UNITED NATIONS ENVIRONMENT PROGRAMME
MEDITERRANEAN ACTION PLAN

MED POL

GUIDELINES FOR THE APPLICATION OF BEST AVAILABLE TECHNIQUES (BATs) AND BEST ENVIRONMENTAL PRACTICES (BEPs) IN INDUSTRIAL SOURCES OF BOD, NUTRIENTS AND SUSPENDED SOLIDS FOR THE MEDITERRANEAN REGION

GEF

Regional Activity Centre for Cleaner Production

MAP Technical Reports Series No. 142

Ministry of the Environment Spain

Government of Catalonia Ministry of the Environment

UNEP/MAP

Athens, 2004

This document was prepared within the GEF Project "Determination of priority actions for the further elaboration and implementation of the Strategic Action Programme for the Mediterranean Sea", under the coordination of Mr. Ante Baric, Ph.D., Project Manager.

Responsibility for the concept and preparation of this document was entrusted to RAC/CP.

RAC/CP prepared the draft document with the contribution of a Tunisian team leaded by Mr Rachid Nafti. The draft document was sent to the Mediterranean countries for review and was additionally reviewed by a meeting of governmental designated experts. The final version was sent to the UNEP/MAP coordination unit for its publication.

ISSN 1011-7148 paper. ISSN 1810-6218 online

For bibliographic purposes this volume may be cited as:

UNEP/MAP/RAC/CP: Guidelines for the application of Best Available Techniques (BATs) and Best Environmental Practices (BEPs) in industrial sources of BOD, nutrients and suspended solids for the Mediterranean region. MAP Technical Reports Series No. 142, UNEP/MAP, Athens, 2004.

The thematic structure of the MAP Technical Series is as follows:

- Curbing Pollution
- Safeguarding Natural and Cultural Resources
- Managing Coastal Areas
- Integrating the Environment and Development

FOREWORD

The riparian States of the Mediterranean Sea, aware of their responsibility to preserve and develop the region in a sustainable way, and recognizing the threat posed by pollution to the marine environment, agreed in 1975 to launch an Action Plan for the Protection and Development of the Mediterranean Basin (MAP) under the auspices of the United Nations Environment Programme (UNEP) and, in 1976, to sign a Convention for the Protection of the Mediterranean Sea against Pollution (the Barcelona Convention). The Convention entered into force in 1978 and was amended in 1995.

Recognizing that pollution from land-based activities and sources has the highest impact on the marine environment, the Contracting Parties to the Barcelona Convention signed in 1980 a Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources (LBS Protocol). The Protocol entered into force in 1983 and was revised in 1996 to better cover industrial pollution sources and activities and to enlarge the coverage to include the hydrologic basin.

A Strategic Action Programme (SAP MED) to address pollution from land-based activities, which represents the regional adaptation of the principles of the UNEP Global Programme of Action (GPA) to address land-based pollution activities, was adopted by the Contracting Parties to the Barcelona Convention in 1997 as a follow up to the provisions of the revised LBS Protocol. The SAP MED identifies the major pollution problems of the region, indicates the possible control measures, shows the cost of such measures and establishes a work plan and timetable for their implementation.

In order to assist the Mediterranean countries in the long-term implementation of the SAP MED, particularly in the formulation, adoption and implementation of National Actions Plans (NAPs), a three-year GEF Project “Determination of priority actions for the further elaboration and implementation of the Strategic Action Programme for the Mediterranean Sea” was implemented by MAP, and in particular by the MED POL Programme, the MAP Regional Activity Centres and WHO/EURO. The project consists of numerous activities which include, among others, the preparation of regional guidelines and regional plans, whose main aim is to guide and assist countries to achieve the pollution reduction targets specified in SAP MED.

The present document is part of a series of publications of the MAP Technical Reports that include all the regional plans and guidelines prepared as part of the GEF Project for the implementation of the SAP MED.

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EXECUTIVE SUMMARY

This document presents guidelines for the application of Best Available Techniques (BATs), Best Environmental Practices (BEPs) and Cleaner Production in general in the major industrial sources of BOD, nutrients (nitrogen and phosphorus) and suspended solids of the Mediterranean countries. Its purpose is to raise awareness of the environmental impacts of those industries and to highlight approaches that industry and governments can undertake to avoid or minimize these impacts by adopting BATs, BEPs and Cleaner Production.

The Guidelines as a regional initiative are intended to facilitate the implementation of the Strategic Action Program (SAP) at the national level of all MAP countries. Furthermore, these Guidelines are presented together with the Regional Plan for the Reduction of Input BOD by 50% by 2005 from industrial sources, as the tool to facilitate implementing the aforementioned Plan. Namely, these Guidelines are designed to give the best approaches based on the application of BATs and BEPs for industrial sources of BOD, nutrients and suspended solids that industry and governments can undertake in order to mitigate the impacts of pollution resulting from land-based activities in the Mediterranean region. The guidelines are designed to serve the needs of those in governments, industry associations and entrepreneurs seeking information and practical advise on how to improve industry environmental performance and enhance its competitiveness within a sustainable perspective.

As these guidelines are launched in the context of the Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources and Activities (LBS Protocol), they cover the industrial sectors that are considered as major sources of BOD, nutrients and suspended solids. The main sectors according to SAP and covered under these guidelines are food and beverages, textiles, tanneries, paper and paper-pulp, phosphatic fertilizers and the pharmaceutical industry. Each of the industrial sectors is described in terms of production process and associated waste characteristics.

Environmental impact of BOD, nutrients and suspended solids in the Mediterranean

The known environmental impacts of these industrial pollutants are that the BOD changes the ecological balance in a body of water by depleting the dissolved oxygen content; nitrogen and phosphorus enhance eutrophication and stimulate undesirable algae growth and with regard to suspended solids impair normal aquatic life of the stream, and sludge blankets containing organic solids will undergo progressive decomposition resulting in oxygen depletion and the production of noxious gases. Their generation in large quantities pose a serious risk for surface water and groundwater quality and represent a potential cause of damage to human health, ecosystems, habitats and biodiversity in the Mediterranean region.

BATs and BEPs for the identified industrial sources of BOD, nutrients and suspended solids

Definition and preliminary comments

BATs & BEPs offer win-win opportunities for waste reduction and increased efficiency in industry. The definition of BATs & BEPs adopted in the guidelines takes into consideration the criteria established by the LBS Protocol and secondarily, the philosophy of the European IPPC Directive. It encompasses a comprehensive integrated approach that is not limited to consumption and emission levels and pollution control techniques, but prioritize environmental management systems, good housekeeping, good operating practices, techniques for prevention and control of accidents, waste minimization, use of alternative materials/resources and rules for decommissioning. In action, the preventive techniques and practices (cleaner production) are considered first and end of pipe techniques, at the end of the spectrum available. The techniques explored include process design/redesign changes to prevent emissions and eliminate waste, process optimization, substitution of materials by environmentally less harmful ones, good housekeeping, recycling and re-use in water management, control measures and as last option, end-of-pipe treatment techniques. The options selected are based on their technical merit, their economical feasibility and environmental benefits. Indeed, according to the definition of BAT and BEP, a technique or practice would have to be technically and economically feasible in order to be considered as BAT or BEP.

BATs and BEPs

1) BATs & BEPs in the ***food and beverage*** industry include a variety of options that are pertinent to most categories of food processing, and there are various good techniques that are used in one sector that may also be applicable in other sectors. General techniques on waste minimization through the industry include:
   - Recover, reuse and recycle as much waste as possible throughout the plant.
   - Convert as much waste as possible to animal feed.
   - Segregate waste streams.
   - Use dry cleanup methods.
   - Drain all product from tanks and vats before cleaning.
   - Develop a leak prevention program for valves, pumps, piping and equipment.
   - Avoid hosing material into drains if possible.
   - Install water meters and read them on a continual basis.
   - Better inventory control.
   - Monitor the treatment plant for BOD_5 on a regular basis.

   BATs & BEPs for <u>specific food branches</u> have the following general characteristics:

   - For *sugar manufacturing*, they should focus on process optimization, recovery, good housekeeping, …
   - For *oil processing*, they should focus on improvements in production efficiency by applying measures across the entire process, such as the of use citric acid instead of phosphoric acid, where feasible, in degumming operations; use where appropriate of physical refining rather than chemical refining of crude oil; recirculate cooling waters, do not use chlorinated fluorocarbons in the refrigeration system; use of the super-critical process in the treatment of bleaching clay, reduce product losses through better production control, …
   - For *brewery*, they should focus first on improvements in production efficiency to reduce losses in production through application of measures throughout the entire process, such as the application of Clean-in-place (CIP) methods for decontaminating equipment, the use of high-pressure low-volume hoses for equipment cleaning, the use of recirculating systems on cooling water circuits, the filtration of bottom sediments from final fermentation tanks for use as animal feed, …
   - For *winery and distillery*, the approach based on BATs and BEPs would focus chiefly on measures leading to waste minimisation, such as avoid overfilling process vessels, use fine mesh baskets to keep raw materials out of the drainage system, return strong liquors to processes or recover them for animal feed or other reuse, avoid disposing of yeast to drain, use cross-flow filtration, meter volume of product into containers, ...
   - For *fruits and vegetable processing*, BATs and BEPs should focus on process modification, recovery and good housekeeping. Techniques include the use of dry methods such as vibration or air jets to clean raw fruit and vegetables; dry peeling methods, the use of countercurrent systems where washing is necessary; separation and recirculation of process wastewater; reuse of cooling, condensate, fluming, cleaning, washing, and filling waters and marketing of all possible by-products, …
   - For *dairy*, they should focus on improvements in production efficiency through the application of techniques throughout the entire process such as the recovery of energy by using heat exchangers for cooling and condensing; the use of high-pressure nozzles to minimize water usage; the use of the automation system of the

plant to eliminate waste; the recirculation of cooling waters and the training of personnel in the proper operation and handling of equipment, …

- For *meat processing and slaughtering*, they should focus first on improvements in production efficiency by applying techniques and good practices such as changing the sub-process of killing and bleeding from recovery of no blood to recovery of all blood; changing from a system of continuous water flow to one of "interruptible" water flow; changing sub-process of wet rendering with no evaporation of tank water to one in which tank water is evaporated; separation of product from wastes and recover and process blood into useful by-products, …
- BATs and BEPs in *fish processing* typically focus on reducing the consumption of resources, increasing yields and reducing the volume and the organic load of effluent discharges. BATs and BEPs measures reported by the fish processing facilities could be achieved mainly through good housekeeping practices, work procedures, maintenance regimes, resource handling, …

2) BATs & BEPs in ***textiles*** could be achieved through selection and use of chemicals, environmental management and good housekeeping, process optimization, process modification, technology change and waste water treatment. Such techniques include the use of pad batch dyeing; matching process variables to type and weight of fabric; the use of transfer printing for synthetics; the use of water-based printing pastes, when feasible, the use of countercurrent rinsing, …

3) BATs & BEPs in ***tanning and leather finishing*** facilities could be achieved through water and wastewater management, substitution of chemicals, process optimization and modification. Such techniques include the use of carbon dioxide in deliming to reduce ammonia in wastewater; the use of drums instead of pits for immersion of hides; the use of batch washing instead of continuous washing; the use of non-organic solvents for dyeing and finishing, …

4) BATs and BEPs for the ***pulp and paper*** industry are mostly process-related because the environmental impact is caused on the level of the different manufacturing processes performed.
These techniques are adapted to each process such as for Kraft pulp and paper mills. Techniques of reducing emissions into water include measures such as dry debarking of wood; oxygen delignification; ECF or TCF final bleaching, some mainly alkaline process water recycling in the bleach plant, …

5) BATs & BEPs in the ***phosphatic fertilizers*** industry could be achieved through water conservation, recycling and reuse practices and less by process-specific measures.
Such techniques include the installation of spill catchment and containment facilities to avoid inadvertent liquid discharges; practicing good housekeeping and maintenance on all valves, fittings and pumps to prevent spills, considering the recycling of Phosphogypsum in the production of gypsum board for the construction industry and road construction, …

6) BATs & BEPs in the ***pharmaceutical industry*** could be achieved through product change, process changes, input material changes, technology process changes, improved operating practices, recycling/reuse activities and treatment. Such techniques include the use of automated filling to minimize spillage; the use of “closed” feed systems into batch reactors; recirculation of cooling water; the use of reverse osmosis or ultra filtration to recover and concentrate active ingredients; the use of non-halogenated solvents, the recovery of solvents, the use of high-pressure hoses for equipment cleaning to reduce wastewater, …

Economics

Applying BATs and BEPs requires studying and considering economical concerns due to the intrinsic definition of both terms, which specifies that a technique or practice will be considered BAT or BEP if it is economically feasible.

The approach adopted and proposed by these guidelines for assessing the feasibility of the options in general, and specifically, for determining their economic viability, is the one presented in the Regional guidelines for the application of Best Available Techniques (BATs), Best Environmental Practices (BEPs) and Cleaner Technologies (CTs) in industries of the Mediterranean countries.

Notably, it takes into consideration that implementing BATs and BEPs will entail plant or process-specific costs and benefits, and thus, assessing the economic feasibility of applying each option will have to be done case by case, by taking into account economical elements such as investments and their derived costs, operating benefits, the payback period and the so-called intangible benefits.

Several case studies from the MAP countries illustrate that the application of BATs & BEPs can provide both economical and environmental benefits.

Concluding remarks

In conclusion, these guidelines promote the concept of sustainable development in industrial sectors that are sources of BOD, nutrients and suspended solids. They are based on principles that environmental issues are no longer only limited to emissions of pollutants but also include the levels of consumption of raw materials, water and energy. The BAT and BEP approach incorporates the concepts of prevention, cleaner production and waste management with a view to improve the overall performance of the industry. It advocates an integrated approach that considers environmental issues upstream and down stream, thus prioritizing prevention technologies and practices first, and considers as a last option treatment technologies for achieving compliance with environmental regulations, which remain specific to each MAP country. It also stresses the human and organizational dimensions of environmental management that are required to develop sound plant management and operational practices. In this respect, the guidelines propose the application of a combination of BATs and BEPs as the best approach for the management of industry sources of BOD, nutrients and suspended solids. It is expected that their application will lead to achieving the goals of improving the environmental performance of industry beyond compliance with environmental norms and achieving further economical benefits.

As these guidelines are general in their scope, they only provide information on BATs & BEPs approaches, options that by no means are exhaustive, and necessarily need to be updated continuously by its users to reflect technology changes or new emerging BATs and BEPs.

Effective implementation of BATs and BEPs requires that industry maintains and sustains collaboration efforts with trade organizations, research institutions, and governmental agencies on an ongoing basis to discuss initiatives for continuous improvements and the future of the industry from both an economic and environmental standpoint. It is recommended to take actions focusing on:

- Information dissemination through organization of seminars, publication of technical newsletters, and development of databases on BATs and BEPs for the different industrial sectors within industry organizations as well as research institutes and environmental organization in support of industry.

- Research and development relating to reduction of process effluents in quantity and quality through source and process integrated measures, cleaner technologies and design of environmentally friendlier products.
- Improving environmental performance through investigation leading to improved environmental compatibility of conventional and developing industrial processes; and complete closure of the effluent system should constitute a major goal for industrial sectors of the future.
- Recycling and improved recovery systems should continue to be priority environmental targets in the MAP countries.
- Process performance and higher efficiency through the use of increasingly sophisticated, online measurement and expert/control systems will be required to achieve higher environmental performance and anticipate to comply with increasingly stringent operating and environmental permits.
- Capacity building through training across the board will be continually required to increase awareness about environmental performance, upgrade the knowledge and skills about the use of best environmental practices and assimilate the best available techniques applicable in industrial sectors that are sources of BOD, nutrients and suspended solids.
- Implementation of environmental management systems will help sustaining the efforts for continuous improvement through the application of BATs and BEPs.

Therefore, the application of BATs and BEPs would play a pivotal role in achieving environmental improvement and economic growth in the industrial sectors that are sources of BOD, nutrients and suspended solids in the Mediterranean basin, thus offering a way out of the dilemma posed often to industry in terms of choice between economic growth today or long-term environmental sustainability.

It is finally noted that for those seeking more detailed information on BATs and BEPs for the studied industrial sectors generating BOD, nutrients and suspended solids, the guidelines make reference to other available and relevant sources of information such as the Best Available Techniques Reference Documents (BREFs), UNEP/DTIE and RAC/CP sector-specific studies on pollution prevention and other references from international institutions.

1. INTRODUCTION

In the Mediterranean region, industry development has been a major priority in terms of investment, employment, promotion of new technologies and continuous modernization efforts. Industry represents 33 per cent of the economic activity[1] and is the second most important sector after tourism[2]. Industry is also characterized by its heterogeneity in terms of sectors and size of enterprises. Industry is heavily concentrated along the coastal areas in coexistence with tourism, and quite often located within urban areas.

Industry development has accompanied population growth that has almost doubled within a forty years' period between 1960 and 2000 (from 246 to 427 millions), and the Blue Plan forecasts that the population will exceed the 520 millions in the year 2025[3]. Thus, the Mediterranean Sea and the Mediterranean countries, and particularly the coastal areas, are exposed to increasing pressure resulting from human activities and uncontrolled rapid development. This situation led to a process of environmental degradation in the form of great pressure on water, energy, resources use and increased generation of liquid and solid wastes in the basin, originating mostly from land-based sources. In this respect, some industrial activities are identified as large consumers of water and major sources of organic waste, nutrients (nitrogen and phosphorus) and suspended solids.

The response to the challenge of reconciling the needed industrial development without irreversibly damaging the environment has been a priority in the region in terms of formulating cleaner industrial policies, implementing training and education, as well as research and development programs. The initiative of developing a guideline to the application of Best Available Techniques, Best Environmental Practices and Cleaner Production in general in the major industrial sources of Biochemical Oxygen Demand (BOD), nutrients and suspended solids in the Mediterranean countries fits in this proactive framework for supporting sustainable industrial development as laid down by the Mediterranean Action Plan (MAP).

The text of the MAP calls for appropriate action in this respect:

> "… In order to respond to national needs and provide access to Mediterranean and international markets so that sustainable development may be achieved, action should be taken:
> - To encourage and facilitate the use of appropriate industrial procedures and clean technologies;
> - To facilitate the transfer, adoption and control of technology among Mediterranean countries;
> - To consolidate and accelerate the introduction of programs for the control and reduction of industrial pollution; and
> - To strengthen and expand programs for the reduction and management of waste."

The MAP called on the riparian nations to adopt a series of agreements designed to address the environmental problems of the Mediterranean Sea. It is a clear indication for the need for action to achieve industrial sustainable development through the promotion and acquisition of clean techniques.

In this context, the initiative of carrying out a Regional Guidelines for the application of BATs and BEPs for industrial sources of BOD, nutrients and suspended solids is intended to show the way and facilitate the implementation of pollution prevention and abatement actions in

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1 The Mediterranean Action Plan UNEP/MAP (leaflet), August 2000.
2 UNEP/MAP RAC/CP Promoting cleaner production in the industrial sector – Towards sustainable development in the Mediterranean, 2002.
3 La démographie en Méditerranée. Situation et projections. Plan Bleu, 2001.

selected industries, by using the most effective techniques to achieve the goals of industrial sustainable development.

1.1 Objectives and Structure of the Guidelines

1.1.1 Objective of the Guidelines

The Guidelines as a regional initiative are intended to facilitate the implementation of the SAP at the national level of all MAP countries. They are designed to highlight the best approaches based on the application of BATs, BEPs for industrial sources BOD, nutrients and suspended solids that industry and government can undertake to prevent or reduce the impacts of pollution resulting from land-based activities in the Mediterranean region.

1.1.2 Target audience

The Guidelines are carried out for reference, orientation and use by the Mediterranean Action Plan countries. Namely, Albania, Algeria, Bosnia and Herzegovina, Croatia, Cyprus, Egypt, France, Greece, Israel, Italy, Lebanon, Libya, Malta, Monaco, Morocco, Serbia & Montenegro, Slovenia, Spain, Syria, Tunisia and Turkey.

The guidelines are designed to serve the needs of those in governments, industry associations and entrepreneurs seeking information and practical advise on how to improve industry environmental performance and enhance its competitiveness within a sustainable perspective. The guidelines support the development of sectoral policies for the promotion of BATs and BEPs and provides a basis for introducing BATs ans BEPs at entreprises level.

1.1.3 Methodology

The Regional Activity Centre for Cleaner Production (RAC/CP) of the Mediterranean Action Plan has prepared these regional guidelines as one of the components of the GEF Project *Priority Actions for the further elaboration and implementation of the Strategic Action Programme to Address Pollution from Land-Based Activities (SAP).* For carrying out these regional guidelines, RAC/CP hired a Tunisian team of experts made up of Mr Rachid Nafti (CITET, Centre International des Technologies de l'Environnement de Tunis, Tunisia) and Mr Hatem Dhaouadi (Faculté des Sciences de Monastir, Tunisia).

The regional guidelines have been elaborated on the basis of review and analysis of selected studies developed in the framework of MAP and in particular those dealing with identification of pollutants and industrial pollution from land-based sources, as well as other sources of documentation on the subject developed, in particular, by the European Integrated Pollution Prevention and Control Bureau (EIPPCB), RAC/CP, UNEP and other international organisations such as UNIDO and the World Bank. Data was also collected through sending a questionnaire in relation to the elaboration of the guidelines to the National Focal Points of the Regional Activity Centre for Cleaner Production (RAC/CP)[4]. The assignment was carried out in close collaboration and supervision of RAC/CP.

1.1.4 Structure and scope of the Guidelines

The developed Guidelines consist of the following structure:

An executive summary provides a synthesis of the content and conclusions of the report.

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[4] A summary of the responses to the questionnaire is included in the Annex 16 of the report.

Chapter 1 provides an introduction of the general framework in which the initiative of carrying out the regional Guidelines was launched and sets the objectives, the methodology and the scope and structure of the Guidelines.

Chapter 2 deals with relevant background information on the major policy and legal instruments being developed and implemented in the Mediterranean context. Namely, the MAP, the Protocol for the Protection of the Mediterranean sea against Pollution from Land-Based Sources and Activities (LBS Protocol), the Strategic Action Program to Address Pollution from land-Based Activities (SAP), the GEF project “Determination of Priority Actions for the further elaboration and implementation of the Strategic Action Program for the Mediterranean Sea” and the identification of the main hotspots in MAP countries. A brief description of the legal and policy framework for the control of pollution and the application of BATs, BEPs and CP is provided highlighting both the available regional and national instruments.

Chapter 3 deals with the identification of the main industrial sources of BOD, nutrients and suspended solids in the MAP countries according to SAP. This chapter provides a general description of each industrial sector and its specific waste characteristics. The industrial sectors studied are food and beverages, textiles, tanneries, paper and paper-pulp, phosphatic fertilizers and the pharmaceutical industry.

Chapter 4 gives a brief description of the environmental impacts of the main industrial sources of BOD, nutrients and suspended solids in the MAP countries, taking into account the specific Mediterranean context.

Chapter 5 gives a general description of the BATs, BEPs and Cleaner Techniques applicable in these industrial sources to decrease BOD, the concentration of nutrients and suspended solids in the MAP countries. This core chapter of the Guidelines contains the following sections:

(1) A general introduction to the BATs, BEPs and Cleaner Techniques, including definitions and examples.
(2) Identification and description of BATs, BEPs and Cleaner Techniques for each identified industry sector that generates BOD, nutrients and suspended solids.
(3) Some general benchmarks for each sector being studied, figures that should only be regarded as orientative and never as an obligation[5].
(4) A case study and example from each industrial sector that has applied successfully BATs, BEPs and CP. Case studies are identified from Mediterranean countries.
(5) A section on economical aspects that should be considered when defermining if a technique or practice is BAT or BEP, depending on each specific case.

Chapter 6 presents the main conclusions and recommendations directed to MAP countries to implement BATs, BEPs and Cleaner Techniques for industrial sources of BOD, nutrients and suspended solids.

The references consulted and a glossary have been included after the final chapter of the guidelines. Several sections have been also included as annexes, such as parts of the LBS Protocol, specific issues concerning environmental impact of BOD, nutrients and suspended solids, sector-specific techniques for effluent treatment, the rank of priorities in environmental

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5 The benchmarks proposed are mainly extracted from the Pollution Prevention and Abatement Handbook (World Bank). Even if they might appear to be slightly high, they should be considered as a starting point (specially for the Small and Medium-Size Enterprises, which make up the large of the industrial base in the Mediterranean) in the process of continuous improvement and thus, expected to evolve with time.

management as well as a summary of the results to the questionnaire sent to RAC/CP National Focal Points.

2. BACKGROUND

Awareness and concern about the environment degradation in the Mediterranean basin and the will to lay out an appropriate setting for the use of the concept of industry and sustainable development led to the adoption of a series of legal, financial and technical instruments both at regional and country levels. The regional Guidelines proposed by this study is part of the approach of industrial sustainability that aims at promoting the use of best available techniques and the best environmental practices taking into account social, economical and technological conditions. The historical background of this initiative -described briefly below-shows the evolution of the instruments and initiatives undertaken to achieve the goals of sustainable development in the Mediterranean region.

2.1 Mediterranean Action Plan (MAP)

Since its adoption in 1975, the MAP has evolved from its original focus on the pollution of the Mediterranean sea and widened its scope to take into consideration pollution originating on land. This evolution was recognized by the contracting parties in the Genoa Declaration of 1985 which marked a gradual shift from a sectorial approach to pollution control, to integrated coastal zone planning and natural resource management. The MAP's mandate was officially broadened in 1995 to include sustainable development and entered a new phase, MAP phase II, and was renamed the Sustainable Development of the Coastal Areas of the Mediterranean. As a consequence, the Barcelona Convention and its Protocols are made more stringent and reflect the "MAP's shift from expressing environmental goals as desired principles to formulating these goals within measurable frameworks, with compliance monitoring as a key aspect". Priority field of actions were adopted and include, among other fields, integrated coastal areas management with a component focusing on industry.

In the framework of sustainable industrial development, the MAP considers cleaner production, the application of BATs and BEPs as one of the priority strategies to ensure that industry incorporates environmental considerations into management processes through the application of more ecologically sound techniques.

This approach is reflected in the MAP Protocols that are designed to assess, control, prevent and, if possible, eliminate pollution. The Protocol for the Protection of the Mediterranean Sea against Pollution from Land-based Sources and activities (LBS Protocol), the Strategic Action Programme to address pollution from land-based activities (SAP) and The Global Environment Facility (GEF) contribution to the implementation of the SAP constitute the framework for the development of these Regional Guidelines for the application of BATs and BEPs in industrial sources of Biochemical Oxygen Demand (BOD), nutrients and suspended solids.

The MAP has an institutional structure made up of a Co-ordination Unit (UNEP/MEDU) assuming Secretariat functions, and Regional Activity Centres (RACs) to aid in the development of the activities program. The Centres have specific functions which are the Programme for the assessment and control of pollution in the Mediterranean Region (MED POL), the Regional Marine Emergency Response Centre for the Mediterranean (REMPEC), the Blue Plan Regional Activity Centre (BP/RAC), the Priority Actions Programme Regional Activity Centre (PAP/RAC), the Specifically Protected Areas Regional Activity Centre (SPA/RAC), the Environment Remote Sensing Regional Activity Centre (ERS/RAC), the Regional Activity Centre for Cleaner Production (CP/RAC) and the Program for the Protection of Coastal Historic Sites (100 HS).

2.2 Land-based Sources Protocol[6]

Pollution created by land-based sources and activities has been identified as the major factor contributing in the proportion of 80%[1] the total pollution load of the Mediterranean Sea. This fact led to giving particular attention to the preparation of an appropriate legal instrument to cover this aspect of pollution.

Initially, the preliminary survey of pollutants from land-based sources in the Mediterranean carried out between 1976 and 1977 within the framework of the Joint Coordinated Program of Mediterranean Pollution Monitoring and Research (MED POL Phase I) described the overall situation of pollution in the Mediterranean. One of the conclusions reached was that while domestic sources largely contributed to organic matter (BOD or Chemical Oxygen Demand (COD)), microbial pollution and nutrients, as well as detergents from household uses and some metals, industrial waste discharges were responsible for considerable amounts of organic matter and suspended solids. It was also confirmed that a considerable proportion of both municipal and industrial waste was being discharged into the sea raw or partially-treated.

The results of this survey constituted a major technical input to the preparation of the Protocol for the Protection of the Mediterranean Sea against Pollution from Land-based Sources that was adopted and signed during the Conference of Plenipotentiaries of the Coastal States of the Mediterranean Region for the Protection of the Mediterranean Sea against Pollution from Land-based Sources, convened by UNEP in Athens, Greece, from 12 to 17 May 1980 (UN, 1980). This Protocol entered in force in June 1983.

With specific regard to effluent discharge, the Protocol applies to discharges originating from land-based point and diffuse sources within the territories of the Contracting Parties that may directly or indirectly affect the Mediterranean Sea Area. The Protocol also applies to polluting discharges from fixed man-made offshore structures which are under the jurisdiction of a Party and which serve purposes other than exploration and exploitation of the continental shelf and the seabed and its subsoil.

The new revised LBS Protocol signed in 1996 in Syracuse takes into account the Global Program of Action for the protection of the marine environment against pollution from land-based activities adopted in Washington in 1995.

In the new version of the Protocol, Annex I (black list of pollutants) and Annex II (grey list) have been amalgamated with slight modifications of the list of substances into one annex (Annex I), which also lists activities liable to result in pollution, with the former Annex III becoming Annex II. A new annex (Annex IV) deals with criteria for the definition of Best available Techniques and Best Environmental Practice. The texts of Annexes I, II and IV to the new revised version of the Protocol are listed in the annexes of the guidelines.

In Article 5, Contracting Parties have undertaken to eliminate pollution deriving from land-based sources and activities. The article also lays down, *inter alia*, that in the adoption of programs, measures and action plans, the Parties shall take into account, either individually or jointly, the best available techniques and the best environmental practice including, where appropriate, clean production technologies, taking into account the criteria set forth in Annex IV.

Overall, the LBS Protocol emphasizes the need to establish and apply plans for the prevention and abatement of pollution in the Mediterranean Sea and underlines the need to implement programs that apply Best Available Techniques and Best Environmental Practices (BATs & BEPs) in industrial sectors that are sources of pollutants of the sea.

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6 Adopted in 1980 and revised in 1996.

2.3 The Strategic Action Program to Address Pollution from Land-based Activities in the Mediterranean Region [SAP MED]

Designed as a tool to facilitate the implementation of the LBS Protocol, the Strategic Action Program to Address Pollution from Land-based Activities in the Mediterranean Region (SAP MED) was approved during the Tenth Ordinary Meeting of the Contracting Parties to the Barcelona Convention held in Tunis in 1997.

Given the importance of industry in the region with its significant contribution to sustainable development, as well as its associated impact on the environment, the SAP calls explicitly for:

> "A program concerning the reduction and to the fullest possible extent elimination of industrial pollution should be applied by all the industrial installations"

The SAP MED provides a broad framework and timetable for the implementation of mechanisms and measures that will lead to the protection of the marine environment including its biological resources and diversity, from polluting land-based activities. This framework includes a basis on which to develop an investment portfolio to address the most acute environment impacts resulting from land-based activities.

The Strategic Action Program has an important part to play in sustainable industrial development and fixes priorities for action based on the results from MED POL and the reports on hot spots and sensitive areas that have already been referred to. Based on the industrial sectors identified by the LBS Protocol and priority pollutants, it determines the specific action to be taken at regional and national levels.

An Operational document for the implementation of the Strategic Action Programme to address pollution of the Mediterranean sea from land-based activities (SAP) was prepared in order to facilitate the real and practical application of the SAP by the Mediterranean countries.

> Priority industrial sectors covered in the SAP

From the thirty sectors of activity primarily considered in the Annex I of the LBS Protocol, twenty-one are industrial. From the twenty-one industrial sectors, six are listed in the table below because they are considered as major sources of BOD, nutrients and suspended solid and will be studied by the present Guidelines.

> The industrial sectors identified as major sources of BOD, nutrients and suspended solids to be addressed by these guidelines are:
>
> - Manufacture of food and beverages: slaughtering, preparing and preserving meat; manufacture of dairy products; canning & preserving of fruit and vegetables; canning, preserving & processing of fish, crustaceans and similar food; manufacture of vegetable oils and fats; sugar factories and refineries; distillation; wine production; beer manufacture;
> - Manufacture of textiles: wool and cotton processing;
> - Tanneries and the leather finishing industry;
> - Paper and paper-pulp industry;
> - Phosphatic fertilizers industry;
> - Pharmaceutical industry: basic substances (fermentation and extraction processes).

In April 1998, a request submitted to GEF on the implementation of the most urgent priorities of SAP MED was approved.

2.4 The Global Environment Facility (GEF) Contribution to the Implementation of the SAP

In the framework of the contribution of the Global Environment Facility (GEF) for the realization of important groundwork activities for the further elaboration and implementation of the SAP, grants and concessional funds are provided to eligible countries for projects and activities that aim to protect the global environment. The GEF is implemented jointly by UNEP, the United Nations development Program (UNDP) and the World Bank.

GEF recognized that the SAP is an important program dealing with some of the most significant impacts regarding international waters. As a result of this recognition, in 1988 the GEF approved the Mediterranean GEF Project (2001-2003) funding a number of activities for facilitating the application of the SAP.

Through a GEF Project Development Facility (PDF) Grant, the MED POL Program prepared a Trans-boundary Diagnostic Analysis (TDA) for the Mediterranean, which presents an overview of the perceived impacts affecting the Mediterranean; including those from land-based activities, and an assessment of their relative magnitude and trans-boundary significance. The TDA also determines the type of interventions needed at regional and national levels to solve these problems as well as an indication of their cost.

Under the same GEF PDF Grant, and as part of the MED POL Program, WHO carried out a study on the 'Identification of Priority Pollution Hot Spots and Sensitive Areas in the Mediterranean'.

Other GEF funded activities converging to the same objective include the preparation and adoption of Regional Guidelines and Plans and Regional training programs. These initiatives will be materialized by the elaboration of complementary instruments to these regional guidelines for the application of BATs and BEPs in industrial sources of BOD, nutrients and suspended solids in the form of:

- Regional Plan for the reduction of input BOD by 50 percent by the year 2005 from industrial sources (Ref: MED/POL programme, UNEP/MAP, Athens 2002).
- Regional Guidelines for the application of Best Available Techniques, Best Environmental Practices and Cleaner Technologies in Industries of the Mediterranean Countries (Ref: Regional Activity Centre for Cleaner Production, February 2002).
- Guidelines for the management of industrial effluents in the Mediterranean Region (Ref: WHO/EURO Project office, Mediterranean Action Plan, June 2002).

The following **Figure 1** summarizes the Mediterranean GEF Project outputs 2001-2003.

The present document deals with the carrying out of Guidelines for the application of BATs and BEPs for the most important industrial sources of BOD, nutrients and suspended solids in the MAP countries. It is carried out within the GEF Project "Determination of Priority Actions for further elaboration and implementation of the Strategic Action Program for the Mediterranean Sea (SAP)" that aims to facilitate the implementation of the Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources and Activities.

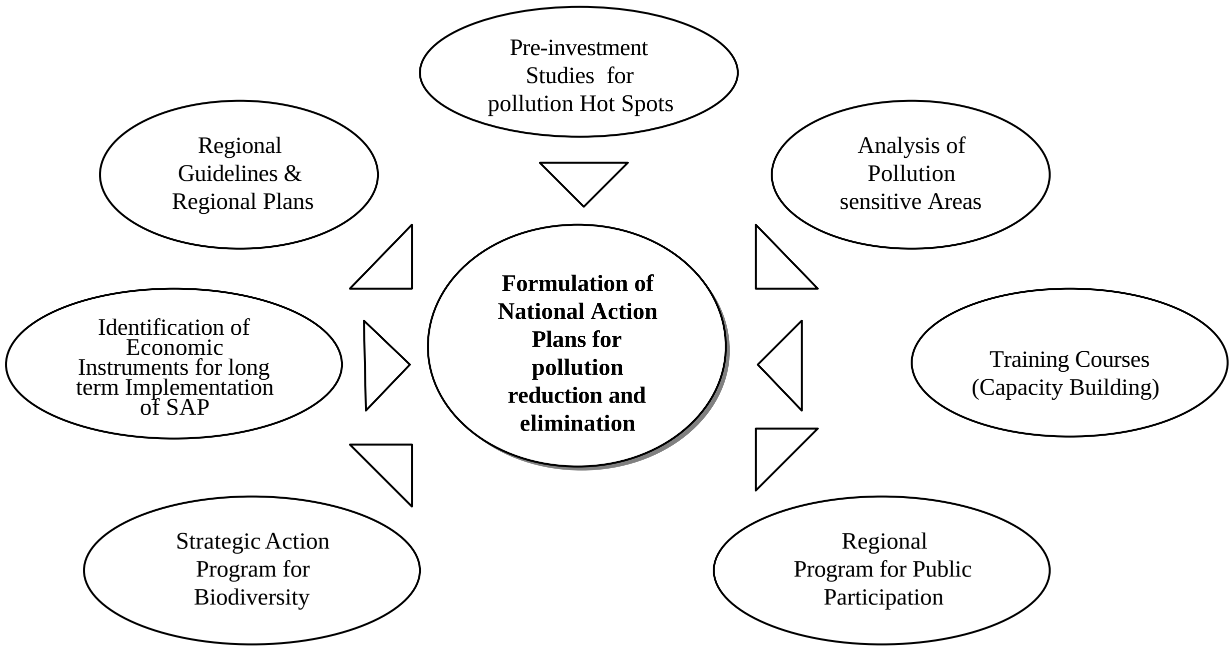

Figure 1. MED GEF Projects outputs (2001 – 2003)

The present document deals with the carrying out of Guidelines for the application of BATs and BEPs for the most important industrial sources of BOD, nutrients and suspended solids in the MAP countries. It is carried out within the GEF Project "Determination of Priority Actions for further elaboration and implementation of the Strategic Action Program for the Mediterranean Sea (SAP)" that aims to facilitate the implementation of the Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources and Activities.

2.5 Formulation of a Regional Plan for the Reduction of 50% of BOD by the Year 2005

The regional plan for the reduction of 50% of BOD by the Mediterranean coastal industrial activities is intended for use by the national bodies for the elaboration of sectorial national plans to reduce the release of BOD in the Mediterranean marine environment. These guidelines for the application of BATs and BEPs in industrial sources of BOD, nutrients and suspended solids present technical support for moving towards the stated target.

2.6 Overview of the Legal and Policy Framework

Aware of the risks of environmental degradation of the Mediterranean sea, the riparian countries adopted environmental legislation at regional and national levels. Regulation at the subregional level has also been adopted and imbibes the spirit of these guidelines, namely the so-called IPPC Directive of application to the countries of the European Union (Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control).

2.6.1 Regional legal framework

At the Mediterranean regional level, the legal framework is basically made up of the 1976 Barcelona Convention of the Marine Environment and Coastal region of the Mediterranean, amended in 1995, and the six Protocols: the so-called Barcelona system. This provides clear indication of the countries' commitment to pursue sustainable development.

The MAP legal framework takes into consideration some of the global agreements such as those developed under the auspices of the United Nations Environment Program (UNEP), like the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, and the Convention on Biological Diversity. Furthermore, the MAP takes into consideration the developments into international environmental law such as the Polluter Pays Principle and the Precautionary Principle.

MAP PROTOCOLS

Dumping Protocol: Protocol for the Prevention and Elimination of Pollution in Mediterranean Sea by Dumping from Ships and Aircraft or Incineration at Sea (1976, amended in 1995)

Emergency Protocol: Protocol Concerning Cooperation in Combating pollution of the Mediterranean Sea by Oil and other Harmful Substances in Cases of Emergency (1976)

LBS Protocol: Protocol for the Protection of the Mediterranean Sea against Pollution from land-Based Sources and Activities (1980, amended in 1996)

SPA and Biodiversity Protocol: Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean (1995, replacing the 1982 SPA Protocol)

Offshore Protocol: Protocol for the Protection of the Mediterranean Sea against Pollution resulting from Exploration and Exploitation of the Continental Shelf and the Seabed and its Subsoil (1994)

Hazardous Wastes Protocol: Protocol on the Prevention of Pollution of the Mediterranean Sea by Transboundary Movements of Hazardous Wastes and their Disposal (1996).

Overall, the Contracting Parties pledge to individual or joint action in conformity with the dispositions of the Barcelona Convention to prevent, reduce, control and eliminate -to the fullest extent possible- pollution in the Mediterranean Basin.

In the application of the Barcelona Convention and its Protocols, the contracting parties underline to apply BATs and BEPs and to promote environmentally sound technologies.

The LBS Protocol contains a general obligation to the Contracting Parties, the task to eliminate pollution from land-based sources through the elaboration of national plans and programs that take into consideration the use of BATs and BEPs and CP. The Contracting Parties pledge to adopt directives and criteria related to the control and gradual substitution of industrial installations, processes and products causing serious harm to the marine environment. The Protocol also encourages co-operation among the contracting countries for information exchange, the development of cleaner production process and new treatment technologies for the reduction or elimination of pollution.

The SAP provides orientations for the design of industrial policy that favours the implementation of the concept of CP, BATs and BEPs. Furthermore, the SAP establishes the priority actions for sustainable industrial development based on the results of MEDPOL and the reports on Hot spots. In this respect, it underlines and/or establishes:

- the priority industrial sectors,
- priority pollutants and
- specific actions to undertake at both at the regional and national levels.

In brief, all the legal instruments in the framework of the Barcelona Convention stress the importance of adopting pollution prevention and abatement approaches based on the use of BATs, BEPs and CP.

2.6.2 Legal and policy framework at the national level

Once the MAP countries have signed and ratified the MAP Protocols, their task is to take the appropriate steps to implement national legal and organizational initiatives to comply with Barcelona system.

All countries in the Mediterranean have developed policy and legislation for environmental protection, pertaining in particular to water resources management and waste management. Among the legislative measures contributing to the prevention and abatement of industrial pollution, they include:

- Environmental impact assessment;
- Permitting schemes;
- Monitoring mechanisms;
- Taxes on polluting activities;
- Hazardous waste management…

Some efforts were undertaken for the introduction of the concept of Cleaner Production in industry. The CP principle is now known by all the Mediterranean countries but its actual implementation by industry varies from one country to another[7].

The development of legislative tools that favors an effective application of CP, BATs and BEPs in the MAP countries is still an emerging activity still requiring more strengthening. Different legal and voluntary instruments schemes are being developed but their scope vary from country to country.

Table 1 below provides a summary of the main legal instruments dealing with pollution prevention and control[8]

Table 1
Legal instruments dealing with pollution prevention and control

	Water pollution control regulation	Environmental Impact Assessment	Voluntary agreements	Legal provision for CP, BATs and BEPs
Albania	•	ð	ð	ð
Algeria	•	•	ð	ð
Bosnia&Herzeg.	•	•	ð	∆
Cyprus	•	•	•	∆
Croatia	•	•	•	•
Egypt	•	•	•	ð
Spain	•	•	•	•
France	•	•	•	•
Greece	•	•	•	•
Israel	•	•	•	ð
Italy	•	•	•	•
Lebanon	•	ð	ð	ð
Libya	•	ð	ð	ð
Malta	•	•	•	∆

7 Ref. State of cleaner production in the Mediterranean Action Plan countries, RAC/CP, June 2001, Barcelona, Spain.

8 The sources used for compiling this table are the questionnaire developed in the framework of this study, the Report on the State of cleaner production in the Mediterranean Action Plan countries by RAC/CP in 2001 and Environmental Assessment in Developing and Transitional Countries by Norman Lee and Clive George, Wiley, 2000.

	Water pollution control regulation	Environmental Impact Assessment	Voluntary agreements	Legal provision for CP, BATs and BEPs
Monaco	•	•	•	∆
Morocco	•	•	ð	ð
Slovenia	•	•	ð	ð
Syria	•	ð	ð	ð
Tunisia	•	•	ð	∆
Turkey	•	•	•	∆
•legislation in place, ∆ under preparation, ð no legislation				

At the institutional level, some countries have established National Cleaner Production Centres (8 centres are already operational), with the mandate to promote the concept of CP, the transfer and implementation of BATs, BEPs within industry.

It is clear that the existence of legal framework reinforces and accelerates the implementation of BATs, BEPs and CP; but its effectiveness could be reinforced by adopting an integrated approach that combines legal instruments with voluntary agreements and other financial and technical instruments. This would create a conductive environment for streaming eco-technologies in industry.

3. ENVIRONMENTAL IMPACTS OF BOD, NUTRIENTS AND SUSPENDED SOLIDS IN THE MEDITERRANEAN CONTEXT

3.1 Introduction

Industrial development in the Mediterranean region contributed to the economical growth of the region as well as the creation of hot spots and sensitive areas. Industrial activities produce liquid effluents that are often discharged untreated directly into the sea or into the hydrographical basin or into urban sanitation systems from which they are released without being pre-treated. The created pollution could have serious impact on the quality of the water in reservoirs, water supply points, estuaries and coastal lagoons, and cases of high fish mortality in estuaries have occurred already in the past.

This chapter describes the environmental impacts associated with the industrial sectors that are major sources of biodegradable organic matter, nutrients (nitrogen and phosphorus), and suspended solids. These industrial pollutants generated in large quantities could pose a serious risk for surface water and groundwater quality and represent a potential cause of damage to human health, ecosystems, habitats and biodiversity in the Mediterranean region.

The revised edition of the MAP technical report of the priority pollution Hot Spots in the Mediterranean provides updated information concerning loads of BOD, nutrients (nitrogen and phosphorous) as well as suspended solids in the region.

In general, on the basis of data collected by the survey of pollutants from land based sources in the Mediterranean[9], which includes information for 12 countries of the region, it could be concluded that approximately 48% of the total amount of industrial process water is discharged untreated, while the remaining 52% is treated before discharge. Approximately 13% of the process water is discharged into municipal sewers, about 15% of this amount being treated. Approximately 14%, two thirds of which remains untreated, is discharged into rivers; 14%, again two thirds of which is untreated, on the shoreline, 1% is discharged on land or into septic tanks, and approximately 1.4% is discharged in an unspecified manner.

[9] UNEP/WHO: Identification of Priority Pollution Hot Spots and Sensitive Areas in the Mediterranean. MAP Technical Reports Series No.124. UNEP, Athens, 1999

The remainder, approximately 57% of the total amount of process water, of which 33% is untreated, is discharged into the sea directly or via outfall.

In general terms, the impact of the undesirable waste constituents from industry on the receiving environment are known universally:

- Biochemical Oxygen Demand (BOD) changes the ecological balance in a body of water by depleting the dissolved oxygen content. Since most receiving waters require maintenance of minimum dissolved oxygen, the corresponding quantity of soluble organics is correspondingly restricted to the capacity of the receiving waters for assimilation or by specified effluent limitation.
- Nitrogen and phosphorus when discharged to lakes, ponds, and the sea, enhance eutrophication and stimulate undesirable algae growth.
- Suspended solids deposited in quiescent stretches of a stream will impair normal aquatic life of the stream. Sludge blankets containing organic solids will undergo progressive decomposition resulting in oxygen depletion and the production of noxious gases.

3.2 Effects on Marine Pollution

The effects of marine pollution on marine organisms have traditionally been related to contaminant concentrations in biotic material, and therefore, monitoring focussed initially on measuring these levels. This approach has now widened to include the measurement of a wide range of genetic, biochemical, physiological and ecological parameters of biological change. Such biological changes, biomarkers, can provide information on exposure to contaminants and sometimes on effects. If no changes are found in biomarkers, organisms or community structure, there is a sound basis for not pursuing investigation of potential pollution.

