical oxygen demand (COD)	200.0
Total Suspended Solids	30.0
Aluminium (as Al)	5.0
Arsenic (as As)	0.100
Barium (as Ba)	2.0
Beryllium (as Be)	0.300
Boron (as B)	1.0
Cadmium (as Cd)	0.010
Chromium (as Cr)	0.050
Cobalt (as Co)	0.050
Copper (as Cu)	0.200
Cyanide (total as CN)	0.100
Flouride (as F)	2.0
Iron (as Fe)	1.5
Lead (as Pb)	0.100
Lithium (as Li)	0.070
Mercury (as Hg)	0.001
Molybdenum (as Mo)	0.05
Nickel (as Ni)	0.100
Nitrogen: Ammoniacal (as N)	1.0
Nitrogen: Nitrate (as N)	15.0
Nitrogen: Organic (Kjeldahl) (as N)	5.0
Total-Nitrogen	15.0
Oil & Grease	15.0
Phenols (total)	0.002
Phosphorus (total as P)	2.0
Selenium (as Se)	0.020
Silver (as Ag)	0.010
Sulphide (total as S)	0.100
Total chlorine (as Cl ₂)	0.4
Vanadium (as V)	0.100
Zinc (as Zn)	1.0
Faecal Coliform Bacteria (per litre)	10,000
Viable Nematode Ova (per litre)	<1
Organo halogens	<0.001
Pesticides or their by-products	<0.001
Organosilicon compounds	<0.001
Organocopper compounds	<0.001
Organotin compounds	0.0001

9.3.5 State of Qatar

Standards for Treated Wastewater Used for Irrigation

PARAMETER (in mg/l except pH, temperature, total coliform bacteria)	Standard
pH	6 - 9
Temperature	$\Delta T \pm 3$ for receiving water
Floating particles	0
Biochemical oxygen demand (BOD)	10
Chemical oxygen demand (COD)	150
Total Suspended Solids (TSS)	50
Total dissolved solids (TDS)	2000
Total organic carbon (TOC)	75
Aluminium	15
Arsenic	0.1
Barium	2
Boron	1.5
Cadmium	0.05
Chromium (total)	0.01
Cobalt	0.2
Copper	0.2
Cyanide (total)	0
Fluoride	15
Iron	1
Lead	0.1
Mercury	0.001
Manganese	0.05
Nickel	0.2
Ammonia (as N)	15
Nitrogen: total Kjeldahl (as N)	35
Phenols (total)	0.5
Phosphate (as P)	30
Oil & grease	10
Sulphide	0.1
Sulphate	400
Free residual chlorine (as Cl ₂)	0.1
Zinc	0.5
Total Coliform Bacteria (MPN per litre)	22

9.3.6 Kingdom of Saudi Arabia

Industrial Effluent Standards for Direct Discharge

PARAMETER (in mg/l except pH, temperature, turbidity, total coliform bacteria)	Standard
pH	6 – 9
Turbidity (in NTU)	75 (max.)
Biochemical oxygen demand (BOD)	25.0
Chemical oxygen demand (COD)	150.0
Total Suspended Solids	15.0
Total organic carbon	50.0
Total chlorinated hydrocarbons	0.1
Arsenic	0.1
Cadmium	0.02
Chromium (total)	0.1
Copper (as Cu)	0.2
Cyanide (total as CN)	0.05
Chlorine (residual)	0.5
Lead	0.1
Mercury	0.001
Nickel	0.2
Nitrogen: Ammonia	1.0
Total-Nitrogen (Kjeldahl)	5.0
Oil & Grease	8.0 (not to exceed 15 mg/l in any individual discharge)
Phenols (total)	0.1
Phosphate (total as P)	1.0
Zinc (as Zn)	1.0
Total Coliform (MPN per litre)	10,000

9.4 APPENDIX IV

MAJOR INDUSTRIAL ACTIVITIES IN THE ROPME REGION

9.4.1 Kingdom of Bahrain

Oil

Refinery

Aluminium

- Smelter
- Atomizer
- Cables & conductors
- Recycled foils
- Aluminium coils
- Vehicle aluminium wheels

Petrochemicals & plastics

- Ammonia
- Methanol
- Urea
- Calcined coke
- Chemicals
- Detergents
- Paints
- Medical & industrial gases
- Plastics
- Synthetic sponges
- Fibreglass
- Heat insulators

Engineering

- Iron palletizing
- Shipbuilding & repair
- Prefabricated piping systems
- Air conditioning units
- Nails & screws
- Cold drinks
- Hospital cooking equipment
- Food processing & pharmaceuticals

9.4.2 Islamic Republic of Iran

The three involved provinces of Islamic Republic of Iran in northern ROPME Sea Area cover 40.9% of the total basin's area as follows:

Khuzestan province: 17%
Bushehr province: 7%
Hormozgan province: 16.9%

There are different types of power plants in these provinces including: atomic (Bushehr, not operational) hydraulic, natural gas, gas-oil and crude oil consuming power plants. There are also some desalination plants in these provinces, the main one is in Kish Island.

