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STRATEGIC ACTION PROGRAMME

REGIONAL PLAN

REDUCTION OF INPUT BOD BY 50 PERCENT BY THE YEAR 2005 FROM INDUSTRIAL SOURCES FOR THE MEDITERRANEAN REGION

In cooperation with

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1. SUMMARY

The main objective of this study is to formulate a regional plan for the reduction of 50 percent of BOD generated by the Mediterranean coastal industrial activities by the year 2005. This plan is intended for use by national bodies as a basis for the elaboration of sectorial national action plans to reduce the releases of BOD into the Mediterranean marine environment.

To achieve the study's objective, an inventory for the industrial activities at over 100 hot spots on the Mediterranean shoreline generating industrial BOD was developed. This inventory is based on the existing information in MAP and other national and regional industrial databases.

The findings of this report can be summarized as follows:

1. The predominant industries contributing to the direct and indirect discharge of BOD in the Mediterranean countries are food and food processing industries (about 15 percent of all industries), followed by textile, leather, fertilizers, chemicals, and pulp and paper (each between 7 and 8 percent of all industries).
2. The current industrial BOD discharges into the Mediterranean are estimated at about 410,000 tons per year. This figure is based on available data provided in reports related to the identification of hot spots, and on specific assumptions made industries present in each hot spot. Egypt contributes about 52 percent of this figure, followed by Algeria at 28 percent.
3. The proposed regional plan for reduction of industrial BOD discharges into the Mediterranean is based on the implementation of end-of-pipe treatment methods and in-plant controls. In this plan, all Mediterranean countries would contribute *equally* for the combined reduction of industrial BOD by 50 percent from the current level.
4. In order to assist the various countries in establishing detailed BOD reduction plans for each active industrial sector, estimates of BOD loads for each industrial sector in every Mediterranean country are presented in Section 7.
5. End-of-pipe methods for BOD reduction include physical and biological methods. Physical methods consist of screening and settling tanks. Biological methods include stabilization ponds, mechanically aerated lagoons, activated sludge, and trickling filters. Stabilization ponds are recommended for the developing countries on the eastern and southern shores of the Mediterranean. Activated sludge is suitable for developed countries on the northern shore.
6. In-plant controls include process changes, segregation of wastes at source, change in raw materials, equalization tanks, and good housekeeping. Industry-specific details are provided in Section 8 of this report.
7. From an economical point of view, physical treatment methods are considered to be significantly cheaper than biological treatment methods. In contrast, the specific cost factor of biological methods increases threefold and in the following order: naturally aerated lagoons or stabilization ponds, mechanically aerated lagoons, activated sludge, and trickling filters.

2. INTRODUCTION

2.1 Background

With the increased awareness of the economic, social, health and cultural value of the marine environment of the Mediterranean Sea area, and of the responsibility to preserve and develop in a sustainable manner this common heritage for the benefit and enjoyment of present and future generations, the riparian States of the Mediterranean Sea agreed in 1975 to launch an *Action Plan for the Protection and Development of the Mediterranean Basin,* which was referred to as "MAP". This was culminated in 1976, by the signing of the *Convention for the Protection of the Mediterranean Sea against Pollution*, also known as the Barcelona Convention.

In 1995, the Contracting Parties adopted in Barcelona Phase II of the MAP for the protection of the marine environment and sustainable development of the coastal areas of the Mediterranean. In 1996, a revised Protocol for the *Protection of the Mediterranean Sea against Pollution from Land-Based Sources and Activities;* also referred to as the "LBS Protocol" was signed in Syracuse. This revised Protocol took into account the *Global Programme of Action* for the protection of the marine environment against pollution from land-based activities adopted in Washington in 1995.

In accordance with the 1996 LBS Protocol, the Contracting Parties to the Barcelona convention agreed (in Article 1) to take all appropriate measures to prevent, abate, combat and eliminate, to the fullest possible extent, pollution of the Mediterranean Sea Area caused by discharges from rivers, coastal establishments or outfalls, or emanating from any other land-based sources and activities within their territories, giving priority to the phasing out of inputs of substance that are toxic, persistent and liable to bioaccumulate.

To this end, the contracting parties agreed (in Article 5) to elaborate and implement national and regional action plans and programs, containing measures and timetables for their implementation. Accordingly, the *Strategic Action Programme,* referred to as "SAP" was formulated. The SAP is based on the preliminary findings of regionally prepared transboundary diagnostic analysis, which represent a regional synthesis of actions regarding the protection of the marine environment from land-based activities. The SAP was prepared by the Secretariat to the Mediterranean Action Plan, and was later considered and approved by the relevant technical bodies of the Contracting Parties.

As recommended in the SAP, an analysis of targets and activities is needed to resolve each transboundary priority problem. These targets and activities would be national or regional, and would be of legal, institutional or technical nature. Several categories of substances were selected as priorities covering both the urban environment and industrial development. The *Biological Oxygen Demand* (BOD) was identified as a problem substance. BOD represents the pollution load resulting from biodegradable organic matter, nutrients and suspended solids that are produced by the liquid-phase waste of many industries.

2.2 Objective and Scope

The main objective of this study is to develop a regional plan for the reduction of 50 percent of BOD generated by the Mediterranean coastal industrial activities by the year 2005. This plan is intended for use by national bodies as a basis for the elaboration of sectorial national action plans to reduce the releases of BOD into the Mediterranean marine environment.

Due to the lack of a comprehensive database that provides information on BOD loads from industrial activities around the Mediterranean coastline, it was decided to make use of the available database assembled by national authorities on priority pollution hot spots and sensitive areas in the Mediterranean. Accordingly, this study focuses on BOD pollution discharges from *industrial hot spots* as identified in the MAP Technical Series Report No. 124[1]. In this report, a hot spot consists of:

- **Point sources** on the coast of the Mediterranean Sea which potentially affect human health, ecosystems, biodiversity, sustainability or economy in a significant manner. They are the main points where high levels of pollution loads originating from domestic or industrial sources are being discharges

- Defined **coastal areas** where the coastal marine environment is subject to pollution from one or more point of diffused sources on the coast of the Mediterranean which potentially affect human health in a significant manner, ecosystems, biodiversity, sustainability or economy.

The objective of this study is accomplished by preparing an inventory for the industrial activities at over 100 hot spots on the Mediterranean shoreline generating industrial BOD. This inventory is based on the existing information in MAP and other national and regional industrial databases. Direct and indirect releases are considered.

The scope of this report can be summarized as follows:

1. Overview of the SAP obligations and the operational strategy;
2. Overview of the regional industrial sectors producing high BOD in the Mediterranean hot spots;
3. Rough estimation of the BOD released into the Mediterranean and the coastal watershed (rivers);
4. Technical options for reduction of BOD in industrial plants;
5. Proposed regional plan for BOD reduction; and
6. Recommended treatment methods and estimated costs

3. OVERVIEW OF THE STRATEGIC ACTION PROGRAMME

3.1 General

The SAP calls for the Mediterranean States to cooperate in a spirit of global partnership to conserve, protect, and restore the health and integrity of the Earth's ecosystem. The Strategic Action Programme[2] (SAP) aims at improving the quality of the marine environment by better-shared management of the land-based pollution. SAP also aims at facilitating the implementation of the Land-Based (LBS) Protocol by the contracting Parties. Therefore, it is designed to assist the Contracting Parties to the Barcelona Convention in taking actions individually or jointly within their respective policies, priorities and resources, which will lead

[1] "Identification of priority pollution hot spots and sensitive areas in the Mediterranean". MAP Technical Reports Series No. 124, Mediterranean Action Plan, MED POL, UNEP, Athens, 1999
[2] "Strategic Action Programme to address pollution from land-based activities". MAP Technical Reports Series No. 119, Mediterranean Action Plan, MED POL, UNEP, Athens, 1998

to the prevention, reduction, control and/or elimination of the degradation of the marine environment, as well as to its recovery from the impacts of land-based activities.

The Strategic Action Programme is consistent with the Global Programme of Action (Washington, 1995) and with the relevant provisions of the convention of the Law of the Sea, of the Convention on Biological Diversity, of the Convention on Climatic Change and with the legal instruments and actions plans and measures adopted by the Contracting Parties to the Barcelona Convention.

3.2 SAP Obligations

The SAP requires that the Contracting Parties protect the environment and contribute to the sustainable development of the Mediterranean Sea area by:

a) Applying the precautionary principle

b) Applying the polluter pays principle

c) Undertaking environmental impact assessments for proposed activities which are likely to have an adverse impact on the environment

d) According priority to integrated pollution control

e) Committing themselves to promote the integrated management of the coastal zones

f) Implementing the convention and the LBS Protocol, whereby they shall:

- Elaborate and implement, individually or jointly, national and regional action plans and programmes.
- Adopt priorities and timetables.
- Consider the Best Available Techniques (BAT) and the Best Environmental Practices (BEP), including clean production technologies.
- Take preventive measures to reduce the risk of accidental pollution.

g) Ensuring that the public is given appropriate access to information on the environmental state and on activities or measures adversely affecting or likely to affect the environment.

h) Ensuring routine and standardized reporting of toxic emissions to air, water and land by polluting facilities.

Based on the foregoing, MAP selected the categories of “urban environment” and “industrial development” as priorities areas. A number of subcategories have been identified for each of the above noted categories. For urban environment, the following subcategories were selected:

a) Municipal sewage

b) Urban solid waste

c) Air pollution

For industrial development, the subcategories consist of:

a) Substances that are toxic, persistent and liable to bioaccumulation

b) Heavy metals

c) Organohalogen compounds

d) Radioactive substances

e) Nutrients and suspended solids

f) Hazardous wastes

Subcategory (e), which deals with nutrients and suspended solids, addresses the priority for formulating a regional action plan for the reduction of input BOD. The plan needs to specify the means by which a 50 percent reduction in industrial BOD can be achieved by the year 2005.

3.3 SAP Operational Strategy

Chapter 5.2 of the SAP calls for collective commitments or “budget commitments” for reducing pollutants released into the Mediterranean. In order to reduce BOD discharges to targeted levels, MAP adopted a regional strategy whereby the Mediterranean countries are expected to reduce by 50 percent their aggregate releases of BOD by the year 2005. This approach implies a “differentiated” commitment between the Mediterranean countries whereby each party is responsible for achieving its level of release. This approach also implies the need for identifying the regional budget baseline and for specifying national baseline budgets for BOD reduction, which are the objectives of this report.

This SAP operational strategy[3] implies that each Contracting Party would make use of the specified national budget baseline as a basis for the elaboration of a sectorial national action plan to reduce the releases of BOD into the Mediterranean marine environment. The “national baseline budget” would be the sum of the individual releases, for which any Party may transfer internally release reduction targets between different activities generating BOD, according to the socio-economic and environmental priorities prevailing in the country.

The SAP operational strategy is hence to provide guidance to the contracting parties for specifying their “national baseline budgets” for BOD reduction. The contracting parties would provide the MAP Secretariat by the year 2003 of their formally adopted “national baseline budget” for BOD reduction considering the year 2003 as the base year such as to be able to monitor BOD changes in subsequent years. The secretariat would regularly review with the contracting Parties, and as appropriate revise, the technical guidelines considering the scientific technical developments related to the issue and the progress in regional and international conventions negotiations that could have impacts on the SAP, and in particular on the discharge of BOD to marine environments. Furthermore, it should be noted that the SAP operational strategy for the adoption of the budget approach does implicitly include a monitoring process to verify the case of compliance and non-compliance in meeting the baseline budget for BOD reduction by each country.

4. OVERVIEW OF THE REGIONAL INDUSTRIAL SECTORS

4.1 General

In this section, the major industrial sectors characterized by their significant BOD loads in their wastewater streams are described. This is followed by classifying the industrial base located on the shores of the Mediterranean, for each country, in terms of sectors and size of enterprises.

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[3] “Operational document for the implementation of the strategic action programme to address pollution of the Mediterranean Sea from land-based activities (SAP)”. Meeting of the MED POL National Coordinators, Venice, Italy, 28-31 May 2001, Mediterranean Action Plan, MED POL, UNEP

4.2 Industrial Sectors with Significant Discharges of BOD

Many industries produce liquid waste with similar characteristics to domestic wastewater. The main pollutants are:

a) Biodegradable Organic Matter
b) Nutrients (Nitrogen and Phosphorus)
c) Suspended Solids

The pollution load of these nutrients may be reported to population-equivalent and measured as Biological Oxygen Demand (BOD) load.

The most important sources of BOD in the industrial wastewater stream are:

a) Manufacture of food and beverages; slaughtering, preparation and preservation of meat; manufacture of dairy products; canning and preservation of fruit and vegetables; canning, preservation and processing of fish, crustaceans and similar foods; manufacture of vegetable oils and fats; sugar factories and refineries; distillation; wine production; beer manufacture; etc.
b) Manufacture of textiles; wool processing and cotton processing
c) Tanneries and the leather finishing industry
d) Paper and paper-pulp industry
e) Phosphatic fertilizers industry
f) Pharmaceutical industry; basic substances (fermentation and extraction processes)
g) The chemical industry, in case of specific types of chemical products, which contain BOD in their effluent wastewater (detergents, etc.).

According to a study published by the regional center for cleaner production[4], the industrial base in the Mediterranean countries, in terms of sector and size, is divided between the various industrial sectors as shown in Figure 4.1. As can be seen, industrial sectors contributing to the discharge of BOD to the Mediterranean coastline include textile, leather, fertilizers, food processing, food industries, chemicals, pharmaceuticals (other: 1%), and paper. Those combined industries amount to over 50 percent of the total industrial base of the Mediterranean countries.

[4] "State of Cleaner Production in the Mediterranean Action Plan Countries." *Regional Activity Centre for Cleaner Production (RPC/CP),* Mediterranean Action Plan. June 2001.

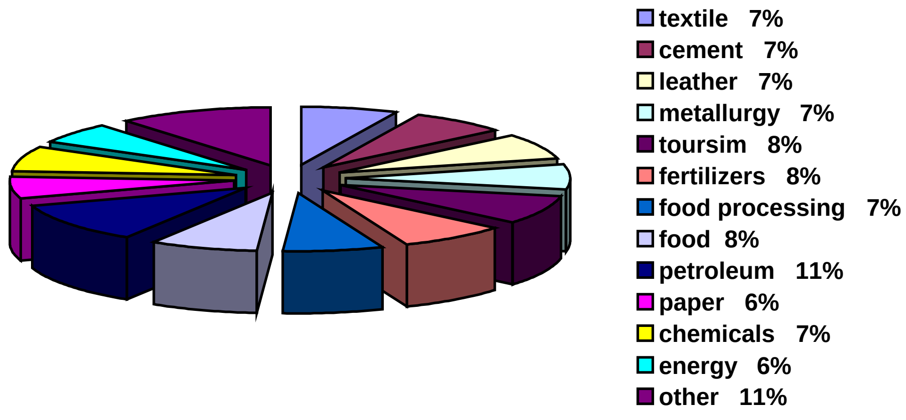

Figure 4.1: The industrial structure in terms of sectors and size of enterprises on the Mediterranean Sea[4]

4.3 Industrial Sectors in the Mediterranean Countries

In this section, an attempt is made to determine the type of industrial sectors contributing to the discharge of BOD in the various Mediterranean countries. Data provided in MAP Report No. 124[1] and in the subsequent updated hot spot reports, and relevant data provided in the report on the State of Cleaner Production[4] are utilized for that purpose. Summary of these findings are tabulated in Table 4.1, which classifies industries in terms of those contributing to the discharge of BOD (listed by type), and other industries that do not contribute to the generation of BOD. This table is intended for use at a later stage for developing the regional action plan for reduction of BOD from the various countries.