There is not always a straightforward relation between a concentration of a contaminant in an organism and the effect produced in that organism, however. The effect is registered as a departure from the normal condition of the organism, particularly in terms of such parameters as physiological or biochemical responses (at the cellular level), or as growth rate, natural mortality, reduced behavioural responses etc. (at the individual level), or species abundance and community composition (at the population level). Since many animals, particularly filter-feeders, accumulate chemicals from their environment (sea water, sediments, food), they can provide early warning of potential pollution problems. Some organisms that respond rapidly to contaminants, can be used for toxicity testing and thus help to develop water-quality standards.

The discharge of nutrient-rich wastes to otherwise nutrient-poor seas, such as the Mediterranean, if in moderation and if contamination by toxic wastes can be excluded, can even somewhat enhance biological production in some fishery resources. If uncontrolled, however, nutrient enrichment inshore and imbalance of nutritive elements also lead to unusual and dense phytoplanktonic blooms which, on decomposition, produce unæsthetic conditions close to the points of discharge, thus adversely affecting coastal activities such as tourism; the Adriatic Sea is a good example of such phenomena (Annex 2). There is an ecosystem adaptation up to the biological limits posed by the modified environment, but the components of this new ecosystem adapted to eutrophic conditions are rarely those of interest for human exploitation.

Experience in the Mediterranean, which is basically an oligotrophic sea (characterized by low biomass, low availability of nutrients, trace metals and/or growth factors), suggests that moderate levels of enrichment of originally nutrient-limited marine systems may favour production and even suspension culture of some bivalve species, and higher production of small pelagic fish of low economic value, but they do so at the expense of more valuable bottom-dwelling fish and crustacea. Increased nutrient loads in the fresh water run-off to semi-enclosed seas may also accelerate phytoplankton growth to the point that it adversely affects aquatic vegetation by reducing light penetration, especially if accompanied by a high load of suspended sediments.

Blooms of toxic phytoplankton species arising from the disposal of nutrients and other compounds into the sea can lead to diarrhoeic shellfish poisoning and other effects on health, necessitating the temporary prohibition of the sale of affected fish products. Untreated sewage can lead to the risk of viral contamination of shellfish and consequent human illness. It should be noted that, even after primary or secondary treatment, the nutrient impact of sewage outflows remains unchanged. Consequent over-fertilization can cause fouling and clogging of nets and cages used in aquaculture. The European Union[10] requires of its member countries tertiary treatment (e.g., denitrification and phosphorus reduction) for discharges into sensitive areas.

The Mediterranean, with a flushing time of some 80 to perhaps 300 years, allows nutrients and toxic materials to accumulate rapidly, which is most likely to lead to a decline in ecosystem diversity and to progressive dominance of the production system by short-live, especially pelagic, species.

Recruitment, mortality and growth of a fish stock are affected by the impacts of other users of the aquatic habitat and its catchment area; such impacts arise potentially from all up-stream economic activities, such as industry and agriculture, as well as from fishing.

The adverse effects of marine pollutants can be viewed from more than one standpoint:
- the changes (such as turbidity, oxygen depletion, chemical contamination) caused in the water that alter its value as a medium for living animals and for human recreation and other uses;
- the changes (such as flocculation, oxygen depletion, chemical contamination) caused in the sediments on the sea bed that alter its value as a habitat for marine organisms, especially those of economic interest;
- the changes (such as tainting, poisoning/toxicity, growth/development inhibition) caused in marine organisms that are of economic or ecological value to humans; and
- effects on humans due to the consumption of altered marine organisms, to bathing in altered waters, and to breathing contaminated marine air.

Some of the parameters of environmental effect cannot yet be measured adequately or have not yet been measured *in situ*, and in some cases, it is necessary to carry out toxicity testing at the laboratory in order to establish levels at which discernible effects occur; it is not normally feasible to conduct such tests directly on human beings, so that most public health standards are based on effects observed on other, physiologically similar animals in the laboratory, leading to an assessment of risk to human health.

In very general terms, the majority of the socio-economic consequences of marine pollution are manifested as immediate or long-term effects on human health. In this context, the two main types of human exposure to pollutants in the marine environment are through direct contact with polluted seawater and/or beach sand, including ingestion of the former while swimming or bathing, and consumption of contaminated seafood.

Coastal industries contribute to degradation of the local marine environment where they discharge, and occupy the terrestrial environment in their vicinity at the expense of other biologically important critical habitats for marine and coastal species. To the extent that habitat loss and contamination depress the quality and abundance of the marine fauna, local

[10] UNEP/MAP, State of the Marine and Coastal Environment in the Mediterranean Region, MAP Technical Reports Series No. 100, UNEP, Athens

fisheries are adversely affected by coastal industry; and, in the long term, the sum of all coastal industrial discharges not fully absorbed by the sea has the potential to affect adversely coastal marine fisheries in general. However, it is not always certain that fishes (of economic, fishery interest) are adversely affected by some forms of chemical pollution. Nevertheless, on the whole, coastal industry (even including industrial-scale fish farming) has the potential to cause an impact on coastal fishery interests.

3.2.1 Environmental impacts of BOD

Industries discharging biodegradable organic wastes into the Mediterranean sea are similar to municipal waste in their adverse effect on the oxygen balance. Such waste requires immediate oxygen demand and biochemical oxygen demand (BOD). Industrial organic wastes such as those from the food and beverage industries, breweries and distilleries, paper industries, tanneries, sugar refineries, canning industries as well as meat packing and processing and fishmeal production might have BOD values measured in thousand and tens of thousands mg/L, compared to municipal waste that might exert between 200 to 1000 mg/L BOD.

Oxygen depletion might cause substantial fish kills in the immediate vicinity of the point of discharge, particularly in sea enclosures. Its effect is often much more marked in confined areas of the sea such as estuaries, lagoons, marinas, close narrows bays and sea-enclosures The effects is limited in the wide-open sea because of its enormous rate of dilution.

The water pollution discharged into the Mediterranean sea, estimated in BOD term, is a by-product of human population, and its significance is in what effect it has directly or indirectly on living populations. The pollutants contained in the discharged wastewater are chemicals that interact with living cells, and biochemical reactions carried out by the cells alter the compounds enzymatically. Furthermore, since the physical properties of substances are dependent upon their chemical configurations, the chemical change in structure bring about the change in physical properties. Eventually the net result is an alteration in environmental quality. The reactions of greatest relevance to water pollution are those concerning biodegradation and chemical conversion that either stimulate or inhibit other living cells. Some pollutants can also act directly as toxic agents or nutrients without undergoing a degradation or chemical transformation, causing damage to the marine living species.

The process of biological oxidation of water pollution can readily proceed in any aquatic habitat such as lake and river just as readily as in a treatment plant. Therefore, it will not be long before organic contaminants which may be dumped directly into lakes without prior treatment will demand most of the available dissolved oxygen (the solubility is 8 ppm at 20°C).When this is allowed to happen, other living creatures in the lakes or rivers which also require dissolved oxygen will perish. This is often the cause of fish kills, and therefore it illustrates the importance of oxidation of that waste in a treatment plant where we are able to replenish the dissolved oxygen.

Microorganisms carry out biochemical oxidation by reactions depending upon the individual kinds of microorganisms present and upon the individual kinds of waste substances. There are ecosystems where oxygen is absent. In this situation, higher forms of life do not exist and protists are the only cells present. Such anaerobic world is very common in the aquatic environment, and anaerobic microorganisms are essential to chemical transformation of pollutants. The biochemical reactions of anaerobic organisms that are of significance to pollution abatement fall into the following general categories:

- Anaerobic respiration, in which sulfate, nitrate or carbon dioxide substitute for oxygen and produce hydrogen sulfide, ammonia or methane.
- Fermentation, in which a carbohydrate is converted to an organic acid or alcohol.

- Hydrolysis, in which polymers are degraded to their monomeric units (hydrolytic reactions are also carried out by aerobes).

Many microorganisms have the facility to metabolize and grow in either the presence or absence of oxygen, and the reaction patterns of these facultative microorganisms will be characteristic of aerobic and anaerobic forms depending upon whether oxygen is present or absent.

3.2.2 Environmental impacts of nutrients

The principal marine nutrients, notably nitrogen and phosphorus, although not themselves contaminants, may have an important effect on the marine environment: eutrophication. Certain coastal zones become eutrophic due to high levels of nutrient discharge arising from human activities, although this may occur, to a lesser degree, naturally and more slowly in upwelling areas.

It is well known that not all phosphorus in suspension in the water is available to marine food webs; like silt, metals and many toxic compounds, much of the phosphorus is precipitated out to estuarine and marine sediments. Unlike nitrogen, phosphorus compounds are not broken down to the gaseous inactive element, and a large proportion of phosphorus in run-off, although partially inactivated if stored in oxygenated sediments, may be more easily recycled from deoxygenated bottom sediments back into the pelagic food web, and contribute once again to eutrophication.

Much scientific debate has focused on whether primary production in aquatic systems is limited by phosphorus or by other nutrients or trace elements. The general consensus seems to be that nitrogen is usually limiting in coastal waters in northern temperate latitudes, although the precedent for considering available phosphorus as a measure of biological production throughout the food web appears to have been established; nevertheless, other elements than phosphorus and nitrogen, such as silicon and iron, should be given closer attention.

Eutrophication is normally manifested as a marked increase in the abundance of phytoplankton, hence a very high primary production, as a result of the high nutrient levels, with substantial detrital "rain" promoting heterotrophic bacteria and flagellates. Sometimes, they lead to seasonal or permanent anoxic zones in bottom water and sediments, with corresponding adverse impact on the benthos and on demersal food webs, but often sustaining a high standing crop of small pelagic fishes and zooplanktivores that are supported by high densities of planktonic herbivores feeding on the phytoplankton (if suitable conditions are present in the affected area).

The over-abundant plankton may lead to:

- fish kills, by asphyxiation due to the clogging of fish gills and increasing consumption of oxygen dissolved in the sea water occurring in oxidization (i.e., decomposition) of dead organic matter in the water;
- by reducing, consequently, the success of fertilization of fish eggs or the survival of fish larvæ, or by inducing the displacement of older fish away from the usual fishing areas; and
- the fouling of fishing nets and the clogging of engine cooling systems.

It may be that these various forms of clogging are due to polymers secreted into the water by the phytoplankters (especially dinoflagellates) involved; these polymers may also be responsible for the formation of slime and of surface foam (which dampens wave action and may even be a mechanism by which phytoplankton creates turbulence-free niches useful for its own survival). All the above phenomena are especially visible in enclosed basins such as the Adriatic (Annex 2).

Some algal blooms are due to certain species of dinoflagellates (such as *Noctiluca, Pyrodinium*) that produce what are known as "red tides" which are, in the Mediterranean, widespread, seasonal and often site-specific. Several species of dinoflagellates produce toxins that may severely affect fish ingesting them and, once accumulated in fish or shellfish, may severely affect human beings eating infected sea food, thus causing disorders such as diarrhoeic or paralytic shellfish poisoning. Human beings may also be affected by the respiration of certain toxic dinoflagellates in ærosols.

Excess of nutrients close to the source, and possibly causing observable eutrophication, may become dispersed farther away and have beneficial effects on the pelagic food chain. Thus, in the Adriatic, an increased abundance of small pelagic species, especially sardines, has been observed and persists even as fishing effort on such species tends to increase. Some studies also report increased standing crops of mussels and oysters on the Istrian peninsula. There is also some indication that Kastela Bay (Croatia) and the Gulf of Saronikos (Greece) may follow the same evolution, provided that the discharge of toxic substances with the nutrients is controlled.

There is some reason to suppose that the conditions that favour eutrophication, if followed by dispersion and dilution of the excess nutrients, may also lead to an increase in productivity which, by increasing the amount of food available, may cause "plagues" of medusæ, especially of the common species *Pelagia noctiluca*. However, other causes may be natural fluctuations in population abundance of the species, changes in the abundance of its predators, significant changes in water currents causing the sudden appearance and accumulation of jellyfish in a particular area at a particular time, or major hydroclimatic changes affecting factors that normally control jellyfish abundance (Annex 3).

Almost all coastal Mediterranean countries[11] are affected by eutrophication, although to varying degrees, and most incidents have been reported for the northern Mediterranean (i.e. the bays of the Ebre delta, the Albufera of València, the bays of the Rhône delta, the gulf of Saronikos, the gulf of Thermaikos, the bay of Izmir). The most important areas of extensive eutrophication are the gulf of Lyons and the northern Adriatic coast, particularly along the semi-enclosed bays of the Po delta, the gulf of Venice and the gulf of Trieste on the Italian coast. The Slovenian coast and the bays of Pula, Rijeka Kastela Sibenk and Dubrovnik in Croatia also suffer.

3.2.3 Environmental impacts of suspended solids

Suspended solids, generally assumed to be colloidal particles, and because of their adsorptive properties, may have direct and indirect effects on the marine environment.

The direct one is related to the fact that the presence of suspended solid, by increasing the water turbidity, may affect the oxygen balance by influencing photosynthesis.

As it has been said above, suspended solids (when deposited in quiescent stretches of a stream) will impair normal aquatic life of the stream. Sludge blankets containing organic solids will undergo progressive decomposition resulting in oxygen depletion and the production of noxious gases.

The indirect effects of suspended solids are related to the pollutants that may be retained on them by adsorption. Persistent chemicals, such as mercury and other metals, DDT, PCBs and a number of other organic substances, which can be retained on suspended solids create a completely different hazard. Following entry into the marine environment, these

[11] Ref. UNEP/MAP: Protecting the Mediterranean from land-based pollution, UNEP/MAP, Athens, 2001.

adsorbed chemicals accumulate in plants and animals as they pass through the marine food chain, reaching their highest levels in filter-feeders, such as bivalve molluscs, and in large predatory fish, such as tuna and swordfish. Effects on humans through the consumption of chemically contaminated seafood are essentially long-term, depending on the adsorbed chemicals themselves, as well as the rate and amount of intake. In general, the principal risk is restricted to those individuals consuming seafood more than two to three times a week, although the risk varies with the type of seafood, the concentration of pollutants and the circumstances of the consumer.

Pathogenic organisms, especially in the case of mixed wastewater discharge, may also be adsorbed on suspended solid and produce different diseases or adverse health effects in human beings and certain marine organisms. The main effects of those pathogenic organisms attached to the suspended solids are summarized in the following:

- *Salmonella*: they are the agents of typhoid and paratyphoid fevers, food poisoning and gastroenteritis, but they have only a short life in sea water; in contrast, they are accumulated in food and, if at a sufficient density, can cause disease.
- *Shigella*: they are the agents of bacillary dysentery, but they have only a short life in sea water.
- *Vibrio*: *V. choleræ* is the agent of cholera, but others are the agents of gastroenteritis, and still others are agents of otitis, sore throat and wound infections.
- *Staphylococcus*: they may cause infections in the skin, skin glands and mucus membranes, meningitis, furunculosis, pyæmia, osteomyelitis, and food poisoning (*S. aureus*). These genera have a relatively long life in sea water.
- *Pseudomonas*: they may cause infections of the ear and eye, of wounds, burns and the urinary tract, and enteritis.
- *Aeromonas*: they may cause diarrhoea, pneumonia, abscesses and wound infections.
- *Enteroviruses*: they may cause paralysis, meningitis, respiratory disease, rash, diarrhoea, fever, herpangina, myocarditis, pleurodynia, encephalitis, hæmorrhagic conjunctivitis.

4. MAIN INDUSTRIAL SECTORS THAT GENERATE BOD, NUTRIENTS AND SUSPENDED SOLIDS ACCORDING TO SAP

4.1 Sectors Identification

As these guidelines are intended to support industrial sustainability in the Mediterranean region, it takes for granted the importance of the industrial sector as a major pillar in the economy of all countries in the region, with an average industrial added value of 30%[12]. The approach taken in these guidelines recognizes the paramount importance of industrial development but also focuses on highlighting the pressure put on the environment by uncontrolled industrial development, and looks finally at solutions with the potential to support industry development, as well as the protection of the environment.

The LBS Protocol identified in its Annex I twenty-one sectors of activity that are industrial, among a total of thirty sectors primarily considered. This provides evidence on the importance of industrial development of the Mediterranean countries and also its capacity to generate pollution and cause damage to the environment, consequently posing potential risk for surface water and groundwater quality in the Mediterranean region.

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[12] Source: World development indicators, World Bank. April 2001.

Particular attention in these guidelines is focussed on industrial sectors that are major sources of biochemical oxygen Demand (BOD), nutrients (nitrogen and phosphorous), and suspended solids. Although they are less persistent and much more localized than other toxic persistent and bioaccumulable pollutants (TPBs) for instance, these pollutants are nevertheless generated in large quantities by some industries and their discharge into the environment can cause damage to human health, ecosystems, habitats and biodiversity.

The Strategic Action Program to address pollution from land-based activities (section 5.2.5) identifies the following sectors as most important industrial sources of suspended solids, biodegradable organic matter and nutrients:

- Manufacture of food and beverages: slaughtering, preparing and preserving meat; manufacture of dairy products; canning & preserving of fruit and vegetables; preserving & processing of fish, crustaceans and similar food; manufacture of vegetable oils and fats; sugar factories and refineries; distillation; wine production; beer manufacture;
- Manufacture of textiles: wool and cotton processing;
- Tanneries and the leather finishing industry;
- Paper and paper-pulp industry;
- Phosphatic fertilizers industry;
- Pharmaceutical industry: basic substances (fermentation and extraction processes).

Other sectors, such as the chemical sector, are generating this kind of pollution (BOD, nutrients and suspended solids) but are not mentioned in the SAP as the main industrial sources of this kind of pollution.

In this chapter each of the sectors identified by the SAP will be briefly presented and its waste characteristics highlighted to show its relative importance and its potential environmental impacts. The pollution load levels indicted represent typical levels for the sector studied and should be considered as guidelines and not absolute figures.

The volume and pollutant load of industrial wastewaters are usually defined in terms of units of production (e.g. Kilograms of BOD per ton of pulp, for a pulp and paper mill waste) and the variation in characteristic by statistical distribution. The magnitude of the variation will depend on the diversity of products manufactured and of process operations contributing to waste, and on whether the operations are batch or continuous. Usually an industrial waste survey is required to establish waste loads and their variations through a material balance of all processes using water and producing waste. As such a survey is not part of the elaboration of the guidelines, description of waste characteristics was based on the referenced documentation and studies undertaken about the industrial sectors that are major sources of BOD, nutrients and suspended solids either in the Mediterranean region or worldwide.

4.2 Industrial Sectors Description and Waste Characteristics

4.2.1 Food and beverage industry

The food and beverage industry is made up of various branches that have a common denominator in term of discharge of effluents with high organic content that is directly linked to high consumption of water and energy, as well the generation of solid wastes and sometimes odour and noise.

Emissions from the food and drink industry are mostly readily biodegradable organic matter and could be considered as relatively benign compared to many other industrial sectors.

However, in large quantity, pollution in waste water and waste produced by the industry may represent a very significant load in some Mediterranean countries.

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

The BOD content of the main food constituents is:

Table 2
BOD equivalent of food constituents

Food component	kg BOD_5/kg food constituent[13]
Carbohydrate	0.65
Fats	0.89
Protein	1.03

BOD_5 from food plants is directly related to food products in the wastewater. In fact, BOD_5 can be estimated in food plant wastewaters by determining the fat, protein and carbohydrate in a particular wastewater and using the factors given in **Table 2**.

Suspended solids concentration varies from negligible to as high as 120,000 mg/L. Waste water from some sub-sectors (e.g. dairy, meat) has high concentrations of fats and oils.

Food processing waste waters vary from the highly alkaline (pH 11) to the highly acidic (pH 3.5).

A more detailed picture of the food industry is given through the presentation of some of the important sub-sectors that are characterized as major sources that generate BOD, nutrients and suspended solids.

4.2.1.1 Dairy industry

4.2.2.1.1 Industry overview

The dairy industry involves processing raw milk into products such as consumer milk, butter, cheese, yogurt, condensed milk, dried milk (milk powder), and ice cream, using processes such as chilling, pasteurization, and homogenization.

The processes taking place at a typical milk plant includes:

- receipt and filtration/clarification of the raw milk;
- separation of all or part of the milk fat (skimming) and standardisation (for standardisation of market milk, production of cream and butter and other fat-based products, and production of milk powders);
- pasteurisation;
- homogenisation (if required);
- deodorisation (if required);
- further product-specific processing;
    - o addition of culture and incubation for yogurt
    - o coagulation, cutting and draining, moulding and pressing, salting, drying and aging for cheese

[13] Pollution Prevention and Abatement Handbook, the World Bank, 1998.

  - o deodorization and packaging for cream
  - o deodorization, curing, churning, and packaging for butter
- packaging and storage, including cold storage for perishable products;
- distribution of final products.

Typical by-products include buttermilk, whey and their derivatives.

4.2.1.1.2 Waste water characteristics

The dominant environmental issue caused by dairy processing is the discharge of large quantities of liquid effluent.

Dairy effluents contain dissolved sugars and proteins, fats, and possibly residues of additives. The key parameters are biochemical oxygen demand (BOD), with an average ranging from 0.8 to 2.5 kilograms per metric ton (kg/t) of milk in the untreated effluent; chemical oxygen demand (COD), which is normally about 1.5 times the BOD level; total suspended solids, at 100–1,000 milligrams per litre (mg/L); phosphorus (10–100 mg/L), and nitrogen (about 6% of the BOD level). Cream, butter, cheese, and whey production are major sources of BOD in wastewater. The waste load equivalents of specific milk constituents are: 1 kg of milk fat = 3 kg COD; 1 kg of lactose = 1.13 kg COD; and 1 kg protein = 1.36 kg COD. The wastewater may contain pathogens from contaminated materials or production processes. A dairy often generates odours and, in some cases, dust, which needs to be controlled. Most of the solid wastes can be processed into other products and by-products.

Typical pollution loads & concentration released with the wastewater from the dairy industry are indicated in the following table:

Parameter	Typical pollution levels & concentration from the dairy industry[13]
BOD_5	0.8 to 25 kg/t
TSS	100 to 1,000 mg/L
Nitrogen	6% of BOD_5
Phosphorus	10 to 100 mg/L

kg/t: kilograms per metric ton of milk

4.2.1.2 <u>Breweries</u>

4.2.1.2.1 Industry overview

Beer is a fermented beverage with low alcohol content made from various types of grain. Barley predominates, but wheat, maize, and other grains can be used. The production steps include:

- Malt production and handling,
- Wort production,
- Beer production.

4.2.1.2.2 Waste characteristics

Untreated effluents typically contain suspended solids in the range 10–60 milligrams per litre (mg/L), biochemical oxygen demand (BOD_5) in the range 1,000–1,500 mg/L, chemical oxygen demand (COD) in the range 1,800–3,000 mg/L, and nitrogen in the range 30–100 mg/L. Phosphorus can also be present at concentrations of the order of 10–30 mg/L.

Effluents from individual process steps are variable. For example, bottle washing produces a large volume of effluent that, however, contains only a minor part of the total organics discharged from the brewery. Effluents from fermentation and filtering are high in organics and BOD but low in volume, accounting for about 3% of total wastewater volume but 97% of BOD. Effluent pH averages about 7 for the combined effluent but can fluctuate from 3 to 12 depending on the use of acid and alkaline cleaning agents. Effluent temperatures average about 30°C.

Typical pollution concentration range released with the wastewater from breweries are indicated in the following table[13]:

Parameter	Typical pollution concentration range from breweries
BOD_5	1,000–1,500 mg/L
TSS	10–60 mg/L
Ammonia nitrogen	30–100 mg/L
Total phosphorous	10–30 mg/L

4.2.1.3 Vegetable oil processing

4.2.1.3.1 Industry overview

The vegetable oil processing industry involves the extraction and processing of oils and fats from vegetable sources (fruits, seeds, nuts and a variety of fruits). The preparation of raw materials includes husking, cleaning, crushing, and conditioning.

The extraction processes are generally mechanical (boiling for fruits, pressing for seeds and nuts) or involve the use of solvents such as hexane. After boiling, the liquid oil is skimmed; after pressing, the oil is filtered; and after solvent extraction, the crude oil is separated and the solvent is evaporated and recovered. Residues are conditioned (for example, dried) and are reprocessed to yield by-products such as animal feed.

Crude oil refining includes degumming, neutralization, bleaching, deodorization, and further refining.

Special case of olive oil

Production of olive oil is one of the most important activities in the vegetable oil processing agro-food sub-sector, and is essentially concentrated in the Mediterranean basin countries. 1/3 of the worldwide production of olive oil is concentrated in Spain and 3/4 in the EU Mediterranean countries[14]. The industrial process of oil extraction generates a great quantity of by-products and residues (spent olives and vegetable waters).

4.2.1.3.2 Waste water characteristics

The wastewater is high in organic content, resulting in a biochemical oxygen demand (BOD_5) of 20,000–35,000 milligrams per litre (mg/L) and a chemical oxygen demand (COD) of 30,000–60,000 mg/L. In addition, the wastewaters are high in dissolved solids (up to 10,000 mg/L), oil and fat residues (5,000–10,000 mg/L), organic nitrogen (500–800 mg/L), and ash residues (4,000–to 5,000 mg/L).

Typical pollution concentration range released with the wastewater from vegetable oil processing industry are indicated in the following table[13]:

[14] Pollution prevention in olive oil production, Regional Activity Centre for Cleaner Production (RAC/CP), Mediterranean Action Plan, November 2000.

Parameter	Typical pollution concentration range from vegetable oil processing industry
BOD_5	20,000–35,000 mg/L
TSS	Up to 10,000 mg/L
Total Nitrogen	500–800 mg/L

4.2.1.4 Meat processing and slaughtering

4.2.1.4.1 Industry overview

The meat processing and rendering industry includes the slaughter of animals and fowl, processing of the carcasses into cured, canned, and other meat products, and the rendering of inedible and discarded remains into useful by-products such as lards and oils.

Since livestock slaughter along with its associated activities contributes the most to pollution loads from the meat processing industry as a whole, these guidelines pay particular attention to slaughterhouse operations.

Processing operations at slaughterhouses vary depending on the type of animal which is being slaughtered. The most significant difference is that the hide is removed for sheep and cattle whereas for pigskins, only the bristles are usually removed. Other differences relate to the difference in animal physiology. Cattle and sheep are ruminants (three stomachs) whereas pigs are mono-gastrics (single stomach).

The slaughter process, although relatively labour intensive, is becoming increasingly automated. Machinery is being developed to increasingly mechanise carcass dressing and this tends to incorporate washing at every stage. Up to 90 cattle and 600 pigs can be killed in one hour. Slaughterhouses can, therefore, typically kill thousands of pigs and hundreds of cattle daily.

For large animals, the main steps in slaughter processing are:

- Animal reception and lairage;
- Stunning and slaughter;
- Bleeding;
- Hide removal and conditioning;
- Head and hoof removal for cattle and sheep;
- Pig scalding (for pigs);
- Pig hair and toenail removal (for pigs);
- Pig singeing (for pigs);
- Rind treatment;
- Evisceration and viscera conditioning;
- Splitting;
- Chilling.

For poultry, the main steps in slaughter processing are:

- Reception of birds;
- Stunning and bleeding;
- Scalding;

- De-feathering;
- Evisceration;
- Chilling;
- Maturation.

4.2.1.4.2 Waste characteristics

The most significant environmental impact resulting from slaughtering activities is emissions to water (wastewater from a slaughterhouse can contain blood, manure, hair, fat, feathers, and organic waste such as muscle, bones, ...). This is related to water consumption, which is the other major environmental issue. High water consumption and high BOD, COD and TSS concentrations in waste water are characteristic features of slaughterhouses. Contamination arises mostly during slaughter and also carcass dressing. The solids break down, releasing colloidal and suspended fats and solids and the BOD and COD increase.

In any slaughterhouse, a major factor affecting water consumption is the amount of floor area used. For hygiene reasons, all process floor areas must be washed down at least after every slaughter session.

Water consumption is, therefore, highly dependant on the layout of individual slaughterhouses and in poultry slaughterhouses will also depend on, e.g., the size of animals; method of slaughter and carcass dressing as well as the degree of automation. Large quantities of water are consumed in poultry slaughterhouses for evisceration, cleaning and washing operations. Blood has the highest COD strength of any liquid effluent arising from both large animal and poultry slaughterhouses. The polluting potential of blood and the huge quantities which are handled and stored, therefore, make it a key environmental issue for assessment and control. It is important that this issue is considered with respect to potential contamination of water from the process, from small leaks and from major technical and operational accidents.

Typical pollution loads released with the wastewater from the slaughtering sector are indicated in the following table[13]:

Parameter[15]	Typical pollution levels from slaughtering sector		
	Cattle	Pigs	Poultry
BOD_5 (kg)	1.8 – 5.2	2.14 – 10	2.62 – 26.43
TSS (g)	300 – 10,000	120 – 5,100	48 – 700
N (g)	172 – 1,840	180 – 2,100	560 – 2,857
P (g)	24.8 – 260	20 – 220	26.2 – 202

Waste characteristics from the overall meat industry include the potential for generating large quantities of waste-water with a biochemical oxygen demand (BOD_5) of 600 milligrams per liter (mg/L). BOD_5 can be as high as 8,000 mg/L, or 10–20 kilograms per metric ton (kg/t) of slaughtered animal; and suspended solids levels can be 800 mg/L and higher.

In some cases, offensive odours may occur. The amounts of wastewater generated and the pollutant load depend on the kind and quantity of meat being processed. For example, the processing of gut has a significant impact on the quantity and quality (as measured by levels of BOD and of chemical oxygen demand, COD) of wastewater generated.

[15] All per ton of carcass

The wastewater may be at a high temperature and may contain organic material and nitrogen, as well as such pathogens as salmonella and shigella bacteria, parasite eggs, and amoebic cysts.

Typical pollution concentration range released with the wastewater from the meat processing industry are indicated in the following table[13]:

Parameter	Typical pollution concentration range in wastewater from the meat industry
BOD_5	600-8,000 mg/L
Suspended solids	100-500 mg/L
Total nitrogen	100-200 mg/L
Total phosphorous	10-20 mg/L

4.2.1.5 Fruit & vegetable processing

4.2.1.5.1 Industry overview

The fruit and vegetable processing industries include the steps of fresh pack, processing, canning and preserving. The processing segment, or packers, includes all unit operations extending the shelf life of food being processed and adding value through product modification to satisfy market niches. The preservation of fruit and vegetables is achieved through canning, drying or freezing, and by the preparation of juices, jams and jellies. Preserving includes raw material preparation, cooking, canning and freezing.

Major water use and waste generation points associated with the fruit and vegetable industry include the washing steps for raw and processed product, peeling and pitting practices, blanching, fluming the product after blanching, sorting, and conveying the product within the plant. Reducing size, coring, slicing, dicing, pureeing, and juicing process steps, as well as filling and sanitizing activities after processing, also contribute to the waste stream.

4.2.1.5.2 Waste water characteristics

Major wastewater characteristics to be considered for the vegetable and fruit processing industry are the wide ranges of wastewater volume and the concentrations of organic materials. Wastewater characteristics can be influenced by a number of factors such as the commodity processed, the process unit operations used, the daily production performance level, and the seasonal variation, e.g., growing condition and crop age at harvest.

The fruit and vegetable industry typically generates large volumes of effluents and solid waste. The effluents contain high organic loads, cleansing and blanching agents, salt, and suspended solids such as fibres and soil particles. They may also contain pesticide residues washed from the raw materials. The main solid wastes are organic materials, including discarded fruits and vegetables.

The following table[16] gives representative wastewater loads per ton of product produced associated with typical vegetable and fruit raw products.

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[16] Waste Management and Utilization in Food Production and Process, CAST, October 1995.

Crop	Minimum flow (m^3/ton)	Medium flow (m^3/ton)	Maximum flow (m^3/ton)
Vegetable products			
Asparagus	7.19	32.18	109.78
Bean, snap	4.92	15.90	42.40
Broccoli	15.52	34.83	79.49
Carrot	4.54	12.49	26.88
Cauliflower	45.42	64.35	90.85
Pea	7.19	20.44	53.00
Pickle	5.30	13.25	41.64
Potato, sweet	1.51	8.33	36.72
Potato, white	7.19	13.63	24.98
Spinach	12.11	33.31	87.06
Squash	4.16	22.71	83.28
Tomato, peeled	4.92	8.33	14.01
Tomato, product	4.16	6.06	9.08
Fruit Products			
Apple	0.76	9.08	49.21
Apricot	9.46	21.20	53.00
Berry	6.81	13.25	34.45
Cherry	4.54	14.76	53.00
Citrus	1.14	11.36	35.20
Peach	5.30	11.36	23.85
Pear	6.06	13.63	29.15
Pineapple	9.84	10.22	14.38
Pumpkin	1.51	10.98	41.64

4.2.1.6 Canning and preserving

4.2.1.6.1 Canning and preserving fruit

Preserves such as jams, marmalade and mincemeat are preserved by the use of high concentrations of sugar which suppress the growth of micro-organisms. The basic ingredients of a preserve are fruit, sweetening agents (typically sucrose and/or various sugar syrups), acids and buffers (typically citric or malic acid and buffers such as trisodium citrate), fats (in curds/mincemeat), citrus peel (mincemeat and marmalade), gelling agents (usually pectin) and anti-foaming agents. In a typical process for preserve manufacture, fruit usually arrives pre-prepared either frozen or sulphited and transferred to appropriate storage. The prepared fruit, pectin, sucrose, glucose syrup and other small ingredients are then blended together in a mixing vessel. The mix is boiled either at atmospheric pressure or under vacuum using batch or continuous methods. After boiling, the jam is filled into containers which vary from individual portions to bulk tankers for bakery use.

Dried fruit processing uses raw materials such as grapes, apricots, pears, bananas and plums. A basic process consists of fruit harvesting, drying, sorting, grading, washing and packing. Many fruits are sun dried at source although some producers use mechanical methods (typically tunnels through which hot air is passed). Some fruits are sulphited before drying; this preserves the fruit and softens the fruit tissue resulting in a faster loss of moisture during drying. In some cases, the fruit is sprayed or dipped after harvesting with potassium carbonate solution also containing “dipping oil”. The composition of the dipping oil varies between producers, for example, some producers use olive oil, others may use mixtures of ethyl esters of fatty acids and free oleic acid.

4.2.1.6.2 Canning and preserving vegetables

In a typical preserving process, raw vegetables are delivered and subjected to washing and screening operations to remove extraneous matter such as stones.

Most vegetables destined for canning, freezing or drying must first be blanched, typically using hot water or steam. If the product is to be frozen, blanching is followed by water cooling (in a cold water flume or with sprays) or air cooling.

Both liquid and steam blanching produce waste water high in BOD; in some cases over half of the total BOD load. The volume of waste water is less with steam blanching than with liquid blanching. The quantity of waste water from steam blanching can be reduced by steam recycling, effective steam seals and equipment designs that minimise steam consumption.

Depending upon the vegetable, the raw material may be steam cooked and then cooled. The product is then peeled (typically using steam) and re-inspected before being cut to the required dimensions, e.g. sliced/diced/shredded and transported to the filling line. The chopped vegetables are then filled into containers. An acidifying liquor is mixed with spices and transferred to the filling line to be used in the pickling sauce. This liquor typically consists of acetic acid, malt vinegar, spirit vinegar, distilled malt vinegar, liquid sugar and salt depending upon the formulation. The acidifying liquor is deposited into the containers. The container is sealed and typically pasteurised (e.g. hot filling and hot water spray tunnel) before cooling and packaging.

Waste water characteristics in those sub-sector are affected by various factors, including the raw material being processed, seasonal and source variations in the raw material, the unit operations, production patterns and operator practice. Typically the waste water is high in suspended solids, organic sugars and starches. Residual pesticides that are difficult to degrade during waste water treatment may be a concern, especially with product imported from countries with less stringent controls on pesticide use.

4.2.1.6.3 Canning and preserving meat

Canned meats must be heat-processed to achieve pasteurisation or shelf stability. The use of hot water or direct steam heating for cooking produces waste water contaminated with fat, protein and fragments of meat.

4.2.1.7 <u>Winery and distillery</u>

This sub-sector includes:

- manufacture of wine from grapes and from concentrated grape must;
- manufacture of grape juice;
- manufacture of fruit wines and other fermented fruit beverages;
- manufacture of malt;
- manufacture of cider and perry;
- manufacture of distilled alcoholic beverages;
- production of ethyl alcohol by fermentation.

Processes for the manufacture of different beverages share common sources of waste water, including:

- plant and equipment cleaning;
- washing of containers (bottles, cans, casks);

- pasteurisation of containers;
- floor washing;
- once-through cooling water or bleed from closed loop cooling systems;
- boiler blowdown;
- backwash from water treatment systems;
- "chase" water purged from pipework between uses.

4.2.1.7.1 Waste characteristics

The preparation and cleaning of equipment is the largest source of waste water in this sector. The cleaning of fermenter vessels in particular is a major source of COD/BOD and suspended solids load. Proprietary products used in the cleaning process (e.g. clay, disinfectants, detergents, sanitizing agents) contribute to the waste water loadings. Dilute solutions of peracetic acid, a widely used sanitizing agent, have a COD of approximately 1000 mg/L.

In addition to these point sources, overflowing vessels and tanks often make a significant contribution to the waste water load.

In the distillery case, the major sources of waste water are the cooling water system, which serves the condensers and fermentation tanks, and the residues (vinasses, mostly wastes from fermentation and waste waters as well as waste products; and sludge from the distillation towers).

In the cider and perry installation, there are two main processes which liberate waste water:

- production of final product from must;
- milling of fruit.

The production of the final product occurs all year round, whereas the milling of fruit is dictated by the harvesting of the fruit itself.

The waste water from the production of the final product is generally generated from wash water, waste product (kept to a minimum), and spillages from storage areas etc.

During the milling season the waste water volumes and loads increase significantly. The main sources of waste water during this period are:

- transport water (conveying the fruit through the process);
- surplus evaporator water (from juice concentrating);
- general waste (wash water etc).

The transport water is recycled as often as possible, however, this waste water is high in load. Towards the middle of the milling season, flows and loads increase due to the quantity of fruit entering an installation. Towards the end of the milling season the volume of waste water decreases; however, the BOD and solids content of the waste water increases due to the deteriorating quality of the fruit being received.

In the malt production case, the main sources of waste water are the discharge from the steeping tanks and the cooling system for the germination stage.

4.2.1.8 Fish processing

4.2.1.8.1 Industry overview

The fish processing industry[17] is very widespread and quite varied in terms of types of operation, scales of production and outputs. The species of fish processed in the Mediterranean include in particular, tuna, sardines, anchovy and mackerel.

Fish processing most commonly takes place at on-shore processing facilities. However some processing can take place at sea, on board fishing vessels.

The end products from fish processing may be fresh, frozen or marinated fillets, canned fish, fish meal, fish oil or fish protein products.

These guidelines will focus on some prominent aspects of the fish processing industry in the Mediterranean region such as the filleting of fish, the canning industry and fish meal.

- The process of filleting of white fish involves a number of unit operations: pretreatment, fish filleting, trimming of fillets, packing and storage.
- The canning process depends on the size of the fish. Small fish species such as sardines are generally canned whole, with only the heads and tails removed. These whole-fish products are cooked in the can after it has been filled with brine or oil. Medium-sized fish species are cut into pieces and pre-cooked in the can before the can is filled with brine or oil. For large fish species such as mackerel and tuna, the fish are filleted, cut into pieces of suitable size and also precooked in the can. Bones and inedible parts are removed when large fish species such as tuna are canned. After precooking, the liquid is drained from the cans and oil, brine or sauces are added. The cans are then sealed, sterilised and stored.
- Fish meal processing consists of transporting the fish from storage by screw conveyors to a cooking process which acts to coagulate the protein. The cooked mixture is then screened, using a strainer conveyor or a vibrating screen, and then pressed to remove most of the water from the mixture.

  The pressed cake is shredded and dried, using an indirect steam drier or a direct flame dryer. The meal passes through a vibrating screen and on to a hammer mill, which grinds it to the appropriate size. The ground meal is automatically weighed and bagged.

Shellfish processing

Shellfish are processed and preserved by a large variety of methods and may be consumed in their primary form, raw or cooked. Preservation methods involved in shellfish processing include:

- freezing;
- chilling;
- canning;
- curing (drying, salting, smoking, fermenting, acid curing);
- modified atmosphere packaging (MAP).

For canned shellfish processing (the most polluting preservation method), washing and trimming raw shellfish (which are often transported under a rocking motion through a

[17] Cleaner Production Assessment in Fish Processing, UNEP - Division of Technology, Industry and Economics and The Danish Environmental Protection Agency, 2000.

scalding system to open the shells and dislodge the flesh) are essential to remove sand and mud, they are then steamed in cooking/cooling tunnels. After steaming, the flesh is filled into cans, which contain either brine, oil or sauce. The cans are sealed by passage through a can seamer. After seaming, the cans pass into a retort for sterilization. Here the product is heated for a time at a sufficient temperature to inactivate food poisoning micro-organisms. The product is then cooled with chlorinated water.

Nearly all those steps (except sterilization of cans) are high BOD and SS producers.

In the case of shrimp processing, the wastewater from most breaded seafood shrimp plants exceeds 2,000 mg/L of BOD_5. It often contains large amounts of organic matter, small particles of shrimp flesh, breading, soluble proteins, and carbohydrates.

4.2.1.8.2 Waste characteristics

Effluent streams generated from fish processing contain high loads of organic matter due to the presence of oils, proteins and suspended solids. They can also contain high levels of phosphates and nitrates.

Sources of effluent from fish processing include the handling and storage of raw fish prior to processing, fluming of fish and product around the plant, defrosting, gutting, scaling, portioning and filleting of fish and the washing of fish products. For operations where skinning is carried out, the effluent can have a high pH due to the presence of caustic.

In canning operations, the effluent is also discharged from the draining of cans after precooking, from the spillage of sauces, brines and oil in the can filling process, and from the condensate generated during precooking.

In fish meal and fish oil production, sources of effluent are bloodwater from unloading the vessels, bloodwater from intermediate storage of fish, stickwater from the centrifuges, condensate from the evaporators and cleaning in general.

Effluent quality is highly dependent upon the type of fish being processed. Pollution loads generated from the processing of oily fish species are much higher than from white fish species, due to the high oil content and the fact that these species are usually not gutted or cleaned on the fishing vessel. The entrails from the gutting of oily fish contain high levels of easily soluble substances, which generally find their way to the effluent stream.

Effluent quality also depends on the type of processing undertaken. For example, additional pollution loads arise from the pickling of fish. Brine is used in this process, the wastewaters from which contain salts and acids, making them difficult to treat.

Fish processing and canning is also notorious for its large consumption of water, energy and generation of solid wastes.

Typical pollution loads released with the wastewater from the fish processing industry are indicated in the following table:

Typical pollution levels from fish processing				
Parameter	Filleting		Canning[17]	
	White fish	Oily fish	Sardine	Tuna
BOD_5	35 kg/t	50 kg/t	9 kg/t	15 kg/t
TSS			5 kg/t	11/kg/t

kg/t: kilogram per ton of raw material

4.2.1.9 Sugar manufacturing

4.2.1.9.1 Industry overview

The sugar industry processes sugar cane and sugar beet to manufacture edible sugar.

For processing sugar cane, the industry uses approximately 20 cubic meters of water per metric ton (m^3/t) of cane processed. Sugar cane contains 70% water; 14% fibre; 13.3% saccharose (about 10 to 15% sucrose), and 2.7% soluble impurities.

Sugar canes are generally washed, after which the juice is extracted from them. The juice is clarified to remove mud, evaporated to prepare syrup, crystallized to separate out the liquor, and centrifuged to separate molasses from the crystals. Sugar crystals are then dried and may be further refined before bagging for shipment.

For processing sugar beet (water, 75%; sugar, 17%), only the washing, preparation, and extraction processes are different. After washing, the beet is sliced, and the slices are drawn into a slowly rotating diffuser where a countercurrent flow of water is used to remove sugar from the beet slices. Approximately 15 cubic meters (m^3) of water and 28 kilowatt-hours (kWh) of energy are consumed per metric ton of beet processed.

Sugar refining involves removal of impurities and decolourisation. The steps generally followed include affination (mingling and centrifugation), melting, clarification, decolourisation, evaporation, crystallization, and finishing. Decolourisation methods use granular activated carbon, powdered activated carbon, ion exchange resins, and other materials.

4.2.1.9.2 Waste characteristics

Sugar manufacturing effluents typically have biochemical oxygen demand (BOD_5) of 1,700–6,600 milligrams per litre (mg/L) in untreated effluent from cane processing and 4,000–7,000 mg/L from beet processing; chemical oxygen demand (COD) of 2,300–8,000 mg/L from cane processing and up to 10,000 mg/L from beet processing; total suspended solids of up to 5,000 mg/L; and high ammonium content. The waste-water may contain pathogens from contaminated materials or production processes.

Besides, a sugar mill often generates air emissions resulting primarily from the combustion of bagasse (the fibre residue of sugar cane), fuel oil, or coal. Other emissions that need to be controlled, such as odour and dust, are also generated. Most of the solid wastes can be processed into other products and by-products. In some cases, pesticides may be present in the sugar cane rinse liquids.

Typical pollution concentration released with the wastewater from sugar production are indicated in the following table[13]:

Parameter		Typical pollution concentration range from the sugar industry
BOD_5	Cane processing	1,700 – 6,600 mg/L
	Beet processing	4,000 – 7,000 mg/L
TSS		up to 5,000 mg/L

4.2.2 Textile sector wet processes

4.2.2.1 Industry overview

The textile industry uses vegetable fibres such as cotton; animal fibres such as wool and silk; and a wide range of synthetic materials such as nylon, polyester, and acrylics. It is a fragmented and heterogeneous sector, composed of a wide number of sub-sectors. It also exhibits a typical variation in scale, ranging from large-scale mechanized to small-scale traditional units. These guidelines focus in particular on textile wet processing because of its significant environmental impacts and contribution to pollution loads associated with organic matter and suspended solids.

The stages of wet textile operations are:

- Preparatory processing which includes desizing, scouring, mercerizing and bleaching;
- Dyeing;
- Printing and finishing.

At all these stages, liquid waste is generated and tends to dominate over air emissions and solid wastes. The discharge of such effluents in aquatic bodies can cause lowering of oxygen and threats to aquatic life and downstream water users.

4.2.2.2 Effluents characteristics

The nature of waste generated depends on the type of textile facility, the processes being operated and the fibres used. Process wastewater is a major source of pollutants. It is typically alkaline and has high BOD_5 -from 700 to 2,000 milligrams per litre (mg/L)- and high chemical oxygen demand (COD), at approximately 2 to 5 times the BOD as bleaching, grease and AOX. Dye waste-waters are frequently highly coloured, may contain heavy metals such as copper and chromium, as well as salts. Printing and finishing generate emissions of VOCs.