Large parts of Iran's oil industry (about 46%) as well as immense gas fields are located in Khuzestan province and consequently the largest petrochemical complexes of Iran are in this area, specifically in Khore Musa and Abadan. Part of the crude oil produced in this province is transported to different refineries such as Abadan and the rest is exported through Khark terminal (Bushehr). There are also oil and gas fields, refineries and petrochemical complexes in Bushehr and Hormozgan Provinces. South Pars Gas Field is one of the world's richest natural gas reserves in Assalouyeh (Bushehr).

Paralleled to the development of South Pars Gas Field a large petrochemical complex is under construction in Assalouyeh which 5 out of 38 phases of it have become operational. Bandar Abbas and Bushehr have harbors capable of receiving oil tankers. The Bushehr harbor is connected to Bushehr reserve stocks via pipes. Bushehr accounts for about 8% of the national oil production and its oil is only used for export.

The recent policies of the government encourage the grouping of individual industries to form intensive industrial zones where supporting services such as roads, transportation, power, sewage, water. In addition environment monitoring can be provided more efficiently and economically. Some of these industrial areas are Shoushtar, Khoramshahr, Masjed Soleiman, Dezful, Abadan, Bushehr industrial area and Chogharak. There are numerous types of industrial activities in these industrial areas including food and drink processing, sugar cane refinery, textiles, clothing and leather, cellulose processing, pulp and paper manufacturing, steel producing, coke exploitation, Ferro metallic and other minerals exploitation, pipe manufacturing, plastic and rubber producing, drug producing, machinery and equipment manufacturing and electronics.

Being coastal provinces, Khuzestan, Bushehr and Hormozgan are also active centers of marine transportation and there are several large and small ports in these areas. The fishery development plan of the country anticipates the construction of 18 harbors and wave breaks and dredging of 12 creeks on the northern coasts of the R.S.A.

9.4.3 Sultanate of Oman

Extractive industries (800,000 barrels/day of oil, 852.076 million cubic meter of natural gas) contribute 72.7% of GDP.

Industrial activities include food industries, chemicals & petrochemicals, metals, marble, paper, wood, textile, copper etc.

Big industrial projects are located in Sur industrial estate include Oman LNG company and the newly created - US\$969 million project - Oman India Fertilizer Company (OMIFCO). A new refinery located in Sohar port is under construction and an aluminum smelter is planned to take place in Sohar industrial estate during the years 2005 - 2006.

9.4.4 State of Qatar

Major industrial facilities in the State of Qatar are distributed in Mesaieed and Ras Laffan. The main oil fields and the degassing stations are situated in Dukhan. There are four power generation/water desalination plants. Two plants RAF B & B1 are located at Ras Abu Fontas, one at Ras Abu Abboud and one at Ras Laffan City. A cement manufacturing complex is also located at Umm Bab.

Following is a brief list of major industries:

Name of the Industry	Type of the Industry	Location
Qatar Fuel Additives Company	Petrochemical	Mesaieed
Qatar Fertilizer Company	Urea & Ammonia	Mesaieed
Qatar Steel Company	Iron & Steel	Mesaieed
Qatar Vinyl Company	Petrochemical	Mesaieed
Qatar Chemical Company	Petrochemical	Mesaieed
Qatar Petrochemical Company	Petrochemical	Mesaieed
Qatar Petroleum Refinery	Refinery	Mesaieed
Boom Waste Treatment Services	Incinerator	Mesaieed
NGL 1,2,3 & 4	Gas processing	Mesaieed
RasGas Company Ltd.	LNG	Ras Laffan
Qatar Liquefied Gas Company	LNG	Ras Laffan
Ras Laffan Power Company	Power & Water	Ras Laffan
Oryx GTL	GTL Fuel	Ras Laffan
Ras Abu Fontas A, B, & B1 & Satellite Stations	Power & Water	Doha

Categories of Light Industries in Doha, Ras Laffan, Mesaieed and Dukhan are as follows:

- Ready Mix
- Concrete
- Textile & Dyeing
- Stone Crusher
- Food & Beverages
- Soap & Detergent
- Plastic
- Automobile Service & Garages
- Paints



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