As can be seen, the predominant BOD generating industry in the Mediterranean basin is food and food processing, followed by textile, leather, fertilizers, chemicals, and pulp and paper. If it is assumed that the number of food and food processing industries can be split equally, then we may conclude that the distribution of the various industrial sectors, as determined from the hot spot reports, is approximately similar to that shown on Figure 4.1 obtained from the report of the State of Cleaner Production in the Mediterranean countries.

Table 4.1: Available Industrial Sectors contributing to the Discharge of BOD in the Mediterranean Countries [4]

Country Name	***Industrial Sector***							
	textile	**leather**	**fertilizers**	**food industry and food processing**	**Chemicals**	**pharmaceutical**	**pulp and paper**	**Other industries (No BOD discharge)**
Albania							●	●
Algeria		●		●			●	●
Bosnia & Herzegovina	●			●				●
Croatia	●			●	●		●	●
Cyprus				●				●
Egypt	●	●	●	●	●		●	●
France				●				●
Greece			●	●				●
Israel	●		●	●	●			●
Italy		●	●		●		●	●
Lebanon		●		●		●		●
Libya	●	●	●		●			●
Malta				●				●
Morocco	●	●		●	●		●	●
Slovenia			●	●	●			●
Syria	●			●				●
Tunisia	●	●		●	●			●
Turkey	●	●	●	●			●	●
Total Number of Industrial Sectors	**9**	**8**	**7**	**15**	**8**	**1**	**7**	**18**

5. ESTIMATION OF BOD RELEASED INTO THE MEDITERRANEAN

5.1 General

As noted previously, estimates of industrial BOD discharges to the Mediterranean Sea were based on data provided in the MAP Technical Report Series No. 124[1] and on the data included in the subsequent updated Hot Spot reports[5]. This approach was adopted due to lack of detailed data on the individual industries and their current BOD discharge loads into the Mediterranean Sea. The database provided in the hot spot reports on BOD discharges was found to be the most comprehensive, based on a *relatively* sound scientific basis, due to the fact that it includes all BOD discharges in the hot spot areas, although actual BOD measurements were not always available. Hence, it is was assumed that industrial BOD discharges outside the hot spots areas do not contribute significantly to the current industrial BOD load into the Mediterranean. Information obtained from the hot spot reports was also supplemented by additional data acquired from MAP Technical Report Series No. 128[6] on municipal wastewater treatment plants in Mediterranean coastal cities. This report was crucial for determining municipal BOD loads needed to estimate industrial BOD discharges when total BOD loads were quoted. The database on the industrial sectors in the various Mediterranean countries provided in the report on the State of Cleaner Production[4] was also utilized. Details of the assumptions made in estimating BOD discharges from the hot spot areas are provided in the following section.

5.2 Basis for BOD Estimation for the Mediterranean Countries

Estimates of industrial BOD discharges from the various hot spots are grouped in individual tables, for each country, and included in Annex ‘A’. Based on assumptions made, and on computed BOD loads for each hot spot, the current combined industrial BOD load discharged into the Mediterranean basin was estimated at about 410,000 tons per year. Industrial BOD discharges from each country are tabulated in Table 5.1. Assumptions made for estimating BOD loads for each country are explained below.

Albania: The updated hot spot report on Albania indicates that industrial sectors do not discharge significant BOD loads to the Mediterranean. Hence, BOD discharged by industrial sources was assumed to be equivalent to 10 percent of the municipal BOD discharged by the local population of 254,000 inhabitants living close to the Mediterranean coast, assuming each inhabitant discharges 60 grams per day. Accordingly, the BOD discharged from industrial sources in Albania was estimated at 540 tons/year.

Table 5.1: Estimates of industrial BOD discharges from the Mediterranean countries

Country	BOD Discharge (tons/year)
Albania	540
Algeria	113,590
Bosnia & Herzegovina	4710

[5] Updated hot spot reports to MAP 124 for Albania, Algeria, Bosnia & Herzegovina, Croatia, Egypt, Lebanon, Libya, Morocco, Slovenia, Syria, Tunisia and Turkey, December 2001
[6] “Municipal wastewater treatment plants in Mediterranean coastal cities”. MAP Technical Reports Series No. 128, Mediterranean Action Plan, MED POL, UNEP, Athens, 2000

Country	BOD Discharge (tons/year)
Croatia	4100
Cyprus	190
Egypt	213,160
France	390
Greece	8960
Israel	5150
Italy	27,140
Lebanon	4090
Libya	2160
Malta	8430
Morocco	5180
Slovenia	450
Spain	0
Syria	580
Tunisia	7250
Turkey	3200
TOTAL	**409,270**

Algeria: The updated hot spot report on Algeria estimates the BOD load based on a value of 60 grams per inhabitant per day. MAP Report No. 128[6] offers data on the population served by the existing municipal wastewater treatment plants (and their treatment level) and those by network only. Accordingly, it was possible to estimate the municipal BOD load discharged into the Mediterranean (the reduction of BOD loads for each type of treatment is included in the tables listed in Annex ‘A’). To estimate the industrial BOD, a ratio of municipal to industrial BOD of 0.7 was used. This ratio was obtained from actual BOD loads measured in the neighboring country of Tunisia. The BOD discharged from industrial sources in Algeria was estimated at 113,590 tons/year. This value is about 28 percent of the total industrial BOD discharged to the Mediterranean.

Bosnia & Herzegovina: The updated hot spot report on Bosnia & Herzegovina provides data on the population equivalent produced by the various industries located in the hot spots. These include textile, and food processing. Based on a BOD load of 60 grams per inhabitant per day, it was possible to estimate the industrial BOD load discharged into the Mediterranean. Hence, the BOD discharged from industrial sources in Bosnia & Herzegovina was estimated at 4710 tons/year.

Croatia: The updated hot spot report on Croatia reports the BOD loads in each hot spot. MAP report 128 offers data on the population served by the existing municipal wastewater treatment plants, and those served by network only. Based on a BOD load of 60 grams per inhabitant per day, it was possible to estimate the municipal BOD load discharged into the Mediterranean. The industrial BOD is subsequently computed by subtracting the municipal

BOD from the reported BOD. However, for a number of hot spots (of municipal and industrial nature), it turned out that estimated municipal BOD was higher than the reported BOD, which puts the reported value at some doubt. Hence, BOD discharged by industrial sources was computed on the basis that the industrial BOD is equivalent to 10 percent of the municipal BOD discharged by the local population. For industrial hot spots, reported BOD was assumed to be equal to the industrial BOD. The BOD discharged from industrial sources in Croatia was estimated at 4100 tons/year.

Cyprus: MAP 124 report on Cyprus reports BOD loads in only one hot spot; Limassol. MAP report 128 offers data on the population served by the existing municipal wastewater treatment plants and those served by network only. Based on a BOD load of 60 grams per inhabitant per day, it was possible to estimate the municipal BOD load discharged into the Mediterranean. The industrial BOD is subsequently computed by subtracting the municipal BOD from the reported BOD. The BOD discharged from industrial sources in Cyprus was estimated at 190 tons/year.

Egypt: The Egyptian Mediterranean coast receives the impact of the major part of the country's population, agricultural and industrial activities. The enormous urban population and adjacent developed agricultural lands, all contribute *indirectly* to the pollution load reaching coastal waters, whether directly (such as the Alexandria region), or via coastal lagoons (such as lake Manzala which receives the major part of the Cairo mixed waste water). Two industrial hot spots are identified, Abu Qir Bay, which is an industrial hot spot (reported BOD is assumed to be the industrial BOD), and El Mex Bay, a mixed municipal and industrial hot spot where the treated domestic wastewater from the 3,000,000 inhabitants of the City of Alexandria is discharged. Based on a BOD load of 60 grams per inhabitant per day, it was possible to estimate the municipal BOD load. The industrial BOD is subsequently computed by subtracting the municipal BOD from the reported BOD. Accordingly, the BOD discharged from industrial sources in Egypt was estimated at 213,160 tons/year. This value is about 52 percent of the total industrial BOD discharged to the Mediterranean.

France: MAP 124 report indicates that only one hot spot is present in France (of industrial nature); however, no data are provided on the type of available industries. MAP report 128 offers data on the population served by the existing municipal wastewater treatment plants and those served by network only. Based on a BOD load of 60 grams per inhabitant per day, it was possible to estimate the municipal BOD load discharged into the Mediterranean. The industrial BOD is subsequently computed on the basis that it is equivalent to 10 percent of the municipal BOD discharged by the local population of 1,200,000 inhabitants living close to the Mediterranean coast. The BOD discharged from industrial sources in France was estimated at 390 tons/year.

Greece: MAP 124 report on Greece presents the BOD loads from each hot spot. MAP report 128 offers data on the population served by the existing municipal wastewater treatment plants and those served by network only. Based on a BOD load of 60 grams per inhabitant per day, it was possible to estimate the municipal BOD load discharged into the Mediterranean. The industrial BOD is subsequently computed by subtracting the municipal BOD from the reported BOD. However, for a number of hot spots (of municipal and industrial nature), it turned out that estimated municipal BOD was higher than the reported BOD, which puts the reported value at some doubt. Hence, BOD discharged by industrial sources was computed on the basis that the industrial BOD is equivalent to 10 percent of the municipal BOD discharged by the local population. For industrial hot spots, reported BOD was assumed to be equal to the industrial BOD. The BOD discharged from industrial sources in Greece was estimated at 8960 tons/year.

Israel: MAP 124 report on Israel includes measured BOD loads. MAP report 128 offers data on the population served by the existing municipal wastewater treatment plants and those served by network only. Based on a BOD load of 60 grams per inhabitant per day, it was possible to estimate the municipal BOD load discharged into the Mediterranean. The industrial BOD is subsequently computed by subtracting the municipal BOD from the reported BOD. The BOD discharged from industrial sources in Israel was estimated at 5150 tons/year.

Italy: MAP 124 report on Italy estimates the BOD load based on a value of 60 grams per inhabitant per day. MAP report 128 offers data on the population served by the existing municipal wastewater treatment plants and those served by network only. Accordingly, it was possible to estimate the municipal BOD load discharged into the Mediterranean. The industrial BOD is subsequently computed by subtracting the municipal BOD from the reported BOD. For some hot spots, the discharged industrial BOD is reduced due to existing industrial wastewater treatment. The BOD discharged from industrial sources in Italy was estimated at 27,140 tons/year.

Lebanon: The updated hot spot report on Lebanon provides data on the discharged BOD load to the Mediterranean from the various hot spots. MAP report 128 offers data on the population served by the existing municipal wastewater treatment plants (and their treatment level) and those by network only. Accordingly, it was possible to estimate the municipal BOD load discharged into the Mediterranean based on 60 grams/inhabitant per day. The industrial BOD is subsequently computed by subtracting the municipal BOD from the reported BOD. The BOD discharged from industrial sources in Lebanon was estimated at 4090 tons/year.

Libya: Only one hot spot was identified in the updated hot spot report for Libya of industrial nature; however, no data were provided on the type of available industries. MAP report 128 offers data on the population served by the existing municipal wastewater treatment plants and those served by network only. Based on a BOD load of 60 grams per inhabitant per day, it was possible to estimate the municipal BOD load discharged into the Mediterranean. To estimate the industrial BOD, a ratio of municipal to industrial BOD of 0.7 was used. This ratio was obtained from actual BOD values measured in the neighboring country of Tunisia. The BOD discharged from industrial sources in Libya was estimated at 2160 tons/year.

Malta: MAP 124 report provides data on the discharged BOD loads to the Mediterranean from the various hot spots in Malta. MAP report 128 offers data on the population served by the existing municipal wastewater treatment plants and those served by network only. Municipal BOD load discharged into the Mediterranean based on 60 grams of BOD per inhabitant per day. The industrial BOD is subsequently computed by subtracting the municipal BOD from the reported BOD. The BOD discharged from industrial sources in Malta was estimated at 8430 tons/year.

Morocco: The updated hot spot report on Morocco provides data on the discharged industrial BOD loads to the Mediterranean from the various hot spots. Accordingly, the BOD discharged from industrial sources was estimated directly at 5180 tons/year.

Slovenia: The updated hot spot report on Slovenia provides data on the discharged BOD load to the Mediterranean from the various hot spots. MAP report 128 offers data on the population served by the existing municipal wastewater treatment plants (and their treatment level) and those by network only. Municipal BOD load discharged into the Mediterranean based on 60 grams of BOD per inhabitant per day. The industrial BOD is subsequently computed by subtracting the municipal BOD from the reported BOD. The BOD discharged from industrial sources in Slovenia was estimated at 450 tons/year.

Spain: According to the hot spot tables included in the MAP 124 report, Spain does not have any industrial hot spots on the Mediterranean coast.

Syria: The updated hot spot report on Syria provides data on the discharged BOD load to the Mediterranean from the various hot spots. MAP report 128 offers data on the population served by the existing municipal wastewater treatment plants and those served by network only. Municipal BOD load discharged into the Mediterranean based on 60 grams of BOD per inhabitant per day. The industrial BOD is subsequently computed by subtracting the municipal BOD from the reported BOD. The BOD discharged from industrial sources in Syria was estimated at 580 tons/year.

Tunisia: The updated hot spot report on Tunisia provides data on the discharged BOD load to the Mediterranean from the various hot spots. MAP report 128 offers data on the population served by the existing municipal wastewater treatment plants and those served by network only. Municipal BOD load discharged into the Mediterranean based on 60 grams of BOD per inhabitant per day. The industrial BOD is subsequently computed by subtracting the municipal BOD from the reported BOD. The BOD discharged from industrial sources in Tunisia was estimated at 7250 tons/year.

Turkey: The updated hot spot report on Turkey provides no data on the discharged BOD load to the Mediterranean from the two identified hot spots. MAP report 128 offers data on the population served by the existing municipal wastewater treatment plants and those served by network only. Municipal BOD load discharged into the Mediterranean based on 60 grams of BOD per inhabitant per day. Due to the fact that one hot spot contains 17 industries, and the other has only one industry, BOD was assumed to be equivalent to 20 percent of the municipal BOD for the hot spot with 17 industries, and 5 percent for the hot spot with one industry. The BOD discharged from industrial sources in Turkey was estimated at 3200 tons/year.

6. TECHNICAL MEASURES FOR REDUCTION OF BOD IN INDUSTRIAL PLANTS

6.1 General

In this section, an attempt has been made to characterize BOD releases from direct and indirect discharges, and to describe in-plant and end-of-pipe treatment methods that may be adopted for BOD reduction and removal from industrial wastewater effluents. Recommendations are presented for each of the main industrial sectors contributing to BOD discharges.

6.2 Pollution Control

In the following sections, details of pollution control measures are described for the following industries:

1. Food processing and food industries
2. Textile industry
3. Leather and tanneries
4. Pulp and paper
5. Phosphatic fertilizers
6. Pharmaceutical manufacturing
7. Chemicals industry

Technical details of physical, chemical and biological treatment methods pertaining to BOD removal are presented in Annexes B, C, and D, respectively.

6.2.1 Food Processing Industry

In general, the food processing industry has a raw waste effluent before treatment that is extremely high in soluble organic matter. The amounts of waste and the quantity of organics and solids discharged from processing operations depend a great deal upon the type of individual processing steps and water use and reuse in each plant. There is a great variation in waste load from plant to plant depending upon the layout of the plant and the manner in which foods are handled.

***Cannery Wastes**:* The greatest source of liquid waste in food canning is normally from the fruit and vegetable washing facilities. Other sources of waste come from the peeling operations and contain large volumes of suspended matter – primarily organic in nature, and from washing equipment, utensils, cookers, etc., as well as washing of floors and general food preparation areas. BOD loads vary depending on the type of the canned product and types of undergoing operations[7]. For apple canning, BOD varies from 1600 to 5500 ppm, for apricots from 200 to 1000 ppm, for mushrooms from 70 to 800 ppm, for tomatoes from 200 to 4000 ppm. This wide variation in BOD concentrations is attributable to the volume of water used. Additional factors include fluming of waste, screening solids, trims and rejects, dewatering of waste solids in presses or cyclones, etc.