Typical pollution loads in wastewater from the wet textile processing according to the different operations is indicated in the table below:

Process		BOD_5	COD	TSS	TDS
		kg per 1000 kg of product			
PREPARATORY PROCESSING (100% cotton)	**Desizing**				
	Enzyme starch	45.5	91.0	89.0	5.0
	Acid starch	45.5	91.0	89.0	7.50
	Polyvinyl alcohol (PVA)	2.5	5.0	5.0	7.5
	Carboxymethyl cellulose (CMC)	4.0	8.0	5.0	45.0
	Scouring				
	Unmercerized greige fabric	21.5	64.5	5.0	50.0
	Mercerized greige fabric	16.5	49.5	5.0	50.0
	Mercerizing				
	Greige fabric	13.0	39.0	5.0	148.0
	Scoured fabric	4.0	12.0	5.0	148.0
	Bleached fabric	2.0	6.0	5.0	148.0
	Bleaching				
	Hydrogen peroxide (woven goods)	0.5	2.0	4.0	22.0
	Sodium hypochlorite (woven goods)	1.0	4.0	4.0	5.0

DYEING PROCESS (50/50% Polyester/Cotton)	Direct and disperse dyeing (woven goods)	10.7	32	-	114
	Vat and disperse dyeing (woven goods)	22.8	68	-	122
	Sulphur and disperse dyeing (woven goods)	22.8	68	-	69.7
	Naphtol and disperse dyeing (woven goods)	13.8	41	-	57.2
	Fibre reactive and dispersive dyeing (woven goods)	13.8	41	-	192
PRINTING & FINISHING (50/50% Polyester/cotton)	**Printing**				
	Pigment (woven goods)	1.26	5.0	0.13	2.5
	Pigment (knot goods)	1.26	5.0	0.13	2.5
	Vat dye (woven goods)	21.5	86	25	34
	Vat dye (knot goods)	21.5	86	25	35
	Finishing				
	Resin finishing flat curing (woven goods)	6.32	25	12	17.3

(Adapted from UNEP DTIE, Cleaner Production in Textile Wet Processing, A workbook for trainers, March 1996.)

4.2.3 Tanning and leather finishing

4.2.3.1 Industry overview

The tannery operation consists of converting the raw hide or skin, a highly putrescible material, into leather, a stable material, which can be used in the manufacture of a wide range of products. The whole process involves a sequence of complex chemical reactions and mechanical processes. Leather production usually involves four distinct phases:

- Preparation of the hides (in the beamhouse);
- The tanning process to make leather (in the tanyard);
- The post-tanning, dyeing and fat-liquoring process;
- Finishing the leather (surface treatment).

The manufacturing process generally consists of:

- Soaking and washing to remove salt, restore the moisture content of the hides, and remove any foreign material such as dirt and manure;
- Liming to open up the collagen structure by removing interstitial material;
- Fleshing to remove excess tissue from the interior of the hide;
- Dehairing or dewooling to remove hair or wool by mechanical or chemical means (not applicable for double-face leather);
- Deliming, bating and pickling to delime the skins and condition the hides to receive the tanning agents;
- Degreasing (sheep and goatskin mainly) to remove the natural fat;
- Tanning to stabilize the hide material and impart basic properties to the hides;
- Retanning, dyeing, and fat-liquoring to impart special properties to the leather, increase penetration of tanning solution, replenish oils in the hides, and impart colour to the leather;
- Finishing to attain final product specifications.

4.2.3.2 Waste water characteristics

The potential environmental impacts of tanning are significant. Composite untreated wastewater, amounting to 20–80 cubic meters per metric ton (m^3/t) of hide or skin, is turbid, coloured, and foul smelling. It consists of acidic and alkaline liquors, with chromium levels of 100–400 milligrams per litre (mg/L); sulfide levels of 200–800 mg/L; nitrogen levels of 200–1,000 mg/L; biochemical oxygen demand (BOD_5) levels of 900–6,000 mg/L, usually ranging from 160 to 24,000 mg/L; chemical oxygen demand (COD) ranging from 800 to 43,000 mg/L in separate streams, with combined wastewater levels of 2,400 to 14,000 mg/L; chloride ranging from 200 to 70,000 mg/L in individual streams and 5,600 to 27,000 mg/L in the combined stream; and high levels of fat. Suspended solids are usually half of chloride levels.

Wastewater may also contain chrome, colour, residues of pesticides used to preserve hides during transport, as well as significant levels of pathogens. Significant volumes of solid wastes are produced, including trimmings, degraded hide, and hair from the beamhouse processes. The solid wastes can represent up to 70% of the wet weight of the original hides. In addition, large quantities of sludge are generated. Decaying organic material produces strong odours. Hydrogen sulfide is released during dehairing, and ammonia is released in deliming. Air quality may be further degraded by release of solvent vapours from spray application, degreasing, and finishing.

Conventional range of concentrations released with the wastewater from the tanning industry are indicated in the following table[13]:

Parameter	Typical pollution concentration levels in composite untreated wastewater from the tanning industry
BOD_5	900–6,000 mg/L
TSS	100 to 35,000 mg/L

The major source of organic matters and suspended solids is associated with the beamhouse processing as indicated in the table below[18]:

Process	BOD_5	COD	N Ammonia
Beamhouse processing	43.5 kg/t	133.3 kg/t	54 kg/t

kg/t: kg per 1,000 kg of raw hide

4.2.4 Pulp and paper

4.2.4.1 Industry overview

The pulp and paper industry is very diversified, using many types of raw materials to produce different kinds of paper by different methods in mills of all sizes. Pulp mills and paper mills may exist separately or as integrated operations.

Raw materials contain cellulose fibres, generally wood, recycled paper, and agricultural residues.

Paper production is basically a two-step process in which a fibrous raw material is converted into pulp, and then the pulp is converted into paper. The main processing operations are:

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[18] Adapted from UNEP DTIE, Cleaner Production in Tanning Processing, A work book for trainers, March 1996.

- Raw material preparation, such as wood debarking and chip making;
- pulp manufacturing;
- pulp bleaching;
- paper manufacturing;
- and fiber recycling.

The manufacture of pulp for paper and card-board employs mechanical (including thermo-mechanical), chemi-mechanical, and chemical methods.

4.2.4.2 Waste water characteristics

The significant environmental impacts of the manufacture of pulp and paper result from the pulping and bleaching processes. In some processes, sulfur compounds and nitrogen oxides are emitted to the air, and chlorinated and organic compounds (AOX), nutrients, suspended solids and metals are discharged to the wastewaters.

Wastewaters are discharged at a rate of 20–250 cubic meters per metric ton (m^3/t) of Adt. The pollution load in wastewater varies according to the type of raw material used and the method of production employed.

Wastewater from chemical pulping contains 12–20 kg of BOD_5/t of Adt, with values of up to 350 kg/t. The corresponding values for mechanical pulping wastewater are 15–25 kg BOD_5/t of Adt. For chemi-mechanical pulping, BOD discharges are 3 to 10 times higher than those for mechanical pulping. The amount of BOD and COD is very dependent on the characteristics of the fibre raw material and not directly related to the environmental status of the paper machine. Pollution loads for some processes, such as those using non-wood raw materials, could be significantly different. Phosphorus and nitrogen are also released into wastewaters. The main source of nutrients, nitrogen, and phosphorus compounds is raw material such as wood.

Typical pollution loads released with the wastewater from the papermaking process are indicated in the following table[19]:

Parameter	Typical pollution levels when low environmental technology is used
BOD_5 (kg/t)	4 – 10
Suspended solids (kg/t)	30 –70
P (g/t)	3 – 300
N (g/t)	10 – 500

The pollution loads ranges are quite wide because of the heterogeneity of the used processes in this kind of industry (kraft pulp, sulphite pulp, recovered paper …)

4.2.5 Phosphatic fertilizer plants

4.2.5.1 Industry overview

Phosphate fertilizers are produced by adding acid to ground or pulverized phosphate rock. If sulfuric acid is used, single or normal phosphate (SSP) is produced, with a phosphorus content of 16–21% as phosphorous pentoxide (P_2O_5). If phosphoric acid is used to acidulate

[19] Adapted from Cleaner Production in Pulp and Paper Mills, UNEP DTIE, a Workbook for trainers; April 1998.

the phosphate rock, triple phosphate (TSP) is the result. TSP has a phosphorus content of 43–48% as P_2O_5.

SSP production involves mixing the sulfuric acid and the rock in a reactor. The reaction mixture is discharged onto a slow-moving conveyor in a den. The mixture is cured for 4 to 6 weeks before bagging and shipping.

Two processes are used to produce TSP fertilizers: run-of-pile and granular.

The run-of-pile process is similar to the SSP process. Granular TSP uses lower-strength phosphoric acid (40%, compared with 50% for run-of-pile). The reaction mixture, a slurry, is sprayed onto recycled fertilizer fines in a granulator. Granules grow and are then discharged to a dryer, screened, and sent to storage.

Phosphate fertilizer complexes often have sulfuric and phosphoric acid production facilities. Sulfuric acid is produced by burning molten sulfur in air to produce sulfur dioxide, which is then catalytically converted to sulfur trioxide for absorption in oleum. Sulfur dioxide can also be produced by roasting pyrite ore. Phosphoric acid is manufactured by adding sulfuric acid to phosphate rock. The reaction mixture is filtered to remove phosphogypsum, which is discharged to settling ponds or waste heaps and some cases discharged in the sea.

4.2.5.2 Waste water characteristics

Fluorides and dust are emitted to the air from the fertilizer plant. All aspects of phosphate rock processing and finished product handling generate dust, from grinders and pulverizers, pneumatic conveyors, and screens. The mixer/reactors and dens produce fumes that contain silicon tetrafluoride and hydrogen fluoride.

Liquid effluents are not normally expected from the fertilizer plant, since it is feasible to operate the plant with a balanced process water system. The fertilizer plant should generate minimal solid wastes.

A sulfuric acid plant has two principal air emissions: sulfur dioxide and acid mist. If pyrites ore is roasted, there will also be particulates in air emissions that may contain heavy metals such as cadmium, mercury, and lead. Sulfuric acid plants do not normally discharge liquid effluents except where appropriate water management measures are absent. Solid wastes from a sulfuric acid plant will normally be limited to spent vanadium catalyst. Where pyrite ore is roasted, there will be pyrite residue, which will require disposal. The residue may contain a wide range of heavy metals such as zinc, copper, lead, cadmium, mercury, and arsenic.

The phosphoric acid plant generates dust and fumes, both of which contain hydrofluoric acid, silicon tetrafluoride, or both.

Phosphogypsum generated in the process (at an approximate rate of about 5 tons per ton of phosphoric acid produced) is most often disposed of as a slurry to a storage/settling pond or waste heap. However, disposal to a marine environment is practiced at some existing phosphoric acid plants in the Mediterranean region, constituting an important suspended solid and fertilizer loading.

Process water used to transport the waste is returned to the plant after the solids have settled out. It is preferable to use a closed-loop operating system, where possible, to avoid a liquid effluent. In many climatic conditions, however, this is not possible, and an effluent is generated that contains phosphorus (as PO_4), fluorides, and suspended solids. The Phosphogypsum contains trace metals, fluorides, and radionuclides (especially radon gas) that have been carried through from the phosphate rock.

4.2.6 Pharmaceutical industry

4.2.6.1 Industry overview

The pharmaceutical industry includes the manufacture, extraction, processing, purification, and packaging of chemical materials to be used as medications for humans or animals.

The pharmaceutical industry utilizes a vast array of complex batch-type processes and technologies in the manufacturing of pharmaceutical products. Due to the diversity of these processes, only two methods in the manufacture of pharmaceutical are considered in these guidelines, namely, natural product extraction and fermentation.

The natural product extraction is the production of basic substances from natural sources such as roots, leaves and animal glands. Such pharmaceutical products include allergy relief medicines, insulin, morphine, alkaloids and papaverine. Product recovery and purification processes include precipitation (using lead and zinc as precipitation agents), and solvent extraction (using ketoses and alcohols).

The fermentation process is typically used for producing steroids, vitamin B12 and antibiotics. Overall, fermentation consists of two major steps: inoculum and seed preparation and fermentation followed by crud product recovery and purification.

4.2.6.2 Waste characteristics

Wastes from natural product extraction include spent raw materials such as leaves and roots, water soluble solvents, solvent vapours and waste water. Extraction waste waters typically have low BOD and COD and TSS levels[20].

Wastes from fermentation are characterized by the large volumes of waste such as the spent aqueous fermentation medium and solid cells debris. The aqueous medium is very impure, containing unconsumed raw materials such as corn steep liquor, fish meal and molasses. Filtration results in large quantities of solids in the form of spent filter cake which includes solid remains of cells, filter aid, and some residual product. After product recovery, spent filtrate is discharged as waste water, augmented by waste water from equipment cleaning operations and fermenter vent gas scrubbing. Wastewater from fermentation operations typically have high BOD, COD and TSS levels.

Typical pollution loads released with the wastewater from the pharmaceutical production industry are indicated in the following table:

Parameter	Typical pollution levels from pharmaceutical production
BOD_5	25 kg/t of product
TSS	3 kg/t of product

5. DESCRIPTION OF THE BATs AND BEPs

5.1 Introduction

As the environmental issues raised by industry have become more complex and the need for action more pressing to reduce its environmental impacts and to promote sustainable development, the different approaches that are likely to be adopted by industry are those

[20] EPA, Guide to Pollution Prevention, The Pharmaceutical Industry, (EPA/625/7-91/017) October 1991.

technologies, processes and practices that can prevent pollution while reducing costs and maintaining or even improving product quality.

The main purpose of these guidelines is to facilitate the application of Best Available Techniques (BATs) and Best Environmental Practices (BEPs) in industrial sectors that are major sources of Biochemical Oxygen Demand (BOD), nutrients and suspended solids, in the perspective of contributing to sustainable industrial development in the Mediterranean region.

The required integrated approach will take into consideration the different environmentally sound techniques (EST) that are related to Source-oriented measures, Process-integrated measures, and End-of-pipe measures. It is anticipated that their application will lead to improving the environmental performance of industry beyond compliance with environmental norms and to achieve further economical benefits.

- Source-oriented measures focus on the source of environmental pollution. Typical source-oriented measures are Good housekeeping, Inventory of chemicals and Substitution of hazardous compounds.

- Process integrated measures are the development of cleaner production techniques as they typically relate to water and energy conservation, optimization of the process, equipment modifications and re-use and recycling.

Only as a last option when pollution cannot be further prevented at source, end-of-pipe measures should be considered, those being intended for pretreatment and final waste-water treatment that is required to comply with environmental emission standards.

5.1.1 Definition of Best Available Techniques (BATs) and Best Environmental Practice (BEP)

As these guidelines are being launched in the context of the Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources and Activities[21], they take into consideration the criteria established for the definition of BATs and BEPs as follows:

5.1.1.1 Best Available Techniques

1. The use of the best available techniques shall emphasize the use of non-waste technology, if available.

2. The term "best available techniques" means the latest stage of development (state of the art) of processes, of facilities or of methods of operation which indicate the practical suitability of a particular measure for limiting discharges, emissions and waste. In determining whether a set of processes, facilities and methods of operation constitute the best available techniques in general or individual cases, special consideration shall be given to:

- comparable processes, facilities or methods of operation which have recently been successfully tried out;
- technological advances and changes in scientific knowledge and understanding;
- the economical feasibility of such techniques;
- time limits for installation in both new and existing plants;
- the nature and volume of the discharges and emissions concerned.

[21] Annex IV of the Protocol for the Protection of the Mediterranean Sea against Pollution from Land-Based Sources and Activities.

3. It therefore follows that what is "best available techniques" for a particular process will change with time in the light of technological advances, economic and social factors, as well as changes in scientific knowledge and understanding.

4. If the reduction of discharges and emissions resulting from the use of best available techniques does not lead to environmentally acceptable results, additional measures have to be applied.

5. "Techniques" include both the technology used and the way in which the installation is designed, built, maintained, operated and dismantled.

This definition of BATs is further clarified in IPCC Directive, article 2 (11) as follows[22]:

- "available" techniques shall mean those developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced inside the Member State in question, as long as they are reasonably accessible to the operator,
- "best" shall mean most effective in achieving a high general level of protection of the environment as a whole.

5.1.1.2 Best Environmental Practice[21]

1. The term "best environmental practice" means the application of the most appropriate combination of environmental control measures and strategies. In making a selection for individual cases, at least the following graduated range of measures should be considered:

(a) the provision of information and education to the public and to users about the environmental consequences of choice of particular activities and choice of products, their use and ultimate disposal;
(b) the development and application of codes of good environmental practice which cover all aspects of the activity in the product's life;
(c) the mandatory application of labels informing users of environmental risks related to a product, its use and ultimate disposal;
(d) saving resources, including energy;
(e) making collection and disposal systems available to the public;
(f) avoiding the use of hazardous substances or products and the generation of hazardous waste;
(g) recycling, recovery and re-use;
(h) the application of economic instruments to activities, products or groups of products;
(i) establishing a system of licensing, involving a range of restrictions or a ban.

2. In determining what combination of measures constitute best environmental practice, in general or individual cases, particular consideration should be given to:

(a) the environmental hazard of the product and its production, use and ultimate disposal;
(b) the substitution by less polluting activities or substances;
(c) the scale of use;
(d) the potential environmental benefit or penalty of substitute materials or activities;
(e) advances and changes in scientific knowledge and understanding;
(f) time limits for implementation;
(g) social and economic implications.

[22] Reference: IPCC Directive, article 2 (11).

3. It therefore follows that best environmental practice for a particular source will change with time in the light of technological advances, economic and social factors, as well as changes in scientific knowledge and understanding.

4. If the reduction of inputs resulting from the use of best environmental practice does not lead to environmentally acceptable results, additional measures have to be applied and best environmental practice redefined.

The reading of the proposed definitions indicate clearly the broad process of determining BATs and BEPs by encompassing a comprehensive integrated approach that is not limited to consumption and emission levels and pollution control techniques, but also environmental management systems, good housekeeping, good operating practices, techniques for prevention and control of accidents, waste minimisation, use of alternative materials/resources and rules for decommissioning.

In other terms, the comprehensive integrated approach based on BATs and BEPs falls in the following categorization:

Input material change: substitution of input materials by less toxic or renewable materials, or by adjunct materials with a longer service lifetime.

Better process control: modification of the working procedures, machine instructions and process record keeping in order to run the processes at higher efficiency as well as lower waste and emission generation rates.

Equipment modification: modification of the existing productive equipment and utilities -for instance by the addition of measuring and controlling devices- in order to run the processes at higher efficiency as well as lower waste and emission generation rates.

Technology change: replacement of the technology, processing sequence and/or synthesis pathway in order to minimize waste and emission generation during production.

On-site recovery and reuse: reuse of the wasted materials in the same process or for another useful application within the company.

Product modification: modification of the product characteristics in order to minimize the environmental impacts of the product during or after its use (disposal), or to minimize the environmental impacts of its production.

Waste minimisation is defined as: “the application of a systematic approach to reducing the generation of waste at source, by understanding and changing processes and activities to prevent and reduce waste.”

Cleaner Production: is defined by UNEP as the 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.

- For production processes, Cleaner Production involves the conservation of raw materials and energy, the elimination of toxic raw materials, and the reduction in the quantities and toxicity of wastes and emissions.
- For product development and design, Cleaner Production involves the reduction of negative impacts throughout the life cycle of the product: from raw material extraction to ultimate disposal.
- For service industries, Cleaner Production involves the incorporation of environmental considerations into the design and delivery of services.

Cleaner Technologies are defined as "manufacturing processes or product technologies that reduce pollution or waste, energy use, or material use in comparison to the technologies that they replace."

End-of-pipe system: technologies aimed at the treatment of wastes and polluting streams - i.e. water, air, noise and solid wastes.

The approach used in the Guidelines for selecting BAT to minimize the environmental impact of factory operations is based on the following actions:

The approach used in selecting BEPs to minimise the environmental impact of factory operations is based on the following actions:

1. Substitution of materials by environmentally less harmful ones.
2. Good housekeeping.
3. Recycling and re-use in water management.

It is important in the consideration of BATs and BEPs to stress that elimination, i.e. the reduction of water pollution at source, is applied instead of, or before, treating the waste water produced, following the rank of priorities of cleaner production.

In this chapter, for each industrial sector, the elements or techniques that are considered relevant in the determination of BATs and BEPs based on the definitions as established by the LBS Protocol are provided, including their conditions of applicability and expected results in terms of environmental and economical advantages.

For each studied sector, a specific set of measures or techniques leading to what is considered as BATs or BEPs would constitute guidelines in a general sense of that sector. They are not meant to be prescriptive techniques nor to set emissions limit values. The suggested emissions and/or consumption levels are only associated with the use of BATs and BEPs in general.

Whenever one has been identified, an example of a company having introduced BATs or BEPs in the specific sector being studied has been included in this chapter. These case studies include brief figures on economical and environmental matters when applying the BATs and BEPs by the company in question. Furthermore, economical concerns have been embodied in a specific section of this chapter that companies wishing to apply BATs and BEPs should take into account regardless of the industrial sector they belong to. This section includes some of the elements that should be considered by businesses when selecting and applying BATs and BEPs.

It should also be underlined that the presented list of BATs and BEPs is not exhaustive and any other technique or combination of techniques achieving the same (or better) performance should also be considered; such techniques may be under development or an emerging technique or already available but not described here.

Finally, given that these guidelines cannot be an exhaustive compilation of all the BATs and BEPs existing in the sectors object of the guidelines, it should be pointed out that companies wishing to introduce BATs and BEPs are most encouraged to consult existing and relevant sources of information. Notably and among others, some of the references available today that might be of interest to businesses are the following:

- Best Available Techniques Reference Documents (BREFs) of the European IPPC Bureau (see eippcb.jrc.es for the documents available).
- RAC/CP sector-specific studies as well as other publications aimed at pollution prevention (sectors studied so far: food preserving and canning, dairy, olive oil,

biotechnology applications in industry, textiles, tanning, metal plating, used oils and graphic arts –see www.cema-sa.org for further information–).

- UNEP (Division of Technology, Industry and Economics) sector-specific studies and other publications related to cleaner production (see www.uneptie.org).
- Resources from international institutions such as the World Bank (www.worldbank.org), UNIDO (www.unido.org) and others.

Apart from sources of specific BATs and BEPs, RAC/CP has also carried out, within the Mediterranean GEF Project, *Regional guidelines for application of BATs, BEPs and CTs in Mediterranean industries*, developing a methodology of guidance to companies that desire to introduce BATs and BEPs in their industrial activities.

5.1.2 General BATs for waste water treatment

Even after undertaking extensive waste minimisation measures, some discharge of waste water from sites is inevitable. There are many factors, which will influence waste water treatment. The main factors are:

a) The volume and the composition of the effluent being discharged.
b) The receiver of the discharge, i.e. sewer, river, estuary, lake, sea, land, etc.
c) The local situation, in terms of limits enforced, whether the municipality is supplying.
d) The treatment cost, disposal, fees etc.

The requirements for the discharge are dictated by the receiving water and the selection from the available options for discharge of final effluents mainly depends on local conditions. However, irrespective of the receiving water, the adequacy of the plant to minimise the emission of specific persistent harmful substances needs to be considered.

5.1.2.1 Waste water best available treatment techniques applied

The description of the various techniques used in the treatment of the waste waters from the different industry sectors that are major source of BOD, suspended solid and nutrients follows the logical sequence that the techniques are likely to be used to achieve a progressively better quality effluent.

Biological treatment techniques are generally used to reduce waste water content in biodegradable organic matter, Nitrogen and in some cases phosphorus. Physic-chemical techniques such as coagulation flocculation and decantation are used to reduce the suspend solid content on waste water.

In these guidelines will be briefly presented the used techniques regarded as BAT in the waste water treatment field by sector. When needed, the details and specifications of each sector are regrouped in the annexes.

a) Primary Treatment BAT

- screening (T1)
- sedimentation / flotation (T2)
- dissolved air flotation (T3)
- pH correction/neutralisation (T4)
- centrifugation (T5)

b) Secondary Treatment BAT

Chemical

- coagulation/flocculation/precipitation with (T6)
- sedimentation/filtration/flotation

Biological

- biofilters (T7)
- anaerobic treatment (T8)
- activated sludge/aeration lagoons (T9)
- extended aeration (T10)
- nitrification/denitrification (T11)
- spraying onto land (T12)

c) Tertiary Treatment BAT

- filtration/coagulation/precipitation (T13)

5.1.2.2 Techniques application

The application of these BATs to treat the various aqueous effluent streams from every industrial sector waste water is given in Table 3.

Table 3
Summary of BATs for treating aqueous effluent streams

Emission Type	Technique
Soluble organic material (BOD/COD)	T6, T7, T8, T9, T10, T12
Total suspended solids	T1, T2, T3, T5
Nitrate, ammonia	T7, T9, T10, T11, T12
Phosphate	T8, T9, T12, T13
Acids/alkali	T4
Oils/fats/greases (free)	T2, T3, T5
Oils/fats/greases (emulsified)	T6, T8

However, waste water produced in different sectors displays considerable variations in composition and pollution levels, and a variety of processes are therefore used to purify it. The reader can refer to the annexes to find out specifications for each sector.

5.2 BATs and BEPs for the Selected Industrial Sectors that Are Major Sources of BOD, Nutrients and Suspended Solids

5.2.1 Food industry

Traditionally the food and drink industry has not been heavily regulated with environmental legislation since emissions have been considered as relatively benign compared to many other industrial sectors. Emissions from the industry are mostly readily biodegradable organic matter.

The impetus for the industry to improve environmental performance has therefore traditionally been based on improving efficiency, i.e. maximising the utilisation of materials, which subsequently leads to a minimisation of waste.

Substantial reductions in the volume of waste water generated in this sector can be achieved through waste minimisation techniques. It is, however, imperative that water conservation measures do not lead to unsatisfactory levels of cleanliness, hygiene or product quality. Therefore, despite the fact that water consumption in the food industry should be reduced, hygienic conditions come first to the ranking of priorities and thus, water reduction should be carried out most carefully.

When reducing waste water generation, effluents may become more concentrated but easier to manage afterwards if they have to be treated.

5.2.1.1 General BATs and BEPs applicable in the food industry

Since the impacts associated with high organic loading in the wastewater are common to most categories of food processing, it is evident that there are various good techniques that are used in one sector that may also be applicable in other sectors. Some general techniques on waste minimization through the industry are given below:

- Recover as much product as possible.
- Reuse and recycle as much waste as possible throughout the plant.
- Segregate waste streams and store them adequately.
- Collect liquid and particles from process facilities before they reach the ground
- Develop a leak prevention program for valves, pumps, piping and equipment.
- Drain all product from tanks and vats before cleaning.
- Use dry cleanup methods.
- Avoid hosing material into drains if possible.
- Install water meters, and read them on a continual basis.
- Monitor the treatment plant for BOD_5 on a weekly basis.
- Better inventory control.
- More efficient use of raw materials.
- Convert as much waste as possible to animal feed.
- Use water sparingly in hosing and cleaning operations.
- Use valves that shut off automatically when water is not needed.
- Control quality at reception of raw materials
- Install pigging systems to recover liquid or semi-liquid products accumulated in pipes, combine with CIP systems.

The reuse of organic material has been the subject of much research and development throughout the industry, due to the magnitude of the impact. Many satisfactory solutions have been found, the most important being the use of organic waste in animal feed. With the substantial interest in biotechnology, increased efforts in investigating bioconversion processes could lead to new by-products; these type of techniques allow new R&D sources of raw/final/intermediate materials by creating add-value products such as ingredients for human consumption additives, biotechnological products, pharmaceutical principles.

5.2.1.2 BATs for waste water treatment

5.2.1.2.1 Waste water treatment techniques applied

Owing to the nature of the raw materials used and the products produced, waste water arising from the food industry is primarily biodegradable in nature. Waste water treatment issues are due to:

- solids (gross and finely dispersed);
- free edible fat/oil;
- emulsified material (e.g. edible oil/fat);
- soluble biodegradable organic material (BOD).

A summary of the methods used in different sub-sectors to treat aqueous effluent streams from food industry is presented in Table 4. Combinations of processes are frequently used to treat heavily polluted waste water (e.g. anaerobic preliminary treatment followed by an aerobic biological stage).

Table 4
BAT for waste water treatment options in different sectors of the food industry

	Breweries	Dairies	Production and processing of vegetable oils and fats	Distilleries and spirits production	Starch production	Sugar production	Soft drinks, fruit juice, mineral waters	Malt production	Meat processing	Wine and sparkling wine production	Sugar confectionery industry	Potato processing industry	Fruit and vegetable processing
Mechanical preliminary treatment processes													
Bar rack and screening				x			x			x	x	x	x
Filtration												x	x
Sedimentation (settling tanks, sand traps)				x			x				x	x	x
Flotation, gasoline separator, fat trap			x				x				x	x	
Centrifugation (separator, centrifuge)			x										
Mixing and equalising tanks			x				x			x	x		x
Physico-chemical preliminary treatment processes													
Precipitation, flocculation, coagulation filtration											x		
Neutralisation			x	x			x			x	x		x
Biological processes: Biological pre-treatment													
Aerobic pre-treatment							x			x	x	x	x
Anaerobic pre-treatment			x	x			x			x	x	x	x
Full biological treatment													
Single stage activated sludge process			x				x			x	x	x	x
Multi stage activated sludge process			x	x			x					x	x
SBR (sequencing batch reactor)							x			x			
Biofilters							x			x		x	x
Sealed aerated lagoons				x			x					x	x

5.2.1.3 <u>BATs and BEPs for selected food and drink sub-sectors: sugar manufacturing</u>

In the following, the proposed list of BATs and BEPs is by no means exhaustive and any other technique or combination of techniques achieving the same (or better) performance should also be considered; such techniques may be under development or an emerging technique or already available but not mentioned/described here.

Since the pollutants generated by the industry are largely losses in production, improvements in production efficiency are recommended first to reduce pollutant loads and treatment of remaining waste for compliance with national requirements. In this respect BATs and BEPs should focus on good housekeeping, process optimization, and recovery.

5.2.1.3.1 BATs applicable across the entire process

- Minimize storage time for juice and other intermediate products to reduce product losses and discharge of product into the wastewater stream.
- Use of less polluting clarification processes such as those using bentonite instead of sulfite for the manufacture of white sugar.
- Switch to the use of dry cleaning methods.
- Recirculate cooling waters.

5.2.1.3.2 BEPs applicable across the entire process

- Apply better production control to reduce product losses.
- Avoid spraying of molasses on the ground for disposal.
- Collect waste for use in other industries - for example, bagasse for use in paper mills and as fuel.
- Use beet chips as animal feed.
- Procure cane washed in the field. In any case, the cane must be at least rinsed at the factory.
- Optimize the use of water and cleaning chemicals.
- Carry out continuous sampling and measurement of key production parameters, which allows production losses to be identified and reduced, thus reducing the waste load.

5.2.1.3.3 BATs for effluent treatment

The high strength supernatant passing from the settlement ponds is ideally suited for treatment using **anaerobic techniques**. Also the betains from the sugar beet (organic nitrogen compounds) can only be degraded anaerobically, not aerobically.

The systems that are used for anaerobic waste water treatment in the sugar industry can be considered to belong to the contact-sludge process, the upflow anaerobic sludge blanket (UASB) process or the fluidised-bed process.

> Many other techniques are regarded as BAT in the sugar industry effluent treatment. In these guidelines, they are presented as options (Annex 4). Those methods usually allow achieving very high levels of pollution control. The choice of the most appropriate one will take into account the geographical and human aspects in order to satisfy the local environmental requirements, which are best, suited to the technical characteristics of the existing plants.

5.2.1.3.4 Benchmarking

The application of the BATs and BEPs such as those described above (some, not necessarily all of them) should lead to achieving the following target pollution loads:

- Wastewater loads can be reduced to at least 1.3 m^3/t of cane processed, and plant operators should aim at rates of 0.9 m^3/t or less through recirculation of wastewater.
- Wastewater loads from beet processing should be less than 4 m^3/t of sugar produced or 0.75 m^3/t of beet processed, with a target of 0.3 to 0.6 m^3/t of beet processed.
- Effluents from sugar manufacturing could be reduced to achieve the following maximum values[23] in a well designed, well operated and well maintained pollution prevention and control systems:

Parameter	Maximum concentration in mg/L
BOD_5	50
TSS	50
Total nitrogen (NH_4^+ - N)	10
Total phosphorus	2

Achieving these targets requires performance monitoring, and effluents should be sampled annually to ensure that biocides are not present at significant levels. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken.

5.2.1.3.5 Case study

Implementation of BATs and BEPs through cleaner production processes and pollution prevention measures can yield both economic and environmental benefits. The following case study from the industry illustrates the win-win option:

Industry sector: sugar manufacturing
Company: CST, Tunisia The factory produces white sugar from beets
Application of BATs & BEPs Recovery, preventive maintenance, process control and good housekeeping • Chip and trash recovery system: reactivate the existing system to recover pieces of whole beets and tips of beet roots containing sugar lost as wastes. • Diffusion and juice purification: control operation parameters to optimize production processes. Such parameters include knife filling, diffuser temperature and stable operation conditions. • Heat exchange and evaporation: monitor and control operation parameters to optimize evaporation and speed-up production. These parameters include venting of non-condensable gases from the bottom of heaters and calandrias as well as controlling sugar end Brix. • Sugar end purity control: modify purity management of the sugar end to lower the purity of molasses and review crystallization management to optimize this operation. • Improved maintenance on pump seals to stop leakages and improve operation methods to provide steady state conditions.
Effects / Results / Costs / Benefits The CP recommendation result in the following advantages: • Increasing sugar production yield by 6.5%, by saving about 1,690,000 kg/year of sugar from being disposed of as waste in the landfill. • Reducing energy consumption by 2.1.%, thus sparing about 150,000 kg/year of heavy fuel oil. • Saving about 2,000,000 kg/year of beet pieces from being disposed of as waste in the landfill. • Overall, the implementation of the CP project leads to an annual saving of 1,400,000 € for a total investment of no more than 35,000 €. The most significant savings result from: • Process optimization through increased productivity and production yield accounting for more than 85% of savings, • Resource conservation due to reduced raw material and energy consumption accounting for 15% of savings.

Reference: EP3 Project -Tunisia

[23] Effluent requirement for direct discharge into surface water.

5.2.1.4 BATs and BEPs in vegetable oil processing

Since the pollutants generated by the industry are largely losses in production, improvements in production efficiency are recommended first to reduce pollutant loads and treatment of remaining waste for compliance with national requirements. In this respect BATs and BEPs should focus on the following main areas:

5.2.1.4.1 BATs applicable across the entire process

- Use citric acid instead of phosphoric acid, where feasible, in degumming operations.
- Where appropriate, give preference to physical refining rather than chemical refining of crude oil, as active clay has a lower environmental impact than the chemicals generally used.
- Recirculate cooling waters.
- Use of the super-critical process in the treatment of bleaching clay (super critical carbon dioxide: critical pressure 74 bar & critical temperature 31°C) allows for almost 100% recovery of oil and the clay recycled. This could replace the current chemical-treatment technology that generates its own waste chemicals that need be safety disposed. Super-critical fluid processes are beginning to find widespread use in such commercial application as coffee and tea decaffeination, processing of hops extract, extraction of nicotine from tobacco, an the extraction of variety of flavours, fragrances, and colorants from plant material.
- In olive oil extraction, the continuous two phases pressing system, applied where appropriate, may allow a 80% volume reduction and 90% pollution load reduction of the effluents, compared to the three phase extraction system[14].

5.2.1.4.2 BEPs applicable across the entire process

- Reduce product losses through better production control.
- Optimize the use of water and cleaning chemicals.
- Collect waste for use in by-products such as animal feed, where feasible without exceeding cattle-feed quality limits.
- Continuous sampling and measuring of key production parameters allow production losses to be identified and reduced, thus reducing the waste load.

5.2.1.4.3 BATs for effluent treatment

In recent years there have been extensive investigations into biological treatment of refinery waste water from oil mills, with the aim of eliminating the hitherto unavoidable waste water loads. Tests have been performed on a laboratory and pilot-plant scale. Treatment strategies developed as a result have hitherto been implemented in two prototype production-scale systems. Both examples are tailored to the special operating conditions of the factories and their local situation. Optimisation of the prototypes is still in progress. Therefore, as yet, one cannot speak of a fully developed technique for biological waste water purification in this industry.

Industry-specific factors:

- Influence of low-volatile lipophilic substances.
- Influence of sulphate on biological waste water treatment.
- Influence of high phosphatide levels on biological waste water treatment.
- Influence of pH on biological waste water treatment.

In view of the residual oil content, it makes sense to use flotation rather than sedimentation for separation of solids -both in preliminary clarification and in final clarification-. In general the waste water lends itself well to biological treatment. One problematic aspect is the elimination of P from the waste water. In the untreated water, phosphate is present in organic form and cannot therefore be precipitated during preliminary treatment. Simultaneous precipitation is not practicable either, because the treatment systems are too sensitive to peak loads. Subsequent precipitation with aluminium salts is possible, but P concentrations of less than 2 mg/L have yet to be achieved.

Moist spent olives should be treated (there are several techniques for this, such as physical oil extraction, oil extraction by solvent, fuel, co-generation, recovery as fertilizer –compost-) and vegetable water as well in case a system of 3-phase extraction is used.

5.2.1.4.4 Benchmarking

The application of the BATs and BEPs such as those described above (some, not necessarily all of them) should lead to achieving the following target pollution loads:

- Wastewater loads are typically 3 - 5 m^3/t of feedstock; plant operators should aim to achieve lower rates at the intake of the effluent treatment system.
- The BOD_5 level should be less than 2.5 kg/t of product, with a target of 1 - 1.5 kg/t.

Effluents from vegetable oil processing could be reduced to achieve the following maximum values[13] in a well designed, well operated and well maintained pollution prevention and control systems:

Parameter	Maximum concentration in mg/L
BOD_5	50
TSS	50
Total nitrogen (NH_4^+ - N)	10
Total phosphorus	10

Achieving these targets requires performance monitoring of the final effluent for the parameters listed in the table above should be carried out at least weekly, or more frequently, if the flows vary significantly. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken.

5.2.1.4.5 Case study

Implementation of BATs and BEPs through cleaner production processes and pollution prevention measures can yield both economic and environmental benefits. The following case study from the industry illustrates the win-win option:

Industry sector: oil processing
Company: Tanta Oil and Soap Company in Tanta, Egypt Tanta factory produces an average of 18,000 ton/year of edible oil extracted from cottonseeds, sunflower seeds and soy bean, 12,000 ton/year of ghee using palm and other oil seeds. The factory also produces 9,000 ton/year of glycerin and *48,000 ton /year* of animal fodder.
Application of BATs and BEPs: **Product recovery, preventive maintenance and good housekeeping** 1. Upgrade loading and unloading procedures for oil, grease and fats to minimise spillage. 2. Improve housekeeping in the Fatty Acids Splitting Unit. 3. Oil recovery from processing units effluents, especially oil refining and packaging units. 4. Improve handling of animal fodder ingredients to prevent losses.

5. Water consumption control, by installing water meters for monitoring water consumption at various units, and installation of self-closing taps to reduce water consumption. 6. Segregation of cooling water and process water and usage of cooling tower to recycle cooling water. 7. Reduce oil losses in spent bleaching earth, by upgrading bleaching filters
Effects / Results / Costs / Benefits 1. Water consumption has been reduced by 23%. 2. The investment required for industrial wastewater treatment plant have been reduced by about 85,000 €. 3. Annual recovery of oil, ghee, fats and animal feed totaling 87,890 €. 4. Raking conditions improved in the animal feed and fatty acids production unit. 5. Oil and grease concentrations in the final effluent reduced by 99%. 6. BOD loads in the final effluent reduced by 85%. The total capital and operation costs invested in the cleaner production measures at Tanta Oil and Soap factory amounts to 105,611.99 €. This has produced total savings of around 108,393.87 € with an average payback period of around 1 year.

Reference: SEAM Project

5.2.1.5 BATs and BEPs in breweries

Since the pollutants generated by the industry are largely losses in production, improvements in production efficiency are recommended first to reduce pollutant loads and treatment of remaining waste for compliance with national requirements. In this respect BATs and BEPs should focus on the following main areas:

5.2.1.5.1 BATs applicable across the entire process

- Apply Clean-in-place (CIP) methods for decontaminating equipment.
- Use high-pressure, low-volume hoses for equipment cleaning.
- Use recirculating systems on cooling water circuits.
- Filtrate bottom sediments from final fermentation tanks for use as animal feed.

5.2.1.5.2 BEPs applicable across the entire process

- Use of grit, weed seed, and discarded grain as chicken feed.
- Use of spent grain as animal feed, either 80% wet, or dry after evaporation.
- Disposal of wet hops by adding them to the spent grain.
- Disposal of spent hop liquor by mixing with spent grain.
- Use for livestock feed of spent yeast that is not reused.
- Disposal of trub by adding it to spent grain.
- Recovery of spilled beer, adding it to spent grain that is being dried through evaporation

5.2.1.5.3 BATs for effluent treatment

In general, where possible, waste water segregation is investigated. Potential may exist for high-volume low-strength streams to be either:

- recycled (following suitable treatment);
- discharged directly to sewer (without treatment);
- mixed with treated final effluent prior to discharge.

The options available will be dependent upon the receiving water and hence the consent to discharge. By segregating low-strength streams, a treatment facility can be reduced in size by designing on high strength waste waters released from an installation.

Fermentable and non-fermentable wastes are kept separate to maximise potential for re-use.

In general, when applying techniques for the treatment of waste waters released from the brewery sub-sector, the following unit processes may be considered:

- Screening.
- Primary treatment.
- With regard to the pollution strength from the BOD point of view, aerobic or anaerobic biological techniques are regarded as BAT.

The reader can refer to Annex 5 for further details.

5.2.1.5.4 Benchmarking

The application of the BATs and BEPs such as those described above (some, not necessarily all of them) should lead to achieving the following target pollution loads:

Water conservation and recycling will allow water consumption to be kept to a minimum.

A new brewery should target on achieving an effluent range of 3 - 5 m^3/ m^3 beer produced.

A new brewery should set as a target the achievement of a treated effluent that has less than 0.3 kilograms (kg) of BOD_5/m^3 beer produced and 0.3 kg of suspended solids/ m^3 beer produced (assuming discharge to receiving waters).

Effluents from breweries could be reduced to achieve the following maximum values in a well designed, well operated and well maintained pollution prevention and control systems:

Parameter	Maximum concentration in mg/L
BOD_5	50
TSS	50
Total nitrogen (NH_4^+ - N)	10
Total phosphorus	10

Achieving these targets requires performance monitoring of the final effluent for the parameters listed above should be carried out at least once per month, or more frequently if the flows vary significantly. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken.

5.2.1.6 BATs and BEPs in fruit and vegetable processing

Since the pollutants generated by the industry are largely losses in production, improvements in production efficiency are recommended first to reduce pollutant loads and treatment of remaining waste for compliance with national requirements. In this respect BATs and BEPs should focus on process modification, recovery and good housekeeping.

5.2.1.6.1 BATs applicable across the entire process

- Use dry methods such as vibration or air jets to clean raw fruit and vegetables. Dry peeling methods reduce the effluent volume (by up to 35%) and pollutant concentration (organic load reduced by up to 25%), or at least, high-efficiency thermal peeling.
- Use countercurrent systems where washing is necessary.
- Use steam instead of hot water to reduce the quantity of wastewater to be treated (taking into consideration, however, the tradeoff with increased use of energy).
- Use of dry caustic peeling or equivalent procedures wherever technically feasible.
- Use pneumatic transportation instead of a water channel as system for transporting products.

5.2.1.6.2 BEPs applicable across the entire process

- Separate and recirculate process wastewaters.
- Minimize the use of water for cleaning floors and machines, by using dry cleanup methods and high-pressure low-volume hoses for equipment cleaning.
- Remove solid wastes without the use of water.
- Reuse concentrated wastewaters and solid wastes for production of by-products.
- Use of in-plant controls to conserve water use and reduce waste loads through:
  a) Maximum practicable recirculation and reuse of cooling, condensate, fluming, cleaning, washing, and filling waters;
  b) Dry handling and disposal of solid wastes from floors, machines, and other work areas. These practices would replace "fluming-to-waste" methods;
  c) Positive control for the prevention of unnecessary overflows, spillages, and dumps;
  d) The elimination of excess running water;
  e) The utilization of best washing methods designed to give clean product commensurate with least water use. Contact time of product with process waters should be minimized.
- Maximum by-product recovery.
- Elimination of extraneous and uncontrolled drainage from refuse storage areas.
- Rapid and efficient removal of grass solids from screens, traps, etc. and adequate reuse and/or final disposal of these material. Contact of waste material and debris with process flows should be minimized.
- Market all possible by-products.
- Adapt cutting systems to the shape and size of product.
- Set the dosing of salt and reuse brines.
- Regenerate brine of vegetable pickles.
- Dry brine by means of solar power.

5.2.1.6.3 BATs for effluent treatment

Waste water streams released from fruit and vegetable processing lends itself to settlement as opposed to flotation. Dissolved air flotation would be applicable to those waste waters with appreciable levels of fats, oils and greases.

Segregation of waste water streams according to their composition is generally desirable, however, it may be uneconomical to segregate small, isolated streams. Water that has only been used for washing incoming products has low levels of BOD and might be screened to remove solids rather than receiving full treatment. The same applies to freezer defrost water.

Depending on BOD level, biological treatment techniques, in aerobic or anaerobic conditions are regarded as BAT in the fruit and vegetable sub-sector.

For further details, refer to Annex 6.

5.2.1.6.4 Benchmarking

The application of the BATs and BEPs such as those described above (some, not necessarily all of them) should lead to achieving the following target pollution loads:

- Reductions in wastewater volumes of up to 95% have been reported through implementation of good practices.
- As an example, recirculation of process water from onion preparation reduces the organic load by 75% and water consumption by 95%.
- Similarly, the liquid waste load (in terms of biochemical oxygen demand, BOD) from apple juice and carrot processing can be reduced by 80%.

Effluents from fruit and vegetable processing could be reduced to achieve the following maximum values in a well designed, well operated and well maintained pollution prevention and control systems:

Parameter	Maximum concentration in mg/L
BOD_5	50
TSS	50
Total nitrogen (NH_4^+ - N)	10
Total phosphorus	5

5.2.1.6.5 Case study

The following example shows that the implementation of BATs and BEPs through cleaner production processes and pollution prevention measures can yield both economic and environmental benefits:

Industry sector: vegetable processing
Company: Bonjus Lebanon, Fruit Juice Co, (Mount, Lebanon). The plant is a medium-sized crisps manufacturing factory.
Application of BATs and BEPs **Recycling of process water** Recycling of water from washing and peeling stages by installing a filter. This action reduced the water consumption by up to 18 m^3/day.
Effects / Results / Costs / Benefits Environmental benefits obtained are a decrease in water consumption as well as a reduction in wastewater generated. The cost of water usage saved was estimated at 3,285.04 € per year. The investment representing the cost of the filter was 5,703.20 €. The pay back period was < 2 years.
Reference: Med Clean N. 25

5.2.1.7 BATs and BEPs in the dairy industry

Since the pollutants generated by the industry are largely losses in production, improvements in production efficiency are recommended first to reduce pollutant loads and treatment of remaining waste for compliance with national requirements. In this respect BATs and BEPs should focus on the following main areas.

5.2.1.7.1 BATs applicable across the entire process

- Use of high-pressure nozzles to minimize water usage.
- Utilization of the automation system of the plant to eliminate waste, collecting the first rinses from tanks and cleaning operations, and saving the water-milk mixtures resulting from start-up and changeover shutdown of HTST units or as an ingredient in milk shakes and other dairy derivatives.
- Install suitable liquid level controls with automatic pump stops, or other devices at all points where overflow are likely to occur.
- Separate sludge from clarification for later recovery.

5.2.1.7.2 BEPs applicable across the entire process

- Collection of waste for use in lower-grade products such as animal feed where this is feasible without exceeding cattle feed quality limits.
- Optimization of use of water and cleaning chemicals; recirculation of cooling waters.
- Segregation of effluents from sanitary installations, processing, and cooling (including condensation) systems; this facilitates recycling of treated wastewater. Effluents from sanitary installations should be discharged directly to municipal sewer (if available), condensates and cooling water are like rainfall waters and may also be discharged directly, this facilitates recycling of process treated water.
- Use of condensates instead of fresh water for cleaning.
- Avoidance of the use of phosphorus-based cleaning agents.
- Segregation of all major sources of waste with separated drains as required being put into all new plants and remodelled plants.
- Installation of trays to catch drips and other milk spills in hygienic conditions.
- Segregation or recycling of non-polluted water.
- Eliminating all product discharged during start-up from product changeover of HTST pasteurizers.
- Improve the efficiency of CIP and sanitizing operation to reduce required concentration on these materials.
- Use of post-cleaning rinses as make-up for sanitizing and/or cleaning.
- Instruct personnel in the proper operation and handling of equipment.
- Mark all valves clearly, especially multiport so that it is practically impossible for inexperience help to turn the valve the wrong way.
- Installation of hermetic valves, alarms and automatic cut-offs to avoid overflow of milk storage tanks.
- Handle with extreme care all sanitary fittings, valves, rotary seals, pump parts and filler parts during every phase of operation to prevent marring which may cause leaks.
- Never fill cheese vats, ice cream mix vats, or cooling tanks to such a high level that spillage will occur when the product is agitated. Use closed vessels and level controllers.

- Worn-out or obsolete equipment or parts of equipment, including sanitary valves, fittings and pumps should be repaired or replace. When a leak cannot be repaired during processing, buckets should be provided so that the product is not allowed to go down the floor drain.
- Foam contains a considerable amount of milk solids and should be kept out of the sewer.
- Do not use a constantly running water hose in any room. Eliminate the cause of spillage, rather than just wash it away after it has occurred.
- Provide a foolproof whey collection system and avoid leaks from valves and fittings on whey lines which will result in ultimate loss of whey to the sewer and in floor corrosion.
- Provide standby pumps for pumping whey from cheese vats to storage tanks in case of power or pump failure.
- Provide whey storage tanks of twice the minimum daily volume for all types of cheese and casein plants.
- Sweep up all spilled cheese curd particles from the floor. Do not wash them down the sewers.
- Pipelines should be installed so that they are properly supported to eliminate vibration-induced leaking joints (where welded lines are not used or points in welded lines where CIP gaskets are utilized) and to insure that the lines are properly pitched to insure draining of the lines.
- All cases, conveyors, and stinkers should be maintained in proper operating condition to avoid jamming and subsequent loss of product from spillage and/or broken packages.
- Water hoses should be turned off when not in use. Hoses equipped with automatic shut-off valves should be utilized to avoid excessive water usage.
- For plastic and glass bottle fillers, cappers should be maintained in first class condition to avoid breakage and product loss. Similarly, paper filling machines should be maintained in order to avoid jams and product spillage. Fillers should be equipped with drip shields and the spills collected to avoid product going to drain.
- Filler valves should be checked to see that all containers are filled to correct capacity at the temperature filling. In glass bottles, filling to the cap seat ma create spillage when the milk warms up by the cap being forced past the cap seat.
- Bottles and paper containers should be handled carefully during casing, stacking, loading and delivery to avoid product losses to drain.
- Where sweetened, whole or condensed skim milk or ice cream mix is manufactured, care needs to be taken so that sugar or dairy ingredients are not spilled on the floor and washed into the sewer. In case dry ingredients are used, any spillage of those should be swept up rather than washed down.
- To have a specific place where to store cleaning and sanitising products in order to prevent accidents from occurring (such as incorporation of cleaning compounds and/or sanitising solution into milk products).
- Adequate weirs and continuous sampling equipment should be provided at the outlets of all dairy plants for monitoring wastes, strengths and volume.
- Eliminate steam-water mixing tees for making hot water and utilize regular hot water systems to permit use of shut-off valves at the end of hose lines. This can result in a 40 to 60% reduction of wastewater volume.
- Thoroughly drain all lines, tanks and processing vats before rinsing. Rinse before product dries on surface.
- Reduce losses from high volume pasteurizing units by better production control.

- Reduce losses through continuous processing.
- Whey removal and utilization is a complex subject, an every effort should be made to develop markets for whey solids as well as processes to extract and produce proteins and carbohydrates from whey: recovery of whey as an ingredient for the bread and confectionary industry, obtention of lactose by evaporation and condensation, obtention of proteins or other by-products, use of whey as a base in culture medium or as liquid feed for cattle.
- Fit bag type filters in the floor drains in the cottage cheese room.
- Reuse evaporator condensate (cow water) and if high enough quality can be used to replace potable water in CIP solution makeup or event be discharged into a local stream. It can also be used for rinsing trucks and equipment, or replacing potable water in boilers.
- Dry elimination of salt from cheese after salting. Recovery of salt brine from the cheese (these two last practices reduce salinity).
- Use of buttermilk as an ingredient.

5.2.1.7.3 BATs for effluent treatment

In addition to segregating storm water, it is desirable to segregate waste water on some or all of the following criteria:

- high solids content;
- very high BOD;
- high salinity.

It may be appropriate to mix high solids content waste water (e.g. CIP sludge) into the main waste water stream from a holding tank.

Waste water balancing and neutralisation facilities may be able to cope with extreme pHs resulting from occasional acid or caustic spills. Condensate that cannot be re-used may be suitable for discharge direct to sewer.

Following primary treatment, further stages may be required either to achieve a consent to discharge or to minimise trade effluent charges.

Depending on BOD level, biological treatment techniques, in an aerobic or anaerobic conditions, are regarded as BAT in dairy processing.

Further details concerning the BATs for effluent treatment are in Annex 8.

5.2.1.7.4 Benchmarking

The application of the BATs and BEPs such as those described above (some, not necessarily all of them) should lead to achieving the following target pollution loads:

- Wastewater loads are typically 1 - 2 cubic meters per metric ton (m^3/t) of milk processed. The plant operators should aim to achieve rates of 1 m^3/t or less at the intake of the effluent treatment system.
- The BOD_5 level should be less than 2.5 kg/t of milk, with a target of 1 - 1.5 kg/t.
- The BOD_5 level from butter and cheese production should be less than 2 kg/t of product.

Effluents from the dairy industry could be reduced to achieve the following maximum values in a well designed, well operated and well maintained pollution prevention and control systems:

Parameter	Maximum concentration in mg/L
BOD_5	50
TSS	50
Total nitrogen (NH_4^+ - N)	10
Total phosphorus	2

Achieving these targets requires performance monitoring and continuous sampling and measuring of key production parameters.

5.2.1.7.5 Case study

The following example shows that the implementation of BATs and BEPs through cleaner production processes and pollution prevention measures can yield both economic and environmental benefits:

Industry sector: dairy
Company: Lura company is the biggest producer of milk and dairy products in Croatia. It produces a wide range of products including fresh and UHT milk, fermented products, cream, desserts and juices.
Application of BATs and BEPs
• Implementation of an employee education program on water consumption reduction and optimal concentration of washing liquids • Using hoses with a smaller diameter (12 mm) for washing the process lines and machinery • Using hot condensate water as additional energy source for heating water • Applying warm water circulation and replacing the steam woth warm water in the mixer.
Effects / Results / Costs / Benefits Significant savings were achieved in water and energy consumption as well as reduced pollution load of the wastewater generated: • Reduction in waste water generation by 27% per year (286,000 m^3) • Reduction in wastewater pollution load Chemical Oxygen Demand (COD) by 25% • Savings in fresh water consumption by 280,000 m^3 per year • Savings of washing liquids by 12% per year (183 t). Total savings have amounted to 328,008 € per year. This was achieved by a single investment of 31,051 €. Therefore, the payback period for this project was 1 month.
Reference: Ref. Med Clean N. 29 RAC/CP

5.2.1.8 BATs and BEPs in slaughtering and meat processing

Since the pollutants generated by the industry are largely losses in production, improvements in production efficiency are recommended first to reduce pollutant loads and treatment of remaining waste for compliance with national requirements. In this respect BATs and BEPs should focus on the following main areas of the slaughterhouse.

5.2.1.8.1 BATs applicable across the entire process

- Pre-shower the animal at the stall.
- Killing and bleeding:

- Change sub-process from recovery of no blood to recovery of all blood with hygienic conditions (Collect as much blood as possible and use of suction blood systems).

- Washing of carcass:
  - Change from a system of continuous water flow to one of "interruptible" water flow.
- Paunch removal
  - Change sub-process of wet dumping of paunch material with off-site disposal to dry dumping of paunch material with off-site disposal.

5.2.1.8.2 BEPs applicable across the entire process

- Dry removal of solid wastes and installation of screens on wastewater collection channels will reduce the amounts and strengths of wastes.
- Separation of product from wastes at each stage is essential for maximizing product recovery and reducing waste loads.
- Recover and process blood into useful by-products.
- Separate cooling water from process water and wastewater, and recirculate cooling water.
- Allow enough time for blood draining (at least seven minutes).
- Minimize water consumed in production by, for example, using taps with automatic shutoff, using high water pressure, and improving the process layout.
- Eliminate wet transport (pumping) of wastes (for example, intestines and feathers) to minimize water consumption (use pneumatic transport systems).
- Reduce the liquid waste load by preventing any solid wastes or concentrated liquids from entering the wastewater stream.
- Cover collection channels in the production area with grids to reduce the amount of solids entering the wastewater.
- Equip the outlets of wastewater channels with screens and fat traps to recover and reduce the concentration of coarse material and fat in the combined wastewater stream.
- Remove manure (from the stockyard and from intestine processing) in solid form.
- Change procedure of primarily wet cleanup to one of dry cleanup followed by wet cleanup.

5.2.1.8.3 BATs for effluent treatment

In addition to the screening and dissolved air flotation, and depending on BOD level, biological treatment techniques are regarded as BAT in this sub-sector. Further details concerning the BATs for effluent treatment are in Annex 9.

5.2.1.8.4 Benchmarking

Effluents from the meat processing industry could be reduced to achieve the following maximum values in a well designed, well operated and well maintained pollution prevention and control systems:

Parameter	Maximum concentration in mg/L
BOD_5	50
TSS	50
Total nitrogen (NH_4^+ - N)	10
Total phosphorus	5

5.2.1.8.5 Case study

Implementation of BATs and BEPs through cleaner production processes and pollution prevention measures can yield both economic and environmental benefits. The following case study from the industry illustrates the win-win option:

Industry sector: meat processing
Company: Shahbaz slaughtering Facility in Semizovac (Bosnia & Herzegovina).
Application of BATs and BEPs Process modification, equipment modification and good housekeeping. The following options were recommended and/or implemented: • Extend bleeding time to at least 7 minutes to reduce effluent pollution load, • Construct an efficient blood collection system and separation of blood from wastewater, • Compost of manure instead of disposal on the riverbank, • Fit hoses with nozzles for more efficient cleaning of floors and surfaces, • Fit drains with screens and /or traps to prevent solids from entering the drains, • Train employees in cleaning practices and water conservation, • Control salt consumption in hide removal and dressing processes, • Undertake dry cleaning before washing with water.
Effects / Results / Costs / Benefits The options implemented were those that required low or no investments. With those, water consumption was reduced by 15% (from 1,831 m^3 to 1,557 m^3) and the wastewater pollutant load was reduced by 34% (BOD5 was reduced from 3,520 mgO_2/l to 2,052 mgO_2/l). The savings achieved annually reached 924.50 € against an annual investment of 58.45 €, making the payback period < 1 month.
Reference: Med Clean N. 35 RAC/CP

5.2.1.9 BATs and BEPs in canning and preserving processes

Canning and preserving fruit and vegetable are only an intermediate step in the whole food transformation process, all the BAT and BEPs mentioned in the general case of agro-food sector are applicable to this specific sub-sector.

5.2.1.10 BATs and BEPs in winery and distillery processes

BATs and BEPs for this industrial branch focus mostly on techniques applicable to achieve waste minimization. The following techniques specific applicable to this sub-sector are listed below:

- avoid overfilling of process vessels, as contents can have very high COD ;
- use fine mesh baskets over floor drains to keep grain, fruit skins, etc. out of the drainage system;
- return strong liquors to the process, or recover them for animal feed or other re-use where practicable;
- avoid disposing of yeast to drain because of its very high COD and propensity to form organic acids;
- use cross-flow filtration rather than conventional product filters, to reduce volume of chase water and product losses;
- meter volume of product into containers rather than filling them to capacity, to avoid overfilling or fit fob return systems to the filling heads;

- collect spillage in returned containers rather than washing it to drain;
- empty vessels by pumping must and fermentation sludge or wine dregs, and later recover must and wine contents;
- reuse rinses and cleaning/sanitising solutions of the bottle washing machines;
- use of pneumatic grape presses;
- segregate fermentation sludge and lees for later extraction of alcohol;
- spray vinasses (water-wine and water-must mixtures) for farming use;
- use good quality stainless steel containers with smooth surfaces which can be easily cleaned;
- mud filtration (volume reduction);
- mud distillation;
- warm wash for bottom container crystallized tartar recovery.

5.2.1.10.1 BATs for effluent treatment

The waste waters generated in this sub-sector can be categorised as follows:

- low-strength high-volume;
- high-strength low-volume;
- continuous regular discharges;
- campaign/seasonal discharges.

In general, when applying techniques for the treatment of waste waters liberated from the winery and distillery sub-sector, the following unit processes may be considered:

- screening;
- primary treatment;
- secondary treatment (aerobic or anaerobic);
- tertiary treatment (depending on sewer or course water/recycling discharge).

More details about the wastewater treatment in this sub-sector can be found in Annex 7.

5.2.1.11 <u>BATs and BEPs in the fish processing industry</u>

BATs and BEPs in fish processing typically focus on reducing the consumption of resources, increasing yields and reducing the volume and organic load of effluent discharges. BATs and BEPs measures reported by the fish processing facilities could be achieved mainly through good housekeeping practices, work procedures, maintenance regimes and resource handling.

5.2.1.11.1 BEPs applicable across the entire process[24]

- Keep work areas tidy and uncluttered to avoid accidents.
- Maintain good inventory control of raw ingredients.
- Ensure that employees are aware of the environmental aspects of the company's operations and their personal responsibilities.

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[24] UNEP Cleaner Production Working Group for the Food Industry, 1999.

- Train staff in good cleaning practices.
- Schedule maintenance activities on a regular basis to avoid inefficiencies and breakdowns.
- Optimise and standardise equipment settings for each shift.
- Identify and mark all valves and equipment settings to reduce the risk that they will be set incorrectly by inexperienced staff.
- Improve start-up and shut-down procedures.
- Segregate waste for reuse and recycling.
- Install drip pans or trays to collect drips and spills.
- Set dosing of salt and reuse brines by regenerating it with activated carbon treatment or membrane technologies.
- Dry brines by means of solar power.
- Use screens and efficient systems for recovering solids.
- Install dry systems for solid waste collection.
- Collect solids from the floor and equipment by sweeping and shovelling the material into containers before actual cleanup begins. Do not use water hoses as brooms.

5.2.1.11.2 BATs and BEPs applicable to individual unit operations within fish processing

Water consumption

- Use offal transport systems that avoid or minimise the use of water.
- Install fixtures that restrict or control the flow of water for manual cleaning processes.
- Use high pressure rather than high volume for cleaning surfaces.
- Reuse relatively clean wastewaters for other applications; for example, thawing wastewaters could be used for offal fluming or for initial cleaning steps in dirty areas.
- Use compressed air instead of water where appropriate.
- Install meters on high use equipment to monitor consumption.
- Use closed circuit cooling systems.
- Pre-soak floors and equipment to loosen dirt before the final clean.
- Recirculate water used in non-critical applications.
- Report and fix leaks promptly.

Effluent

In general, efforts to reduce water consumption will also result in reduced effluent generation. Other measures to reduce effluent pollution load include the following:

- Sweep up solid materials for use as a by-product (not for human consumption), instead of washing them down the drain.
- Clean dressed fish with vacuum hoses and collect the blood and offal in an offal hopper rather than the effluent system.
- Fit drains with screens and/or traps to prevent solid materials from entering the effluent system.
- Use dry cleaning techniques where possible, by scraping equipment before cleaning, pre-cleaning with air guns and cleaning floor spills with squeegees.

By-products

- Recover marketable by-products from fish wastes.
- Use vacuum systems to transport offal directly to storage containers.

Thawing

- Use the so-called *Lorenzo method:* in this method, thaw water is heated to 30 - 35°C to facilitate thawing and the water is agitated with an air sparge, giving a better contact between fish and water. It is reported that water consumption is reduced by about 40% to about 3 m^3/t RM.
- Or use the *moist air method* that utilises a warm, humid air stream and consumes virtually no water. It is therefore a preferred method in terms of water consumption.

De-icing, washing and grading

- Install a level-actuated switch to control water feed at the de-icing equipment.
- Use an automated shut-off system. This could save about 1 m^3/t RM.
- Use the ice/water mixture overflowing from the de-icer tanks may be used for other processes that require chilled water (e.g. scaling operations).

Scaling

- Filter and recirculate wastewater from the scaling operation.

Filleting

- Replace spray nozzles with smaller or more.
- Reduce water pressure.
- Operate sprays intermittently (e.g. 3 seconds on, 3 seconds off), instead of constantly.
- Use solenoid valves to stop water flow when the machines are not in operation.

Skinning

An important way of reducing the loss of flesh during the skinning operation is:

- To improve the quality of the fish received into the plant, through proper handling from the moment the fish are caught in order to reduce the loss of flesh during the skinning operation.
- Improve maintenance of machinery to ensure that the skinning process is as efficient as possible.
- Use a vacuum system as an alternative to water for removing the skin, fat and flesh pieces from the skinner drum. This will almost eliminate the water consumption from the process. However the high capital cost of such equipment must be considered.

Trimming and cutting

- Install spray guns at work areas for occasional cleaning tasks and automatic spray systems can be fitted with solenoid valves so that they operate intermittently.
- Adapt cutting systems to the shape and size of the product.
- Use automatic fish-cutting systems.
- Automatic knife settings.
- Use cutting rejects in making surimi.

Collection and transport of offal

- Instead of transporting offal via drains and water flumes, a conveyor with a mesh size of about 1 mm can be installed underneath each filleting line. As well as transporting the offal away, the conveyor acts as a filter.
- Use pneumatic transportation.
- Set up a filter conveyor to collect offal from the de-heading, filleting and skinning machines.
- Consider the removal of offal by a vacuum system.

5.2.1.11.3 Examples of performance achieved at process unit level

- **Thawing**: using an automated shut-off system could save about 1 m^3/t RM, with an initial investment of about Eur 800.

- **Scaling**: if it can be avoided, water savings will be in the order of 10 - 15 m^3 per ton fish, with no need for capital investment.
- **Cutting of fillets**: using vacuum system to remove the entrails from the filleting of oily fish and transports the viscera away from the filleting machine can reduce the consumption of water in this area by about 70%, a reduction of approximately 1.3 m^3 per ton of fish. It can also reduce the COD of the wastewater stream by about the same proportion, which is a reduction of approximately 4 - 8 kg per ton of fish.
- **Skinning**: a vacuum system can be mounted on skinning units for oily fish to remove all skin, oil and flesh pieces from the skinner drum. With the exception of a single, small spray nozzle, which sprays water into the drum to keep it moist, water consumption is virtually eliminated. A typical investment for four filleting machines is about Eur 88,000. The benefits are a reduction in water consumption of about 95%, as well as a reduction in the COD of the wastewater. Across the whole filleting process, total water consumption can be reduced by 17%. This also results in a reduction in overall COD load from filleting and skinning.
- **Collection and transport of offal**: in the white fish industry, it is estimated that filter conveyors decrease the total COD of the load from a facility by 5 - 15% if the factory has a central filter conveyor, or 15 - 25% if the factory has a rotary sieve. In the herring filleting industry, the reductions in COD that can be achieved are as high as 30 - 50%, due to the greater pollution that is normally generated from gutted oily fish.

5.2.1.11.4 BATs and BEPs applicable to shellfish processing

All the presented list of BATs and BEPs for the entire sector is still applicable here.

Specific measures for shrimp processing are outlined, essentially dry clean-up. To make it effective, the following should be respected:

- Collect any dripping batter by placing pans under breading tables.
- Squeegee spilled batter into a pan from the floor so batter will not enter the drain during wet cleanup.
- Empty batter tanks into barrels instead of pumping their contents into the drain.
- Place trays under conveyor belts to catch particles of breading, a concentrated source of soluble and suspended BOD_5.
- Place trays under machines to help keep breading off the floor.
- Remove leftover breading from machines such as sifters by hand, not hosed or air-gunned, so that it will not enter the drain.
- Dry cleanup utensils should be cleaned and stored separately from regular wet cleanup gear.
- Use a stiff broom to sweep breading from the floor. Scraping and then brushing is the only effective way to recover breading from under equipment.
- Place salvaged breading in barrels so it can be given or sold for animal feeding; it is a good source of carbohydrates and energy.
- Remove shrimp hulls by dry cleanup whenever possible. When left in contact with water, enzyme action turns them into a major source of pollution.
- Install a hydro-sieve to remove any shrimp hulls and particles that enter the floor drains during wet cleanup. Collect material in a dumpster and dispose of it in an approved manner.

- Look for opportunities to make use of waste materials. Sieved wastes containing shrimp hulls, breading, and other particulate wastes can be rendered into meal for animal food if enough can be collected.

The effect of screening and dry cleanup on BOD_5 load in a shrimp plant is presented (kg BOD_5/ ton of shrimp)[25]

Operation	Before	With screening	With dry cleanup and screening
Processing	117	72	71
Cleanup	104	49	21
Total	221	121	92

5.2.1.11.5 BATs for effluent treatment

Treatment of wastewater from seafood processing plants can be costly and complex. High strength wastewaters and highly variable seasonal loadings make many treatment schemes ineffective and not cost-efficient.

The BOD_5 of seafood processing plant effluents is sometimes as high as 2,000 mg/L. Suspended solids, almost completely absent from some wastes, may be found in concentration as high as 120,000 mg/L. The waste may be highly alkaline (pH 11.0) or highly acidic (pH 3.5). Nutrients such as nitrogen and phosphorous may be absent or they may be present in quantities in excess of those necessary to promote good environmental conditions for biological treatment.

The best pretreatment schemes in this sub-sector include screening, clarification or dissolved air flotation (DAF).

A majority of the pollutants of concern in the aquatic products processing industry are organic. Most biological treatment methodologies (biofiltration, activated sludge, etc.) as well as land disposal are regarded as BAT.

5.2.1.11.6 Case study

Implementation of BATs and BEPs through cleaner production processes and pollution prevention measures can yield both economic and environmental benefits. The following case study from the industry illustrates the win-win option:

Industry sector: canned fish
Background Case study carried out in Morocco under the GEM project: in-house pollution prevention, an environmental protection tool, 1995.
Application of BEPs Preventive and good housekeeping measures intended to saving water and reducing the organic load of wastewater: • Installation of smaller nozzles for the cleaning lines and floor • Closed circuiting • Improvements in the grid and bin washing system • Use of soft water for washing and recovery of tins to avoid rusting and lime deposits • Dry cleaning of lines to recover guano and minimize the organic load of wastewater.

25 Processing plant waste management guidelines –Aquatic Fishery Products-, Seafood & the environment, Roy E. Carawan, Ph D Professor (Food Engineering Specialist), 1991

Effects / Results / Costs / Benefits
The company achieved savings of over 8,000 m^3 per year and has managed to optimize its production process and recover useful by-product the guano. The improvements required a 6,000 € investment, and the annual savings achieved reached over 1,400 € per year.

Ref. Med Clean No. 31 RAC/CP

5.2.2 Textile industry

BATs and BEPs reported by the textile facilities could be achieved through avoiding whenever possible the use of chemicals, dosing and dispensing chemicals, environmental management and good housekeeping, process optimization, process modification, technology change, selecting incoming raw materials and finally, waste water treatment.

5.2.2.1 BATs applicable across the entire process

- Use pad batch dyeing (saves up to 80% of energy requirements and 90% of water consumption, and reduces dye and salt usage).
- Match process variables to type and weight of fabric (reduces wastes by 10 - 20%).
- Use transfer printing for synthetics (reduces water consumption from 250 l/kg to 2 l/kg of material and also reduces dye consumption).
- Use water-based printing pastes, when feasible.
- For knitted goods, exhaust dyeing is preferred.
- Use jet dyers, with a liquid-to-fabric ratio of 4:1 to 8:1, instead of winch dyers, with a ratio of 15:1, where feasible.
- Use countercurrent rinsing.

5.2.2.2 BEPs applicable across the entire process

- Avoid non degradable or less degradable surfactants (for washing and scouring) and spinning oils.
- Manage batches to minimize waste at the end of cycles.
- Control the quantity and temperature of water used.
- Avoid the use, or at least the discharge, of alkylphenol ethoxylates.
- Ozone-depleting substances should not be used.
- Use of organic solvents should be minimized.
- Avoid benzidine-based azo dyes and dyes containing cadmium and other heavy metals.
- Do not use chlorine-based dyes.
- Use less toxic dye carriers and finishing agents. Avoid carriers containing chlorine, such as chlorinated aromatics.
- Replace dichromate oxidation of vat dyes and sulfur dyes with peroxide oxidation.
- Reuse dye solution from dye baths.
- Use peroxide-based bleaches instead of sulfur-and chlorine-based bleaches, where feasible.
- Control chemicals formulation.

- Reuse and recover process chemicals such as caustic (reduces chemical costs by 30%) and size (up to 50% recovery is feasible).
- Replace nondegradable spin finish and size with degradable alternatives.
- Use biodegradable textile preservation chemicals.
- Do not use polybrominated diphenylethers, dieldrin, arsenic, mercury, or pentachlorophenol in mothproofing, carpet backing, and other finishing processes. Where feasible, use permethrin for mothproofing instead.
- Recover heat from wash water (reduces steam and energy consumption).

5.2.2.3 BATs & BEPs for unit processes and operations

5.2.2.3.1 Preparation stages

Wool scouring
Wool scouring can be done using water (most common situation) or organic solvents. Both methods are determined as BAT, provided that a number of requirements are satisfied.

Wool scouring with water
- substitute alkylphenol ethoxylates detergents with alcohol ethoxylates or other readily biodegradable substitutes that do not give rise to toxic metabolites;
- use dirt removal / grease recovery loops of high capacity. BAT-associated values for water consumption are 2 to 4 l/kg of greasy wool for medium and large mills (processing 15000 tons/year of greasy wool) and 6 l/kg for small mills. Associated values for grease recovery range between 25 and 30% of the grease estimated to be present in the wool scoured;
- combine the use of dirt removal / grease recovery loops with evaporative effluent treatment and recycling of water in the process as an option for:
  1. new installations
  2. existing installations with no on-site effluent treatment
  3. installations seeking to replace life-expired effluent treatment plant;
- combine the use of dirt removal / grease recovery loops with evaporative effluent treatment and incineration of the resulting sludge with full recycling of water and energy as an option for very large installations.

Scouring
Chlorinated solvents for scouring should be avoided and take all action possible in order to minimise fugitive losses (VOCs) as well as to prevent any possible contamination of groundwater arising from diffuse pollution and accidents, by using the latest technology available to that end. Furthermore, it is recommended to use biodegradable tensioactives.

Desizing
BAT is to do one of the following:
- select raw material processed with low add-on techniques (e.g. pre-wetting of the warp yarn) and more effective bioeliminable sizing agents combined with the use of efficient washing systems for desizing, as well as low F/M waste water treatment techniques to improve the bioeliminability of the sizing agents;
- adopt the oxidative route when it is not possible to control the source of the raw material;
- combine desizing/scouring and bleaching in one single step.

Bleaching
- use hydrogen peroxide bleaching as preferred bleaching agent combined with techniques for minimising the use of hydrogen peroxide stabilisers, or using biodegradable/bioeliminable complexing agents;

- use sodium chlorite for flax and bast fibres that cannot be bleached with hydrogen peroxide alone. A two-step hydrogen peroxide-chlorine dioxide bleaching is the preferred option. It must be ensured that elemental chlorine-free chlorite is used. Chlorine-free chlorite is produced using hydrogen peroxide as the reducing agent of sodium chlorate;
- limit the use of sodium hypochlorite only to cases in which high whiteness has to be achieved and to fabrics that are fragile and would suffer depolymerisation. To reduce the formation of hazardous AOX, sodium hypochlorite bleaching must be carried out in a two-step process in which peroxide is used in the first step and hypochlorite in the second. Effluent from hypochlorite bleaching must be kept separate from the other streams and mixed effluents in order to reduce formation of hazardous AOX.

Mercerizing
BEP is to either:
- recover and re-use alkali from mercerizing rinsing water;
- or re-use the alkali-containing effluent in other preparation treatments.

5.2.2.3.2 Dyeing

General BATs for batch dyeing processes
- BAT is to use machinery fitted with: automatic controllers of fill volume, temperature and other dyeing cycle parameters, indirect heating & cooling systems, hoods and doors to minimize vapour losses.
- BAT is to select new machinery according as far as possible to the requirements below:
  - low- or ultra-low liquor ratio;
  - in-process separation of the bath from the substrate;
  - internal separation of process liquor from the washing liquor;
  - mechanical liquor extraction to reduce carry-over and improve washing efficiency;
  - reduced duration of the cycle.
- Substitute overflow-flood rinsing method in favour of drain and fill (batch method) or other methods (smart rinsing for fabric).
- BEP is to re-use rinse water for the next dyeing or reconstitution and re-use the dye bath when technical considerations allow. This technique is easier to implement in loose fibre dyeing where top-loading machines are used. The fibre carrier can be removed from the dyeing machine without draining the bath. However, modern batch dyeing machines are equipped with built-in holding tanks allowing for uninterrupted automatic separation of concentrates from rinsing water.

BAT for continuous dyeing processes
Continuous and semi-continuous dyeing processes consume less water than batch dyeing, but highly concentrated residues are produced.

BAT is to reduce losses of concentrated liquor by:
- using low add-on liquor application systems and minimizing volume capacity of the dip trough when using pad dyeing techniques;
- adopting dispensing systems where the chemicals are dispensed on-line as separate streams, being mixed only immediately before being fed to the applicator;
- implementing systems for dosing the padding liquor based either on measurement of the pick-up for the preparation of the next comparable batch or preparing the dyestuff solution just in time, based on on-line measurement of the pick-up (rapid batch dyeing technique). The latter is preferred when economic considerations allow.

Dosage and dispensing of dye and chemicals/auxiliaries
BAT is to use automated systems for dosage and dispensing of dyes and chemicals/auxiliaries. For large installations, preference is given to decentralised dosing stations that do not premix the chemicals in a colour kitchen (avoid colour kitchen) and that are fully automatically cleaned.

<u>PES & PES blends dyeing with disperse dyes</u>

- BEP is avoiding the use of hazardous carriers by (in order of priority):
  - using non-carrier dyeable polyester fibres (PET type), when product market considerations allow;
  - dyeing in HT conditions without use of carriers. This technique is not applicable to PES/WO blends;
  - substituting conventional dye carriers with compounds based on benzylbenzoate and N-alkylphthalimide, when dyeing WO/PES fibres.
- BEP is to substitute sodium dithionite in PES after treatment, by applying one of the two proposed techniques:
  - replace sodium dithionite with reducing agent based on sulphinic acid derivatives. This should be combined with measures in order to ensure that only the strict amount of reducing agent needed to reduce the dyestuff is consumed (e.g. by using nitrogen to remove oxygen from the liquor and from the air in the machine);
  - use of disperse dyes that can be cleared in alkaline medium by hydrolitic solubilisation instead of reduction.
- BEP is to use optimised dye formulations that contain dispersing agents with high degree of bioeliminability.

<u>Dyeing with sulphur dyes</u>

BEPs are:

- replace conventional powder and liquid sulphur dyes with stabilised non-pre-reduced sulphide-free dyestuffs;
- replace sodium sulphide with sulphur-free reducing agents or sodium dithionite, in that order of preference;
- adopt measures to ensure that only the strict amount of reducing agent needed to reduce the dyestuff is consumed (e.g. by using nitrogen to remove oxygen from the liquor and from the air in the machine);
- use hydrogen peroxide as preferred oxidant.

<u>Batch dyeing with reactive dyes</u>

BAT is to:

- use high-fixation, low-salt reactive dyes.

<u>Pad-batch dyeing with reactive dyes</u>

BAT is either to:

- use the Econtrol process for dyeing of cellulosic fabric with selected reactive dyes. This technique is more cost effective than pad-batch dyeing in terms of total processing costs, but the initial investment cost is high. For this reason this technique is determined as BAT for operators of new installations or existing installations seeking to replace equipment

OR

- use the silicate-free fixation method.

<u>Wool dyeing</u>

- BEP is to substitute chrome dyes with reactive dyes or use afterchrome dyeing methods, BAT-associated emission value for chromium is 50 mg/kg of wool treated and the concentration of chromium in the spent chroming bath is below 5 mg/L.
- BAT is to use the “Lanaset TOP process” for dyeing wool with metal-complex dyes.

5.2.2.3.3 Printing

<u>Process in general</u>

- BEP is to reduce printing paste losses in rotary screen printing by:
  - minimizing the volume of printing paste supply systems;
  - recovering printing paste from the supply system at the end of each run;
  - recycling residual printing paste.

- Reduce water consumption in cleaning operations by a combination of:
  - start/stop control of cleaning of the printing belt;
  - re-use of the cleanest part of the rinsing water from the cleaning of the squeegees, screens and buckets;
  - re-use of the rinsing water from cleaning of the printing belt.
- BAT is to install digital printing machines for the production of samples for flat fabrics. It is not considered BAT to use solvent to prevent blocking when the printer is not in use.
- BAT is to switch to digital injection dyeing technique for printing carpet and bulky fabrics.

Reactive printing

BAT is to avoid the use of urea by either:

- the controlled addition of moisture either as foam or by spraying a defined quantity of water mist

OR

- the two-phase printing method.

Pigment printing

BAT is to use optimized printing pastes that fulfil the following requirements:

- Thickeners with low-emission of volatile organic carbon (or not containing any volatile solvent at all) and formaldehyde-poor binders. The associated air emission value is <0.4 g Org.-C/kg textile (assuming 20 m^3 air/kg textile).
- APEO-free and high degree of bioeliminability.
- Reduced ammonia content. Associated emission value: 0.6 g NH_3/kg textile (assuming 20 m^3 air/kg textile).

5.2.2.3.4 Finishing

Process in general

BEP is to:

- minimize residual liquor by:
  - using minimal application techniques (foam application, spraying) or reducing volume of padding devices;
  - re-using padding liquors if quality is not affected;
- segregate and dispose separately of unavoidable residual liquors.

Easy-care treatment

BAT is to use formaldehyde-free or formaldehyde-poor (<0.1% formaldehyde content in the formulation) cross-linking agents.

Mothproofing treatments

- **Process in general**

  BEP is to:
  - adopt appropriate measures for material handling;
  - select dyeing auxiliaries that do not exert a retarding action on the uptake (exhaustion) of the insect-resist agent during the dyeing process.
- **Mothproofing of yarn produced via the dry spinning route**

  BAT is to use one or both of these techniques:
  - combine acid after treatment (to increase the uptake of mothproofer active substance) and re-use of the rinse bath for the next dyeing step;
  - apply proportional over-treatment of 5% of the total fibre blend combined with dedicated dyeing machinery and waste water recycling systems to minimise active substance emissions to water.
- **Mothproofing of loose fibre dyed / yarn scoured production**

  BAT is to:
  - use dedicated low-volume application systems located at the end of the yarn scouring machine;

- recycle low-volume process liquor between batches and processes designed specifically to remove active substance from spent process liquor. These techniques may include adsorptive or degradative treatments;
- apply mothproofer directly to the carpet pile (when mothproofing during carpet manufacture) using foam application technology.

- **Mothproofing of yarn dyed production**

  BAT is to:
  - BAT is to use a separate after treatment process to minimize emissions from dyeing processes which are carried out under less than optimum conditions for mothproofer uptake;
  - BAT is to use semi-continuous low-volume application machinery or modified centrifuges;
  - BEP is to recycle low-volume process liquor between yarn batches and processes designed specifically to remove active substance from spent process liquor. These techniques may include adsorptive or degradative treatments;
  - BAT is to apply mothproofer directly to the carpet pile (when mothproofing during carpet manufacture) using foam application technology.

5.2.2.3.5 Washing

BEP is to:

- substitute overflow washing/rinsing with drain/fill methods or “smart rinsing” techniques reduce water & energy consumption in continuous processes by:
  - installing high-efficiency washing machinery;
  - introducing heat recovery equipment;
- use fully closed-loop equipment when using organic solvent to wash fabric that is heavily loaded with preparations that are difficult to remove with water (e.g. silicone oils).

5.2.2.4 <u>BATs for effluent treatment</u>

Waste water treatment in the textile industry follows at least three different strategies:

- central treatment in a biological waste water treatment on site;
- central treatment off site in a municipal waste water treatment plant;
- decentralised treatment, subsequent balancing and discharge.

All three strategies are BAT options when properly applied to the actual waste water situation.

The following techniques are determined as general BAT for treatment of waste water from the textile finishing and carpet industry:

- treatment of waste water in activated sludge system with low food-to-microorganisms ratio (F/M);
- treatment of selected and segregated, non-biodegradable waste water by chemical oxidation (Fenton reaction);
- anaerobic colour removal of residual dyestuffs from padding liquor and printing pastes.

For effluent treatment in the wool scouring sector (water-based process)

BAT is to:

- use evaporative effluent treatment for new installations, or for installations with no on-site effluent treatment plant, or for installations seeking to replace life-expired effluent treatment plant;
- use coagulation/flocculation treatment in existing mills already using it in conjunction with discharge to sewerage system employing aerobic biological treatment.

Other information with regards to BAT for wastewater treatment in this sector is available in Annex 10.

5.2.2.5 Benchmarking

The following production-related waste load figures can be achieved by implementing BATs and BEPs (some of the described ones, not necessarily all of them):

- Wastewater load levels should preferably be less than 100 cubic meters per ton of fabric, but up to 150 m^3 is considered acceptable.

Effluents from the textile industry could be reduced to achieve the following maximum values in a well designed, well operated and well maintained pollution prevention and control systems. The following levels can be achieved by adopting BATs and BEPs:

Parameter	Maximum concentration in mg/L
BOD_5	50
COD	250
TSS	50

Achieving these targets requires performance monitoring of the final effluent for the parameters listed above should be carried out at least weekly. Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken.

5.2.2.6 Case study

Implementation of BATs and BEPs through cleaner production processes and pollution prevention measures can yield both economic and environmental benefits. The following case studies from the industry illustrate the win-win options:

Industry sector: textile (1)
Company: First Textile is located in Corlu - Turkey, and produces knitted textile, yarn, and fabric dyed textile (cotton, PES and cotton/PES) and printed textile.
Application of BATs and BEPs • The company changed the recipe for cotton bleaching and dyeing processes by omitting overflow rinsing, as well as neutralisation stages and detergent usage • The company optimized the regeneration process of resins for the softening of raw process water • The company installed air-water heat exchangers at the end of the stenters to supply hot process water for certain dyeing recipes
Effects / Results / Costs / Benefits **Environmental benefits:** • Reduction of water, energy and chemical consumption • Reduction of water and salt consumption • Reduction of steam and energy consumption; air pollution control **Economical benefits:** • The annual savings achieved by the first option totalled approximately between 54,300 € and 30,100 €, with no initial investment required. • The annual savings achieved by the second option were 53,700 €, with a payback period of only 3 months. • Implementing the last option was paid back in 1 year and it yields annual savings of 477,700 €. The implemented process changes resulted in significant water conservation and also in reduction of the pollutant load of wastewater that has to be treated. In addition to that, energy conservation is achieved by heat recovery from process water. Also a significant reduction on the consumption of chemicals used in the process was achieved.

Reference: RAC/CP case study n.°13

Industry sector: textile dyeing (2)

Company: BACOTIM, Tunisia

The plant is a commission dyeing house treating yarns and knitted fabrics of cotton and polyester / cotton blends together with small amounts of other fibres.

Good housekeeping, recovery and reuse

The cleaner production options generated to improve the unit operations include:

- Good housekeeping measures such as production planning, fixing broken instruments, rationalizing raw materials use and having effective control on operations and processes.
- Recovery and storage in the existing tanks of clear wash water for reuse.
- Heat recovery from hot wastewater using a heat exchanger specially developed for the textile industry.
- Recovery and reuse of caustic soda from the mercerizing operations.

Effects / Results / Costs / Benefits

Environmental advantages:

- Lowering consumption of dyestuff by 30-40% (thus lowering wastewater loads) and energy consumption by 4% by simple housekeeping measures
- Lowering wastewater volume by 35-40% and consumption of water by 25 - 30%.
- Lowering the consumption of energy by 10%

Economic advantages:

- raw material conservation measures resulting in about 50% of savings
- water conservation measures leading to 37% of savings, and
- energy conservation measures accounting for about 13% of total savings

Overall, the implementation of the CP project leads to annual saving of 350,000 € for a total investment of about 300,000 €.

Reference: EP3 Project -Tunisia

5.2.3 Tanning industry

BATs and BEPs reported by the tanning facilities could be achieved through water and wastewater management, substitution of chemicals, process optimization and modification.

5.2.3.1 <u>BATs applicable across the entire process</u>

- Flesh green hides instead of limed hides.
- Use the method of hair-saving, reducing BOD and sulfide in the wastewater .
- Recycle or re-use process liquors where possible:
    - Recycling the lime solution to reduce sulfide and lime levels in wastewater;
    - Recycling the piquel solution to reduce salt and acid in wastewater;
    - Recycling the chrome solution to reduce chrome and salt in wastewater.
- Consider the use of carbon dioxide in deliming to reduce ammonia in wastewater.
- Use non-organic solvents for dyeing and finishing.
- Use batch washing instead of continuous washing, for reductions of water consumption.
- Use low-float methods (for example, use 40 - 80% floats).
- Use drums instead of pits for immersion of hides.

5.2.3.2 <u>BEPs applicable across the entire process</u>

- Avoid the use of hides treated with persistent insecticides and fungicides.
- Process fresh hides or skins to reduce the quantity of salt in wastewater, where feasible.
- Reduce the quantities of salt used for preservation.
- When salted skins are used as raw material, pretreat the skins with salt elimination methods.

- When antiseptics or biocides are necessary, avoid toxic and less degradable ones, especially those containing arsenic, mercury, lindane, or pentachlorophenol or other chlorinated substances.
- Recover chrome from chrome-containing wastewaters, which should be kept segregated from other wastewaters.
- Use screens to remove hair from wastewater.
- Segregate wastewater streams to simplify treatment.
- Monitor and control process waters to reduce water consumption.
- Reuse wastewaters for washing -for example, by recycling lime wash water to the soaking stage.
- Reuse treated wastewaters in the process to the extent feasible (for example, in soaking and pickling).
- Recover energy from the drying process to heat process water.
- To provide information and training of personnel; technical provisions for safety, personal protection against releases of harmful substances and organisation to minimise handling of potentially harmful agents.

5.2.3.3 <u>BATs & BEPs applied to tanning operations</u>

Table 5
Process-integrated BAT measures. Source: Reference Document on Best Available Techniques for the Tanning of Hides and Skins, European Integrated Pollution Prevention and Control (IPPC) Bureau, May 2001

	PROCESS UNIT	BAT is:
BEAMHOUSE	Curing and soaking	• To process fresh hides, as far as they are available Exceptions: - When long transport time is necessary (max 8 - 12 hours for fresh, unchilled hides; 5 - 8 days if a cooling chain of 2 °C is maintained) - For certain types of end-products - Sheepskins, calf skins • To reduce the amount of salt used as far as possible.
	Unhairing & liming	• To use hair-save technology, but economics can be an issue for existing plants when re-use of the saved hair is not possible • To reduce sulphide consumption by the use of enzyme preparations; not for sheepskins • To recycle spent liquors only when processing sheepskins, which are dewoolled by painting
	Splitting	• To use lime splitting Exceptions: - When the starting material is wet blue - When a firmer leather has to be produced (e.g. shoe-leather) - When a more uniform and accurate thickness is needed in the final product • To maximize the use of split
TANYARD OPERATIONS	Deliming and bating	• To make a partial substitution of ammonium salts with CO_2 and/or weak organic acids
	Sheepskin degreasing	• To optimise wet degreasing using surfactants, with or without organic solvents • Closed machines with abatement for air and waste water releases when organic solvents are used to degrease skins in dry state
	Pickling	• To use partial recycling or re-use of pickle liquors (*) split view; see below • To use a volume of floats in the range of 50 - 60 % (based on fleshed weight) for ovine skins and bovine hides in order to reduce salt consumption

	PROCESS UNIT	BAT is:
	Tanning	• To increase the efficiency of the chrome tanning process through careful control of pH, float, temperature, time and drumspeed, all in combination with chrome recovery through precipitation for waste water streams containing Cr_{total} > 1 g/l (**) • To use high-exhaustion tanning methods where chrome recovery is not possible (**) • To maximise exhaustion of the vegetable tanning liquor with counter-current (pit system) or recycling (drum tanning)
POST- TANNING OPERATIONS	Retanning, chrome fixation and neutralisation	• To enhance exhaustion of post-tanning treatment agents and fixation of tanning agents in the leather • To reduce the salt content of spent liquors
	Dyeing	• To enhance exhaustion of dyestuffs
	Fatliquoring	• To enhance exhaustion of fatliquor
	Drying	• To optimise mechanical dewatering prior to drying where possible
	Applying a surface coat	• To use roller coating • To use curtain coating • To use HVLP spray guns • To use airless spray guns Exception for all four above-mentioned techniques: When very thin finishes are applied, e.g. on aniline and aniline-type leather

(*) **split view on pickling**: partial recycling or re-use of pickle liquors is BAT. Some experts from the tanning industry did not fully agree with this because in their view an exception has to be made. In their view BAT is:
• To use partial recycling or re-use of pickle liquors with an exception for high quality leathers.

(**) **split view on tanning**: some experts from the tanning industry do not fully support this BAT. Their opinion is that a separate treatment of chrome-containing liquors is not currently economically viable for a large part of the Mediterranean leather industry, particularly in situations where a common specialised treatment plant is not available. In their view BAT is:
• To increase the efficiency of the chrome tanning process through careful control of pH, float, temperature, time and drumspeed
• To use chrome recovery through precipitation
Exceptions:
- When common specialized recovery plants are not available
- When the recovered chrome cannot be recycled in order to produce high quality leathers
• To use high-exhaustion tanning methods
Exception:
- High quality leather production.

5.2.3.4 BATs for effluent treatment

Usually the first treatment of the raw effluent is the mechanical treatment that includes screening to remove coarse material. Up to 30 - 40 % of gross suspended solids in the raw waste stream can be removed by properly designed screens. Mechanical treatment may also include skimming of fats, grease, oils and gravity settling. After mechanical treatment, physico-chemical treatment is usually carried out, which involves the chrome precipitation and sulphide treatment described above. Coagulation and flocculation are also part of this treatment to remove a substantial percentage of the COD and suspended solids.

Effluent from tanneries after mechanical and physico-chemical treatment is generally easily biodegradable in standard aerobic biological treatment plants.

More information with regards to BAT for effluent treatment in the tanning sector are available in Annex 11.

5.2.3.5 Benchmarking

For bovine hides it is reported that a water consumption of 40 - 50 m^3/t raw hide can be cut to 12 - 30 m^3/t, if the tannery operates efficient technical control and good housekeeping. For the processing of calf skins, about 40 m^3 /t and sometimes more is needed.