In order to reduce BOD loads in the effluent wastewater, food waste solids should be kept out of the water. The addition of waste solids to water for fluming and conveying from one point to another appreciably increases at time the concentration of soluble organics in the wastewater. Therefore, wastewater should be screened as a first step in any treatment process. Furthermore, washing water should be reclaimed and reused in a counter flow.

As noted previously, there is a wide variation in the concentration of the strength of the waste as concerns BOD. Some of this strength variation is attributable to the volume of water used. In general, the larger the volume of water used, the weaker the waste. However, there are a number of things which greatly increase the BOD concentration of the waste, such as fluming of the waste, screening solids, trims, and rejects, dewatering of waste solids in presses or cyclones without separate disposal of the liquor so created, and comminution of solids in grinders. From an economic standpoint, it is normally less costly to treat a high-strength low-volume waste rather than a large-volume diluted waste. The food processor discharging to a municipal system, faced with the additional cost of paying for treatment on a BOD basis, should consider the treatment of a low-volume high-strength waste in a relatively small system at the plant. Employee education is also recommended in order to ensure that spilled materials and other wastes are shoveled up rather than flushed down the sewer.

Poultry wastes: A great deal of poultry waste is created in the killing of chicken, which permits the bleeding of the poultry. The blood of chickens is reported to contain more than 90,000 ppm BOD. The composition of combined poultry plant wastes are characterized with a BOD in the range of 150 to 2400 ppm. This material should be kept away from the plant sewers. For that reason, it is necessary to collect the blood in containers for separate disposal. Another source of waste is manure and unconsumed feed along with water used to wash the cages and the entire storage floor area. A major reduction in pollution load can be achieved if the manure and spilled feed and feathers from the receiving area can be handled in a dry fashion. This material can be disposed of as fertilizer. The cleaning of cages before they are put on trucks and returned to the farms is another major source of pollution. Using

[7] N. H. Sanborn, "Disposal of Food Plant Wastes," *NCA Research Laboratories*, Washington, D.C.

high-pressure sprays under carefully controlled conditions can reduce the volume of wash water being utilized in this stage.

Meat packing wastes: Liquid waste generated from meat packing industry is largely organic in character with a BOD load in the range of 400 to 3000 ppm. The volume and organic content of meat wastes vary appreciably according to the type of operation and the degree of by-product recovery practice. Some plants are involved only in the slaughter and therefore fall into slaughterhouses, where animals are killed and the meat is dressed for distribution. As in the case of the poultry operation, the blood from the killing operation is excessively high, approximately 100,000 ppm BOD, and must be handled separately in order to avoid excessive pollution in the sewer. Another major problem in the slaughterhouses is the paunch manure. This should be handled in a dry fashion if at all possible, because it adds considerable BOD and suspended solids to the liquid waste from the plant. The combined plant BOD is generally in the range of 650 to 2200 ppm.

Slaughterhouse and packinghouse wastes are typically treated in municipal sewage treatment plants; however, prior to release into city sewers, pretreatment practices of screening, sedimentation and gravity flotation are normally practiced.

Dairy food wastes: In the dairy food industry, most plants consist of several operations and the types of waste vary accordingly. Among these operations, there may be receiving stations, bottling plants, creameries, ice cream plants, cheese plants, and condensed and dried milk product plants. As in the rest of the food industry, controlled product losses reduce potential waste pollution problems. The approximate quantities of BOD vary from 0.1 to 1 kg per ton of milk. Because of the method of processing and the products, which are produced, there are at times, with various operations, surpluses of separated milk, buttermilk, as well as occasional batches of sour milk. Unfortunately, there is no simple, economical method to reclaim and utilize these materials as by-products, and therefore the disposal of this material becomes a very serious problem. In discriminate dumping of this material into the sewers should be avoided, and where possible, these extremely strong wastes should be treated separately, or disposed of by hauling away.

The treatment of milk wastes is normally handled through municipal plants. Pretreatment by screening is a good practice. In some cases, grit removal also should be utilized.

Beet sugar wastes: Beet sugar refineries create wastewater that is extremely high in dissolved organic matter. The largest amount of wastewater will come from the fluming and washing operations of the beet and contains suspended beet fragments, stems, roots, leave, and dissolved organic matter. The waste stream has a significant BOD with a minimum value (in case the beets are in a good condition) of 200 ppm. The BOD load does, however, vary significantly, depending if the beets are decomposed because of freezing and other factors, and based on the process used in the beet processing operations. BOD is present in the wastewater resulting from the extraction of sugar from the beets, which is known as pulp screen water. BOD is also present in lime cake slurry, which is produced from mixing and conveying the lime cake.

The most conventional means of treating beet sugar wastes is lagooning. The wastes usually discharged to the lagoon are the flume and wash water and the lime cake slurry, although in some plants the lime cake is reburned and reused in the process. Most plants dry the spent pulp, thus eliminating the need for treatment of this liquid waste, and condenser wastewater has a low enough BOD to allow it to be discharged, without treatment, to a receiving stream. A lagoon allows enough retention time for solids setting and a partial BOD reduction.

Brewery wastes: Beer brewery wastewater is extremely high in dissolved organic matter. The waste stream has a significant BOD with a concentration, which may reach 7000 ppm[8]. The BOD load does require pretreatment before discharge. The treatment process comprises screening followed by primary settlement. The brewery waste is deficient in nutrients; therefore, it will be necessary to pass the effluent stream in a trickling filter before allowing the waste stream into final settlement basins.

Fermentation and distillation wastes: Wine fermentation wastewater is high in dissolved organic matter. The waste stream has a significant BOD with a concentration of over 2000 ppm[8]. The BOD load does require pretreatment before discharge. The treatment process comprises screening to remove the larger suspended solids, such as grape skins, followed by aerated balancing prior to passing the effluent wastewater stream in a trickling filter, and then final settlement. The aeration process will require the use of diffused air flotation.

Yeast wastes: Yeast wastewater is high in dissolved organic matter. The waste stream has a significant BOD with a concentration of over 2000 ppm[8]. The BOD load does require pretreatment before discharge. The treatment process comprises screening to remove the larger suspended solids followed by aerated balancing, and then final settlement.

Waste treatment methods and control for food industries: Generally, waste treatment methods for food processing plants can be divided into in-plant control, and end-of-pipe treatment methods. In plant controls include:

1. Reuse of clean or relatively clean water in appropriate operations
2. A reduction in the volume of water used for product transport
3. Removal of solid wastes by hand or mechanical means rather than flushing them to the gutter
4. Segregation of highly concentrated waste streams for separate treatment or disposal
5. Separation of can cooling or other clean waters for disposal without treatment to reduce the volume of waste
6. Recombining, under appropriate conditions, clean waters with treated waters to give dilution at the point of final discharge

End-of-pipe treatment methods include:

1. Screening of food processing wastes to remove solids. These consist of coarse screening or bar racks and fine mesh screening. It should be noted that fine mesh screening could result in BOD reductions greater than primary settling tanks, and at lower costs.
2. Grease recovery is required for plants handling significant quantity of meat or poultry in order to remove grease in their wastewaters.
3. Biological treatment in which microorganisms remove the organic loads by adsorption and direct metabolism. These include trickling filters, activated sludge, lagoons, and anaerobic digestion treatment processes.

6.2.2 Textile Industry

Cotton textile production operations consist of a number of processes including desizing, scouring, bleaching, mercerizing, dyeing, finishing; each of which generates a liquid waste with its own peculiar character. The desizing process, which must always be performed at

[8] "River Barada pollution control study", Report prepared by Howard Hymphreys & Sons, Consulting Engineers, Surrey, England, and presented to the Ministry of Housing and Utilities, Syria

the finishing mill on yarn received from the weaving mill, contributes a minimum of 45 percent of the BOD load discharged with the wastewater from a textile-finishing mill. Over 50 percent reduction can be achieved when carboxyl methyl cellulose (CMC) is substituted for cornstarch in the sizing process. Soap can also result in reduction of BOD generated in the cotton dyeing process if used instead of detergent. Typically, the average overall BOD in the wastewater stream for a cotton finishing plant varies between 200 and 800 ppm.

Table 6.1 lists BOD treatment removal efficiencies for various treatment methods used on cotton finishing wastes.

Table 6.1: Treatment process removal efficiency for cotton finishing wastes[9]

Removal Method	*% BOD Removal Efficiency*
Screening	0 – 5
Plain sedimentation	5 – 15
Chemical coagulation	25 – 60
Trickling filter	40 – 85
Activated sludge	70 – 95
Lagoon	30 – 80
Aerated lagoon	50 – 95

In case of wool, the equalized residual waste from the wool scouring and finishing mill is characterized by a BOD of approximately 1000 ppm. Table 6.2 lists BOD treatment removal efficiencies for various treatment methods used on wool finishing wastes.

Table 6.2: Treatment process removal efficiency for wool finishing wastes[9]

Removal Method	*% BOD Removal Efficiency*
Grease recovery	
- Acid cracking	20 - 30
- Centrifuge	20 - 30
- Evaporation	95
Screening	0 – 10
Sedimentation	30 – 50
Flotation	30 – 50
Chemical coagulation	40 – 80
Activated sludge	85 – 90
Trickling filter	80 – 85
Lagoon	0 – 85

Synthetics generate a wastewater, which when equalized, is characterized by an average BOD of 300 to 500 ppm. Table 6.3 lists BOD treatment removal efficiencies for various treatment methods used on synthetic finishing wastes.

[9] From FWPCA, "The Cost of Clean Water", Vol. III, Industrial Waste Profile No. 4, *Textile Mill Products*, September 1967,

Table 6.3: Treatment process removal efficiency for synthetic finishing wastes[9]

Removal Method	*% BOD Removal Efficiency*
Screening	0 – 5
Sedimentation	5 – 15
Chemical coagulation	25 – 60
Trickling filter	40 – 85
Activated sludge	70 – 95
Naturally aerated lagoon	30 – 80
Mechanically aerated lagoon	50 – 95

6.2.3 Leather Tanning Industry

Leather tanning is a general term for the numerous processing steps involved in converting animal hides or skins into finished leather. Leather tanning may be performed by means of vegetable or chrome tanning processes; although, chrome tanning accounts for the majority of leather tanning production. Chrome tanning consists of soaking, fleshing, liming/dehairing, deliming, bating and pickling, followed by the drying and finishing stages.

Tanneries waste is typically rich in chromium salts, which are toxic to human beings and the environment. Any hexavalent chromium, in the form of dichromate as tanning agent, has to be treated separately prior to entering the collection system. The dichromate waste should be reduced to the trivalent form. The waste stream has a BOD with a concentration, which may reach 2000 ppm[8]. Pretreatment of the waste stream comprises screening to avoid blockage of the collection system. The collected wastewater can then pass directly into conventional settlement tanks fitted with mechanical sludge scrapers and scum removal equipment. The settled effluent may finally be discharged into the public sewer system connected to the municipal wastewater treatment plant.

6.2.4 Pulp and Paper Industry

The pollution problem of the pulp and paper mills arises from the fact that the mills' processes are totally dependent on water. Water is used as a vehicle for transporting wood within the mill; in cooking and grinding processes; and, for carrying the separated fibers through the bleaching, refining and sheet forming phases of manufacture. Pollutants thus occur in a highly dilute form, the ratio of water to pollutant varying from a few hundred to one, to several thousands to one. The removal of these dissolved or highly dispersed materials economically is a problem, which defies simple solution. The five major types of pollutants generated by the pulp and paper industry consist of suspended solids, soluble organics, aesthetic pollution, pollution toxic to aquatic life, and soluble inorganics. Typically, pollutants vary with the types of pulp and paper produced. Of concern for this study are the methodologies for reducing soluble organics discharged to the Mediterranean Sea.

The soluble organic material, expressed as BOD, is the second most significant source of pollution in industry. BOD load may reach a value as high as 350 kg per ton of pulp product. The lignin compounds in wastes from the pulping processes decompose very slowly. The influence that they exert is gradual and usually absorbed by the normal reaeration characteristics of the stream. Other organic compounds resulting such as carbohydrates, however, have a high and rapid BOD. This type of BOD can deliver a shock loading to the receiving environment, which exceeds the stream's capacity to handle.

Treatment methods include clarification to remove suspended solids to reduce BOD loading in the pulp and paper mill waste followed by various biological treatment methods. The effectiveness of clarification on BOD removal varies widely, from practically zero for the sulfite wastes to 10 percent for kraft; 15 to 20 percent for newsprint; 20 to 25 percent for book mill, and 35 to 65 percent for tissue.

Biological treatment methods include aerated lagoons; either naturally or mechanically, activated sludge and trickling filters. Naturally aerated lagoons or stabilization ponds are most suited for mills situated in the warmer southern region of the Mediterranean. Effectiveness of the ponds in removing BOD is dependent upon ambient temperature and exposed surface area. Stabilization ponds are usually quite shallow. In case of lack of surface area, then loadings can be increased with an increase of storage time of waste. Stabilization basins or naturally aerated lagoons have the distinct advantage of dependable performance, of being able to absorb wide variations in BOD load and of inexpensive operation.

Mechanically aerated basins, on the other hand, are considered ideal for dealing with the high BOD problem of the pulp and paper industry. They have the advantage of stability of operation, six to ten times the BOD loading capacity per acre of a naturally aerated basin, and they avoid the extremely difficult problem of secondary sludge encountered in the activated sludge process. Reductions of BOD in the order to 60 to 75 percent have been reported with 4 days retention time without supplementary feeding where ambient temperatures were high. The BOD removal efficiency may even reach 90 to 94 percent after 6 days with supplementary feeding.

Activated sludge treatment is recommended for reducing BOD discharge in pulp and paper mills where space is of major concern. An activated sludge basin will accomplish in 4 to 6 hours the same 85 percent reduction as a natural aeration basin achieves in 25 days' retention time or mechanically aerated basins in 6 days. The big disadvantage of the activated sludge process is the problem of disposal of the secondary sludge formed.

Trickling filters, when operated at a high rate give reductions in BOD of from 40 to 60 percent. Their chief advantage lies in the ability to handle large volumes of wastes over a wide range of BOD concentrations. Use of plastic filter media may eliminate the problem of clogging that was experienced with stone media. Trickling filters are not so widely used in the pulp and paper industry as other bio-oxidation processes. Trickling filters occasionally serve as cooling towers in situations where waste temperature must be reduced before subsequent treatment or discharge. Such applications yield a BOD reduction of low magnitude.

6.2.5 Phosphatic Fertilizers Industry

The primary products of the phosphatic fertilizers industry are phosphoric acid, ammonium phosphate, normal superphosphate, and triple superphosphate.

The major source of wastewater from any phosphatic fertilizer manufacturing process is referred to as "pond water." Phosphoric acid production creates large quantities of pond water for cooling of the process; concentration of the product; and for processing and storage of the gypsum byproduct. Gypsum slurry water is decanted from the top of the gypsum stacks and sent to the cooling pond through collection ditches. Through evaporation and recycling, contaminant concentrations in pond water can reach several grams per liter of phosphates and fluoride. Additional elemental contaminants in pond water, which originate in phosphate rock are arsenic, cadmium, uranium, vanadium and radium.

The most common industry treatment for removing phosphorous is lime neutralization and settling ponds.

6.2.6 The Pharmaceutical Industry

Pharmaceutical manufacturing represents all the various operations that are involved in producing a packaged product suitable for administering as a finished usable drug. It would include such things as mixing of ingredients, drying of granules, tableting, capsulation, coating of pills and tablets, preparation of sterile product, and finally the packaging of the finished product. In general, none of these processes may be considered to be serious water polluters, for the simple reason that they do not use water on any basis that would cause pollution. In spite of this, however, there are a number of places where water pollution can be expected. These include wash-up operations, where too much water to too great an area can flush unusual materials, in terms of both quantity and concentration, into a sewer.

The most common type of wastewater treatment for pharmaceutical manufacturing is biological treatment with trickling filters or activated sludge process. The choice must be made, however, carefully, in terms of the type of wastes that are to be treated, their volume and of particular importance, the completeness of the treatment that is required. Trickling filters are flexible in the sense that they can be sized to most plants, whereas an activated sludge facility tends to operate more satisfactorily at larger volumes and should in general be restricted to larger plants or larger loadings. It should be noted that many pharmaceutical plants do utilize a municipal sewer and treatment system, which may be adequate for their waste disposal problem.

6.2.7 Chemical Industry

The chemical industry is characterized by its great diversity in chemical products, processes and wastes. The large number of chemicals commercially produced and the diversity of their effect on water make it impractical to generalize for the entire chemical industry. The wastes from a chemical plant may be inorganic, insoluble, soluble, inert, toxic or any combination thereof. Both organic and inorganic wastes have water quality effects essentially different from sanitary sewage. The abatement technique applied by the chemical industry for its pollution problems bears the stamp for the industry's own technology. Most waste treatment facilities are unique and individually conceived and constructed. To protect the beneficial uses of the receiving waters adequately, it is necessary to minimize the waste, characterize the effects of the waste on the receiving waters and have knowledge of the assimilative capacity of the receiving waters. An intimate knowledge of the characteristics of a waste stream is necessary. Needed information includes, but is not limited to, biological oxygen demand (BOD), toxicity, suspended and settleable matter, insoluble oil, taste, odor, pH, temperature, etc.

One example from the chemical industry producing high levels of BOD is the soap and oil industry. The wastewater stream is characterized by BOD concentrations reaching about 1400 ppm[8]. Wastewater treatment requires the installation of a balancing tank to even the flow of the soap liquor from the process vessels with wastewater generated through the pretreatment units. This is followed by grease removal and wastewater neutralization with the use of caustic soda before discharge to the municipal treatment plant.

7 PROPOSED REGIONAL PLAN FOR REDUCTION OF BOD DISCHARGES INTO THE MEDITERRANEAN

7.1 General

In this section, details are presented on the regional plan for BOD reduction by the year 2005. The regional plan consists of national plans for all Mediterranean countries offered in terms of the current estimated BOD discharge from each industrial sector, and required BOD reduction levels. A summary table for BOD reduction for all Mediterranean countries is also included.

7.2 Regional Plan for Industrial BOD Reduction

The proposed regional plan for reduction of industrial BOD discharges into the Mediterranean is based on the implementation of end-of-pipe treatment methods, which aim to reduce the combined industrial BOD discharges by the year 2005 by 50 percent in *each* Mediterranean country. This plan would ensure that all Mediterranean countries would contribute *equally* for the combined reduction of industrial BOD from the current level of about 410,000 tons per year to about 205,000 tons by the year 2005. It should be noted that the recommended reduction levels were presented in the absence of accurate data on the status and degree of industrial wastewater treatment facilities in the various industrial sectors in the Mediterranean countries.

In order to assist the various countries in establishing detailed BOD reduction plans for each existent industrial sector, it is attempted in this section to estimate BOD loads for each industrial sector in every Mediterranean country. These BOD loads are determined based on data provided in Table 4.1 listing the industry sectors in each country, and Table 5.1 with an estimate of current BOD discharges, and computed for the average BOD effluent concentrations tabulated in Table 7.1. The BOD contribution for each industry is calculated as a proportion of the total BOD discharge to the total BOD effluent concentration from the available industries in each country.

Table 7.1: Average BOD concentrations in the wastewater effluents for the various industry sectors

Industry Sector	*BOD Effluent Concentration (ppm)*
Textile	300
Leather	2000
Fertilizers	40
Food processing	2500
Chemicals	20
Pharmaceuticals	30
Pulp and paper	4000

Although it is left to the discretion of each country to implement the most suitable method of treatment for each industry such as to achieve a combined BOD reduction of 50 percent from all industries by year 2005, in the following regional plan, estimates were based on 50 percent BOD reduction from each industry. The individual countries can vary these individual reduction levels provided that a combined 50 percent BOD reduction level can be achieved by the year 2005.

Action Plan for Albania

Available Industrial Sectors	*BOD (tons) Contribution*	*BOD (tons) Reduction*
Pulp and paper	540	270
Discharged BOD = 540 tons/year		
50% BOD reduction = 270 ton/year		

Action Plan for Algeria

Available Industrial Sectors	*BOD (tons) Contribution*	*BOD (tons) Reduction*
Leather	27,727	13,864
Food	33,409	16,704
Pulp and paper	53,454	26,727
Discharged BOD = 114,590 tons		
50% BOD reduction = 57,295 tons		

Action Plan for Bosnia & Herzegovina

Available Industrial Sectors	*BOD (tons) Contribution*	*BOD (tons) Reduction*
Textile	505	253
Food	4205	2102
Discharged BOD = 4710 tons/year		
50% BOD reduction = 2355 tons		

Action Plan for Croatia

Available Industrial Sectors	*BOD (tons) Contribution*	*BOD (tons) Reduction*
Textile	180	90
Food	1503	752
Chemicals	12	6
Pulp and paper	2405	1202
Discharged BOD = 4100 tons/year		
50% BOD reduction = 2050 tons		

Action Plan for Cyprus

Available Industrial Sectors	*BOD (tons) Contribution*	*BOD (tons) Reduction*
Food	190	95
Discharged BOD = 190 tons/year		
50% BOD reduction = 95 tons		

Action Plan for Egypt

Available Industrial Sectors	*BOD (tons) Contribution*	*BOD (tons) Reduction*
Textile	7218	3609
Leather	48,117	24,058
Fertilizers	962	481
Food	60,147	30,073
Chemicals	481	240
Pulp and paper	96,235	48,117
Discharged BOD = 213,160 ton/year		
50% BOD reduction = 106,580 tons		

Action Plan for France

Available Industrial Sectors	*BOD (tons) Contribution*	*BOD (tons) Reduction*
Food	390	195
Discharged BOD = 390 tons/year		
50% BOD reduction = 195 tons		

Action Plan for Greece

Available Industrial Sectors	*BOD (tons) Contribution*	*BOD (tons) Reduction*
Fertilizers	141	70
Food	8819	4410
Discharged BOD = 8960 tons/year		
50% BOD reduction = 4480 tons		

Action Plan for Israel

Available Industrial Sectors	*BOD (tons) Contribution*	*BOD (tons) Reduction*
Textile	540	270
Fertilizers	72	36
Food	4502	2251
Chemicals	36	18
Discharged BOD = 5150 ton/year		
50% BOD reduction = 2575 tons		

Action Plan for Italy

Available Industrial Sectors	*BOD (tons) Contribution*	*BOD (tons) Reduction*
Leather	8957	4478
Fertilizers	179	90
Chemicals	90	45
Pulp and paper	17,914	8957
Discharged BOD = 27,140 ton/year		
50% BOD reduction = 13,570 tons		

Action Plan for Lebanon

Available Industrial Sectors	*BOD (tons) Contribution*	*BOD (tons) Reduction*
Leather	1806	903
Food	2257	1128
Pharmaceuticals	27	14
Discharged BOD = 4090 ton/year		
50% BOD reduction = 2045		

Action Plan for Libya

Available Industrial Sectors	*BOD (tons) Contribution*	*BOD (tons) Reduction*
Textile	275	138
Leather	1831	915
Fertilizers	37	19
Chemicals	18	9
Discharged BOD = 2160 ton/year		
50% BOD reduction = 1080 tons		

Action Plan for Malta

Available Industrial Sectors	*BOD (tons) Contribution*	*BOD (tons) Reduction*
Food	8430	4215
Discharged BOD = 8430 ton/year		
50% BOD reduction = 4215 tons		

Action Plan for Morocco

Available Industrial Sectors	*BOD (tons) Contribution*	*BOD (tons) Reduction*
Textile	176	88
Leather	1175	588
Food	1468	734
Chemicals	12	6
Pulp and paper	2349	1174
Discharged BOD = 5180 ton/year		
50% BOD reduction = 2590 tons		

Action Plan for Slovenia

Available Industrial Sectors	*BOD (tons) Contribution*	*BOD (tons) Reduction*
Fertilizers	9	5
Food	566	283
Chemicals	5	2
Discharged BOD = 580 ton/year		
50% BOD reduction = 290 tons		

Action Plan for Syria

Available Industrial Sectors	*BOD (tons) Contribution*	*BOD (tons) Reduction*
Textile	62	31
Food	518	259
Discharged BOD = 580 ton/year		
50% BOD reduction = 290 tons		

Action Plan for Tunisia

Available Industrial Sectors	*BOD (tons) Contribution*	*BOD (tons) Reduction*
Textile	452	226
Leather	3008	1504
Food	3760	1880
Chemicals	30	15
Discharged BOD = 7250 ton/year		
50% BOD reduction = 3625 tons		

Action Plan for Turkey

Available Industrial Sectors	*BOD (tons) Contribution*	*BOD (tons) Reduction*
Textile	109	54
Leather	724	362
Fertilizers	14	7
Food	905	453
Pulp and paper	1448	724
Discharged BOD = 3200 ton/year		
50% BOD reduction = 1600 tons		

Based on the above noted country action plans, results are summarized in Table 7.2 showing the estimated industrial BOD discharges prior to and after the implementation of the action plans with a 50 percent reduction levels.

Table 7.2: Estimates of industrial BOD discharges from the Mediterranean countries prior to and after the implementation of the proposed regional plan

Country	Current BOD Discharge in 2000 (tons/year)	50 percent BOD Reduction by 2005 (tons)
Albania	540	270
Algeria	114,590	57,295
Bosnia & Herzegovina	4710	2355
Croatia	4100	2050
Cyprus	190	95
Egypt	213,160	106,580
France	390	195
Greece	8960	4480
Israel	5150	2575
Italy	27,140	13,570
Lebanon	4090	2045
Libya	2160	1080
Malta	8430	4215
Morocco	5180	2590
Slovenia	580	290
Spain	0	0
Syria	580	290
Tunisia	7250	3625
Turkey	3200	1600
TOTAL	**410,400**	**205,200**

8. RECOMMENDED TREATMENT METHODS AND ESTIMATED COSTS

8.1 General

In this section, details are presented on the factors affecting the choice of treatment methods and their associated costs. The incurred industrial wastewater treatment costs for the reduction of BOD by 50 percent by each of the Mediterranean countries are also estimated.

8.2 Treatment Alternatives for Reduction of BOD

There are several ways to reduce the impact of the BOD waste stream on the environment. These consist of in-plant controls, and end-of-pipe treatment methods.

In-plant controls include:

1. Process changes to minimize or eliminate wastes from a given process
2. Segregation of process streams
3. Change in raw materials
4. Equalization or retention tanks or basins, which provide for the controlled release of large quantities of chemicals to the sewers or receiving waters.
5. Housekeeping, including proper maintenance of plant and machinery, and prevention measures for accidental spills, etc.

End-of-pipe treatment methods may consist, if available, of municipal sewage treatment. This alternative is often the most practical and economic solution for dissolved organic wastes provided that:

1. secondary treatment is provided by the facility;
2. there is sufficient excess oxidative capacity above that required for domestic sewage; and,
3. the organic wastes are readily biodegradable.

Generally, such wastes are governed by local sewer ordinances, which regulate the discharge of industrial wastes and usually specify the manner by which the waste may be admitted. Pretreatment may be required to remove toxic substances, flammable compounds, heavy metals, or to adjust pH prior to discharge to the sewers.

Joint municipal-industrial treatment has the advantage of lower costs, and dilution and addition of nutrients that speed biological processes which break down the wastes to harmless substances. Nevertheless, extensive pilot plant or laboratory work is frequently needed to determine properly the treatment method(s) for a given waste prior to discharge to receiving water.

End-of-pipe treatment methods suitable for BOD reduction include physical and biological methods. Physical methods include screening and settling tanks. Biological methods include stabilization ponds and mechanically aerated lagoons, activated sludge and trickling filters. The average percentage BOD removal efficiencies for the various treatment methods were discussed in detail in Section 6, and can be estimated based on the average BOD removal efficiencies summarized in Table 8.1.

Table 8.1: Estimated percentage BOD removal efficiencies in the wastewater effluents for the recommended physical and biological treatment methods

Treatment Method	*Percentage BOD Removal Efficiency*
Screening and settling tanks	40
Stabilization pond	70
Mechanically aerated lagoon	90

Treatment Method	*Percentage BOD Removal Efficiency*
Activated Sludge	90
Trickling filter	90

8.3 Factors Affecting the Choice and Cost of Treatment Methods

The factors that affect the choice of the treatment methods with a high BOD removal efficiency (over 70 percent) can be divided into reliability requirements and costs[10].

***Reliability requirements**.* These include:

1. *Resistance to shock load of organic and toxic materials*. Available treatment methods that resist shock loads can be ranked in the order of best to worst as stabilization ponds, trickling filters and activated sludge systems.

2. *Sensitivity to intermittent operations*. Treatment methods that are least sensitive to intermittent operations are activated sludge systems, followed by trickling filters and finally stabilization ponds.

3. *Operator skill requirement*. Treatment methods requiring high levels of operators' skills are activated sludge systems, followed by trickling filters and finally stabilization ponds.

***Cost**.* These include:

1. *Land requirement*. Treatment methods requiring large surface area are stabilization ponds, followed by trickling filters and finally activated sludge systems with the least land requirement.

2. *Capital cost*. Treatment methods with the highest capital cost are activated sludge systems, followed by trickling filters and finally stabilization ponds.

3. *Operations and maintenance costs*. Treatment methods requiring high operation and maintenance cost are stabilization ponds, followed by trickling filters and finally activated sludge systems.

Capital treatment cost is influenced by a number of factors. These include the size of the treatment facility, method of treatment and/or BOD removal efficiency. Additional costs are also incurred due to the geographical location of the treatment facility, and related maintenance and operating costs. These factors are discussed in this section.

8.3.1 Wastewater Treatment Costs in Relation to Capacity

Plant sizes of 100,000-population equivalent require only 50% of the specific construction cost of a plant of 10,000-population equivalent. With increases in population by a factor of 100 for example, specific construction costs are cut by one-forth and specific operation costs

[10] Atef Deib, « Capital and Operation Cost in Wastewater Treatment", Dissertation submitted for the Degree of Master of Science in Environmental Engineering, The University of Newcastle Upon Tyne, Department of Civil Engineering, Environmental Engineering Group, November 1999.

to about one-third, respectively[11]. It is to be noted that in this study, BOD loading is converted to population equivalent based on a BOD load of 60 g/day per capita.

Hence in the developing countries on the southern and eastern shores of the Mediterranean, where there is a shortage in capital cost and the labor cost is low, it is recommended to build small (non-centralized) wastewater treatment plants (for each industrial facility) with high loaded biological treatment process (reaching 70 percent). This will reduce the cost of sewerage system needed in big treatment plants, which require three to five times the capital investment cost of the plant itself.

In the developed countries of the northern shores of the Mediterranean, a higher level of industrial production and good standard of life has been achieved. Manpower is expensive. Accordingly, higher BOD removal efficiencies may be achieved, and a centralized wastewater treatment is recommended (for an entire industrial complex).