With a combination of batch washing and short floats, savings of water consumption up to 70 % can be achieved, compared with a conventional process.

Effluents from the leather tanning industry could be reduced to achieve the following maximum values in a well designed, well operated and well maintained pollution prevention and control systems. The following levels can be achieved by adopting BATs and BEPs:

Parameter	Maximum concentration in mg/L
BOD_5	50
COD	250
TSS	50
Total nitrogen (NH_4^+ - N)	10
Total phosphorus	2

Achieving these targets requires performance monitoring of the final effluent for the parameters listed above should be conducted monthly (once a record of consistent performance has been established). Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken.

5.2.3.6 Case study

Implementation of BATs and BEPs through cleaner production processes and pollution prevention measures can yield both economic and environmental benefits. The following case study from the industry illustrates the win-win option:

Industry sector: tanning
Company: Gremi de Blanquers d'Igualada, in Spain. (A program adopted in 13 companies in this group)
Application of BATs and BEPs The new technology adopted for hair recovery in the liming process is based on an immunization of the hair with an alkali such as sodium hydroxide or lime at a pH of 12.8-13 during 45-60 minutes. Sodium sulfide or sodium sulfhydrate are then added in quantities of 1-1.2% and after 30 minutes, a chemical shaving of the hair happens. At this moment the bath is emptied from the drum and in a closed circuit passes through a filter separating the hair in its solid form. In the same filter the hair is washed diminishing its salt content, thus facilitating its usage for agricultural purposes due to its high content in nitrogen. The re-circulation of the water continues during approximately 90 minutes. Afterwards, a small quantity of sodium sulfide and lime (0.5%) is added (0.5%) to destroy any remaining hair roots. Smaller quantities of water are needed in the following steps, thus realizing the same soaking and liming operation with a quantity of 15-16 litres/kg of hide.
Effects / Results / Costs / Benefits Environmental benefits This technology change considered as BAT was applied in 13 companies and resulted in addition to the reduction in the consumption of chemical products and water, the process change carried contributed to the reduction of pollution loads (COD and suspended matter) in wastewaters respectively by 40 and 60%. This way, the wastewater discharge costs have been reduced and the possibility of valuating this waste for agricultural purposes has appeared, reducing waste management costs even more.

Financial benefits
The overall financial results achieved in the targeted 13 companies are estimated at on yearly based:

- Annual savings: 372,260 €
- Investment costs: 600,962 €
- Payback period: 1.6 years

Reference: RAC/CP Med Clean case studies No. 24

5.2.4 Pulp and paper industry

BATs and BEPs for the pulp and paper industry are mostly process-related because the environmental impact is caused on this level, i.e. by different manufacturing processes. In this sector, BATs and BEPs are not defined solely by describing unit processes, instead, the whole installations must be examined and dealt with as entities. BAT and BEP in pulp and paper industry is linked to the environmental performance of mills.

The list of BATs and BEPs presented below is not considered exhaustive and any other technique or combination of techniques achieving the same (or better) performance should also be considered; such techniques may be under development or an emerging technique or already available but not mentioned/described here.

5.2.4.1 Kraft pulp and paper mills

5.2.4.1.1 List of applicable BATs for reduction of emissions to water

- Dry debarking of wood.
- Modified cooking either in batch or continuous system.
- Highly efficient brown stock washing and closed cycle brown stock screening.
- Oxygen delignification.
- ECF or TCF final bleaching and some, mainly alkaline, process water recycling in the bleach plant.

5.2.4.1.2 List of applicable BEPs for reduction of emissions to water

- Purification and reuse of condensates.
- Effective spill monitoring, containment, and recovery system.
- Sufficient black liquor evaporation plant and recovery boiler to cope with the additional liquor and dry solids loads due to collection of spills, bleach plant effluents, etc.
- Collection and reuse of clean cooling waters.
- Provision of sufficiently large buffer tanks for storage of spilled cooking and recovery liquors and dirty condensates to prevent sudden peaks of loading and occasional upsets in the external effluent treatment plant.
- Training, education and motivation of staff and operators. Pulp and paper mills are operated by people. Therefore, training of staff can be a very cost-effective way of reducing discharges of harmful substances.
- Process control optimisation. To be able to reduce different pollutants simultaneously and to maintain low emissions, improved process control is required.
- To maintain the efficiency of the technical units of pulp mills and the associated abatement techniques at a high level, sufficient maintenance has to be ensured.
- Environmental management system which clearly defines the responsibilities for environmentally relevant aspects in a mill. It raises awareness and includes goals and measures, process and job instructions, check lists and other relevant documentation.

5.2.4.1.3 BAT for waste water treatment

For the Kraft process effluents, in addition to the process-integrated measures and primary treatment, biological treatment is considered BAT. Activated sludge plants consisting of equalisation basin, aeration basin, secondary clarifier and sludge handling show excellent performance for the treatment of pulp mill effluents. Low loaded activated sludge plants with a sludge load below 0.15 kg BOD_5/(kg MLSS*d) and typical retention times in the aeration basin of about one day (up to 2 days) are regarded as BAT. They can achieve high removal efficiencies and a stable treatment system.

It should be noted that any other treatment with comparable emission levels and comparable costs can also be regarded as BAT.

5.2.4.1.4 Benchmarks

The following emission to water associated with the use of BAT and BEP can be generally achieved **before** biological treatment:[26]

Table 6
Emission levels associated with the use of a suitable combination of best available techniques achieved after primary treatment. Values for bleached and unbleached kraft pulp mills are given

Parameters	Units	Bleached Kraft [1]	Integrated unbleached Kraft [3]
COD	kg/Adt	30 [2] - 45	15 - 20
BOD_5	kg/Adt	13 [2] - 19	6 - 9
TSS	kg/Adt	2 - 4	2 - 4
AOX	kg/Adt	(-) -0.4	*
Total P	kg/Adt	0.04 - 0.06 [4]	0.01-0.02
Total N	kg/Adt	0.3 - 0.4	0.1 - 0.2
Process wastewater amount	m^3/Adt	30-50	15 - 25

Notes:
*This parameter is not relevant here. Low emissions of AOX may occur from re-pulping of purchased bleached pulp
1) Emission levels for non-integrated and integrated bleached Kraft pulp mills per ton of pulp.
2) Lower values are achievable when only hardwood is pulped
3) Unbleached Kraft pulp mills are all integrated mills. They produce kraftliner, unbleached board grades and sack and other Kraft paper. Many of them use recycled fibres and purchased bleached pulp. Higher emission levels are usually found in mills using more recycled fibres as raw material. Figures are per ton of liner/paper/board produced
4) Due to the higher content of phosphorus in the pulp wood eucalyptus pulp mills can not achieve this values.
Current mill data for P emissions to water range from 0.037 - 0.23 kg P/Adt. The average of the reported data is 0.11 kg P/Adt

The following emission to water associated with the use of BAT and BEP can be generally achieved **after** biological treatment:

26 Reference Document on Best Available Techniques in the Pulp and Paper Industry, European Integrated Pollution Prevention and Control (IPPC) Bureau, December 2001.

Table 7
Emission levels associated with the use of a suitable combination of best available techniques after biological treatment

Parameters	Unit	Bleached Kraft [1]	Unbleached Kraft + kraftliner or sackpaper [2]
COD	kg/Adt	8 – 23	5.0 - 10
BOD_5	kg/Adt	0.3 - 1.5	0.2 - 0.7
TSS	kg/Adt	0.6 - 1.5	0.3 - 1.0
AOX	kg/Adt	(-) - 0.25	-
Total P	kg/Adt	0.01 - 0.03 [3]	0.01 - 0.02
Total N	kg/Adt	0.1 - 0.25 [4]	0.1 - 0.2
Process wastewater amount [5]	m^3 /Adt	30-50	15-25

Notes:
1. Emission levels for non-integrated and integrated bleached Kraft pulp mills
2. Emission levels for integrated unbleached Kraft pulp and paper/liner mills
3. Due to the higher content of phosphorus in the pulp wood some eucalyptus pulp mills can not achieve these values if P is in excess of the need of the biological treatment plant. Emission will be determined by P-content of the wood. No phosphorus needs to be added to the wastewater treatment plant.
4. Any nitrogen discharge associated with the use of complexing agents should be added to the figure of tot-N
5. Cooling water and other clean water are discharged separately and are not included

Table 6 & Table 7 should be read together with the additional explanations of the Annex 12 **(**Table 18**).**

To ensure a continuously well running wastewater treatment plant, an emergency basin to protect the biomass from toxic or hot concentrated liquors, as well as an equalisation basin to equalise load and flows, can be beneficial.

5.2.4.1.5 Case studies

Implementation of BATs and BEPs through cleaner production processes and pollution prevention measures can yield both economic and environmental benefits.

Examples of mills using the **combination of techniques presented above with primary treatment only** achieved the range of emissions indicated in the table below:

Table 8
Examples of achieved emission levels to water after only primary treatment of some existing pulp mills in Mediterranean countries

Mills	COD [kg/Adt]	$BOD_{5 or 7}$ [kg/Adt]	TSS [kg/Adt]	AOX [kg/Adt]	Tot N [kg/Adt]	Tot P [kg/Adt]	Flow [m^3/Adt]	Production 97 [Adt/a]	Remarks
ENCE, Huelva mill, Spain	28	n/a.	5.2	0.17	n/a.	n/a.	41.2	310,000	Bleached hardwood ECF market pulp (eucalyptus)
Modo Alizay, France (all site)	42.3	11	12.3	n/a.	n/a.	n/a.	61	244,500	Pulp 220000 paper Integrated ECF bleached pulp & paper mill
Smurfit CdP Facture mill, France *	17.3	7.7	1.6	-	0.25	9.10^{-3}	28.4	350,000 - 400,000	Unbleached Kraft + kraftliner, 20% recycled fibres, 10% purchased pulp

Notes:
n/a. = data not available
* Per ton of liner produced

Emission levels of a pulp mill in a Mediterranean country (France) that has implemented a set of process-integrated BAT and BEP measures together with biological wastewater treatment:

Table 9
Examples of achieved emission levels to water after biological treatment of an existing pulp mill in France

Pulp mills	Reported achieved emission levels after biological treatment (annual averages)							Type of treatment
	COD [kg/Adt]	$BOD_{5 or 7}$ [kg/Adt]	AOX [kg/Adt]	TSS [kg/Adt]	Total P [kg/Adt]	Total N [kg/Adt]	Flow [1]) [m^3 /Ad]	e.g. normal-/ low-load
Modo Alizay, France (all site) [2]	11.1 (180)	0.6 (10)	0.1 (1.6)	2.24 (37)	0.08 (1.3)	0.38 (6.2)	61	Activated sludge
Water flow excludes cooling water Figures are per ton of finished product. Figures per ton of bleached Kraft pulp produced would be different, e.g. for COD 13 kg/Adt, BOD5 0.63 kg/Adt, TSS 2.82 kg/Adt, flow 64 m^3 /Adt; data refer to 1998 (Figures given within brackets in the table are in terms of concentration [mg/L]).								

5.2.4.2 Sulphite pulp and paper mills

The techniques or combination of techniques that are considered as BATs and BEPs for integrated and non-integrated sulphite pulp mills are given below.

5.2.4.2.1 List of applicable BATs for reduction of emissions to water

- Dry debarking.
- Extended delignification in the closed part of the process. This is achieved by a combination of extended cooking and oxygen delignification. It has to be kept in mind that there is a difference in magnesium-bisulphite and magnefite-pulping concerning achievable kappa number after extended cooking.
- Highly efficient brown stock washing and closed cycle brown stock screening. A carry-over from the washed pulp to the bleach plant of < 5 kg COD/t is achievable.
- Closure of the bleach plant when sodium based cooking processes is being used.
- TCF bleaching. For bleaching of sulphite pulp the use of chlorine containing bleaching chemicals can be avoided. The application of high consistency peroxide bleaching results in short and efficient bleaching sequences.
- Neutralizing weak liquor before evaporation.

5.2.4.2.2 List of applicable BEPs for reduction of emissions to water

- Effective spill monitoring, containment, and recovery system.
- Re-use of most condensates in the process or separate biological treatment.
- Use of sufficiently large buffer tanks for storage of concentrated or hot liquids from the process.
- Training, education and motivation of staff and operators. Pulp and paper mills are operated by people. Therefore, training of staff can be a very cost-effective way of reducing discharges of harmful substances.
- Process control optimisation. To be able to reduce different pollutants simultaneously and to maintain low emissions, improved process control is required.
- To maintain the efficiency of the technical units of pulp mills and the associated abatement techniques at a high level, sufficient maintenance has to be ensured.

- Environmental management system which clearly defines the responsibilities for environmentally relevant aspects in a mill. It raises awareness and includes goals and measures, process and job instructions, check lists and other relevant documentation.

5.2.4.2.3 BAT for wastewater treatment

In addition to primary treatment of wastewater, biological wastewater treatment in activated sludge system or by use of other techniques achieving the same or better performance or efficiency is considered BAT for sulphite pulp mills. Activated sludge plants consisting of equalisation basin, aeration basin, secondary clarifier and sludge handling show excellent performance for the treatment of pulp mill effluents. Low loaded activated sludge plants with a sludge load below 0.15 kg BOD5/(kg MLSS*d) and typical retention times in the aeration basin of about one day are regarded as BAT. They can achieve high removal efficiencies and a stable treatment system. It should be noted that any other waste water treatment system with comparable emission levels and comparable costs can also be regarded as BAT.

When implementing suitable combinations of BAT achievable emission levels for non-integrated and integrated sulphite pulp mills are considered to be in the same range as far as the pulping side is concerned. For integrated mills, the measures related to pulp mills and additionally the measures described on papermaking have to be considered.

5.2.4.2.4 Benchmarks

Assuming adequate design and capacity of the wastewater treatment plant and appropriate operation and control by skilled operators the following discharge after biological treatment is generally achievable:

Table 10
Emission levels associated with the use of a suitable combination of best available techniques after biological treatment. For integrated sulphite pulp mills these figures refer only to the pulp produced. The emissions from papermaking have to be considered separately. The water circuits however are linked and the water flow can not be simply added.

Parameters	Units	Bleached sulphite [1]
COD	kg/Adt	20 - 30 [2]
BOD_5	kg/Adt	1 – 2
TSS	kg/Adt	1.5 - 2.0
AOX	kg/Adt	(-)
Total P	kg/Adt	0.02 - 0.05
Total N	kg/Adt	0.15 - 0.5
Process wastewater amount [3]	m^3 /Adt	40 - 55 [4]

Notes:
1. Emission levels for non-integrated and integrated bleached sulphite pulp mills
2. Because of higher kappa number after cooking for magnefite process the BAT associated level is 35 kg COD/Adt
3. Cooling water and other clean water are discharged separately and are not included.
4. Process water from the paper mill in integrated sulphite pulp mills is not included

Table 10 should be read together with the additional explanations of the Annex 12 (Table 19).

To ensure a continuously well running wastewater treatment plant, an emergency basin to protect the biomass from toxic or hot concentrated liquors, as well as an equalisation basin to equalise load and flows, can be beneficial.

5.2.4.3 Mechanical and chemi-mechanical pulp and paper mills

For mechanical and chemi-mechanical pulp and paper mills, the following techniques or combination of techniques are considered as BATs and BEPs:

5.2.4.3.1 List of applicable BATs for reduction of emissions to water

- Dry debarking of wood. Dry techniques use less water circulation through the drum stage. Water systems in debarking plants are kept very closed. Solid material is removed from the circulation water, which is only used for log washing, and separation of undesirable material. A part of the clarified water is separated for wastewater treatment.
- Water circulation system in mechanical pulping department. In order to keep the accumulation of dissolved and dispersed substances at an acceptable level, the water circuits are opened to a certain extent.
- Effective separation of the water systems of the pulp and paper mill by use of thickeners. A dewatering lock after pulping leads to a significant decrease of contaminants in the paper machine water system. The filtrate of thickening is returned to the pulping process. This measure prevents that contaminants dissolved from the wood are travelling through the whole papermaking process. Isolation of process units makes it possible to remove contaminations inside the process unit in which they are generated.
- Countercurrent white water system from paper mill to pulp mill depending on the degree of integration. The recirculation of process water from the paper machine to the pulp mill might not be possible when the mill has two or more paper machines making different types of paper, the white waters of which are incompatible, or when coloured paper is manufactured.
- Use of sufficiently large buffer tanks and storage for liquids from the process (mainly for CTMP).

5.2.4.3.2 List of applicable BEPs for reduction of emissions to water

- Training, education and motivation of staff and operators. Training of staff can be a very cost-effective way of reducing the environmental impact of mills.
- Process control optimisation. To be able to reduce different pollutants simultaneously and to maintain low emissions, improved process control is required. The target of the controls is to keep the process at the desired operating point.
- To maintain the efficiency of the technical units of pulp mills and the associated abatement techniques at a high level, sufficient maintenance has to be ensured.
- Environmental management system which clearly defines the responsibilities for environmentally relevant aspects in a mill. It raises awareness and includes goals and measures, process and job instructions, check lists and other relevant documentation.

5.2.4.3.3 BAT for wastewater treatment

In addition to the process-integrated measures and primary treatment, biological treatment is considered BAT for mechanical and chemi-mechanical pulp and paper mills. Activated sludge plants consisting of equalisation basin, aeration basin, secondary clarifier and sludge handling show excellent performance for the treatment of those effluents. Low loaded activated sludge plants with a sludge load below 0.15 kg BOD_5/(kg MLSS*d) and typical retention times in the aeration basin of about one day are regarded as BAT. They can achieve high removal efficiencies (COD: 75-90%; BOD_5: 95+%) and a stable treatment system. A few mills achieved also good performances (>85% COD reduction) with high load biological treatment.

For CTMP mills, effluent treatment either by biological treatment systems in one or two stages with or without chemical treatment or internal chemical treatment of white water of the first washing stage plus activated sludge treatment of the rest is regarded as BAT. A combination of an anaerobic and aerobic treatment of the waste water is also regarded as an efficient treatment system. Finally, evaporation of the most contaminated waste water and burning of the concentrate plus biological treatment of the rest might a solution for upgrading mills is regarded as BAT.

For new mills and those that significantly increase capacity, the evaporation of the selected highly polluted partial wastewater streams to support the biological treatment or whole effluents and incineration of the concentrates are considered as BAT.

5.2.4.3.4 Benchmarks

The following emission levels are achievable in association of application of BATs and BEPs following discharge **after** biological treatment are associated with the use of BATs and BEPs.

Table 11
BAT associated emission levels as yearly average for manufacturing of wood-containing paper (> 50% mechanical pulp). Values refer to integrated mills after biological treatment. Emissions from the paper machine are included.

Parameter	Units	Integrated mechanical pulp and paper mills such as newsprint [1], LWC paper [2], SC paper [3] mills
BOD_5	kg/t of paper	0.2 - 0.5
COD	kg/t of paper	2.0 - 5.0
TSS	kg/t of paper	0.2 - 0.5
AOX	kg/t of paper	< 0.01
Total P	kg/t of paper	0.004 - 0.01
Total N	kg/t of paper	0.04 - 0.1
Wastewater amount	m^3 /t of paper	12 - 20

Explanatory notes:
1. It is assumed that > 50% of the fibres consists of mechanical pulp manufactured at the mill. Fibre furnish might be e.g. 50-60% bleached TMP, 40-50% DIP
2. It is assumed that > 50% of the fibres consists of mechanical pulp manufactured at the mill. Fibre furnish might be e.g. 30-40% purchased bleached kraft pulp, 50-60% PGW or TMP
3. It is assumed that > 50% of the fibres consists of mechanical pulp manufactured at the mill. Fibre furnish might be e.g. 10-20% purchased bleached kraft pulp, 80-90% PGW or TMP. 20-45% of the raw material might consists of fillers and sizes

Table 11 should be read together with the additional explanations of the Annex 12 (Table 20).

5.2.4.4 <u>Paper mills processing recovered paper</u>

For mills processing recovered paper the following techniques are considered as BATs and BEPs.

5.2.4.4.1 List of applicable BATs and BEPs for reduction of emissions to water

- Reduction of fresh water consumption and thus, wastewater flows, can be achieved by application of a combination of different techniques such as:
- Separation of less contaminated water from contaminated one and recycling of process water. Separation and reuse of clean cooling waters and recycling of sealing and process water from pumps for vacuum generation are ways to reduce fresh water consumption.
- Optimal water management (water loop arrangement), water clarification by sedimentation, flotation or filtration techniques and recycling of process water for different purposes.
- Reduction of fresh water consumption by strict separation of water loops and counter-current flows.
- Generation of clarified water for de-inking plants (flotation).

- Training, education and motivation of staff and operators. Paper mills are operated by people. Therefore, training of staff can be a very cost-effective way of reducing water consumption and discharges of harmful substances as for instance accidental releases of chemicals.
- Process control optimisation. To be able to reduce different pollutants simultaneously and to maintain low emissions, improved process control and measurement are required.
- To maintain the efficiency of the technical units of paper mills and the associated abatement techniques at a high level, sufficient maintenance has to be ensured.
- Environmental management system which clearly defines the responsibilities for environmentally relevant aspects in a mill. It raises awareness and should include goals and measures, process and job instructions, check lists and other relevant documentation.

5.2.4.4.2 BAT for wastewater treatment

It is difficult to present reliable figures on wastewater loads before biological treatment because it is rare that those emissions are reported transparently. For instance, it is often not clear which process-integrated techniques are applied to achieve the reported emission levels with primary treatment only. Emissions to water before treatment depend to a large extent on the quality of raw materials used (recovered paper, chemical additives) and process lay out (consistency, temperature, alkaline treatment, and water loop design).

Water pollution abatement is strongly related to recovery and recycling of process water in order to reduce fresh water consumption. Increased process water closure will result in smaller and more concentrated discharges, which in general can be treated more efficiently. Decrease of process water flows will also increase the applicability of advanced technologies. Therefore, reduction of the intake of fresh water can result in decreasing discharges to surface waters. The intake of fresh water is mainly determined by product requirements, paper grades and the design of the water system of the paper mill (condition of the mill). The water consumption is dependent on the amount of water required for showers. Furthermore, amount of fresh water consumption depends on the knowledge about water management and the motivation of the whole staff to support the vision of running a paper mill using as less water as necessary. Excess white water and other polluted process water is purged from the system and is treated biologically.

The following measures, dealing with wastewater treatment in recovered paper processing, are regarded as BAT:

1. Installation of an equalisation basin and primary treatment.
   These measures are applied at nearly all paper mills and are rather considered as good practice. They are a pre-requisite for well and stable performing biological wastewater treatment plants. For RCF processing paper mills they are not considered as BAT as a stand-alone technique.
2. Aerobic biological treatment. This is the preferable option for de-inked grades and depending on the conditions also for non-de-inked grades. There are a lot of different treatment options available that achieve good results in reducing the organic load to the recipients. The choice of the treatment option is mainly governed by the initial concentration, the wastewater characteristics and the removal efficiency to be achieved. Proper design and maintenance of the treatment plant is a prerequisite for good performing biological systems. Common treatment of wastewater from a paper mill or a consortium of paper mills in the municipal biological wastewater treatment plant is also considered as BAT when comparable removal efficiencies are achieved by this common treatment.
3. Combined anaerobic and aerobic biological treatment. This is the preferable option for non-deinked grades. They have usually to treat higher polluted wastewater either because of higher degree of water circuit closure and/or larger amounts of organic substances dissolved in the stock preparation. There are a few good experiences for

anaerobic treatment of wastewater from DIP plants also. Anaerobic treatment is never used as stand-alone biological treatment but is always followed by aerobic treatment. Compared to aerobic treatment only the combined treatment generates significantly less excess sludge.

5.2.4.4.3 Benchmarks

Emission levels associated with a combination of the techniques mentioned above are considered to be those given in the table below:

Table 12
Yearly average emission and consumption levels associated with the use of BAT for integrated RCF processing (> 50% RCF) paper mills with (e.g. newsprint, copy paper, folding boxboard in a few cases) and without de-inking (e.g. white topliner/testliner/wellenstoff/fluting mills)

Parameter	Units	Without de-inking [4]	With de-inking [1]	RCF based tissue
BOD_5	kg/t of paper	<0.05-0.15 [5]	<0.05-0.2 [5]	<0.05-0.5 [5]
COD	kg/t of paper	0.5-1.5	2.0-4.0	2.0-4.0
TSS	kg/t of paper	0.05-0.15	0.1-0.3	0.1-0.4
AOX	kg/t of paper	<0.005	<0.005	<0.005
Total P	kg/t of paper	0.002-0.005 [2]	0.005-0.01 [2]	0.005-0.015 [2]
Total N	kg/t of paper	0.02-0.05 [2]	0.05-0.1 [2]	0.05-0.25 [2]
Wastewater amount	m^3/t of paper	<7	8-15	8-25 [3]

Explanatory notes:
1) A mixture of other fibre types (such as GWP, TMP or CTMP) might be used as different shares ranging from 0 - 30 % of the fibre furnish
2) Emissions of N and P depend on the optimised dosage of these nutrients to the biological wastewater treatment plant. To achieve low emissions a certain fine-tuning of the added nutrient feed is required
3) For tissue production there is a number of factors that might lead to somewhat higher specific water consumption: lower basic weights of paper produced (down to 12 g/m^2), higher cleanliness of the product, frequent changes of grade or colours, lower speeds of the paper machines, and the use of processes that need higher amounts of high pressure showers. Therefore, for tissue a process water demand of 8 - 25 m^3 /t is regarded as BAT
4) Coated cartonboard manufacturing requires some more water than e.g. testliner, wellenstoff or uncoated cartonboard production (7-15 m^3 /t). Therefore, the upper end of the emission range associated with BAT is valid for coated cartonboard
5) The lower end of the BOD emission range indicates an almost complete removal of biodegradable organic matter. It should be understood as such and not be taken as a precise figure.

Table 12 above should be read together with the additional explanations of the Annex 12 (Table 21).

5.2.4.5 Paper mills

For paper mills the following techniques are considered as BAT and BEP:

5.2.4.5.1 Applicable BATs

- Construction of a balanced white water, (clear) filtrate and broke storage system and use of constructions, design and machinery with reduced water consumption when practicable. This is normally when machinery or components are replaced or at rebuilds.

5.2.4.5.2 Applicable BEPs:

- Minimising water usage for different paper grades by increased recycling of process waters and water management.
- Exact knowledge on water consumption and quality in different uses forms the basis for good water management.
- On-line measurements and accurate process control are essential for effective and stable papermaking.
- Measures to reduce frequency and effects of accidental discharge.
- This includes training of staff for the case of accidental releases of chemicals to the effluent treatment plant and sufficient precautionary measures to prevent accidents.
- Collection and reuse of clean cooling and sealing waters or separate discharge.
- Recycling of cooling and sealing waters can be increased by use of heat exchangers or a cooling tower. However, microbial and water quality monitoring and control methods are required to ensure disturbance-free performance of the system.
- Separate pre-treatment of coating wastewaters.
- In cases where recovery and re-use of coating colours from coating wastewaters by membrane technique is not possible flocculation of this concentrated partial wastewater stream is considered as BAT. The UF separation technique is mentioned as a measure to reduce solid waste.
- Substitution of potentially harmful substances by use of less harmful alternatives.
- The removal efficiency after wastewater treatment and the environmental impact as a whole can be improved by using non-toxic and better biodegradable product aids and process chemicals.
- Training, education and motivation of staff and operators. Paper mills are operated by people. Therefore, training of staff can be a very cost-effective way of reducing water consumption and discharges of harmful substances as for instance accidental releases of chemicals.
- Process control optimisation. To be able to reduce different pollutants simultaneously and to maintain low emissions, improved process control and measurement are required.
- To maintain the efficiency of the technical units of paper mills and the associated abatement techniques at a high level, sufficient maintenance has to be ensured.
- Environmental management system which clearly defines the responsibilities for environmentally relevant aspects in a mill. It raises awareness and includes goals and measures, process and job instructions, check lists and other relevant documentation.

5.2.4.5.3 BAT for wastewater treatment

- Effluent treatment of wastewater by installation of an equalisation basin and primary treatment: These measures are applied at nearly all paper mills and are rather considered as good practice. They are a pre-requisite for well and stable performing biological wastewater treatment plants. They are not considered as BAT as a stand-alone technique except for a few paper grades that release very low specific emission loads to water.
- Secondary or biological treatment of wastewater, and/or in some cases, secondary chemical precipitation or flocculation of wastewater. When only chemical treatment is applied the discharges of COD will be somewhat higher but mainly made up of easily degradable matter.

Pollution load removal efficiencies associated with BAT in wastewater treatment are considered to be:

Table 13
Examples of removal efficiencies of suitable biological treatment systems for effluents from paper mills

Initial range of concentration	Treatment	COD removal	BOD removal	AOX removal	TSS after treatment	Nutrients
BOD_5 > 500 mg /L	Trickling filter + activated sludge	80 – 90 %	95+ %	30 - 50%	Concentr. below 30 mg/L	Added to the wwtp
BOD_5 > 500 mg /L	Trickling filter (pre-treatment)	50 – 60 %	60 - 70%	30 - 50%	Concentr. high around 100 mg/L	Added to the wwtp
BOD_5 > 100 mg /L	Activated sludge [1)2)]	75 – 90 %	90 - 95+ %	30 - 50%	Concentr. below 30 mg/L	Added to the wwtp
BOD_5 < 150 mg /L	Biofiltration	40 – 60%	60 - 80 %	30- 50%	Concentr.: 10 - 30 mg/L	Added to the wwtp

Notes: wwtp = wastewater treatment plant
1) This removal efficiencies are achieved by low load activated sludge systems with a food/mass ratio between 0.1 and 0.2 kg BOD_5/kg TSS*d (or about 1 day retention time).
2) In a few applications also for high load plants good removal efficiencies are reported.

5.2.4.5.4 Benchmarks

Assuming adequate design and capacity of the wastewater treatment plant and appropriate operation and control by skilled operators, emission levels associated with a combination of BAT are considered to be those given in Table 14. The effluent loads exclude the contribution of pulp manufacturing.

In spite of the huge number of different kinds of paper products manufactured it can be stated that paper mills that have implemented BAT achieve relatively similar emissions to water. As regards the discharges after suitable wastewater treatment from the various paper production categories, further significant differences between paper grades were not identified.

The emission data refer to non-integrated paper production. However, there is an increasing number of mills in the Mediterranean countries which are only partly integrated, i.e. for a part of the furnish there is a pulp production whereas the other parts consists of purchased pulp. In that case, the emissions from pulp processing have to be added to paper production according to the contribution of pulping activities.

Table 14 should be read together with the additional explanations of the Annex 12 (Table 22).

Table 14
Yearly average emission and consumption levels associated with the use of BAT for non-integrated uncoated fine paper mills, non integrated coated fine paper mills and non-integrated tissue mills

Parameters	Units	Uncoated fine paper [1]	Coated fine paper [2]	Tissue [3]
BOD_5	kg/t	0.15-0.25	0.15-0.25	0.15-0.4
COD	kg/t	0.5-2	0.5-1.5	0.4-1.5
TSS	kg/t	0.2-0.4	0.2-0.4	0.2-0.4
AOX	kg/t	< 0.005	< 0.005	< 0.01 [4]
Total P	kg/t	0.003-0.01	0.003-0.01	0.003-0.015
Total N	kg/t	0.05-0.2 [5]	0.05-0.2	0.05-0.25
Waste water amount	m^3/t	10-15 [6]	10-15	10-25 [7]

Notes:
1) The fibre furnish might be e.g. 100 % bleached kraft pulp and fillers and sizes might amount to 15-30 %. For mass sized paper the upper ranges for COD and BOD have to be considered
2) The fibre furnish might be e.g. 100 % bleached kraft pulp and fillers and coating colour might amount to 20-40 %. Upgrading of paper consists of both surface sizing and application of coating colours
3) Fibre furnish 100 % purchased chemical pulp
4) The higher AOX value can be caused by wet strength agents that contain chlorinated organic substances
5) For coloured grades the nitrogen-releases can be higher when N-containing azo dyestuffs are used
6) For mills which are producing coloured or strong coloured grades fresh water consumption can normally not be brought below 17 m^3 /t
7) A change of basis weight and speed of the paper machine have a significant effect on the specific water consumption (SWC). Lower basis weights (down to 12 g/m^2) and lower speeds correspond to higher SWC

5.2.4.5.5 Case study

Implementation of BATs and BEPs through cleaner production processes and pollution prevention measures can yield both economic and environmental benefits. The following case study from the industry illustrates the win-win option:

Industry sector: manufacture of paper

Company: Aussedat-Rey paper mill, France

Application of BATs and BEPs

- Extended continuous heating process: the continuous digester with extended heating ensures maximum lignin removal. Thus, less lignin is in the bleaching stages is reduced, leading to a significant decrease in its derivatives contained in the effluents
- Using chlorine dioxide instead of chlorine reduces the discharges of organo-halogen compounds coming from the bleaching sequences by a factor of 15
- Using a washing press ensures a decrease in the water consumption and chemical products. The quantity of dissolved organic and inorganic matters is reduced by 75 % at this level

Effects / Results / Costs / Benefits

Environmental and economic benefits included:

- Decrease in the water consumption by 30%
- Decrease in COD contained in the discharges by 50 %
- Contribution to the public image of the company, by means of its decisive participation in the action plan of the Water Agency for the Vienne river water quality

Investments: 41,400,000 €

Reference: UNEP ICPIC
Water Agency Loire-Bretagne.

5.2.5 Phosphatic fertilizers industry

5.2.5.1 BATs and BEPs in phosphatic fertilizers industry

Because waste water in the fertilizers industry is primarily generated not by the production or formulating processes themselves but by cleaning operations of the process areas and associated equipment, BATs and BEPs reported by this industry could be achieved through water conservation, recycling and reuse practices and not by process-specific measures.

5.2.5.1.1 BATs applicable across the entire process

- The discharge of sulfur dioxide from sulfuric acid plants should be minimized by using the double-contact, double-absorption process, with high efficiency mist eliminators.
- Use well-bundled storage tanks, and install spill catchment and containment facilities to avoid inadvertent liquid discharges.

5.2.5.1.2 BEPs applicable across the entire process

- Maintain an operating water balance to avoid an effluent discharge.
- Put in place tight operating procedures and pay close attention to constant cleanup of spills and to other housecleaning measures.
- Minimize potential contamination of stormwater runoff from the property.
- Practice good housekeeping and maintenance to prevent spills and accidental discharges.
- Line the tailings storage area to prevent contamination of groundwater by fluoride.
- Consider the recycling of Phosphogypsum in the production of gypsum board for the construction industry and road construction.
- Improve production practices through the following measures:
  - triple-rinsing raw material shipping containers directly into the formulation;
  - scheduling production to minimize cleanouts;
  - segregating processing/formulating/packaging equipment by:
    - ✓ individual product
    - ✓ products that contain similar active ingredients in different concentrations
  - storing interior equipment rinse waters for use in formulating the same product;
  - packaging products directly from formulation vessels;
  - using raw material drums for packaging final products.
- Apply housekeeping practices through:
  - performing preventive maintenance on all valves, fittings and pumps;
  - placing drip pans under leaky valves and fittings or under any valves or fittings where hoses or lines are routinely connected and disconnected;
  - cleaning up spills or leaks in outdoor bulk containment areas to prevent contamination of storm water.
- use equipment that reduces or eliminates wastewater generation such as:
  - low-volume/high-pressure hoses;
  - spray nozzle attachments for hoses;
  - squeegees and mops;
  - low-volume/recirculating floor scrubbing machines;
  - portable steam cleaners;
  - drum triple rinsing stations;
  - roofs over outdoor tank farms.

5.2.5.1.3 BATs & BEPs methods applied to waste streams in the fertilizers industry

Equipment cleaning wastes

- Maximize production runs.
- Store and reuse cleaning wastes.

- Use wiper blades and squeegees.
- Use low-volume, high-efficiency cleaning.
- Use plastic or foam “pigs”.

Spills and area washdowns
- Use a dedicated vacuum system.
- Use dry cleaning methods.
- Use recycled water for initial cleanup.
- Actively involved supervision.

Containers
- Return containers to supplier and or reuse as directed.
- Triple rinse containers.
- Drums with liners versus plastic drums or bags.
- Segregate solid waste.

5.2.5.2 BATs for effluent treatment

If it is not possible to maintain an operating water balance in the phosphoric acid plant, treatment to precipitate fluorine, phosphorus, and heavy metals may be necessary. Chemical precipitation using lime is regarded here as BAT.

5.2.5.3 Benchmarking

Effluents from the phosphatic fertilizers industry could be reduced to achieve the following maximum values in a well designed, well operated and well maintained pollution prevention and control systems. The following levels can be achieved by adopting BATs and BEPs:

Parameter	Maximum concentration in mg/L
BOD_5	50
COD	250
TSS	50
Total phosphorus	5

Achieving these targets requires performance monitoring of the final effluent for the parameters listed above should be conducted monthly (once a record of consistent performance has been established). Monitoring data should be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken.

5.2.6 Pharmaceutical industry

BATs and BEPs measures reported by the pharmaceutical manufacturing facilities could be achieved through product change, process changes, input material process changes, technology process changes, improved operating practices, recycling/reuse activities and treatment.

It should be noted at the outset that the presented list of BATs and BEPs is not exhaustive and any other technique or combination of techniques achieving the same (or better) performance should also be considered; such techniques may be under development or an emerging technique or already available but not described here.

5.2.6.1 BATs applicable across the entire process

- Use automated filling to minimize spillage.
- Use “closed” feed systems into batch reactors.
- Recirculate cooling water.

- Use high-pressure hoses for equipment cleaning to reduce wastewater.
- Use reverse osmosis or ultra filtration to recover and concentrate active ingredients.

5.2.6.2 BEPs applicable across the entire process

- Every effort should be made to replace highly toxic and persistent ingredients with degradable and less toxic ones.
- Control loss and wastage of active ingredients.
- Meter and control the quantities of active ingredients to minimize wastage.
- Reuse by-products from the process as raw materials or as raw material substitutes in other processes.
- Recover solvents used in the process by distillation or other methods.
- Give preference to the use of non-halogenated solvents.
- Minimize raw material and product inventory to avoid degradation and wastage.
- Label and store toxic and hazardous materials in secure, bunded areas.
- Measures to avoid the release of harmful substances should be incorporated in the design, operation, maintenance, and management of the plant.
- Provide storm water drainage and avoid contamination of storm water from process areas.
- Design and implement employee-training program to all personal operating equipment or handling wastes. They should be trained in proper equipment care, equipment operation, material handling, and spill cleanup. They also should be taught methods for detecting chemical releases and be briefed on regulatory requirements.

Equipment cleaning
- Maximize number of campaigns to reduce cleaning frequency.
- Use final rinse as pre-rinse on next cleaning cycle.
- Use wiper blades and squeegees and rework remainders into products.
- Use low-volume high-efficiency cleaning (e.g. spray heads).

Wastes spills and area washdown
- Use dedicated vacuum systems.
- Use dry cleaning methods.
- Use recycled water.

Solvents production
- Substitute aqueous systems where possible.
- Reduce quantity of solvent used.
- Regenerate/recover spent solvent.

Off-specification products
- Rework off-specification material.
- Use automated processing systems.

Containers
- Return empty containers to supplier.
- Thoroughly empty and triple rinse with minimal water.
- Use containers with recyclable liners.
- Segregate solid waste.

5.2.6.3 BATs for effluent treatment

Several wastewater treatment technologies are used by pharmaceutical manufacturing facilities. The use of neutralization, equalization, activated sludge, primary clarification, multimedia filtration, steam stripping, secondary clarification, granular activated carbon, and oxidation have all increased, while the use of aerated lagoons, chlorination, waste stabilization ponds, and trickling filters has decreased slightly.

The detail of each unit operation can be found in Annex 14.

5.2.6.4 Benchmarking

Effluents from the pharmaceutical industry could be reduced to achieve the following maximum values in a well designed, well operated and well maintained pollution prevention and control systems. The following levels can be achieved by adopting some (not necessarily all of the) BATs and BEPs:

Parameter	Maximum concentration in mg/L
BOD_5	30[a]
COD	150
TSS	10

[a]. A BOD test is to be performed only in cases where the effluent does not contain any substance toxic to the microorganisms used in the test.

5.2.6.5 Case study

Implementation of BATs and BEPs through cleaner production processes and pollution prevention measures can yield both economic and environmental benefits. The following case study from the industry illustrates the win-win option:

Industry sector: pharmaceutical industry
Company: SANOFI, Ambares Plant in France The company manufactures pharmaceutical products in dry form (tablets, capsules, micro-pills) or liquid form (injectable vials, small bottles, solutions).
PROCESS MODIFICATION The process modification consisted of adding a network for specific catchment of the solvents coming from the tanks cleaning. Automatic gates direct them towards 3 intermediate tanks of 1 m^3; they are then delivered by pumping, into 2 tanks of 6 m^3 in order to be incinerated in a registered centre.
Effects / Results / Costs / Benefits - Total removal of chlorinated discharges (300 l/day) - Decrease by 50 % in COD (400 kg/day) - Authorization for connection to the public sewage network. - Total cost of direct investment: 76,350 € (1992)

Reference: adapted from UNEP, ICPIC
Database Agence de l'Eau Adour-Garonne

5.3 Economic Aspects for the Implementation of BATs & BEPs

Further to their technical and environmental analysis, the selection of BATs and BEPs options has much to do with decision making between several options in light of a particular situation and naturally, it has to do with economics and competitiveness. The main question that one has to answer is: how can one operate a complex site and manage its demands for a supply of resources and discharge of waste with the least possible impact on the environment as a whole, with the highest economic efficiency and without any loss of product quality?

Economics are inherently part of the concept of BAT, which stands for the most efficient technique of protecting the environment with present technological and economical conditions. Therefore, in order for a technique to be considered as BAT, it has to be economically feasible for the company in question. Selecting a technique that would be further introduced in a company is thus a key process where its economic feasibility has to be analysed: if applying the technique were not economically viable, this would not be considered as BAT according to the definition seen at the beginning of this chapter.

The economical viability of BATs and BEPs require the application of an assessment methodology of the economical feasibility based on criteria pertaining to the cost of the investment and the training required for its efficient implementation, the associated annual savings to be achieved and the determination of the payback period of the investment. The analysis should determine the economical viability of the options before they are adopted.

In this respect, these Guidelines advise to refer to the methodology developed in the Regional Guidelines for the Application of Best Available Techniques (BATs), Best Environmental Practices (BEPs) and Cleaner Technologies (CTs) in industries of the Mediterranean countries, developed by the Regional Activity Centre for Cleaner Production.

Since the costs involved in implementation of BATs and BEPs will always be plant and/or process-specific, these Guidelines cannot consider that adequately. It has thus been chosen to illustrate the chapter with case studies of Mediterranean companies having applied BATs or BEPs including economic figures; those have been included in a specific section within the sectors studied, whenever success stories were identified.

The Guidelines also consider and explain in the following paragraphs the factors or items to take into account when evaluating cost data that are not generally included in this document because of their site- and process-specific characteristics. The items to consider include in general investment costs, operating costs, the investment payback period and intangible benefits, as summarized next.

5.3.1 Investments and their derived costs

These include the investments that might be necessary to implement the alternative BAT or BEP:

ENGINEERING, CONSULTANTS
SITE MATERIALS AND PREPARATION Demolition, dismantling / buildings and accessories / electric material / piping / insulation
CONSTRUCTION AND INSTALLATION
ADDITIONAL INSTALLATIONS storage / dispatch of products / laboratories, analysis
PURCHASE OF EQUIPMENT FOR PROCESSES cost / taxes, insurance, customs duties / spare parts transportation
CONNECTION TO PUBLIC UTILITIES electricity, diesel oil / steam / refrigeration and water for refrigeration / water for processes / air plant / inert gas
SET-UP supplier / contractor / fitter / training / pilot trials
TRAINING OF PERSONNEL
LICENCES AND AUTHORISATION
ROYALTIES, PATENTS AND R+D
TAX DERIVATIVES (+/-)
INCIDENTAL EXPENSES

5.3.2 Operating benefits

This includes the reduction in the operating expenditure that may occur when the alternative is implemented, and that will entail a different cash flow for the company.

REDUCTION OF COSTS FOR TREATMENT/DISPOSAL taxation / transportation costs / costs of internal treatment (including collection) costs of external treatment / costs of storage material / analysis costs license costs
REDUCTION OF MATERIAL INPUT COSTS raw materials / additives / auxiliary products
REDUCTION IN THE COST OF PUBLIC UTILITIES electricity, diesel oil / steam / refrigeration for processes and in general / water for processes / air plant / inert gas
REDUCTION IN OPERATING COSTS AND INTERNAL TREATMENT Maintenance / cleaning / personnel
REDUCTION IN THE COST OF INSURANCE
REDUCTION IN THE COSTS OF POOR QUALITY

5.3.3 Investment payback period (IPP)

This is defined as the necessary time for the accumulated differential cash flow to offset the investment made in the project.

The differential cash flow is defined as the net saving attributable to the implementation of the proposed alternative compared to the current production process.

The entrepreneur can thus know the moment when changes introduced in the company begin to produce a net profit for the operating performance income statement, and therefore, decide if an option is feasible to implement or not, taking into account the specific characteristics of the company.

5.3.4 Intangible benefits

When making the decision to implement a change in the production system, the entrepreneur needs objective, assessable elements to help direct his/her actions. However, one should never forget the series of benefits accruing at the same time for the company that result from this change. These are the so-called intangible benefits.

It is difficult to quantify intangible benefits and they can normally only be assessed via qualitative criteria. They are frequently just as important as the profitability analysis, if not more so. For this reason, they can be determinant when implementing an alternative that may apparently not be profitable enough.

The most common intangible benefits that are generated as a result of the implementation of alternatives for pollution prevention and reduction are the following:

- Impact on the environment.
- Improved competitiveness with respect to the rest of the sector.
- Improved quality of the product.
- Improved corporate image and improved relationships with dealers and suppliers, clients, government authorities and people living nearby.
- Improved control of the productive process, while it also encourages information to be obtained for other actions in the future.
- Reduced risk of penalties.
- Effect on the health of the workers.
- Improved conditions at work, reduced risk of accidents and the increase in the level of satisfaction and training of the personnel.
- It facilitates the compliance with future legislation.
- Reduced possibility of future liabilities concerning waste or emissions generated by the company, such as accidents in the transportation of waste, leaks from storage tanks that pollute the soil, etc.

6. CONCLUSION AND RECOMMENDATIONS

The development of industry in the Mediterranean region remains a high priority because of its significant contribution to the growth of the economy in the region. It is also accepted that the industrial development should integrate the concept of sustainable development to ensure its long term competitiveness and compatibility with environmental protection. The present Guidelines on BATs and BEPs for major industrial sources of BOD, nutrients and suspended solids are undertaken to facilitate the implementation of the SAP at the national level of all MAP countries.

The negative impacts of these industrial pollutants are associate in particular with changing the ecological balance in the body of water by depleting the dissolved oxygen content; enhancing eutrophication and stimulating undesirable algae growth as well as impairing normal aquatic life of the sea. If aggravated, this situation if aggravated would pose a serious risk for surface water and groundwater quality and represent a potential cause of damage to human health, ecosystems, habitats and biodiversity in the Mediterranean region.