8.3.2 Wastewater Treatment Costs in Relation to Levels of Treatment

Research studies[12] have shown that 80 percent removal by biological treatment is less expensive in terms of kilograms of BOD removal than the application of only mechanical treatment. The cost of BOD removal increases threefold from mechanical to biological treatment methods with a rated BOD removal efficiency between 35 and 60 percent. The cost further increases fivefold when BOD removal efficiency reaches 90 percent.

A World Bank report by Arthur (1994) titled “Economic Comparison of Biological Treatment Methods for the City of Sana’a, Yemen”, gives a detailed cost analysis for waste stabilization ponds, mechanically aerated lagoons, activated sludge and trickling filters. The data presented in this report are applicable to various developing countries on the shores of the Mediterranean. Based on a population size of 250,000, BOD of 40 g/day per capita, a flow of 120 l/day per capita, and a reduced effluent BOD of 25 mg/l, it is determined that stabilization ponds are clearly the cheapest option. Cost data for the various treatment methods are tabulated in Table 8.2.

Table 8.2: Capital and operating costs and land area requirement of various types of treatment (Arthur, 1994)[⊗]

Treatment Method	*Capital Cost (million USD)*	*Yearly Operation Cost (million USD)*	*Land Area (Hectares)*
Stabilization pond	5.7	0.21	46
Mechanically aerated lagoon	7.0	1.28	50
Activated sludge	4.8	1.49	20
Trickling filters	7.7	0.86	25

Clearly, the preferred solution is very sensitive to the price of land, which is cheaper in developing countries. It should be noted that a population of 250,000 generates 3650 tons/year of BOD (the author assumes a rate of 40 g/day per capita).

[11] Gernot, “Economic Consideration on Local or Centralized Wastewater Treatment System”. *Proceedings of a workshop held in Vienna*, Austria, 1980.
[12] Wesley, “Cost Information for Water Supply and Sewage Disposal”. *Water Research Center*, United Kingdom, 1980.

[⊗] Figures are 1994 based, and have not been adjusted for inflation

Operating costs include sludge treatment, levies, investment costs, manpower, energy, maintenance, chemicals, etc. An example of the distribution of these itemized operating costs for the dairy industry is shown in Figure 8.1[13].

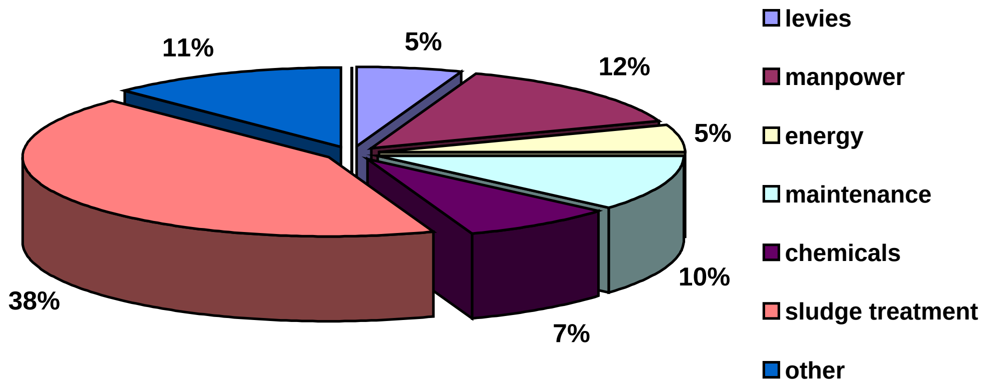

Figure 8.1: Operating costs components for a wastewater treatment plant in the dairy industry

Hence, it is concluded that waste stabilization ponds are generally the cheapest methods of treatment when the land price is reasonable. This method becomes more attractive when the cost of energy is high and the energy resources are limited. Biological or trickling filters are generally the most expensive treatment options and very sensitive to the cost of filter medial. These should only be considered where filter media is relatively cheap. Activated sludge is the most favorable option in terms of overall cost (with the exception of stabilization ponds) [14].

The applicability and limitations of each treatment method when considered for implementation by the various Mediterranean countries can be summarized as follows:

a) Screening and settling tanks are considered primary treatment methods that precede the implementation of advanced biological treatment methods.

b) Naturally aerated lagoons or stabilization ponds are most suited in the warmer southern region of the Mediterranean.

c) Mechanically aerated basins are considered ideal for dealing with high BOD discharges, where space is available and cost of land is reasonable.

d) Activated sludge treatment is recommended where space is of major concern; the disadvantage is the problem of disposal of the secondary sludge formed. Hence, this method is most suitable for countries on the northern coast of the Mediterranean.

e) Trickling filters are capable of handling large volumes of wastes over a wide range of BOD concentrations; their main disadvantage is the high filter cost.

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[13] Vanderhaegen et al., "Cost Model of Small Wastewater Treatment Plants". *Interim Journal of Environmental Studies,* 1994.

[14] Middlebrooks, E. J. "Wastewater stabilization lagoon design, performance and upgrading", Macmillan publishing, New York, USA.

In addition to the above, in-plant controls need to be considered in conjunction with end-of-pipe treatment methods. These include process changes, segregation of wastes at source, change in raw materials, equalization tanks, and good housekeeping, in order to reduce the amount of waste contributing to the generation of BOD.

From an economical point of view, physical treatment methods are considered to be significantly cheap, but these should be regarded as a pre-requisite to biological treatment methods. In contrast, the cost factor of biological methods increases in the following order: naturally aerated lagoons or stabilization ponds, mechanically aerated lagoons, activated sludge, and trickling filters.

8.4 Estimation of Costs of Treatment for the Mediterranean Countries

Based on the foregoing, it is concluded that many variables impact the costs for reducing BOD discharges from industrial sources. These include plant size, type of treatment, and land cost. In order to obtain a rough estimate of the capital and operating costs to be incurred by each country for reducing their industrial BOD discharges by 50 percent, which can be used in the future in developing their individual plans, the following assumptions were made:

1. Land cost is ignored
2. Activated sludge treatment is implemented by the countries overlooking the northern shore of the Mediterranean
3. Stabilization ponds are applied by the countries overlooking the eastern and southern shores of the Mediterranean
4. Cost of inflation is ignored
5. Due to the lack of accurate data, it is assumed that no industrial wastewater treatment infrastructure is in place
6. The socio-economic conditions and the variability of cost of labor are ignored
7. Specific costs listed in Table 8.2, which were determined for treating a wastewater effluent with a BOD load of 3650 tons/year, are utilized for the purpose of computing costs of BOD reduction by the various Mediterranean countries. The specific cost figures entail a BOD reduction efficiency of 37 percent. Since available literature indicates that the cost of reduction of BOD to 50 percent is nearly the same as to 37 percent[12], then the listed costs in Table 8.2 are equally applicable for this study, after adjusting for the BOD load.
8. The specific costs for the variable BOD loads by the individual countries are adjusted based on the population equivalents and specific cost multipliers[11] tabulated in Table 8.3.

Table 8.3: BOD loads, population equivalent, and multipliers to specific costs for estimating costs of treatment for the various Mediterranean countries[11; 12]

BOD load tabulated in Table 7.2 (tons/year)	*Population equivalent based on 60 g/day per capita*	*Multipliers to Specific Costs tabulated in Table 8.2*
22 - 220	1000 – 10,000	4

220 – 2200	10,000 – 100,000	2
2200 – 22,000	100,000 – 1,000,000	1
> 22,000	> 1,000,000	1

Estimated capital and operating costs for each Mediterranean country are presented in Table 8.4. As can be seen, the total capital investment cost for reducing industrial BOD discharges by 50 percent by year 2005 for all Mediterranean countries is over 600 million USD, with a yearly operating cost of about 40 million USD. These figures entail, however, a number of assumptions that should be taken into account in particular the inflation rates. Accordingly, these figures should be considered merely as an *indicator*, and have to be modified based on the actual situation in each country.

Table 8.4: Estimates of the capital and operating costs for reducing BOD discharges by 50 percent from the various Mediterranean countries

Country	Current BOD Discharge in 2000 (tons/year)	Type of Treatment	Capital Cost in millions USD	Operating Yearly Cost millions USD
Albania	540	Activated sludge	1.4	0.4
Algeria	114,590	Stabilization pond	178.9	6.6
Bosnia & Herzegovina	4710	Activated sludge	6.2	1.9
Croatia	4100	Activated sludge	5.4	1.7
Cyprus	190	Activated sludge	1.0	0.3
Egypt	213,160	Stabilization pond	332.9	12.3
France	390	Activated sludge	1.0	0.3
Greece	8960	Activated sludge	11.8	3.7
Israel	5150	Stabilization pond	8.0	0.3
Italy	27,140	Activated sludge	35.7	11.1
Lebanon	4090	Stabilization pond	6.4	0.2
Libya	2160	Stabilization pond	6.7	0.2
Malta	8430	Stabilization pond	13.2	0.5
Morocco	5180	Stabilization pond	8.1	0.3
Slovenia	580	Activated sludge	1.5	0.5
Spain	None	Activated sludge	0	0
Syria	580	Stabilization pond	1.8	0.1
Tunisia	7250	Stabilization pond	11.3	0.4

Country	Current BOD Discharge in 2000 (tons/year)	Type of Treatment	Capital Cost in millions USD	Operating Yearly Cost millions USD
Turkey	3200	Stabilization pond	5.0	0.2
TOTAL	**410,400**		636.4	41.0

ANNEX 'A'

TABLES OF BOD LOADS DISCHARGED IN THE HOTSPOT AREAS BORDERING THE MEDITERRANEAN SEA

Estimation of BOD Discharged by Industrial Sources to the Mediterranean Sea from Hot Spots Located in ALBANIA

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Durres		Industrial	NA	NA	-	Deposit of 20,000 tons of solid waste containing 4-5% of hexavalent chromium
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
None	None	None		None		Listed industry does not generate BOD
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
0	0	Area rehabilitation: Solid waste disposal site		0		Negligible

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Vlora		Industrial	NA	NA	-	Area of 11 hectares contaminated by elemental mercury No BOD discharges
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
None	None	None		None		Industry does not discharge BOD
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
0	0	Area rehabilitation: Prevention of leakage from chloralkaline plant		0		Negligible
COUNTRY	***ALBANIA***	**INDUSTRIAL BOD DISCHARGED** *(tons/year)*				**536** [15]

[15] Industrial BOD assumed to be 10% of BOD generated by the local population of 254,000 inhabitants living in all the hot spot areas close to the Mediterranean coast at 60 g/inhabitant/day

Estimation of BOD Discharged by Industrial Sources to the Mediterranean Sea from Hot Spots Located in ALGERIA

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Algiers	Municipal and Industrial	89,792	53,875	1.67	Reported computed COD and BOD values

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	***By Network Only***			
2,410,069	50,000	Secondary (capable of eliminating 85% of discharged BOD from plant and network)	9012	BOD calculated based on 60 g/ihb/day 98% of population served by MWWTP

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
NA	NA	Construction of IWWTP	12,874	Assuming similar conditions to Tunisia, ratio of municipal BOD to industrial BOD is equivalent to 0.7

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Annaba	Municipal and Industrial	20,275	12,165	1.67	Reported computed COD and BOD values

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	***By Network Only***			
499,937	55,548	Lagoon (capable of eliminating 85% of discharged BOD from plant and network)	2859	BOD calculated based on 60 g/ihb/day 90% of population served by MWWTP

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
NA	NA	Construction of IWWTP	4084	Assuming similar conditions to Tunisia, ratio of municipal BOD to industrial BOD is equivalent to 0.7

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Oran	Municipal and Industrial	46,770	28,062	1.67	Reported computed BOD and COD values

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	***By Network Only***			
0	1,281,378	None	28,062	BOD calculated based on 60 g/ihb/day MWWTP Plant out of service

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
NA	NA	Construction of IWWTP	40,089	Assuming similar conditions to Tunisia, ratio of municipal BOD to industrial BOD is equivalent to 0.7

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Skikda	Municipal and Industrial	33,239	19,943	1.67	Reported computed BOD and COD values

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	***By Network Only***			
-	910,680	None	19,943	BOD based on 60 g/ihb/day There is no MWWTP

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
NA	NA	Construction of IWWTP	28,490	Assuming similar conditions to Tunisia, ratio of municipal BOD to industrial BOD is equivalent to 0.7

<table>
<tr><th colspan="2">Hot Spot Name</th><th>Hot Spot Type</th><th>Reported COD (tons/year)</th><th>Reported BOD (tons/year)</th><th>COD / BOD</th><th>Nature of Problem</th></tr>
<tr><td colspan="2">Béjaia</td><td>Municipal and Industrial</td><td>32,896</td><td>19,737</td><td>1.67</td><td>Reported computed BOD and COD values</td></tr>
<tr><th colspan="2">Reported Populations Served</th><th colspan="2" rowspan="2">Degree of Treatment of Wastewater in MWWTP</th><th colspan="2" rowspan="2">BOD Generated from Municipal Sources (tons/year)</th><th rowspan="2">Comments</th></tr>
<tr><th>By Plant and Network</th><th>By Network Only</th></tr>
<tr><td>873,541</td><td>27,722</td><td colspan="2">Secondary (capable of eliminating 85% of discharged BOD from plant and network)</td><td colspan="2">3477</td><td>BOD based on 60 g/ihb/day
97% of population served by MWWTP</td></tr>
<tr><th>Total BOD Generated in Hot Spot (tons/year)</th><th>Industrial BOD Generated in Hot Spot (tons/year)</th><th colspan="2">Nature of Required Investment for Improvement</th><th colspan="2">BOD Discharged from Industrial Sources (tons/year)</th><th>Comments</th></tr>
<tr><td>NA</td><td>NA</td><td colspan="2">Construction of IWWTP</td><td colspan="2">4967</td><td>Assuming similar conditions to Tunisia, ratio of municipal BOD to industrial BOD is equivalent to 0.7</td></tr>
</table>

<table>
<tr><th colspan="2">Hot Spot Name</th><th>Hot Spot Type</th><th>Reported COD (tons/year)</th><th>Reported BOD (tons/year)</th><th>COD / BOD</th><th>Nature of Problem</th></tr>
<tr><td colspan="2">Mostaganem</td><td>Municipal and Industrial</td><td>22,974</td><td>13,784</td><td>1.67</td><td>Reported computed BOD and COD values</td></tr>
<tr><th colspan="2">Reported Populations Served</th><th colspan="2" rowspan="2">Degree of Treatment of Wastewater in MWWTP</th><th colspan="2" rowspan="2">BOD Generated from Municipal Sources (tons/year)</th><th rowspan="2">Comments</th></tr>
<tr><th>By Plant and Network</th><th>By Network Only</th></tr>
<tr><td>-</td><td>629,445</td><td colspan="2">None</td><td colspan="2">13,783</td><td>BOD based on 60 g/ihb/day
There is no MWWTP</td></tr>
<tr><th>Total BOD Generated in Hot Spot (tons/year)</th><th>Industrial BOD Generated in Hot Spot (tons/year)</th><th colspan="2">Nature of Required Investment for Improvement</th><th colspan="2">BOD Discharged from Industrial Sources (tons/year)</th><th>Comments</th></tr>
<tr><td>NA</td><td>NA</td><td colspan="2">Construction of IWWTP</td><td colspan="2">19,690</td><td>Assuming similar conditions to Tunisia, ratio of municipal BOD to industrial BOD is equivalent to 0.7</td></tr>
</table>

<table>
<tr><th>Hot Spot Name</th><th>Hot Spot Type</th><th>Reported COD (tons/year)</th><th>Reported BOD (tons/year)</th><th>COD / BOD</th><th>Nature of Problem</th></tr>
<tr><td>Ghazaouet</td><td>Municipal and Industrial</td><td>4760</td><td>2,380</td><td>1.67</td><td>Reported computed BOD and COD values</td></tr>
</table>

Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**	**BOD Generated from Municipal Sources** *(tons/year)*	**Comments**
By Plant and Network	***By Network Only***			
-	108,692	None	2380	BOD based on 60 g/ihb/day There is no MWWTP
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**	**BOD Discharged from Industrial Sources** *(tons/year)*	**Comments**
NA	NA	Construction of IWWTP	3401	Assuming similar conditions to Tunisia, ratio of municipal BOD to industrial BOD is equivalent to 0.7
COUNTRY	***ALGERIA***	**INDUSTRIAL BOD DISCHARGED** *(tons/year)*		**113,593**

Estimation of BOD Discharged by Industrial Sources to the Mediterranean Sea from Hot Spots Located in BOSNIA & HERZEGOVINA

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Municipality of Konjic		Municipal and Industrial	NA	NA	-	Town located upstream of Mostar on Neretva river, indirect discharge. Metal finishing Industries
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
-	20,000	No municipal wastewater treatment		438		BOD calculated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
NA	110	Construction of IWWTP		110		Industrial BOD computed based on population equivalent of 5000 reported in the national hot spot report prepared in 2001

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Municipality of Mostar		Municipal and Industrial	NA	NA	-	Food processing industries (meat, milk, wine, juice), textile, metal finishing, aluminum electrolysis
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
-	130,000	No municipal wastewater treatment		2847		BOD calculated based on 60 g/ihb/day

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
NA	3942	Upgrading and Construction of IWWTP	3942	Industrial BOD computed based on a total population equivalent of 180,000 (30,000 from wine production, 50,000 from food processing, 100,000 for textile industries), as reported in the national hot spot report prepared in 2001

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Municipality of Bileca	Municipal and Industrial	NA	NA	-	Textile industries (carpet production)

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	***By Network Only***			
-	15,000	Sewage treatment plant is ruined during the war	329	BOD calculated based on 60 g/ihb/day

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
NA	657	Upgrading existing pretreatment facilities of IWWTP (currently not operational)	657	Industrial BOD computed based on population equivalent of 30,000 reported in the national hot spot report prepared in 2001

COUNTRY	***BOSNIA & HERZEGOVINA***	**INDUSTRIAL BOD DISCHARGED** *(tons/year)*	**4709**

Estimation of BOD Discharged by Industrial Sources to the Mediterranean Sea from Hot Spots Located in CROATIA

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Pula		Municipal and Industrial	NA	555	-	Industrial waste consisting of heavy metals, oil and phenols
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
73,000	12,000	Primary (capable of eliminating 30% of discharged BOD from plant and network)		1382		85% of population served by primary MWWTP BOD from municipal sources estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
Reported value is less than that which should result from population	NA	Extension of sewerage system		138		Assume industrial BOD is equivalent to 10% of municipal BOD

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Rijeka and Kvarner Bay		Industrial	585	331	1.77	Industrial waste consisting of heavy metals, oil and phenols
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
NA	NA	NA		NA		This is an industrial hot spot
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
NA	331	Extension of IWWTP		331		Figures reported are for industrial discharges only

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Urinj Oil Refinery		Industrial	121	32	3.78	Industrial waste consisting of oil

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	***By Network Only***			
NA	NA	NA	NA	BOD reported is for industrial discharges only
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**	**BOD Discharged from Industrial Sources** *(tons/year)*	**Comments**
NA	32	Extension of IWWTP	32	-

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Zadar	Municipal and Industrial	3940	1056	3.73	Industrial waste consisting of heavy metals and oil

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	***By Network Only***			
0	85,000	None	1862	BOD from municipal sources estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**	**BOD Discharged from Industrial Sources** *(tons/year)*	**Comments**
1056	NA	Construction of IWWTP	186	Assume industrial BOD is equivalent to 10% of municipal BOD

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Zadar Adria Cannery	Industrial	121	67	1.80	Various types of industrial waste

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	***By Network Only***			
NA	NA	NA	NA	Reported BOD is from industrial sources only
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**	**BOD Discharged from Industrial Sources** *(tons/year)*	**Comments**
67	67	Construction of IWWTP	67	Due to lack of IWWTP, then BOD discharged is same as that generated

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Zadar (Soya & Cannery)	Industrial	37	11	3.38	Various types of industrial wastes

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	*By Network Only*			
NA	NA	NA	NA	-

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
11	11	Construction of IWWTP	11	Due to lack of IWWTP, then BOD discharged is same as that generated

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Sibenik	Municipal and Industrial	375	121	3.10	Industrial waste consisting of Aluminum

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	*By Network Only*			
0	85,000	None	1862	BOD from municipal sources estimated based on 60 g/ihb/day

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
121	NA	Construction of IWWTP	186	Assume industrial BOD is equivalent to 10% of municipal BOD

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Kastela Bay	Municipal and Industrial	11,095	5006	2.22	Industrial waste consisting of heavy metals

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	***By Network Only***			
0	85000	None	1862	BOD from municipal sources estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**	**BOD Discharged from Industrial Sources** *(tons/year)*	**Comments**
5,006	3144	Extension of IWWTP	3144	Industrial BOD is estimated from deducting the municipal BOD from that reported

COUNTRY	***CROATIA***	**INDUSTRIAL BOD DISCHARGED** *(tons/year)*	**4095**

Estimation of BOD Discharged by Industrial Sources to the Mediterranean Sea from Hot Spots Located in CYPRUS

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Limassol		Municipal and Industrial	2185	1181	1.85	A number of wineries, distilleries and a brewery
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
89,000	41,000	Tertiary (capable of eliminating 95% of discharged BOD from plant and network)		995		69% of population served by tertiary MWWTP BOD from municipal sources estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
1181	186	Construction of IWWTP		186		Industrial wastewater is not being treated
COUNTRY	***CYPRUS***	**INDUSTRIAL BOD DISCHARGED** *(tons/year)*				**186**

Estimation of BOD Discharged by Industrial Sources to the Mediterranean Sea from Hot Spots Located in EGYPT

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
El-Mex Bay	Municipal and Industrial	175,654	219,498	0.80 [16]	Fertilizer, food, pulp and paper, tanneries and textile industries,

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	*By Network Only*			
3,000,000	NA	Primary (30% BOD removal efficiency) El Mex Bay receives the Alexandria-treated municipal wastewater	45,990	BOD load of 60 grams per inhabitant per day is assumed

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
219,498	173,508	Construction of IWWTP	121,456	Assume 30% of industrial BOD is treated

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Abu Qir Bay	Industrial	575,490	91,701	6.30	Fertilizer, food, pulp and paper industries

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	*By Network Only*			
NA	NA	NA	NA	BOD due to industrial sources only

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
NA	NA	Construction of IWWTP	91,701	Industrial wastewater is not being treated

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Lake Manzala	Municipal	NA	NA	-	Lake Manzala receives the major part of the Cairo mixed wastewater

COUNTRY	***EGYPT***	**INDUSTRIAL BOD DISCHARGED** *(tons/year)*	**213,157**

[16] Calculated ratio as per COD and BOD reported values in MAP Report No. 124

Estimation of BOD Discharged by Industrial Sources to the Mediterranean Sea from Hot Spots Located in FRANCE

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Gardanne		Industrial	NA	NA	-	No data provided on this hot spot
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
1,200,000	NA	Secondary (capable of eliminating 85% of discharged BOD from plant and network)		3942		BOD from municipal sources estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
NA	NA	NA		394		Assume industrial BOD is equivalent to 10% of municipal BOD
COUNTRY	***FRANCE***	**INDUSTRIAL BOD DISCHARGED** *(tons/year)*				**394**

Estimation of BOD Discharged by Industrial Sources to the Mediterranean Sea from Hot Spots Located in GREECE

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Thermaikos Gulf	Municipal and Industrial	1043	297	3.51	-

Reported Populations Served: By Plant and Network	Reported Populations Served: By Network Only	Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
NA	NA	NA	NA	-

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
297	NA	Expansion of MWWTP	30	Assume 10% of discharged BOD is due to industrial sources

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Inner Saronic Gulf	Municipal and Industrial	118,735	59,368	2.00	-

Reported Populations Served: By Plant and Network	Reported Populations Served: By Network Only	Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
3,345,000	NA	Primary (eliminates 30% of discharged BOD from plant and network)	51,279	Municipal BOD estimated based on 60 g/ihb/day

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
59,368	8,089	Construction of IWWTP	8,089	Industrial wastewater is not being treated

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Patraikos Gulf	Municipal and Industrial	473	127	3.72	-

Reported Populations Served: By Plant and Network	Reported Populations Served: By Network Only	Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
NA	155,180	None	3398	Municipal BOD estimated based on 60 g/ihb/day

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
127	NA	Construction of MWWTP	340	Assume industrial BOD is equivalent to 10% of municipal BOD

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Pagasitikos Gulf	Municipal and Industrial	1095	657	1.67	-

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	***By Network Only***			
77,907	NA	Primary (capable of eliminating 30% of discharged BOD from plant and network)	1194	Municipal BOD estimated based on 60 g/ihb/day Since municipal BOD is higher than that reported, then industrial BOD is negligible

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
657	NA	Construction of MWWTP	119	Assume industrial BOD is equivalent to 10% of municipal BOD

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Elefsis Bay	Industrial	446	61	7.31	-

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	***By Network Only***			
NA	NA	NA	NA	-

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
61	61	Construction of IWWTP	61	Industrial wastewater is not being treated

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem

NA Saronic Gulf	Industrial	22	22	1.00	-

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	*By Network Only*			
NA	NA	NA	NA	-

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
22	22	Construction of IWWTP	22	Industrial wastewater is not being treated

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Nea Karvali Bay	Industrial	739	295	2.51	-

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	*By Network Only*			
NA	NA	NA	NA	-

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
295	295	Construction of IWWTP	295	Industrial wastewater is not being treated

COUNTRY	***GREECE***	**INDUSTRIAL BOD DISCHARGED** *(tons/year)*	**8956**

Estimation of BOD Discharged by Industrial Sources to the Mediterranean Sea from Hot Spots Located in ISRAEL

<table>
<tr><th colspan="2">Hot Spot Name</th><th>Hot Spot Type</th><th>Reported COD (tons/year)</th><th>Reported BOD (tons/year)</th><th>COD / BOD</th><th>Nature of Problem</th></tr>
<tr><td colspan="2">Haifa Bay</td><td>Municipal and Industrial</td><td>20,000</td><td>5,300</td><td>3.77</td><td>River discharge and municipal and industrial discharges</td></tr>
<tr><th colspan="2">Reported Populations Served</th><th colspan="2" rowspan="2">Degree of Treatment of Wastewater in MWWTP</th><th colspan="2" rowspan="2">BOD Generated from Municipal Sources (tons/year)</th><th rowspan="2">Comments</th></tr>
<tr><th>By Plant and Network</th><th>By Network Only</th></tr>
<tr><td>500,000</td><td>None</td><td colspan="2">Secondary (capable of eliminating 85% of discharged BOD from plant and network)</td><td colspan="2">1643</td><td>Municipal BOD estimated based on 60 g/ihb/day</td></tr>
<tr><th>Total BOD Generated in Hot Spot (tons/year)</th><th>Industrial BOD Generated in Hot Spot (tons/year)</th><th colspan="2">Nature of Required Investment for Improvement</th><th colspan="2">BOD Discharged from Industrial Sources (tons/year)</th><th>Comments</th></tr>
<tr><td>5300</td><td>3657</td><td colspan="2">Upgrade of IWWTP</td><td colspan="2">3657</td><td>Assume industrial wastewater is not being treated</td></tr>
<tr><th colspan="2">Hot Spot Name</th><th>Hot Spot Type</th><th>Reported COD (tons/year)</th><th>Reported BOD (tons/year)</th><th>COD / BOD</th><th>Nature of Problem</th></tr>
<tr><td colspan="2">Ashdod</td><td>Industrial</td><td>4400</td><td>2000</td><td>-</td><td>Industrial wastes</td></tr>
<tr><th colspan="2">Reported Populations Served</th><th colspan="2" rowspan="2">Degree of Treatment of Wastewater in MWWTP</th><th colspan="2" rowspan="2">BOD Generated from Municipal Sources (tons/year)</th><th rowspan="2">Comments</th></tr>
<tr><th>By Plant and Network</th><th>By Network Only</th></tr>
<tr><td>155,000</td><td>None</td><td colspan="2">Secondary (capable of eliminating 85% of discharged BOD from plant and network)</td><td colspan="2">509</td><td>Municipal BOD estimated based on 60 g/ihb/day</td></tr>
<tr><th>Total BOD Generated in Hot Spot (tons/year)</th><th>Industrial BOD Generated in Hot Spot (tons/year)</th><th colspan="2">Nature of Required Investment for Improvement</th><th colspan="2">BOD Discharged from Industrial Sources (tons/year)</th><th>Comments</th></tr>
<tr><td>2000</td><td>1491</td><td colspan="2">Upgrade of IWWTP</td><td colspan="2">1491</td><td>Assume industrial wastewater is not being treated</td></tr>
<tr><th>COUNTRY</th><th>ISRAEL</th><th colspan="4">INDUSTRIAL BOD DISCHARGED (tons/year)</th><th>5148</th></tr>
</table>

Estimation of BOD Discharged by Industrial Sources to the Mediterranean Sea from Hot Spots Located in ITALY

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Genova		Municipal and Industrial	63,184	15,796	4.00	-
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
679,000	None	Secondary (capable of eliminating 85% of discharged BOD from plant and network)		2231		Municipal BOD estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
15,796	13565	Upgrade of IWWTP		9496		Assume existing installation capable of eliminating 30% of discharged industrial BOD

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Augusta Priolo-Melilli		Municipal and Industrial	7232	1808	4.00	Port and refinery
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
None	53,000	None		1161		Municipal BOD estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
1808	647	Construction of IWWTP		647		Assume industrial wastewater is not treated for removal of BOD

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Brindisi		Municipal and Industrial	8308	2077	4.00	Port and refinery

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	*By Network Only*			
50,000	45,000	Secondary (capable of eliminating 85% of discharged BOD from plant and network)	1150	Municipal BOD estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**	**BOD Discharged from Industrial Sources** *(tons/year)*	**Comments**
2077	927	Upgrade of IWWTP	649	Assume existing installation capable of eliminating 30% of discharged industrial BOD

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Gela	Municipal and Industrial	8578	2144	4.00	Port and refinery

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	*By Network Only*			
None	73,000	None	1599	Municipal BOD estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**	**BOD Discharged from Industrial Sources** *(tons/year)*	**Comments**
2144	545	Construction of IWWTP	545	Assume industrial wastewater is not treated for removal of BOD

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
La Spezia	Municipal and Industrial	15,796	3949	4.00	Energy and power station

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	*By Network Only*			
42,000	68,000	Secondary (capable of eliminating 85% of discharged BOD from plant and network)	1627	Municipal BOD estimated based on 60 g/ihb/day

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
3949	2322	Upgrade of IWWTP	1625	Assume existing installation capable of eliminating 30% of discharged industrial BOD

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Milazzo	Municipal and Industrial	2464	616	4.00	Port and refinery

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	***By Network Only***			
31,541	None	Primary (capable of eliminating 30% of discharged BOD from plant and network)	414	Municipal BOD estimated based on 60 g/ihb/day

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
616	202	Construction of IWWTP	202	Assume industrial wastewater is not treated for removal of BOD

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Golfo di Napoli	Municipal and Industrial	65,005	16,251	4.00	Port and refinery

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	***By Network Only***			
1,540,814	None	Secondary (capable of eliminating 85% of discharged BOD from plant and network)	5062	Municipal BOD estimated based on 60 g/ihb/day

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
16,251	11,189	Upgrade of IWWTP	7832	Assume existing installation capable of eliminating 30% of discharged industrial BOD

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Ravenna		Municipal and Industrial	25,453	6363	4.00	Port and refinery
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
135,844	None	Tertiary (capable of eliminating 95% of discharged BOD from plant and network)		149		Municipal BOD estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
6363	6214	Upgrade of IWWTP		4350		Assume existing installation capable of eliminating 30% of discharged industrial BOD

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Taranto		Municipal and Industrial	9937	2484	4.00	Port and refinery
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
232,334	None	Primary (capable of eliminating 30% of discharged BOD from plant and network)		3562		Municipal BOD estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
2484	NA	Construction of IWWTP		356		Assume industrial BOD is equivalent to 10% of municipal BOD

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Rosignano Solvay (Marritimo)	Municipal and Industrial	747	187	4.00	Port and refinery

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	***By Network Only***			
None	30,021	None	657	Municipal BOD estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**	**BOD Discharged from Industrial Sources** *(tons/year)*	**Comments**
187	NA	Construction of IWWTP	66	Assume industrial BOD is equivalent to 10% of municipal BOD

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Livorno	Industrial	10,792	2698	4.00	-

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	***By Network Only***			
154,000	13,000	Primary (capable of eliminating 30% of discharged BOD from plant and network)	2646	Municipal BOD estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**	**BOD Discharged from Industrial Sources** *(tons/year)*	**Comments**
2,698	52	Construction of IWWTP	52	Assume industrial wastewater is not treated for removal of BOD

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Manfredonia	Municipal and Industrial	5087	1272	4.00	Port and refinery

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	***By Network Only***			
None	58,100	None	1272	Municipal BOD estimated based on 60 g/ihb/day

Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**	**BOD Discharged from Industrial Sources** *(tons/year)*	**Comments**
1,272	0	Construction of IWWTP	0	Assume industrial wastewater is not treated for removal of BOD

Hot Spot Name	**Hot Spot Type**	**Reported COD** *(tons/year)*	**Reported BOD** *(tons/year)*	**COD / BOD**	**Nature of Problem**
Ancona-Falconara	Municipal and Industrial	11,959	2990	4.00	Port and refinery

Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**	**BOD Generated from Municipal Sources** *(tons/year)*	**Comments**
By Plant and Network	***By Network Only***			
85,000	46,000	Tertiary (capable of eliminating 95% of discharged BOD from plant and network)	1100	Municipal BOD estimated based on 60 g/ihb/day

Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**	**BOD Discharged from Industrial Sources** *(tons/year)*	**Comments**
2990	1890	Upgrading of IWWTP	1323	Assume existing installation capable of eliminating 30% of discharged industrial BOD

COUNTRY	***ITALY***	**INDUSTRIAL BOD DISCHARGED** *(tons/year)*	**27,143**

Estimation of BOD Discharged by Industrial Sources to the Mediterranean Sea from Hot Spots Located in LEBANON

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Greater Beirut Area		Municipal and Industrial	50,122	29,235	1.71	-
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
820,000	880,000	Primary (capable of eliminating 30% of discharged BOD from plant and network)		31,843		Municipal BOD estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
29,235	NA	Construction of IWWTP		3184		Assume industrial BOD is equivalent to 10% of municipal BOD

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Jounieh		Municipal and Industrial	6191	4280	1.45	-
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
None	210,000	None		4600		Municipal BOD estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
4280	NA	Construction of IWWTP		460		Assume industrial BOD is equivalent to 10% of municipal BOD

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Saida-Ghaziye	Municipal and Industrial	6486	5134	1.26	-

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	*By Network Only*			
None	220,000	None	4818	Municipal BOD estimated based on 60 g/ihb/day

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
5134	316	Construction of IWWTP	316	Assume industrial wastewater is not treated for removal of BOD

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Batroun Selaata	Municipal and Industrial	1769	1077	1.64	-

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	*By Network Only*			
None	60,000	None	1314	Municipal BOD estimated based on 60 g/ihb/day

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
1077	NA	Construction of IWWTP	131	Assume industrial BOD is equivalent to 10% of municipal BOD

COUNTRY	***LEBANON***	**INDUSTRIAL BOD DISCHARGED** *(tons/year)*	**4091**

Estimation of BOD Discharged by Industrial Sources to the Mediterranean Sea from Hot Spots Located in LIBYA

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Zanzur		Industrial	NA	NA	-	-
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
None	69,000	None		1511		Municipal BOD estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
NA	NA	Construction of IWWTP		2159		Assuming similar conditions to Tunisia, ratio of municipal BOD to industrial BOD is equivalent to 0.7
COUNTRY	***LIBYA***	**INDUSTRIAL BOD DISCHARGED** *(tons/year)*				**2159**

Estimation of BOD Discharged by Industrial Sources to the Mediterranean Sea from Hot Spots Located in MALTA

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Weid Ghammieq		Municipal and Industrial	16,021	10,250	1.56	-
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
270,085	None	Primary (capable of eliminating 30% of discharged BOD from plant and network)		4140		Municipal BOD estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
10,250	6110	Construction of IWWTP		6110		Assume industrial BOD is not being treated

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Cumnija		Municipal and Industrial	3599	2412	1.49	-
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
None	59,224	None		1297		Municipal BOD estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
2412	1115	Construction of IWWTP		1115		Assume industrial BOD is not being treated

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Ras il-Hobz		Municipal and Industrial	3318	1777	1.86	-

Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**	**BOD Generated from Municipal Sources** *(tons/year)*	**Comments**
By Plant and Network	***By Network Only***			
None	25,957	None	568	Municipal BOD estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**	**BOD Discharged from Industrial Sources** *(tons/year)*	**Comments**
1777	1209	Construction of IWWTP	1209	Assume industrial BOD is not being treated
COUNTRY	***MALTA***	**INDUSTRIAL BOD DISCHARGED** *(tons/year)*		**8434**

Estimation of BOD Discharged by Industrial Sources to the Mediterranean Sea from Hot Spots Located in MOROCCO

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD/BOD	Nature of Problem
Tangier		Municipal and Industrial	-	-	-	Slaughterhouse, brewery and textile industries
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
None	323,000	None		5102		Municipal BOD reported in country report
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
-	2469[17]	Construction of IWWTP		2469		Assume industrial BOD is not being treated

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD/BOD	Nature of Problem
Tetouan		Municipal and Industrial	-	-	-	Slaughter house, pulp and paper, rubber, thermal power plan, textile, food, tannery, tobacco, cement plant
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
None	214,000	None		329		Municipal BOD reported in country report
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
-	1614[17]	Construction of IWWTP		1614		Assume industrial BOD is not being treated

[17] Industrial BOD reported in updated hot spot report

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Nador		Municipal and Industrial	-	-	-	Cement, sugar, canned fish, textile
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
73,000	86,000	Tertiary (capable of eliminating 95% of discharged BOD from plant and network)		192		Municipal BOD reported in country report
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
-	887[17]	Construction of IWWTP		887		Assume industrial BOD is not being treated

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Al Hoceima		Municipal and Industrial	-	-	-	-
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
-	46,000	None		63		Municipal BOD reported in country report
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
-	210[17]	Construction of IWWTP		210		Assume industrial BOD is not being treated

COUNTRY	***MOROCCO***	**INDUSTRIAL BOD DISCHARGED** *(tons/year)*	**5180**

Estimation of BOD Discharged by Industrial Sources to the Mediterranean Sea from Hot Spots Located in SLOVENIA

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Kopper		Municipal and Industrial	2054	583	3.52	Commercial port activities, chemical industry and wine production
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
27,500	20,750	Primary (capable of eliminating 30% of discharged BOD from plant and network)		876		Municipal BOD estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
583	NA	Construction of IWWTP		88		Assume industrial BOD is equivalent to 10% of municipal BOD

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Piran		Municipal and Industrial	594	270	2.20	Metal manufacturing, production of chemicals and food industry
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
15,000	2440	Primary (capable of eliminating 30% of discharged BOD from plant and network)		283		Municipal BOD estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
270	NA	Construction of IWWTP		28		Assume industrial BOD is equivalent to 10% of municipal BOD

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Izola		Municipal and Industrial	1976	641	3.08	Shipyard wastes and food processing industries
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
Direct discharge to the sea	***By Network Only***					
2900	11,670	Network discharges to the sea without treatment		319		Municipal BOD estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
641	322	Construction of IWWTP		322		Assume industrial BOD is not being treated

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Delamaris		Industrial	399	16	24.9	Fish cannery
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
NA	NA	None		None		Assume municipal BOD is negligible
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
16	16	Extension of IWWTP		16		There is only a pre-treatment plant to deal with industrial BOD

COUNTRY	***SLOVENIA***	**INDUSTRIAL BOD DISCHARGED** *(tons/year)*	**454**

Estimation of BOD Discharged by Industrial Sources to the Mediterranean Sea from Hot Spots Located in SYRIA

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Lattakia	Municipal and Industrial	12,222	7367	1.66	Commercial seaport various and food industries

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	*By Network Only*			
None	500,000	None	10,950	Municipal BOD estimated based on 60 g/ihb/day

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
7,300	NA	Construction of IWWTP	109	Assume industrial BOD is equivalent to 10% of municipal BOD

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Banias	Municipal and Industrial	7846	3240	2.42	Oil terminal and refinery and thermal power plant

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	*By Network Only*			
None	143,000	None	3132	Municipal BOD estimated based on 60 g/ihb/day

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
3,240	108	Construction of IWWTP	108	Assume industrial BOD is not being treated

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Tartous		Municipal and Industrial	7846	3240	2.42	Port activity and cement plant
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
None	164,000	None		3592		Municipal BOD estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
3,240	NA	Construction of IWWTP		359		Assume industrial BOD is equivalent to 10% of municipal BOD

COUNTRY	***SYRIA***	**INDUSTRIAL BOD DISCHARGED** *(tons/year)*	**576**

Estimation of BOD Discharged by Industrial Sources to the Mediterranean Sea from Hot Spots Located in TUNISIA [18]

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Gabes	Municipal and Industrial	2759	1815	1.52	Phosphate mining, cement, chemical and mechanical industries

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	*By Network Only*			
78,000	48,000	Tertiary (capable of eliminating 96% of discharged BOD from plant and network)	1120	Municipal BOD estimated based on 60 g/ihb/day

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
1815	695	Construction and extension of IWWTP	695	Assume industrial BOD is not being treated

Hot Spot Name	Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Sfax - South	Municipal and Industrial	5680	3245	1.75	Phosphate mining, cement, chemical and mechanical industries

Reported Populations Served		Degree of Treatment of Wastewater in MWWTP	BOD Generated from Municipal Sources *(tons/year)*	Comments
By Plant and Network	*By Network Only*			
151,000	59,000	Secondary (capable of eliminating 80% of discharged BOD from plant and network)	1953	Municipal BOD estimated based on 60 g/ihb/day

Total BOD Generated in Hot Spot *(tons/year)*	Industrial BOD Generated in Hot Spot *(tons/year)*	Nature of Required Investment for Improvement	BOD Discharged from Industrial Sources *(tons/year)*	Comments
3245	1292	Construction and extension of IWWTP	1292	Assume industrial BOD is not being treated

[18] Treatment efficiency of the municipal wastewater treatment plants are reported in the updated hotspot country report

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Lake of Tunis - South		Municipal and Industrial	9636	4818	2.00	Chemical, mechanical, ceramics, textile, cement industries, etc.
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
117,000	58,000	Secondary (capable of eliminating 90% of discharged BOD from plant and network)		1526		Municipal BOD estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
4818	3292	Construction and extension of IWWTP		3292		Assume industrial BOD is not being treated

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD / BOD	Nature of Problem
Lake Bizerte		Municipal and Industrial	11,170	5758	1.94	Metallurgical, ceramics and glass, textile, food industries and naval construction yards
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
38,000	172,000	Tertiary (capable of eliminating 97% of discharged BOD from plant and network)		3792		Municipal BOD estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
5758	1966	Construction and extension of IWWTP		1966		Assume industrial BOD is not being treated

COUNTRY	***TUNISIA***	**INDUSTRIAL BOD DISCHARGED** *(tons/year)*	**7245**

Estimation of BOD Discharged by Industrial Sources to the Mediterranean Sea from Hot Spots Located in TURKEY

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD/BOD	Nature of Problem
Icel Area		Municipal and Industrial	NA	NA	-	About 17 industries
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
None	510,530	None		11,180		Municipal BOD estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
NA	NA	Construction and extension of IWWTP		2236		Assume industrial BOD is 20% municipal BOD due to various degrees of industrial treatments of the 17 plants

Hot Spot Name		Hot Spot Type	Reported COD *(tons/year)*	Reported BOD *(tons/year)*	COD/BOD	Nature of Problem
Icel Area		Municipal and Industrial	NA	NA	-	One industry
Reported Populations Served		**Degree of Treatment of Wastewater in MWWTP**		**BOD Generated from Municipal Sources** *(tons/year)*		**Comments**
By Plant and Network	***By Network Only***					
None	878,736	None		19,244		Municipal BOD estimated based on 60 g/ihb/day
Total BOD Generated in Hot Spot *(tons/year)*	**Industrial BOD Generated in Hot Spot** *(tons/year)*	**Nature of Required Investment for Improvement**		**BOD Discharged from Industrial Sources** *(tons/year)*		**Comments**
NA	NA	Construction and extension of IWWTP		962		Assume industrial BOD is 5% municipal BOD due to existence of one plant only

COUNTRY	***TURKEY***	**INDUSTRIAL BOD DISCHARGED** *(tons/year)*	**3198**

ANNEX 'B'

PHYSICAL WASTEWATER TREATMENT METHODS

B.1 General

Physical wastewater treatment methods are commonly referred to as primary treatment operations. The purpose of primary treatment is to remove from wastewater some of its constituents, which can clog or damage pumps and/or interfere with subsequent treatment processes. Primary treatment units are designed to fulfill three tasks:

1. to remove or reduce in size the large suspended or floating organic solids;
2. to remove heavy inorganic solids such as sand, gravel and cinder, known as grit; and,
3. to remove excessive amounts of fat and grease

A number of devices and equipment are used to achieve these objectives. The principle unit operations/processes and their functions as applied to physical treatment of wastewater are shown in Table B.1.

Table B.1: Unit operations involved in the primary treatment of wastewater

Operation/Process	*Functions*
Screens and racks	Removal of inorganic and organic floating and settleable solids
Grinders, cutters and shredders	Size reduction of solids
Presedimentation Tanks (Grit chambers)	Removal of grit
Skimming and grease traps	Removal of oil and grease
Settling tanks	Removal of settleable solids
Dissolved air flotation units	Removal of finely divided suspended solids

B.2 Screens and Racks

A screen is a device with openings, generally of uniform size. The purpose of screening is to protect water pumps from clogging and to remove coarse floating solids from wastewater. For that reason, screens are the first units employed in wastewater treatment. They do not take up a lot of valuable space.

The screen may consist of parallel bars, rods, or wire mesh or perforated plates. The openings may be of any shape but generally they are circular or rectangular. Screen sizes may vary from 100 mm for coarse screens to less than 20 mm for fine screens. The screens may be housed for protection and to prevent accidents to operating personnel.

Screening devices are usually located where they are easily accessible because the nature of materials handled requires frequent inspection and maintenance of the installation. Frequency of cleaning, when done by hand should be as often as possible. When done mechanically, cleaning may be arranged according to either preset time intervals or head loss across the screen. Mechanical screens should be kept properly lubricated and painted at least once a year. Screen chambers should be hosed at least once a day. Checks should be performed on screens to ensure that grit has not accumulated at the base of bars clogging flow.