The guidelines are designed to serve the needs of those in governments, industry associations and entrepreneurs seeking information and practical advise on how to improve industry environmental performance and enhance its competitiveness within a sustainable perspective. They are based on accepted principles that environmental issues are no longer only limited to emissions of pollutants but also include the levels of consumption of raw materials, water and energy. Environmental issues are not anymore seen as distinct from industrial ("productive") processes relying solely on end-of-pipe controls and "external" treatment of pollution. The BAT and BEP approach incorporate the concepts of prevention, cleaner production and waste management with a view to improve the overall performance of the industry. Within this framework, industry recognizes and promotes the concept of sustainable development, in which growth and environmental protection are compatible.

For this reason, the proposed BATs and BEPs encompass an integrated approach that considers environmental issues upstream and down stream, thus prioritizing prevention technologies and practices first and considers as a last option treatment technologies for achieving compliance with environmental regulations, which remain specific to each MAP country.

As the purpose of the guidelines is to provide information, the approaches, options and technologies proposed should only be considered as recommendations and should by no means be viewed as rules. They are not considered exhaustive either and any other technique or combination of techniques achieving the same (or better) performance should also be considered; such techniques may be under development or an emerging technique or already available but not described here. The guidelines being only a starting point for the industries wishing to apply BATs and BEPs, indicate some of the available and relevant sources of information where to refer for more detailed information concerning the BATs and BEPs for the industrial sectors that are sources of BOD, nutrients and suspended solids.

This is also proposed as an evolving tool to be updated continuously by industry organizations, environmental bodies, Research and Development institutions and its users in general. It should therefore, follow a dynamic process driven by technology changes (manufacturers of machinery), requirements of consumers, new product development and other considerations affecting the entire life cycle of the industry.

The BATs and BEPs approach encourages the continual improvement of processes, the installation of controls, and the monitoring of performance. It also stresses the human and organizational dimensions of environmental management that are required to develop sound plant management and operational practices.

The guidelines propose the application of a combination of BATs and BEPs as the best approach for the management of industry sources of BOD, nutrients and suspended solids. The combination takes into consideration the different environmental sound techniques (EST) that are related to Source-oriented measures, Process-integrated measures, and End-of-pipe measures. It is anticipated that their application will lead to achieving the goals of improving the environmental performance of industry beyond compliance with environmental norms and achieving further economical benefits. These techniques fall generally into the three aforementioned categories:

- Source-oriented techniques focus on the source of environmental pollution by applying prevention techniques through process optimization, good housekeeping, inventory control and selection of raw materials.
- Process integrated measures that apply to water and energy conservation, optimization of the process, equipment modifications and re-use and recycling.
- End-of-pipe techniques that are intended for pretreatment and final waste-water treatment that is required to comply with environmental emissions standards.

It is recommended for the effective implementation of BATs and BEPs within the industrial sectors identified as major sources of BOD, nutrients and suspended solids, that industry maintains and sustains collaboration efforts with trade organizations, research institutions, and governmental agencies on an ongoing basis to discuss initiatives for continuous improvements and the future of the industry from both an economic and environmental standpoint. The technology-related issues, that interfere with environmental aspects should be in the centre of the interest of the stakeholders and lead to developing an agenda for the next decade for the industry outlining what needs to be done to increase its economical and environmental performance through the adoption of BATs and BEPs. In this respect, particular attention should be given to the following topics:

- **Information dissemination**: information is still recognized as a constraint for accessing BATs and BEPs, especially for SMEs. Effort should be undertaken in this respect through organization of seminars, publication of technical newsletters, and development of databases on BATs and BEPs for the different industrial sectors within industry organizations as well as research institutes and environmental organization in support of industry. The dissemination efforts could be carried out through industrial associations which could share information fairly readily as sectorial based networks tend to have similar responses to environmental management.

- **Research and development**: R&D should continue on development of BATs to reduce process effluents in quantity and quality through source and process integrated measures, cleaner technologies and design of environmentally friendlier products.

- **Environmental performance**: improved environmental compatibility of conventional and developing industrial processes should be investigated on continuous basis and attention directed to the effects of those processes on human health and reduction of emissions as well as effluents that have potentially harmful consequences on the environment. Complete closure of the effluent system should constitute a major goal for industrial sectors of the future.

- **Recycling**: waste reduction and improved recovery systems should continue to be priority environmental targets in the MAP countries.

- **Process performance**: Higher efficiency through the use of increasingly sophisticated, online measurement and expert/control systems will be required to achieve higher environmental performance and anticipate to comply with increasingly stringent operating and environmental permits.

- **Capacity building**: training across the board will be continually required to increase awareness about environmental performance, upgrade the knowledge and skills about the use of best environmental practices and assimilate the best available techniques applicable in industrial sectors that are sources of BOD, nutrients and suspended solids.

- In the same order, the implementation of **environmental management systems** will help sustaining the efforts for continuous improvement through the application of BATs and BEPs.

In summary, the application of BATs and BEPs could play a pivotal role in achieving environmental improvement and economic growth in the industrial sectors that are sources of BOD, nutrients and suspended solids in the Mediterranean basin, thus offering a way out of the dilemma posed often to industry in terms of choice between economic growth today or long-term environmental sustainability. The adoption of BATs and BEPs would require a set of levers to influence its rate and direction including access to information, training, funding, research and development, networking as well as partnership between industry and institutions of education, as well as R&D.

GLOSSARY

- Adt: Air dry metric ton of pulp meaning dry solids content of 90%. Please note that an air dry ton of paper is defined as paper with 6% moisture content.

- AOX: Adsorbable Organic Halogen (X). The total concentration in milligrams per litre, expressed as chlorine, of all halogen compounds (except fluorine) present in a sample of water that are capable of being adsorbed on activated carbon.

- APE, APEO: Alkyl Phenol Ethoxylates

- BAT: Best Available Technique

- BEP: Best Environmental Practice

- BOD: Biochemical Oxygen Demand: a measure of the oxygen consumed by bacteria to biochemically oxidise organic substances present in water to carbon dioxide and water. The higher the organic load, the larger the amount of oxygen consumed. As a result, with high organic concentrations in the effluent, the amount of oxygen in water may be reduced below acceptable levels for aquatic life. BOD tests are carried out at 20 °C in dilute solution and the amount of oxygen consumed is determined after 5, 7, 20 or, less commonly, 30 days. The corresponding parameters are called BOD_5, BOD_7, BOD_{20} and BOD_{30}. The unit of measurement is mg O_2/l.

- CIP: Cleaning-in-place

- CO_2: Carbon dioxide

- COD: Chemical Oxygen Demand: The amount of potassium dichromate, expressed as oxygen, required to chemically oxidize at approximately 150 °C substances contained in waste water. The unit of measurement is mg O_2/l or mg O_2/g of substance

- CP: Cleaner Production

- Cr: Chromium

- CTMP: Chemi-thermo-mechanical pulp
- DIP: Deinked pulp – pulp produced from recovered printing paper, e.g. newsprint, through de-inking process.
- DS: Dry solids
- ECF: Elemental Chlorine Free (bleaching)
- EDDS: Ethylene-diamine-di-succinate
- EDTA: Ethylene-diamine-tetra-acetate
- EP3: Environmental Pollution Prevention Project
- F/M: Food on micro-organism ratio
- GAC: Granular activated carbon
- GW: Groundwood
- GWP: Groundwood pulp
- HC: High consistency - pulp concentration in the interval 30 - 50% dry solid content
- HT: High temperature (process)
- HTST: High temperature short time
- HVLP: High Volume Low Pressure
- ICPIC: International Cleaner Production Information Clearinghouse
- LC: Low consistency - pulp concentration in the interval 3 - 5% dry solid content
- LWC: Lightweight coated paper
- MBR: Membrane bio-reactor
- MF: micro-filtration
- MGDA: Methyl-glycine-di-acetate
- MLSS: Mixed Liquor Suspended Solids
- NCPC: National Cleaner Production Centre
- NPE: Nonylphenol ethoxylates
- NSSC: Neutral Sulphite Semi Chemical pulp is the most common type of semichemical pulp which is produced by a combination of chemical and mechanical pulping. In the process wood chips are partially digested to weaken the bonds between fibres and lignin. The chips are then mechanically treated in a refiner.
- NTA: Nitrilo-tri-acetate

- N-tot: Total nitrogen
- OC: Organochlorines (group of pesticides)
- Org-C: Organic carbon
- PES: Polyester fibres
- PET: Polyethylene
- PGW: Pressurised ground wood (pulping)
- RAC/CP: Regional Activity Centre for Cleaner Production
- RCF: Recycled fibre(s); pulp obtained from recovered paper processing
- RM: raw material
- RMP: Refiner mechanical pulping
- S^{2-}: Sulphide
- SBR: Sequencing batch reactor
- SC: Supercalendered paper
- SEAM: Support for Environmental Assessment and Management
- SS: Suspended Solids
- TCF: Totally chlorine free (bleaching)
- TKN: Total Kjeldahl Nitrogen. The Kjeldahl technique is used to determine fixed nitrogen in organic and inorganic materials.
- TMP: Thermo-mechanical pulp
- TSS: Total suspended solids
- UASB: Upflow anaerobic sludge blanket (reactor)
- UNEP: United Nation Environment Programme
- UF: Urea Formaldehyde (resin)
- UV: Ultraviolet
- WO: Wool

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Annex 1

Annexes I, II and IV of the LBS Protocol

Protocol for the protection of the Mediterranean Sea against pollution from land-based sources and activities (as adopted 1996)

"Table 1 Annex I"

Elements to be taken into account in the preparationof programmes and measures for the elimination of pollution from land-based sources and activities

This annex contains elements which will be taken into account in the preparation of action plans, programmes and measures for the elimination of pollution from land-based sources and activities referred to in Articles 5, 7 and 15 of this Protocol.
Such action plans, programmes and measures will aim to cover the sectors of activities listed in Section A and also cover the groups of substances enumerated in Section C, selected on the basis of the characteristics listed in Section B of this Annex.
Priorities for action should be established on the basis of the relative importance of the impact on public health, the environment and socio-economic and cultural conditions. Such programmes shall cover point sources, diffuse sources and atmospheric deposition.

In preparing action plans, programmes and measures, the Parties, in conformity with the Global programme of Action for the Protection of the Marine Environment from Land-based Activities, adopted in Washington, DC in 1995, will give priority to substances that are toxic, persistent and liable to bioaccumulate, in particular to persistent organic pollutants POPs), as well as to wastewater treatment and management.

A. SECTORS OF ACTIVITIES

The following sectors of activities (not listed in order of priority) will be primarily considered when setting priorities for the preparation of action plans, programmes and measures for the elimination of pollution from land-based sources and activities:

1. Energy production
2. Fertilizer production
3. Production and formulation of biocides
4. The Pharmaceutical industry
5. Petroleum refining
6. The paper and paper-pulp industry
7. Cement production
8. The tanning industry
9. The metal industry
10. Mining
11. The shipbuilding and repairing industry
12. Harbour operations
13. The textile industry
14. The electronic industry

"Table 1 Annex I" (continued)

15. The recycling industry
16. Other sectors of the organic chemical industry
17. Other sectors of the inorganic chemical industry
18. Tourism
19. Agriculture
20. Animal husbandry
21. Food processing
22. Aquaculture
23. Treatment and disposal of hazardous waste
24 Treatment and disposal of domestic wastewater
25. Management of municipal solid waste
26. Disposal of sewage sludge
27. The waste management industry
28. Incineration of waste and management of its residues
29. Works which cause physical alteration of the natural state of the coastline
30. Transport

B. CHARACTERISTICS OF SUBSTANCES IN THE ENVIRONMENT

For the preparation of action plans, programmes and measures, the Parties should take into account the characteristics listed below:

1. Persistence
2. Toxicity or other noxious properties (*e.g*. carcinogenicity, mutagenicity, teratogenicity)
3. Bioaccumulation
4. Radioactivity
5. The ratio between observed concentrations and "no observed effect concentrations" (NOEC)
6. The risks of eutrophication of anthropogenic origin
7. Health effects and risks
8. Transboundary significance
9. The risk of undesirable changes in the marine ecosystem and irreversibility or durability of effects
10. Interference with the sustainable exploitation of living resources or with other legitimate uses of the sea
11. Effects on the taste and/or smell of marine products for human consumption
12. Effects on the smell, colour, transparency or other characteristics of seawater
13. Distribution pattern (i.e. quantities involved, use patterns and probability of reaching the marine environment)

"Table 1 Annex I" (continued)

C. CATEGORIES OF SUBSTANCES

The following categories of substances and sources of pollution will serve as guidance in the preparation of action plans, programmes and measures:

1. Organohalogen compounds and substances which may form such compounds in the marine environment. Priority will be given to Aldrin, Chlordane, DDT, Dieldrin, Dioxins and Furans, Endrin, Heptachlor, Hexachlorobenzene, Mirex, PCBs and Toxaphene;

2. Organophosphorus compounds and substances which may form such compounds in the marine environment;

3. Organotin compounds and substances which may form such compounds in the marine environment;

4. Polycyclic aromatic hydrocarbons;

5. Heavy metals and their compounds;

6. Used lubricating oils;

7. Radioactive substances, including their wastes, when their discharges do not comply with the principles of radiation protection as defined by the competent international organizations, taking into account the protection of the marine environment;

8. Biocides and their derivatives;

9. Pathogenic microorganisms;

10. Crude oils and hydrocarbons of petroleum origin;

11. Cyanides and fluorides;

12. Non-biodegradable detergents and other non-biodegradable surface-active substances;

13. Compounds of nitrogen and phosphorus and other substances which may cause eutrophication;

"Table 1 Annex I" (continued)

14.	Litter (any persistent manufactured or processed solid material which is discarded, disposed of, or abandoned in the marine and coastal environment);
15.	Thermal discharges;
16.	Acid or alkaline compounds which may impair the quality of water;
17.	Non-toxic substances that may interfere with any legitimate use of the sea;
18.	Non-toxic substances that may have adverse effects on the physical or chemical characteristics of seawater.

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"Table 2 Annex II"

Elements to be taken into account in the issue of the authorizations for discharges of wastes

With a view to the issue of an authorization for the discharge of wastes containing substances referred to in Article 6 of this Protocol, particular account will be taken, as the case may be, of the following factors:

A. CHARACTERISTICS AND COMPOSITION OF THE WASTE

1. Type and size of waste source (*e.g.* industrial process).
2. Type of waste (origin, average composition).
3. Form of waste (solid, liquid, sludge, slurry).
4. Total amount (volume discharged, *e.g.* per year).
5. Discharge pattern (continuous, intermittent, seasonally variable, etc.).
6. Concentrations with respect to categories of substances listed in Annex I, and of other substances as appropriate.
7. Physical, chemical and biochemical properties of the waste discharges.

B. CHARACTERISTICS OF WASTE CONSTITUENTS WITH RESPECT TO THEIR HARMFULNESS

1. Persistence (physical, chemical, biological) in the marine environment.
2. Toxicity and other harmful effects.
3. Accumulation in biological materials or sediments.
4. Biochemical transformation producing harmful compounds.
5. Adverse effects on the oxygen content and balance.
6. Susceptibility to physical, chemical and biochemical changes and interaction in the aquatic environment with other sea water constituents which may produce harmful biological or other effects on any of the uses listed in Section E below.
7. All other characteristics as listed in Annex I, Section B.

C. CHARACTERISTICS OF DISCHARGE SITE AND RECEIVING MARINE ENVIRONMENT

1. Hydrographic, meteorological, geological and topographical characteristics of the coastal area.
2. Location and type of the discharge (outfall, canal, outlet, etc.) and its relation to other areas (such as amenity areas, spawning, nursery and fishing areas, shellfish grounds) and other discharges.

"Table 2 Annex II" (continued)

3. Initial dilution achieved at the point of discharge into the receiving environment.
4. Dispersion characteristics such as effects of currents, tides and wind on horizontal transport and vertical mixing.
5. Receiving water characteristics with respect to physical, chemical, biological and ecological conditions in the discharge area.
6. Capacity of the receiving marine environment to receive waste discharge without undesirable effects.

D. AVAILABILITY OF WASTE TECHNOLOGIES

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

(a) Alternative treatment processes;
(b) Re-use or elimination methods;
(c) On-land disposal alternatives;
(d) Appropriate low-waste technologies.

E. POTENTIAL IMPAIRMENT OF MARINE ECOSYSTEMS AND SEA WATER USES

1. Effects on human health through pollution impact on:
   (a) Edible marine organisms;
   (b) Bathing waters;
   (c) Aesthetics.

2. Effects on marine ecosystems, in particular living resources, endangered species and critical habitats.

3. Effects on other legitimate uses of the sea.

Protocol for the protection of the Mediterranean Sea against pollution from land-based sources and activities (as adopted 1996)

“Table 3 Annex IV”

Criteria for the definition of best available techniques and best environmental practice

A. BEST AVAILABLE TECHNIQUES

1. The use of the best available techniques shall emphasise the use of non-waste technology, if available.

2. The term "best available techniques" means the latest stage of development (state of the art) of processes, of facilities or of methods of operation which indicate the practical suitability of a particular measure for limiting discharges, emissions and waste. In determining whether a set of processes, facilities and methods of operation constitute the best available techniques in general or individual cases, special consideration shall be given to:

(a) comparable processes, facilities or methods of operation which have recently been successfully tried out;

(b) technological advances and changes in scientific knowledge and understanding;

(c) the economic feasibility of such techniques;

(d) time limits for installation in both new and existing plants;

(e) the nature and volume of the discharges and emissions concerned.

3. It therefore follows that what is "best available techniques" for a particular process will change with time in the light of technological advances, economic and social factors, as well as changes in scientific knowledge and understanding.

4. If the reduction of discharges and emissions resulting from the use of best available techniques does not lead to environmentally acceptable results, additional measures have to be applied.

5. "Techniques" include both the technology used and the way in which the installation is designed, built, maintained, operated and dismantled.

"Table 3 Annex IV" (continued)

B. BEST ENVIRONMENTAL PRACTICE

6. The term "best environmental practice" means the application of the most appropriate combination of environmental control measures and strategies. In making a selection for individual cases, at least the following graduated range of measures should be considered:

(a) the provision of information and education to the public and to users about the environmental consequences of choice of particular activities and choice of products, their use and ultimate disposal;

(b) the development and application of codes of good environmental practice which cover all aspects of the activity in the product's life;

(c) the mandatory application of labels informing users of environmental risks related to a product, its use and ultimate disposal;

(d) saving resources, including energy;

(e) making collection and disposal systems available to the public;

(f) avoiding the use of hazardous substances or products and the generation of hazardous waste;

(g) recycling, recovery and re-use;

(h) the application of economic instruments to activities, products or groups of products;

(i) establishing a system of licensing, involving a range of restrictions or a ban.

7. In determining what combination of measures constitute best environmental practice, in general or individual cases, particular consideration should be given to:

(a) the environmental hazard of the product and its production, use and ultimate disposal;

(b) the substitution by less polluting activities or substances;

(c) the scale of use;

"Table 3 Annex IV" (continued)

(d) the potential environmental benefit or penalty of substitute materials or activities;

(e) advances and changes in scientific knowledge and understanding;
time limits for implementation;

(g) social and economic implications.

8. It therefore follows that best environmental practice for a particular source will change with time in the light of technological advances, economic and social factors, as well as changes in scientific knowledge and understanding.

9. If the reduction of inputs resulting from the use of best environmental practice does not lead to environmentally acceptable results, additional measures have to be applied and best environmental practice redefined.

Annex 2

Eutrophication: the case of the northern Adriatic sea

Starting in the 1970s, eutrophication phenomena such as algal blooms and the production of mucilage have, particularly in the northern Adriatic, given rise to great concern because of their new considerable frequency, intensity and geographical extension.

The physico-geographical characteristics of the Adriatic, in addition to specific climatic conditions and the prevailing surface water circulation, make this basin (already a theatre of natural eutrophication phenomena) an especially vulnerable area in view of the extensive land and river inputs of pollutants deriving from human activities. However, the situation differs considerably from the southern part to the northern part of the Adriatic. According to the 1996 assessment by UNEP/MAP, based on the work of many researchers during the last twenty years, the trophic conditions of the Adriatic sea can be summed up as follows:

- coastal areas in the north-western Adriatic and at some sites on the coasts of Croatia and Montenegro that have high nutrient levels and are affected by recurrent microalgal blooms are classified as eutrophic;
- the open sea waters of the north-western basin are mesotrophic-oligotrophic; and
- the majority of the central-southern basin is oligotrophic.

The serious deterioration that has occurred in the northern area of the Adriatic for over twenty years is attributable to the nutrient input in amounts that exceed the basin's natural assimilation capacity. The Po, carrying some 100,000 tons/year of inorganic nitrogen and some 6,000 tons/year of inorganic phosphorus, contributes most of the total nutrient load of the northern Adriatic basin. The next largest of the rivers flowing into the northern Adriatic, the Adige, contributes about 14,000 tons/year of total nitrogen and 1,200 tons/year of total phosphorus, although its mean nutrient concentrations are lower than those of the Po. The total nitrogen and total phosphorus discharged into the northern Adriatic from Italy alone amounts to some 270,000 and 24,000 tons/year, respectively. To these must be added the inputs from Istria, estimated at 12,600 and 600 tons/year of total nitrogen and total phosphorus, respectively.

The other areas of the northern Adriatic, between the Po delta and Trieste, generally have lower levels than the adjacent area. The hydrodynamics of this basin are such that Po waters tend to be carried mainly southwards by the currents. Further, the area north of the Po delta receives a lower input of eutrophying substances, and residence times of water from local tributaries are shorter because of the absence of clear low-salinity fronts.

Eutrophication phenomena, with a distribution and persistence much greater than in any other part of the Mediterranean, have occurred and continue to occur in the coastal waters of Emilia-Romagna to the south of the Po delta. The first cases reported date back to 1969. These were followed by a relatively long period in which the phenomenon was not observed until it returned in 1975, when an immense bloom of flagellates caused widespread anoxia in the bottom waters, accompanied by bottom fauna kills and the beaching of large quantities of bottom fish (7,000 tons in the Municipality of Cesenatico alone). Subsequently, events succeeded one after another in the summer of almost all the following years. The blooms in this area are normally caused by diatoms and dinoflagellates. The former, although they may cause blooms at any time of the year, tend to dominate during winter and spring, whereas flagellate blooms occur especially in the summer and autumn.

The recurrent anoxia in the bottom waters caused profound modifications in the benthic ecosystem; there were considerable reductions in the original populations of the least mobile bottom organisms (molluscs, crustaceans and polychaetes) most sensitive to oxygen deficiency. Repetition of these dystrophies has led to the disappearance of about fifteen species of mollusc and three species of crustacean.

Further, the recurrent phenomena of eutrophication and the general deterioration of water quality in the north-western Adriatic have had serious negative repercussions on the economy of the region, especially tourism and fisheries. With regard to fishing, and mollusc farming in particular, considerable damage has been done by the dinoflagellate of the genus *Dinophysis*, which produces (D.S.P.) toxins. The occurrence of these flagellates, which have become more plentiful during the last decade, has led to temporary and prolonged bans on the harvesting and sale of mussels (*Mytilus galloprovincialis*) farmed in the coastal and lagoon areas of Emilia-Romagna. Further, *Alexandrium tamarensis*, a dinoflagellate capable of producing (P.S.P.) toxins, has been observed in the waters of the northern Adriatic, although no pathologies in the resident populations attributable to PSP intoxication have ever been encountered.

Considering that the eutrophication phenomena are no longer occasional events, but are provoked by structural deficiencies on land, there is a need to eliminate such deficiencies, which are mostly linked to tourism, agriculture, animal husbandry and municipal sewerage. During the eighties, important laws, decrees and norms were approved at the European Community and the national levels mostly addressing the reduction of phosphorus in the detergents produced, bringing the limit down to 1 percent. As a result, it has been possible to quantify a decrease of 10,000 t/year in the input of phosphorus to the sea. In contrast, no important reduction of nitrogen in the sea has been monitored, in spite of a 1991 Community norm in that direction. This is mostly due to the difficulty of applying the norm (e.g., lack of economic incentives) and the lack of controls.

There is ample scientific evidence of the increased spread and intensity of eutrophication in several areas of the Mediterranean endangering the natural equilibria of the basin. The status of the Adriatic is in fact only a mirror of a situation more and more worrying for the entire Mediterranean. Methods already exist for the abatement of the intensity and extension of the eutrophication phenomena through appropriate analysis and management of the activity sectors concerned and the implementation of legal, technical and other measures. The fight against the causes of eutrophication should be a priority for all the Mediterranean Coastal States.

Annex 3

Jellyfish blooms in the Mediterranean

The occurrence of massive blooms of the schyphomedusa *Pelagia noctiluca* in various areas of the Mediterranean is a case of the common and still not fully understood gelatinous zooplankton blooms. Large *Pelagia* blooms were first reported in the Adriatic in 1977; during their peak (1981-1983) they involved extensive areas of coastal waters throughout the north-western, central and north-eastern Mediterranean and had a significant impact mostly on tourism and fishing; they also created considerable concern for human health. The following are the findings of the MED POL Jellyfish Programme coordinated by UNEP/MAP and carried out from 1984 to 1986.

P. noctiluca (Semaeostomeae, Pelagiidae) was first described by Forskal in 1775 as *Medusa noctiluca*. Unlike meroplanktonic jellyfishes (Anthomedusae and Leptomedusae) which are usually restricted to shallow waters because of their dependence on a hard substrate on which their benthic life stages may settle, holoplanktonic jellyfishes, as *P. noctiluca*, may complete their life cycle in open waters because of the absence of a benthic stage.

The periodicity of occurrence of the bloom period appears to differ greatly between different parts of the Mediterranean. In the western Mediterranean, or at least in the Ligurian Sea, there appears to be a rough periodicity of 12 years. Bloom periods appear to be much less frequent in the Adriatic during the present century where they were reported during 1907-1914 and then not again until 1977. On the other hand, only a few aggregations of *Pelagia* were reported along the Lebanese and Turkish shores.

During the bloom period of the eighties, enormous numbers of *Pelagia* individuals (in some cases up to 100 individuals per cubic metre) were reported in coastal waters and on the shores of the Ligurian Sea, the central Mediterranean, the Adriatic and parts of the Aegean Sea. Between the bloom periods, *Pelagia* appears to be absent from the Adriatic and rare in the western Mediterranean offshore waters.

Observations in the Mediterranean suggest that the bloom period may be divided into three phases: the initial phase, the peak phase and the phase of decline. The initial phase is recorded at different times in the different regions. During the blooms of the eighties, the first reports of *Pelagia* aggregations in coastal waters came from the northern Adriatic and only later in Maltese waters and in the Ligurian Sea. The occurrence of the peak phase and the declining phase appear instead to be more synchronized over the whole geographical region. Pronounced seasonal fluctuations in the populations of *Pelagia* have been shown to occur during the initial and the declining phases of the bloom period, with coastal aggregations being more evident during the March-June period. On the other hand, during the peak phase, *Pelagia* adults could be detected throughout the whole year. For example, during 1981-1983 (peak phase) the presence of *Pelagia* in the coastal waters off Villefranche did not change significantly although the seasonal fluctuations in seawater temperatures ranged from 13° to 26°C.

Reports from the northern Adriatic indicate that some aggregations are formed by actively swimming individuals generally at subsurface levels. Reports from the same region, as well as from the central Mediterranean, indicate that other surface aggregations could also be passively maintained by surface currents.

The distribution of *Pelagia* in the Mediterranean during the bloom period appears to have been determined by the hydrological and, possibly, the natural trophic characteristics of the particular area. For example, in the Ligurian Sea, this was found to be correlated with natural eutrophic conditions, so that relatively large numbers were found to be concentrated on both sides of the Liguro-Provincial Front. The occurrence of *Pelagia* aggregations was never found to be directly correlated with localized land-based pollution. However, any enrichment in nutrients, whether by natural means or as a result of man's activities, may lead to localized increased productivity and this in turn may be expected to lead to increased numbers of *Pelagia*. It has been suggested that temperature may have a predominant influence on the stability and persistence of an aggregation. Aggregations in the Gulf of Trieste were normally formed when the seawater temperature ranged from 16° to 20°C, whereas in Greek waters they were more often associated with seawater temperatures ranging from 20° to 25°C, and were rarely seen at temperatures above 25°C.

The phenomenon of blooms of *P. noctiluca* in the Mediterranean may be taken to be a highly visible biological expression of the epipelagic community's response to long-term hydroclimatic changes in the physical environment. Although human activities, such as overfishing of the natural jellyfish predators and the discharge of land-based pollution, may help to sustain its blooms for longer periods of time, their occurrence is a natural phenomenon which has been recorded in the region long before man's impact on the marine environment could have reached significant proportions.

Various hypothesis to explain the triggering and controlling mechanisms of the *Pelagia* blooms have been suggested. For the northwestern Mediterranean, it was suggested that the occurrence of *Pelagia* bloom periods over the last hundred years may be correlated with pluri-annual climatic and hydrological cycles. The years prior to the bloom periods are in fact characterized by a deficit in rainfall and by anomalous high temperatures and atmospheric pressures, especially in May and June. Such climatic factors may possibly enhance the reproductive potential and, as a result, the increased investment in growth (hormesis) may constitute the biological response of this species to natural stressors as its populations are introduced into new areas by anomalous water currents. Another hypothesis suggests that blooms in *Pelagia* or other planktonic species may result when their internal circannual clocks anticipate the regular and seasonal fluctuations in the environment so that they would be able to exploit the favourable season with greater success than their natural competitors, thus leading to a population explosion. It has still to be established whether any such factors trigger the blooming phenomenon simultaneously in the various Mediterranean regions affected, or in some restricted primary centres from which it later spreads by means of water movements.

Annex 4

Sugar industry

Waste water treatment specification

The organic material in the fluming water breaks down into shorter chain organic acids.

Historically pH correction has occurred using additives such as lime. However, this "acidification" of the waste water stream is ideally suited for anaerobic treatment.

"Acidogenesis" is an essential reaction that takes place in anaerobic conditions to break the longer chain organic material into more treatable organic acids. A number of anaerobic installations require an acidification tank upstream of the anaerobic reactor in order to initiate the acidogenesis stage. Hence pH correction of the fluming water is no longer required.

Operating problems may occur as a result of changes in the composition of the organic constituents of the waste water and also its high calcium content.

In the methane reactor, the presence of calcium from the carbonation process (present in the waste water) in combination with carbon dioxide (formed in the reactor) leads to the precipitation of calcium carbonate. Experience shows that regardless of the concentration on the incoming waste water and regardless of the process used, the calcium content is reduced to around 0.3 - 0.7 kg/m^3. This means annual calcium carbonate loads of 300 to 1000 ton remain in the reactor. This gives rise to problems with mixing in the system, and also to additional work and cost to keep the relevant pumps, heat exchangers and pipes in good working order.

To eliminate lime during operation, some factories use hydrocyclones that remove the more lime-laden bacterial sludge from the system. In nearly all factories it is, nevertheless, necessary at regular intervals (every 2 - 5 years) to open the reactors during the off-season period and mechanically remove the lime that has formed. This is not necessarily the case with fluidised beds; lime is precipitated almost entirely on the carrier material, which can then be drawn off during operation. The lime concentrations on removal are around 800 - 1000 kg/m^3 of carrier material.

Since such operations are seasonal, the aerobic system downstream of the anaerobic system must be activated accordingly at the start of the season.

A portion of the anaerobically treated effluent can be recycled as fluming water.

The methane produced as part of the anaerobic process is used for drying beet pulp intended for use as animal feed. Low grade heat is used to preheat the waste water entering the anaerobic reactor.

The waste process water is considered to be high in ammonia content, yet low in COD. The recommended process for reducing the ammonia levels would be to use **aerobic biological** processes configured to allow for the nitrification of the ammonia. In order for this to take place, the waste water stream requires dosing with an external carbon source. For those installations using anaerobic technique for treating the fluming water, combining the effluent from the anaerobic process with the excess process water is usually sufficient to provide a feed of adequate balance onto the aerobic treatment stage.

The aerobic treatment stage is typically an activated sludge type plant or a variant of Coarse bubble aerated lagoons, extended aeration (oxidation ditch) and conventional forms of activated sludge are acceptable.

The final effluent from this stage may be of a high enough quality to be discharged to water course. Alternatively discharge would be to sewer.

For potential recycling of final effluent, tertiary treatment techniques could be employed on a portion of the final effluent.

The following options indicate the techniques, which are used successfully to achieve the appropriate level of environmental protection, having taken into account the environmental needs of the area, the geographical and weather conditions and the legal requirements. In general, the costs increase with the level and sophistication of the plant and equipment and the numbers of people required to make it operate.

Option 1 (Land spreading)
In areas, which permit it, transport water can be spread directly onto suitable land. When it is correctly managed, this technique, which recycles those natural elements previously exported with the crop, may be considered to be a good option. As an example, the approach used in France is presented. It consists of three steps.

Step 1: Preliminary studies

There must be an impact study to exhaustively analyse the mixture of soil and water, geology, hydrogeology, climate and agricultural techniques of the proposed land. If the impact study concludes that this technique is feasible, and excluding areas for which it is not suitable, an expert may recommend the exact operational details.

Step 2: The operations

The spreading operations must be carried out according to the expert specifications. The principle of water purification results from both the digestion of organic compounds by the micro-organisms of the soil and from the absorption of the inorganic salts by the plants. This latter part prevents soil pollution and ground water pollution by salts and nitrogen. It controls the amount of water to be sprayed and the timing of the interval between sprayings. There will need to be other operational controls to ensure even distribution of spraying and to prevent spraying during frosts etc.

This agronomical balance requires a high level of co-operation between the farmer and the sugar factory and requires a high standard of supervision.

Step 3: Monitoring

Every predicted effect is verified by analysis of soils, ground profiles and ground waters to ensure full control.

Option 2
The soil is settled out from the transport water in settling ponds. The decanted water can then be treated through extensive or intensive methods.

- Extensive methods

The water decanted from the soil settling ponds can be stored in treatment lagoons to allow for natural treatment to meet appropriate standards. Note that the use of lagoons can make it possible to use the water to irrigate the land during dry weather, which also reduces the need for abstracting water from the rivers or from the ground.

For the treatment of process waters in southern Mediterranean countries, it may be possible to use lagoons for natural water evaporation due to the high average temperatures.

The technique of lagoons is as follows. The bacterial population in large lagoons will, under the appropriate conditions of temperature and time, degrade the biochemical oxygen demand of stored water. Surface area and depth are key elements in the rate of degradation of the biochemical oxygen demand. Degradation of the biochemical oxygen demand relies on natural processes such as the carbon, nitrogen and sulphur cycles, with both anaerobic and aerobic bacteria responsible for this degradation.

- Intensive treatments

If there is a risk of offensive odour or should the needs of the environment dictate a more stringent level of treatment, then there are two main alternatives:

- ✓ primary soil settlement followed by natural treatment in lagoons enhanced by surface aeration, and
- ✓ preceding the above with aerobic treatment.

Surface aeration

Surface aeration uses the lagoon as the basis. To increase the rate of aerobic bacterial activity, additional oxygen is diffused into the water by electrically driven "free" or "fixed" floating aerators. Occasionally wind powered aerators are used where weather conditions are favourable.

Indeed, mixed wind and electrical systems are now available. The same limitations as for lagoons prevail. At low temperatures bacterial activity is reduced. The additional oxygen, whilst increasing bacterial food, is derived from air at ambient temperature. Hence during the winter bacterial activity is reduced. Nevertheless, they can be, under the right conditions, both efficient and cost effective.

Injection of pure oxygen is an extension to the surface aeration technique. However, the running costs of purchasing the liquid oxygen are high.

Aerobic treatment

Aerobic treatment is commonly referred to as activated sludge plants. These operate by mixing waste water with a mixture of micro-organisms, nutrients and air (oxygen), which then oxidise the organic impurities in the waste water. The activated sludge consists of aerobic bacteria, which break down the organics in the waste, and protozoa and rotifers which feed on the bacteria. The activated sludge is settled out in settlement tanks or clarifiers and part of it is returned to the aeration tank for mixing with the waste water. The clear, treated water is decanted off from the settlement tank or clarifier.

Aerobic treatment plants can receive the oxygen input from either surface injection or sub-surface injection. Surface injection of oxygen is by means of either surface aerators or oxygenation cages. This type of plant will treat low BOD water highly efficiently and cost effectively. Low winter air and water temperatures will, however, depress the treatment capacity as bacterial activity is reduced. However, low-grade waste heat from the sugar process can usually be used to increase temperatures in the system and enhance bacterial activity.

Sub-surface aerobic treatment plants are usually categorised as either fine or medium / large bubble aeration systems. They can be used to treat high or low BOD waste waters. Fine bubble systems can be highly efficient, cost effective systems. Oxygen uptake into the waste water from fine bubble diffusers is high and therefore fewer units and less air is required to remove a fixed biological load compared to medium / large bubble diffusers. Both systems need a large input of air and power, and as such can be expensive to operate. Fine bubble aeration is more cost effective than medium bubble aeration in terms of operation, but both systems can be highly efficient in degrading biochemical oxygen demands. The type of system installed depends upon the constituents in the waste water. High calcium waters will quickly scale up fine bubble diffusers. The heat of compression from the air can increase the water temperature by up to 80 ºC, which increases the rate of bacterial activity during this period.

Aerobic treatment will convert the biochemical oxygen demand of the water by bacterial action but will leave organic waste, usually termed effluent sludge. This sludge will require removal from the plant and can often be put to a beneficial use. It should also be noted that there are a large number of designs of this system. The selection of the most appropriate one must take many factors into account, such as availability of space and costs.

Option 3
Should the environmental needs dictate that further levels of treatment are required, primary soil settlement, anaerobic treatment followed by oxygenation and/or aerobic digestion with a final sludge settlement process may be considered.

Anaerobic treatment is carried out in the absence of "free" oxygen. Anaerobic bacteria breakdown the organics in the waste water in the simultaneously occurring stages; Hydrolysis, Acidification and finally Methanogenesis. The final breakdown products are methane and carbon dioxide. This reaction is optimised at 37 ºC, although a lower rate of digestion can take place at 20 ºC or less.

Anaerobic digestion is normally used for high BOD waste waters and sludges, but recent designs are more flexible. Technological advances have greatly altered both the size and performance of anaerobic treatment plants. The methane gas can either be used to heat the waste water or used as a fuel in the main process. They also require less nutrient addition compared to aerobic systems and produce far less surplus sludge (approximately 5 % by volume versus 50 % by volume for aerobic systems). Most anaerobic plants will remove about 95 % of the influent BOD. If the influent BOD rises, the effluent BOD rises. But, if the influent BOD rises too much, the removal rate may decrease. In practice, anaerobic effluents always need subsequent aerobic treatment.

Option 4
For those circumstances which demand additional control of nitrogen and its compounds, it will be necessary to install suitable designed nitrification and denitrification systems. There are many designs of such systems, they can be either batch or continuously operated. In essence the effect is to nitrify the ammonium ions into nitrites and nitrates. These are then denitrified into elemental nitrogen gas, which is then harmlessly discharged to air.

There are several biological and non-biological techniques available for reducing levels of ammonium (NH_4^+) ions in discharged effluents.

Annex 5

Breweries

BAT for wastewater treatment

Treatment for discharge to sewer
The level of treatment required prior to discharge to sewer is dependent upon the consent to discharge conditions. An economic balance needs to be achieved taking into account trade effluent charges and the capital and operating costs of a new effluent treatment plant.

The soft drinks and beverages sub-sector is a diverse sector on its own, however, for the purposes of effluent treatment, the waste waters generated can be categorised as follows:

- low strength high volume
- high strength low volume
- continuous regular discharges
- campaign/seasonal discharges.

- **Screening** to remove gross solids is recommended for installations in this sub-sector. Static wedge screens are cleaned several times a day to remove build-up. Self-cleaning screens are preferable, otherwise regular manual cleaning takes place. Vibrating screens have also been used successfully within this sub-sector.

Due to the batch-wise nature of the processes and washdown regimes, flow and load balancing would be required. The waste water from this sub-sector tends to be highly biodegradable and contain active bio-organisms. Excessive retention in the balance tank are avoided to ensure that the contents do not become anaerobic, leading to acidity and odour. The balance tank is agitated to prevent sludge accumulation, minimising the potential for methane build-up. A balance tank would typically have a retention time of 6 - 12 hours.

- High trade effluent charges will make it cost-effective for most installations to carry out some form of **primary treatment**. Dissolved air flotation is widely used in this sub-sector for the removal of fats, oils and greases and of suspended solids. The separated material can generally be re-used as animal feed if suitable coagulants and flocculants have been chosen.

In some instances, discharge to sewer could occur downstream of a primary process, depending upon the efficiency of the process and the receiving sewage treatment works. In this case operators must allow for a contingency strategy for failure of the primary treatment process, e.g. a diversion tank.

- Following primary treatment, further stages may be required, either to achieve a consent to discharge or to minimise trade effluent charges. For waste water streams with a BOD concentration greater than 1000 - 1500 mg/L BOD **anaerobic treatment** processes are considered. If anaerobic technique is used, operators ensure that fats, oils and greases are not allowed to reach the anaerobic reactor as well as minimising any biocides from reaching this stage of the process. Final effluent from the anaerobic process could be discharged directly to sewer, following flash aeration.

- For lower strength waste water streams **aerobic treatment** would be the preferred option. Conventional activated sludge systems have been used for such waste water streams, and (where economics allow) activated sludge variants (pure oxygen, SBR, MBR) would also be applicable. High rate trickling filters have also been employed as well as the standard rate configuration.

Hybrid aerobic reactors, such as the submerged biological aerated filter are also gaining popularity in this field.

For installations affected by seasonal produce, a number of options exist. Installations such as these will have general waste water generated all year round from the continuous production on-site. During the season or campaign, further waste water is generated from intensive processes. The nature of the general waste water and the campaign waste water will dictate the technique for the installation.

Typically the campaign waste water will be higher in strength than the general waste water and a number of factors will affect an operators choice of techniques under these conditions, e.g. the discharge points for the waste water streams may not be close to each other and there may be little or no process benefit in combining the streams.

The main choice facing operators here will be whether to treat the waste water streams separately or together. This will be site-specific and will be dependent upon the nature of the streams, the nature of the streams when combined, and the economics of constructing an effluent treatment plant capable of receiving significantly higher loads during a campaign.

If treated separately, the general waste water stream may require primary treatment only (prior to discharge to sewer), however, secondary treatment requirements would be aerobic biological treatment, typically conventional activated sludge, trickling filters and hybrid reactors, such as the submerged biological aerated filter.

The campaign/seasonal waste water is typically high in strength and comparatively low in volume. As the waste water stream is generated during certain times of the year only, anaerobic treatment would be considered for the treatment of the stream. Final effluent from the anaerobic process could be discharged directly to sewer, following flash aeration.

For treating the streams together, a treatment plant must be of modular construction with two or more reactors working in parallel. This will allow for one reactor to be used out of season with the plant brought up to full capacity during the seasonal production. A technique to consider for this configuration would be a conventional activated sludge process with pure oxygen supplementation during the high loads associated with the seasonal production. The plant may require artificial feeding in preparation for the increased flows and loads.

Treatment for discharge to water course or for recycling

For discharges to water courses, or for treating effluent to a quality suitable for re-use, further treatment stages would be required.

- For high strength waste waters that have already passed through an **anaerobic treatment** plant, **a further aerobic plant** will be generally required. Typically anaerobic reactors are followed by conventional activated sludge systems for further treatment. A two stage biological system (anaerobic followed by aerobic) if designed correctly achieves a quality of effluent suitable for discharge to a water course. Should suspended solids consent be low a tertiary macrofiltration system (sandfilter) would be required.

Further tertiary treatment would be required for recycling all or part of the final effluent. Due to the nature of the waste, GAC filters and/or crossflow microfiltration would be required. Disinfection would also be recommended should recycled water be used in hygienic areas.

Annex 6

Fruit and vegetable processing

<u>BAT for wastewater treatment</u>

Treatment for discharge to sewer

The following unit processes can be considered:

Screening to remove gross solids is essential for installations in this subsector. Static wedge screens are cleaned several times a day to remove build-up. Self-cleaning screens are preferable.

Due to the nature of the processes, the washdown regime and the use of shift work, flow and load balancing would be required. Adequate mixing and aeration are allowed for. A balance tank would typically have a retention time of 6 - 12 hours.

Those waste waters that are colloidal in nature will require chemical conditioning in order to facilitate settlement at the primary stage.

Installations with a high degree of starch in the waste water (potato starch processing) would benefit from recovery of the starch. Typically this is achieved through centrifuges without the addition of chemicals.

In some instances, discharge to sewer could occur downstream of the primary settlement tanks, depending upon the receiving sewage treatment works.

Following primary treatment, further stages may be required, either to achieve a consent to discharge or minimise trade effluent charges. For waste water streams with a BOD concentration greater than 1000 - 1500 mg/L anaerobic treatment processes are considered. Anaerobic treatment has been applied to various potato processing facilities. If an anaerobic technique is used, operators need to ensure that fats, oils and greases are not allowed to reach the anaerobic reactor, as well as minimising any biocides from reaching this stage of the process. Final effluent from the anaerobic process could be discharged directly to sewer, following flash aeration.

Fruit and vegetable processing waste waters are often deficient in nitrogen and phosphorus and will require supplements of these nutrients to support adequate biological activity.

For lower strength waste water streams, aerobic treatment would be the preferred option. Conventional activated sludge systems have been used for such waste water streams, and hybrid aerobic reactors, such as the submerged biological aerated filter have been used within this sector. Advanced forms of activated sludge (pure oxygen, SBR and MBR) can be considered should space be at a premium and if economics allow.

Treatment for discharge to watercourse or for recycling

For discharges to watercourses, or for treating effluent to a quality suitable for re-use, further treatment stages would be required.

For high strength waste waters that have passed through an anaerobic treatment plant a further aerobic plant will be required. Typically anaerobic reactors are followed by conventional activated sludge systems for further treatment. A two stage biological system (anaerobic followed by aerobic) if designed correctly achieves a quality of effluent suitable for discharge to a water course. Should suspended solids consent be low a tertiary macrofiltration system
(sandfilter) would be required.

Further tertiary treatment would be required for recycling all or part of the final effluent. Due to the nature of the waste, GAC filters and/or crossflow microfiltration would be required.

Disinfection would also be recommended should recycled water be used in hygienic areas.

Figure 2 shows a typical schematic for a process flow diagram for effluent treatment applicable to fruit and vegetable processing waste waters.

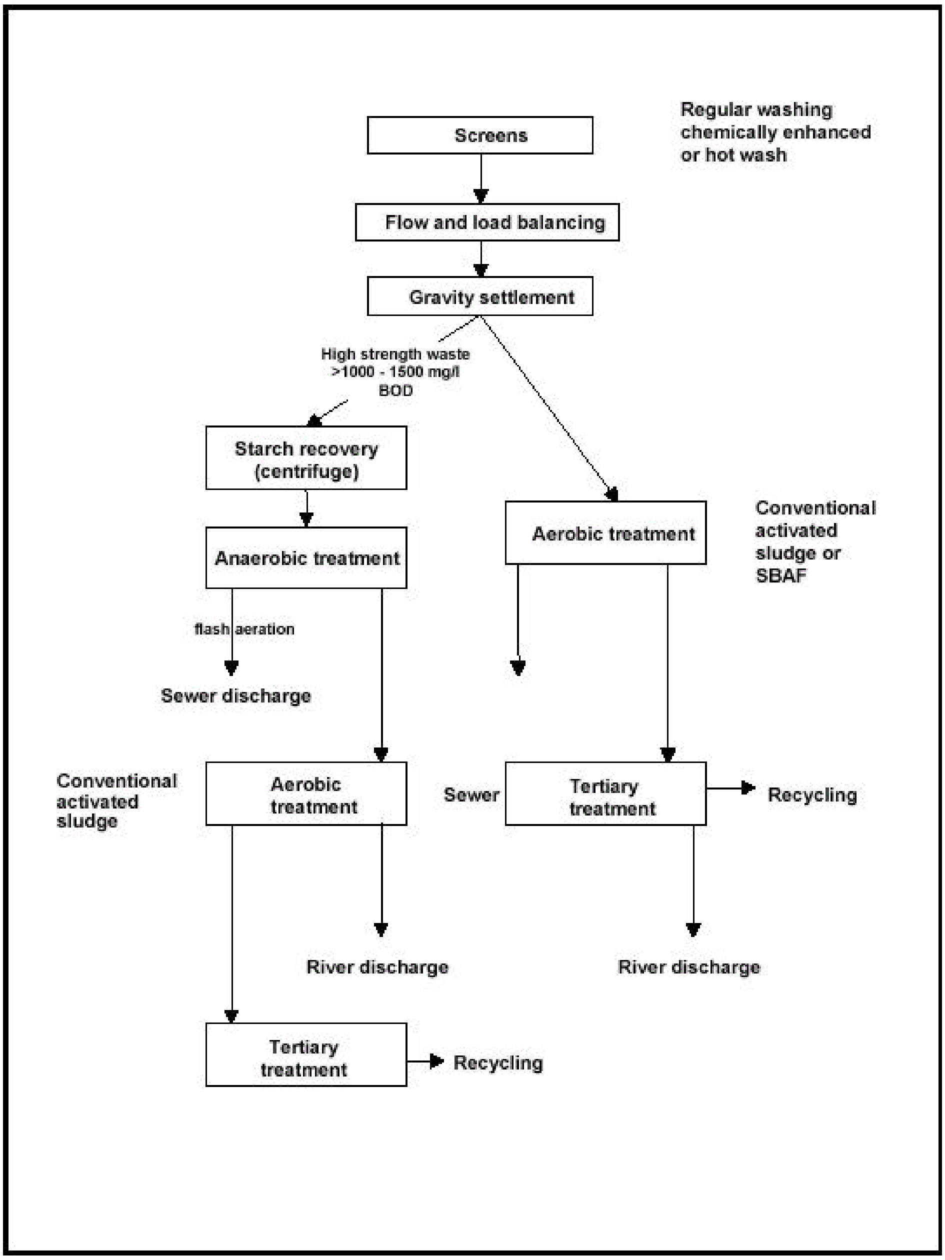

Figure 2. Flow sheet of the treatment for fruit and vegetable processing

Potato processing industry case

Although the organic constituents of the waste water from the potato processing industry are readily biodegradable, problems may arise during waste water treatment. These are largely due to the following factors:

- pollution loads that fluctuate substantially in the course of the day, week, year
- mostly high concentrations of impurities
- imbalanced composition of waste water (preponderance of carbohydrates and sometimes imbalanced mineral nutrient supply)
- presence of foam-producing substances (protein)
- risk of bulking sludge formation
- temperature of production waste water sometimes exceeds 35 to 40°C, which may make it necessary to use evaporation coolers
- the rapid onset of the anaerobic fermentation process may give rise to undesirable odours.

Moreover, the acids present during the fermentation processes may result in the pH being reduced to between 4 and 4.5. This acidification takes place within about 2 hours.

In anaerobic/aerobic treatment systems it is necessary to investigate whether, in view of the N_{tot} load, it is possible to treat the entire production waste water or only a sub-stream in order to ensure that the aerobic stage still has enough carbon for nitrogen elimination. If the above considerations are taken into account, it is certainly possible to use biological processes to clean the highly concentrated waste water from potato processing facilities.

Techniques to consider for the fruit and vegetable processing industry in drainage and effluent treatment:

Table 15

List of techniques to consider for drainage and waste water treatment in the fruit and vegetable processing industry

Technique	Comments
Maintaining an effluent log book	
Match size of effluent treatment plant to the amount of effluent to be treated	
Separate collection and transport of industrial effluent	
Separate collection and transport of water from toilets and washbasins	
Separate collection and transport of rainwater	
Spread production with high pollution of water(organic material, pH, etc.)	Low profitability
Remove coarse particles (organic material) from the effluent using "sieves" (grilles, sieve, drum sieve)	
Removal of heavy particles from the effluent by "sedimentation" (sand trap)	
Clean sand trap regularly, so that it can remove sand effectively from the effluent	
Remove floating particles from the effluent during primary treatment by means of "flotation" (air flotation, blade separator)	Can be applied for removal of fats, applied only in potato processing sector
Collect primarily cleaned effluent before further secondary treatment in a mixing tank (correct of pH and temperature), neutralisation tanks (correction of pH), buffer tanks (continuous feed biological treatment unit) or pre-sedimentation tanks (deposit of sinkable particles by use of the force of gravity)	
Anaerobic pre-cleaning of the effluent (natural fermentation, anaerobic integrated into the aerobic cleaning stage UASB)	May not be suitable for potato peeling firms
Aerobic cleaning of the effluent (active sludge process)	
Stimulate nitrification process by controlling the aeration process during aerobic cleaning of the effluent	May not be suitable for potato peeling firms
Stimulate dephosphatation process by controlling the aeration process during aerobic cleaning of the effluent	May not be suitable for potato peeling firms
Dimension the aerobic cleaning to achieve low sludge content	
Anoxic post-cleaning of the effluent (denitification process)	May not be suitable

Technique	Comments
	for potato peeling firms
Separate secondary sludge and effluent into a sedimentation tank	
Effluent cleaning by means of "coagulation / flocculation", followed by "sand filtration"	Not suitable for any case, its use depends on the receiving surface water
Effluent cleaning using "active carbon filtration"	High energy costs, waste production
Effluent cleaning using "microfiltration"	High energy costs, waste production
Effluent cleaning by "reverse osmosis"	High energy costs, waste production
Clean effluent by application of primary cleaning alone	If water is to be re-used
Clean effluent by application of primary cleaning + aerobic	If water is to be re-used and for potato processing
Clean effluent by application of primary cleaning + anaerobic + aerobic without stimulation of biological denitrification/dephosphatation	
Clean effluent by primary cleaning + anaerobic + aerobic + denitrification + dephosphatation	Not suitable for potato peeling firms
Clean effluent using primary cleaning + anaerobic + aerobic + denitrification / dephosphatation + coagulation / flocculation + filtration	Waste production. Its use depends on requirements of the protection of the receiving water; not suitable for potato peeling firms
Clean effluent using primary cleaning + anaerobic + aerobic + denitrification / dephosphatation + coagulation / flocculation + filtration + active carbon filtration	If water is to be re-used
Clean effluent using primary cleaning + anaerobic + aerobic + denitrification / dephosphatation + coagulation / flocculation + filtration + active carbon filtration + microfiltration	If water is to be re-used
Clean effluent using primary cleaning + anaerobic + aerobic + denitrification / dephosphatation = coagulation / flocculation + filtration + active carbon filtration + microfiltration + reverse osmosis	If water is to be re-used
Cover over the anaerobic system (+ possibly extract air and feed it back to the aeration tanks, in which the odour components are then broken down)	If odour is a nuisance
Treat the air in the anaerobic tanks with a biofilter (packaging material e.g. turf, compost, wood bark, etc.)	If odour is a nuisance
The system must be completely waterproof to avoid contamination of the soil and groundwater	
Valorisation of biogas, formed during anaerobic cleaning (e.g. heating a reactor, generating electricity via a gas engine, etc.	
Dewater sludge by means of mechanical compression via a	

Technique	Comments
sieve belt press	
Dewater sludge by means of gravity compression via a sedimentation tank	
Dewater sludge by means of gravity compression via sludge storage	
Dewater sludge via flotation compression by means of bubbling air	
Stabilise sludge chemically by treating with lime	
Stabilise sludge biologically by mineralization	
Stabilise sludge biologically by fermentation	
Stabilise sludge biologically by composting	
Stabilise sludge thermally by drying	
Stabilise sludge thermally via pasteurisation	

Annex 7

Winery and distillery

Treatment for discharge to sewer
The level of treatment required prior to discharge to sewer is dependent upon the consent to discharge conditions. An economic balance needs to be achieved taking into account trade effluent charges and the capital and operating costs of a new effluent treatment plant.

In general, when applying techniques for the treatment of waste waters liberated from the winery and distillery sub-sector, the following unit processes may be considered:

Screening to remove gross solids is recommended for installations in this sub-sector. Static wedge screens are cleaned several times a day to remove build-up. Self-cleaning screens are preferable, otherwise regular manual cleaning takes place. Vibrating screens have also been used successfully within this sub-sector.

The primary treatment in winery and distillery processing consists of sedimentation as well as flow and load equalisation

Sedimentation
Sedimentation is the separation from water, by gravity settling, of suspended particles that are heavier than water. The settled solids are removed as sludge from the bottom of the device.

Flow and load equalisation
Due to the batch-wise nature of the processes and washdown regimes, flow and load balancing would be required.
Buffer storage or balancing tanks are normally provided to cope with the general variability in flow and composition of waste water, or to provide corrective treatment, e.g. pH control, chemical conditioning.

If no balancing is provided, the operator may show how peak loads are handled without overloading the capacity of the waste water treatment plant.

In some instances, discharge to sewer could occur downstream of a primary process, depending upon the efficiency of the process and the receiving sewage treatment works. In this case operators must allow for a contingency strategy for failure of the primary treatment process, e.g. a diversion tank.

Following primary treatment, further stages may be required, either to achieve a consent to discharge or to minimise trade effluent charges. For waste water streams with a BOD concentration greater than 1000 – 1500 mg/L BOD **anaerobic treatment** processes are considered. If anaerobic technique is used, biocides are not allowed to reach the anaerobic reactor Final effluent from the anaerobic process could be discharged directly to sewer, following flash aeration.

For lower strength waste water streams **aerobic treatment** would be the preferred option. Conventional activated sludge systems have been used for such waste water streams, and (where economics allow) activated sludge variants (pure oxygen, SBR, MBR) would also be applicable. High rate trickling filters have also been employed as well as the standard rate configuration.

Hybrid aerobic reactors, such as the submerged biological aerated filter are also gaining popularity in this field.

For installations affected by seasonal produce, a number of options exist. Installations such as these will have general waste water generated all year round from the continuous production on-site. During the season or campaign, further waste water is generated from intensive processes. The nature of the general waste water and the campaign waste water will dictate the technique for the installation.

Typically the campaign waste water will be higher in strength than the general waste water and a number of factors will affect an operators choice of techniques under these conditions, e.g. the discharge points for the waste water streams may not be close to each other and there may be little or no process benefit in combining the streams.

The main choice facing operators here will be whether to treat the waste water streams separately or together. This will be site-specific and will be dependent upon the nature of the streams, the nature of the streams when combined, and the economics of constructing an effluent treatment plant capable of receiving significantly higher loads during a campaign.

If treated separately, the general waste water stream may require primary treatment only (prior to discharge to sewer), however, secondary treatment requirements would be aerobic biological treatment, typically conventional activated sludge, trickling filters and hybrid reactors, such as the submerged biological aerated filter.

The campaign/seasonal waste water is typically high in strength and comparatively low in volume. As the waste water stream is generated during certain times of the year only, anaerobic treatment would be considered for the treatment of the stream. Final effluent from the anaerobic process could be discharged directly to sewer, following flash aeration.

For treating the streams together, a treatment plant must be of modular construction with two or more reactors working in parallel. This will allow for one reactor to be used out of season with the plant brought up to full capacity during the seasonal production. A technique to consider for this configuration would be a conventional activated sludge process with pure oxygen supplementation during the high loads associated with the seasonal production. The plant may require artificial feeding in preparation for the increased flows and loads.

Treatment for discharge to water course or for recycling

For discharges to water courses, or for treating effluent to a quality suitable for re-use, further treatment stages would be required.

For high strength waste waters that have already passed through an **anaerobic treatment** plant, **a further aerobic plant** will be generally required. Typically anaerobic reactors are followed by conventional activated sludge systems for further treatment. A two stage biological system (anaerobic followed by aerobic) if designed correctly achieves a quality of effluent suitable for discharge to a water course. Should suspended solids consent be low a tertiary macrofiltration system (sandfilter) would be required.

Further tertiary treatment would be required for recycling all or part of the final effluent. Due to the nature of the waste, GAC filters and/or crossflow microfiltration would be required.

Disinfection would also be recommended should recycled water be used in hygienic areas.

In the following, an example of wastewater treatment plant of a distillery (molasses distillery).

Description

The condensed vapours from the facility's condensation unit and the singlings from distillation / rectification are cleaned in a two-stage waste water treatment system (anaerobic/aerobic). At the heart of the system is a biobed reactor (expanded granular sludge bed – EGSB – reactor) in which the organic load is largely degraded to methane gas under anaerobic conditions. There is a further reduction in COD load and nitrogen load in the downstream activated sludge unit. The methane gas is burned in a CHP (Co-generation of heat and power (combined heat and power)) plant to generate electricity and heat. In view of the high efficiency of the biobed reactor, only small quantities of aerobic surplus sludge are produced. This is concentrated in a decanter and used for agricultural purposes or disposed of via the municipal sewerage system. The following schematic diagram shows the process sequence in the factory waste water treatment system.

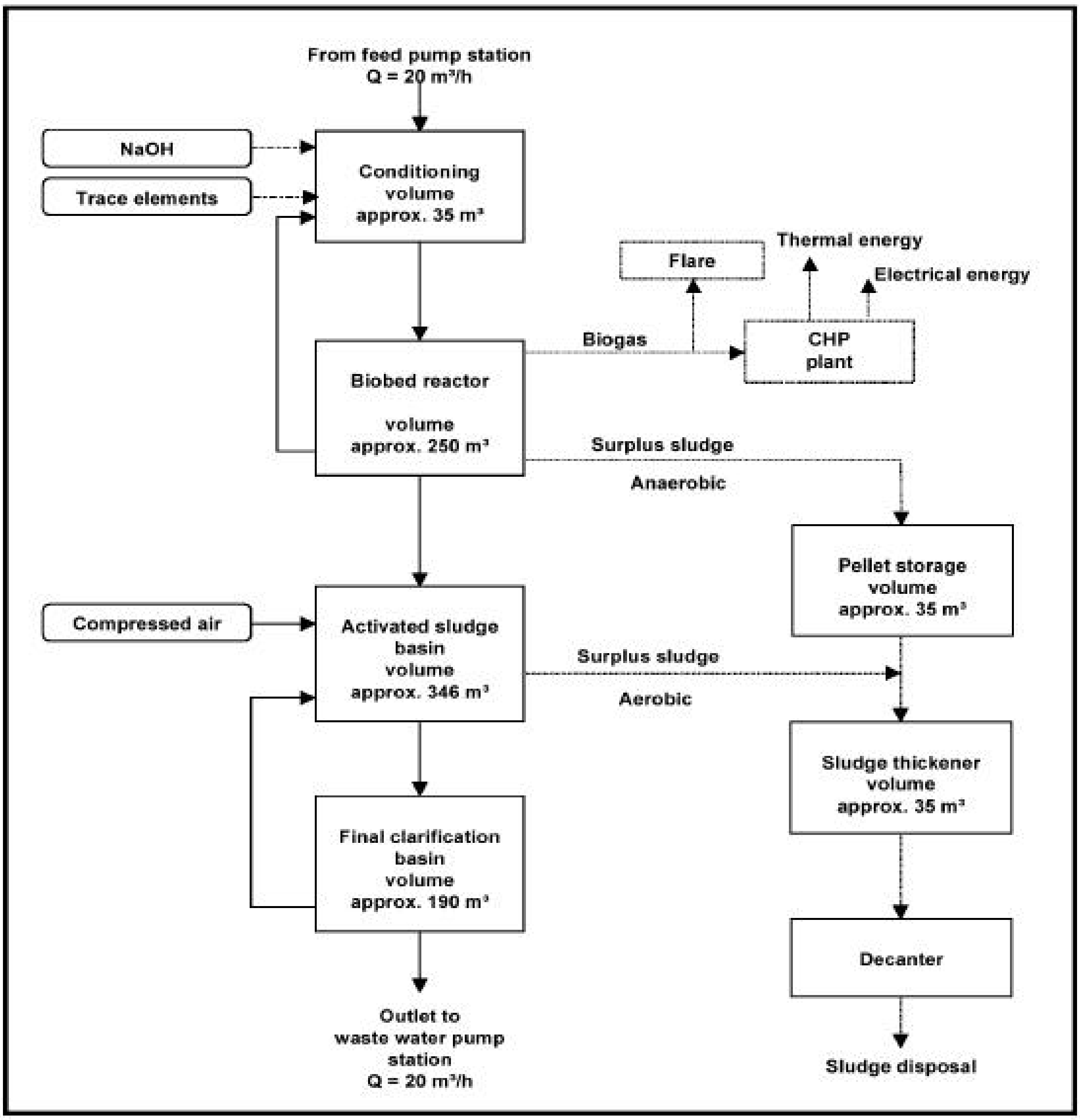

Figure 3.   Flow chart and dimensions of the anaerobic/aerobic waste water treatment system at a distillery

Annex 8

Dairy processing

BAT for wastewater treatment

Treatment for discharge to sewer

Important characteristics of dairy waste water for the purposes of treatment are:

- large diurnal variation in flow rate
- variable pH
- generally nitrogen deficient
- may be high in phosphorus if phosphoric acid used for clean-up (risk of phosphorus release in final effluent if treatment process becomes anaerobic).

In general, when applying techniques for the treatment of waste waters liberated form dairy processing installations, the following unit processes may be considered:

- **Screening**. Screens are installed to remove gross solids (including gloves, hats, etc.) as a protective measure for downstream processes. Self-cleaning screens are preferable, otherwise regular chemical cleaning is needed to dissolve fatty deposits. A hot water supply for cleaning purposes is also recommended for this purpose.

- **Balancing**. Due to the large diurnal variation in waste water discharge volumes, flow and load balancing are required. Adequate mixing and aeration are allowed for to prevent stratification within the balance tank and to maintain a positive dissolved oxygen level. A balance tank would typically have a retention time of 6 - 12 hours, pH correction would also be required at this stage.

- **Primary treatment**. If there are high trade effluent charges it is cost-effective for most installations to carry out some form of primary treatment. Dissolved air flotation is widely used in this subsector for the removal of fats, oils and greases, and of suspended solids. The separated material can generally be re-used as animal feed if suitable coagulants and flocculants have been chosen.

In some instances, discharge to sewer could occur downstream of a dissolved air flotation process, depending upon the efficiency of the process and the receiving sewage treatment works. In this case, operators allow for a contingency strategy for failure of the dissolved air flotation process or the chemical conditioning process associated with it, e.g. a diversion tank.

- For waste water streams with a BOD concentration greater than 1000 - 1500 mg/L BOD **anaerobic treatment** processes may be considered. If an anaerobic technique is used, operators ensure that fats, oils and greases are not allowed to reach the anaerobic reactor. Final effluent from the anaerobic process can be discharged directly to sewer, following flash aeration.

- For lower strength waste water streams **aerobic treatment** would be the preferred option. High rate trickling filters have been used at some dairies. The high rate trickling filter uses a high voidage filter packing media and can allow for a high rate of flow and load across the process. Systems are typically designed to remove 50 - 60 % BOD. It is essential that the levels of fats, oils and greases have been minimised prior to feed onto a high rate filter. Secondary settlement is required following a high rate filter and (depending upon the consent to discharge conditions) discharged direct to sewer.

For a higher degree of treatment conventional activated sludge systems have been used for such waste water streams, and (where economics allow) activated sludge variants (pure oxygen, SBR, MBR) can also be applicable. Hybrid aerobic reactors, such as the submerged biological aerated filter are also popular due to the historical use of biofiltration processes in the dairy industry.

Treatment for discharge to watercourse or for recycling
For discharges to watercourses, or for treating effluent to a quality suitable for re-use, further treatment stages would be required.

For the high strength waste waters that have passed through an anaerobic treatment plant a further aerobic plant will be required. Typically anaerobic reactors are followed by conventional activated sludge systems for further treatment. A two stage biological system (anaerobic followed by aerobic), if designed correctly, achieves a quality of effluent suitable for discharge to a water course. Should suspended solids consent be low a tertiary macrofiltration system (e.g. sandfilter) would be required.

Further tertiary treatment would be required for recycling all or part of the final effluent. Due to the nature of the waste, GAC filters and/or crossflow microfiltration would be required.

Disinfection would also be recommended should recycled water be used in hygienic areas.

Figure 4 shows a typical schematic for a process flow diagram for effluent treatment applicable to dairy processing waste waters.

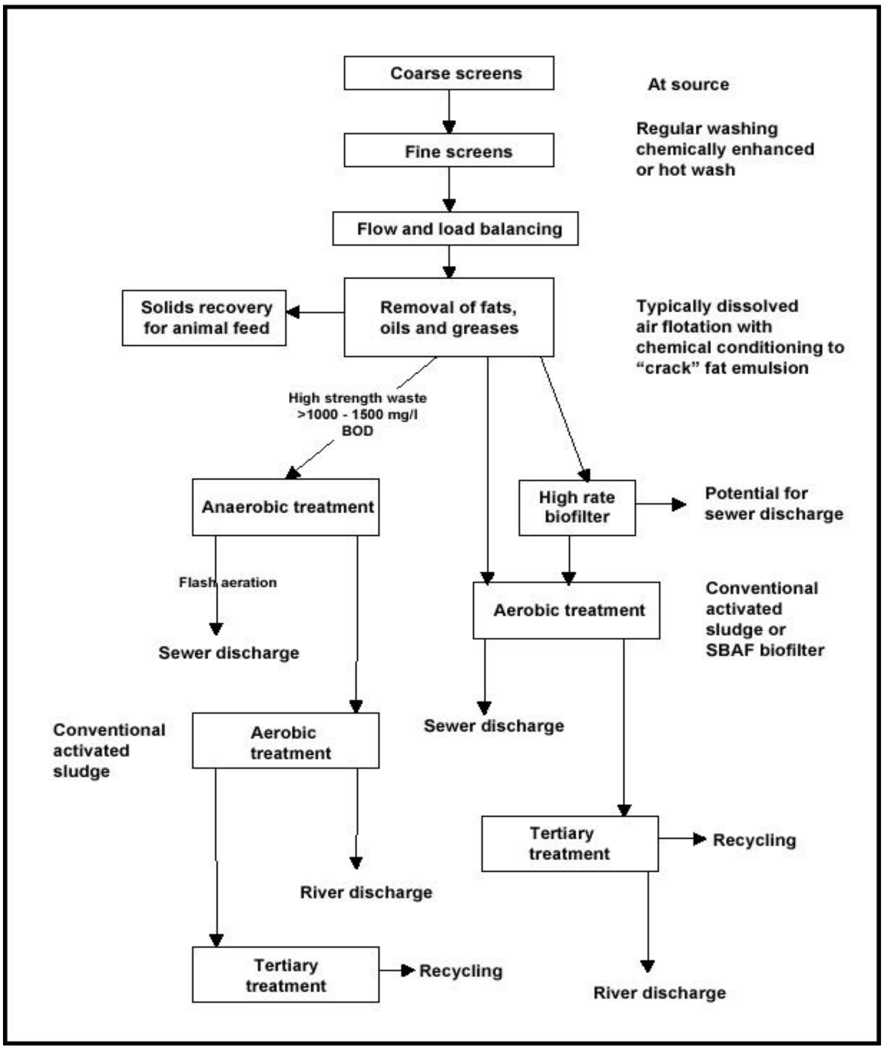

Figure 4. Flow sheet of the treatment for dairy waste water

Problems in waste water management in the dairy industry

Waste water from dairies is generally readily biodegradable, but there are a number of specific conditions that need to be observed to ensure reliable purification results:

- As a result of the cleaning cycles, there are considerable fluctuations in pH, waste water concentrations and flow volumes. A mixing and equalisation basin is therefore recommended.
- In order to deal with problems during operation it may make sense to provide an emergency tank.
- Despite preceding equalization basins it is necessary to allow for peak loads when designing the oxygen supply.
- Widely differing conditions with regard to phosphorus are encountered at the individual facilities. Some factories use phosphate-rich cleaners on a considerable scale, resulting in substantial phosphate loads. In view of the necessary precipitation measures, this has a major impact on sludge production.
- In the case of dairy waste water, surplus sludge production is considerably lower than with domestic waste water, for instance, owing to the lower content of filterable substances and the higher waste water temperatures.
- Dairy waste water has a considerable bulking sludge potential. Activated-sludge systems with light loads are less at risk in this respect than systems subject to heavy loads. System design makes use of the so-called “contact basin effect” or “selector effect”, in which the sludge is briefly subjected to a very heavy load and then once again to a low load. When designing a final clarification basin, special attention must be paid to the sludge index.
- The installation of a sand or grit trap is particularly necessary in cases where washing water from vehicle washing units and rainwater from sealed surfaces pass into the factory waste water treatment system. A screen or fine bar rack is also recommended, as this simplifies later removal of the sludge and avoids problems with operation of the treatment system (clogging, deposits).

In milk processing facilities there may be substantial nitrate concentrations in the untreated waste water as a result of the nitric acid used for cleaning purposes.

Annex 9

Meat processing

BAT for wastewater treatment

Treatment for discharge to sewer

Screening to remove gross solids is essential for installations in this subsector. Static wedge screens are cleaned several times a day to remove build-up. Self-cleaning screens are preferable, otherwise regular chemical cleaning takes place to dissolve fatty deposits. A hot water supply for cleaning purposes is also recommended in order to reduce fatty deposits. However, these can re-congeal lower down the system. Therefore, grease and fat must be retained in a trap close to the source.

Due to the nature of the processes, the washdown regime and use of shift work, flow and load balancing are required. Adequate mixing and aeration is allowed for. The formation of scum on the surface of the balance tank is minimised and, where necessary, scum removal arrangements installed. A balance tank typically has a retention time of 6 - 12 hours.

Dissolved air flotation is widely used in this sub-sector for the removal of fats, oils and greases and suspended solids. The separated material can generally be re-used as animal feed if suitable coagulants and flocculants have been chosen.

In some instances, discharge to sewer could occur downstream of a dissolved air flotation process, depending upon the efficiency of the process and the receiving sewage treatment works. In this case operators must allow for a contingency strategy for failure of the dissolved air flotation process or the chemical conditioning process associated with it, e.g. a diversion tank.

Following primary treatment, further stages may be required, either to achieve the required effluent quality or to minimise trade effluent charges. For waste water streams with a BOD concentration greater than 1000 - 1500 mg/L anaerobic treatment processes may be considered.

If an anaerobic technique is used, operators must ensure that fats, oils and greases are not allowed to reach the anaerobic reactor, as well as minimising any biocides from reaching this stage of the process. Final effluent from the anaerobic process could be discharged directly to sewer, following flash aeration.

For lower strength waste water streams aerobic treatment would be the preferred option, provided that the necessary BOD:N:P ratios are achieved. Conventional activated sludge systems have been used for such waste water streams, and (where economics allow) activated sludge variants (pure oxygen, SBR, MBR) would also be applicable. Hybrid aerobic reactors, such as the submerged biological aerated filter are also gaining popularity in this field.

Treatment for discharge to watercourse or for recycling

For discharges to watercourses, or for treating effluent to a quality suitable for re-use, further treatment stages would be required.

For high strength waste waters that have passed through an anaerobic treatment plant a further aerobic plant will be required. Typically anaerobic reactors are followed by conventional activated sludge systems for further treatment. A two stage biological system (anaerobic followed by aerobic), if designed correctly, achieves a quality of effluent suitable for discharge to a water course. Should suspended solids consent be low a tertiary macrofiltration system (sandfilter) would be required.

Further tertiary treatment would be required for recycling all or part of the final effluent. Due to the nature of the waste, GAC filters and/or crossflow microfiltration would be required.

Disinfection would also be recommended should recycled water be used in hygienic areas.

Figure 5 shows a typical schematic for a process flow diagram for effluent treatment applicable to meat and poultry processing waste water.

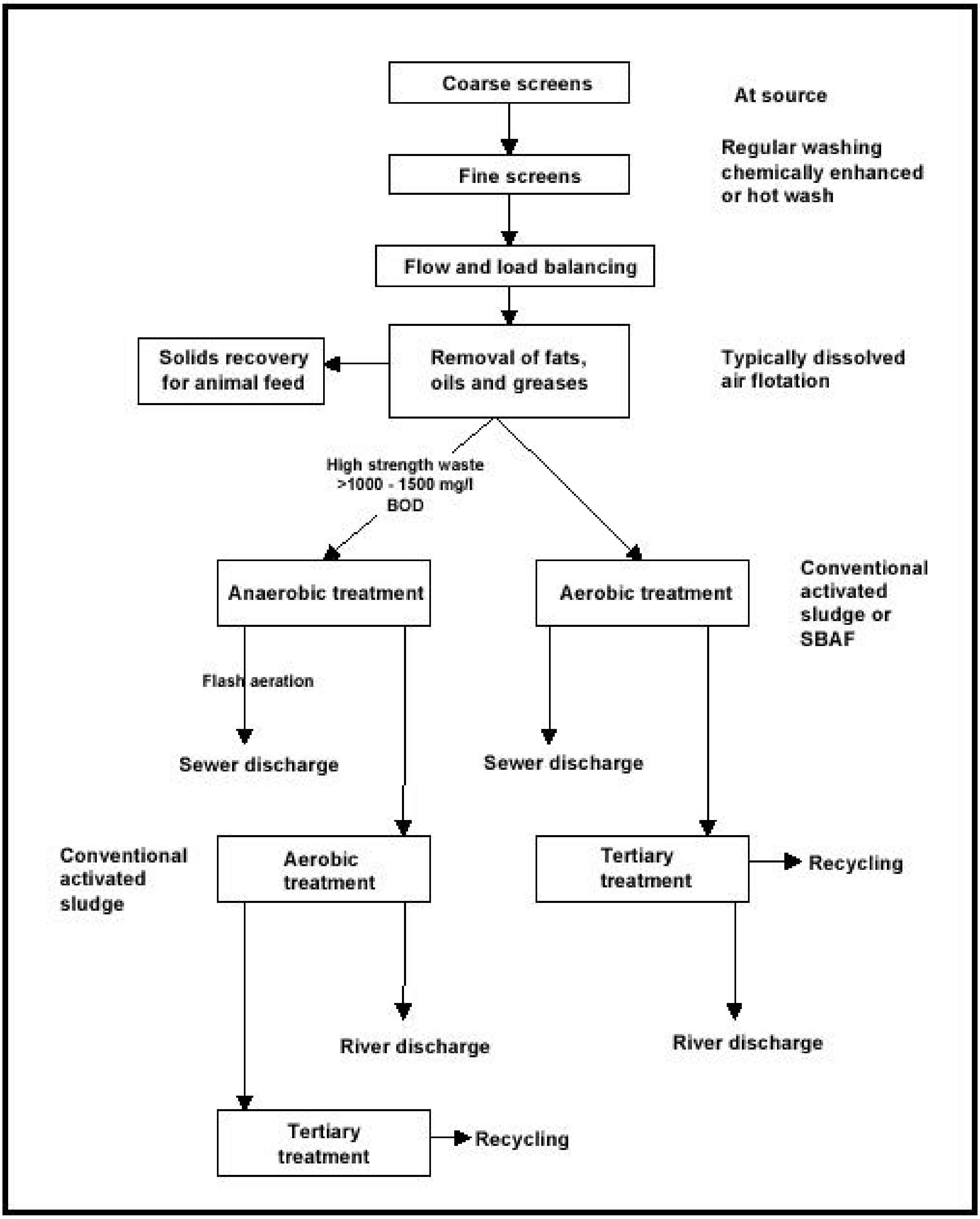

Figure 5. Flow sheet of the treatment for meat and poultry processing waste waters

Annex 10

Textile industry

BAT for wastewater treatment

Textile waste water is a mixture of many different chemical compounds which can roughly be classified into easily biodegradable, hardly biodegradable (recalcitrant) and non-biodegradable compounds.

Aerobic biological treatment techniques are widely used to treat mixed textile waste water. In most cases, complete-mix activated sludge systems are used. In activated sludge systems, easily biodegradable compounds are mineralised, whereas hardly biodegradable compounds need special conditions, such as low food-to-mass-ratios (F/M).

Today, many activated sludge systems meet these system conditions, which also enables almost complete nitrification. In these conditions, both easily and hardly biodegradable compounds can be discharged. On the contrary, effluents containing non-biodegradable compounds should be treated/pretreated at the source, but this is done only in a few mills. Therefore, in most cases, in addition to activated sludge a further treatment step is necessary, such as flocculation/precipitation, coagulation/adsorption/precipitation, adsorption to activated carbon, ozonation and Fenton reaction.

Membrane techniques are also applied in various ways for the treatment of segregated streams so as to allow water reclamation and re-use closely integrated with the process.
This technique is also used for the treatment of waste water containing pigment printing pastes with full re-use of the resulting permeate.

This technique is applicable to all textile finishing industries, provided that proper waste water segregation is practised and selection of membrane-compatible single waste water streams is made. Recipes have to be checked in terms of membrane compatibility and have to be changed if necessary. Structural changes for additional pipelines are needed in existing mills for waste water segregation. Additional tanks (space demand) for interim storage have to be installed.

Highly concentrated waste water streams result from various processes in the textile finishing chain. Depending on the efficiency of the washing machines (water consumption) and load of sizing agents on the fabric, COD-concentrations of desizing baths up to 20000 mg O_2/l can be observed. Depending on the class of dyestuffs, exhausted dye baths have COD-concentrations between 1000 and 15000 mg O_2/l are possible. Residual padding liquors from dyeing and finishing and residual printing pastes show even higher COD-concentrations.

Desizing baths with non-biodegradable sizing agents and exhausted dye baths can be treated by oxidation in a special reactor at 100-130°C and about 3 bars pressure (max. 5 bars).
The main oxidising agent is molecular oxygen. Hydrogen peroxide only initiates the oxidation reaction and keeps it running (delivering 1/5 of the reactive oxygen). Iron(II)-salt is added as catalyst in acid medium. With COD of the feed of more than 2500 mg/L, the reaction is exothermic. The process is called “Thermal Fenton Process”.

Printing pastes and padding liquors for continuous and semi-continuous dyeing contain high concentrations of dyestuffs. Residual padding liquors and printing pastes can be treated in anaerobic digesters, preferably in co-fermentation with primary and excess sludge from biological treatment. In practice, the residues are fed into anaerobic digesters at municipal waste water treatment plants.

The anaerobic colour removal represents a significant improvement compared to discharge of residual padding liquors for dyeing and printing pastes in the biological treatment plant without dedicated pretreatment.

Treatment of textile waste water by precipitation/flocculation in order to reduce organic load and especially colour has been performed for more than 100 years. However, today there are techniques that minimise the quantity of sludge produced and reduce negative effects associated with its disposal. Instead of landfill disposal, the sludge can be incinerated using state-of-the-art technology, thus avoiding simply shifting pollutants from one medium to another.

In modern plants the precipitate is separated from the aqueous phase not just by sedimentation but also by dissolved air flotation. Flocculation agents are specifically selected in order to maximise COD and colour removal, and to minimise sludge formation. In most cases, best performances are obtained with a combination of aluminium sulphate, cationic organic flocculant and very low amounts of an anionic polyelectrolyte.

Annex 11

Tanning industry

List of chemical substitutes in the tanning industry

Table 16
BAT for the substitution of chemicals

SUBSTANCE	SUBSTITUTE
Biocides	• Products with the lowest environmental and toxicological impact, used at the lowest level possible e.g. sodium or potassium-di-methyl-thiocarbamate
Halogenated organic compounds	• They can be substituted completely in almost every case. This includes substitution for soaking, degreasing, fatliquoring, dyeing agents and special post-tanning agents - Exception: the cleaning of Merino sheepskins
Organic solvents (non-halogenated) The finishing process and the degreasing of sheepskins are the major areas of relevance.	Finishing: • Aqueous-based finishing systems - Exception: if very high standards of topcoat resistance to wet-rubbing, wet-flexing and perspiration are required • Low-organic solvent-based finishing systems • Low aromatic contents Sheepskin degreasing: • The use of one organic solvent and not mixtures, to facilitate possible re-use after distillation
Surfactants APEs such as NPEs	• e.g. alcohol ethoxylates, where possible
Complexing agents EDTA and NTA	• EDDS and MGDA, where possible
Ammonium deliming agents	• Partially with carbon dioxide and/or weak organic acids
Tanning agents - Chromium - Syntans and resins	• 20 - 35 % of the fresh chrome input can be substituted by recovered chrome • products with low formaldehyde, low phenol and low acrylic acid monomer content
Dyestuffs	• De-dusted or liquid dyestuffs • High-exhausting dyes containing low amounts of salt • Substitution of ammonia by auxiliaries such as dye penetrators • Substitution of halogenic dyes by vinyl sulphone reactive dyes
Fatliquoring agents	• Free of agents building up AOX - Exception: waterproof leathers • Applied in organic solvent-free mixtures or, when not possible, low organic solvent mixtures • High-exhausting to reduce the COD as much as possible
Finishing agents for topcoats, binders (resins) and cross-linking agents	• Binders based on polymeric emulsions with low monomer content • Cadmium- and lead-free pigments and finishing systems

SUBSTANCE	SUBSTITUTE
Others: - Water repellent agents - Brominated and antimony-containing flame retardant	• Free of agents building up AOX - Exception: waterproof leathers • Applied in organic solvent-free mixtures or, when not possible, low organic solvent mixtures • Free of metal salts - Exception: waterproof leathers • Phosphate-based flame retardants

BAT for effluent treatment

In order to carry out effluent treatment in the most effective manner in the tanning industries, flow segregation is useful to allow preliminary treatment of concentrated waste water streams, in particular for sulphide-and chrome-containing liquors. And although a reduction of water consumption does not reduce the load of many pollutants, concentrated effluents are often easier and more efficient to treat.

Where segregation of flows is not possible, thorough mixing of chrome-bearing effluents and other effluent streams improves the efficiency of the effluent treatment plant because the chromium tends to precipitate out with the protein during pretreatment.

The treatment of chrome-containing liquors consist on chrome precipitation. Chrome precipitation is a relatively simple technique and is more efficient if it is carried out in separated effluents after screening. The precipitation of chrome is achieved by increasing the pH to above pH 8 using alkali such as calcium hydroxide, magnesium oxide, sodium carbonate, sodium hydroxide and sodium aluminate. Chrome and other metals are precipitated as highly insoluble hydroxides. The pH value required for the precipitation depends upon the type of chrome-containing waste water to be treated.

It is common practice to keep sulphide-containing effluent from the beamhouse separate and at a high pH until the sulphide is treated, because at a pH lower than 9.0 the formation of toxic hydrogen sulphide gas can occur. The sulphides in the deliming and pickle liquors can easily be oxidised in the drum by adding hydrogen peroxide, sodium metabisulphite or sodium bisulphite. The associated emission level after treatment of sulphide is 2 mg/L in a random sample in the separate effluent. Where segregation of sulphide-bearing liquors is not possible, the sulphides are generally removed by means of precipitation with iron (II) salts and aeration. A disadvantage of this precipitation is the generation of high volumes of sludge. The levels that can be achieved in treating the mixed effluent are -depending on the mixing rate- 2 mg S^{2-} /l and 1 mg Cr_{total} /l (e.g. if 50 % of the mixed effluent consist of the chrome-bearing effluent and 50 % of the mixed effluent consist of the sulphide-bearing effluent, emission levels for the total effluent will be 1 mg S^{2-} /l and 0.5 mg Cr_{total} /l).

The data in the table below represent typical values for tannery waste water treatment efficiency for conventional process liquors for production of finished leather from raw material.

Table 17
Typical values for tannery waste water treatment efficiency

Parameter	COD		BOD_5		SS		Chrome	S^{2-}	TKN	
% or mg/L	%	mg/L	%	mg/L	%	mg/L	mg/L	mg/L	%	mg/L
PRETREATMENT										
Grease removal (dissolved air flotation)	20 - 40									
Sulphide oxidation (liming and rinsing liquors)	10							10		
Chromium precipitation							1 - 10			
PRIMARY TREATMENT										
Mixing + Sedimentation	25 - 35		25 - 35		50 - 70		20 - 30		25 - 35	
Mixing + Chemical treatment + sedimentation	50 - 65		50 - 65		80 - 90		2 - 5	2 - 10	40 - 50	
Mixing + Chemical treatment + flotation	55 - 75		55 - 75		80 - 95		2 - 5	2 - 5	40 - 50	
BIOLOGICAL TREATMENT										
Primary or chemical + Extended aeration	85 - 95	200 - 400	90 - 97	20 - 60	90 - 98	20 - 50	<1	<1	50	150
Primary or chemical + Extended aeration with nitrification and denitrification	85 - 95	200 - 400	90 - 97	20 - 60	90 - 98	20 - 50	<1	<1	80 - 90	30 – 60

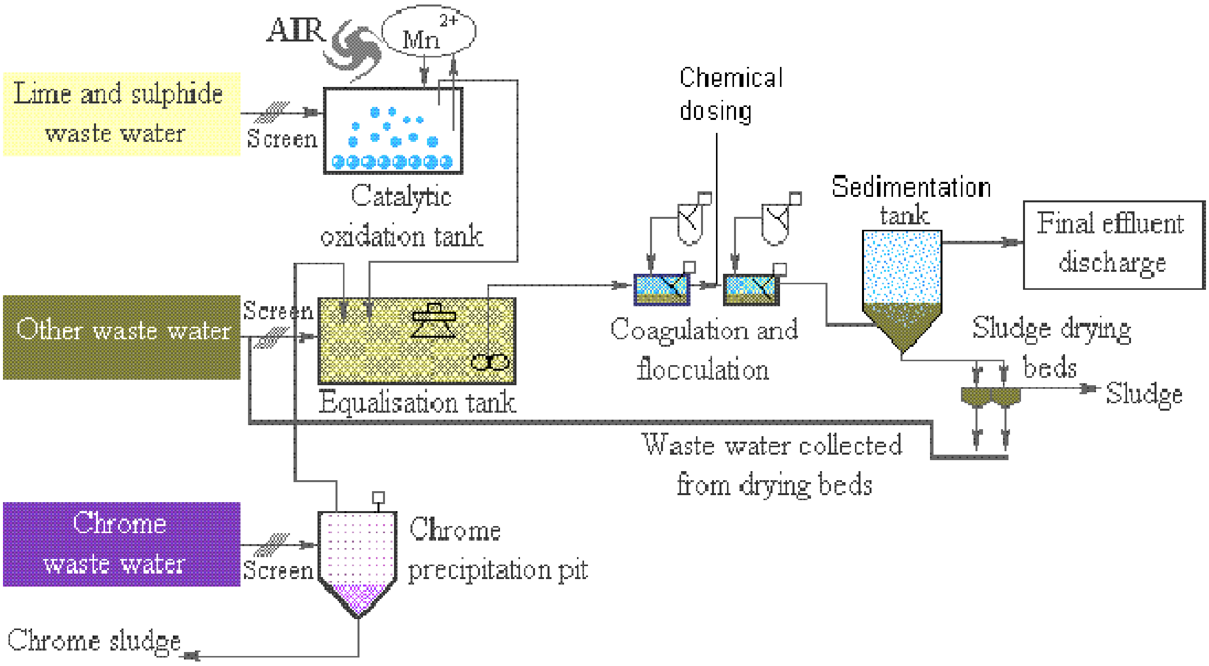

Figure 6. Typical scheme for physico-chemical treatment

Annex 12

Pulp and paper

Benchmarks (Kraft process)

Table 18
Additional explanation with regard to benchmarks in the Kraft process

- **Chemical oxygen demand** (COD): the reduction rate for COD is related to the types and amounts of effluents treated (e.g. condensates are more degradable than spills), the construction and hydraulics of the treatment plant and appropriate adjustment of the operating parameters. COD removal rates of 65 - 75 % are achieved by well designed and controlled low loaded plants. However, long retention times means big aeration basins and more consumption of pumping and aeration energy is needed. To be regarded as well performing plant the COD reduction rates in treatment should exceed 55%. Consequently, emission levels of 8 - 23 kg COD/Adt can generally be achieved by bleached Kraft pulp mills. The concentration measured in effluents of these mills is in the range of 250 - 400 mg COD/l. The most common reasons for less performing activated sludge plants are chosen design and too high load. On the other hand, the best plants achieving a COD-removal of about 75% are operating at a level where further reduction of organic matter (measured as COD) is very limited by means of biological treatment.
- **Biochemical oxygen demand** ($BOD_{5\ or\ 7}$): in well designed treatment plants BOD is removed almost completely (95% + removal) from pulp mills wastewater when the carbon-phosphorus- nitrogen ratio and oxygen supply is maintained sufficient and well controlled. In case of disturbances or if some of the running parameters are moving away from the target level, the BOD concentration in effluents will start to increase. This calls for adjustment of the running parameters and/or analysis of the biomass. The BOD concentration in the effluent is related to the control of system and can be used as an indicator of the health of the active biomass. The BOD_5 concentration in treated effluents between 10 and 25 mg/L are associated with BAT. Depending on the water flow this corresponds to 0.3 kg BOD_5/Adt (at 10 mg/L and 30 m^3 flow/Adt) and 1.3 kg BOD_5/Adt respectively (at 25 mg/L and 50 m^3 flow).
- **Total suspended solids** (TSS): under normal operation conditions, the water from the secondary clarifier is fairly clear and suspended solids content is in the range of 20 to 30 mg/L. This corresponds to discharges of 0.6 - 1.5 kg TSS/Adt (at a water flow of 30 - 50 m^3 /Adt). The values depend on the surface load of the secondary clarifier and the characteristics of the biomass.
- **Phosphorus and nitrogen** (Tot-P and Tot-N): mineral nutrients are usually added to the biological treatment plant to keep the balance C: P: N which is of crucial importance for the growth of active biomass. Therefore, only focussing on incoming concentration or reduction rates for N and P will not achieve its purpose. It is rather necessary to find and keep a balance between incoming N- and P-compounds that are available for biomass and the amount of nutrients, if any, added which requires a certain fine-tuning of the nutrient feed. Often, pulp mills do not add phosphorus to their wastewater whereas nitrogen addition (usually as urea) is essential for pulp mills. When the system is well optimised the phosphorus discharge of 0.2 - 0.5 mg tot-P/l and 2 - 5 mg tot-N/l are achieved. The corresponding loads are 0.01 - 0.03 kg P/Adt and 0.1 - 0.25 kg N/Adt respectively (at a water flow of 50 m^3 /Adt). Tot-P from bleached pulp is slightly higher than from unbleached because phosphorus is dissolved out in the bleach plant.

Benchmarks (Sulphite process)

Table 19
Additional explanation with regard to benchmarks in the sulphite process

- **Chemical oxygen demand** (COD): the reduction rate for COD is related to the types and amounts of effluents treated (e.g. condensates are more degradable than spills), the construction and hydraulics of the treatment plant and appropriate adjustment of the operating parameters. To be regarded as well performing plant the COD reduction rates in aerobic treatment should exceed 55%. Consequently, emission levels of 20 - 30 kg COD/Adt can generally be achieved by bleached sulphite pulp mills. The concentration measured in effluents of these mills is in the range of 400 - 600 mg COD/l. The most common reasons for less performing activated sludge plants are chosen design and overload.