B.3 Grinders, Cutters and Shredders

These are devices used to break or cut up solids to such size that they can be returned to wastewater without the danger of clogging pumps or piping or affecting subsequent treatment devices. There may be separate devices to grind solids removed by screens of a combination of screen and cutters installed within the wastewater flow channel. These later devices are made by a number of manufacturers under various trade names. They consist of fixed or rotating oscillatory teeth or blades acting together to reduce the solids to a size, which will pass through fixed or rotating screens or grids having opening of about 0.6 cm.

Provision should be made to by-pass grinders or cutters in case wastewater flow exceeds their actual capacity, or in case there is a mechanical or power failure.

B.4 Grit Chambers

Grit consists of sand, ash, cinder, egg shells, etc. The objective of grit removal is to protect pumps, valves and piping from damage due to abrasion. Grit, due to its high specific gravity (2.0 to 2.6) can be separated from organic solids at slow velocities (less than 0.3 m/sec) in a grit chamber or a presedimentation tank. There are three types of grit chambers that can be used for that purpose, grit channels, aerated grit chambers, and Detritus tanks.

Grit channels are intended for slow wastewater flows. Velocity control is achieved by constructing the grit channel with an approximately parabolic shape. They are usually manually cleaned, but may be also provided with mechanical equipment for collection, elevation and washing of grit.

Aerated grit chambers are provided with grit separation and washing arrangements. Grit removal from the chambers is done with mechanical equipment. Separation of the grit from the wastewater flow is achieved by means of compressed air bubbled into the flowing wastewater.

Detritus tanks are used to collect the heavy, coarse mixture of grit and organic matter carried by wastewater. Detritus tanks achieve separation and washing of grit by mechanical means. This type of device does not require velocity control over the wastewater flowing through it.

Grit chambers are normally located directly after bar screens. The frequency of grit removal should be adjusted such that the storage compartment is never more than about half-full at any time. In manual cleaning, the flow is shut-off and the chamber is emptied by gravity or pumping. For mechanically cleaned grit chambers, cleaning operations may be either on continuous or intermittent basis. In this case, mechanical parts should be lubricated as per manufacturer’s requirements. Excessive organic matter in grit is indicative of a low wastewater flow velocity. Carry-over of grit occurs when wastewater flow velocity is high.

B.5 Skimming and Grease Traps

Fats, waxes, fatty acids, soaps, mineral oil and vegetable oil present in wastewater are collectively referred to as fat and grease. The presence and quantity of fat and grease in wastewater vary from industry to industry. Industries discharging fat and grease include dairies, biscuit manufacturers, vegetable oil extraction, refining and hydrogenation, petroleum refining, etc. Fat and grease often accumulate on the surface of water causing scum problems and also decompose slowly giving rise to foul odors. Fat and grease are typically removed before biological treatment. There is incentive for most food processors to recover grease, since grease has a market value and can be sold as a by-product.

Grease from food processing operations falls into two main categories: free floating and emulsified. The free floating grease can be recovered in short detention periods of 5 to 10 minutes in flow rates of 1 to 3 meters/min. Emulsified grease is created by process operations such as cooking and pumping. The grease tends to stay in suspension and requires long detention periods of quiescent conditions to rise to the surface. Highly emulsified grease may require 30 minutes to over 1 hour to be recovered. Increased grease recovery may be achieved by the use of air flotation units and vacuum flotation systems. Grease traps are designed as skimming tanks with submerged inlet and bottom outlet. In the skimming tank, the floating matter rises and remains on the surface of the wastewater and the effluent flows out through deep outlets. Often air is injected into the bottom to enhance the separation.

B.6 Settling Tanks

The simplest method of removing suspended impurities is by plain sedimentation. Water or wastewater is allowed to stand quiescent or move very slowly through natural or artificial basin until the suspended impurities settle to the bottom and the relatively clear water is drawn of the top. Normally, sedimentation tanks are designed to provide a detention period of 90 to 150 minutes at average flow. Tanks that provide shorter detention period (30 to 60 minutes), with less removal of suspended solids, are sometimes used for preliminary treatment ahead of biological treatment units.

Settling tanks are classified according to the direction of flow of wastewater as horizontal or vertical flow tanks. These may be rectangular, square or circular in shape. According to the method of sludge collection and removal, settling tanks are classified as flat-bottom tanks, hopper-bottom tanks, or flat-bottom tanks provided with mechanical cleaning devices. Flat-bottom tanks must be emptied when the sludge is to be removed. Hopper-bottom tanks have an apex from which the sludge is withdrawn. Flat-bottom tanks are equipped with scrapers to remove the sludge to a collecting point from where it is withdrawn. Almost all treatment units now use mechanically cleaned sedimentation tanks of a standardized circular or rectangular design. The most common type of sludge scraping in circular or square tanks consists of revolving mechanism with radial arms having ploughs or blades set at an angle just above floor.

The performance of settling tanks is very much influenced by inlet arrangement, which is intended to keep down the entrance velocity and to distribute and draw the flow evenly across the basin while ensuring minimal interference with the settling zone. In rectangular horizontal tanks, inlets and outlets are placed opposite to each other, separated by the length of tank with inlet perpendicular to the direction of flow. The outlet is generally an overflow weir located at the effluent end. For circular tanks, the wastewater enters a circular well designed to distribute the flow equally in all directions. The outlet is peripheral weir. The flow is from center to periphery. Inlets and outlets should be kept clean and hosed at least once a week. Sidewalls should be periodically brushed and hosed.

Sludge removal from settling tanks should be sufficiently frequent to avoid development of septic conditions and reduce floating scum. Settling tanks provided with mechanical sludge scrapers may be operated continuously or at predetermined intervals by automatic starting and stoppage of pumps. Scum and grease is usually removed and directed to a grease trough for disposal. It should be noted that dark floating matter and rising bubbles on the surface indicate improper cleaning and inadequate sludge removal.

B.7 Dissolved Air Flotation Units

Flotation is used to separate solids or dispersed liquids from a liquid phase. The separation is effected by introducing fine gas bubbles, usually air, into the system. There are four basic types of flotation techniques, dispersed air-froth flotation, dispersed air-foam flotation, dissolved air flotation and electrolytic flotation.

Dispersed air flotation, termed froth flotation, requires violent agitation, usually by means of mechanical mixers, for aeration and dispersion of the processed wastewater. Dispersed air-foam flotation supplies air bubbles by diffusing air through porous media into the flotation cell. In dissolved air flotation, the air bubbles are generated by a reduction of the pressure of a liquid stream saturated with air. The air bubbles by this process are fine bubbles and their size is usually less than 0.1 mm. No mechanical agitation of the wastewater is required.

In recent years, the most widely used dissolved air flotation system is pressure flotation (DAF). Normally, a treated subportion of the liquid mass (20 to 50%) is saturated with air under an excess pressure of about 6 bars. When this saturated recycled flow is mixed with the wastewater to be treated and the pressure is reduced, very small air bubbles are released. These fine air bubbles either adhere to, or are trapped in, the particle’s structure making the particles buoyant and bringing them to the surface.

Electrolytic flotation uses electrolysis to generate small bubbles of oxygen and hydrogen similar in size to those produced in dissolved air flotation. A major problem of this process is the fouling of the electrodes.

DAF units are designed in rectangular and circular configurations and are commonly purchased as complete packages from equipment manufacturers. DAF mechanical equipment typically includes a pressurizing pump, an air supply, a retention tank, chemical feed equipment, float and settled sludge removal equipment. Air is furnished to the unit by a compressor designed to operate at the desired pressure of the system.

Process variables that influence performance include the pH of the wastewater. Sometimes, it may be necessary to add a special flotation agent or to adjust the pH value in order to achieve a satisfactory flotation. Temperature is also an important parameter affecting the solubility of air. If the temperature of the wastewater is high, the temperature of the recycled flow should be higher in order to ensure the solubility of air in water. Finally, the two variables under the control of the designers, hydraulic and solids loading can affect the operation of a flotation system. In general, performance can be expected to decrease dramatically at high hydraulic loading. Solids loading can also hinder performance at higher concentrations.

ANNEX 'C'

CHEMICAL WASTEWATER TREATMENT METHODS

C.1 General

Chemical treatment methods are commonly referred to as secondary operations in wastewater treatment plants. The purpose of secondary operations is to remove impurities such as taste, odor, color, organic impurities, non-degradable organics, heavy metals, etc. Chemical treatment contributes indirectly to the reduction of BOD and is presented here in this context. The principle unit operations/processes and their functions as applied to advanced physical-chemical treatment of water and wastewater are shown in Table C.1.

Table C.1: Unit operations involved in the advanced physical-chemical treatment of wastewater

Operation/Process	*Functions*
Coagulation and Chemical Precipitation	Removal of fine suspended solids, organics, colors, heavy metals and toxic substances
Adsorption	To remove taste, odor, color, organic impurities, non-degradable organics, heavy metals, etc., from wastewater

C.2 Coagulation and Chemical Precipitation

Coagulation is applied to remove fine suspended solids, which could not be removed from wastewater by sedimentation or flotation, soluble organic and toxic substances, and trace metals. The most common coagulants used are alum, ferric chloride, lime or polyelectrolytes. Addition of these chemicals requires only moderate mixing. However, initial, or flash mixing, is necessary to disperse the coagulant chemical quickly and evenly. Several systems are available for flash mixing including diffuser grid systems, chemical jet systems and in-line blender systems. The grid system requires extensive piping and small-diameter injection orifices that tend to clog, so practical use of this system is limited. Chemical jet systems disperse the coagulant irreversibly into the water in a fraction of a second. The coagulant is fed into coming flow through a nozzle by a vertical turbine pump. In-line blenders are plugflow-type reactors that make use of high-power devices for mixing. They come in the form of standard units manufactured commercially to be fitted in the water pipe itself. In order to prevent clogging injection orifices, alum or ferric salts should not be diluted below a concentration of 2.5 percent solution prior to addition to water (JMM, 1985).

C.3 Adsorption

Adsorption is a physical phenomenon by which molecules of the solids are attached on the surface of adsorbent materials due to the intermolecular forces of attraction and are thereby removed. Adsorption is a relatively expensive method and is used mainly for removal of relatively small amounts of non-biodegradable toxic or potentially bio-accumulating compounds. In most cases adsorption is used as a final or tertiary treatment process. The most commonly used adsorbent is activated carbon, but other materials like peat, wood, charcoal, fly ash, and slag are also in use.

Powdered activated carbon may be used together with flocculants or may be used within a biological treatment system. During operation, the carbon must be disposed of or regenerated once its adsorptive capacity has been fully utilized. Typically, the carbon is removed by sedimentation and dewatered together with other sludge materials. Several carbon filters are often operated in series or in parallel. The filters can then successively be taken out of operation for reactivation or replacement of the carbon. Reactivation can be carried out at the mill at large installations or at a central reactivation unit. A complete activated carbon adsorption system includes carbon storage vessels and thermal regeneration facilities. Steam reactivation is applicable for organics with evaporation temperatures of 100 to 150 degrees Celsius. Kiln reactivation is suitable to burn off non-volatile organics at 700 to 800 degrees Celsius. Ion exchange resins may be used to remove metal ions. However, in order to operate effectively, the incoming level of suspended solids and organics should be very low. Pretreatment is thus often required.

ANNEX ‘D’

TERTIARY WASTEWATER TREATMENT OPERATIONS

D.1 General

Tertiary operations in wastewater treatment plants consist of biological processes for treating soluble organic chemicals dissolved in water. The principle unit operations/processes and their functions as applied to biological treatment of wastewater are shown in Table D.1.

Table D.1: Unit operations involved in the biological treatment of wastewater

Operation/Process	*Functions*
Trickling filter	Requires large surface area and is sensitive to operating temperature
Activated sludge	Requires smaller area, lower capital cost, and provides higher degree of treatment
Aerated lagoons and oxidation ponds	Used where land is available and cheap and the climate is temperate
Anaerobic digestion	Is well suited for treating wastes with BOD's in excess of 10,000 ppm

D.2 Trickling Filter

A trickling filter consists of a bed of stone, gravel or slag from 1.3 to 2.5 meters deep covered with slime growth over which the waste is distributed evenly. As the waste passes through the filter, organic matter present in the waste is removed by the biological film. Depending on the hydraulic loading and depth of the filter, BOD removal efficiencies of about 90 percent may be reached on some wastes. The maximum BOD concentration, which can be effectively handled is approximately 500 ppm applied to the top of the filter. The main advantages of the trickling filter are its basic simplicity, low power consumption and ease of operation and maintenance. Disadvantages include the large surface area required and sensitivity to operating temperature.

D.3 Activated Sludge

Activated sludge is the most versatile biological treatment since it can be tailored to handle a wide variety of wastes and effluent requirements. The activated sludge process utilizes the same type of bacteria as the trickling filter process. In activated sludge, however, the bacteria are suspended in water and aerated in the presence of organic wastes. With 4- to 8-hour retention time, activated sludge may provide up to 90 percent BOD removal.

Oxygen may be supplied by mechanical or diffused aeration systems, such as diffused aeration units, swing diffusers, surface aerators, turbine aerators, and spargers. The advantages of activated sludge, compared with the trickling filter, include its smaller area, lower capital cost, higher degree of treatment, greater flexibility and more precise control. The main disadvantages are higher power costs and the greater complexity of properly operating the system.

Both the trickling filters and activated sludge produce a biological sludge, which must be disposed of. This sludge contains the excess bacteria developed during the oxidation process. The sludge can be partially digested anaerobically and filtered followed by burning or can be filtered directly and burned or buried.

D.4 Lagoons, Stabilization or Oxidation Ponds

The oxidation pond is widely used where land is available and cheap and the climate is temperate. An oxidation pond is a large shallow lagoon or basin with wastewater added at one point and stabilized effluent removed from another. Depth is usually between 0.7 and 1.3 meters. Oxygen is supplied by respiration of algae and from wind action on the surface of the pond.

Deeper ponds, 1 to 2 meters deep, are called facultative ponds and are divided by loading and thermal stratification into an aerobic surface and an anaerobic bottom. Sludge deposited on the bottom will undergo anaerobic decomposition, producing methane and other gases. Eventually the pond must be dredged to remove settled inert matter and microorganisms.

BOD removal is at a rate of about 20 kg/acre/day, without forced aeration. Biochemical activity is related to sunlight and temperature, and BOD removal efficiency therefore varies seasonally. Aerated lagoons using mechanical surface aerators or diffusers are able to treat much greater organic loads. Floating surface aerators, turbine aerators, and brush aerators are commonly used. The method is a form of the activated sludge process without sludge recirculation with a relatively dilute concentration of microorganisms.

The organic loading can be increased by a factor of five compared with an ordinary oxidation pond. Raising the organic load, however, also raises the microbe population. In order to produce a low BOD effluent, these microbes must be removed. These suspended biological solids are commonly removed in a second-stage lagoon or pond.

D.5 Anaerobic Lagoons

Anaerobic digestion is widely used to stabilize concentrated organic solids removed from settling tanks and from aerobic biological treatment systems. The waste is mixed with large quantities of microbes, and oxygen is excluded. Under these conditions, anaerobic bacteria thrive, converting up to 90 percent of the degradable organics into methane and carbon dioxide. The high degree of destruction minimizes the problem of excess sludge disposal. Power costs are reduced because oxygen is not required. In addition, the methane gas is a source of energy for heating of for the generation of electricity. Disadvantages include the fact that a relatively high temperature for heating the tanks is needed for efficient operation. Dilute wastes may not produce enough methane to take care of the heating. Also, methane-producing bacteria grow at a slow rate, making it difficult to start the process and adjust to changing operating conditions. The system is well suited to treating concentrated wastes with BOD’s in excess of 10,000 ppm.