- **Biochemical oxygen demand** ($BOD_{5 \text{ or } 7}$): in well designed treatment plants BOD is removed almost completely (95% removal) from pulp mills wastewater when the carbon-phosphorus-nitrogen ratio and oxygen supply is maintained sufficient and well controlled. In case of disturbances or if some of the running parameters are moving away from the target level, the BOD concentration in effluents will start to increase. This calls for adjustment of the running parameters and/or analysis of the biomass. The BOD concentration in the effluent is related to the control of system and can be used as an indicator of the health of the active biomass.
- The BOD_5 concentration in treated effluents of 20 - 30 mg/L is achievable. Depending on the water flow this corresponds to 1.0 kg BOD_5/Adt (at 20 mg/L and 55 m^3 flow/Adt) and 1.7 kg BOD_5/Adt respectively (at 30 mg/L).

- **Total suspended solids** (TSS): under normal operation conditions, the water from the secondary clarifier is fairly clear. The content of suspended solids is in the range of 20 to 30 mg/L. This corresponds to discharges of 0.8 - 2.0 kg TSS/Adt (at a water flow of 55 m^3 /Adt). The values depend on the surface load of the secondary clarifier and the characteristics of the biomass.

- **Phosphorus and nitrogen** (Tot-P and Tot-N): mineral nutrients are usually added to the biological treatment plant to keep the balance C: P: N which is of crucial importance for the growth of active biomass. It is necessary to find and keep a balance between incoming N- and P-compounds that are available for biomass and the amount of nutrients added which requires a certain fine-tuning of the nutrient feed. Often, pulp mills do not add phosphorus to their wastewater whereas nitrogen addition (usually as urea) is essential for pulp mills. When the system is well optimised the phosphorus discharge of below 0.5 mg tot-P/l and below 5 mg tot-N/l are achieved. The corresponding loads are 0.02 - 0.05 kg P/Adt and 0.15 - 0.5 kg N/Adt respectively (at a water flow of 50 m^3 /Adt).

Benchmarks (Mechanical and chemi-mechanical pulp and paper mills)

Table 20
Additional explanation with regard to benchmarks in the mechanical and chemi-mechanical pulp and paper mills

- **Chemical oxygen demand** (COD): the reduction rate for COD is related to the types and amounts of effluents treated (e.g. peroxide bleached TMP, reductive bleached SGW, DIP production, effluents from coating), the construction and hydraulics of the treatment plant and appropriate adjustment of the operating parameters. The wastewater from mechanical pulping is easier degradable than those from chemical pulping. COD removal rates of 75 - 90 % are achieved by well designed and controlled low loaded plants. Consequently, emission levels of 2 - 5 kg COD/Adt can generally be achieved by mills manufacturing wood-containing paper. The concentration measured in effluents of this mills are in the range of 125 - 200 mg COD/l. CTMP mills discharge higher concentrated wastewater. Because of the chemical pretreatment of the woodchips CTMP mills discharge higher emissions to water.

- **Biochemical oxygen demand** ($BOD_{5\ or\ 7}$): in well designed treatment plants BOD is removed almost completely (95% + removal) from mechanical pulp mills waste water when the carbon-phosphorus- nitrogen ratio and oxygen supply is maintained sufficient and well controlled. The BOD_5 concentration in treated effluents below 25 mg/L (often close to the detection limit) are associated with BAT. Depending on the water flow this corresponds to 0.2 kg BOD_5/Adt and 0.7 kg BOD_5/Adt.

- **Total suspended solids** (TSS): under normal operation conditions, the water from the secondary clarifier is fairly clear and its suspended solids content in the range of 20 to 30 mg/L. This corresponds to discharges of 0.2 - 0.5 kg TSS/Adt. The values depend on the surface load of the secondary clarifier and the characteristics of the biomass.

- **Phosphorus and nitrogen** (Tot-P and Tot-N): mineral nutrients are usually added to the biological treatment plant to keep the balance C: P: N which is of crucial importance for the growth of active biomass. It is necessary to find and keep a balance between incoming N- and P-compounds that are available for biomass and the amount of nutrients, if any, added which requires a certain fine-tuning of the nutrient feed. When the system is well optimised the phosphorus discharge of below 0.5 mg tot-P/l and 1 - 5 mg tot-N/l are achieved. The corresponding loads are 0.005 - 0.01 kg P/Adt and 0.05 - 0.2 kg N/Adt respectively.

Benchmarks (recovered paper processing)

Table 21
Additional explanation with regard to benchmarks in the recovered paper processing

BOD: in well designed treatment plants BOD is removed almost completely (95% + removal) from RCF processing paper mill wastewater when the carbon-phosphorus-nitrogen ratio and oxygen supply is maintained sufficiently and well controlled. BOD_5 levels will usually be well below 25 mg BOD_5/l and can reach values down to 5 mg/L i.e. almost completely removal. BOD levels around 5 mg/L are hardly to measure accurately and reproducible. They should be read as values close to the detection limit. Depending on the water flow these performance levels corresponds to <0.05 kg BOD_5/t and 0.3 kg BOD_5/t respectively.

TSS: under normal operation conditions, the water from the secondary clarifier is fairly clear. The content of suspended solids is in the range of below 10 to 30 mg/L. This corresponds to discharges of 0.1 - 0.3 kg TSS/t. The values depend on the surface load of the secondary clarifier and the characteristics of the biomass.

N and P: mineral nutrients are usually added to the biological treatment plant to keep the balance C: P: N which is of crucial importance for the growth of active biomass. To find and keep a balance between biodegradable carbon, nitrogen- and phosphorus-compounds a certain fine-tuning of the added nutrient feed is required. Usually, phosphorus is added as phosphorus acid and nitrogen in form of urea. When the system is well optimised nutrients discharge well below 1 mg tot-P/l and 5 mg total N/l are achievable. The corresponding loads are 0.005-0.01 kg P/t and 0.05-0.1 kg N/t respectively with de-inking and somewhat less for mills without de-inking because of lower water flows.

COD: de-inking processing results in higher COD emissions than emissions caused by processing without de-inking. Factors such as raw materials used, paper grade manufactured, applied process-integrated and external measures, and water flow per ton of product, have an influence on the final pollution load. Concentrations between below 100 mg/L up to 200 mg COD/l (without de-inking) and 200 mg/L to 300 mg/L COD (with de-inking) are achievable when BAT is applied.

Benchmarks (paper mill)

Table 22
Additional explanation with regard to benchmarks in the paper mill

BOD: in well designed treatment plants BOD is removed almost completely (95% + removal) from paper mill wastewater when the carbon-phosphorus-nitrogen ratio and oxygen supply is maintained sufficient and well controlled. In case of disturbances or if some of the running parameters are moving away from the target level, the BOD concentration in effluents will start to increase. This calls for adjustment of the running parameters and/or analysis of the biomass. BOD_5 levels will usually be below 25 mg BOD_5/l and can reach values down to 5 mg/L (almost completely removal). However, BOD_5 levels around 5 mg/L are hardly to measure accurately and reproducible. Depending on the water flow this corresponds to 0.15 kg BOD_5/t (at 10 mg/L and 15 m^3 flow/t) and 0.25 kg BOD_5/t respectively (at 25 mg/L and 10 m^3 flow).

TSS: under normal operation conditions, the water from the secondary clarifier is fairly clear and its suspended solids content in the range of 20 to 30 mg/L. This corresponds to discharges of 0.2 - 0.4 kg TSS/t. The values depend on the surface load of the secondary clarifier and the characteristics of the biomass. With biofiltration also lower concentrations are normally achievable.

N and P: mineral nutrients are usually added to the biological treatment plant to keep the balance C: P: N which is of crucial importance for the growth of active biomass. To find and keep a balance between biodegradable carbon, nitrogen- and phosphorus-compounds a certain fine-tuning of the added nutrient feed is required. Usually, phosphorus is added as phosphorus acid and nitrogen in form of urea. When the system is well optimised nutrients discharge of well below 1 mg tot-P/l and 5 mg tot-N/l are achievable. The corresponding loads are 0.003 - 0.001 kg P/t and 0.05 - 0.2 kg N/t respectively.

COD: depending on the paper grade manufactured, the applied techniques for prevention and control of emissions and the water flow per ton of product, the wastewater from paper mills after treatment contains between 50 - 150 mg COD/l.

Annex 13

Fertilizer industry

Waste minimization methods for the fertilizer industry	
Waste stream	Waste minimization methods
Equipment cleaning wastes	Maximize production runs. Store and reuse cleaning wastes. Use of wiper blades and squeegees. Use of low-volume, high-efficiency cleaning. Use of plastic or foam "pigs."
Spills and area washdowns	Use of dedicated vacuum system. Use of dry cleaning methods. Use of recycled water for initial cleanup. Actively involved supervision.
Containers	Return containers to supplier and or reuse as directed. Triple rinse containers. Drums with liners versus plastic drums or bags. Segregating solid waste.
Air emissions	Control bulk storage air emissions. Dedicate dust collection systems. Use automatic enclosed cut-in hoppers. Eliminate emissions of ammonia from reaction of anhydrous ammonia and phosphoric acid.
Miscellaneous wastewater streams	Pave high spillage areas.

Annex 14

Pharmaceutical industry

Wastewater treatment techniques

Advanced Biological Treatment
General Description

Advanced biological treatment is used in the pharmaceutical manufacturing industry to treat BOD_5, COD, TSS, and to degrade various organic constituents. The term "advanced" is used to refer to treatment systems that consistently surpass, on a long-term basis, 90% BOD_5 reduction and 74% COD reduction in pharmaceutical manufacturing wastewater. To provide reduction of ammonia in the wastewater using advanced biological treatment, nitrification is necessary.

Biological systems can be divided into two basic types: aerobic (treatment takes place in the presence of oxygen) and anaerobic (treatment takes place in the absence of oxygen).
The four most common aerobic treatment technologies in the industry are activated sludge systems, aerated lagoons, trickling filters, and rotating biological contactors (RBC).
In aerobic biological treatment processes, oxygen-requiring microorganisms decompose organic and nonmetallic inorganic constituents into carbon dioxide, water, nitrates, sulfates, organic byproducts, and cellular biomass. The microorganisms are maintained by adding oxygen and nutrients (usually nitrogen and phosphorous) to the system. Activated sludge and aerated lagoon processes are suspended-growth processes in which the microorganisms are maintained in suspension within the liquid being treated. The trickling filter and RBC processes are attached-growth processes in which microorganisms grow on an inert medium (e.g., rock, wood, plastic).
The majority of biological treatment systems used in the pharmaceutical industry are activated sludge systems.
An activated sludge treatment system normally consists of an equalization basin, a settling tank (primary clarifier), an aeration basin, a secondary clarifier, and a sludge recycle line. Equalization of flow, pH, temperature, and pollutant loads is necessary to perform consistent, adequate treatment. The settling tank is used to remove settleable solids prior to aeration. The aerobic bacterial population is maintained in the aeration basin, in which oxygen, recycled sludge, and nutrients are added to the system. Oxygen is normally supplied by aerators that also provide mixing to help keep microorganisms in suspension. Recycled sludge is added to keep an optimal concentration of acclimated microorganisms in the aeration basin. The secondary clarifier controls the amount of suspended solids discharged, as well as provides sludge for recycle to the aeration basin. Sludge produced by these systems generally consists of biological waste products and expired microorganisms. This sludge may accumulate under certain operating conditions and may therefore require periodic removal from the aeration basin.

Generated sludge will require some type of storage, handling, and disposal. Biological sludges are normally treated in a two-step process prior to disposal: thickening followed by dewatering.

Other sludge treatment may also be performed, but these processes are the most common. The goal for each of these operations is to decrease the overall volume of sludge. Thickening of waste-activated sludge is normally performed in one of three ways: gravity separation, dissolved-air flotation, or centrifuging. Generally, thickeners will increase the solids content of sludge from 1% (typical from biological treatment) to 4 or 5%. Sludge dewatering is normally performed using some type of filter, including filter presses, vacuum filters, and belt filters. These units normally can increase the solids content in sludge from 5% up to 15 to 30%, which greatly reduces the shipping, handling and disposal costs associated with sludge generation from a biological treatment unit.

Some key design parameters for activated sludge systems include nutrient-to-microorganism ratio, mixed liquor suspended solids (MLSS), sludge retention time, oxygen requirements, nutrient requirements, sludge production, substrate removal rate constant (K), and percent BOD_5 of effluent TSS. Pharmaceutical manufacturing industry averages for some of these parameters are presented in the following table.

Parameter	Subcategories A and C Average	Subcategories B and D Average
Food to Microorganism Ratio (kg/kg/day)	0.561	0.054
MLSS (mg/L)	5,521	3,443
Sludge Retention Time (hours)	33.0	22.9
K	11.14	2.06
%BOD_5 of TSS	23	24

Ammonia treatment by nitrification is achieved in biological treatment units by incorporating two additional sets of autotrophic microorganisms. The first set of microorganisms (Nitrosomonas bacteria) converts ammonia to nitrites and the second set (Nitrobacter bacteria) converts nitrites to nitrates. These microorganisms are maintained in the treatment tank in a similar fashion as the microorganisms described above (addition of oxygen, nutrients, etc). Nitrification can be accomplished in either a single or two-stage activated sludge system. Indicators of nitrification capability are:
biological monitoring for ammonia oxidizing bacteria (AOB) and nitrite oxidizing bacteria (NOB) to determine if nitrification is occurring, and
analysis of the nitrogen balance to determine if nitrifying bacteria reduce the amount of ammonia and increase the amount of nitrite and nitrate.

Common design criteria for single and two-stage systems with nitrification capability are:

Parameter	Single Stage	Two-Stage
Suspended growth Food/Microorganism ratio (g BOD_5 /g MLVSS/d)	0.05-0.15	<0.15
Sludge retention time (days)	20-30	10-20
MLVSS (mg/L)	2,000 - 3,000	1,500 - 2,500
pH	7.2 - 8.5	7.2 - 8.5

Multimedia Filtration
General Description

Multimedia filtration is used in the pharmaceutical manufacturing industry to reduce TSS in wastewater. This technology may also serve to treat BOD in wastewater by removing BOD_5 associated with particulate matter. A multimedia filtration system operates by introducing a wastewater to a fixed bed of inert granular media. Suspended solids are removed from the wastewater by one or more of the following processes: straining, interception, impaction, sedimentation, and adsorption. This operation is continued until there is either solids "breakthrough" (solids concentration increases to an unacceptable level in the discharge from the bed), or the head loss across the bed becomes too great (due to trapped solids) to operate the bed efficiently.

If either of these conditions occurs, the bed must be cleaned by backwashing before it can be operated effectively again. Backwashing usually is accomplished by reversing the flow to the bed and introducing a "clean" stream of wash water. Wash water is introduced until the bed becomes fluidized (expanded). At this point, the solids are washed from the bed and carried away from the unit. It is common to return the backwashed solids stream to the biological treatment system (if applicable).

In multimedia filtration, a series of layers, each with a progressively smaller grain size medium (travelling from inflow to outflow of the bed) are used in the filtration bed. This design allows solids to penetrate deeper into the bed before becoming fixed, thus increasing the capacity of the bed and decreasing the buildup of head loss in the unit. Typical filtration media include garnet, crushed anthracite coal, resin beads, and sand. Though downflow (gravity flow) systems are the most common, upflow and biflow (influent is introduced above and below the filter medium, and the effluent discharges from the centre of the filter medium) filtration units can also be used.

Figure 7 shows a cross-of a typical downflow, multimedia filtration bed.
Some key design parameters associated with multimedia filtration units include wastewater flow rate, hydraulic loading rate, and filter medium depth. The following table shows ranges of values for each of these parameters for treatment units currently operated in the pharmaceutical manufacturing industry.

Parameter	Range	Units
Flow Rate	0.03 - 2.18	MGD
Hydraulic Loading Rate	2.0 - 5.0	gpm/ft^2
Depth of Medium	6 - 72	inches

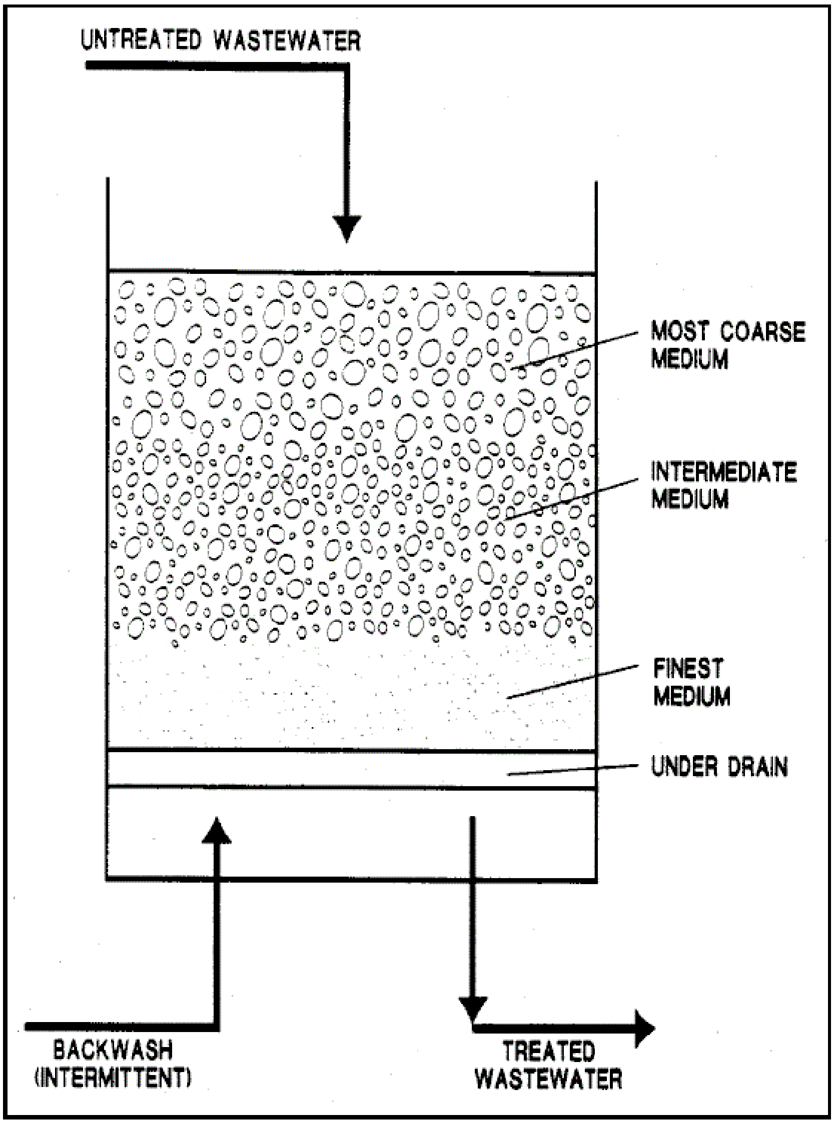

Figure 7. Typical Downflow Multimedia Filter Bed

Polishing Pond
General Description
Polishing ponds are used in the pharmaceutical manufacturing industry to remove TSS from wastewater using gravity settling. Some BOD removal associated with the settling of suspended solids may also occur.

The wastewater is introduced at one end of the pond and ultimately flows out the other end. The pond is designed such that the water retention time is long enough and the water velocity is slow enough to allow solids to fall out of suspension. If the flow is too fast, or other mixing is added to the system, solids may be maintained in suspension and discharged from the pond. To avoid anaerobic conditions in the bottom portion of the pond, these units must be designed to be shallow, which may require a large land area if flow to the unit is high. Depths of polishing ponds currently used in the industry range from 2.5 to 14 feet. Retention times range from 0.2 to 14.6 days.

Cyanide Destruction
General Description
Several cyanide destruction treatment technologies are currently used in the pharmaceutical manufacturing industry, including alkaline chlorination, hydrogen peroxide oxidation, and basic hydrolysis. The alkaline chlorination treatment process involves reacting free cyanide with hypochlorite (formed by reacting chlorine gas with an aqueous sodium hydroxide solution) to form nitrogen and carbon dioxide. The reaction is a two-step process and is normally performed separately in two reactor vessels. Because treatment is normally performed in batches, it is necessary to use an additional equalization tank to store accumulated wastewater during treatment. The reactors need to be equipped with agitators, and both reaction steps require close monitoring of pH and oxidation/reduction potential (ORP). These reactions are normally performed at ambient temperatures.

Hydrogen peroxide treatment involves adding hydrogen peroxide to cyanide-bearing wastewater to convert free cyanide to ammonia and carbonate ions. This treatment is normally performed batch-wise in a reaction vessel or vessels. The treatment process consists of heating the wastewater to approximately 125°F and adjusting the pH in the reaction vessel to approximately 1l Hydrogen peroxide is added to the vessel and is allowed to react for approximately one hour.

Required equipment for this process includes reaction vessel(s), storage vessels for hydrogen peroxide and a pH adjustment compound (typically sodium hydroxide), an equalization tank, and feed systems for hydrogen peroxide and sodium hydroxide.

Hydrolysis treatment involves reacting free cyanide with water under basic conditions to produce formaldehyde and ammonia. This process requires approximately one hour to proceed and is typically performed at a temperature between 170 and 250°C, and at a pH of between 9 and 12. Hydrolysis is normally performed in a reactor vessel equipped with a heat exchanger and a system to store and deliver sodium hydroxide (or other basic compound).

Steam Stripping and Steam Stripping with Rectification
Steam stripping and steam stripping with rectification are used both in industrial chemical production (for chemical recovery and/or recycle) and in industrial waste treatment to remove gases and/or organic chemicals from wastewater streams by providing steam to a tray or packed column. Under both technologies, differences in relative volatility between the organic chemicals and water are used to achieve a separation. The more volatile components of the feed mixture concentrate in the vapour, while the less volatile components concentrate in the liquid residue (bottoms). Steam stripping and steam stripping with rectification are effective treatment for a wide range of aqueous streams containing organic compounds and ammonia. Appropriately designed and operated columns can treat a variety of waste streams ranging from wastewaters containing a single volatile constituent to

complex organic/inorganic mixtures. Steam stripping and steam stripping with rectification can be used both as in-plant processes to recover concentrated organics from aqueous streams and as end-of-pipe treatment to remove organics from wastewaters prior to discharge or recycle. For most effective wastewater treatment, columns should be placed after the process generating the wastewater and before the wastewater is combined with other wastewater that does not contain the pollutants being treated. Wastewater with high concentration and low flow is easier and less expensive to treat than wastewater with high flow and/or low concentration. In addition, the amount of volatiles emitted to the air can be minimized if columns are placed prior to exposure of the wastewater stream to the atmosphere.

General Description

Steam stripping and steam stripping with rectification can be conducted as either a batch or continuous operation in a packed tower or fractionating column (sieve tray or bubble cap) with more than one stage of vapour-liquid contact. In a steam stripping column, the wastewater feed enters near the top of the column and then flows downward by gravity, countercurrent to the steam which is introduced at the bottom of the column. In a steam stripping with rectification column, the wastewater feed enters lower down the column to allow for a rectification above the feed. In the rectification section, a portion of the condensed vapours are refluxed to the column to countercurrently contact the rising vapours. This process concentrates the volatile components in the overhead stream.

Steam may either be directly injected or reboiled, although direct injection is more common. The steam strips volatile pollutants from the wastewater, which are then included in the upward vapour flow. As a result, the wastewater contains progressively lower concentrations of volatile compounds as it moves toward the bottom of the column. The extent of separation is governed by physical properties of the volatile pollutants being stripped, the temperature and pressure at which the column is operated, and the arrangement and type of equipment used.

The difference between steam stripping columns and steam stripping with rectification columns is the location of the feed stream. Stripping columns have a feed stream located near the top of the column while steam stripping with rectification columns have a feed stream located further down the column. Pollutants that phase separate from water can usually be stripped from the wastewater in a steam stripper (a column without rectifying stages). Pollutants that are not phase-separable, such as methanol, need a column with rectifying stages to achieve a high concentration of the pollutants in the overhead stream.

The ancillary equipment used in conjunction with steam stripping and steam stripping with rectification columns includes a condenser and subcooler, pumps for the feed, overhead, bottoms, and reflux streams, a feed preheater and bottoms cooler, a decanter, a storage tank, a distillate tank, and an air pollution control device to contain any vapours from the condenser. The condenser and subcooler condense and cool the overhead stream to a temperature amenable for storage and disposal. The pumps supply the force to move the waste stream: either into the column at the feed position or at a point above the feed in the case of a reflux stream. The bottoms pump moves the bottoms from the stripping column to the bottoms cooler, and the overheads distillate pump moves the distillate from the decanter to the distillate receiver tank. The feed preheater/bottoms cooler is a heat exchanger that heats the feed before it enters the column at the same time it cools the bottoms stream so that it can be sent to a storage area or treatment system. The decanter separates the aqueous layer from the organic layer after the stream comes from the condenser and subcooler. The aqueous layer can be refluxed back to the column while the organic layer is usually disposed of or reused. The storage tank provides a steady feed for the steam stripper column, equalizing flow and waste variability. An air pollution control device may be needed to contain any pollutants that do not condense in the condenser and would otherwise escape to the air. Wet scrubbers, carbon adsorption devices, or venting to a combustion device may be used to control air emissions. Figure 8 shows a flow diagram of a typical steam stripping treatment system and Figure 9 shows a flow diagram of a typical steam stripping with rectification treatment system.

The typical construction material for steam stripping and steam stripping with rectification columns in the pharmaceutical manufacturing industry is stainless steel. If a wastewater stream is highly corrosive, a more corrosion-resistant material, may be required for construction of the column. The majority of pharmaceutical manufacturing facilities which currently use steam stripping and/or steam stripping with rectification columns to treat their wastewater use stainless steel.

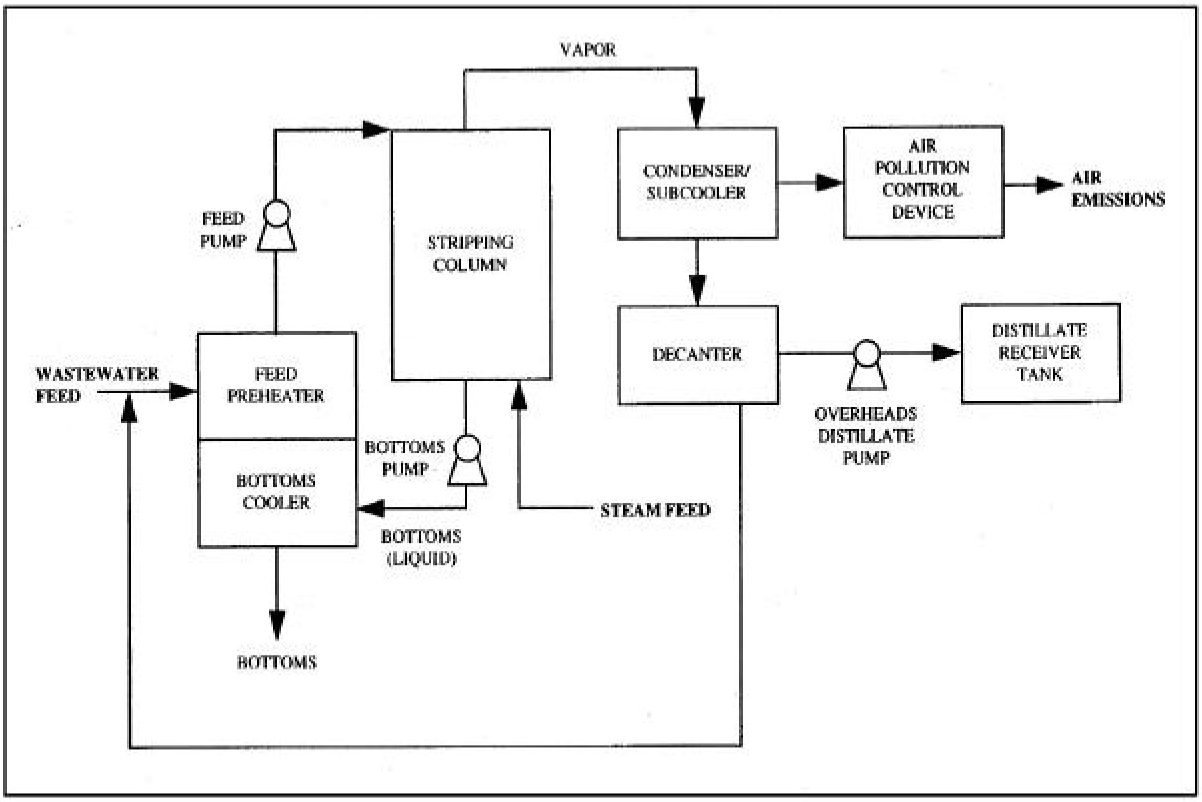

Figure 8. Steam Stripping Column Diagram

Salts and other pollutants may contribute to scaling and corrosion inside the column. Timely maintenance should be provided to deter scaling problems.

The key design parameters for stripping columns are the steam-to-feed ratio and the number of trays or equilibrium stages in packed columns. These parameters are calculated using the equilibrium ratio of the least strippable contaminant in the wastewater stream and the removal efficiency required to treat the contaminant to the desired concentration. Typical ranges for steam-to-feed ratios vary from 1:3 to 1:35, and the typical number of trays or equilibrium stages vary from 2 to 20. Generally, columns with smaller diameters are packed while columns with larger diameters have trays. Typical column packings are Pall rings, Rashing rings, Berl saddles, and Intalox saddles.

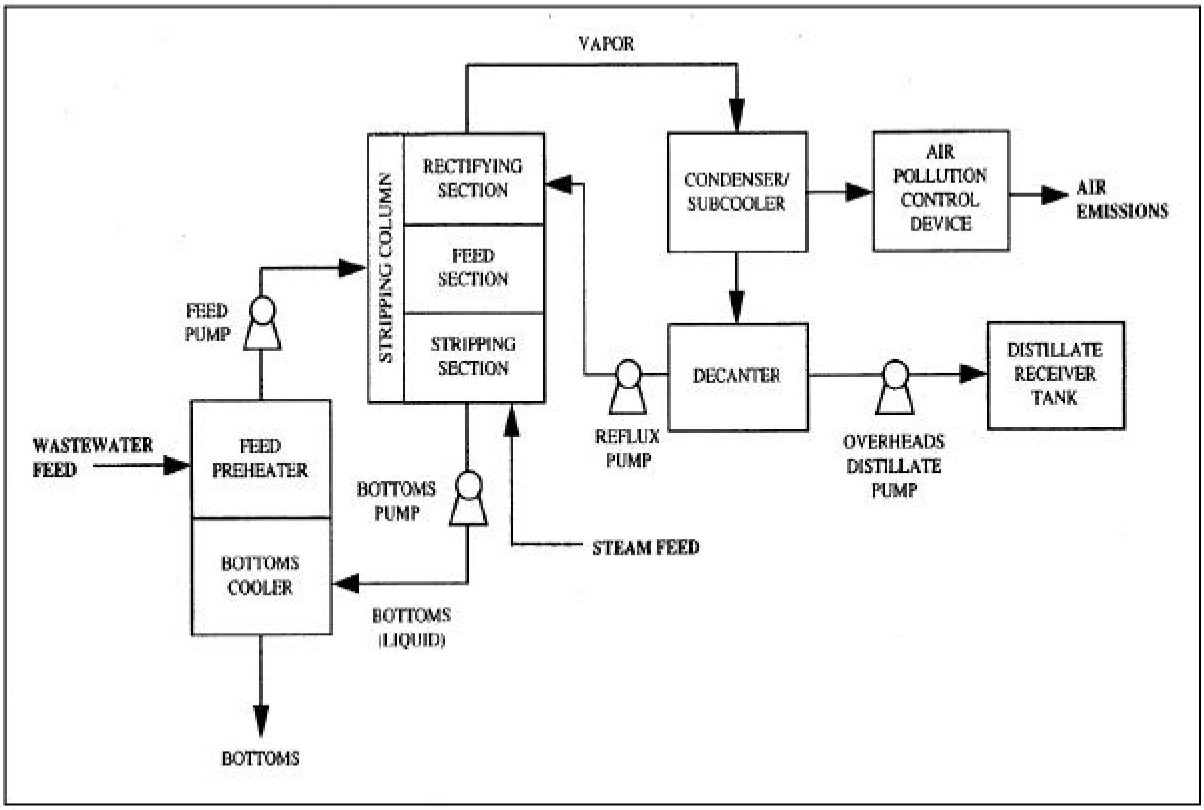

Figure 9. Steam Stripping and Rectification Column Diagram

Granular Activated Carbon Adsorption
General Description

Granular activated carbon (GAC) adsorption is used in the pharmaceutical manufacturing industry to treat BOD, COD, or organic constituents in wastewater. Adsorption is a process in which soluble or suspended materials in water are bonded onto the surface of a solid medium. Activated carbon is an excellent medium for this process because of its high internal surface area, high attraction to most adsorbates (the constituents to be treated), and the fact that it is hydrophobic (water will not occupy bonding sites and interfere with the adsorption process). Constituents in the wastewater bond onto the GAC grains until all surface bonding sites are occupied. At this point, the carbon is considered to be "spent", and requires regeneration, cleaning, or disposal.

Activated carbon is normally produced in two standard grain sizes: powdered activated carbon (PAC) with diameters less than a 200 mesh, and GAC with diameters greater than 0.1 mm. PAC is generally added to the wastewater, whereas GAC is normally used in flow-through fixed bed units.

For treatment units, GAC is packed into one or more beds or columns. Multiple beds are more common, and are normally operated in series because this design allows for monitoring between beds, and therefore minimizes the risk of discharging wastewater from the system with concentrations above acceptable levels. Wastewater flows through a bed and is allowed to come in contact with all portions of the GAC. The GAC in the upper layers of the bed is spent first as bonding sites are occupied, and the GAC in progressively lower regions is spent over time as the adsorption zone moves down through the unit. When contaminant concentrations begin to increase at the bottom of the bed above acceptable levels, the bed is considered to be spent and must be removed. The above description assumes that beds are operated in downflow mode; however, it is also possible to use an upflow design for GAC systems.

Once a bed is spent, the carbon can be treated in three ways: regeneration, backwash, or disposal. Normally, it is possible to use high heat (1,500 to 1,700°F), steam, or chemical treatment to regenerate the spent carbon. These processes remove contaminants from the carbon without significantly affecting the carbon itself; however, some carbon is lost each time this procedure is performed, and carbon performance decreases slightly with each regeneration. Because the bonds formed between the GAC and the adsorbate are not generally strong, it may also be possible to backwash the carbon bed. If the carbon cannot be regenerated or backwashed, it must be disposed of as a solid waste.

The performance of GAC treatment units can be affected by several factors. Three important design criteria are saturation loading, wastewater TSS concentration, and hydraulic loading.
Saturation loading is a treatment performance coefficient relating mass of contaminant adsorbed versus mass of carbon used. If this coefficient is very low (as is the case for highly soluble constituents), a GAC system will not perform efficiently. Parameters that effect solubility (i.e., pH and temperature) must also be considered when calculating a design saturation loading for a system. High TSS concentrations in wastewater will foul the GAC system. Solids will occupy bonding sites on the carbon and will get plugged in the pore spaces between GAC grains. If this happens, head loss may occur and a portion of the carbon bed will not be used for treatment.

Flushing to remove solids can upset the mass flux zone in the GAC system. In some cases, it may be necessary to install some type of filtration prior to GAC treatment to keep TSS concentrations within acceptable limits. The effectiveness of GAC can only improve with lower TSS, and ideally, TSS levels in the influent should be as close to zero as possible. The amount of time the wastewater spends in contact with the GAC is directly related to hydraulic loading rate. If this time is not long enough, effluent contaminant concentrations will be higher than expected.

pH Adjustment/Neutralization

General Description

Because many treatment technologies used in the pharmaceutical manufacturing industry are sensitive to pH fluctuations, pH adjustment, or neutralization, may be required as part of an effective treatment system. A pH adjustment system normally consists of a small tank (10 to 30 minutes retention time) with mixing and a chemical addition system. To adjust pH to a desired value, either acids or caustics can be added in the mixing tank. Some treatment technologies require a high or low pH to effectively perform treatment (e.g., air stripping of ammonia requires a pH of 10 to 11). pH is generally adjusted to between 6 and 9 prior to final discharge.

Equalization

General Description

Because many of the treatment technologies listed in this are performed continuously and some are sensitive to spikes of high flow or high contaminant concentrations, it is necessary to include equalization as a part of most treatment systems. Equalization is normally performed in large tanks or basins designed to hold a certain percentage of a facility's daily wastewater flow.

Equalization will equalize high- and low-flow portions of a typical production day by allowing wastewater to be discharged to downstream treatment operations at a constant flow rate.
Equalization can also provide a continuous wastewater feed to operations such as biological treatment that perform more effectively under continuous load conditions.
The mixing that occurs in an equalization basin minimizes spikes of various contaminants in the discharged wastewater. This equalization will prevent loss of treatment effectiveness or treatment system failures associated with these spikes.

Air Stripping
General Description
Air stripping is used in the pharmaceutical manufacturing industry to remove volatile organic constituents from wastewater. Air stripping can also be used to remove ammonia from wastewater. Air stripping is normally performed in a countercurrent, packed tower or tray tower column. In these systems, the wastewater is introduced at the top of the column and allowed to flow downward through the packing material or trays. Air is simultaneously delivered at the bottom of the column and blows upward through the water stream. Volatile organics are stripped from the water stream, transferred to the air stream, and carried out of the system at the top of the column. Treated water discharges from the bottom of the column. If ammonia treatment is desired, the pH of the waste stream would be adjusted to between 10 and 11 prior to introduction to the column.

Incineration
General Description
Incineration is used in the pharmaceutical manufacturing industry to treat organic and inorganic constituents in wastewater. This treatment is typically performed in a fixed bed or multiple hearth incinerator equipped with an acid gas scrubber for control of generated hydrochloric acid.

Contaminants in the wastewater are destroyed by combustion and the remaining water vapor is discharged to the atmosphere.

Annex 15

Environmental management options hierarchy

I. Source Reduction
- A. Product Changes
  - · Design for Less Environmental Impact
  - · Increase Product Life
- B. Process Changes
  1. Input Material Changes
     - · Material Purification
     - · Substitution of Less Toxic Materials
  2. Technology Changes
     - · Layout Changes
     - · Increased Automation
     - · Improved Operating Conditions
     - · Improved Equipment
     - · New Technology
  3. Improved Operating Practices
     - · Operating and Maintenance Procedures
     - · Management Practices
     - · Stream Segregation
     - · Material Handling Improvements
     - · Production Scheduling
     - · Inventory Control
     - · Training
     - · Waste Segregation

II. Recycling
- A. Reuse
- B. Reclamation

III. Treatment

Annex 16

Questionnaire results

<u>Summary of results</u>

In the framework of the preparation of the regional guidelines for the application of BATs and BEPs for industrial sources of BOD, nutrients and suspended solids, a questionnaire was prepared and sent to all RAC/CP National Focal Points (NFP) in MAP countries. Eleven NFP responded to the questionnaire. Namely, Turkey, Egypt, Malta, Italy, Algeria, Morocco, Tunisia, Croatia, Bosnia & Herzegovina, Israel, and Cyprus. The aim of the questionnaire was to collect hard data for use in the report. The rate of response reached 55%.

The analysis of the results highlighted the following aspects:

1. Standards for emissions of BOD, COD, TSS and nutrients

All responding countries apply standards for BOD, TSS and nutrient emissions to surface water. The standard is formalized in environmental regulation, except for Morocco where the draft standard is still in the form of draft regulation.

2. Total and sectorial quantity of waste water and pollutants generated by industrial sectors that are sources of BOD, TSS and nutrients:

The response to this question is in general incomplete and provides evidence on the lack of data available or at least on the difficulty to collect it.
General data was more readily available rather than sectorial.

3. Best available techniques and best environmental practices applied in MAP countries

27% of responding countries apply BATs
63% of countries apply CP
81% of countries apply good housekeeping

4. Technological institutions in MAP countries for support of BATs and BEPs

45% of countries have industry-specific technical centres
63% of countries have public environmental technology centres
45% of countries have private environmental technology centres

5. Economical indicators of the industrial sectors sources of BOD, TSS and nutrients

The data collected provides the importance of the industrial sectors in terms of production, jobs and added value.

Analysis of the questionnaires received

1. Standards for emissions of BOD, COD, TSS and nutrients

Parameter	Emission limit for discharge into surface water in milligrams per litre (mg/L)										
	Turkey [27]	Egypt [28]	Italy	B&H	Algeria	Croatia	Morocco [29]	Israel	Malta	Cyprus	Tunisia
BOD_5	50	60	40	20 [30]	40	40 [31]	100	1,200	300 - 350	10	30
COD	180	100	160	40	120	200	500	2,000	600	30	90
TSS	60	60	80	100	30	50	50	1,000	500	10	30
Total Nitrogen	20	40	NH_4:15 NO_2:20 NO_3:20	[32]	40	25	30	-	100	10	30
Total Phosphorus	2	5	10		-	4	10	-	-	2	0.1

[27] These standards change according to the type of wastewater and industrial sectors; given values are the mean standards.
[28] Emissions to the sea.
[29] Standards are not adopted yet (draft regulation only).
[30] Data concerning BOD_5, COD and TSS refer to the IV class.
[31] IV class.
[32] Limits available for particular nitrogen compounds; for the III and IV class: nitrites (0.5), ammoniac (0.5), nitrates (15).

2. Total and sectorial quantity of wastewater and pollutants generated by industrial sectors that are sources of BOD, TSS and nutrients

	TOTAL						
	Turkey	Egypt	B&H	Algeria	Croatia	Morocco[33]	Israel[34]
Industrial waste water generated	1,033,400,000 m^3/year	1 billion m^3/year	750,422,480 m^3/year	220,000,000 m^3/year	52,042,128 m^3/year	66,956,719 m^3/year	129,200,000 m^3/year[35]
BOD_5	265,000 t/year		100,347,260 m^3/year	55,000 t/year		124,331.17 t/year	
TSS	917,315 t/year		246,206,735 m^3/year	134,000 t/year		55,808.52 t/year	
NN (nitrogen and phosphorus)	3,200 t/year		1,184,425 m^3/year	8,000 t (N) /year			
Treated industrial waste water	209,400,000 m^3/year			20,000,000 m^3/year	17,928,331 m^3/year		

	TOTAL	
	Cyprus[36]	Tunisia
Industrial waste water generated	1,630 m^3/day	35.5 Mm^3/year
BOD_5	2,020 mg/L day	35,000 t/y
TSS	4150 mg/L day	55,000 t/y
NN (nitrogen and phosphorus)		30,000 t/y
Treated industrial waste water	500 m^3/day[37]	26,82 Mm^3/year

33 Data available by industrial sector (source: FODEP). The figures included in the table concerning industrial waste water, BOD and TSS refer to the food, textile, pulp and paper, tanning and pharmaceuticals sectors.
34 Quantity by sector is available.
35 Data including the following sectors: food, metal, electricity, high-tech, oil, textiles, pulp and paper, chemical and pharmaceuticals.
36 Sectorial data for food and textile provided. The figures included in the table refer to the food, textile and tanning sectors.
37 Data for the food sector.

3. Best available techniques and best environmental practices applied in MAP countries:

Environmental practices	Turkey		Egypt		Italy		Bosnia and Herzegovina	
	yes	% firms	yes	% firms	yes	% firms	yes	% firms
ISO 14000	X		X	5-10	X			
EMAS					X			
Cleaner production	X		X	25				
Best Available Techniques					X			
Good housekeeping			X	65			X	<5%
Recycling	X		X	40			X	<5%
Source reduction measures			X	30				
Process integrated measures								

Environmental practices	Algeria		Croatia		Morocco		Israel	
	yes	% firms	yes	n. firms	yes	% firms	yes	% firms
ISO 14000			X	25	X		X	10%
EMAS								
Cleaner production	X	5%	X	40	X		X	
Best Available Techniques					X		X	
Good housekeeping	X	10%	X				X	
Recycling	X	15%	X		X		X	
Source reduction measures	X	5%	X		X		X	
Process integrated measures	X	5%	X	Only few	X		X	

Environmental practices	Malta		Cyprus		Tunisia	
	yes	% firms	yes	% firms	yes	% firms
ISO 14000	X	10%	X	1	X	12
EMAS	X	1%				
Cleaner production	X	1%	X	10	X	30
Best Available Techniques	X	20%	X	25		
Good housekeeping	X	18%	X	50	X	50
Recycling	X	40%	X	30	X	35
Source reduction measures	X	20%	X	50	X	30
Process integrated measures			X	40	X	15

4. Technological institutions in MAP countries for support of BATs and BEPs

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

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

5. Economical indicators of the industrial sectors sources ob BOD, TSS and nutrients

Industrial sector	Turkey			Egypt			Italy		
	T.prod/y	employment	Value in Eur	T.prod/y	employment	Value in mil Eur	T.prod/y	employment	Value in mil Eur
The food industry(*)					4.3 million[38]	3,443		446,514	
Textiles (wet processing)						1,638		691,725	
Tanning and leather finishing industry	2,500,000	300,000				3,530		230,543	
Pulp and paper industry	1,822,086	7,383	32,977,53 9			3,436	8,810,355	260,436	
Pharmaceutical industry									
Phosphatic fertilizers industry	942,222	5,791	24,543					227,807	

38 Total in all industrial sectors.

Industrial sector	B&H			Algeria			Croatia		
	T.prod/y	employment	Value in mil Eur	T.prod/y	employment	Value in mil Eur	T.prod/y	employment	Value in mil Eur
The food industry(*)	33,571			79,284,000 t/y	39,429	2,106	22,000,000		
Textiles (wet processing)	144	76,000		35,401,000 ML	20,583	123		37,600	533
Tanning and leather finishing industry	755	28,000		18,037 feet^2	4,490	32.5		10,000	130
Pulp and paper industry	19,367			23,536,000 t/y	3,783	70.7		5,700	270
Pharmaceutical industry				110,000,000 UV	3,412	5.5		8,000	600
Phosphatic fertilizers industry				212,000 t/y	2,731	130.4		2,800	264

Industrial sector	Morocco			Israel			Malta		
	T.prod/y	employment	Value in mil Eur	T.prod/y	employment	Value in thousand Eur[39]	T.prod/y	employment	Value in mil Eur
The food industry(*)					57,000	141		4,400	30,000,000
Textiles (wet processing)	71,103	3,706	74,688,000		38,000	71			
Tanning and leather finishing industry	44,936	1,754	47,197,000		100,000	557		845	40,000,000
Pulp and paper industry	198,727	2,261	208,770,000		9,000	130		365	20,000,000
Pharmaceutical industry	244,253	4,135	256,620,000		24,000	257		806	72,000,000
Phosphatic fertilizers industry	88,778	557	93,257,000						

For Cyprus, data data are only available qualitatively: the most important sector contributing to productivity is food. Regarding the number of industrial installations, there is one for the textiles, one for tanning and leather finishing, and three for the pharmaceuticals

[39] As a turnover per employee of the particular sector.

ACKNOWLEDGEMENTS

The development of the regional guidelines for the application of BATs & BEPs for industrial sectors sources of BOD, nutrients and suspended solids in the Mediterranean Action Plan countries is the result of cooperation among a number of organizations and individual experts that have been solicited by the team engaged by the Regional Activity Centre for Cleaner Production to lead this assignment. The following are acknowledged for their contributions as supervisors, reviewers, and providing useful input:

Ms Mar Santacana, technical advisor at RAC/CP
RAC/CP National Focal Points from Italy, Malta, Egypt, Morocco, Turkey, Algeria, Tunisia, Israel, Croatia, Bosnia & Herzegovina and Cyprus.
Mr Anis Gaida Mahjoub from the Agribusiness Technical Center in Tunisia
Mr Boujemaa Harbaoui from the Textile Technical Center in Tunisia

While their help was highly valuable in shaping these guidelines, neither these individuals nor the organizations they represent should bear any responsibility for the final product.

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